PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 13: OSCILLATIONS

SCORE	PERCENTAGE
/220	%

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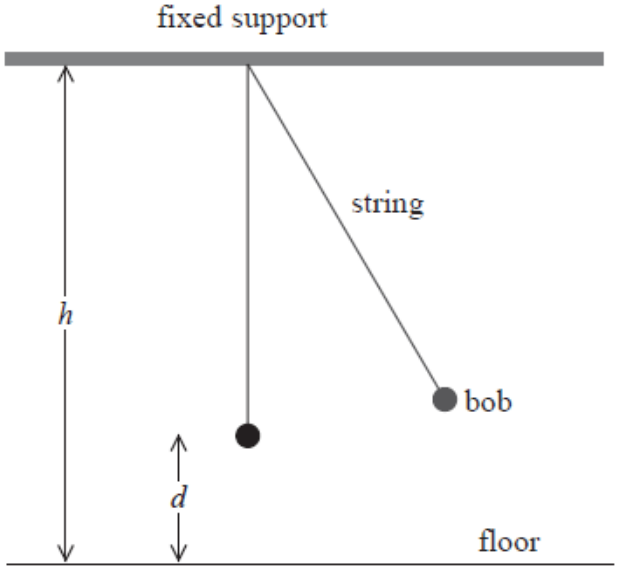
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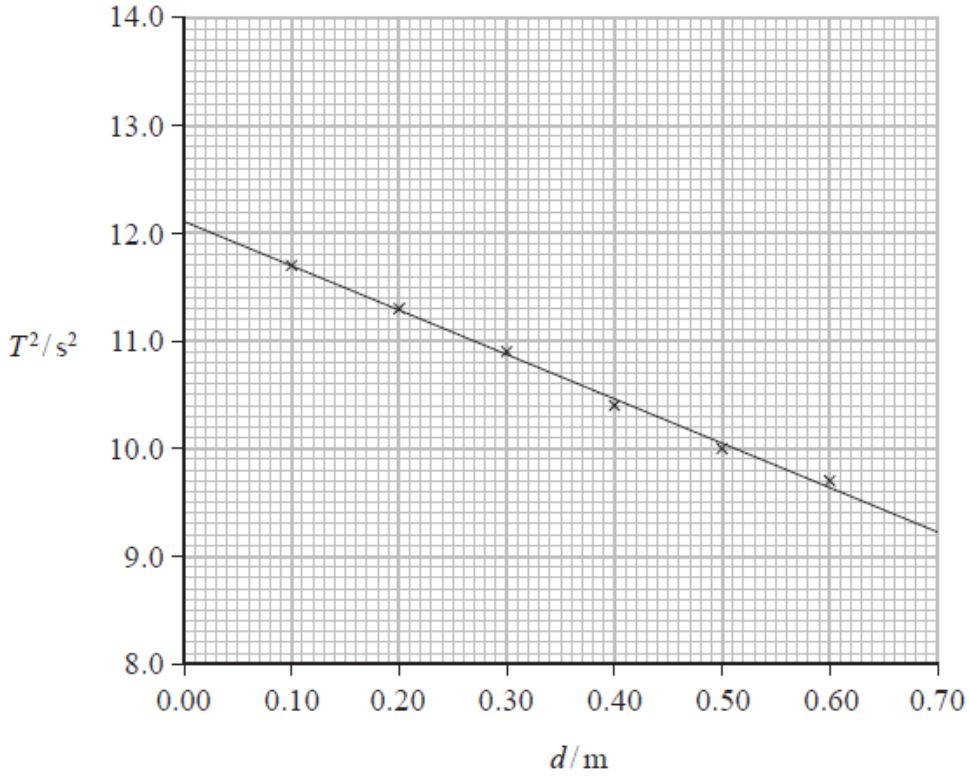
Q1.

A student carried out an experiment with a pendulum hung from a fixed support. The fixed support was a distance *h* above floor level as shown.



As the student was unable to measure the length of the pendulum directly, she measured the distance *d* from the bob to the floor.

The student used her data to plot a graph of T^2 against *d* as shown below.



Determine a value for the acceleration due to gravity *g*.

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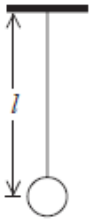
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g = ...

(Total for question = 5 marks)

Q2.

A student is using a simple pendulum to determine a value for the acceleration of free fall g.



She measures the length l of the pendulum four times with a metre rule and records the following values.

l / cm			
l_1	l_2	l_3	l_4
85.5	86.0	87.5	85.5

She calculates the mean length l_m of the pendulum using the following method:

$$l_m = \frac{85.5 + 86.0 + 87.5 + 85.5}{4} = 86.1 \text{ cm}$$

(i) Calculate a more accurate value for l_m.

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I_m = ...

(ii) Determine the time period of the oscillations of this pendulum, using your calculated value for I_m.

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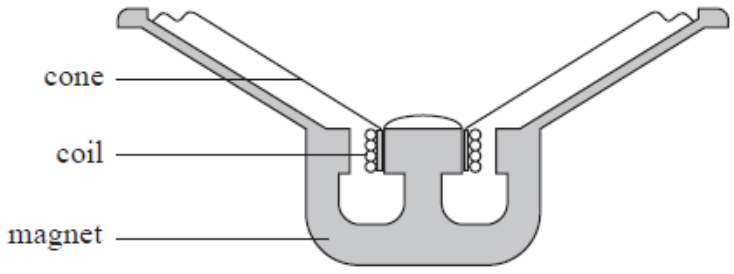
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Time period of oscillations = ...

(Total for question = 4 marks)

Q3.

*****A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate. The loudspeaker is mounted in a wooden box. A cross-section through the loudspeaker is shown.



A student made the following observations:

- when an alternating potential difference (p.d.) is applied to the coil, the cone oscillates
- the frequency of oscillation is the same as the frequency of the p.d.
- at particular frequencies, the box vibrates with a large amplitude.

Explain these observations.

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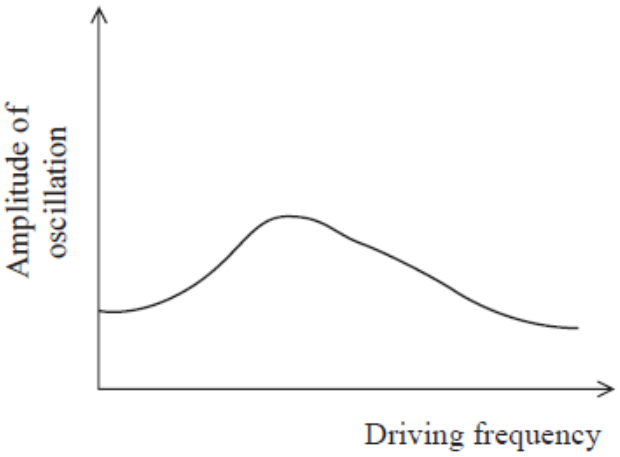
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(Total for question = 6 marks)

Q4.

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 damped mass-spring system is driven into oscillation. The graph shows the amplitude of oscillation as the driving frequency is varied.



The damping is decreased.

Which row of the table describes what happens to the maximum amplitude of oscillation and the driving frequency at which this occurs?

	Maximum amplitude	Frequency at which maximum amplitude occurs
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(Total for question = 1 mark)

Q5.

A mass is hanging vertically from a spring. The mass is set into small amplitude vertical oscillations.
The total energy of the undamped oscillating system is

☒ **A** a maximum at an extreme position of the mass.

☒ **B** a maximum at the mean position of the mass.

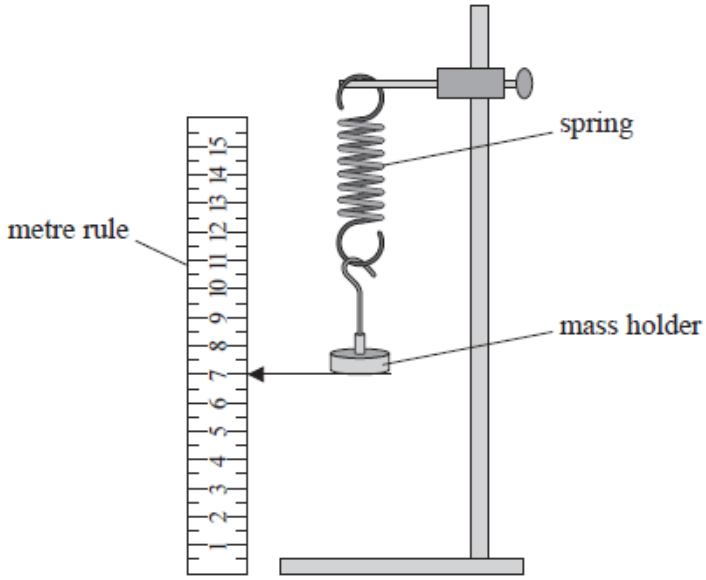
☒ **C** a minimum at the mean position of the mass.

☒ **D** the same at all positions of the mass.

(Total for question = 1 mark)

Q6.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached.

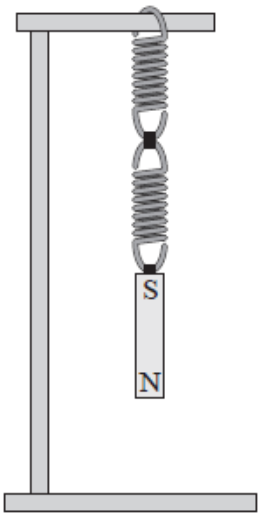


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
70	3	0.69
90	3.5	0.9
110	4.5	1.08
130	5.3	1.28
150	5.8	1.47

Two identical springs are joined in series and a bar magnet is hung from one end as shown.



The bar magnet is displaced a small distance vertically from its equilibrium position and released.

Calculate the frequency at which the system oscillates.

mass of magnet = 120 g
spring constant of each spring = 22 N m^{-1}

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Frequency = ...

(Total for question = 4 marks)

Q7. A mass is bouncing on the end of a vertical spring. Its motion will be simple harmonic if the spring

- ☒ **A** can store energy.
- ☒ **B** has elasticity.
- ☒ **C** is hung vertically.
- ☒ **D** obeys Hooke's law.

(Total for Question = 1 mark)

Q8.

Fission and fusion are both nuclear processes.

Which of the following statements is correct for both processes?

- ☒ **A** Neutrons are released.
- ☒ **B** No harmful radiation is produced.
- ☒ **C** The binding energy per nucleon increases.
- ☒ **D** The total mass increases.

(Total for Question = 1 mark)

Q9.

An object is hung from a vertical spring and undergoes undamped simple harmonic motion.

It is correct to say that there are **no** changes in the

- ☒ **A** elastic potential energy of the oscillating system.
- ☒ **B** gravitational potential energy of the oscillating system.
- ☒ **C** kinetic energy of the oscillating system.
- ☒ **D** total energy of the oscillating system.

(Total for Question = 1 mark)

Q10.

The damping force acting on an oscillating system is always

☒ **A** in the opposite direction to the acceleration.

☒ **B** in the opposite direction to the velocity.

☒ **C** in the same direction as the acceleration.

☒ **D** in the same direction as the velocity.

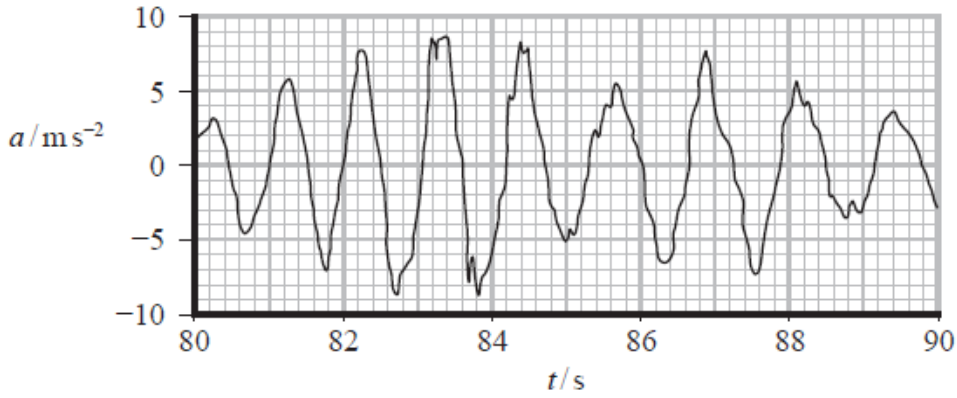
(Total for question = 1 mark)

Q11.

In 2011, a tsunami was caused by a massive earthquake centred some distance off the coast of Japan. The tsunami caused a cooling system failure at the Fukushima Nuclear Power Plant. This resulted in a nuclear meltdown and radioactive materials were released into the surroundings.

Buildings in nearby Tohoku University suffered structural damage during the 2011 earthquake.

The graph shows how the acceleration of one of the buildings, measured on the 9th floor, varied with time during the earthquake.



(Source: https://www.sciencedirect.com/science/article/pii/S0038080612001035)

At the time it was reported that during the earthquake the 9th floor of the building displaced by more than 30 cm from its normal position.

Assess the accuracy of this report.

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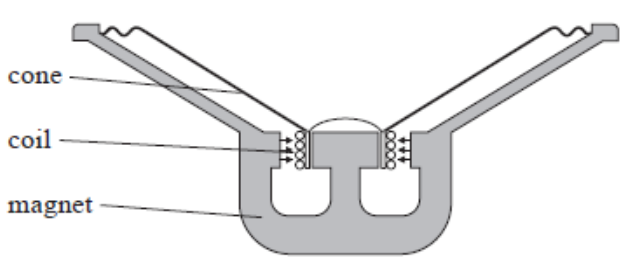
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(Total for question = 5 marks)

Q12.

A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate.





The loudspeaker cone undergoes simple harmonic motion.

(i) State what is meant by simple harmonic motion.

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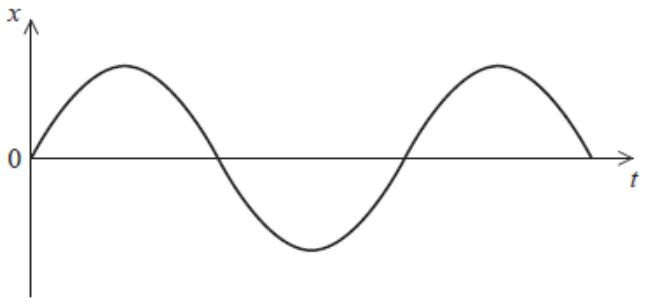
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(ii) The graph below shows how the displacement x of the cone varies with time t.

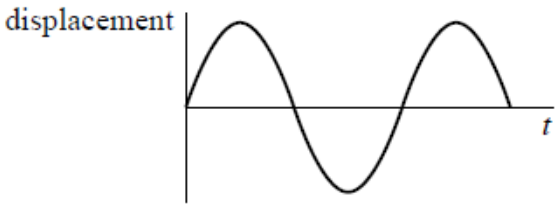
Add another line to the graph to show how the acceleration of the cone varies over the same time interval.

(1)

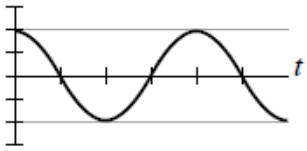


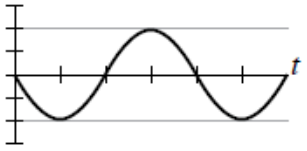
Q13.

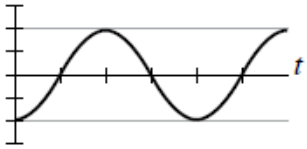
The graph shows the variation of displacement with time for a particle undergoing simple harmonic motion.

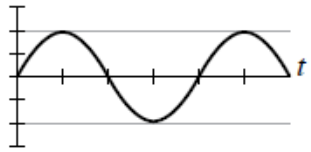


Select the graph that correctly shows the variation of velocity with time for the particle.

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for question = 1 mark)

Q14.

A very long pendulum set into oscillation continues to swing for several hours. During this time, as a result of the Earth's rotation, the pendulum will appear to change its direction of swing.

The movement of this pendulum is an example of

☒ **A** critical oscillation.

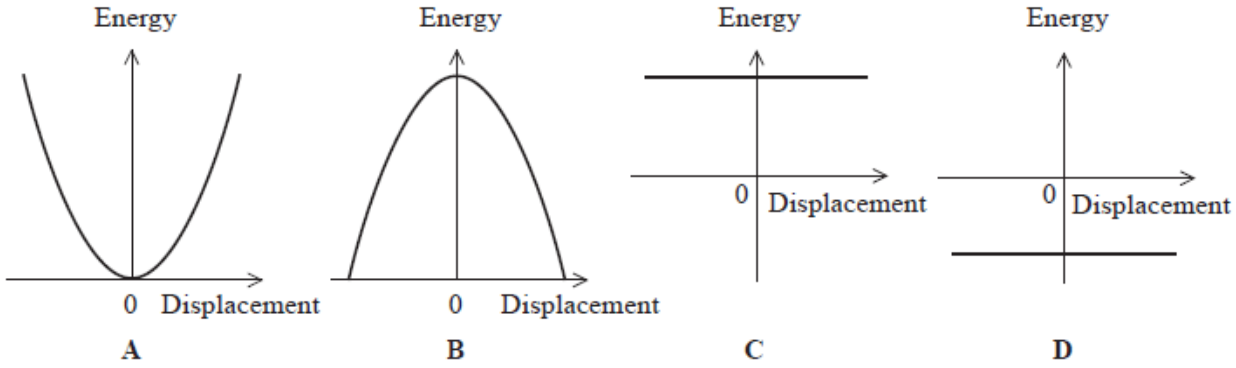
☒ **B** forced oscillation.

☒ **C** free oscillation.

☒ **D** resonant oscillation.

(Total for question = 1 mark)

Q15.



Which graph correctly shows the variation of potential energy with displacement for a particle undergoing simple harmonic motion?

☒ **A**

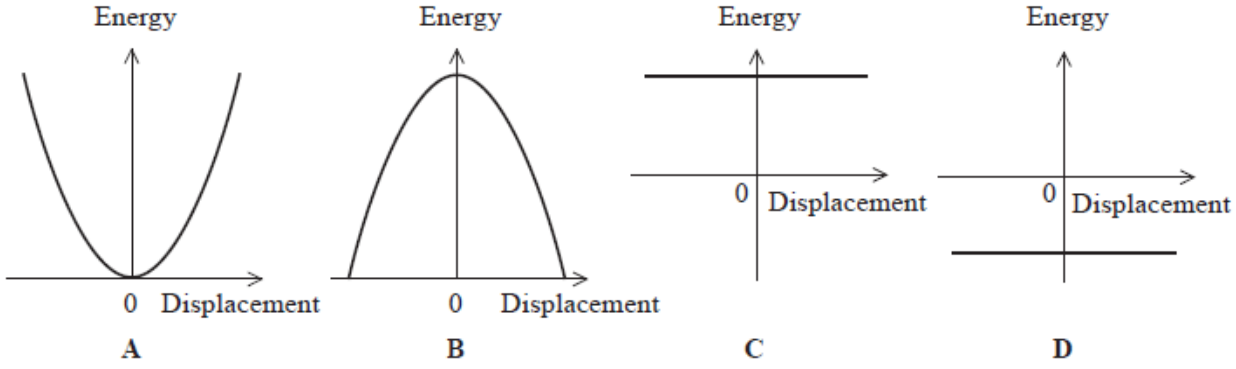
☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q16.



Which graph correctly shows the variation of total energy with displacement for a particle undergoing simple harmonic motion?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q17.

New buildings in earthquake zones are often designed to be earthquake resistant. Such buildings incorporate mechanisms to reduce the tranfer of kinetic energy from the ground to the building.

Which of the following would be the most important property of a material used in such a mechanism?

☒ **A** density

☒ **B** ductility

☒ **C** stiffness

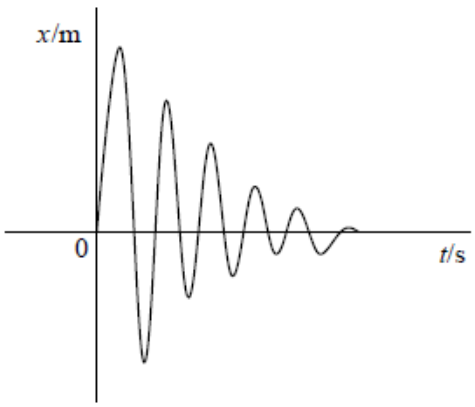
☒ **D** strength

(Total for question = 1 marks)

Q18.

A tennis player uses a racket to hit a ball over a net. When the racket strikes the ball the racket frame is set into oscillation.

The graph shows how the displacement *x* of the centre of the frame varies with time *t* immediately following the strike.



Hollow spaces are built into the racket frame and small lead spheres are packed into these spaces.

Explain how this results in the graph shown.

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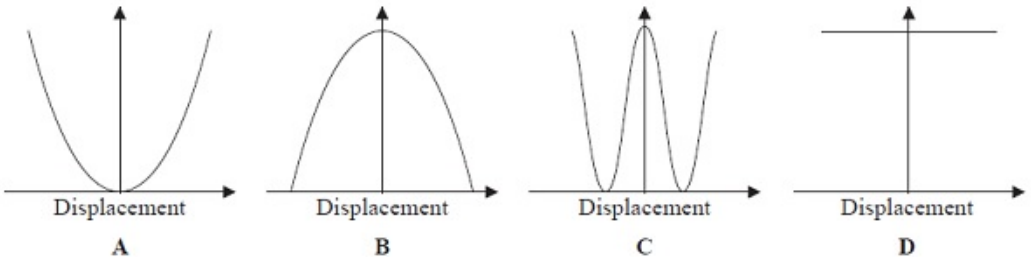
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(Total for question = 6 marks)

Q19.

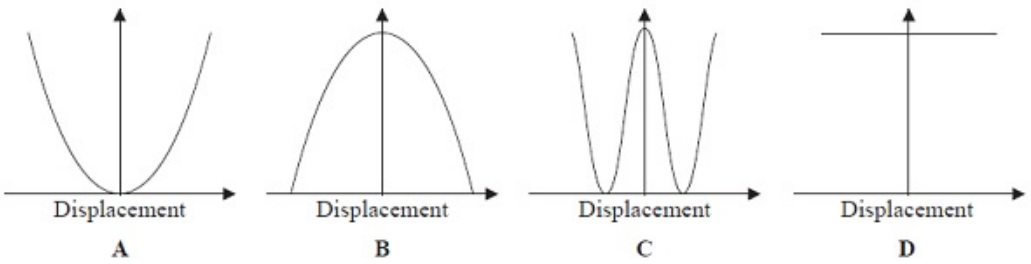


For an object undergoing simple harmonic motion select the graph that represents the variation of kinetic energy with displacement.

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question = 1 mark)

Q20.



For an object undergoing simple harmonic motion select the graph that represents the variation of the total energy with displacement.

☒ **A**

☒ **B**

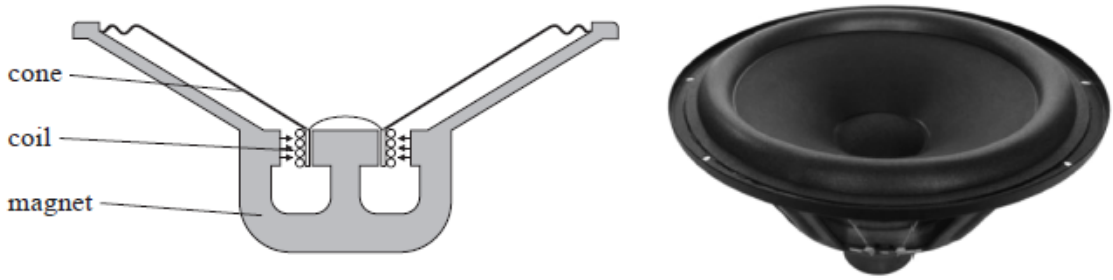
☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q21.

A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate.



Some sand is sprinkled onto the cone. The sand oscillates vertically with the frequency of the cone. Keeping the frequency constant, the current is increased. This increases the amplitude of oscillation of the cone.

At a particular amplitude of oscillation the sand begins to lose contact with the cone.

(i) By considering the forces acting on a grain of sand, explain why this happens.

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(ii) At a particular frequency, when the amplitude of the cone is 0.25 mm, a grain of sand loses

contact with the cone.

Calculate this frequency.

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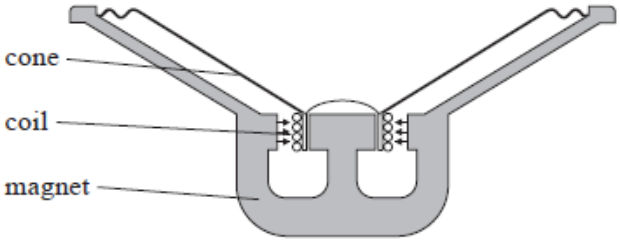
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Frequency = ...

Q22.

A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate.





* Explain why an alternating current in the coil causes the cone to oscillate with the frequency of the alternating current.

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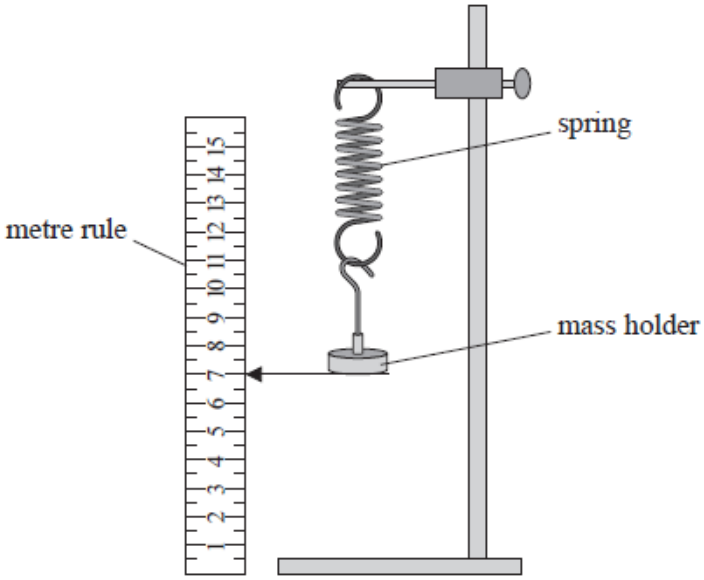
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Q23.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached.

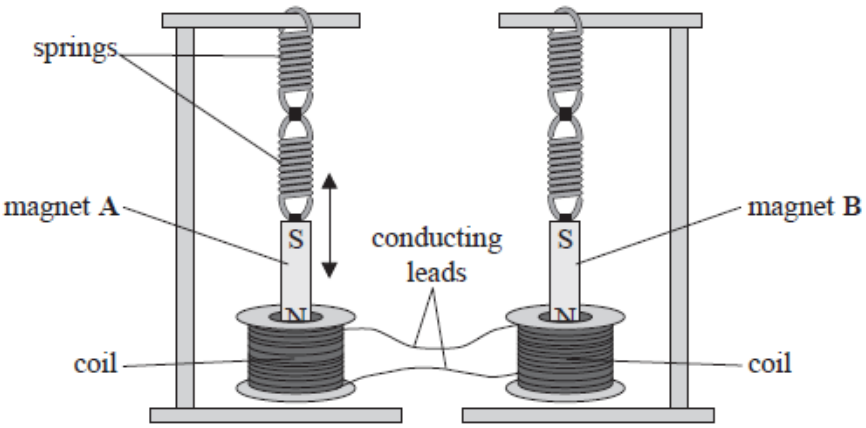


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
70	3	0.69
90	3.5	0.9
110	4.5	1.08
130	5.3	1.28
150	5.8	1.47

* Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

Explain why magnet B starts to oscillate with an increasing amplitude.

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(Total for question = 6 marks)

Q24.

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 of length *l* with a bob of mass *m* oscillates with frequency *f*.

What is the frequency of a pendulum of length 4*l* with a bob of mass 2*m*?

☒ **A** $4f$

☒ **B** $2f$

☒ **C** f

☒ **D** $\frac{f}{2}$

(Total for question = 1 mark)

Q25.

A playground swing completes 24 oscillations in 1 minute.

Which of the following is the frequency of the oscillations?

(1)

☒ **A** 0.042 Hz

☒ **B** 0.40 Hz

☒ **C** 2.5 Hz

☒ **D** 24 Hz

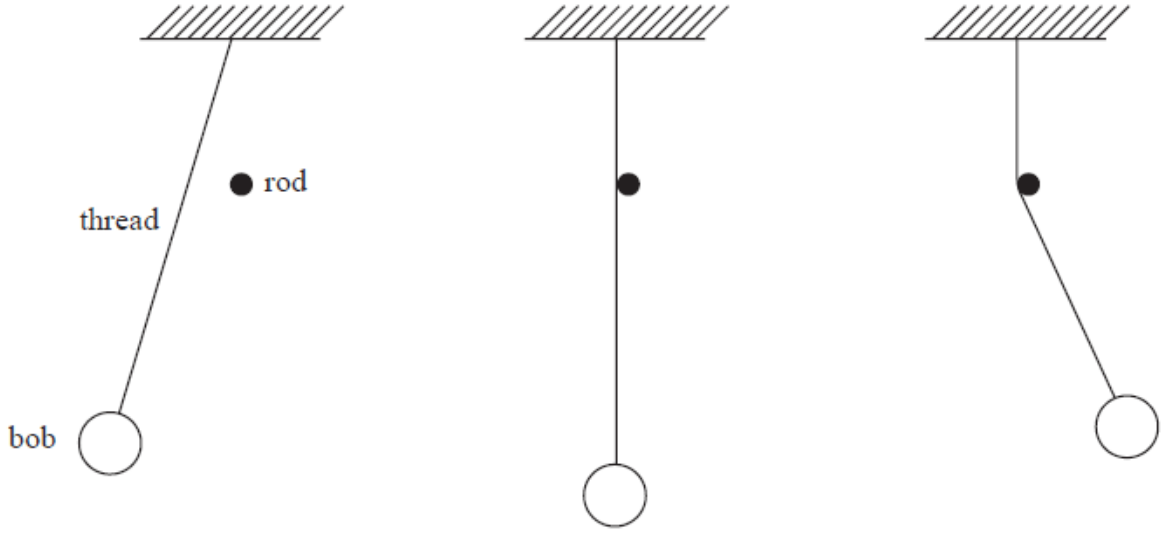
(Total for question = 1 mark)

Q26.

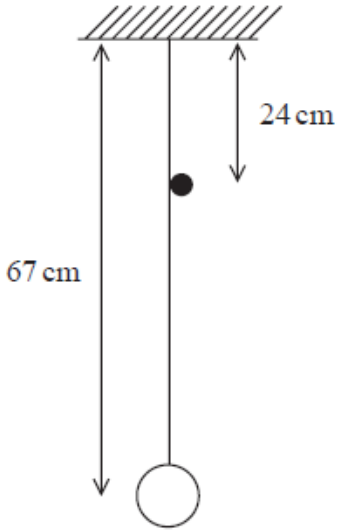
A simple pendulum consisting of a thread and a bob is set up next to a horizontal rod.

The bob is displaced to the left and released. When the bob reaches the equilibrium position the thread strikes the horizontal rod. For half of the cycle, only the lower part of the pendulum moves.

The diagram shows the swing of the pendulum.



The diagram below shows the dimensions of the pendulum.



Determine the frequency of the oscillations of the pendulum.

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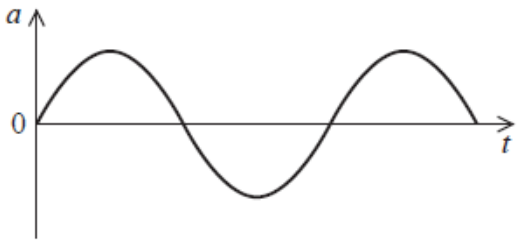
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Frequency = ...

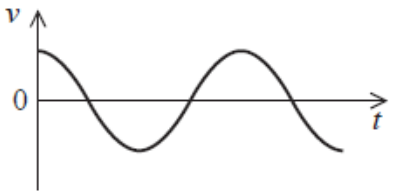
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Q27.

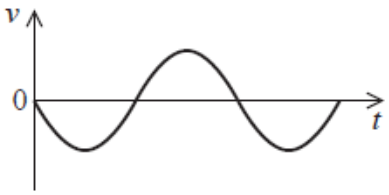
The graph shows how the acceleration varies with time for an object undergoing simple harmonic motion.



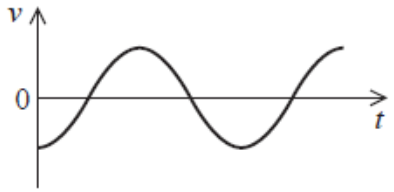
Which of the following graphs, **A**, **B**, **C** or **D**, shows how the velocity of the object varies with time?



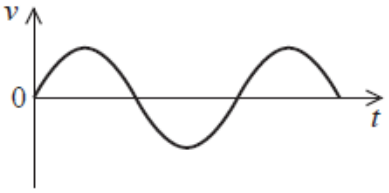
A



B



C



D

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 mark)

Q28.

A baby-bouncer is a light harness, into which a baby can be placed, suspended by a vertical spring.



The height of the baby-bouncer is adjusted so that the baby's feet are a few centimetres above the floor when the baby is in equilibrium in the harness. If the baby is then displaced downwards and released, the system oscillates vertically with simple harmonic motion.

It is stated in a textbook that "a mass-spring system that obeys Hooke's law will lead to simple harmonic motion when the mass is displaced."

*(a) Explain why a system consisting of a mass and a spring that obeys Hooke's law may be set into simple harmonic motion.

(3)

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(b) The acceleration experienced by a baby of mass 8.2 kg is 0.49 m s^{-2} when the displacement from the equilibrium position is 3.0 cm.

Show that the period of vertical oscillations for this baby is about 1.6 s.

(3)

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(c) The amplitude of the oscillations quickly decreases, so the baby has to keep kicking on the floor to maintain them.

(i) State the name given to oscillations that die away quickly.

(1)

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(ii) State the name that is given to oscillations such as those that are kept going by the baby kicking on the floor.

(1)

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(iii) If the baby kicks on the floor at a certain frequency, the amplitude of the bounces can be made to increase to a maximum.

Name this effect and calculate the frequency at which it occurs.

(2)

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Frequency = ...

(d) The baby is replaced by a baby of less mass. This baby also kicks to produce maximum amplitude of oscillation. Without further calculation, explain how the frequency at which the baby must kick compares to that for the larger mass baby.

(2)

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(Total for Question = 12 marks)

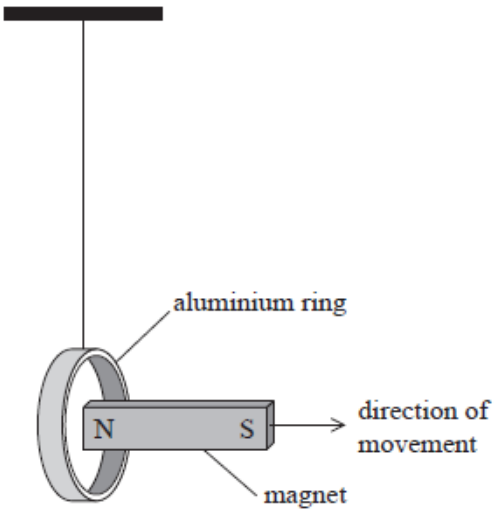
Q29.

The Shanghai Maglev Train is the first commercially operated high-speed magnetic levitation train in the world, connecting the airport and central Shanghai.



* A linear induction motor provides the force to accelerate the train forwards. A current flows in sequence through coils of wire mounted in the track. The train is dragged along as the magnetic field progresses along the coils of wire in the track. This is similar to moving a permanent magnetic field away from a conductor.

A teacher demonstrates this effect by quickly removing one end of a bar magnet from a suspended aluminum ring.



When the magnet is removed from the ring, the ring moves in the same direction as the magnet.

Explain, using the laws of electromagnetic induction, why the ring moves in the direction of the magnet.

(6)

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(Total for question = 6 marks)

Q30.

The Shanghai Maglev Train is the first commercially operated high-speed magnetic levitation train in the world, connecting the airport and central Shanghai.



Electromagnetic forces enable the train to levitate above a steel rail.

Explain why magnetic levitation is an advantage for a high-speed transport system.

(2)

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(Total for question = 2 marks)

Q1.

The photograph shows an example of a Foucault pendulum.



This is a pendulum that consists of a massive sphere, suspended by a long wire from a high ceiling. Over time the vertical plane through which the pendulum swings appears to rotate because of the rotation of the Earth.

mass of sphere = 28.0 kg

To show the rotation of the Earth, the pendulum needs to oscillate for several hours.

Explain how using a heavy sphere is better than using a light sphere of the same diameter.

(3)

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(Total for question = 3 marks)

Q2.

The International Space Station (ISS) is in a low Earth orbit. Astronauts in ISS have an apparent weight of zero. In order to determine their mass, the astronauts must secure themselves to a platform which is set into oscillation and moves with simple harmonic motion.





Explain why the astronauts in the ISS have an apparent weight of zero.

(2)

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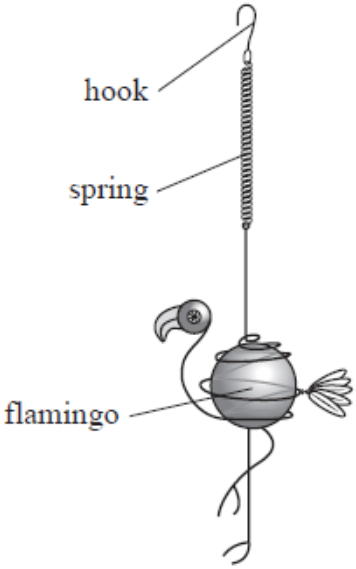
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(Total for question = 2 marks)

Q3.

A garden ornament consists of a metal flamingo suspended from a spring as shown. The spring is hung from a support using the hook.



After being set into vertical oscillation, the flamingo comes to rest after a short time.

Explain why the flamingo comes to rest.

(2)

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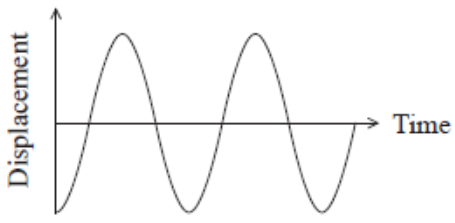
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(Total for question = 2 marks)

Q4.

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 (☒).

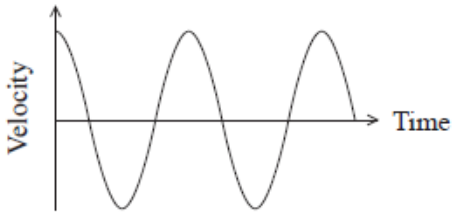
The graph shows how the displacement of a simple harmonic oscillator varies with time.



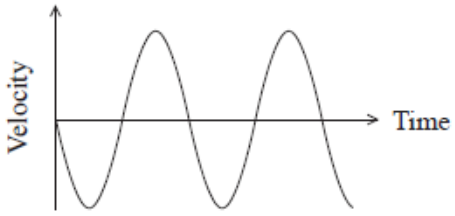
Which of the following graphs shows how velocity varies with time for the same oscillator, over

the same time period?

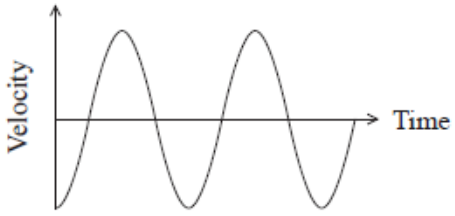
☐ **A**



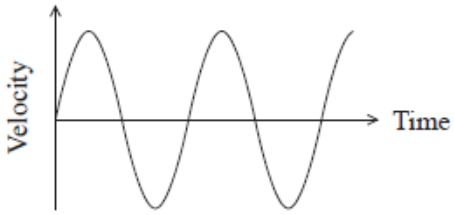
☐ **B**



☐ **C**



☐ **D**

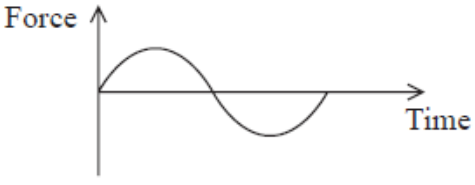


(Total for question = 1 mark)

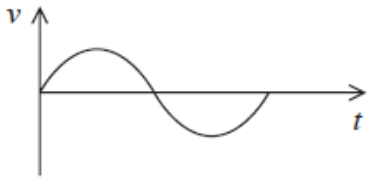
Q5.

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 ☒.

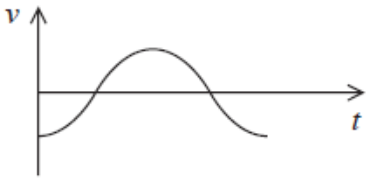
A mass is suspended from a spring and allowed to come to equilibrium.
The mass is displaced vertically and moves with simple harmonic motion.
The graph shows how the resultant force on the mass varies with time.



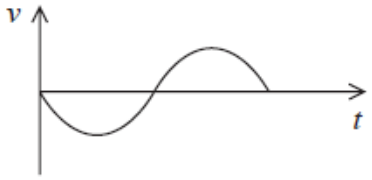
Which of the following graphs shows how the velocity *v* of the mass varies with time *t* over the same time interval?



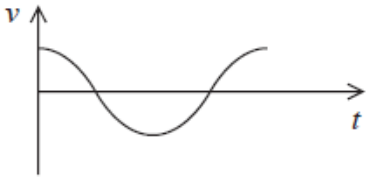
A



B



C



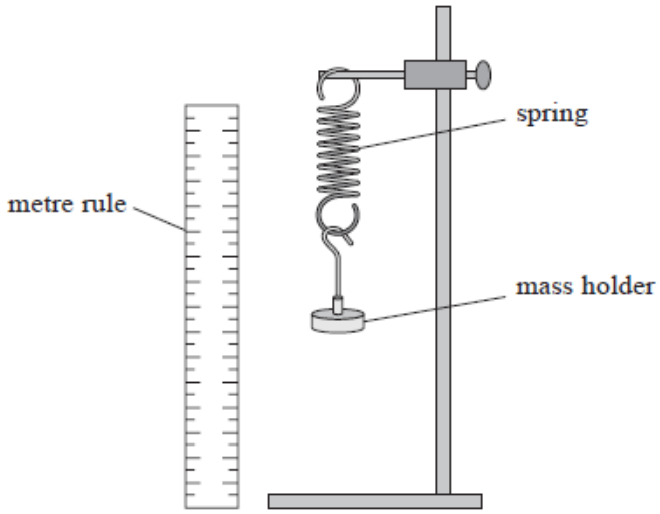
D

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 mark)

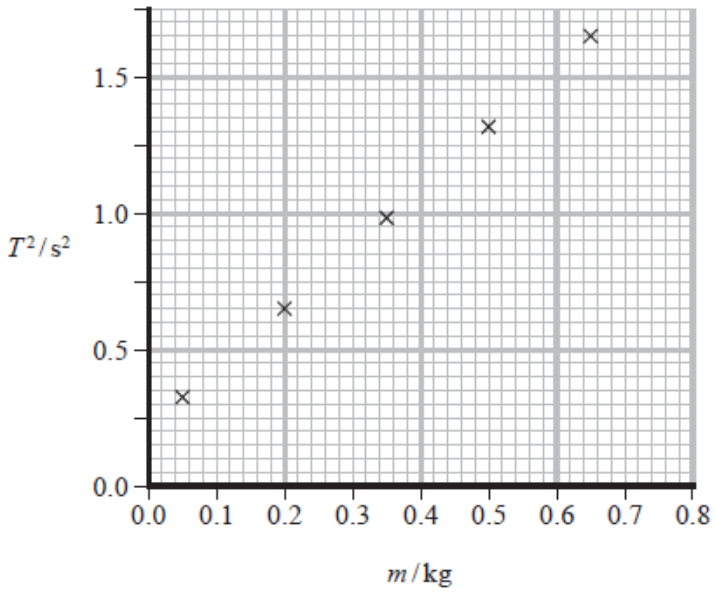
Q6.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached as shown.



In another experiment, the student displaced the mass vertically each time a mass was added to the spring. He used a stopwatch to determine the period of vertical oscillations of each mass.

The student used his data to plot a graph of T^2 against m as shown.



When determining the period of oscillation for each mass, the student measured the time for 20 oscillations. He repeated this measurement to obtain a mean time for 20 oscillations.

Explain how the student's procedure contributed to the accuracy of the measurement.

(3)

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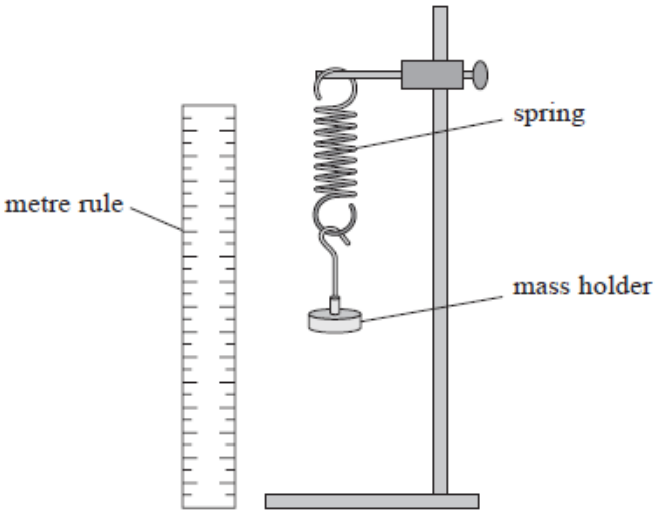
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(Total for question = 3 marks)

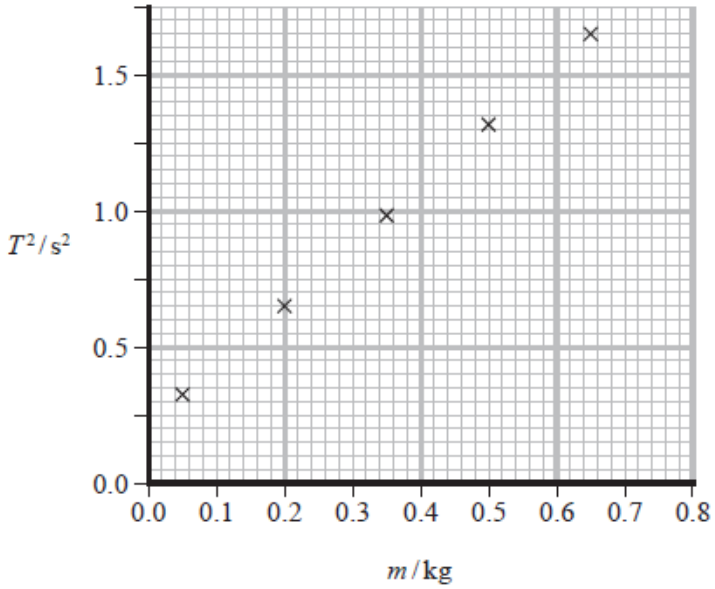
Q7.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached as shown.



In another experiment, the student displaced the mass vertically each time a mass was added to the spring. He used a stopwatch to determine the period of vertical oscillations of each mass.

The student used his data to plot a graph of T^2 against m as shown.



The student expected the graph to be a straight line through the origin. He thought that there may be systematic error due to reaction time.

(i) Give an example of another possible systematic error in this experiment.

(1)

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(ii) Another student suggests that to reduce the uncertainty in the value for the period, a data logger connected to a light gate could be used to measure time.

Comment on the student's suggestion.

(3)

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(iii) Determine a value for the stiffness of the spring.

(3)

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Stiffness of spring = ...

(Total for question = 7 marks)

Q8.

The Millennium Bridge is a pedestrian suspension bridge across the River Thames in London. The bridge had to be closed soon after its opening because of a large swaying motion created by people walking across it. A damping mechanism was installed to fix the problem.

The damping mechanism

☒ **A** increased the stiffness of the bridge.

☒ **B** increased the natural frequency of the bridge.

☒ **C** dissipated energy from the bridge.

☒ **D** decreased the forcing frequency on the bridge.

(Total for question = 1 mark)

Q9.

Whilst a car is being driven over a bridge, it sets the bridge into vibration. Which of the following terms definitely describes the oscillations of the bridge?

The oscillations of the bridge are

☒ **A** free.

☒ **B** forced.

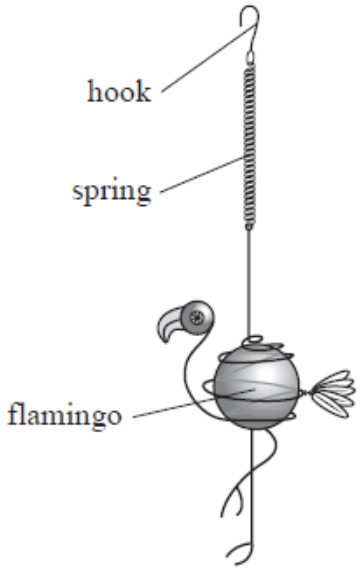
☒ **C** natural.

☒ **D** resonant.

(Total for question = 1 mark)

Q10.

A garden ornament consists of a metal flamingo suspended from a spring as shown.
The spring is hung from a support using the hook.



The mass of the flamingo is 65 g. When the flamingo is suspended vertically the spring extends by 8.5 cm.

The flamingo is pulled downwards by a small extra displacement and then released.
The flamingo undergoes simple harmonic motion vertically.

The instructions state that the flamingo will oscillate with a frequency of 2.5 Hz.

Deduce whether this statement is correct.

(5)

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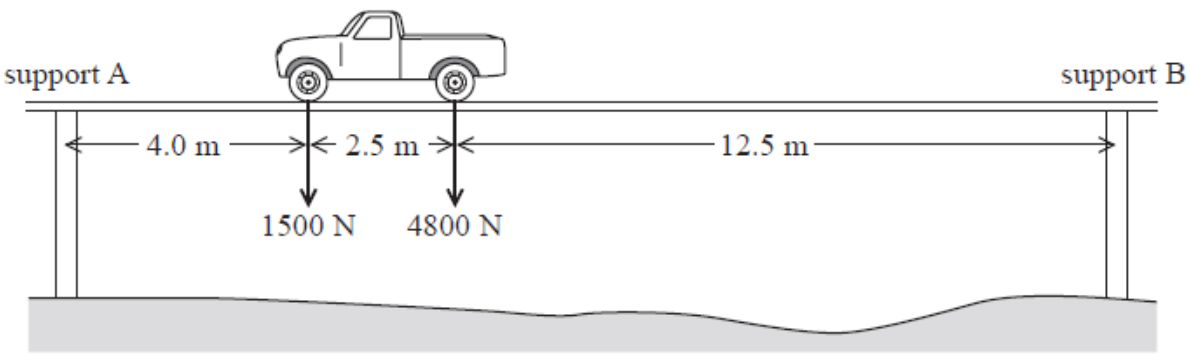
(Total for question = 5 marks)

Q11.

A beam bridge is a rigid structure that consists of one horizontal beam supported at each end.

The diagram shows a bridge with a uniform beam of mass 8 500 kg.

A small truck is crossing the beam bridge. The position of the truck and the forces of the truck on the bridge are shown, but are not drawn to scale.



(a) (i) State the conditions necessary for the bridge to be in equilibrium.

(2)

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(ii) Calculate the vertical forces at each of the bridge supports.

(5)

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Force at A = ...

Force at B = ...

The Volgograd Bridge is a concrete beam bridge across the River Volga in Russia.



In 2010 the bridge was closed to traffic due to windy conditions leading to resonance of the structure.

(i) Explain what is meant by resonance in this context.

(2)

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(ii) To suppress the oscillations of the bridge, dampers were installed.

Explain how damping resulted in the suppression of the oscillations of the bridge.

(3)

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(iii) Each damper contains an enclosure filled with a fluid. When this fluid is subjected to a magnetic field, the viscosity of the fluid greatly increases.

Describe how the behaviour of the fluid would change in a magnetic field and how this would be useful for the operation of the dampers.

(2)

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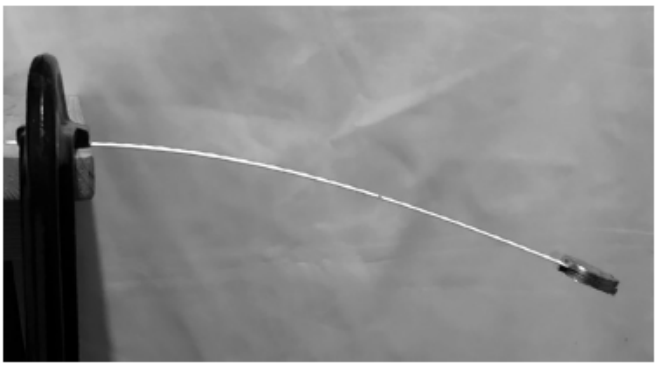
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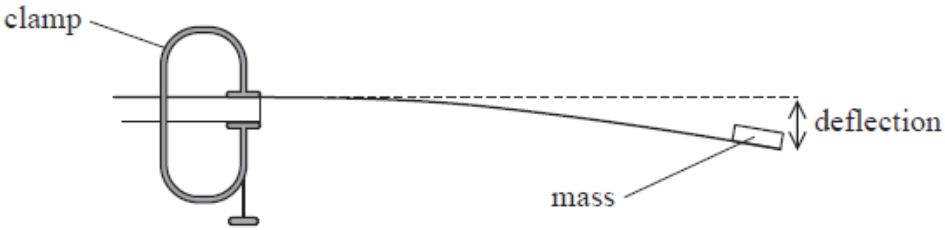
(Total for question = 14 marks)

Q12.

A student measured the deflection of a mass attached to the end of a thin strip of metal.

The strip was clamped to a bench at one end as shown.

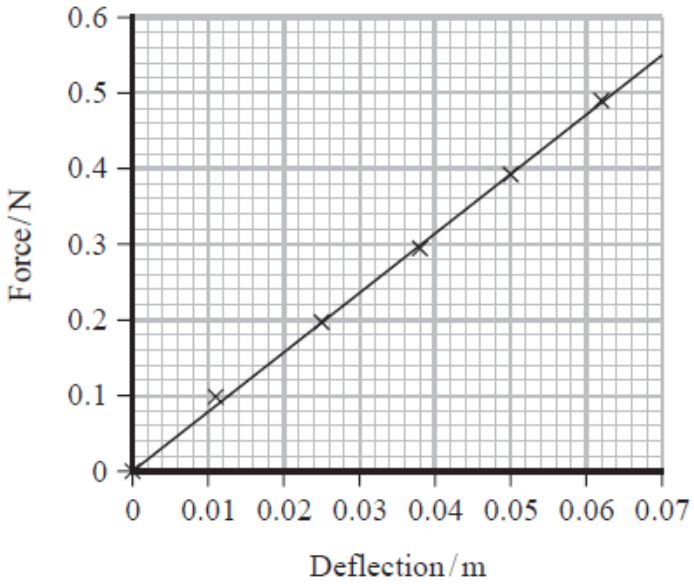




The student varied the force on the end of the strip by changing the mass attached.

The deflection was measured each time when the mass was in its equilibrium position.

The student obtained the following graph of deflection against force.



The student then investigated the oscillations of the mass on the metal strip. The student fixed different numbers of 10 g masses to the end of the metal strip.

The student noticed that the smaller the mass the higher the frequency of the oscillations. He estimated that the maximum number of oscillations he could count was two per second. He decided that the smallest mass he should use was 50 g.

Determine whether 50 g is the smallest mass he should use.

You may assume that the system acts in the same way as a mass on a spring.

(5)

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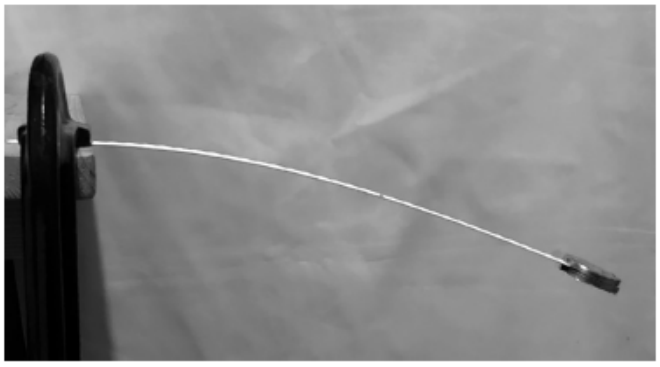
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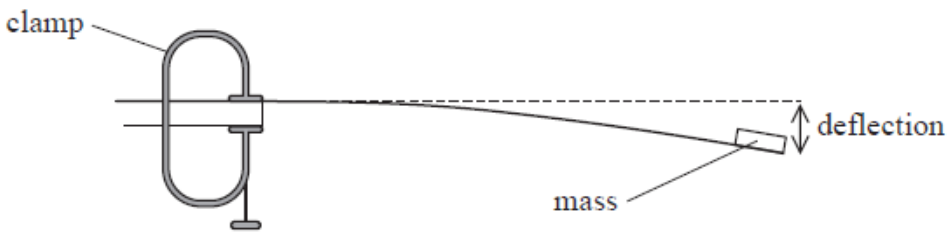
(Total for question = 5 marks)

Q13.

A student measured the deflection of a mass attached to the end of a thin strip of metal.

The strip was clamped to a bench at one end as shown.

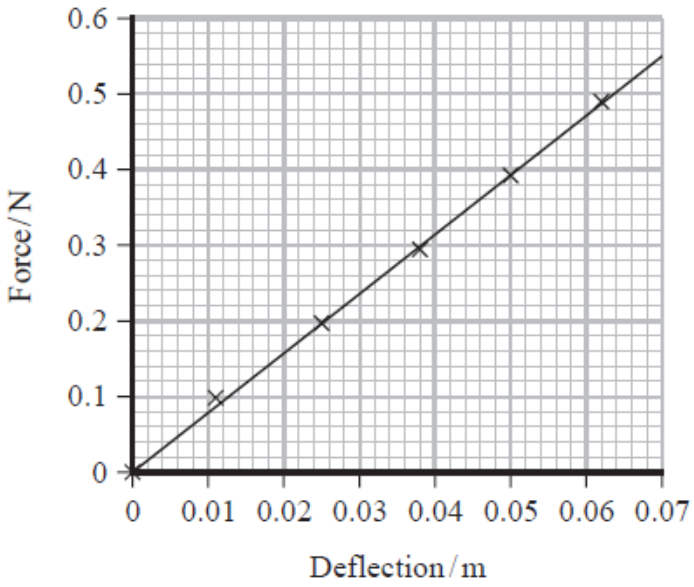




The student varied the force on the end of the strip by changing the mass attached.

The deflection was measured each time when the mass was in its equilibrium position.

The student obtained the following graph of deflection against force.



State why the mass will oscillate with simple harmonic motion when it is displaced slightly from its equilibrium position and released.

(2)

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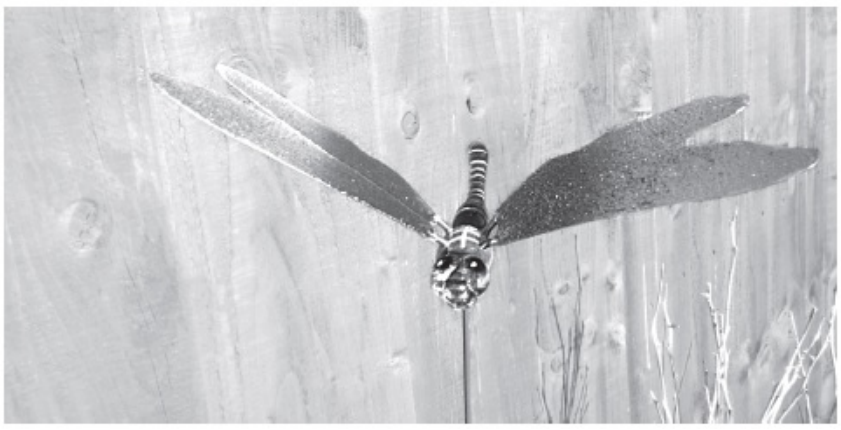
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(Total for question = 2 marks)

Q14.

A garden ornament consists of a plastic dragonfly mounted on a stick. The dragonfly's wings are attached to the body with springs, and they flutter up and down in a gentle breeze.



(a) When the air is not moving and the wings are displaced through a small vertical distance,

they oscillate. The time for 10 oscillations is recorded. This is repeated twice more.

Time / s		
t_1	t_2	t_3
6.2	6.6	6.9

(i) Calculate the frequency of oscillation of the wings

(3)

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Frequency = ...

(ii) The oscillation of the wings is thought to be simple harmonic motion.

State the conditions required for the oscillations to be simple harmonic.

(2)

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(b) The amplitude of the wings' oscillation dies down after only a small number of oscillations.

Explain why this happens

(2)

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(c) In certain breezy conditions the wings are seen to oscillate with a very large amplitude.

Name this effect and state the condition for it to occur.

(2)

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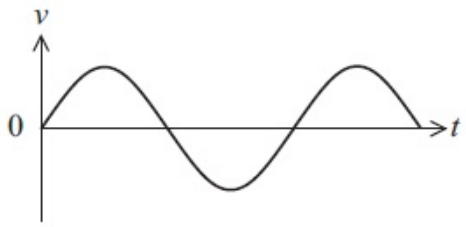
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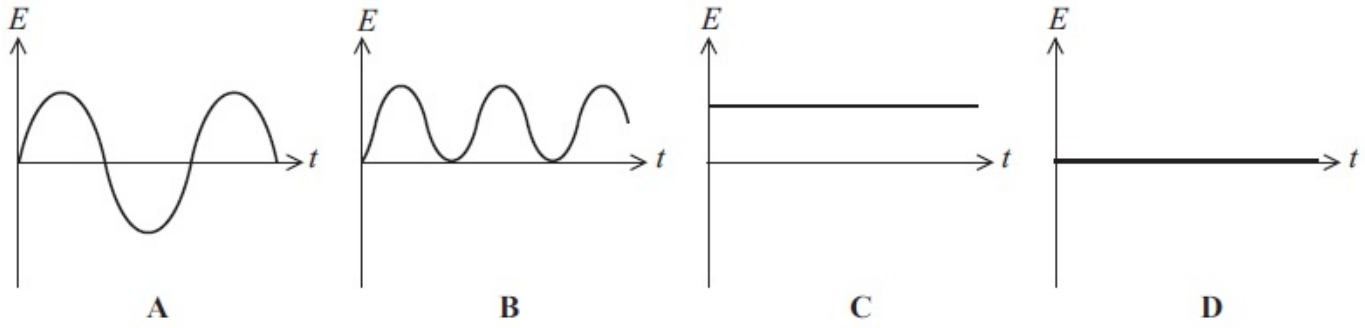
(Total for question = 9 marks)

Q15.

The graph below shows how the velocity varies with time for an object undergoing simple harmonic motion.



Which graph shows the variation of total energy with time?

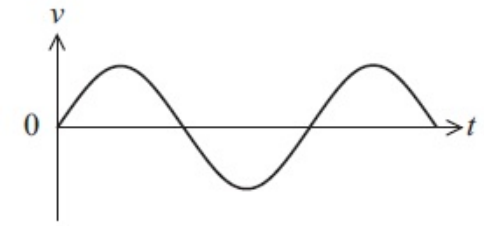


- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

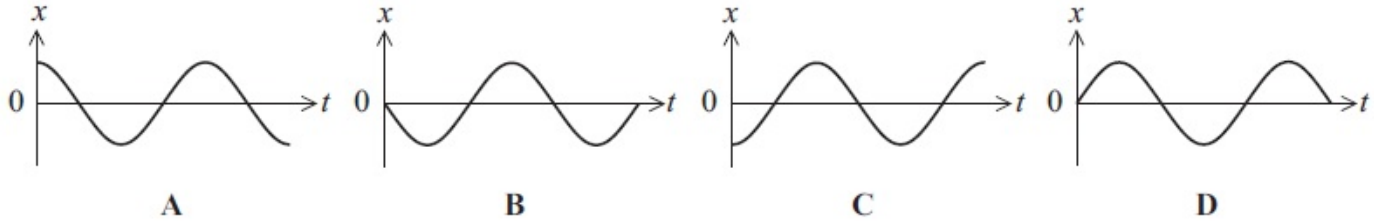
(Total for question = 1 marks)

Q16.

The graph below shows how the velocity varies with time for an object undergoing simple harmonic motion.



Which graph shows the variation of displacement with time?

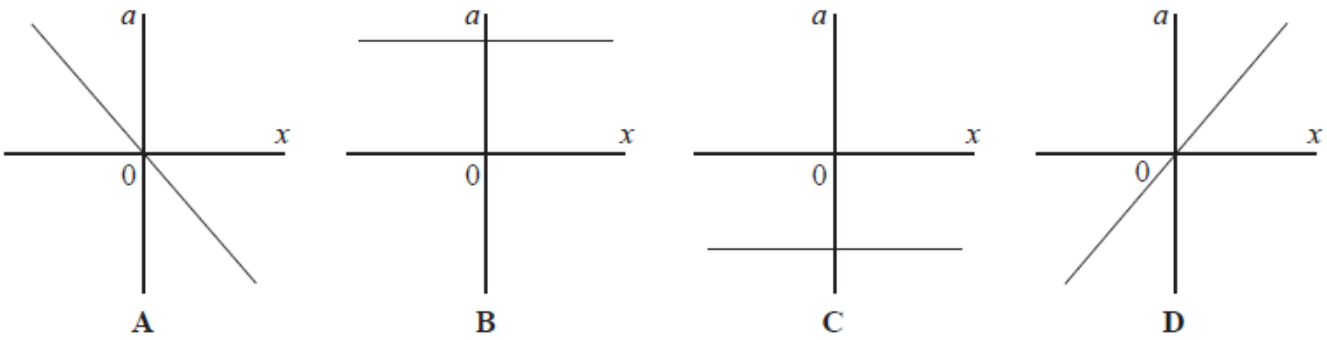


- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 marks)

Q17.

An object is undergoing simple harmonic motion.
Which graph shows how the acceleration *a* varies with displacement *x* from the equilibrium position?



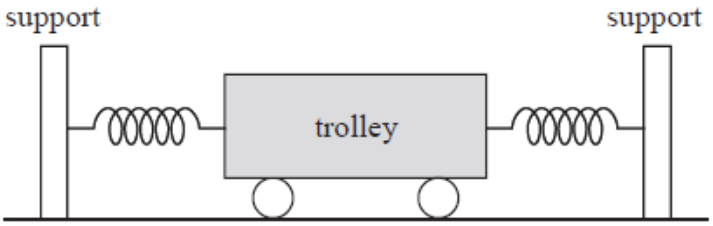
- ☒ **A**
- ☒ **B**
- ☒ **C**

☒ **D**

(Total for question = 1 mark)

Q18.

The diagram shows a mass-spring system that consists of a trolley held in equilibrium by springs attached to two fixed supports.



The trolley has a mass *m* and the spring arrangement has a force constant *k*.

(a) (i) The trolley is displaced towards one of the supports through a distance *x* and then released. Show that the initial acceleration of the trolley when it is released is given by $a = -\frac{kx}{m}$

and explain the significance of the minus sign.

(2)

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(ii) Use the expression in (i) to show that the trolley will oscillate with a time period *T* given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

(3)

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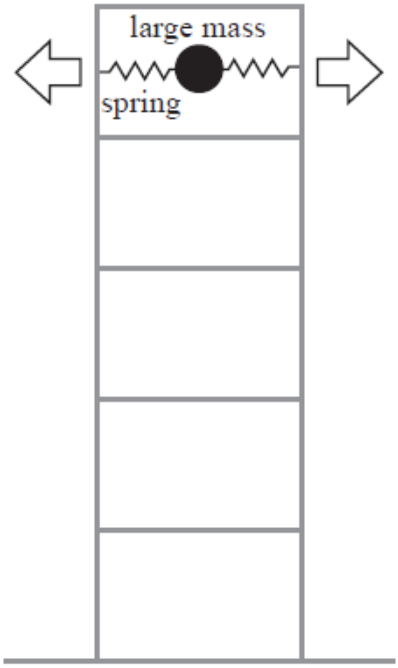
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(b) Mass-spring systems are sometimes used in tall buildings to reduce the oscillation of the building due to strong winds.



As the top of the building moves the mass is set into oscillation. The mass-spring system is designed to have a natural frequency equal to that of the building.

(i) In one building a mass-spring system has a mass of 3.5×10^5 kg and the spring arrangement has a force constant of 4.8×10^6 N m^{-1}.

Show that the natural frequency of the mass-spring system is about 0.6 Hz.

(3)

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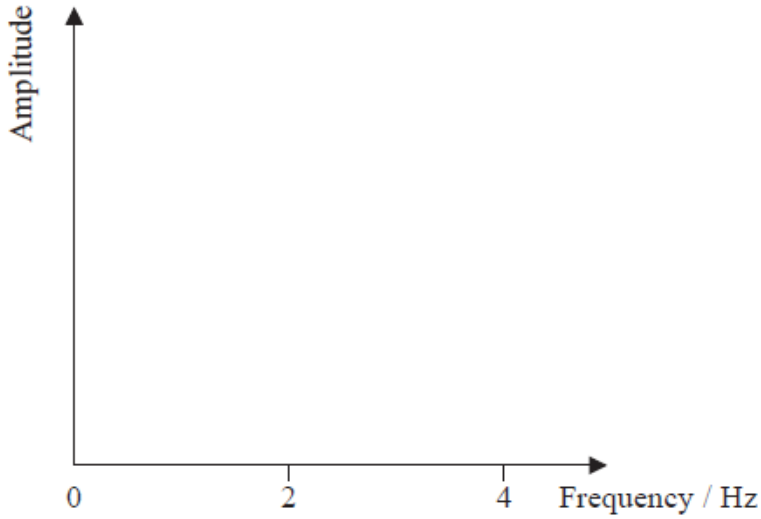
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(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)



(iii) In order to be effective the mass-spring system needs to be damped.

Explain what is meant by damping in this context and suggest why damping is a desirable feature of the mass-spring system in a tall building.

(3)

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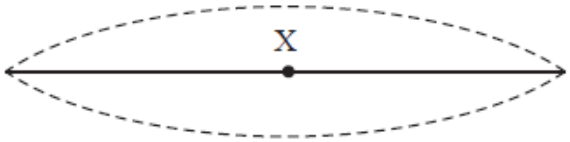
(Total for question = 14 marks)

Q19.

Guitar strings can oscillate with simple harmonic motion.



Shortly after the string is plucked, a standing wave exists on the string. The simplified diagram below shows a string in three positions of the standing wave.



(a) State what is meant by simple harmonic motion.

(2)

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(b) (i) Describe the acceleration of point X on the string as it moves between the extreme positions of its motion.

(2)

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(ii) Comment on the energy changes in the string as it moves between the extreme positions of its motion.

(3)

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(c) The oscillating string has a length of 0.53 m. Calculate the frequency of the sound emitted when the string oscillates as shown previously.

speed of the wave on the string = 270 m s^{-1}

(3)

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Frequency = ...

(Total for question = 10 marks)

Q20.

The photograph shows a 'singing bowl'.



When the handles are rubbed with both hands the bowl 'sings', producing a loud note with a frequency of 720 Hz.

A vibration generator is attached to the bowl and connected to a signal generator. The signal generator is adjusted to produce frequencies from 600 Hz to 800 Hz.

At all frequencies in this range the bowl produces a sound at the applied frequency. The sound is quiet for all frequencies except 720 Hz, when it is much louder.

Explain these observations.

(6)

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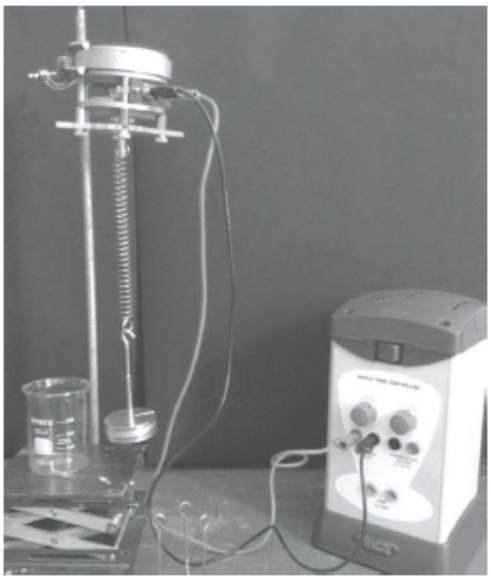
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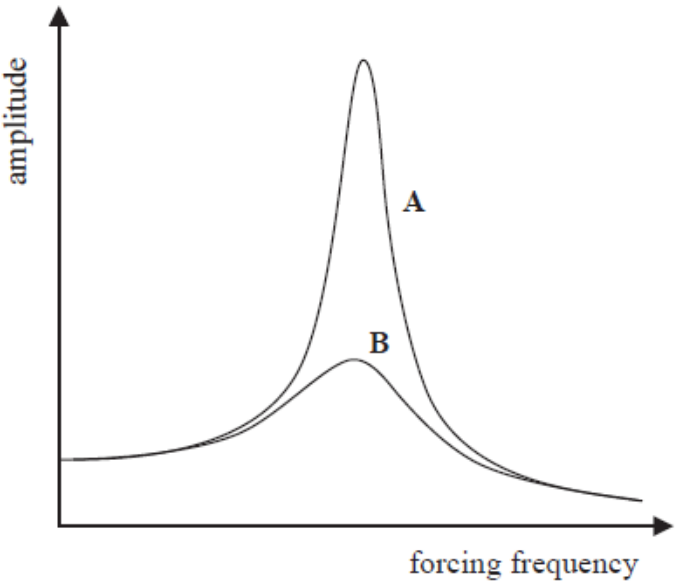
(Total for question = 6 marks)

Q21.

* A student uses the apparatus shown below to investigate the behaviour of a mass-spring system when it is forced into oscillation.



The graph shows how the amplitude of the oscillating mass varies over a range of forcing frequencies.



Curve A shows the results of the investigation using the apparatus as shown.

The student repeats the investigation with the oscillating mass in a beaker of water.
Curve B shows these results.

Making reference to important features in the graph, describe and explain the two sets of results.

(4)

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(Total for question = 4 marks)

Q22.

Figure 1 shows a wine glass being driven into oscillation at its natural frequency by a high-power loudspeaker. The loudspeaker is close to, but not touching, the glass. The loudspeaker is driven by a sine-wave generator.



Figure 1



Figure 2

In Figure 2, the amplitude of vibration of the glass has become so large that the glass shatters.

(a) (i) Name the effect being demonstrated.

(1)

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(ii) Explain why this effect occurs.

(2)

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(b) A rubber band may be placed around the glass to provide some damping. This would reduce the amplitude of vibration and prevent the glass from shattering.

Explain how a rubber band around the glass would provide damping.

(2)

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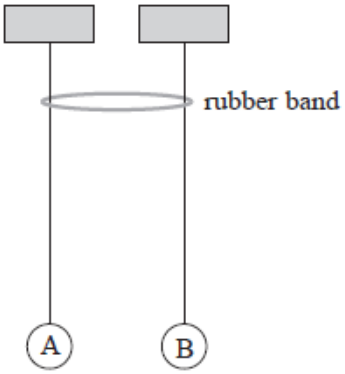
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(Total for question = 5 marks)

Q23.

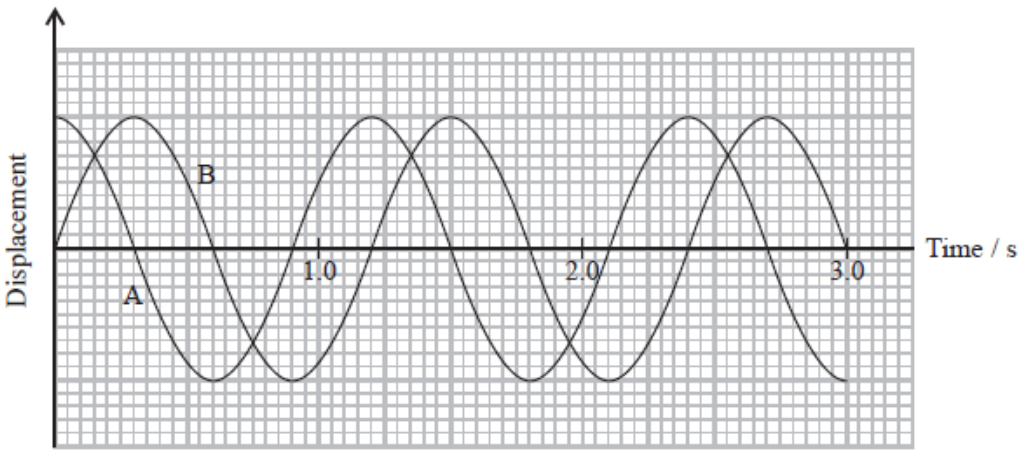
The diagram shows two identical pendulums, A and B, side by side with a rubber band placed over both strings.



Pendulum A is displaced and starts to oscillate. As pendulum A oscillates, pendulum B starts to oscillate with the same time period, its amplitude increasing as the amplitude of pendulum A decreases. At one stage pendulum A is no longer oscillating and pendulum B has its maximum amplitude. Then pendulum A starts to oscillate again with increasing amplitude, as the amplitude of pendulum B decreases.

The apparatus is adjusted so that the pendulums do not have the same length as each other. When the first pendulum is set into oscillation, the second pendulum starts to oscillate, but with very small amplitude; the first pendulum does not stop oscillating.

The graph shows how the displacement of each pendulum varies with time at one stage in the motion.



(i) State the phase relationship between the two pendulums.

(1)

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(ii) Determine the length of pendulums A and B.

(3)

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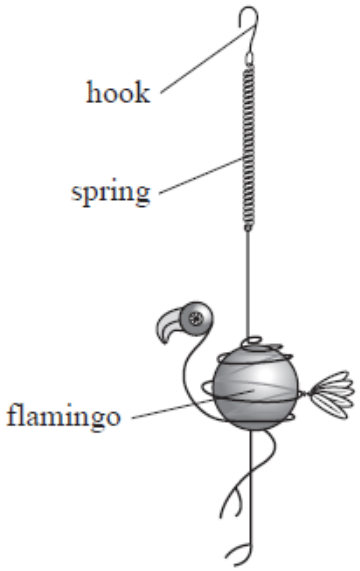
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Length = ...

(Total for question = 4 marks)

Q24.

A garden ornament consists of a metal flamingo suspended from a spring as shown. The spring is hung from a support using the hook.



In a slight breeze the flamingo swings from side to side and behaves as a simple pendulum.

(i) Show that the period of oscillation of the flamingo pendulum is about 2.2 s.

pendulum length = 1.25 m

(2)

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(ii) The amplitude of oscillation of the flamingo pendulum is 7.5 cm.

Calculate the maximum velocity of the flamingo pendulum.

(3)

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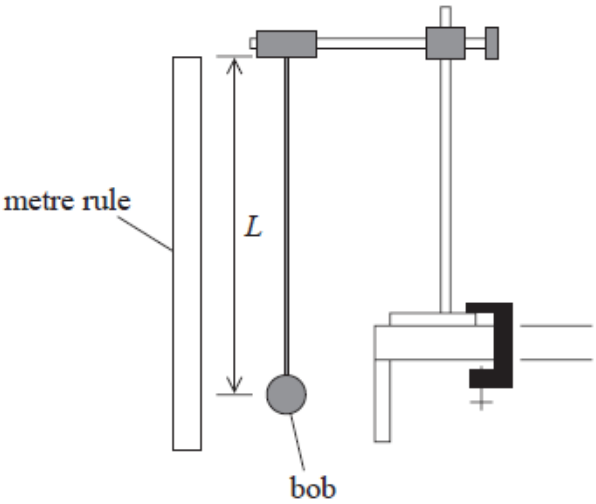
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Maximum velocity = ...

(Total for question = 5 marks)

Q25.

A student set up a "seconds pendulum". This is a simple pendulum for which the time taken to move from the bob's highest position on one side to its highest position on the opposite side is 1.00 s.



(a) Calculate the length L required for the pendulum to be a "seconds pendulum".

(2)

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L = ...

(b) The student set the pendulum into oscillation. She used a stopwatch to check the accuracy of the pendulum's period T.

Describe the procedure the student should have used to obtain an accurate value for T.

(2)

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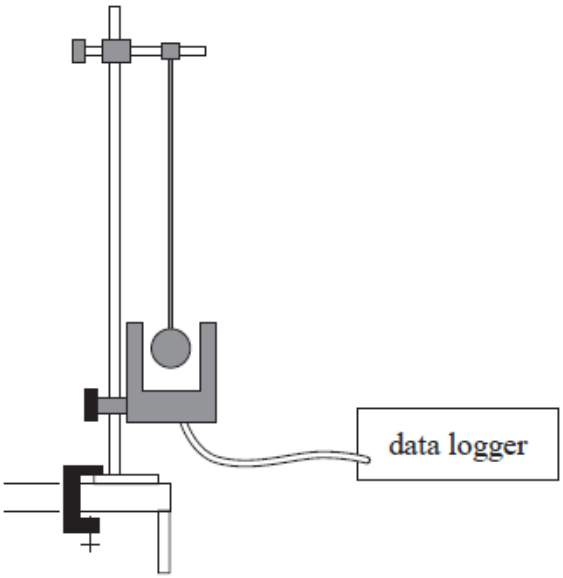
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(c) Another student suggested that the uncertainty in the measurement of the time period of the pendulum could be reduced by using a light gate and a data logger. The data logger would record the time between successive interruptions of the light beam. Both the data logger and the stopwatch have a resolution of 0.01 s.



Comment on the student's suggestion of using a data logger rather than a stopwatch.

(4)

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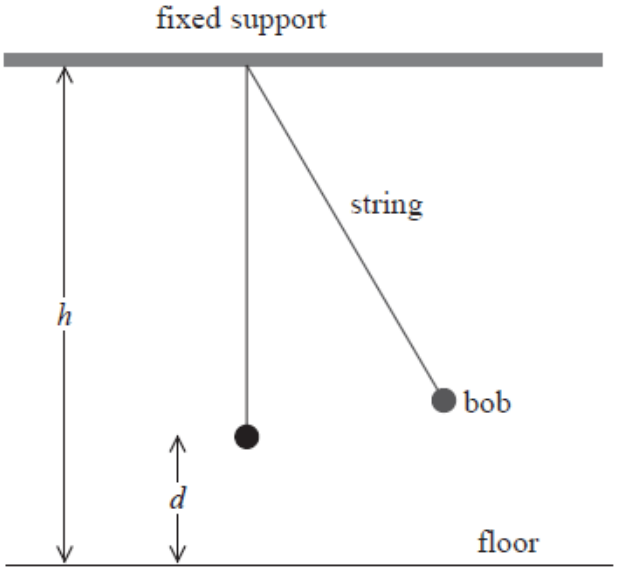
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(Total for question = 8 marks)

Q26.

A student carried out an experiment with a pendulum hung from a fixed support. The fixed support was a distance *h* above floor level as shown.



As the student was unable to measure the length of the pendulum directly, she measured the distance *d* from the bob to the floor.

To determine the period *T* of the pendulum, the student used the following method:

- release the bob from its highest position and start a stopwatch
- stop the stopwatch when the bob reaches the same position again.

Criticise the student's method for measuring the period.

(2)

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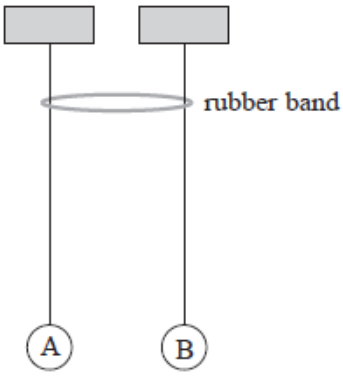
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(Total for question = 2 marks)

Q27.

The diagram shows two identical pendulums, A and B, side by side with a rubber band placed over both strings.



Pendulum A is displaced and starts to oscillate. As pendulum A oscillates, pendulum B starts to oscillate with the same time period, its amplitude increasing as the amplitude of pendulum A decreases. At one stage pendulum A is no longer oscillating and pendulum B has its maximum amplitude. Then pendulum A starts to oscillate again with increasing amplitude, as the amplitude of pendulum B decreases.

The apparatus is adjusted so that the pendulums do not have the same length as each other. When the first pendulum is set into oscillation, the second pendulum starts to oscillate, but with very small amplitude; the first pendulum does not stop oscillating.

* Explain this behaviour.

(6)

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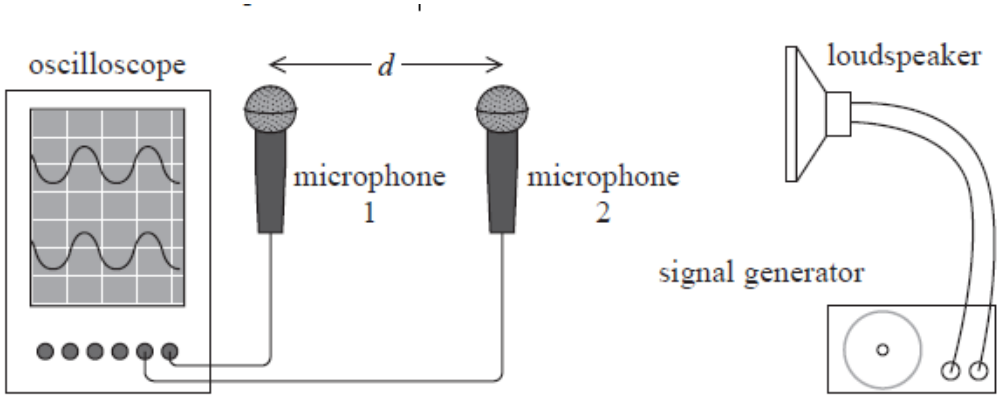
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(Total for question = 6 marks)

Q28.

In an experiment to determine the speed of sound in air a student connected two microphones to an oscilloscope, as shown.

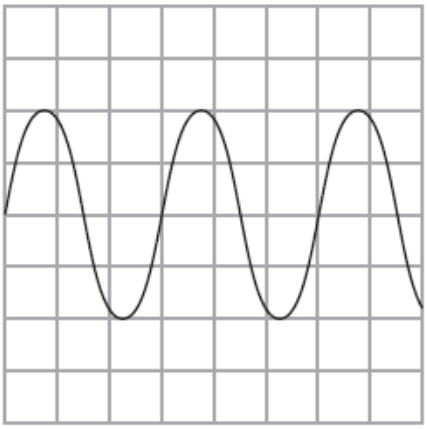


The microphones detect sound from the loudspeaker, converting it to an electrical signal. The signal is displayed on the oscilloscope screen.

Both microphones were initially positioned the same distance from the loudspeaker. The two signals were in phase on the oscilloscope screen. The student slowly moved microphone 2 towards the loudspeaker, until the two signals on the oscilloscope were in phase again. He then measured the distance *d* between the microphones to determine the wavelength λ of the sound waves.

d = 20.5cm

The oscilloscope trace for the signal from microphone 1 is shown below.



The time base of the oscilloscope was set to 0.20 ms div^{-1}.

Determine a value for the speed of sound in air.

(5)

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Speed of sound = ...

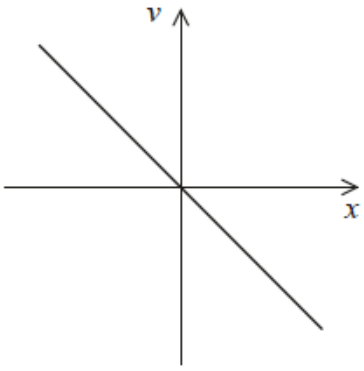
(Total for question = 5 marks)

Q29.

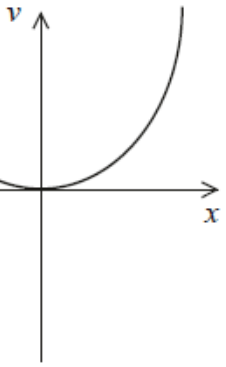
A mass at the end of a spring is set into small amplitude simple harmonic motion.

Which of the following graphs correctly shows the variation of velocity *v* of the mass with displacement *x* for one complete oscillation?

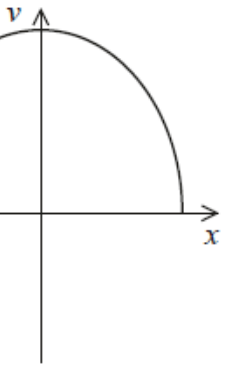
☒ **A**



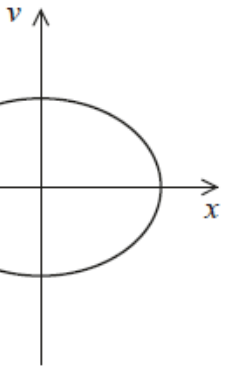
☒ **B**



☒ **C**



☒ **D**



(Total for question = 1 mark)

Q30.

The photograph shows an example of a Foucault pendulum.



This is a pendulum that consists of a massive sphere, suspended by a long wire from a high ceiling. Over time the vertical plane through which the pendulum swings appears to rotate because of the rotation of the Earth.

mass of sphere = 28.0 kg

The pendulum makes 8 complete oscillations in 52.2 s.

Show that the length of the wire supporting the sphere is about 10 m.

diameter of sphere = 60.0 cm

(4)

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(Total for question = 4 marks)