Orbits: direction, radius and period

Student activity • observation and reasoning

YEAR 11 / LESSON 106 / PHYSICS + SCIENCE (DOUBLE AWARD)

The question

Why does a constant orbital speed still involve changing velocity?

Draw circular and elliptical orbital models and calculate average speed for stated circular examples.

Equipment

- Booklet, graph paper, ruler, compass or circle stencil, calculator

Paper models only. No swinging bungs, strings, rotating masses or released projectiles. Use compasses carefully or a circle stencil.

Course coverage: Shared Physics / Double Award: 8.1, 8.4–8.6. Orbital paths and v = 2πr/T for circular motion.

Plan, model or apparatus sketch

Draw clearly labelled astronomical axes, spectra or orbital/pathway diagrams as appropriate.

Method and reasoning

Read the whole sequence before starting

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1. Draw a circular orbit and mark four positions. At each draw velocity tangentially and gravitational force toward the central body.

2. Explain that velocity changes because its direction changes even when its magnitude is constant. There is an inward resultant force; do not add an equal outward force to balance it in the inertial-frame diagram.

3. For a practice circular orbit with radius 7.0×10^6 m and period 6000 s, calculate circumference and speed using $v = 2\pi r/T$. The radius is measured from the central body's centre, not its surface.

4. For a second practice orbit use $r = 4.2 \times 10^7$ m and $T = 86400$ s. Compare the calculated speeds without inferring that orbital speed depends on radius alone.

5. Draw a nearly circular planetary orbit and a more elongated typical comet orbit with the Sun at one focus. Explain that comet speed varies and is greatest nearest the Sun in the ideal bound orbit.

6. Compare moons and artificial satellites orbiting planets. State that $2\pi r/T$ applies to a circular orbit and must not be used as an exact ellipse perimeter formula.

Cleanup

- Return drawing tools and retain calculations.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Original practice values give approximately 7.33×10^3 m s^{-1} and 3.05×10^3 m s^{-1}. These are ideal circular examples, not tracked satellite measurements. Real orbital paths and gravitational systems vary.

Model	Radius / m	Period / s	Speed / m s^{-1}
Circular example 1	7.0×10^6	6000	
Circular example 2	4.2×10^7	86400	
Elliptical comparison	Not one fixed radius		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Which direction is velocity in a circular orbit?

2. Which direction is gravitational force?

3. Why is velocity changing at constant speed?

4. Find the first practice speed.

5. Where is orbital radius measured from?

6. Can 2πr be used as the exact perimeter of an elongated ellipse?