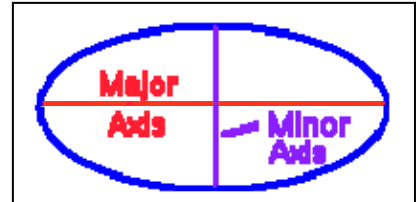


Who is the Most Accurate Researcher?

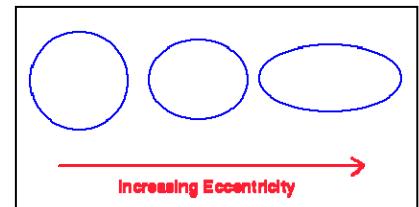
Historical Background: In 1605 Johannes Kepler formulated three laws which were able to predict planetary motion. The first of Kepler's three laws is that every planet moves in an elliptical orbit, shown in the diagram below, with the sun at one of the foci, a special point used to define an ellipse.

Kepler could not explain why his laws worked. The explanation came about 100 years later when Sir Isaac Newton, using his invention of calculus, was able to prove them from his laws of motion and his law of universal gravitation.



The major axis is the ellipse's long axis, and the minor axis is the shorter one. Half of the major axis is called the *semi-major axis* while half of the minor axis is called the *semi-minor axis*.

The eccentricity is a parameter used to describe an ellipse, which is like a flattened circle. The eccentricity, e , ranges from $e = 0$ to 1, where $e = 0$ is a perfect circle and $e = 1$ is a straight line. In other words, the greater the eccentricity, the flatter is the ellipse.



Logically we would expect Gamma to move in an elliptical orbit, and astronomers would want to determine its eccentricity.

Instructions

1. Select a laboratory director from among your group. Then listen carefully to the instructions the director gives you concerning the contest.
2. Use the ruler provided to measure the major axis and the minor axis on the scale drawing of the orbit of planet Gamma to the nearest millimeter. Record the results to the nearest whole millimeter on the data sheet.
3. Determine the semi-major and semi-minor axis length, and put them in your data sheet.

4. Calculate the eccentricity, e , using the formula below.

$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

where a is the semi-major axis and b is the semi-minor axis.

- Record all the measurements and calculations on the data sheet below. Show your calculation including units of measurement.
- Report your results to your director.
- After the results from all the teams have been tabulated, the director will give you a Student Data Table of the results of all teams. Look at the last three rows of the Student Data Table, the Average, Maximum and Minimum. Compare and contrast the results.
- Answer the questions on the worksheet and hand them into your instructor.

Data for "Planet Gamma"

Researcher's Name: _____

Research Group: _____

Major axis: _____ mm.

Semi-major axis, a : _____ mm.

Minor axis: _____ mm.

Semi-minor axis, b : _____ mm.

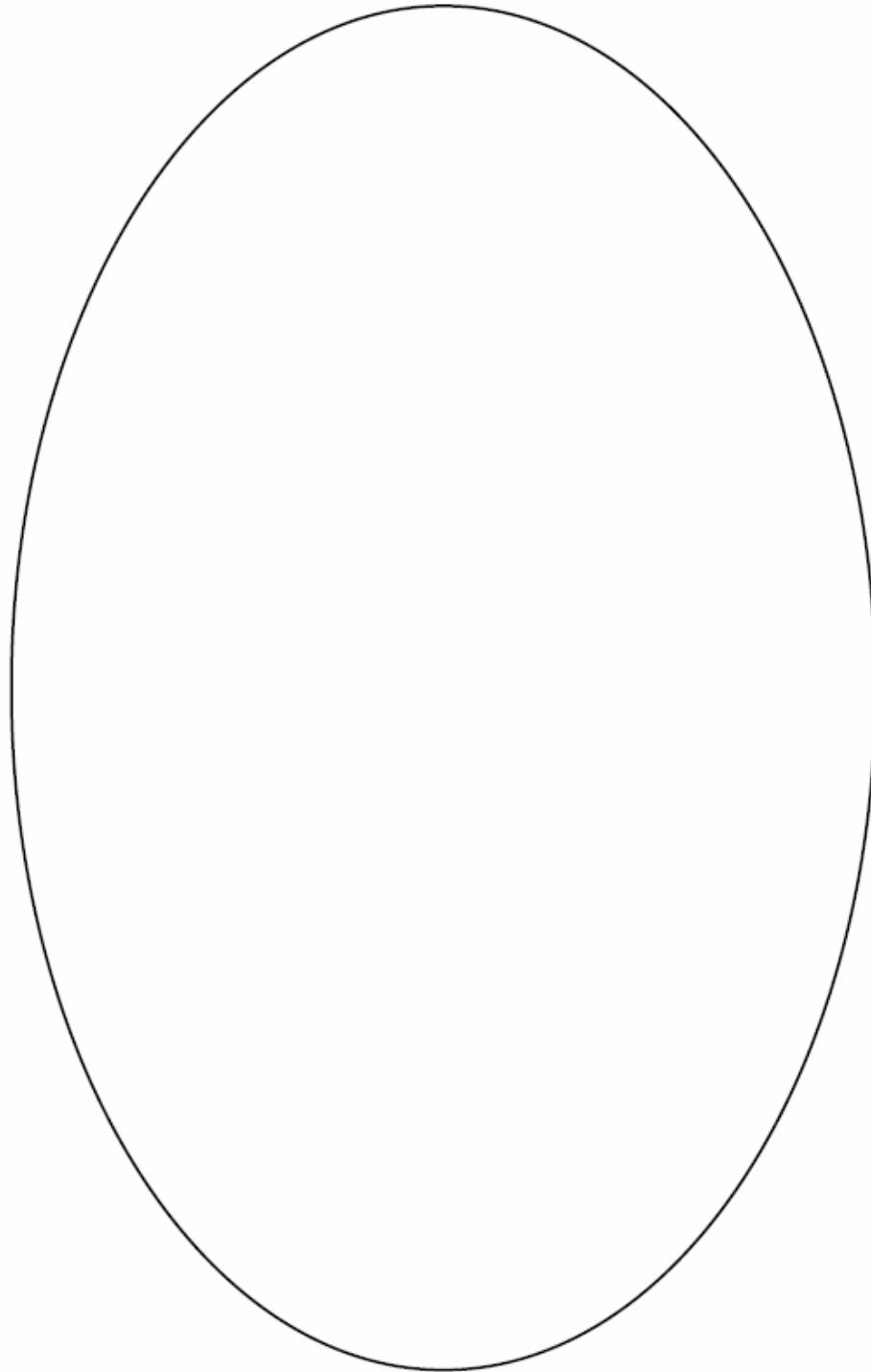
Eccentricity: _____.

Calculation:

The Orbit of Planet Gamma



Student Handout:



Student Data Table

	Group A			Group B			Group C		
	Major Axis	Minor Axis	<i>e</i>	Major Axis	Minor Axis	<i>e</i>	Major Axis	Minor Axis	<i>e</i>
Measurement 1									
Measurement 2									
Measurement 3									
Measurement 4									
Measurement 5									
Measurement 6									
Measurement 7									
Measurement 8									
Measurement 9									
Measurement 10									
Average									
Minimum									
Maximum									

4. Do the calculated values of eccentricity for one group show the same variation when compared to the values for eccentricity calculated by other groups that was noted for the major axis and minor axis data? What might account for this?

5. Define random error in your own words.

6. Define systematic error in your own words.

7. a) Do systematic errors tend to "average out" over many observations?

b) Do random errors tend to "average out" over many observations?

8. Which of the three laboratories, A, B or C deserves recognition as the most accurate and advanced researchers in the world? Defend your answer.