How Round or Flat Is an Orbit?

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Eccentricity of an ellipse:

What is an ellipse?

Where do we find them?

How do we construct them?

What is eccentricity and how does it relate to ellipses?

An ellipse is a symmetrically shaped closed oval. It has two points around which it is constructed and these points are called foci. The foci act as the combined center for the ellipse. The eccentricity of an ellipse refers to how flat or round the shape of the ellipse is. The more flattened the ellipse is, the greater the value of its eccentricity. The more circular, the smaller the value or closer to zero is the eccentricity. The eccentricity ranges between one and zero. If the eccentricity is one, it will be a straight line and if it is zero, it will be a perfect circle. The formula to determine the eccentricity of an ellipse is the distance between foci divided by the length of the major axis.

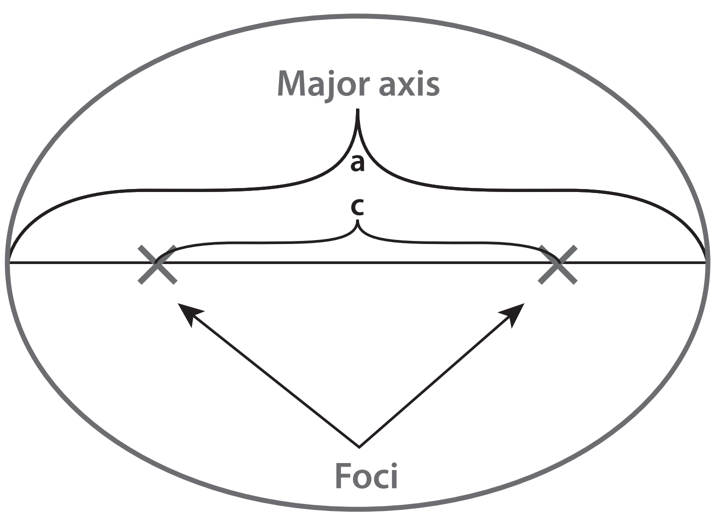
E=c/a

E= eccentricity

c = distance between the focal points

a= length of major axis

Eccentricity increases



VOCABULARY:

Eccentricity

Ellipse

Foci

Kepler's First Law

Major Axis

Inside This Packet

Students will be able to:

Define the parts of an ellipse

Construct three different eccentric ellipses

Calculate eccentricity of an ellipse

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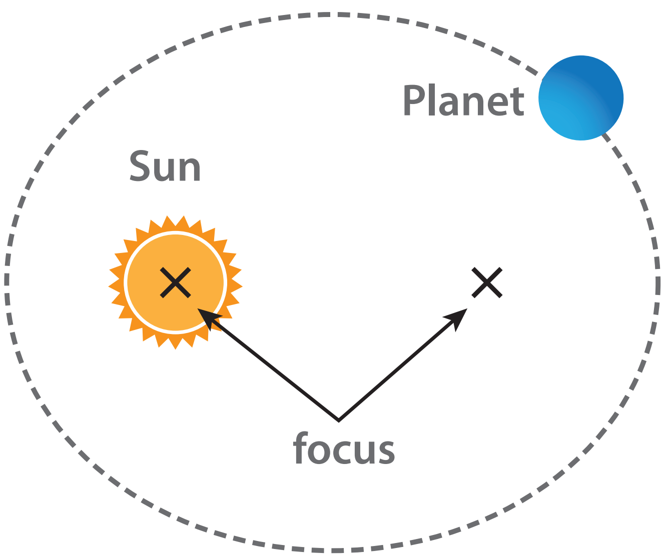
Ellipses are found naturally in orbits of planets or satellites and in shapes found in nature. Understanding the nature of ellipses helps us to understand how planets balance the gravitational pull and the opposing forces of the planet's inertia.

Johannes Kepler (1571-1630) used the Mars observations of his mentor, Tycho Brahe, and the understanding of a heliocentric solar system developed by Copernicus to accurately describe the elliptical pattern of the planets. This was brilliant thinking for the time and accurately portrayed the movement of planets in ellipses around the sun vs in circles. Kepler's first law is outlined below. Kepler's second and third laws apply to planetary motion but not to eccentricity.

"Kepler's First Law: The orbits of the planets are ellipses, with the Sun at one of the focus points of the ellipse."



Kepler's First Law is illustrated in the image shown above. The picture exaggerates the eccentricity of the planet for learning purposes. Most of the planets have just slightly eccentric ellipses except for Mercury, which has quite an elliptical orbit.

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MATERIALS NEEDED PER TEAM:

Sharp pencil

Round string

Two push pins

Tack board (cardboard) 8 in by 8 in or larger

White paper

Scotch tape

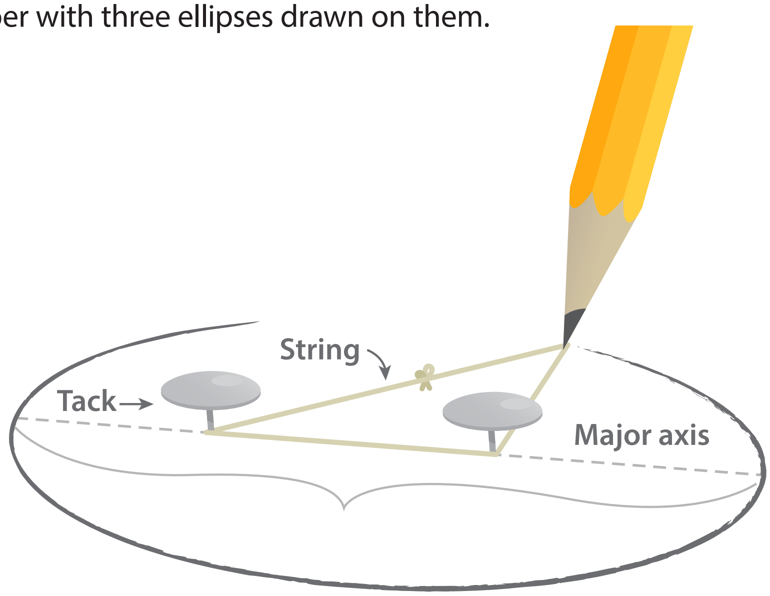
Ruler

Calculator

Earth Science Reference Tables

Making An Ellipse and Measuring Eccentricity:

1. On the top of your lab paper, write your name and your partner's name. Repeat this procedure, creating a copy for each of you.
2. Place the white paper on the tack board and tape the corners down.
3. Cut a piece of string about 14 to 16 inches long.
4. Tie the end of the string tightly together to form a loop of string.
5. Press the push pins in the center of the paper about two inches apart and press securely in place. They will act as the foci for the ellipse. Label these points A and B.
6. Place the string around the foci push pins and pull taunt while the partner holds the push pins in place.
7. Use a sharp pencil to keep the string taunt and draw an ellipse by drawing around the two foci push pins with the string taunt. A complete ellipse should be created. Label this ellipse 1.
8. Construct another ellipse with the tacks closer together. Label these foci points C and D. Label the ellipse 2.
9. Construct a third ellipse with the foci farthest apart and label these points E and F. Label the ellipse 3.
10. When you finish you should have three ellipses drawn of different eccentricities. Repeat the complete process so that each student has their own paper with three ellipses drawn on them.



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Name: ____ Date: __________

Partner's name: _______________________________________

Write out the formula for eccentricity and label each variable:

Calculations For Ellipse 1: Using a ruler, measure the distance between A and B.

Record foci distance: ____________________________

Measure the major axis for the ellipse created by A and B

Record major axis distance: ____________________________

Determine the eccentricity of the ellipse created by AB, and show work below

Repeat the above procedure for ellipse 2 (foci CD) and ellipse 3 (foci EF). Show your work below.

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Using the ESRT (Earth Science Reference Table) complete the following:

Celestial Object	Eccentricity
Mercury	.206
Venus	
Earth	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	

Questions:

1. Which planet has the most flattened orbit or most eccentric orbit?
2. Which planet has the most circular orbit?
3. What celestial object is located at one of the foci of the planets' ellipses?
4. What did you learn from this activity?
5. What question(s) did this experience generate?

New York State Standards

Standard 1 Math: Key Idea 1

Standard 1 Science: Key Idea 1

Standard 4: Key idea 1

Standard 6: Key Idea 2