

Kepler's Laws

1. Read FYI: *Orbits & Ellipses* and FYI: *Kepler's Laws*. Complete the reading guide and questions after reading.
2. You will now construct three ellipses on three separate sheets of paper.

Page 1

- Place a piece of paper over the cardboard and insert the two straight pins into the cardboard to represent the two foci of the ellipse. For the first ellipse, place the foci 8 cm apart.
- Tie a string into a closed loop (or use an existing loop) and place it over the bottom of the two pins.
- Carefully draw the ellipse by stretching the string so it is taut, but try not to pull the pins out of the cardboard.
- Choose one focus and draw the Sun at that focus.
- On this **first** ellipse, pick one point (on the ellipse you just drew) near the Sun and one point far from the Sun. At these points, draw straight arrows to represent the force of the Sun's gravity at that point. (Longer arrows for greater force.)
- Also at those same two points draw a straight arrow to represent the speed of a particular planet at that point. (Longer arrows for greater speed.)
- Ask your teacher for assistance if you are unsure.

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- Now for the **second** ellipse, change the distance between the foci to 6 cm and trace the ellipse.
- Choose one focus and draw the Sun at that focus.
- Pick a point on the ellipse and draw a line connecting that single point to each focus. Measure the length of these lines and label the lengths on your paper (include units). Add these two distances and get a total for this particular point on the ellipse—also list this on your paper.
- Repeat the previous step on the same ellipse and see how those total distances compare. (How should they compare?)

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- On the **third** ellipse, change the distance between the foci to 4 cm and trace the ellipse.
- Choose one focus and draw the Sun at that focus.
- On this 3rd ellipse, label *aphelion* (the point farthest from the Sun) and *perihelion* (the point closest to the Sun.)

Staple all three pages together with this page on top and answer the following:

Questions:

- A. How does changing the focal length affect the *shape* (not the size) of the ellipse?
 - B. Where in the planet's orbit (on the ellipse) is its speed the greatest?
3. Complete the sheet *Exploring Kepler's Second and Third Laws*.

Exploring Kepler's Second and Third Laws

Investigating Planets: Exploration Two: Activity 3

Kepler's Second Law

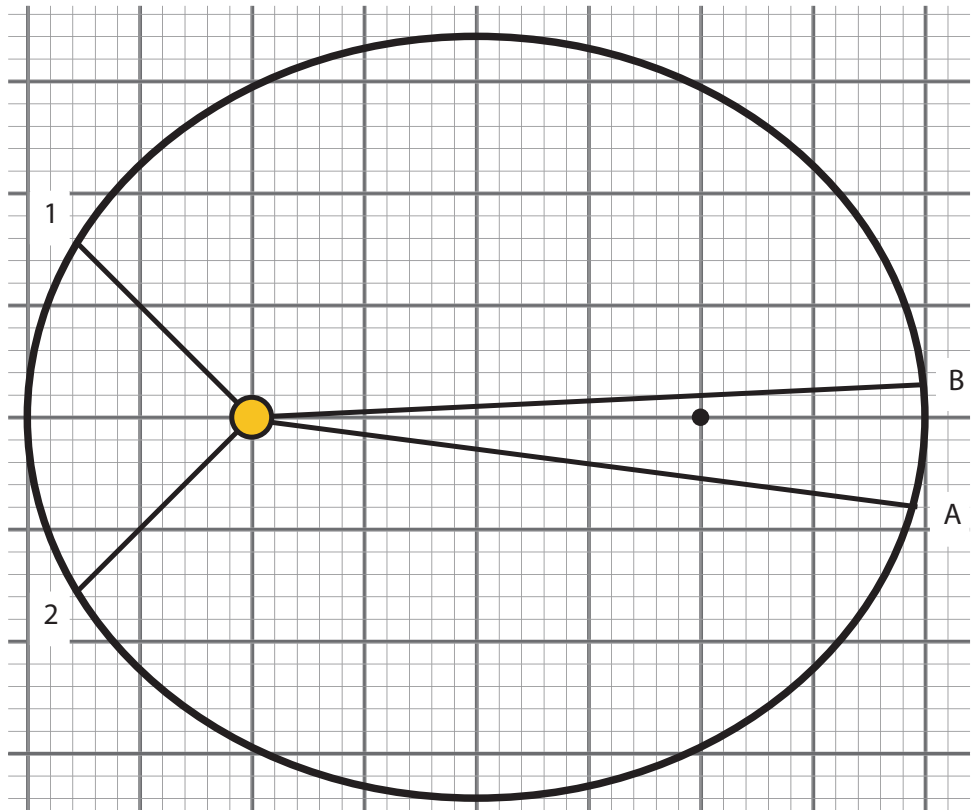
1. Area swept from point 1 to point 2

_____ squares

2. Area swept from point A to point B

_____ squares

3. What does Kepler's second law of planetary motion say about the time it took for the planet to move from point 1 to point 2 compared to from point A to point B?

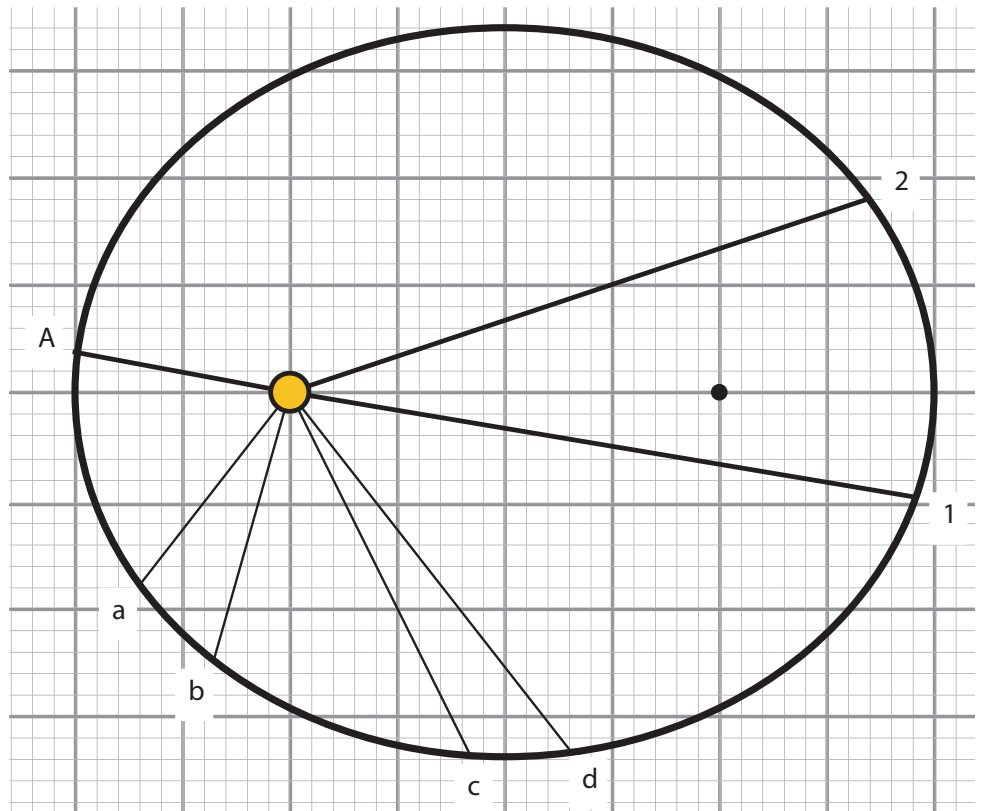


4. Area swept from point 1 to point 2

_____ squares

5. In the amount of time it took the planet to move from point 1 to point 2, the planet moved from point A to which point? (circle one)

a b c d

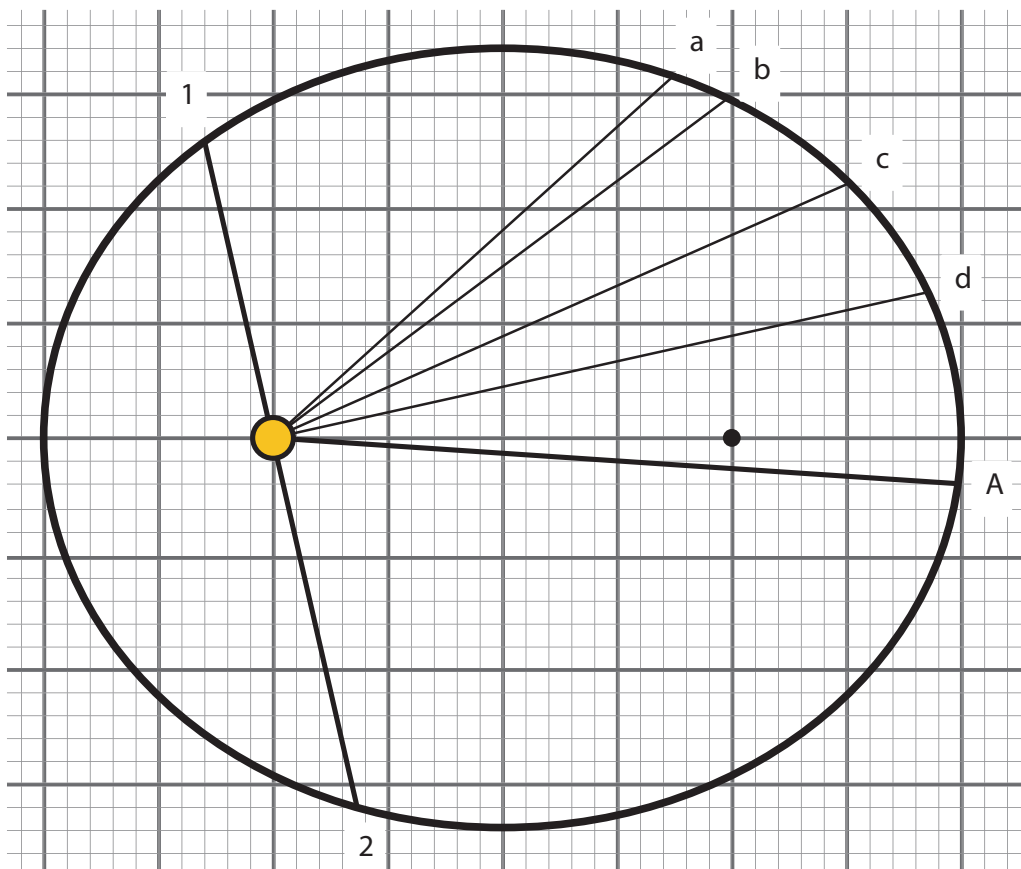


6. Area swept from point 1 to point 2

_____ squares

7. In the amount of time it took the planet to move from point 1 to point 2, the planet moved from point A to which point? (circle one)

a b c d



Kepler's Third Law

Use the following equation to answer questions 8, 9, and 10.

$$(\text{Earth years it takes planet to orbit once})^2 = (\text{average distance, au, between planet and sun})^3$$

8. If it takes a planet 1.88 Earth years to orbit the sun once, which of the following is the average distance between that planet and the sun?

- a. 1.67 b. 1.59 c. 1.52 d. 0.98

9. If it takes a planet 164.8 Earth years to orbit the sun once, which of the following is the average distance between that planet and the sun?

- a. 52.15 b. 43.02 c. 39.74 d. 30.06

10. If a planet has an average distance of 9.54 au from the sun, which of the following is the time, in Earth years, it takes that planet to orbit the sun once?

- a. 31.98 b. 29.47 c. 24.13 d. 22.78

Hint

Try each of the possible answers to see which works in the equation. For example, in question 8:

$$(1.88)^2 = (1.88)(1.88) = 3.53$$

Check "a."

$$(1.67)^3 = (1.67)(1.67)(1.67) = 4.66$$

4.66 is not equal to 3.53, so the answer is not "a."

Continue with b, c, and d:

$$(1.59)^3 = (1.59)(1.59)(1.59) = \underline{\hspace{2cm}}$$

$$(1.52)^3 = (1.52)(1.52)(1.52) = \underline{\hspace{2cm}}$$

$$(0.98)^3 = (0.98)(0.98)(0.98) = \underline{\hspace{2cm}}$$