

Springs, pendulums and simple harmonic motion

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

Model answers and marking guidance are given for every question. Award marks for correct physics even when the wording differs, and allow error carried forward in multi-part calculations.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 7

Question 1 Define SHM (2 marks)

- a. The net force is **proportional to the displacement from equilibrium**, $F = -kx$. (1 mark)
- b. The force is **directed toward the equilibrium position** (opposite to the displacement). (1 mark)

Marking: 1 mark for each condition; the word restoring alone earns no mark without a link to displacement.

Question 2 Spring period (2 marks)

- a. $T = 2\pi\sqrt{(m/k)} = 2\pi\sqrt{(0.18 \div 72)} = 2\pi \times 0.050 = \mathbf{0.31 \text{ s}}$. (1 mark)
- b. $f = 1 \div 0.3142 = \mathbf{3.2 \text{ Hz}}$. (1 mark)

Marking: 1 mark each; accept 0.314 s and 3.18 Hz.

Question 3 Pendulum design (2 marks)

- a. $T = 2\pi\sqrt{(1.60 \div 9.81)} = 2\pi \times 0.4038 = \mathbf{2.54 \text{ s}}$. (1 mark)
- b. $L = gT^2/4\pi^2 = 9.81 \times 1.00 \div 39.48 = \mathbf{0.248 \text{ m}}$. (1 mark)

Marking: 1 mark each; units required.

Question 4 Graph analysis (3 marks)

- a. Amplitude **4.0 cm**, period **1.2 s**. (1 mark)
- b. The kinetic energy is greatest when $x = 0$ and the object passes through equilibrium, for example at **$t = 0 \text{ s}$, 0.60 s or 1.2 s** , because all the energy is then kinetic. (1 mark)
- c. $v = 2\pi \times 0.040 \div 1.2 = \mathbf{0.21 \text{ m/s}}$. (1 mark)

Marking: accept any valid crossing time; the value for part c may be written as 21 cm/s.

Question 5 Changing amplitude (2 marks)

- a. The period is **unchanged**; the greatest speed $v = A\sqrt{k/m}$ **doubles**. (1 mark)
b. $E = \frac{1}{2}kA^2$, so doubling A makes the total energy **four times larger**. (1 mark)

Marking: the equation or equivalent justification is needed for the second mark.

Question 6 Energy at a point (3 marks)

- a. $E = \frac{1}{2}kA^2 = \frac{1}{2} \times 80 \times 0.10^2 = \mathbf{0.40 \text{ J}}$. (1 mark)
b. $U = \frac{1}{2} \times 80 \times 0.060^2 = 0.144 \text{ J}$, so $K = 0.40 - 0.144 = \mathbf{0.256 \text{ J}}$. (1 mark)
c. $v = \sqrt{2K/m} = \sqrt{2 \times 0.256 \div 0.50} = \mathbf{1.0 \text{ m/s}}$. (1 mark)

Marking: 1 mark for each correct result; allow error carried forward.

Question 7 Experimental design (3 marks)

- a. Independent variable: **starting amplitude**; dependent variable: **period**. (1 mark)
b. Time 10 or 20 complete oscillations with a stopwatch and divide by the number of oscillations; repeat and average. Controlled: **the mass and the spring** (also the same support). (1 mark)
c. The periods are the **same within the uncertainty** for every amplitude, so a graph of T against amplitude is a flat horizontal line. (1 mark)

Marking: award part b only if a way of reducing timing error is described.

Question 8 Heavier bob claim (3 marks)

The claim is incorrect. A heavier bob does feel a larger restoring force, $mg \sin \theta$, but its inertia is larger by the same factor, so the acceleration along the arc, $g \sin \theta$, is unchanged. The mass therefore cancels from $T = 2\pi\sqrt{L/g}$, and the period depends only on the length and on g (for small angles). A heavier bob gives the same period.

Marking: 1 mark for stating the claim is wrong; 1 mark for the force and inertia both proportional to m; 1 mark for the equation or the conclusion that period depends on L and g only.