Mark Scheme

Q1.

Question Number	Answer	Mark
	C	1

Q2.

Question Number	Answer	Mark
	B	1

Q3.

Question Number	Answer	Mark
	B	1

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Answer	Mark
	C	1

Q6.

Question Number	Answer	Mark
	A	1

Q7.

Question Number	Answer	Mark
	C	1

Q8.

Question Number	Answer	Mark
	D	1

Q9.

Question Number	Answer	Mark
	D	1

Q10.

Question Number	Answer	Mark
	D	1

Q11.

Question Number	Answer		Mark
	MAX 3		
	Curve A:		
	The system has a maximum amplitude at a particular frequency	(1)	
	This is an example of resonance	(1)	
	Resonance occurs when the forcing frequency is at (or near to) the natural frequency of the system	(1)	
	At resonance there is an efficient/maximum transfer of energy (to the mass-spring system)	(1)	
	MAX 3		
	Curve B:		
	B has a smaller amplitude than A (for a wide range of frequencies)	(1)	
	The modified system has (greater) damping	(1)	
	Energy is being removed from the system	(1)	
	The frequency at which resonance occurs is lower for the damped system	(1)	**4**
	Total for question		**4**

Q12.

Question Number	Answer		Mark
(a)(i)	Resonance / resonating / resonates	(1)	**1**
(a)(ii)	Loudspeaker/driving frequency close or equal to its natural frequency	(1)	
	so energy transfer is maximised/large **Or** energy transfer is very efficient	(1)	**2**
(b)	Idea that energy would be transferred (from the glass) to the rubber band (as it deforms) **Or** work is done on the rubber band (by the glass)	(1)	
	Some of the (transferred) energy becomes internal energy of rubber band **Or** some of the (transferred) energy is dissipated in the rubber band	(1)	**2**
	Total for Question		**5**

Q13.

<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><th>Number of indicative points seen in answer</th><th>Number of marks awarded for indicative points</th></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 <u>flux</u> (linkage)
The change in magnetic flux linkage <u>induces an emf</u> 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><th></th><th>Number of marks awarded for structure and lines of reasoning</th></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>

Q14.

Question Number	Acceptable Answers	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 following table shows how the marks should be awarded for indicative content.	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	3

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Max linkage mark available
6	4	2
5	3	2
4	3	1
3	2	1
2	2	0
1	1	0
0	0	0

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

	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	0

	points and is unstructured **Indicative content** • The pendulums have the same length, so they have the same time period/frequency • The first pendulum causes forced oscillations of the second pendulum • The driving frequency equals the natural frequency • Resonance occurs, so there is maximum transfer of energy so the amplitude increases until all energy is transferred • The second pendulum then acts as a driver for the first pendulum **Or** the process repeats with energy transfer from B to A • When the lengths differ the driving frequency is not the natural frequency of the second pendulum so little energy transfer occurs			

Q15.

Question Number	Answer		Mark
(a)(i)	Calculation of average time period [accept average time for 10T] Use of $f = \frac{1}{T}$ $f = 1.5$ Hz Example of calculation $T = \frac{t_1 + t_2 + t_3}{30} = \frac{(6.2 + 6.6 + 6.9)\text{s}}{30} = 0.657\text{ s}$ $f = \frac{1}{0.657\text{ s}} = 1.52\text{ Hz}$	(1) (1) (1)	3
(a)(ii)	Force (or acceleration): proportional to displacement from equilibrium position always acting towards the equilibrium position **Or** always in the opposite direction to the displacement [accept rest/centre point for "equilibrium position"] [both marks can be gained from an equation with terms clearly defined including a correct reference to the negative sign]	(1) (1)	2
(b)	There is (large) drag force [accept air resistance for drag] Producing a deceleration **Or** the oscillation is (heavily) damped **Or** energy is transferred/removed from the system [e.g. transferred to the surroundings.] [Do not accept "lost" for "transferred"]	(1) (1)	2
(c)	Resonance Driven at a frequency equal/near the natural frequency of the wings [accept their answer to (a) as a numerical value] [for "driven" accept "forced/made to oscillate"]	(1) (1)	2

Q16.

Question Number	Answer		Mark
(a)	Force (or acceleration): • proportional to displacement from equilibrium/undisplaced/rest position • always acting towards the equilibrium/undisplaced/rest position **Or** always in the opposite direction to the displacement	(1) (1)	2
(b)(i)	Acceleration is a maximum at an extreme position (towards X) Acceleration decreases to zero at X	(1) (1)	2
(b)(ii)	**Max 3** Total energy remains constant (Elastic) potential energy is transferred to kinetic energy as string moves towards X Kinetic energy is zero at an extreme position and a maximum at X (Elastic) potential energy is a maximum at an extreme position and a minimum at X	 (1) (1) (1) (1)	3
(c)	Use of $\lambda = 2l$ Use of $v = f\lambda$ $f = 250$ Hz <u>Example of calculation:</u> $\lambda = 2 \times 0.53$ m $= 1.06$ m $f = v/\lambda = 270$ m s^{-1}/1.06 m $= 254.7$ Hz	(1) (1) (1)	3
	Total for question		**10**

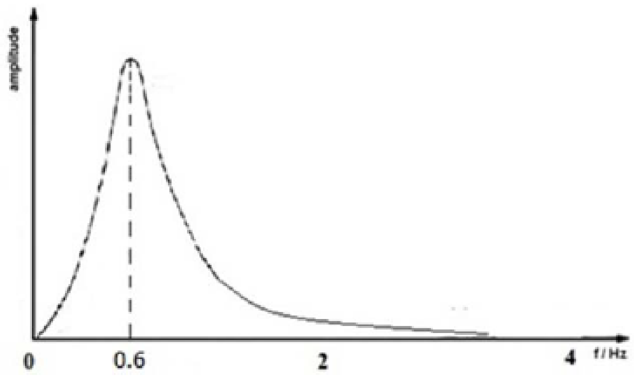
Q17.

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** $F = k\Delta x$ An extension of the spring causes a force towards the equilibrium position **Or** (resultant force towards the equilibrium position, so) $ma = -k\Delta x$ 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)** **(1)** **(1)**	**3**
(b)	Use of $a = -\omega^2 x$ Use of $T = \frac{2\pi}{\omega}$ $T = 1.55$ (s) [Credit use of F = k Δx and use of $T = 2\pi\sqrt{\frac{m}{k}}$ for first two marking points] Example of calculation: $\omega = \sqrt{\frac{0.49\text{ m s}^{-2}}{3.0\times10^{-2}\text{ m}}} = 4.04\text{ s}^{-1}$ $T = \frac{2\pi}{4.04\text{ s}^{-1}} = 1.55\text{ s}$	**(1)** **(1)** **(1)**	**3**
(c)(i)	Damped / damping [Do not accept critical/heavy damping]	**(1)**	**1**
(c)(ii)	Forced / driven	**(1)**	**1**
(c)(iii)	Resonance f = 0.65 Hz [accept s^{-1}] [0.625 Hz if show that value is used, 0.64 Hz if unrounded value used] 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]	**(1)** **(1)**	**2**
(d)	(With a smaller mass baby) the natural frequency of oscillation would increase **Or** The natural frequency of the system would increase		

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

Q18.

Question Number	Answer		Mark
(a)(i)	Use of Newton's 2nd law (F = ma) with F = –kx Acceleration/force is in opposite direction to the displacement from the equilibrium position **Or** acceleration/force is (always) towards the equilibrium/undisplaced/rest position <u>Example of calculation:</u> m a = - k x $a = -\frac{k}{m}x$	**(1)** **(1)**	**2**
(a)(ii)	See $a = -\omega^2 x$ Compare with $a = -\frac{k}{m}x$ to give $\omega^2 = \frac{k}{m}$ Substitute for ω using $\omega = \frac{2\pi}{T}$ <u>Example of calculation:</u> $a = -\omega^2 x$ and $a = -\frac{k}{m}x$ $\omega^2 = \frac{k}{m}$ and $\omega = \frac{2\pi}{T}$ $\left(\frac{2\pi}{T}\right)^2 = \frac{k}{m} \quad \therefore T = 2\pi\sqrt{\frac{m}{k}}$	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ Use of $f = \frac{1}{T}$ f = 0.59 Hz <u>Example of calculation:</u> $T = 2\pi\sqrt{\frac{3.5\times10^5\ \text{kg}}{4.8\times16^6\ \text{N m}^{-1}}} = 1.7\ \text{s}$ $f = \frac{1}{T} = \frac{1}{1.7\ \text{s}} = 0.588\ \text{Hz}$	**(1)** **(1)** **(1)**	**3**

(b)(ii)	Correct shape Single sharp peak With the peak labelled at 0.6 Hz 	(1) (1) (1)	3
(b)(iii)	(Max) amplitude of oscillation is reduced as energy is transferred from the mass-spring system and then dissipated (in the surroundings)	(1) (1) (1)	3
	Total for question		**14**