Name: _____

Topic 13: Oscillations Part 1

Date:

Time:

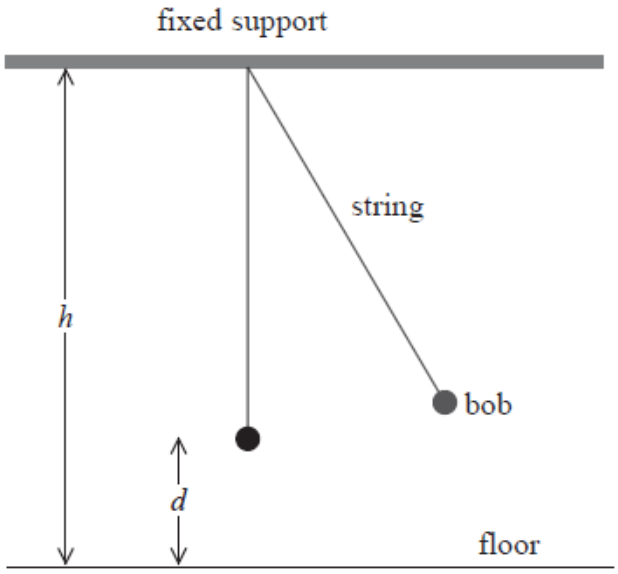
Total marks available:

Total marks achieved: _____

Questions

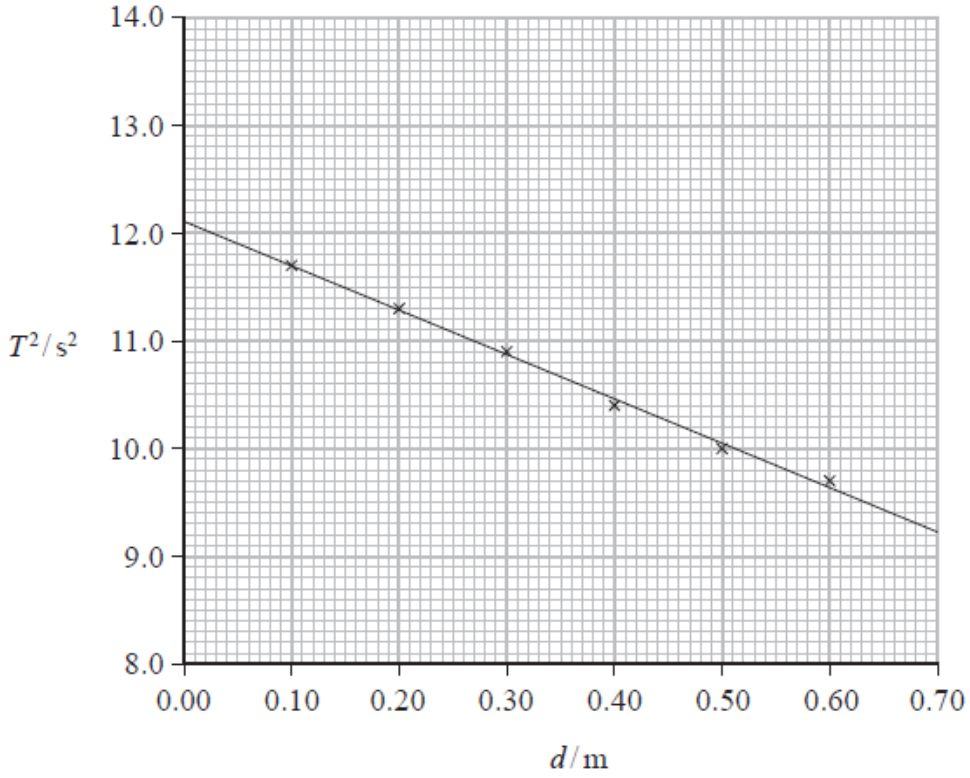
Q1.

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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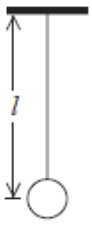
g = ...

(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.

(2)

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I_m = ...

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

(2)

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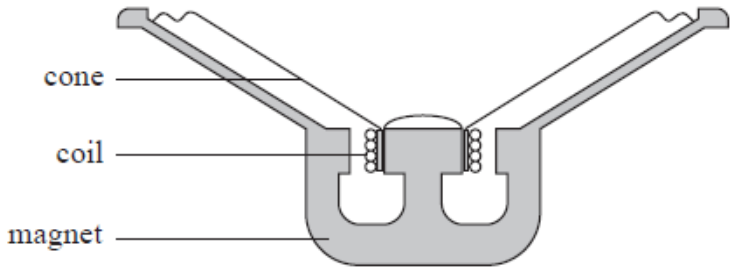
Time period of oscillations = ...

(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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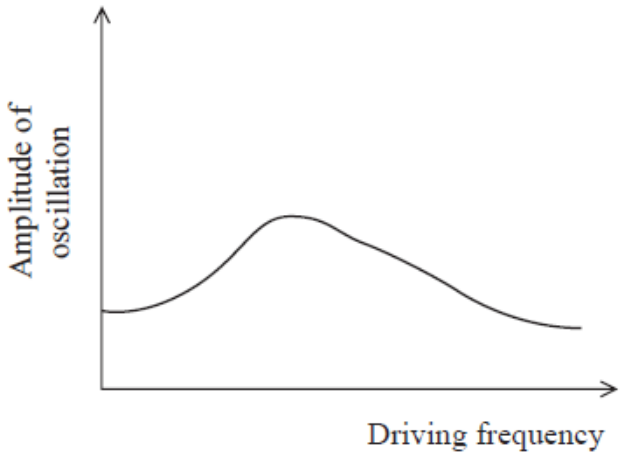
(Total for question = 6 marks)

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.

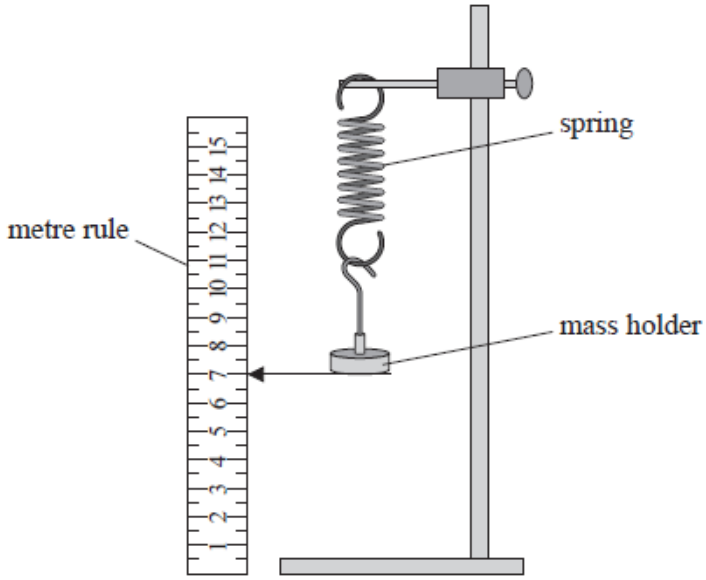
☒ **C** a minimum at the mean position of the mass.

☒ **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.

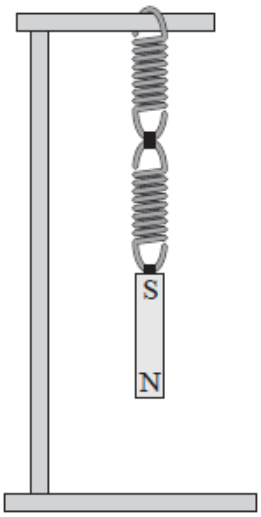


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

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}

(4)

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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.

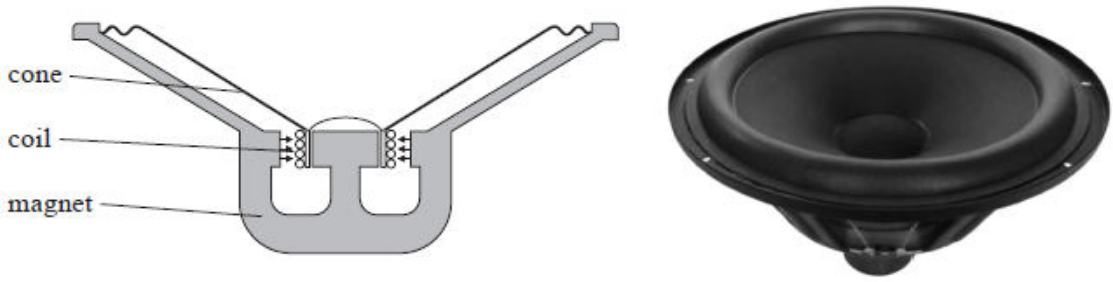
☒ **C** in the same direction as the acceleration.

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

(Total for question = 1 mark)

Q11.

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.

(2)

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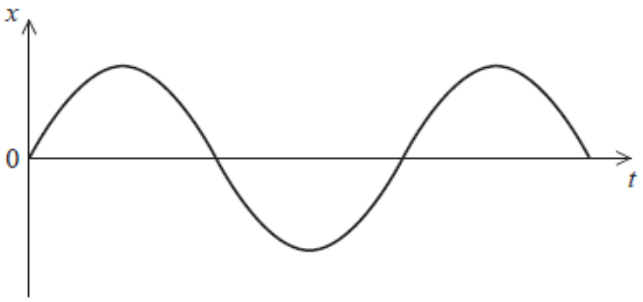
(ii) The graph below shows how the displacement *x* of the cone varies with time *t*.

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

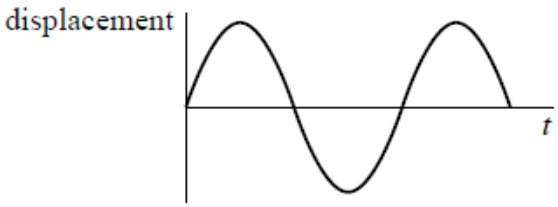
time interval.

(1)

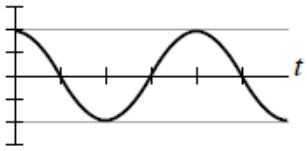


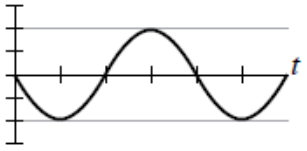
Q12.

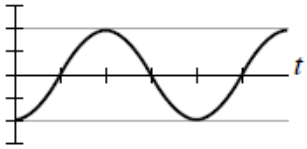
The graph shows the variation of displacement with time for a particle undergoing simple harmonic motion.

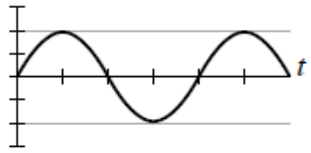


Select the graph that correctly shows the variation of velocity with time for the particle.

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for question = 1 mark)

Q13.

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.

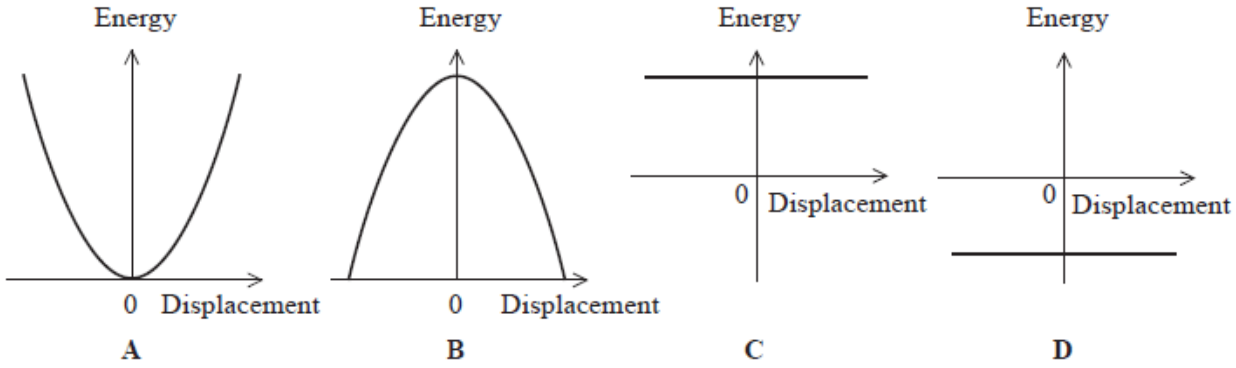
☒ **B** forced oscillation.

☒ **C** free oscillation.

☒ **D** resonant oscillation.

(Total for question = 1 mark)

Q14.



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

☒ **A**

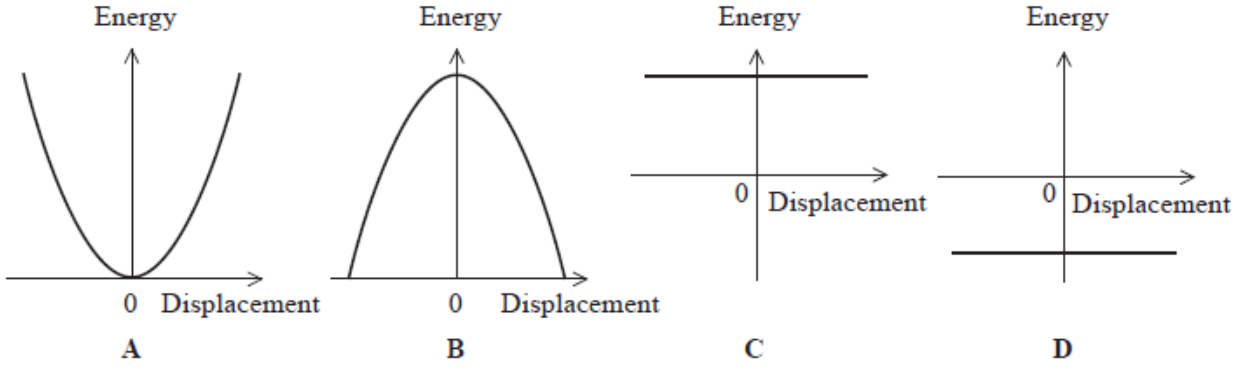
☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q15.



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)

Q16.

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

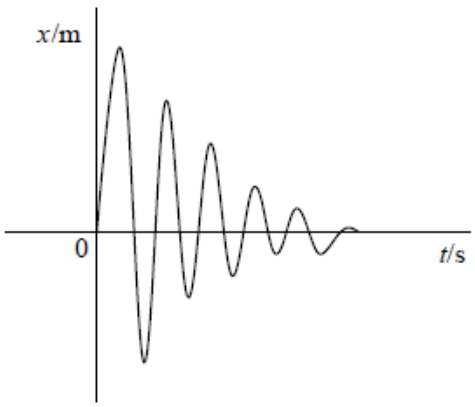
☒ **D** strength

(Total for question = 1 marks)

Q17.

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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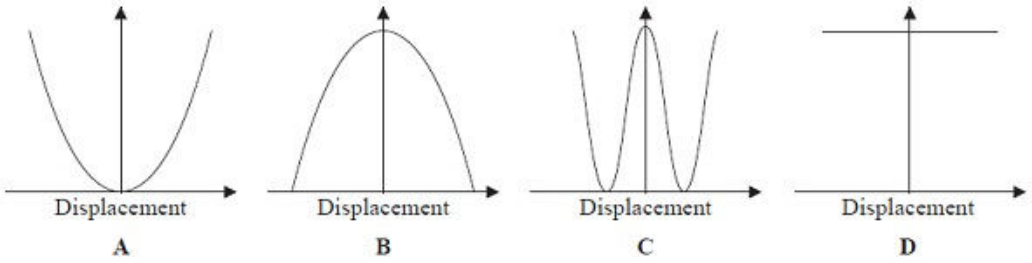
(Total for question = 6 marks)

Q18.



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

☒ **A**

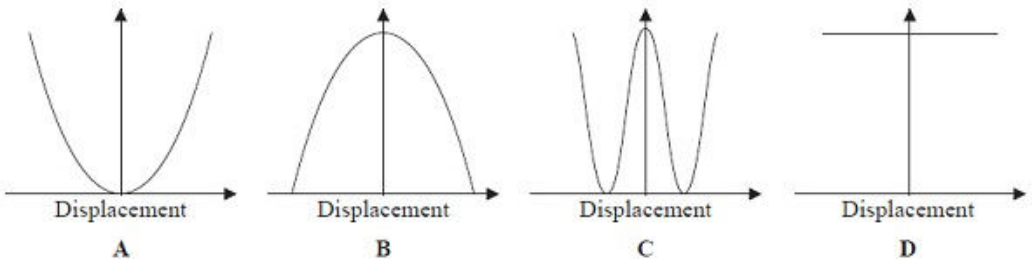
☒ **B**

☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q19.



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

☒ **A**

☒ **B**

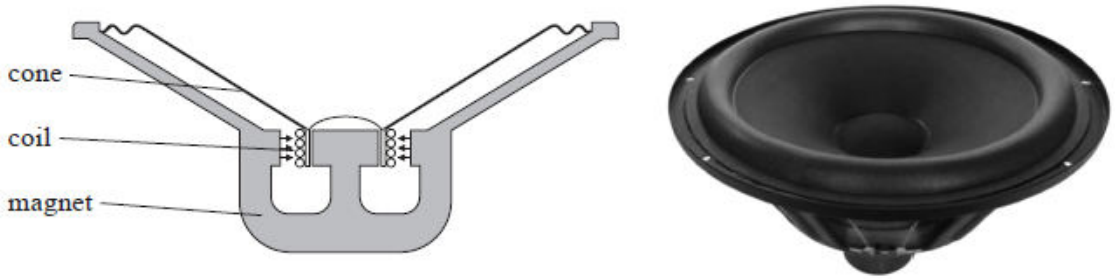
☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q20.

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.

(3)

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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.

(3)

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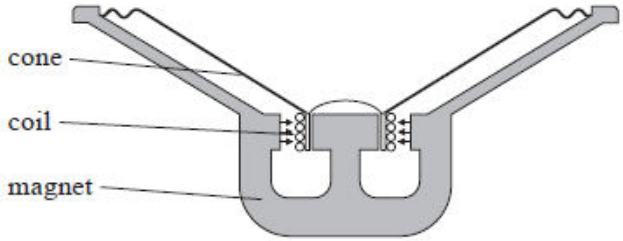
Frequency = ...

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.



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

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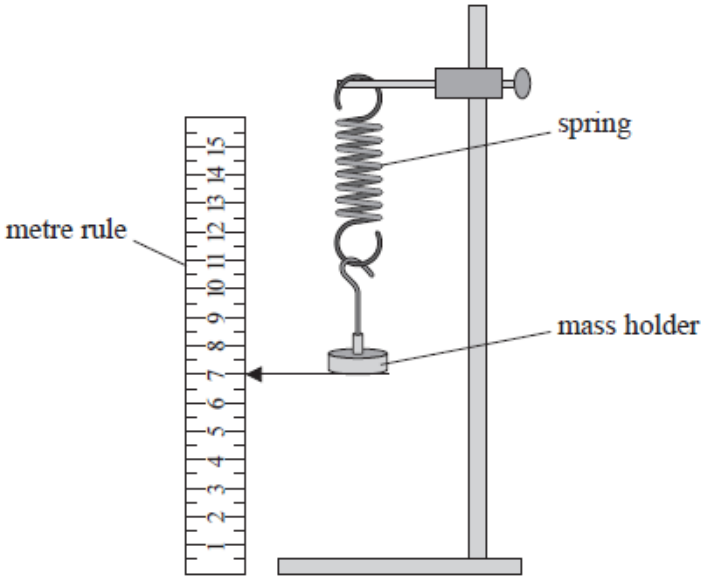
Q22.

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

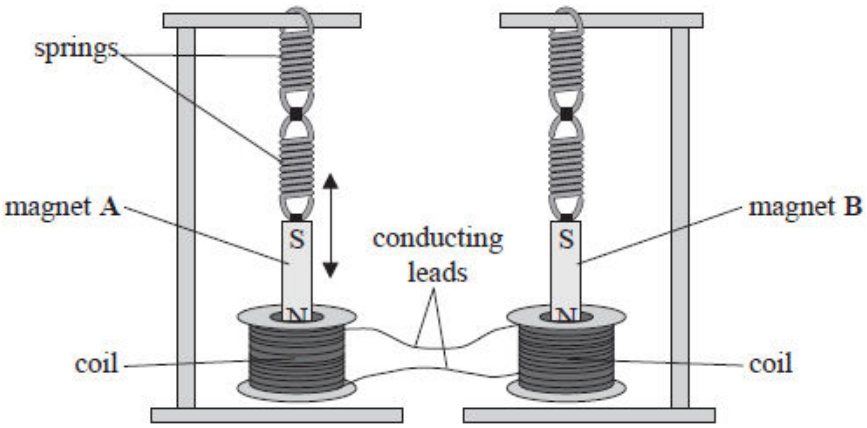


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

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.

(6)

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(Total for question = 6 marks)

Q23.

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)

Q24.

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

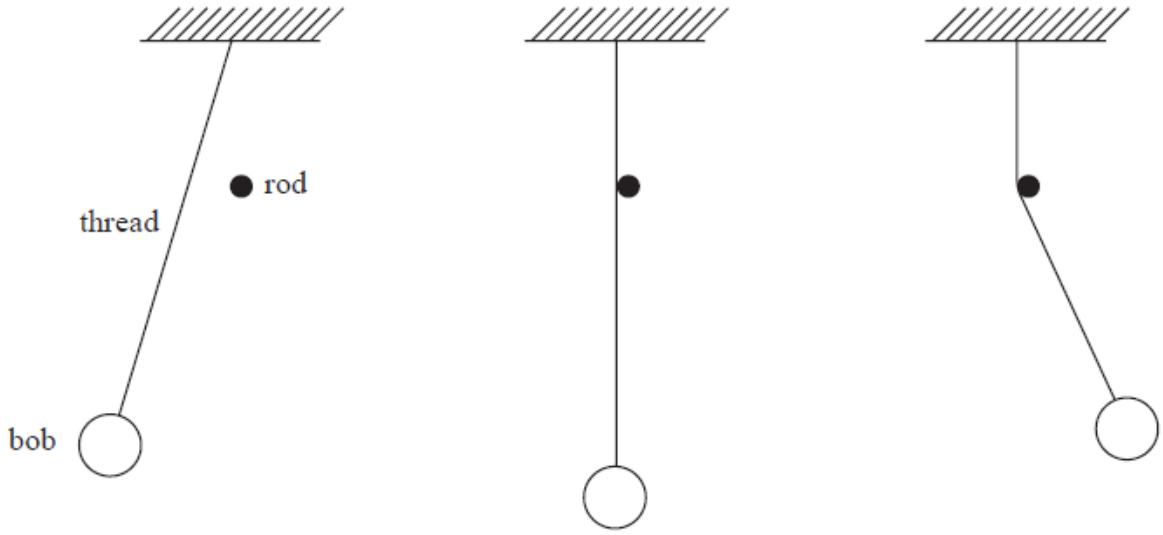
(Total for question = 1 mark)

Q25.

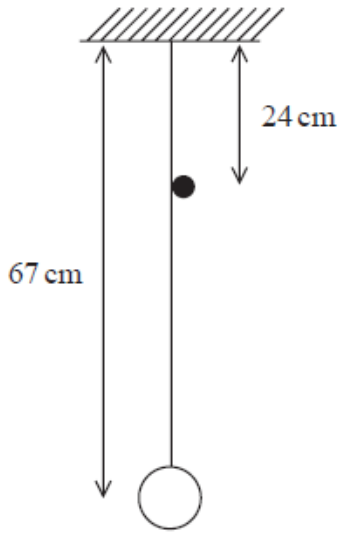
A simple pendulum consisting of a thread and a bob is set up next to a horizontal rod.

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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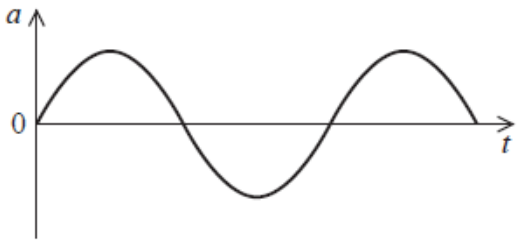
Frequency = ...

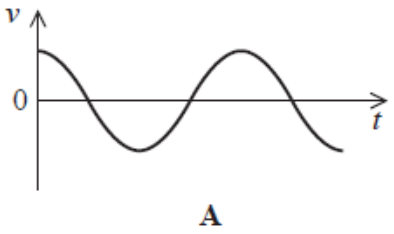
(Total for question = 4 marks)

Q26.

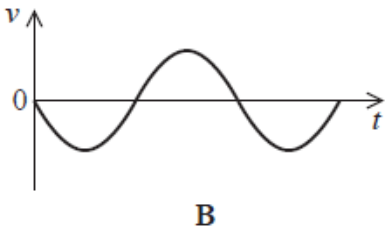
The graph shows how the acceleration varies with time for an object undergoing simple harmonic motion.



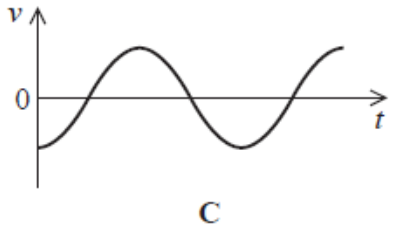
Which of the following graphs, **A**, **B**, **C** or **D**, shows how the velocity of the object varies with time?



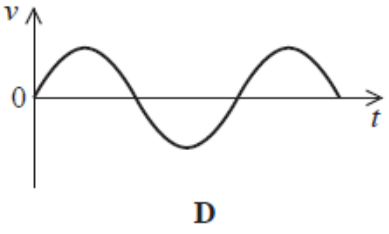
A



B



C



D

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

(Total for question = 1 mark)

Q27.

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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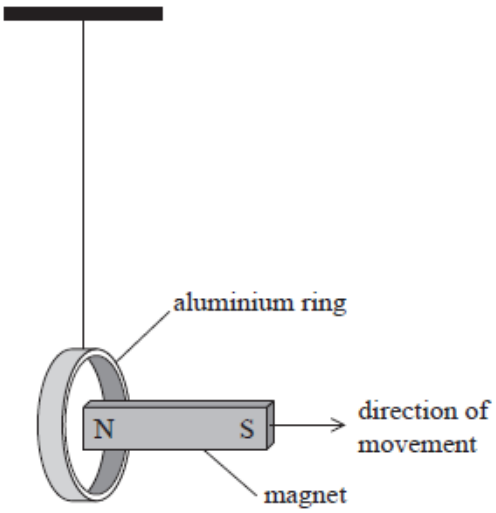
(Total for Question = 12 marks)

Q28.

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)

Q29.

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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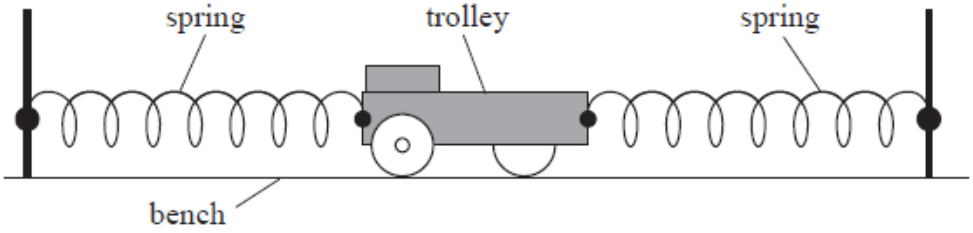
(Total for question = 2 marks)

Q30.

A trolley is attached to the ends of two springs as shown. When displaced from its equilibrium position, the trolley moves with simple harmonic motion.



The student displaces the trolley a greater distance from the equilibrium position, so the amplitude of oscillation is doubled. The trolley still moves with simple harmonic motion.

Explain how the maximum kinetic energy of the trolley will change.

(3)

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Determination of gradient (1) • Re-arrangement of $T = 2\pi\sqrt{\frac{l}{g}}$ (1) • Algebra to show $T^2 = -\frac{4\pi^2}{g}d + \frac{4\pi^2}{g}h$ (1) • Gradient = $(-)\frac{4\pi^2}{g}$ (1) • g = 9.6 m s^{-2} [accept 9.5 → 9.7 m s^{-2}] (1)	$T^2 = \frac{4\pi^2}{g}l$ $T^2 = \frac{4\pi^2}{g}(h-d)$ $T^2 = -\frac{4\pi^2}{g}d + \frac{4\pi^2}{g}h$ Example of calculation gradient $= \frac{(12.1-9.2)\text{ s}^2}{(0.00-0.70)\text{ m}}$ $= -4.1\text{ s}^2\text{m}^{-1}$ $\therefore g = \frac{4\pi^2}{4.1\text{ s}^2\text{m}^{-1}} = 9.6\text{ m s}^{-2}$	5

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• discards value for l_3 (1) • l_m=85.7 (cm) (1)	MP2: answer to 1 d.p. only Example of calculation $l_m = \frac{85.5+86.0+85.5}{3} = 85.7$ cm	2
(ii)	• Use of $T = 2\pi\sqrt{\frac{\ell}{g}}$ (1) • T=1.86 s (1)	ECF from (i) MP2: accept T = 1.9 s Example of calculation $T = 2\pi\sqrt{\frac{\ell}{g}}$ $= 2\pi \times \sqrt{\frac{0.857\text{ m}}{9.81\text{ m s}^{-2}}} = 1.86$ s	2

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	See table below	See table below	

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Indicative content:

IC1 Alternating p.d. causes an alternating current in the coil

IC2 Current carrying conductor in a magnetic field experiences a force

IC3 Current is alternating, so force changes direction with current (same frequency)
Or the alternating current drives the cone at the frequency of the p.d.

This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The table shows how the marks should be awarded for indicative content and structure and lines of reasoning.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Alternative to first 3 indicative content points:

IC1 Current in coil causes a magnetic field

IC2 Current is alternating so field changes direction with current (same frequency)

IC3 Field interacts with permanent magnet's field so coil experiences oscillating force

	IC4 The loudspeaker forces the box into oscillation IC5 (At certain frequencies) the frequency of oscillation equals the natural frequency of oscillation of the air in the box IC6 Maximum energy is transferred and the amplitude of vibration of the box increases	IC6 Resonance occurs and the amplitude of vibration of the box increases	6

Q4.

Question Number	Acceptable answer	Additional guidance	Mark
	D	The only correct answer is **D** because when damping is decreased maximum amplitude increases and the frequency at which it occurs increases A is not correct because it states that they both decrease B is not correct because it states that the maximum amplitude decreases C is not correct because it states that the frequency decreases	1

Q5.

Question Number	Answer	Mark
	D	1

Q6.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• new spring constant = 11 N m^{-1}	(1)	Example of calculation: $k = 22/2 = 11\ \text{N m}^{-1}$	
	• Use of $T = 2\pi\sqrt{\frac{m}{k}}$	(1)	$T = 2\pi\sqrt{\frac{0.12\,\text{kg}}{11\,\text{N m}^{-1}}} = 0.66\,\text{s}$	
	• Use of $f = 1/T$	(1)		
	• f = 1.5 Hz	(1)	f = 1/0.66 s = 1.5 Hz	4

Q7.

Question Number	Answer	Mark
	D	1

Q8.

Question Number	Answer	Mark
	C	1

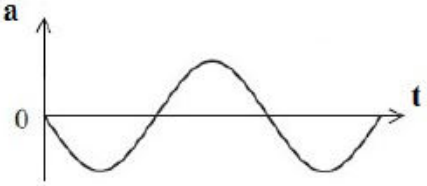
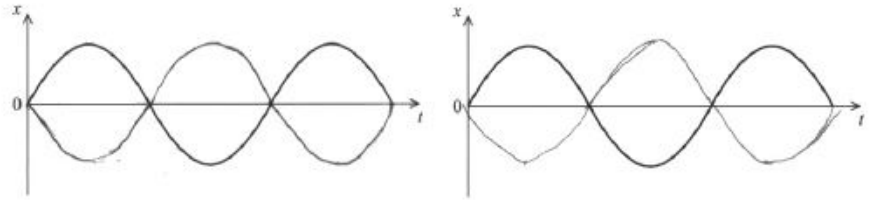
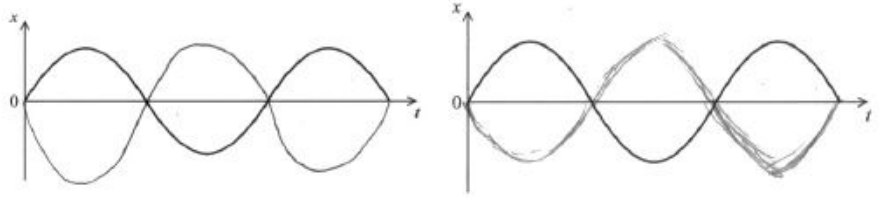
Q9.

Question Number	Answer	Mark
	D	1

Q10.

Question Number	Answer	Mark
	B	1

Q11.

Question Number	Answer	Mark
(b)(i)	Acceleration is: • proportional to displacement from equilibrium position **(1)** • (always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement **(1)** **Or** Force is: • proportional to displacement from equilibrium position **(1)** • (always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction" **(1)** [accept undisplaced point/fixed point/central point for equilibrium position] [An equation with symbols defined correctly is a valid response for both marks. e.g. $a \propto -x$ **or** $F \propto -x$]	2
(b)(ii)	Minus sine curve with constant amplitude **(1)** **a**  Examples of acceptable graphs:  Examples of unacceptable graphs:  	1

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
	A		1

Q13.

Question Number	Answer	Mark
	C	1

Q14.

Question Number	Answer	Mark
	A	1

Q15.

Question Number	Answer	Mark
	C	1

Q16.

Question Number	Answer	Mark
	B	1

Q17.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to: **Either** • The oscillating frame causes the lead spheres to deform plastically **(1)** • And this removes energy from the oscillating frame **(1)** • So the amplitude of oscillations decrease with time as shown by the graph **(1)** **OR** • Spheres collide/vibrate **(1)** • Hence energy dissipated **(1)** • So the amplitude of oscillations decrease with time as shown by the graph **(1)**		**3**

Q18.

Question Number	Answer	Mark
	B	**1**

Q19.

Question Number	Answer	Mark
	D	**1**

Q20.

Question Number	Answer	Mark
(i)	Identification of weight and force from cone, F_c, as the two forces acting on the sand **(1)** Weight $- F_c = m\omega^2 x$ **(1)** So as x increases, F_c decreases, sand loses contact with cone when $F_c = 0$ **(1)**	3
(ii)	Resultant force equated to weight **Or** acceleration equated to g **(1)** Use of $\omega = 2\pi f$ **(1)** $f = 32$ Hz **(1)** Example of calculation: $mg = m\omega^2 x_0$ $\omega = \sqrt{\frac{g}{x_0}} = \sqrt{\frac{9.81\,\text{m s}^{-2}}{0.25\times10^{-3}\,\text{m}}} = 198\,\text{rad s}^{-1}$ $f = \frac{\omega}{2\pi} = \frac{198}{2\pi} = 31.5\,\text{Hz}$	3

Q21.

Question Number	Answer	Mark
*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Current carrying conductor in a magnetic field **(1)** Coil experiences a force **(1)** Current is alternating, so force changes direction with current (same frequency) **(1)** **Or** Current in coil causes a magnetic field **(1)** Current is alternating so field changes direction with current (same frequency) **(1)** Field interacts with permanent magnet's field so coil experiences oscillating force **(1)**	3

Q22.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><td>Number of indicative points seen in answer</td><td>Number of marks awarded for indicative points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
Indicative content:

As magnet A moves, its coil experiences a change of magnetic flux (linkage)
The change in magnetic flux linkage induces an emf in the coil
The (induced) emf causes a current in both coils
The current in the second coil causes a force to act on magnet B, driving magnet B into oscillation
Because both mass-spring systems have the same period/frequency
Resonance occurs (and magnet B oscillates with increasing amplitude)

</td>
<td>The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><td></td><td>Number of marks awarded for structure and lines of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkage between points and is unstructured</td><td>0</td></tr>
</table>
Linkage Marks

IC points 1 – 4
Three of these points could score one linkage mark

IC points 5 & 6 could score one linkage mark</td>
<td>6</td>
</tr>
</table>

Q23.

Question Number	Acceptable answer	Additional guidance	Mark
	D	The only correct answer is **D** because the frequency is inversely proportional to the square root of length and independent of the mass, so if length is quadrupled, frequency is halved to $f/2$ A is not the correct answer because it is $4f$ B is not the correct answer because it is $2f$ C is not the correct answer because it is f	1

Q24.

Question Number	Answer	Mark
	B – 0.40 Hz	**1**
	Incorrect Answers: Correct method: $f = 24 \div 60\ s = 0.40\ Hz$ A – uses 1 minute ÷ 24 C – uses 60 s ÷ 24 D – uses 24 ÷ 1 minute	

Q25.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use of $T = 2\pi\sqrt{(l/g)}$	**(1)**	Example of calculation $T = 2\pi\sqrt{(l/g)}$ $T = 2\pi\sqrt{(0.43 / 9.81)}$ $= 1.32$ s $T = 2\pi\sqrt{(0.67 / 9.81)}$ $= 1.64$ s $T = (1.32\ s + 1.64\ s) / 2 = 1.48$ s $f = 1 / 1.48\ s = 0.68$ Hz	**4**
	• Apply factor of 2 correctly for 2 half cycles	**(1)**		
	• Use of $f = 1/T$	**(1)**		
	• $f = 0.68$ Hz	**(1)**		

Q26.

Question Number	Answer	Mark
	C	1

Q27.

Question Number	Answer		Mark
(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Hooke's Law:) for a spring, force is proportional to extension **Or** $F = k\Delta x$	**(1)**	
	An extension of the spring causes a force towards the equilibrium position **Or** (resultant force towards the equilibrium position, so) $ma = -k\Delta x$	**(1)**	
	Condition for shm is restoring force [acceleration] is proportional to displacement (from equilibrium position) [QWC question, so max 2 if equations given with no further explanation]	**(1)**	**3**
(b)	Use of $a = -\omega^2 x$	**(1)**	
	Use of $T = \frac{2\pi}{\omega}$	**(1)**	
	$T = 1.55$ (s)	**(1)**	**3**
	[Credit use of F = k Δx and use of $T = 2\pi\sqrt{\frac{m}{k}}$ for first two marking points] Example of calculation: $\omega = \sqrt{\frac{0.49\ \text{m s}^{-2}}{3.0\times10^{-2}\ \text{m}}} = 4.04\ \text{s}^{-1}$ $T = \frac{2\pi}{4.04\ \text{s}^{-1}} = 1.55\ \text{s}$		
(c)(i)	Damped / damping [Do not accept critical/heavy damping]	**(1)**	**1**
(c)(ii)	Forced / driven	**(1)**	**1**
(c)(iii)	Resonance	**(1)**	
	f = 0.65 Hz [accept s^{-1}] [0.625 Hz if show that value is used, 0.64 Hz if unrounded value used]	**(1)**	**2**
	Example of calculation: f = 1/1.55 s = 0.645 Hz [allow 2nd mark if they use either their value from (b) or 1.6 s]		
(d)	(With a smaller mass baby) the natural frequency of oscillation would increase **Or** The natural frequency of the system would increase		

	Or (1) The periodic time of the system would decrease Smaller mass baby would have to kick at a higher frequency (to force system into resonance) (1) [accept larger mass baby would have to kick at a lower frequency]	**2**
	Total for question	**12**

Q28.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The table shows how the marks should be awarded for indicative content and structure and lines of reasoning. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 – 4 5–4 – 3 3–2 – 2 1 – 1 0 – 0 Number of marks awarded for structure of answer and sustained line of reasoning Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout – 2 Answer is partially structured with some linkages and lines of reasoning – 1 Answer has no linkages between points and is unstructured – 0	IC Points / IC Mark / Max linkage mark avail. / Max final mark 6 / 4 / 2 / **6** 5 / 3 / 2 / **5** 4 / 3 / 1 / **4** 3 / 2 / 1 / **3** 2 / 2 / 0 / **2** 1 / 1 / 0 / **1** 0 / 0 / 0 / **0** IC1: accept references to flux cutting Alternative indicative content for IC4 – IC5 4. The current is in the magnetic field produced by the magnet 5. The current experiences a magnetic force	**6**

	Indicative content: 1. Removing the magnet from the ring changes the magnetic flux (linked with the ring) 2. This induces an e.m.f. (in the ring) 3. E.m.f. causes a current in the ring 4. Which produces a magnetic field 5. The magnetic fields interact/combine 6. This opposes the change, causing an attractive force to act		

Q29.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • (Magnetic levitation) reduces frictional forces (acting on the train as it moves) **(1)** • This reduces the work done against friction **Or** this makes it more efficient **Or** there is less time to reach maximum speed **Or** there is a higher maximum speed **(1)**	MP1: accept removes/no frictional forces MP2: accept there is less fuel used **Or** less energy is wasted	**2**

Q30.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • $v_{max} = \omega A$ and ω constant (1) • If A doubles, then v_{max} doubles (1) • Hence max E_k will quadruple, since $E_k = \frac{1}{2}mv^2$ [dependent upon MP2] (1) OR • $\Delta E_{el} = \frac{1}{2}F\Delta x$ **and** $\Delta F = k\Delta x$ (1) • $\Delta E_{el} \propto (\Delta x)^2$ since k is constant (1) • Hence max E_k will quadruple, since max E_k = max ΔE_{el} (dependent upon MP2) (1)		3