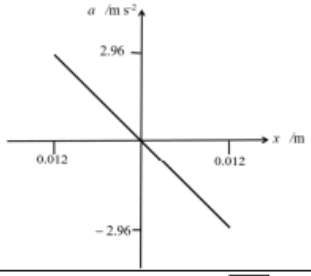
Marking Scheme

#1

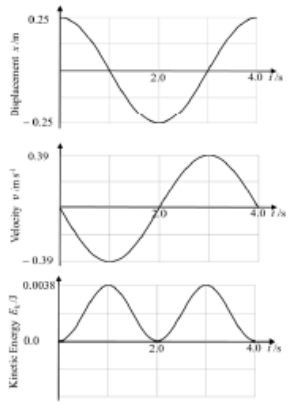
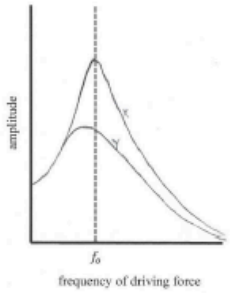
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4			**Measurement:** Diagram to assist answer Measure length of string Measure time for several oscillations Use of fiducial point Repeat for each length Repeat for several lengths of string **Analysis and theory:** Small angle / amplitude Use of $T = 2\pi\sqrt{\frac{l}{g}}$ Plot T^2 vs l **or** T vs $\sqrt{l}$ Is a straight line [through the origin] Gradient is $\frac{4\pi^2}{g}$ or $\frac{2\pi}{\sqrt{g}}$ respectively Use the gradient or points to calculate g	6			6		6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Comprehensive description of both the method and the analysis. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either the method or the analysis **or** limited description of both areas provided. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either the method or the analysis provided. *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 4 total	**6**	**0**	**0**	**6**	**0**	**6**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		a = acceleration ω = angular velocity or angular frequency or pulsatance x = displacement **All 3 correct** (1)	1			1		
	(b)	(i)	$\omega = \frac{2\pi}{0.4}$ (1) [= 15.7 s^{-1}] $a_{max} = \omega^2 A = (15.7)^2 \times 0.012$ (1) = 2.96 [m s^{-2}] (1)	1	 1 1		 3	 2	
		(ii)	 One value of a on graph (1) **ecf** from *(b)*(i) Any straight line (1) Correct position of line (1)		3		3	2	
	(c)		$x =$ [0.012] cos([15.7] $t +$ [$\frac{3\pi}{2}$]) (1 × 3 – one mark for each box) (alternative for angle: $-\frac{\pi}{2}$) Accept 5π for 15.7. **ecf** on ω		3		3	1	
	(d)	(i)	Example e.g. microwave ovens **or** swing (1) Oscillator and driving force named e.g. water molecules and microwaves **or** swing and person pushing (1)	2			2		
		(ii)	Example and consequence e.g. bridge and falling **or** something in the dashboard and buzzing (1) Driving force e.g. wind / soldiers marching **or** engine (1) Resonance explained i.e. both frequencies are the same (1)	3			3		
			Question 3 total	**7**	**8**	**0**	**15**	**5**	**0**

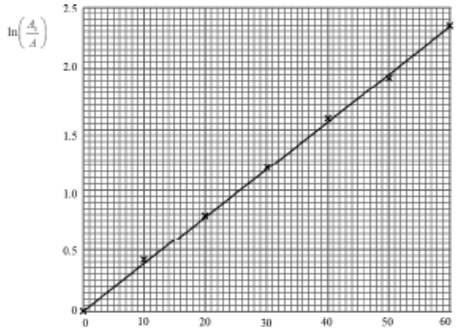
#3

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)	$T = 2\pi\sqrt{\frac{l}{g}}$ $\omega = \frac{2\pi}{T} = \sqrt{\frac{g}{l}}$ combining formulae (1) $= \sqrt{\frac{9.81}{4.0}}$ $= 1.57\ \text{rad s}^{-1}$ (1) convincing		2		2	2	
		(ii)	$v_{max} = \omega A$ (1) v_{max} [$= 1.57 \times 0.25$] $= 0.39\ \text{m s}^{-1}$ (1)		2		2	1	
		(iii)	$E_k = \frac{1}{2}mv^2$ and $v = (-)A\omega\sin\omega t$ / $v = (-)0.39\sin 1.57t$ (1) $E_k = \frac{1}{2} \times 0.05 \times (0.39)^2 \sin^2 1.57t$ (1) $= 3.8 \times 10^{-3} \sin^2 1.57t$ [convincing]	1	1		2	1	
		(iv)	 Phase of the velocity graph (1) Period of the kinetic energy graph (1) Kinetic energy curve always ≥ 0 with shape and phase (1) Values on the axes of both graphs (1)		4		4	2	
		(v)	$mgh = 3.8 \times 10^{-3}$ J ecf (1) $h = \frac{3.8 \times 10^{-3}}{0.05 \times 9.81} = 0.008$ m (1) (= 8 mm) Or: using trig: 4 – 4 cos (0.25/4) (1) = 8 mm (1)		2		2	2	
	(b)	(i)	 Sensible curve [X] with label [accept curve to the origin]	1			1		
		(ii)	Resonance	1			1		
		(iii)	Sensible curve with label (see part (b) (i) [cannot cross X – always below, can co-incide at low frequencies] (1) Lower maximum amplitude at the same frequency or to left of maximum of curve **X** (1)	2			2		
			Question 7 total	**5**	**11**	**0**	**16**	**8**	**0**

#4

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		T tension in the string **and** mg weight of mass (gravitational force or gravity)	1			1		
		(ii)		T does not have a component tangential to the arc (1) Component of mg tangential to the arc is $mg\sin\theta$, (1) this is in the opposite direction to s (or θ) **and** so the negative sign (1)		3		3	1	
		(iii)		acceleration $= \frac{-mg\sin\theta}{m} = -g\sin\theta$ $= -g\theta$ (1)(using the approximation) $\theta = \frac{s}{l}$ or $\sin\theta = \frac{s}{l}(1) = -\frac{gs}{l}$		2		2	2	
		(iv)		Acceleration $\propto \theta$ (or s) measured [from a fixed position] (1) and opposite in direction (-ve) so SHM (1)			2	2		
	(b)	(i)	I	Substitution: $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{1.2}{9.81}}$ (1) $= 2.20$ [s] (1)	1	1		2	2	
			II	$f = \frac{1}{T} = 0.45[5]$ [H]z **ecf** (1)		1		1	1	
		(ii)		For maximum distance along the arc $\theta_{max} = 0.067$, also $\sin\theta_{max} = 0.067$ As $\theta_{max} = \sin\theta_{max}$ (i.e. for the largest value of θ) (1) then $\sin\theta$ is equal to θ for all θ, and approximation holds for SHM. System oscillates with SHM (1)			2	2	1	
				Question total	**2**	**7**	**4**	**13**	**7**	**0**

#5

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)	$kx = mg$ (1) $x = \frac{0.150 \times 9.81}{7.5}$ = 0.196 m answer (1)		2		2	2	2
		(ii)	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.150}{7.5}}$ substitution (1) = 0.889 s (1) NB. No credit for use of $T = 2\pi\sqrt{\frac{l}{g}}$	1	1		2	2	2
	(b)		Drop in amplitude at beginning and end compared, e.g. 0.033 m and 0.005 m over first and last intervals. [Or rates of decrease: 0.0033 m per oscillation and 0.0005 m per oscillation] consider rate of decrease (1)] Justify by noting the magnitude is larger at the start than at end of experiment. (1)			2	2		2
	(c)	(i)	When $n = 0$, $A = A_0 e^{-\frac{0}{N}} = A_0 e^0 = A_0$ [Alternative: say $e^0 = 1$, so $A = A_0$.]			1	1	1	1
		(ii)	$A = A_0 e^{-\frac{n}{N}}$; $0.029 = 0.095 e^{-\frac{30}{N}}$ substitution (1) $N = \frac{-30}{\ln\left(\frac{0.029}{0.095}\right)}$ or equiv → N =25.28 ≅ 25 answer (1)	1	1		2	2	2
	(d)	(i)	<table><tr><th>Oscillation number (n)</th><th>Amplitude (A) /m</th><th></th></tr><tr><td>0</td><td>0.095</td><td>0</td></tr><tr><td>10</td><td>0.062</td><td>0.43</td></tr><tr><td>20</td><td>0.043</td><td>0.79</td></tr><tr><td>30</td><td>0.029</td><td>1.19</td></tr><tr><td>40</td><td>0.019</td><td>1.61</td></tr><tr><td>50</td><td>0.014</td><td>1.91</td></tr><tr><td>60</td><td>0.009</td><td>2.36</td></tr></table>All three values correct (1) [accept 1.6, 1.9, 2.4 if consistent]		1		1	1	1
		(ii)	 Labelled axes with a suitable choice of scales (1) All points plotted correctly including origin (1) (ecf) Appropriate line of best fit [not necessarily through origin] ecf (1)	1	1 1		3	3	3
		(iii)	Any two of: 1) It is a straight line, or positive gradient (1) 2) Passes through the origin (1) 3) The measured points lie essentially on a straight line or little scatter(1)			2	2		2
		(iv)	Gradient = $\frac{2.35 - 0}{60 - 0}$ (from graph) = 0.039 ecf (1) $N = \frac{1}{\text{gradient}}$ (1) = 25.6 (1) Accept answers in range 25 – 26. Use of a point on the line – allow. Use of a data point not on the line → 1st mark not available.			3	3	3	3
		(v)	Expected to be the one from *(d)*(iv) as straight line based on all points [The value in *(c)*(ii) is calculated from only a single point, which may be anomalous.]			1	1		1
			Question 6 total	**3**	**7**	**9**	**19**	**14**	**19**