A Level OCR Physics

Chapter 17 Oscillations

Question	Answers	Extra information	Mark	AO	Spec reference
1 (a) (i)	Period = 4.8 s/3 = 1.6 s $f = 1/T$ = 1/1.6 s = 0.625 = 0.63 Hz	Evidence of use of graph to find T Frequency	1 1	2	5.3.1
(ii)	Maximum velocity = $\omega A = 2\pi fA$ = 2 × π × 0.63 × 0.02 = 0.0786 m s^{-1} = 0.079 m s^{-1}	Evidence of use of frequency	1 1	1 2	5.3.1
(b)	Find the maximum gradient / gradient at $x = 0$		1	1	5.3.1
(c)	Sinusoidal/same number of waves / frequency / periodic time Inverted / a negative cosine graph Maximum acceleration = $\omega^2 A = (2\pi f)^2 A/$ = 0.308 m s^{-2} = 0.31 m s^{-2}		1 1 1	2	5.3.1
(d)	Condition for SHM is that $a \propto -x$ So the graph of a is the same shape as that of x, but inverted		1	1	5.3.1
2 (a) (i)	Strategy: States that readings of T (as the dependent variable) will be measured for different values of independent variable, wire diameter, d. Clearly identifies at least 2 correct control variables, e.g. length/number of coils on spring, mass Make springs using wire of different diameters and measure the time period Repeat measurements, omit outliers, find mean	Identifies dependent, independent and 2 control variables Change d, measure T Repeat, take mean How to deal with outliers	1 1 1 1	1	5.3.1
(ii)	Measure the time for 10 oscillations and divide the time by 10	Allow other multiples of T	1	1	5.3.1

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(b)	Plausible reason e.g. the length of wire is the same so the volume/mass of the wire will vary with the area of the wire, which is proportional to d^2.		1	3	5.3.1
(c)	Use the time period and mass to find the k: $T = 2\pi\sqrt{\frac{m}{k}}$ $k = \left(\frac{2\pi}{T}\right)^2 m$ Plot a graph of k (y-axis) against d^2 (x-axis), and if it is a straight line through the origin then the hypothesis is correct.	Evidence of use of equation to find k Correct axes identified Allow graph of T^{-2} vs. d^2	1 1	2	
3 (a)	$T = 2\pi\sqrt{\frac{m}{k}}$ Plot a graph of T against $\sqrt{\frac{1}{k}}$: the gradient = $2\pi\sqrt{m}$ Or Plot T^2 against $1/k$: gradient = $4\pi^2 m$ You need to collect values of time period and spring constant. Change k, measure time period, use at least 6 different springs Displace the trolley and measure the time for many oscillations with a stop clock, e.g. 5 and divide by 5 to find each time period Repeat measurements and find the average time period for each value of k.	Correctly identifies variables to plot, and how gradient relates to mass Indication of range of independent variable Accurate measurement of time Repeat measurements	1 1 1 1	1	5.3.1
(b)	Use the full reading on the stopwatch (to hundredths of a second) in measurements and calculation of the mean. Round up to one decimal place, and use uncertainty in using the	Use of full display on stopwatch until the calculation of final value.	1	1	5.3.1

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	stopwatch = ± 0.2 s due to reaction time for both starting and stopping the stopwatch Giving a total uncertainty of ± 0.4 s	Estimation of reaction time Total uncertainty is double the reaction time	1 1		
(c)	Suitable method: Set up the light gate so that it is horizontal, and triggered by the mass when it goes through its equilibrium position. Attach a straw/light rod to the mass that breaks the beam as the mass goes through its equilibrium position. The measurement of T will be double the time measured by the light gate	Suitable practical arrangement Measurement of T that is accurate for the arrangement.	1 1	1	5.3.1
(d)	Each spring produces a restoring force of $-kx$, so the total restoring force = $-2kx$ $ma = -2kx$ compared to $ma = -kx$ so $\omega^2 = \frac{2k}{m}$, ω increases by $\sqrt{2}$ $T = \frac{2\pi}{\omega}$ so T is reduced by $\sqrt{2}$	Analysis to produce double the restoring force Use of $a = \omega^2 x$ Answer	1 1 1	2	5.3.1
4 (a) (i)	For each length: Allow the pendulum to swing 3 times (or more) Take the times recorded by the light gate and double them to find the time period Find the mean of all of the measurements.		1 1 1	1	5.3.1
(ii)	x-axis length, y-axis T^2 Line of best fit through (0, 0),	Both labels needed	1	2	5.3.1

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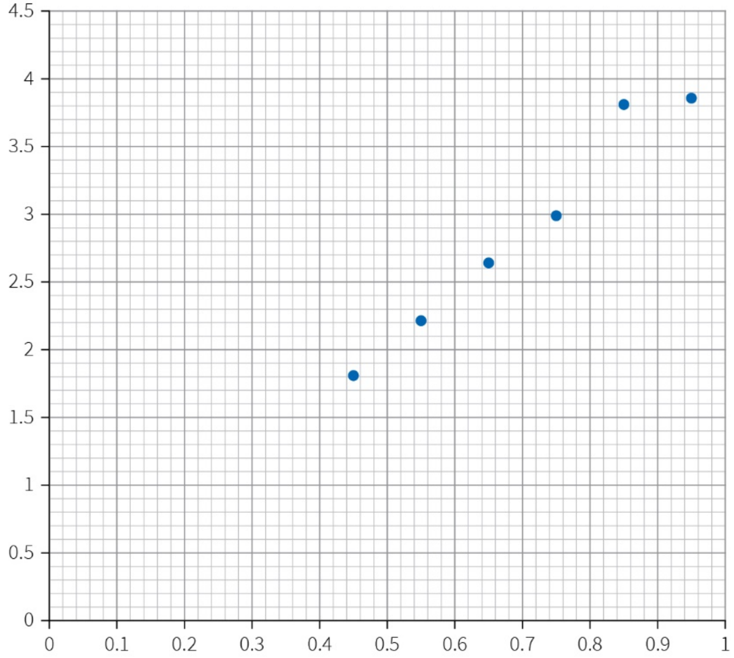

Line of best fit ignoring anomalous result, with gradient of 4.0 s^2 m^{-1}

$T = 2\pi\sqrt{\frac{l}{g}}$

$T^2 = 4\pi^2\frac{l}{g}$ so graph of T^2 vs l has a gradient of $\frac{4\pi^2}{g}$

$g = \frac{4\pi^2}{\text{gradient}} = \frac{4\pi^2}{4.0}$ = 9.9 (9.87) m s^{-2}
</td><td>Allow 3.9–4.1

Evidence of manipulation of equation

Allow 9.62–10.1</td><td>1

1

1</td><td></td><td></td></tr>
<tr><td>(iii)</td><td>Bigger – small angle approximation does not hold, bob may fall rather</td><td>Do not allow effect on g without</td><td>1</td><td>1</td><td>5.3.1</td></tr>
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Question	Answers	Extra information	Mark	AO	Spec reference
	than swing, time period will be shorter than it should, g will be smaller than it should Smaller – amplitude does not affect time period, g not affected	explanation	1		
(b)	Systematic error in measurement of length		1	1	5.3.1
5 (a) (i)	The angle through which the pendulum is displaced should be small so that you can use the small angle approximation So that $T = 2\pi\sqrt{\frac{l}{g}}$, which is independent of mass		1 1	1	5.3.1
(ii)	$x = A\cos\omega t$ $A = 4.3\times10^{-2}$ m, $\omega = \frac{2\pi}{T} = \frac{2\pi}{1.8} = 3.5$ rad s^{-1} $x = 4.3\times10^{-2}\cos(3.5\,t)$	Calculation of angular velocity Equation	1 1	2	5.3.1
(b) (i)	Maximum velocity = $\omega A = 3.5 \times 4.310^{-2} = 0.15$ m s^{-1} Maximum kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2}0.26\,(0.15)^2 = 2.9\times10^{-3}$ J Graph that is correct shape ($y = 1 - x^2$) Maximum labelled, x-axis from −3 cm to +3 cm	Calculation of maximum kinetic energy	1 1 1	2	5.3.2

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	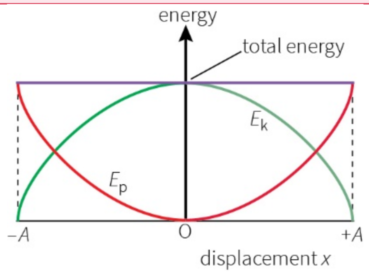				
(ii)	Assuming the total energy is constant, the potential energy against time graph is x^2 graph So that the k.e. + p.e. at any position = total energy Or Total energy = $\frac{1}{2}kA^2$ So p.e = total energy – k.e. $= \frac{1}{2}kA^2 - \frac{1}{2}mv^2$	Assumption description	1 1	1	5.3.2
(c)	The mass decreases, so kinetic energy decreases The line will not be symmetrical / the line will reach a lower value		1	2	5.3.2
6 (a)	Bathroom scales are compressed when you stand on them by an amount that is proportional to your weight/mass. In the ISS, both the scales and the astronaut are in free fall so the scales will not be compressed.		1 1	2	3.2.1 5.2.2
(b) (i)	The acceleration is proportional to the displacement, and in the opposite direction.		1	1	5.3.1
(ii)	$T = 2\pi\sqrt{\frac{m}{k}}$			2	5.3.1

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	$k = m\left(\frac{2\pi}{T}\right)^2$ $= 72.65\ kg\left(\frac{2\pi}{2.103}\right)^2$ $= 648.5\ \text{N m}^{-1}$		1 1		
(iii)	0.9 × 72.65 kg = 65.39 kg $T = 2\pi\sqrt{\frac{61.76\ \text{kg}}{648.5\ \text{N m}^{-1}}}$ $= 1.995\ \text{s} = 2.0\ \text{s}$ T is proportional to $\sqrt{m}$ so as mass decreases so does periodic time	Allow ecf from b) ii)	1 1 1	2	5.3.1
(iv)	Max displacement = amplitude which is proportion to energy Energy transferred to thermal store due to friction		1 1	3	5.3.1
(v)	No The mass depends on the time period, which is independent of amplitude		1 1	1	5.3.1
(c) (i)	The normal force between the outer edge of the station and the astronaut would ‘simulate’ gravity The normal force provides the centripetal force to keep the astronaut moving in a circle		2	3	5.2.2
(ii)	$g = v^2/r = 9.81\ \text{m s}^{-2}$ $v = \sqrt{9.81 \times 20}$ $= 14.0\ \text{m s}^{-1}$	Use of g to find v Or allow finding omega = 0.7 rad s^{-1}	1 1	3	5.2.2

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	$v = \frac{2\pi r}{T} = 2\pi r f$ $f = \frac{v}{2\pi} = \frac{14}{40\pi} = 0.11$ Hz Revolutions per minute (rpm) = 0.11 × 60 = 6.7 rpm	Correct value of f Correct rpm	1		
7 (a) (i)	The acceleration is proportional to the displacement, and in the opposite direction/so as to restore the object to its equilibrium position		1	1	5.3.1
(ii)	Volume of water displaced = Ax = 0.62 cm^2 × 1.5 cm = 0.93 cm^3 Mass of water = density of water × volume = 0.93 cm^3 × 1 g cm^{-3} = 0.93 g = 9.3×10^{-4} kg Weight = mg = 9.3×10^{-4} kg × 9.81 N kg^{-1} = 9.12×10^{-3} N	Correct use of equations for density and weight	1 1	2	3.2.4 3.2.1
(iii)	The restoring force is proportional the distance that the tube is displaced from its equilibrium position: $F = -Ag\rho.x$	Explanation of $F \propto x$	1	3	5.3.1
(iv)	Acceleration = F/m = 9.1×10^{-3} N/16×10^{-3} kg $a_{\max}$ = 0.57 m s^{-2} $a_{\max} = \omega^2 A$ $= (2\pi f)^2 A$ $f = \sqrt{\frac{a_{\max}}{A(2\pi)^2}}$	Calculation of acceleration Use of $a_{\max} = \omega^2 A$ Alternatively, use $a_{\max} = \omega^2 A$ to find ω, then use $T = 2\pi/\omega$ Answer	1 1 1	3	5.3.1

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	$f = \sqrt{\dfrac{0.57\ \text{ms}^{-1}}{0.015\ \text{m}(2\pi)^2}}$ f = 0.98(1) Hz $T = 1/f$ = 1/0.98 Hz = 1.02 s				
(b) (i)	Restoring force $F = -Ag\rho x$ $a = -\dfrac{\text{Area} \times g \times \text{density}}{\text{mass of tube}} . x$ $\omega^2 = \dfrac{\text{Area} \times g \times \text{density}}{\text{mass of tube}} = (2\pi f)^2 = \dfrac{(2\pi)^2}{T^2}$ density $\propto \dfrac{1}{T^2}$ A plot of density vs 1/period^2 is a straight line	Derivation of value of ω^2 Manipulation to show time period Answer	1 1 1	3	5.3.1
(ii)	A series circuit with an LDR and a fixed resistor A cell/ battery and a voltmeter across either the LDR or resistor		1 1	1	4.3.1
8 (a) (i)	$k = F/x$ = 750 N/2.5×10^{-2} mm = 30 000 N m^{-1}		1	2	3.4.1
(ii)	$f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}} = \dfrac{1}{2\pi}\sqrt{\dfrac{30\ 000}{1200}}$ = 0.080 Hz (0.796) $T = 1/f$ = 1/0.70 = 1.2(6) s.		1 1	2	5.3.1
(iii)	If the car goes over a bump/speed bump it will displace the car from its equilibrium position		1	3	5.3.3
(iv)	$T = 2\pi\sqrt{\dfrac{m}{k}}$	Appropriate plot Gradient that matches plot.	1 1	2	5.3.1

Question	Answers	Extra information	Mark	AO	Spec reference
	Either: plot T^2 vs m, gradient = $\frac{4\pi^2}{k}$ Or: plot T vs $\sqrt{m}$, gradient = $2\pi\sqrt{\frac{1}{k}}$				
(b)	The oscillations are heavily/critically damped		1	2	5.3.3
(c) (i)	The engine vibration causes the door to vibrate and reflected vibrations set up standing waves in the door with nodes/ antinodes Where there are nodes there is little/no deformation, where there are antinodes there is maximum deformation		1 1	3	4.4.4
(ii)	The distance between the nodes is half a wavelength $\lambda = 2 \times 0.22$ m = 0.44 m $v = f\lambda$ = 11 300 × 0.44 = 5000(4972) m s^{-1}	Calculation of wavelength Answer to 2 significant figures	1 1	2	4.4.4