Orbit Clues

Use a circular-orbit model to test Kepler's third law.

PHY.2.11 "Explain centripetal acceleration while undergoing uniform circular motion to explore Kepler's third law using online simulations, models, and/or probe systems."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline statements that explain why acceleration occurs or where it points, circle what stays fixed in the simulation, and number the table rows from smallest to largest radius to help you trace how radius and period are related.

A Spacecraft Changes Direction

1. A spacecraft in a circular orbit can move at steady speed while its velocity changes direction. Its centripetal acceleration points toward the star, not along its path. Its magnitude is $a = v^2/r$, where v is speed and r is orbital radius. During one period T, it travels $2\pi r$, so $v = 2\pi r/T$.

2. In an orbit simulation, a student holds the star's mass fixed and sets three circular paths. The student records each path's radius and the time for one revolution. The units are scaled: a radius of 1 and a period of 1 serve as reference values. The same star supplies the inward gravitational pull in every run.

CIRCULAR-ORBIT SIMULATION RESULTS

Radius r (scaled units)	Period T (scaled units)
1	1
4	8
9	27

3. For a fixed central mass, gravity weakens with the square of the distance: doubling r makes inward acceleration one-fourth as large. Combining this gravitational rule with $a = v^2/r$ and $v = 2\pi r/T$ gives Kepler's third law: T^2/r^3 stays constant. The ratio describes orbits around the same central mass; changing that mass changes the ratio.

2 ANSWER WITH EVIDENCE

Use the passage

1. If the spacecraft is at the top of its circular path, which way does its acceleration point? Explain why it accelerates even at steady speed.

2. Use the rows for radii 1 and 4 to test Kepler's third law. How do the changes in r^3 and T^2 compare?

3. Starting with the row for radius 1, use Kepler's third law to predict the period at radius 9. Does the table support your prediction?

4. Why must the star's mass stay fixed when you use these runs to test whether T^2/r^3 stays constant?

3 YOUR TURN

Your own words

Plan one more circular-orbit simulation run around the same star at radius 16. Use the row for radius 4 to predict its period, then explain how its speed and inward acceleration would compare with that run.

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PART 1 · READ AND MARK

Underline statements that explain why acceleration occurs or where it points, circle what stays fixed in the simulation, and number the table rows from smallest to largest radius to help you trace how radius and period are related. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	If the spacecraft is at the top of its circular path, which way does its acceleration point? Explain why it accelerates even at steady speed.	**It points down, toward the star at the center. The spacecraft accelerates because its velocity changes direction.**
2	Use the rows for radii 1 and 4 to test Kepler's third law. How do the changes in r^3 and T^2 compare?	**The radius increases by a factor of 4, so r^3 increases by $4^3 = 64$. The period increases by a factor of 8, so T^2 increases by $8^2 = 64$. The changes agree with the law.**
3	Starting with the row for radius 1, use Kepler's third law to predict the period at radius 9. Does the table support your prediction?	**Since $9^3 = 729$ and $27^2 = 729$, the predicted period is 27. The table supports it.**
4	Why must the star's mass stay fixed when you use these runs to test whether T^2/r^3 stays constant?	**Changing the star's mass changes the inward gravitational pull and the value of T^2/r^3. Keeping it fixed lets the student compare the effect of radius.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Increasing the radius from 4 to 16 multiplies it by 4, so the period grows by $4^{3/2} = 8$, from 8 to 64. Since speed is $2\pi r/T$, the new speed is half the speed at radius 4. The inward acceleration is one-sixteenth as large because the new orbit is four times as far from the star.

Accept equivalent calculations using T^2/r^3, $v = 2\pi r/T$, and $a = v^2/r$. In the open task, acceleration must still point toward the star.