Forced Oscillations and Damping - Questions by Topic

Q1.

The diagram shows a loudspeaker unit. The unit contains two different loudspeakers, a woofer and a tweeter. Each loudspeaker contains a cone.

A signal applied to a coil attached to the centre of each cone causes the cone to vibrate and set the air into vibration.

The tweeter is used to produce high frequency sounds and the woofer is used to produce low frequency sounds.

(a) A sinusoidal signal is applied to the woofer. The woofer cone moves with simple harmonic motion and emits a sound of frequency 100 Hz. The centre of the cone moves with an amplitude of 2.5 mm.

(i) State the conditions for an object to move with simple harmonic motion.

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(ii) Calculate the maximum velocity of the centre of the woofer cone.

(3)

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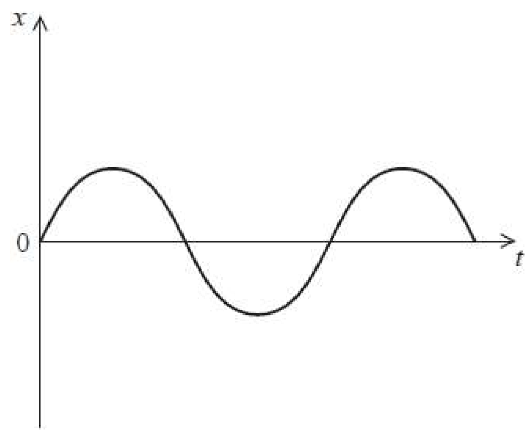
Maximum velocity = ...

(iii) The graph shows how the displacement x of the cone varies with time t.

Add a line to the graph to show how the velocity of the cone varies over the same time interval.

(2)



(b) At a particular frequency the sound produced is distorted as the loudspeaker unit starts to oscillate with increasing amplitude.

*(i) Explain why the loudspeaker unit starts to oscillate with increasing amplitude.

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(ii) Explain how the effect described may be reduced.

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(c) Suggest why the woofer and the tweeter are different sizes.

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(Total for question = 14 marks)

Q2.

A car suspension system can be thought of as a mass-spring system. The natural frequency of the system is determined by the force constant of the suspension *k* and the total mass of the system *m*.

(a) (i) A car is set into vertical oscillation by applying a momentary downwards force.

Show that the frequency of oscillation *f* is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

(4)

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(ii) The car is displaced through a vertical distance of 27.5 mm when a man of mass 85.0 kg sits in the car.

Show that k is about 30 kN m^{-1}.

(2)

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(iii) Calculate the natural frequency of oscillation of the car with the man sitting in it.

mass of car = 1130 kg

(2)

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Natural frequency = ...

(b) Car suspension systems are examples of damped systems.

*(i) State what is meant by damping, and explain why this is desirable for a car suspension system.

(3)

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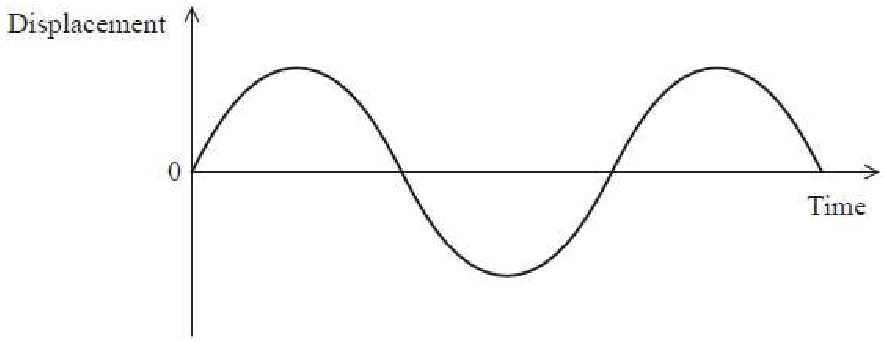
(ii) The graph shows the way in which the displacement varies with time for an undamped mass-spring system.



On the axes below draw a graph to show how the velocity varies with time for the damped system over the same time interval.

(2)

(Total for question = 13 marks)

Q3.

A drum is played by striking a circular membrane with a drumstick. The resulting vibration of the membrane may produce resonance.

(a) (i) Explain what is meant by resonance.

(2)

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(ii) Suggest why a larger diameter membrane would produce a lower frequency note when the drum is struck.

(1)

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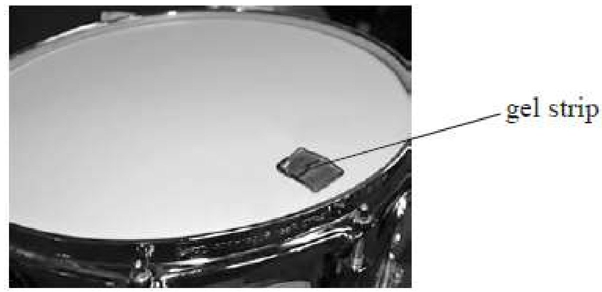
(b) The sound produced when the drum is struck may persist for too long and so damping is used. Some drummers attach strips of a gel to the drum membrane. The gel is able to deform plastically and hence shorten the time that the drum sounds.

gel strip



gel strip attached to drum skin

(i) State what is meant by damping.

(2)

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(ii) Explain how a gel that can deform plastically is able to produce damping.

(3)

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(Total for question = 8 marks)

Q4.

A child of mass 35 kg is standing on a trampoline. At equilibrium the surface of the trampoline is displaced vertically by 22 cm from the unloaded position.

(a) Show that the force constant of the trampoline is about 1600 N m^{-1}.

(2)

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(b) The child bounces up and down, always staying in contact with the trampoline. The motion is simple harmonic.

(i) Calculate the child's frequency of oscillation.

(3)

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Frequency of oscillation = ...

(ii) The height of each bounce above the equilibrium position is 21 cm.

Calculate the maximum speed of the child and identify the position at which she has this speed.

(3)

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Maximum speed of child = ...

Position = ...

(c) (i) The child bends her knees and pushes against the surface of the trampoline at each bounce. Her amplitude of oscillation gradually increases.

Name this effect and explain why there is an increase in amplitude.

(3)

Name of effect ....

Explanation

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*(ii) As her amplitude of oscillation increases she starts to lose contact with the surface of the trampoline.

Explain why the motion can no longer be described as simple harmonic.

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(Total for question = 14 marks)

Q5.

Earthquake-proof buildings may include materials in their structure to absorb energy from the movement of the building.

The table shows some properties of two different building materials.

	Material X	Material Y
Deforms elastically	✓	✗
Deforms plastically	✗	✓
Stiff	✓	✓
Strong	✗	✓

Which of the following explains the most suitable material to absorb energy from the moving building?

(1)

☐ **A** Material X because it is stiff

☐ **B** Material X because it deforms elastically

☐ **C** Material Y because it deforms plastically

☐ **D** Material Y because it is both stiff and strong

(Total for question = 1 mark)

Q6.

Some mobile phones may be set to vibrate rather than ring. A mobile phone is placed on a wooden table and sets the table into oscillation as it vibrates. The vibration now sounds louder.

This is an example of

(1)

☐ **A** free oscillation.

☐ **B** forced oscillation.

☐ **C** resonance.

☐ **D** standing waves.

(Total for question = 1 mark)

Q7.

The photograph shows the Millennium Bridge in Salford. The bridge which is 91 m long straddles the Manchester Ship Canal.

When large numbers of people cross the bridge at the same time, the bridge begins to oscillate with large amplitude simple harmonic motion.

(a) Explain why there is large amplitude oscillation of the bridge under these conditions.

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(b) The bridge oscillates with a frequency of 0.55 Hz. The amplitude of oscillation is greatest at the mid-point and falls gradually to zero at the ends.

Calculate the speed of transverse waves along the bridge.

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Wave speed = ...

(Total for question = 6 marks)

Q8.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A pendulum is driven into oscillation and resonance occurs.

What happens to the maximum damping force as the amplitude of oscillation increases?

☐ **A** The maximum damping force gradually decreases.

☐ **B** The maximum damping force gradually increases.

☐ **C** The maximum damping force increases and then decreases.

☐ **D** The maximum damping force stays constant.

(Total for question = 1 mark)

Q9.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒). If you change your mind about an answer, put a line through the box and then mark your new answer with a cross (☒).

Some buildings contain materials that can dissipate the energy from earthquakes. These materials deform as the ground shakes.

Which of the following properties of the material is necessary for the energy dissipation to be effective?

☐ **A** elastic

☐ **B** plastic

☐ **C** stiff

☐ **D** strong

(Total for question = 1 mark)

Q10.

Some buildings are designed to withstand earthquakes. The energy from the earthquake waves is dissipated by deforming some parts of the building.

For this to be effective, these parts of the building must be

- ☐ **A** able to undergo elastic deformation.
- ☐ **B** able to undergo plastic deformation.
- ☐ **C** stiff under compressive forces.
- ☐ **D** strong under compressive forces.

(Total for question = 1 mark)