

Centripetal acceleration and gravity in orbit

AP Physics 1 (algebra-based) · Test answers (mark scheme)

Model answers with a marking guide. Award the mark for a correct method even when an arithmetic slip follows, and apply the unit and significant-figure conventions used in the course.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 2

Question 1 Arrows at one point (2 marks)

- a. **A** (tangent to the path, in the direction of motion).
- b. **B** (toward the centre).

Marking: 1 mark for each correct arrow.

Question 2 Control-line aircraft (3 marks)

- a. $v = 2\pi r / T = 2\pi(8.0) \div 2.5 = \mathbf{20 \text{ m/s}}$.
- b. $a_c = v^2 / r = 404 \div 8.0 = \mathbf{51 \text{ m/s}^2}$.
- c. $T = m a_c = 0.50 \times 50.5 = \mathbf{25 \text{ N}}$.

Marking: 1 mark per part; allow 25 N from 20.1 m/s.

Question 3 A heavier, bigger planet (2 marks)

- a. $g \propto M / R^2$, so the ratio is $4 \div 2^2 = \mathbf{1}$.
- b. $W = 60 \times 9.81 = \mathbf{5.9 \times 10^2 \text{ N}}$, the same as on Earth.

Marking: 1 mark for each correct answer.

Question 4 Titan around Saturn (3 marks)

- a. $v = \sqrt{G M / r} = \sqrt{(6.67 \times 10^{-11} \times 5.68 \times 10^{26} \div 1.22 \times 10^9)} = \mathbf{5.57 \times 10^3 \text{ m/s}}$.
- b. $T = 2\pi r / v = 2\pi(1.22 \times 10^9) \div 5.57 \times 10^3 = 1.376 \times 10^6 \text{ s} = \mathbf{15.9 \text{ days}}$.

Marking: (a) 1 for the equation, 1 for the value; (b) 1 for the value.

Question 5 Vertical circle (3 marks)

- a. $T + m g = m v^2 / r$ (both forces point down toward the centre).
- b. $T = m(v^2 / r - g) = 0.30 \times (20 - 9.81) = \mathbf{3.1 \text{ N}}$.
- c. $T - m g = m v^2 / r$, so $T = 0.30 \times (31.25 + 9.81) = \mathbf{12 \text{ N}}$.

Marking: 1 mark per part.

Question 6 Outward force argument (3 marks)

The claim is incorrect. If the forces were balanced, the net force would be zero and the Moon would move in a straight line. The only significant force is the Earth's gravity, which is unbalanced and gives a centripetal acceleration v^2 / r toward the Earth. The Moon does fall toward the Earth all the time, but its sideways velocity means the Earth's surface curves away beneath it, so the distance stays almost constant.

Marking: 1 mark for rejecting the balanced-force claim, 1 for stating that gravity is the net centripetal force, 1 for linking the sideways velocity to continuous falling.

Question 7 Two orbits compared (2 marks)

a. $v \propto r^{-1/2}$, so the ratio is $1/\sqrt{2} = \mathbf{0.71}$.

b. $T \propto r^{3/2}$, so the ratio is $2^{3/2} = \mathbf{2.8}$.

Marking: 1 mark per part.

Question 8 Linear graph (2 marks)

Plot F against $1/T^2$. Because $F = 4\pi^2 m r / T^2$, the graph is a straight line through the origin with gradient $\mathbf{4\pi^2 m r}$.

Marking: 1 mark for the axes, 1 mark for the gradient with the supporting equation.