WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 1

PHYSICS



EXAM QUESTION PACK

1.6 VIBRATIONS

SCORE	PERCENTAGE
/107	%

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#1

10. A silver ring on a light rod swings as a pendulum with damped simple harmonic motion. The damping is caused by a stationary magnet as shown in the diagram.



(a) Explain why the motion of the pendulum is damped. [4]

(b) Explain what, if anything, would happen to the motion of the pendulum if the bar magnet were reversed. [2]

(c) The resistivity of silver is $1.59 \times 10^{-8}\,\Omega m$, the radius of the silver ring is 2.5 cm and the cross-sectional area of the silver wire of the ring is $2.4 \times 10^{-5}\,m^2$. Show clearly that the resistance of the silver ring is approximately $0.1 \times 10^{-3}\,\Omega$. [2]

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(d) The maximum current induced in the silver ring is 5.5 A. Calculate the maximum rate at which the magnetic flux density inside the ring changes. [3]

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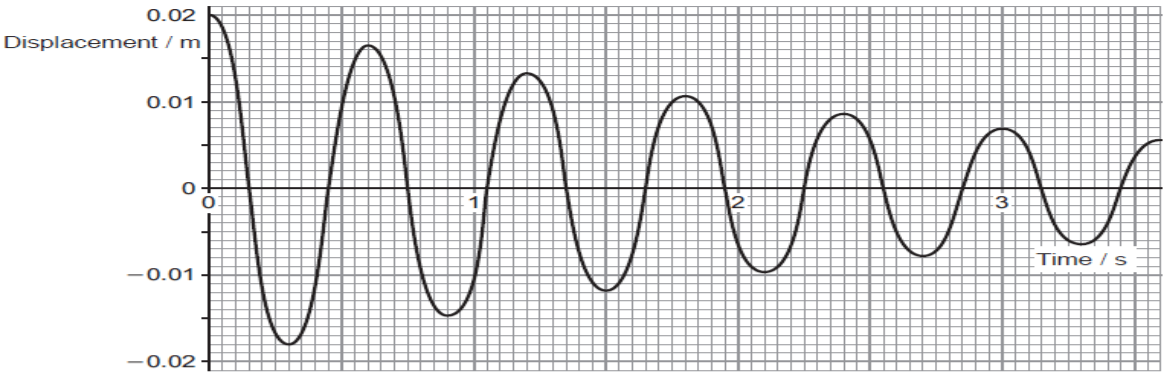
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Question taken from Eduqas examination paper 842103, June 2018

#2

A metal sphere of mass 0.200 kg, hanging from a light spring of stiffness k = 22.0 N m^{-1}, is set oscillating up and down about its equilibrium position. A datalogger records the sphere's position and plots the graph shown below.



(a) State what feature of the graph shows that the sphere's oscillations are damped and identify the force responsible for this feature. [2]

(b) Evaluate whether or not ordinary simple harmonic motion theory predicts the actual periodic time as shown on the graph convincingly. [4]

(c) **Mark with a small circle** the point on the graph where the sphere's speed is the greatest. Use shm theory to calculate a value for this speed **and** explain whether this value is likely to be too high or too low. [4]

(d) The amplitude, A, (in m) of the oscillations at time t is given by the equation:

$$A = 0.020\, e^{-\lambda t}$$

Determine the value of λ. [2]

Question taken from Eduqas examination paper 842101, June 2017

#3

5. *(a)* Rachel investigates a simple pendulum consisting of a small metal sphere suspended by a thread. She determines its period to be 2.40 s.

(i) Calculate the length of the pendulum. [2]

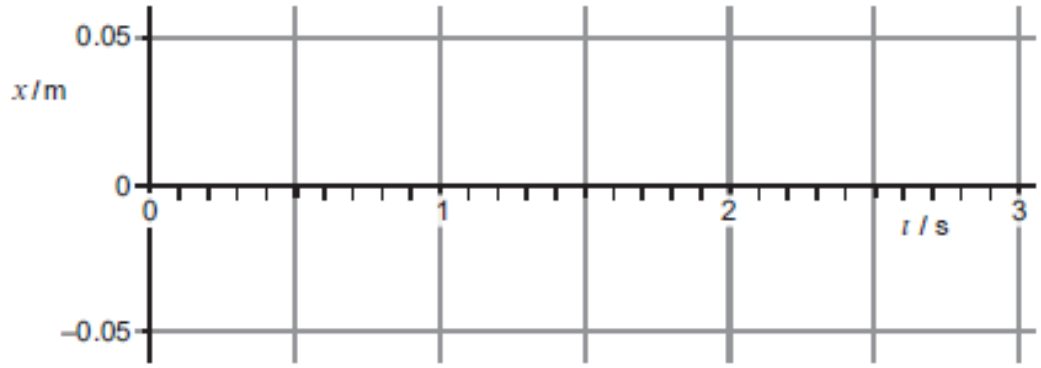
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(ii) Rachel now displaces the sphere by 0.050 m to one side of its equilibrium position and releases it at time $t = 0$.



I. Sketch a graph of displacement, x, against time, t, for the sphere between $t = 0$ and $t = 3.00$ s **on the grid provided**. Take the initial value of x to be positive. [2]

II. Use an appropriate equation to calculate the sphere's displacement at $t = 1.60$ s. [2]

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III. Calculate the sphere's velocity at $t = 1.60$ s. [2]

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IV. State the next time at which the sphere has the same velocity. [1]

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(b) Explain what is meant by *resonance*, and how its effects can be reduced in a particular case where resonance should be avoided. [6 QER]

Question taken from Eduqas examination paper 842101, June 2018

#4

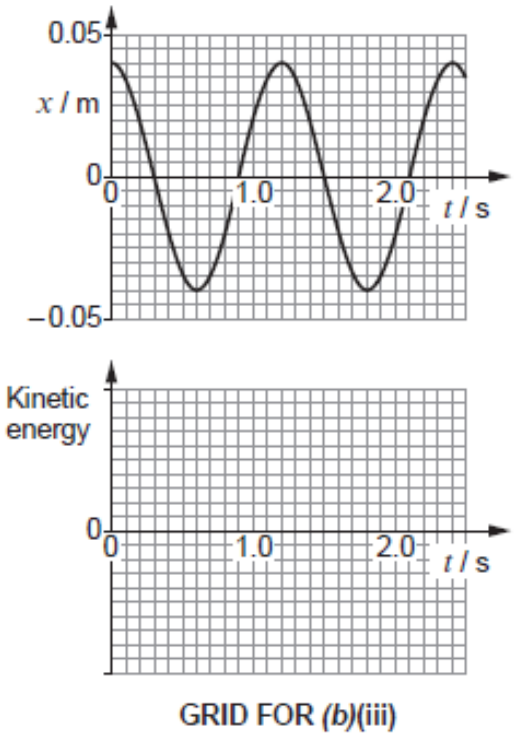
5. *(a)* Define *simple harmonic motion.* [2]

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(b) A metal sphere of mass 0.175 kg hangs from a spring whose top end is clamped. The sphere is set oscillating up and down, and a displacement-time graph is plotted.



GRID FOR *(b)*(iii)

(i) Calculate the stiffness constant, k, of the spring. [3]

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(ii) Calculate the maximum kinetic energy of the sphere. [3]

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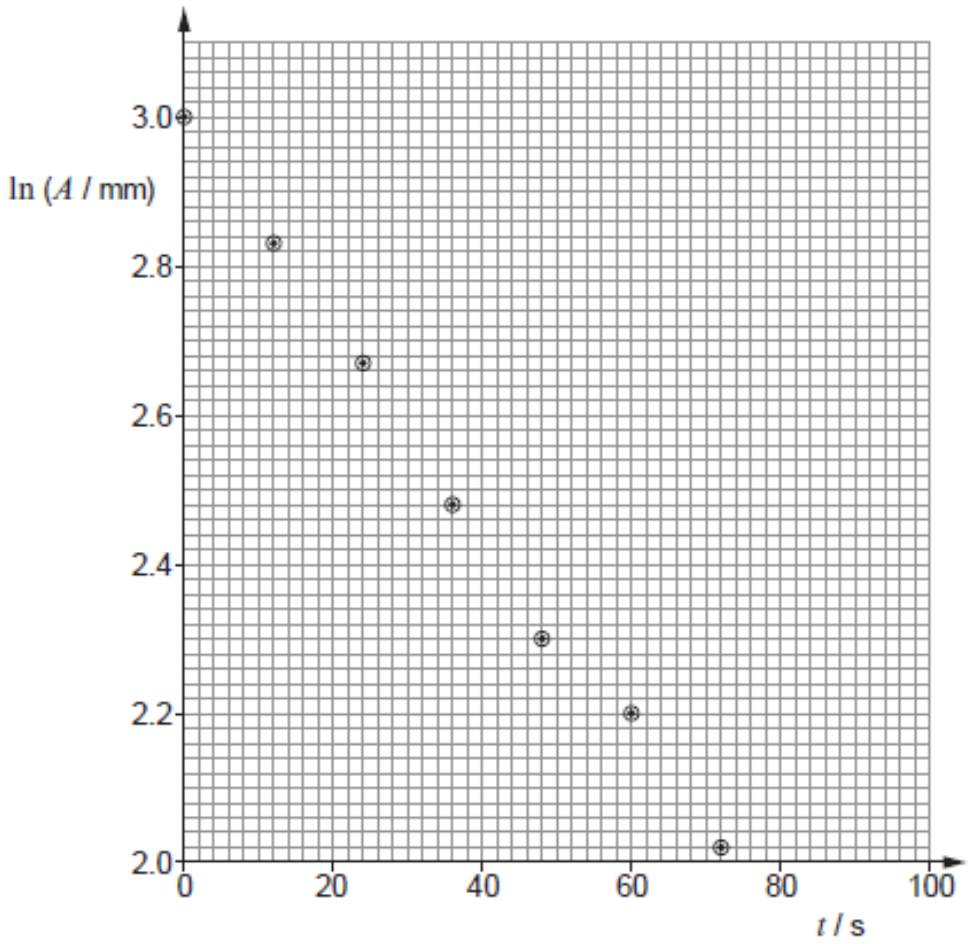
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(iii) Carefully sketch a graph of the sphere's kinetic energy against time **on the axes provided on the opposite page**. A vertical scale is **not** needed. [3]

(c) Over several oscillations it is clear that the amplitude of the sphere's motion is decreasing. Evgeniya suspects that the amplitude is decreasing exponentially, according to the equation:

$$A = A_0 e^{-\lambda t}$$

To check this idea she uses readings of the amplitude, A, taken at regular intervals to plot $\ln (A / \text{mm})$ against time, t.



Evgeniya claims that the points she has plotted support the exponential decrease of amplitude. Justify her claim **and** determine a value for λ. [5]

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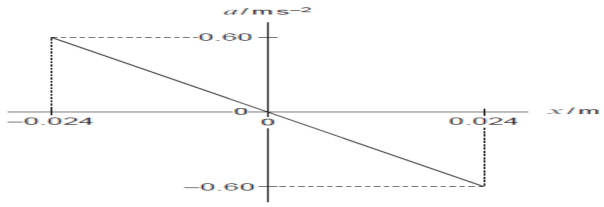
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Question taken from Eduqas examination paper 842101, June 2019

#5

(a) The acceleration, a, of a body is plotted against its displacement, x, from a fixed point.

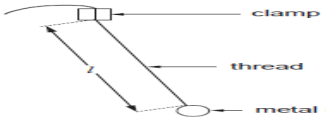


(i) State the features of the **graph** that show the body is performing *simple harmonic motion*. [2]

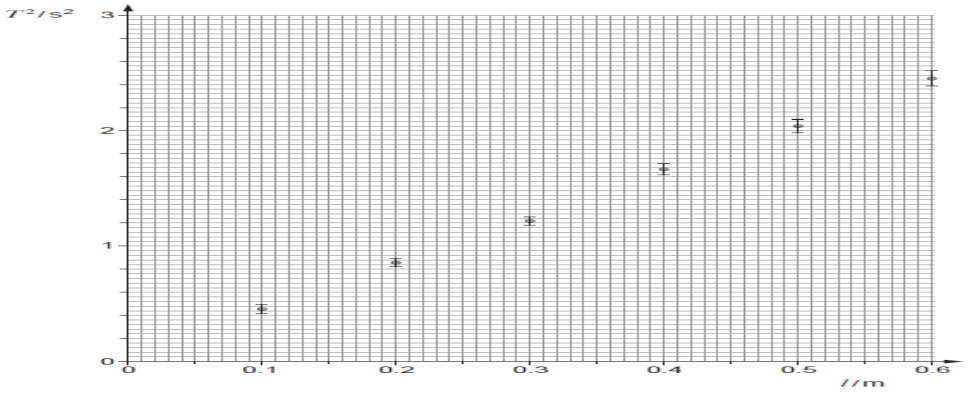
(ii) Determine the *amplitude* of the motion. [1]

(iii) Calculate the *periodic time* of the motion. [3]

(b) Charlotte performed an experiment to determine the acceleration due to gravity, g, using a simple pendulum.



Using a metre ruler she measured the length, l, shown in the diagram. She then recorded the time for 10 small amplitude oscillations, repeated the timing and calculated values for the mean periodic time, T, and its uncertainty. She repeated the procedure for another five values of l. She plotted her values of T^2 against l on the following grid.



(i) State why you would not expect the line of best fit to pass exactly through the origin. [1]

(ii) Determine a value for the acceleration due to gravity, g, together with its **percentage** uncertainty. Give your reasoning clearly. [6]

(c) A tennis ball attached by a **spring** to a fixed point is displaced vertically from its equilibrium position and released. It performs *damped oscillations*.

(i) What observed feature of the oscillations shows them to be damped? [1]

(ii) Explain in terms of *forces* how the damping comes about. [2]

(d) Explain what is meant by *critical damping*, **and** state one application of critical damping (or of damping that is close to critical). [3]

Question taken from Eduqas examination paper 842101, November 2020

#6

Two students, Simon and Natalie are investigating the mechanical properties of a steel wire of length 2.5 m and cross-sectional area 1.0 mm^2.

(a) They are given the following information.
[Young modulus, $E_{steel} = 2.0 \times 10^{11}\,N\,m^{-2}$, Stress, σ_{steel} (at elastic limit) $= 1.0 \times 10^{8}\,N\,m^{-2}$].

(i) Show that the maximum extension possible for the wire without the elastic limit being exceeded is 1.25 mm. [2]

(ii) Simon believes that this maximum extension (1.25 mm) of the steel wire depends on the radius of the wire. Natalie disagrees. Discuss who is correct, explaining carefully how you arrive at your answer. [3]

(b) Natalie suspends a mass, m, from the wire vertically. The wire can be considered to be weightless.

(i) Show that the force per unit extension, k, of the wire is 80 $kN\,m^{-1}$. [3]

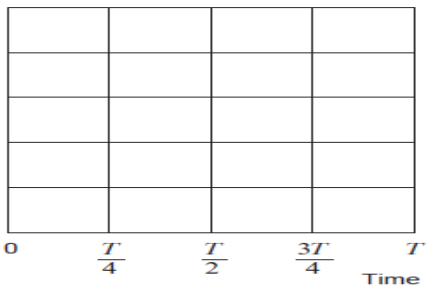
(ii) Determine the mass, m, that causes an equilibrium extension of 1.0 mm. [2]

(c) This mass is given a small downward displacement and released from rest. The mass oscillates with simple harmonic motion (SHM) **provided that the maximum extension of the wire never exceeds the elastic limit**.

(i) Calculate the period of this oscillation. [2]

(ii) Calculate the maximum possible velocity of the mass, m. [3]

(iii) Assuming the mass is released when the wire is at maximum extension without exceeding the elastic limit, sketch a graph showing how the stress in the wire varies with time **for one complete oscillation** from the moment of release of the mass. Indicate appropriate numerical values on the stress axis of your graph.
Space for calculations. [4]



Question taken from Eduqas examination paper 842102, November 2020

Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
10	(a)		Flux changes in ring as it approaches [or recedes from] magnet (1) Emf induced (1) [or by implication by next marking point] Current induced (complete circuit) (1) [Motor effect force] opposes motion or energy lost or Lenz's law stated(1)		4		4		
	(b)		Nothing [or equiv](1) Always opposes motion (Lenz) / field in opposite direction / current in opposite [not: the force opposite] (1)		2		2		
	(c)		Length = $2\pi r$ used (1) [0.157 m] $R = \frac{1.59\times10^{-8}\times2\pi\times0.025}{2.4\times10^{-6}}$ seen (or 1.04×10^{-4} [Ω] seen) (1)	1	1		2	1	
	(d)		Ohm's law used (1) $\text{Emf} = \frac{BNA}{t}$ i.e. Faraday's used (1) [= 0.55 mV] [NB c.s.a of wire used → no credit and no ecf] Answer, $\frac{B}{t}$ = 0.29 T s^{-1} (or 0.28 depending on rounding)(1)	1	1 1		3	2	
			Question 10 total	**2**	**9**	**0**	**11**	**3**	**0**

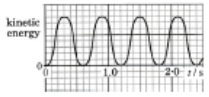
#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Falling amplitude (1) [Air] resistance **or** dissipative forces **or** equivalent (1)	2			2		
	(b)		$T = 2\pi\sqrt{\frac{0.200}{22.0}}$ [s] (1) = 0.599 [s] (1) T read from graph = 0.60 [s] (1) Prediction convincing [no significant difference] (1)			4	4	2	
	(c)		Point at 0.15 s marked – no tolerance (first displacement zero) (1) $v_{max} = 0.020 \times \frac{2\pi}{0.60}$ [m s^{-1}] (1) = 0.21 m s^{-1} **UNIT** (1) Too large owing to energy dissipation in first quarter cycle (1) **Accept** less detailed reason, such as 'because of damping' **Alternative for last 3 marks:** $v_{max} = 0.018 \times \frac{2\pi}{0.60}$ [m s^{-1}] (1) = 0.19 m s^{-1} **UNIT** (1) Too small because amplitude has fallen or equivalent (1) **Alternative for last 3 marks (mean found):** $v_{max} = 0.019 \times \frac{2\pi}{0.60}$ [m s^{-1}] (2) = 0.20 m s^{-1} **UNIT** (1) no comment required	1	1 1 1		4	2	
	(d)		Data from one maximum or minimum on the graph (other than at t = 0) substituted into the given equation or equivalent accept slips (1) λ = 0.35 [s^{-1}] [±0.03 s^{-1}] (1)		2		2	1	
			Question total	**3**	**5**	**4**	**12**	**5**	**0**

#3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)		Correct substitution of data (1) $\ell = 1.43$ m (1)	1	1		2	2	2
		(ii)	I	Recognisable cosine graph of amplitude 0.050 m (1) Zeros at approximately 0.6 s, 1.8 s, 3.0 s, that is correct period [even if –cosine graph] (1)		2		2	1	2
			II	x [/m] $= 0.050 \cos 2\pi\frac{1.6}{2.4}$ or equivalent or by implication (1) $x = -0.025$ m (1) If no working given, 0 marks for any incorrect answer (e.g. –0.24 m)		2		2	2	2
			III	v [/m s^{-1}] $= -0.050 \times \frac{2\pi}{2.4} \sin 2\pi\frac{1.6}{2.4}$ or equivalent (1) $v = 0.11$ m s^{-1} (1) For tangent method on sketch graph, award the second mark for 0.11 ± 0.03 m s^{-1}		2		2	2	2
			IV	2.0 s		1		1		1
	(b)			**A: Meaning of resonance** A1 Term applies to forced oscillations. A2 Forced oscillations occur when a system is subjected to a periodic driving force. A3 Resonance occurs at a particular frequency of driving force… A4 .. which is the same frequency as the system's natural frequency A5 At resonance the amplitude of the oscillations is a maximum [for a given amplitude of driving force]. **B: How effects can be lessened** B1 System mentioned where resonance is a nuisance (e.g suspension bridge). B2 A little information given about the oscillations and/or the driving force for this system. B3 Increasing the damping will lessen the amplitude of the oscillations. B4 Making sure the forcing frequency avoids the system's natural frequency (e.g. by shifting system's natural frequency) will also lessen amplitude	6			6		
				5-6 marks **Expect**: A2 + A4 + A5, B1 + B2 + (B3 or B4) There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** **Expect**: (A1 or A2) + (A3 or A4) + A5 B1 + (B3 or B4) There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** **Expect** 3 points with at least 1 point made from each of A and B. There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. **0 marks** No attempt made or no response worthy of credit.						
				Question 5 total	**7**	**8**	**0**	**15**	**7**	**9**

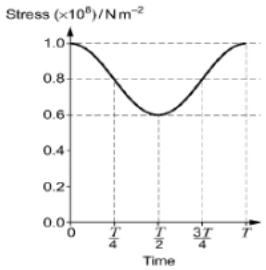
#4

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			[Motion such that] acceleration proportional to displacement from a fixed point [1] but in opposite direction or directed towards that point [1] **or** $a = -\omega^2 x$ with a = acceleration and x = displacement [1] ω [or ω^2] constant [1]	2			2		
	(b)	(i)		T = 1.2[0] s (from graph) or by implication [1] Correct re-arrangement $k = \frac{4\pi^2 m}{T^2}$ at any stage **or by impl.** [1] k = 4.80 N m^{-1} **unit mark** [1]		3		3	2	
		(ii)		Correct use of $v_{max} = A\omega$ [= 0.209 m s^{-1}] **or by implic** [1] Correct use of $E_k = \frac{1}{2}mv^2$ **ecf** on slips in v_{max} [1] $E_{k\,max}$ = 3.8 × 10^{-3} J [1]	1 1	1		3	2	
		(iii)		 Zeros at t = 0, 0.6 s, 1.2 s, 1.8 s, 2.4 s [1] KE never negative with equal peaks [1] Smooth (sinusoidal) curve [1]	1 1	1		3	2	
	(c)			Reasonable straight line of best fit drawn [1] Straight line expected as equation equivalent to $\ln A = \ln A_0 - \lambda t$ [1] Some comment about scatter of points – either supporting or casting doubt on straight line [1] λ = –gradient **or by impl.** [1] Gradient calculated correctly e.g. 0.014 [s^{-1}] No *second* penalty for mishandling minus sign [1]			5	5	3	5
				Question 5 total	**6**	**5**	**5**	**16**	**9**	**5**

#5

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Straight line through origin [1] Negative gradient [1] [1 mark for a whole answer like "Acceleration proportional to negative displacement" i.e. without referring to graph]	2			2		
		(ii)		0.024 [m]	1			1		
		(iii)		$\omega^2 = \frac{0.60}{0.024}$ [= 25 s^{-2}] [1] $T = \frac{2\pi}{5\ [s^{-1}]}$ **ecf on** ω^2 [1] T = 1.26 [s] **no ecf** [1]		3		3	3	
	(b)	(i)		No. l not measured to centre of sphere.			1	1		1
		(ii)		Graph gradient = $\frac{4\pi^2}{g}$ or equivalent [1] Correct division sum set up to calculate gradient from graph [1] Max gradient between 4.0 and 4.2 [s^2 m^{-1}] [1] Min gradient between 3.7 and 3.9 [s^2 m^{-1}] [1] g = 9.9 m s^{-2} **ecf** on mean gradient [1] Uncertainty 5 % **ecf** on max and min gradients [1]			6	6	4	6
	(c)	(i)		Decreasing amplitude (or equivalent)	1			1		
		(ii)		Resistive or dissipative forces (or equivalent incl air res) [1] [Always] oppose motion **or** transfer energy from system/ball [1]	2			2		
	(d)			Body, displaced and released, returns to equilibrium without oscillating **or** without overshoot [1] Resistive force just large enough for this (or equiv) [1] Car suspensions (or other plausible example) Accept bridges [1]	3			3		
				Question total	**9**	**3**	**7**	**19**	**7**	**7**

#6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Substitution and re-arrange e.g. $\Delta x_{max} = \frac{(1.0 \times 10^8 \times 2.5)}{2.0 \times 10^{11}}$ [1] $\Delta x_{max} = 1.25 \times 10^{-3}$ m or 1.25 mm [1] Accept use of 1.25 mm to show $E_{steel} = 2.0 \times 10^{11}$ [N m^{-2}]		2		2	2	
		(ii)		Stress required to reach elastic limit will remain constant irrespective of radius e.g. If radius is doubled the tension is increased by factor 4 [1] Δx_{max} (of this wire) will be the same (depends only on stress) [1] Δx_{max} does not depend on the radius, Natalie correct (or Simon incorrect) [1]			3	3		
	(b)	(i)		Re-arrangement and substitute: $F = \frac{EA\Delta x}{l}$ i.e. $F = \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-6} \Delta x}{2.5}$ [1] $F = k\Delta x$ seen or implied [1] Correct algebra to show $k = 8 \times 10^4$ [N m^{-1}] [1] **Alternative:** At elastic limit $k = \frac{100}{1.25 \times 10^{-3}}$ (= 80 kN m^{-2}) - award 3 marks		3		3	3	
		(ii)		$mg = k\Delta x$ seen or implied [1] $m = \frac{8.0 \times 10^4 \times 1 \times 10^{-3}}{9.81}$ m = 8.2 k[g] [1]		2		2	1	
	(c)	(i)		Substitution into $T = 2\pi\sqrt{\frac{m}{k}}$ [1] (**ecf** on m) T = 0.06[3 s] [1]	1	1		2	2	
		(ii)		Elastic limit must not be exceeded, so max possible displacement = 1.25 mm – 1.0 mm = 0.25 [mm] [1] Substitution into $v_{max} = A\omega$ or equivalent: e.g. $v_{max} = 0.25 \times 10^{-3} \times \frac{2\pi}{0.06}$ [1] (**ecf** on T and Δx_{max}) v_{max} = 0.026 [m s^{-1}] [1]	1	1 1		3	2	
		(iii)		Stress in equilibrium position calculated or seen on graph i.e. $= \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-3}}{2.5}$ (= 0.8 × 10^8 N m^{-2}) [1] Appropriate stress scale e.g. as shown or in steps of 0.2 × 10^8 N m^{-2} [1] Correct general shape with no reference to time/ stress scales [1] Correct shape and stress and timings [1]  		4		4	2	
				Question total	**2**	**14**	**3**	**19**	**12**	**0**