

Questions on Oscillations MS

1. Data for speaker and equation

Equation for shm: $x = A \cos \omega t$

A amplitude = 1.0 mm or 1.0×10^{-3} m

$\omega = 2\pi f = 6.28 \times 10^2$ (rad s⁻¹) – no unit penalty for ω (1) 2

Calculations

(i) $A = A \omega^2$

$$= 1.0 \times 10^{-3} \text{ m} \times (6.28 \times 10^2 \text{ rad s}^{-1})^2 = 394 \text{ m s}^{-2} \text{ (1)}$$

(ii) $v = A \omega$ (1)

$$= 1.0 \times 10^{-3} \text{ m} \times 6.28 \times 10^2 \text{ rad s}^{-1} = 0.63 \text{ m s}^{-1} \text{ (1)} \quad 3$$

Acceleration - time graph

Two cycles of sinusoidally shaped graph (1)

Period = 10 m s (1)

Amplitude = 394 m s⁻² [e.c.f from (i)] (1) 3

Explanation

Resonance (stated or implied by explanation) (1)

Increased amplitude at resonant frequency (1) 2

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2. Phenomenon of resonance in the context outlined etc

Any five from:

- spheres can oscillate
- resonance when forcing frequency = natural frequency
- sound provides forcing frequency
- low frequency due to mass/density of lead spheres

At resonance, there is:

- large amplitude of oscillation (of spheres)
 - maximum energy transfer to spheres
 - energy transfer to thermal in the rubber
 - minimum energy transfer to neighbours
- 5

[5]

3. Energy:

Potential energy = $mgh = 40 \times 10 \times 0.3 = 120$ J (1)

Kinetic energy as child hits rubber pillow is about the same value (120 J) (1)

$m v^2 = 2 \times 120$ gives $v = 2.5$ m s⁻¹ (1)

Kinetic energy transferred to air in pillow, gets warm (1)

Use of $3kT/2$ (1)

Oscillations:

Oscillations because to and fro motion about a point (1)

Damped oscillations (1)

$$F = kx \text{ to } 400 = k \quad 0.2 \text{ gives } k = 2000 \text{ N m}^{-1} \text{ (1)}$$

$$T = 2\sqrt{k/m} \text{ gives about } 6 \text{ s (1)}$$

Idea that oscillations are not simple harmonic (1)

Max 7

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4. Material

e.g. porous material / made up of small fibres

1

Explanation

Any 1 point from the following:

- inelastic collisions between air molecules and fibres/materials
- fibres/materials absorb energy from the sound

fibres/materials deform plastically rather than transmitting vibrations

Max 1

Physics of sound reduction

Any 4 from:

- Microphone is used to detect sound and feed to electronic device
- Signal treated to produce output identical in frequency
- but in antiphase with original OR inverted
- This output fed to loudspeaker

Interferes destructively with original sound

Max 4

Resonance

Sound vibrations (forcing vibrator) have same frequency as another vibrator's natural frequency (1)

increasing amplitude/energy of other vibrator's vibrations (1)

2

Process

Damping

1

[9]