Mark Scheme

Q1.

Question Number	Answer	Mark
	D is the correct answer A, B and C are incorrect because $T = \frac{2\pi}{\omega}$ and $\omega = \sqrt{\frac{a}{x}}$	**(1)**

Q2.

Question Number	Answer	Mark
	C is the correct answer A is incorrect as the frequency has been substituted for the period B is incorrect as period has been substituted for frequency and the half amplitude value used D incorrect as half amplitude has been substituted	**(1)**

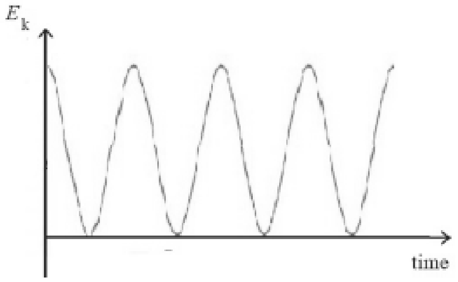
Q3.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as T is inversely proportional to the square root of k C is not the correct answer as T is inversely proportional to the square root of k D is not the correct answer as T is inversely proportional to the square root of k	**(1)**

Q4.

Question Number	Answer		Mark
(a)	(For simple harmonic motion the) acceleration is:		
	• (directly) proportional to <u>displacement</u> from equilibrium position	(1)	
	• acceleration is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position	(1)	
	OR		
	(For simple harmonic motion the resultant) force is:		
	• (directly) proportional to <u>displacement</u> from equilibrium position	(1)	
	• force is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position	(1)	2
	(An equation with symbols defined correctly is a valid response for both marks For equilibrium position accept: undisplaced point/position or fixed point/position or central point/position)		

(b)	Use of $F = k\Delta x$	(1)	
	Use of $T = 2\pi\sqrt{\frac{m}{k}}$	(1)	
	Use of $v_{max} = \omega A$ with $\omega = \frac{2\pi}{T}$	(1)	
	Use of $E_k = \frac{1}{2}mv^2$	(1)	
	$E_k = 9.1 \times 10^{-3}$ J	(1)	
	OR		
	Use of $F = k\Delta x$	(1)	
	Statement that E_k max = ΔE_{el}	(1)	
	Because energy is conserved	(1)	
	Use of $\Delta E_{el} = \frac{1}{2}F\Delta x$ with $F = k\Delta x$	(1)	
	$E_k = 9.1 \times 10^{-3}$ J	(1)	5
	<u>Example of calculation</u>		
	$k = \frac{F}{\Delta x} = \frac{0.25\text{ kg} \times 9.81\text{ N kg}^{-1}}{0.165\text{ m}} = 14.9\text{ N m}^{-1}$		
	$T = 2\pi\sqrt{\frac{0.25\text{ kg}}{14.9\text{ N m}^{-1}}} = 0.814\text{ s}$		
	$E_k = \frac{1}{2} \times 0.25\text{ kg} \times \left(\frac{2\pi \times 3.5 \times 10^{-2}\text{ m}}{0.814\text{ s}}\right)^2 = 9.13 \times 10^{-3}\text{J}$		

Question Number	Answer		Mark
(c)	Sinusoidal curve with twice the frequency of displacement graph	(1)	
	Always positive and maximum E_k at t = 0	(1)	2
	Example of graph  		
(d)	There would be viscous/drag forces on the mass as it moved through the water	(1)	
	This would remove energy (from the oscillation) **Or** this causes damping	(1)	
	The amplitude would decrease over time (dependent on MP2)	(1)	3
	Total for question		**12**

Q5.

Question Number	Answer	Mark
	C is the correct answer, as $l = \frac{T^2 g}{4\pi^2}$	**(1)**

Q6.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as T for the pendulum is 2.00 s not 1.00 s C is not the correct answer as incorrect value of T used and equation has not been correctly rearranged D is not the correct answer as equation has not been correctly rearranged	**(1)**

Q7.

Question Number	Answer		Mark
(a)	The natural frequency of the water molecule is about 10 GHz The microwave radiation frequency (2.45 GHz) is not at/about the natural frequency of the water molecule and so this is not resonance **Or** The driving frequency is not is not at/about the natural frequency of the water molecule and so this is not resonance	(1) (1)	2
(b)(i)	The (rotating) water molecules collide with other molecules (in the food) There is a transfer of kinetic energy to (adjacent) molecules (in the food) This increases the internal energy and hence the temperature of the food **Or** this increases the (average) kinetic energy (of the molecules) and hence the temperature of the food	(1) (1) (1)	3
(b)(ii)	Ice is a solid and so the molecules have fixed positions This prevents the molecules in the solid ice from rotating **Or** only molecules in liquid water around the ice can rotate	(1) (1)	2

Question Number	Answer		Mark
(c)(i)	Use of $\Delta E = mc\Delta\theta$ and use of $P = \frac{\Delta W}{\Delta t}$	(1)	
	Use of efficiency = $\frac{\text{useful power output}}{\text{power input}}$ **Or** Use of efficiency = $\frac{\text{useful energy output}}{\text{energy input}}$	(1)	
	Efficiency = 56 %, so the manufacturer's claim is invalid	(1)	3
	<u>Example of calculation</u> $P = \frac{0.325\text{ kg} \times 4190\text{ J kg}^{-1}\text{ K}^{-1} \times (85.0 - 25.0)\text{ °C}}{225\text{ s}} = 363\text{ W}$ $\text{efficiency} = \frac{363\text{ W}}{650\text{ W}} \times 100\ \% = 55.8\ \%$		
(c)(ii)	Energy transfer from water cooling = energy transfer to melt ice + energy transfer to heat ice	(1)	
	Use of $\Delta E = mc\Delta\theta$	(1)	
	Use of $\Delta E = mL$	(1)	
	$\theta = 59$ °C	(1)	4
	<u>Example of calculation</u> Energy transfer from water cooling = energy transfer to melt ice + energy transfer to heat ice $m_{\text{water}}\, c\, \Delta\theta_{\text{water}} = m_{\text{ice}}\, L + m_{\text{ice}}\, c\, \Delta\theta_{\text{ice}}$ $0.325\text{ kg} \times 4190\text{ J kg}^{-1}\text{K}^{-1}\,(85.0 - \theta)$ $= 0.0625\text{ kg} \times 3.33 \times 10^{5}\text{ J K}^{-1} + 0.0625\text{ kg} \times 4190\text{ J kg}^{-1}\text{ K}^{-1}(\theta - 0.0)$ $1362\,\theta + 262\,\theta = +1.16 \times 10^{5}\text{ J} - 2.08 \times 10^{4}\text{ J}$ $\therefore \theta = \frac{9.52 \times 10^{4}}{1620} = 58.8\text{ °C}$		
	Total for question		**14**

Q8.

Question Number	Answer		Mark
(a)	(The mass meets the conditions for simple harmonic motion as) There is a (resultant) force acting on the mass which is proportional to its displacement from its equilibrium position. The force is always directed towards the equilibrium position (An equation with symbols defined, and the negative sign justified, may be a valid response for both marks For equilibrium position accept: undisplaced point/position or fixed point/position or central point/position)	 (1) (1)	2
(b)(i)	Use of $\Delta F = k\Delta x$ k =26.2 (N m^{-1}) Example of calculation $k = \frac{0.2 \text{ kg} \times 9.81 \text{ N kg}^{-1}}{7.5 \times 10^{-2} \text{ m}} = 26.16 \text{ N m}^{-1}$	(1) (1)	2

(b)(ii)	Combine $T = 2\pi\sqrt{\frac{m}{k}}$ with $f = \frac{1}{T}$ to obtain $f^2 = \frac{k}{4\pi^2}m^{-1}$ Compare with $y = mx + c$ to identify gradient as $\frac{k}{4\pi^2}$ Gradient of graph calculated Large triangle used for gradient calculation k =26.7 N m^{-1} A conclusion consistent with the value calculated in (i) (accept comparison with "show that" value from (i)) Example of calculation $T^2 = \frac{4\pi^2 m}{k} \therefore f^2 = \frac{k}{4\pi^2}m$ So gradient $= \frac{k}{4\pi^2}$ Gradient= $\frac{(3.25 - 0.00) \text{ s}^{-2}}{(5.00 - 0.20) \text{ kg}^{-1}} = 0.677 \text{ kg s}^{-2}$ $k = 4\pi^2 \times 0.677 \text{ kg s}^{-2} = 26.7 \text{ N m}^{-1}$	(1) (1) (1) (1) (1) (1)	6
	Total for question		**10**

Q9.

Question Number	Answer		Mark
	At least 1 cycle of a sinusoidal graph	(1)	
	Displacement axis shows amplitude as 5 cm	(1)	
	Use of $a = (-)\omega^2 x$ and $\omega = \frac{2\pi}{T}$ to calculate T	(1)	
	Time axis shows period as calculated value of T	(1)	4
	<u>Example of calculation</u> $\omega = \sqrt{\frac{8.0 \text{ cm s}^{-2}}{5.0 \text{ cm}}} = 1.26 \text{ s}^{-1}$ $T = \frac{2\pi}{1.26 \text{ s}^{-1}} = 4.97 \text{ s}$		
	Total for question		**4**

Q10.

Question Number	Answer		Mark
(a)	(When the object is displaced): there is a (resultant) force that is proportional to the displacement from the equilibrium position and (always) acting towards the equilibrium position [Accept force is in the opposite direction to displacement] (Accept 'acceleration' for 'force') (For equilibrium position accept: undisplaced point/position or fixed point/position or central point/position, do not accept mean position)	 (1) (1)	2
(b)(i)	Frequency/period calculated from oscillations per minute $T = 0.22$ s [can be seen on graph] Use of $\omega = 2\pi f$ **Or** Use of $\omega = \frac{2\pi}{T}$ Use of $v = A\omega \sin \omega t$ $v = 1.1$ m s^{-1} [can be seen on graph] At least 1 cycle of a sinusoidal graph with calculated values of v and T on axes <u>Example of calculation</u> $f = \frac{270 \text{ min}^{-1}}{60 \text{ s min}^{-1}} = 4.5 \text{ Hz}$ $\omega = 2\pi \text{ rad} \times 4.5 \text{ s}^{-1} = 28.3 \text{ rad s}^{-1}$ $v = \left(\frac{8.0 \times 10^{-2} \text{ m}}{2}\right) \times 28.3 \text{ s}^{-1} = 1.13 \text{ m s}^{-1}$	(1) (1) (1) (1) (1) (1)	6
(b)(ii)	Use of $a = -\omega^2 x$ $a = 32$ m s^{-2} [ecf from (i)] <u>Example of calculation</u> $a = -(28.3 \text{ s}^{-1})^2 \times 4.0 \times 10^{-2} \text{ m} = 32.0 \text{ m s}^{-2}$	(1) (1)	2
(b)(iii)	The particles are free to move inside the can **Or** Not all the particles will move with simple harmonic motion **Or** Amplitude/frequency/period of oscillation of particles is different to amplitude of can **Or** The particles may continue to move upwards as the can starts moving downwards **Or** The particles may collide with each other **Or** the force on the paint particles is not equal to the force on the can.	(1)	1
	Total for question		**11**

Q11.

Question Number	Answer	Mark
	D is the correct answer A is not the correct answer as damping occurs at all frequencies B is not the correct answer as energy is transferred at all frequencies C is not the correct answer as energy is dissipated at all frequencies	**(1)**

Q12.

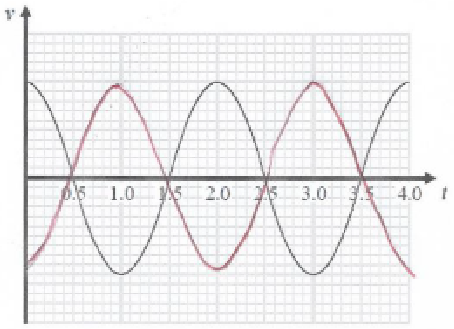
Question Number	Answer	Mark
	A is the correct answer B is not the correct answer as 'normal' is not the correct description C is not the correct answer as 'optimum' is not the correct description D is not the correct answer as 'damping' is not the correct description	**(1)**

Q13.

Question Number	Answer		Mark
(a)(i)	Same time period as velocity **and** constant amplitude	(1)	
	Wave shifted a quarter cycle to the right [i.e. a positive sine wave, displacement is zero at time zero.]	(1)	2
(a)(ii)	T = 2.0 s from graph	(1)	
	Use of $T = 2\pi\sqrt{\frac{\ell}{g}}$ (accept any value of T that could be read from the graph)	(1)	
	$\ell = 0.99$ m	(1)	3
	Example of calculation $2.0\text{ s} = 2\pi\sqrt{\frac{\ell}{9.81\text{ m s}^{-2}}}$ $\ell = \frac{(2.0\text{ s})^2 \times 9.81\text{ m s}^{-2}}{4\pi^2} = 0.994\text{ m}$		
(b)	**EITHER**		
	Suitable data logger application identified	(1)	
	Reason why data logger is an advantage in this situation	(1)	
	OR **Max 2** from		
	When data has to be collected over a very short time interval	(1)	
	When multiple data sets have to be collected simultaneously	(1)	
	When data has to be collected over a very long time interval	(1)	2
	Total for question		7

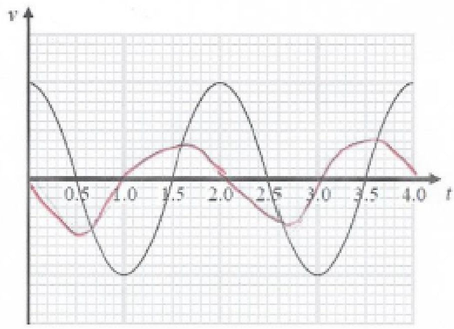
(a)(i)

Examples of possible responses:



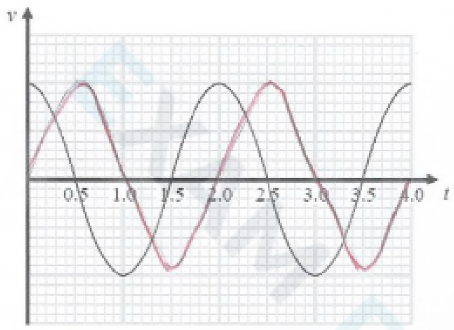
Response 1

MP1 only



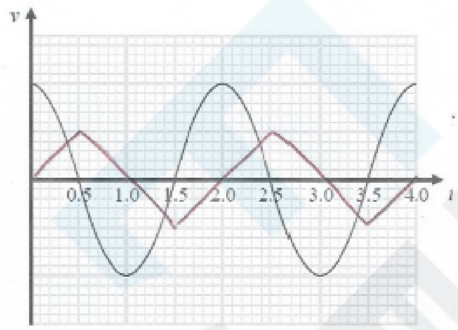
Response 2

No marks



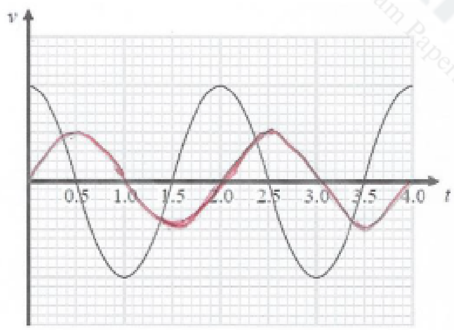
Response 3

MP1 & MP2



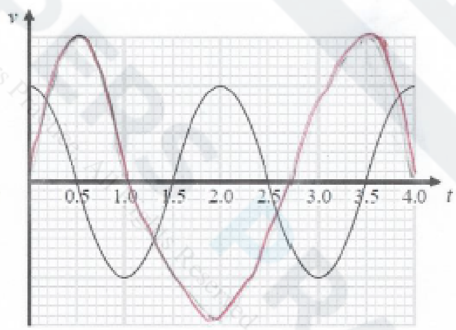
Response 4

MP1 only



Response 5

MP1 & MP2



Response 6

MP2 only

Q14.

Question Number	Answer	Mark
	D is the correct answer. as both the amplitude and the natural frequency increase	(1)

Q15.

Question Number	Answer	Mark
	B is the correct answer as $v_{max} = \omega A$ and $\omega = \frac{2\pi}{T}$, so $v_{max} = \left(\frac{2\pi}{T}\right) \times A$	**(1)**