2.2.3 Lab: Exploring Orbits
Earth Science, Semester 1
Points Possible: 50

Name____________________________

Date_____________________________

In 1609, the German mathematician and astronomer Johannes Kepler deciphered a major puzzle of the solar system. The strange back-and-forth motions of the planets in the sky were

around the sun. Orbits were always believed to be circular, but Kepler used mathematics to discover they were actually elliptical.

An ellipse is an oval that is characterized by two quantities. The first quantity is the length of the ellipse, which is called the major axis. The second quantity is called the eccentricity, which is a measure of how stretched out the ellipse is. Eccentricity is defined as the ratio of the distance between the foci (focal length) to the length of the major axis (A circle is an ellipse with zero eccentricity.)

For planets, one focus of their orbital ellipse is the sun (see illustration on Page 3). The other is an empty point in space which is an equal distance from the ellipse midpoint. The orbit of each planet is elliptical, but each planet's orbit has different major axes and eccentricities. Once Kepler understood the proper nature of orbits, the movements of the planet in the sky could be predicted with precision.

In this investigation you will understand how to draw ellipses, calculate their eccentricities, observe an interesting property of ellipses, and compare the drawn ellipses with the orbital eccentricities of Earth and other planets in the solar system. Make sure you understand the procedure so you can interpret the data provided.

Problem

What do the elliptical orbits of the planet look like?

Pre-Lab Discussion

Read the entire investigation. Then answer the following questions.

1. **Predicting** Each planet's orbit is shaped like an ellipse. Predict the shapes of the planet's orbits: Do you think they are more like circles or elongated ellipses?

2. **Applying Concepts** What is the focal point that the elliptical orbits of all planets, asteroids, and most comets have in common?

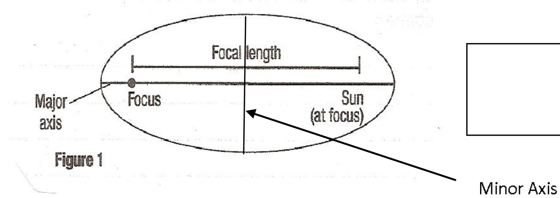


Figure 1

Focal Length

3. **Controlling Variables** What is the independent variable (the variable you manipulate) of the ellipses in the procedure? Is it focal length, major axis, or eccentricity?

4. **Controlling Variables** What are the dependent variables (the variables that change as a result of manipulating the independent variable) for the ellipses drawn? (focal length, major axis, or eccentricity?)

5. As the distance between pins in the procedure is decreased, what part of the ellipse changed?

6. When using the push pins in the procedure, what happens to the major and minor axes as the focal length decreases?

7. As the focal length decreases, are the ellipses becoming more or less circular?

8. What is happening to the eccentricity with each change in the positions of the push pins?

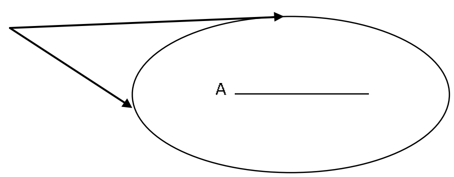
Part A: Drawing Ellipses and Calculating Eccentricity
Measurement data for the major axis and focal lengths of several ellipses are listed in Data Table 1. Use the length of the major axis and focal length to calculate the eccentricity of each ellipse. Record these values in Data Table 1 below. The eccentricity of each ellipse is calculated by dividing focal length by the length of the major axis:

Data Table 1: Ellipse Measurements. Calculate eccentricity for each ellipse.

Ellipse	Major Axis (cm)	Focal Length (cm)	Eccentricity (cm)
1	10	5	
2	44	16	
3	12	3	
4	30	4	
5	27	2	

Part B: Observing Properties of Ellipses
Data Table 2 lists distances between each focal point (A or B) and a third point (C) along an ellipse. Examine Data Table then calculate the length of AC + BC for each position of C. Record these values in Data Table 2 above.

C is any point on the ellipse. The length of AC + BC is equal to the major axis.



Data Table 2

Position of C	Length of AC (cm)	Length of BC (cm)	AC + BC (cm)
1	3	7.6	
2	4.6	6	
3		3.1	
4	2.2	8.4	

Analysis and Conclusions

1. Looking at the planet vs. eccentricity table, which two planets have the greatest eccentricity?

Planet	Eccentricity
Mercury	0.206
Venus	0.007
Earth	0.017
Mars	0.093
Jupiter	0.048
Saturn	0.056
Uranus	0.047
Neptune	0.009
Pluto	

2. Which two have the smallest eccentricity?

3. Looking at the eccentricity of the earth's orbit; is it more circular or more elliptical?

4. Since 7 of the planets have an orbital eccentricity of less than 0.1, can you make a general statement about the planetary orbits: circular or elliptical? Does this evaluation coincide with your original prediction (in Q1 of the prelab discussion).

5. What shape would you make if both pushpins were placed at a single central point? What would be the focal length and eccentricity of this shape.

6. In Part B: Observing properties of Ellipses: What did you discover about the sums of lines AC and BC. Write your findings as a "basic law of ellipses."

7. Think about the orbit of the moon compared to the orbit of planets. What is one focal point of the moon's orbit?