

Oscillations, springs, pendulums and resonance

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Model answers with a marking guide. Award method marks even when the final number is wrong, provided the substitution is correct. Check that answers have the right unit.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.1

Question 1 Identify SHM (2 marks)

- a. (i) only: acceleration is proportional to displacement and opposite in direction.
- b. $\omega^2 = 9$, $\omega = 3.0 \text{ rad/s}$; $T = 2\pi \div 3.0 = \mathbf{2.09 \text{ s}}$.

Marking: (a) 1 for (i) with reason; (b) 1 for ω and T .

Question 2 Pendulum on a hook (3 marks)

- a. $T = 2\pi\sqrt{L/g} = 2\pi\sqrt{1.50 \div 9.81} = \mathbf{2.46 \text{ s}}$.
- b. No change: the mass cancels.

Marking: (a) 1 for formula and substitution, 1 for answer; (b) 1.

Question 3 Spring oscillator (3 marks)

- a. $\omega = \sqrt{k/m} = \sqrt{30 \div 0.15} = \sqrt{200} = \mathbf{14.14 \text{ rad/s}}$.
- b. $v_{\max} = \omega A = 14.14 \times 0.040 = \mathbf{0.566 \text{ m/s}}$.
- c. $a_{\max} = \omega^2 A = 200 \times 0.040 = \mathbf{8.0 \text{ m/s}^2}$.

Marking: 1 mark for each part.

Question 4 Energy graph sketch (3 marks)

- a. The total energy is a horizontal line at $E = \frac{1}{2}kA^2$. The potential energy is an upward-opening parabola with a minimum of zero at $x = 0$ and value E at $\pm A$. The kinetic energy is a downward-opening parabola with maximum E at $x = 0$ and zero at $\pm A$. **The two curves cross at $x = \pm A/\sqrt{2}$ and always add up to E .**

Marking: 1 for the flat total line, 1 for the E_p parabola, 1 for the E_k parabola with the correct intercepts.

Question 5 Buoy in the swell (3 marks)

- a. $A = 0.40 \text{ m}$, $T = 4.0 \text{ s}$.
b. $\omega = 2\pi \div 4.0 = 1.571 \text{ rad/s}$.
c. $v_{\max} = \omega A = 1.571 \times 0.40 = 0.628 \text{ m/s}$.

Marking: 1 mark for each part.

Question 6 Pushing a swing (2 marks)

The push must be applied at the natural frequency of the swing so that the force is always in step with the motion. Each push then does positive work and adds energy faster than damping removes it. The effect is **resonance**.

Marking: 1 for driving frequency equals natural frequency; 1 for energy transfer and the word resonance.

Question 7 Car suspension (2 marks)

Critical damping returns the car body to equilibrium in the shortest time without any oscillation after a bump. With less damping the car would bounce; with heavy damping it would recover too slowly and ride low for longer. **Critical damping gives a quick, comfortable recovery.**

Marking: 1 for no oscillation and shortest time; 1 for comparison with under- or over-damping.

Question 8 Time to move out (2 marks)

$x = A \sin \omega t$, so $0.040 = 0.080 \sin \omega t$ and $\sin \omega t = 0.5$, giving $\omega t = \pi/6 = 0.5236 \text{ rad}$. $\omega = 2\pi \div 0.50 = 12.57 \text{ rad/s}$. $t = 0.5236 \div 12.57 = 0.0417 \text{ s}$ (T/12).

Marking: 1 for $\omega t = \pi/6$; 1 for t .