Kepler's Laws

Before Kepler, it was thought that the orbits of the planets were all circular.

Part A: Strings and Pins

1. ____ Secure a piece of paper to the cardboard sheet with tape (one piece in each corner).
2. ____Place the two pushpins 10 centimeters apart near the middle of the paper.
3. ____Make a 15-centimeter loop with your string. Loop the string over the two pushpins.
4. ____Using a pencil, form a triangle with the string, keeping it tight. Allowing no slack, move your pencil around the two push pins, drawing an ellipse on your paper.
5. ____Remove the string and two pushpins in the center of the paper. Each hole is called a **focus** of the ellipse. Choose one and label it "sun." Somewhere on the ellipse, put a dot and label it "planet."
6. ____Along the planet's orbit, find the place where the planet is closest to the sun. This is called "**perihelion**." Label this location.
7. ____Along the planet's orbit, find the place where the planet is farthest from the sun. This is called "**aphelion**." Label this location.
8. ____Find the point that is halfway between the two foci and make an "X."
9. ____Draw a straight line from the "X" to the sun. Label this line "c."
10. ____Draw another straight line from the "X" through a focus until you intersect the ellipse. This line is similar to the radius of a circle, but with an ellipse it is called the "**semi-major axis**." Label this line "a."
11. ____Mathematicians use the word "**eccentricity**" to measure the flatness of an ellipse. Eccentricity of an ellipse can be found if one knows the semi-major axis (a) and the distance from the center of ellipse to one of the foci (c). Use the following equation to find the eccentricity of the ellipse that you drew. Use the space below to show your work.
    Eccentricity = c/a

Part B: Eccentricity of the Planet's Orbits

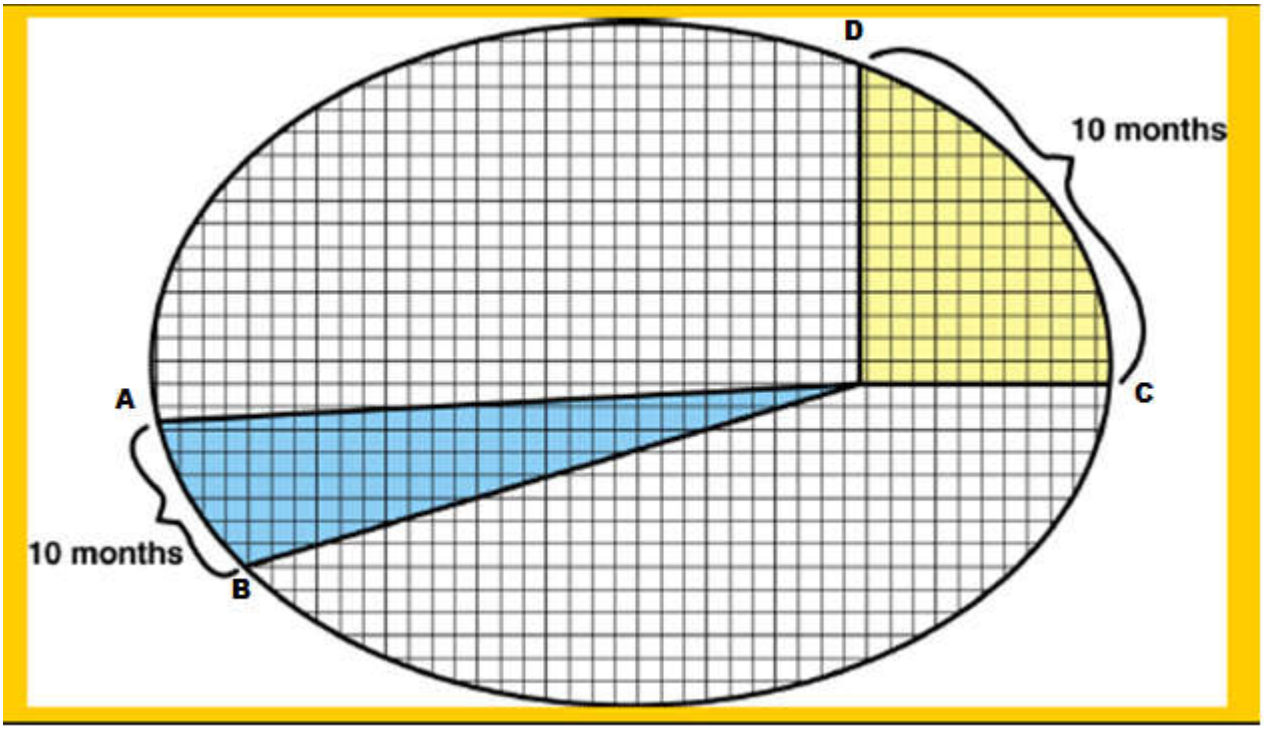
Using the formula **e = c/a**, find the eccentricity of each of the objects by filling in the chart below:

Planet	Distance from center of ellipse to focus in Astronomical Units (c)	Semi-major Axis in Astronomical Units (a)	Eccentricity (e)
Mercury	0.080	0.387	
Venus	0.005	0.723	
Earth	0.017	1.000	
Mars	0.142	1.524	
Jupiter	0.250	5.203	
Saturn	0.534	9.540	
Uranus	0.901	19.180	
Neptune	0.271	30.060	
Pluto	9.821	39.440	

1. Which planetary orbit is the most eccentric? What does this mean?
2. Which planetary orbit is the closest to being a circle?
3. Which two orbits have the closest eccentricity?
4. What other planet has an orbital eccentricity most similar to the Earth's?

Part C: Sweeps

1. Observe the following diagram. This shows an elliptical orbit of a planet around the sun. Determine the area of the two shaded areas.



2. If it takes a planet the same amount of time to move from point A to point B as it does from point C to point D, what can you say about the speed of the planet as it moves around the sun in this elliptical orbit?

3. Describe the speed of the planet at perihelion (closest point to the sun) versus aphelion (furthest point from the sun).

Part D: ratios

Planet	Period (yr)	Average Distance (au)
Mercury	0.241	0.39
Venus	.615	0.72
Earth	1.00	1.00
Mars	1.88	1.52
Jupiter	11.8	5.20
Saturn	29.5	9.54
Uranus	84.0	19.18
Neptune	165	30.06
Pluto	248	39.44

Time^2	**Distance^3**	