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) $A = A\omega^2$

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

(ii) $\upsilon = A\omega$ **(1)**

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

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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)**
$m\upsilon^2 = 2 \times 120$ gives $\upsilon = 2.5$ 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)**
$F = kx$ to $400 = k$ 0.2 gives $k = 2000$ N m^{-1} **(1)**
$T = 2\sqrt{k/m}$ gives about 6 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]