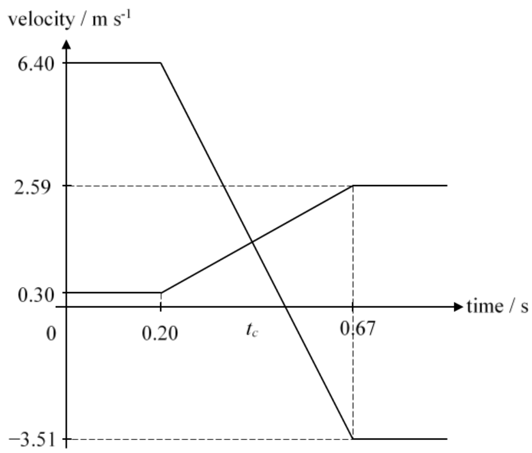
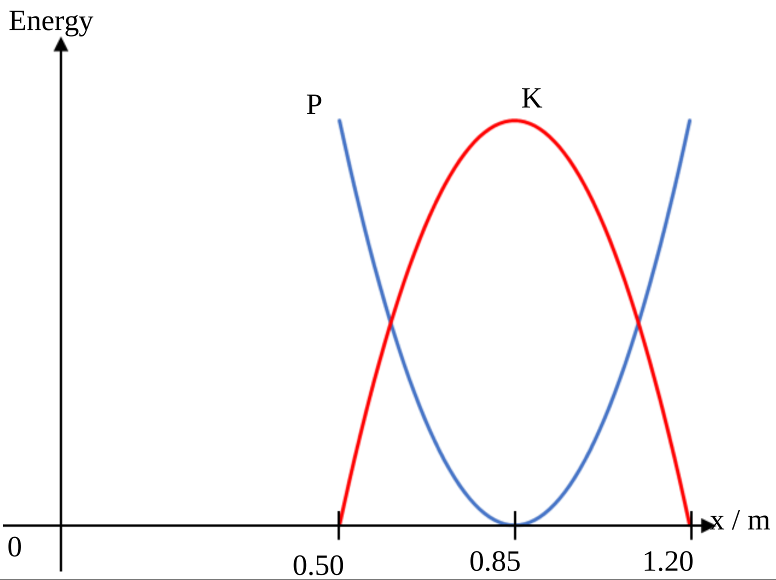
Annotations used in marking
BOD - Benefit of doubt
ECF - Error carried forward
POT - Powers of ten error
TE - Transfer error
CE - Calculation error
XP - Wrong physics
ENG - Generally bad english, phrasing and expression
PP - Poor presentation of answers
Note: For POT and TE, we can award the M mark, not the A mark.

Qn	**Suggested MS**
1	
(a)	Weight of cylinder = $A h \rho g$
	Pressure = $\frac{F}{A} = \frac{A h \rho g}{A}$
(b)(i)	An ideal gas is one where there are no intermolecular forces.
	An ideal gas obeys the ideal gas law $pV = nRT$ where p = pressure, V = volume, n = number of moles, (R = molar gas constant) and T = thermodynamics temperature
(b)(ii)	Since it is in <u>equilibrium</u>, the pressure of the trapped gas is the sum of the atmospheric pressure and the pressure due to the weight of the mercury.
	$(p_o + p_m) \times 0.190 = \frac{nRT}{A}$
(b)(iii)	Recognize that $\frac{nRT}{A}$ is a constant OR 190 p_o + 190 p_m = 208 p_o - 208 p_m
	$p_m = 0.035 \times 1.36 \times 10^4 \times 9.81 = 4.67 \times 10^3$ Pa $p_o = 1.03 \times 10^5$ Pa
(b)(iv)	Since temperature stay constant, there is no change to the internal energy of the gas.
	Negative work done results in a postive Q since ΔU=0.

2	
(a)	The total final momentum of a system after a collision is equal to the total initial momentum of a system before the collision
	provided that the net external force acting on the system is zero.
(b)(i)	$m_A u_A + m_B u_B = m_A v_A + m_B v_B$ $(1.2)(6.40)+(5.2)(0.30)=1.2v_A+5.2v_B$
	$u_A - u_B = v_B - v_A$ $v_A = v_B - 6.10$ or $v_B = v_A + 6.10$
	$1.2v_A + 5.2(v_A + 6.10) = 9.24$ or $1.2(v_B - 6.10) + 5.2v_B = 9.24$ $v_A = -3.5125 \text{ m s}^{-1}$ $v_B = 2.5875 \text{ m s}^{-1}$
	$= 2.59 \text{ m s}^{-1}$ (shown)
(b)(ii)	Considering B
	$\Delta p = (5.2)(2.59 - 0.3)$ $= 11.895$
	$F = \frac{\Delta p}{t}$ $= \frac{11.895}{0.47} = 25.31 \text{ N}$
	Using Newton's 3rd law, force A exerts on B is equal in magnitude but opposite in direction to the force B exerts on A, therefore the force B on A will be -25.31N
b)(iii)	
	Correct label for u_A, v_A and straight line before t and after t + 0.47
	Straight line with negative slope between t and t + 0.47

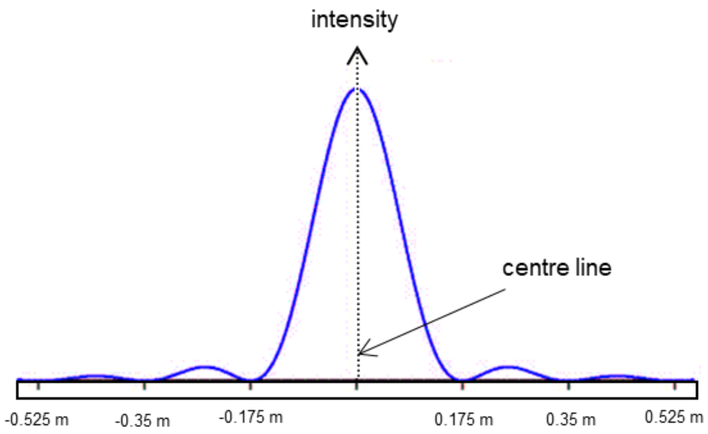
(b)(iv)	t_c at intersection between the 2 lines
(b)(v)	Kinetic energy of the system is conserved before and after elastic collisions
	At t_c, some of the kinetic energy is converted to elastic potential energy and stored in the spring.

3	
(a)(i)	Electric field strength at a point is the electric force exerted per unit positive charge placed at that point.
(ii)	The electric field strength at a point is equal to the negative electric potential gradient at that point.
(b)(i)	2.9 cm
(ii)	At the maximum, the electric potential gradient is zero. Therefore, the resultant electric field strength is zero.
	$E_A = E_B$ $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q_A}{x^2} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_B}{\left(7.0\times10^{-2} - x\right)^2}$
	$q_B = \left(\dfrac{7.0\times10^{-2} - x}{x}\right)^2 q_A$ $= \left(\dfrac{7.0\times10^{-2} - 2.9\times10^{-2}}{2.9\times10^{-2}}\right)^2 \left(-2.0\times10^{-9}\right)$ $= -4.0\times10^{-9}$ C
(iii)	The electron accelerates towards charge B until x = 2.9 cm.
	After x = 2.9 cm, it accelerates in the opposite direction towards charge A.
	The electron oscillates about x = 2.9 cm.

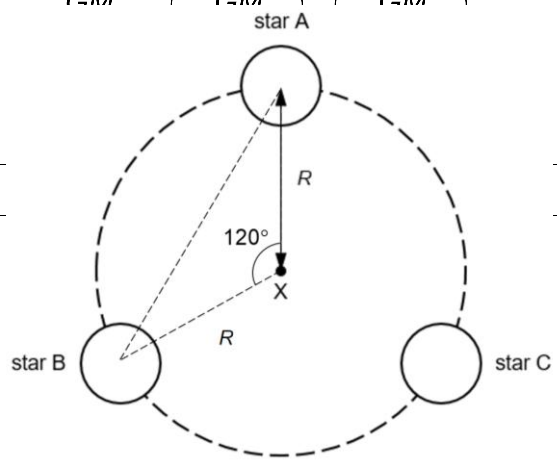
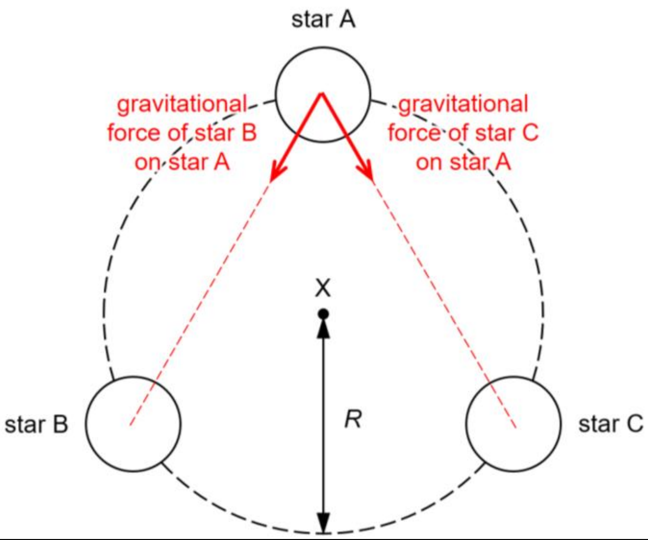
4	
(a)(i)	The graph is a straight line, which indicates that force (and hence acceleration, since mass is constant) is proportionate to displacement
	from the equilibrium position of 0.85 m.
	The graph has negative gradient, which indicates that force (and hence acceleration) points towards an equilibrium position.
(a)(ii)1.	Amplitude = $1.20-0.85$ or $0.85-0.50=0.35$ m
(a)(ii)2.	$a_0=\omega^2 x_0$ $\omega=\sqrt{\dfrac{a_0}{x_0}}=\sqrt{\dfrac{3.42}{0.35}}$ $=3.1259$ rad s^{-1}
	$f=\dfrac{\omega}{2\pi}=0.4975$ Hz
	The building's oscillation is driven by the wind, so its oscillation follows the frequency of the wind
(a)(iii)	
	Correct shape of either graph
	Correct shape of other graph, and correct x-values

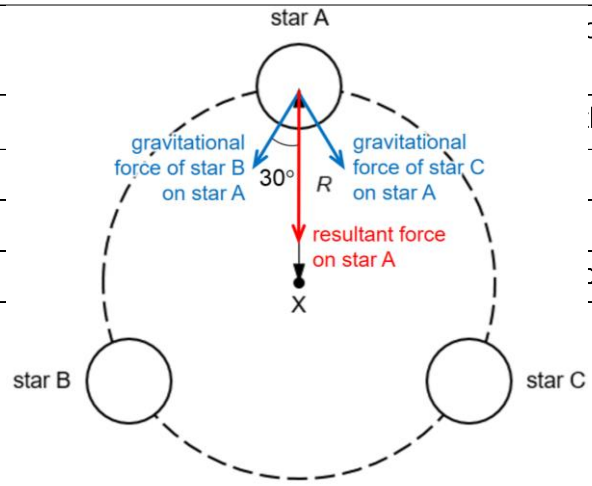
(a)(iv)	$\frac{KE}{PE}=\frac{1}{2}\Rightarrow\frac{KE}{KE_{\max}}=\frac{KE}{KE+PE}=\frac{1}{3}$ $\frac{\frac{1}{2}m(\omega\sqrt{c_0^{\ 2}-c^2})^2}{\frac{1}{2}m(\omega c_0)^2}=\frac{1}{3}$
	$\frac{c_0^{\ 2}-c^2}{c_0^{\ 2}}=\frac{1}{3}$ $\frac{c^2}{c_0^{\ 2}}=\frac{2}{3}$ $c^2=\frac{2}{3}(0.35)^2$ $c=0.29m$ $x=0.29+0.85=1.14m$
(b)	The natural frequency of those buildings matched the frequency of the earthquake, so resonance occurred.
	There is maximum transfer of energy to the buildings / the buildings oscillate with maximum amplitude

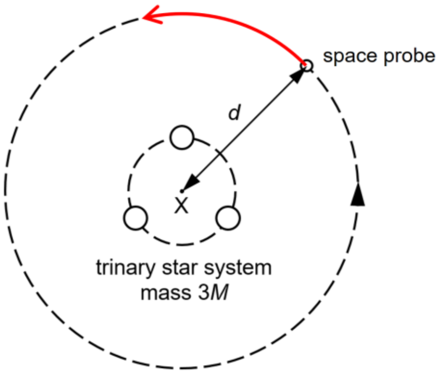
6(a) **5(c)(i)**	The principle of superposition states that the net displacement at a given place and time caused by two or more waves which transverse the same space and meet is. $\sin\theta = \frac{\lambda}{b}$
	the vector sum of the displacement which would have been produced by the individual waves separately at that position and instant of time $= \frac{550\times10^{-9}}{2.20\times10^{-6}} = 0.25$
(b)(i)	$x = \frac{\lambda D}{a}$ $= \frac{(650\times10^{-9})(6.5)}{(1.65\times10^{-3})}$ $\sin\theta = \frac{dist}{0.7} = 0.25$ $dist = 0.175$ $width = 2(0.175) = 0.35m$
	$x = 2.56\times10^{-3}m$
(ii)	Bright fringe becomes less bright as the amplitude of the light from the darken slit is lower
	Dark fringe will increase in brightness as the two wave cannot fully cancel each other
(iii)	$\theta_R = \frac{\lambda}{b}$ $= \frac{650\times10^{-9}}{3.5\times10^{-3}}$ $= 1.86\times10^{-4}rad$
	$d \approx r\theta$ $1.65\times10^{-3} = r(1.86\times10^{-4})$ $r = 8.88m$
(iv)	When pupil becomes larger, θ_R becomes smaller
	Therefore he will be able to resolve the 2 sources from an even further distance. He will still be able to resolve the 2 light sources

ii)	
	Symmetrical, intensity of centre bright fringe significantly higher (at least 1:5) than the adjacent fringe
	Width of centre bright fringe twice of other fringes, width properly labelled
iii)	$I = \frac{P}{S} = \frac{P}{4\pi r^2}$ $I = kA^2$ $A \alpha \frac{1}{r}$
	$\frac{A_{new}}{A_0} = \frac{r_0}{r_{new}}$ $A_{new} = \frac{0.8}{1.1} A_0 = 0.727 A_0$

7	
(a)	The direction of the object's motion changes. Therefore, its velocity changes and it accelerates.

(b)(iii)1.	Since it travels at a constant speed, the direction of the acceleration, and hence resultant force is perpendicular to the direction of motion. gravitational potential energy $= U_{AB} + U_{BC} + U_{AC}$
(b)(i)	
(b)(iii)2.	
	distance between stars $= \sqrt{R^2 + R^2 - 2(R)(R)\cos(120°)}$ $= R\sqrt{2 - 2\cos(120°)}$ $= 1.732R$
	$= 1.73R$
(b)(ii)	
	The two forces are drawn with equal magnitudes and in the correct directions.
	The two forces are labelled correctly.

(b)(iv)	...ot sufficient to provide for the centripetal
	...h a larger radius.
(c)(i)1.	... of the trinary star system.
(c)(i)2.	... of the trinary star system.
(c)(i)3.	...ces the trinary star system.
	
	gravitational force of one star on another star $=\dfrac{GM^2}{(1.73^2)R^2}$ $=0.333\dfrac{GM^2}{R^2}$
	resultant force on each star $=\dfrac{GM^2}{3R^2}\cos(30°)+\dfrac{GM^2}{3R^2}\cos(30°)$ $=0.577\dfrac{GM^2}{R^2}$
(b)(iii)3.	The resultant gravitational force on each star provides for the centripetal force
	$0.577\dfrac{GM^2}{R^2}=\dfrac{Mv^2}{R}$ $\dfrac{0.577}{2}\dfrac{GM^2}{R}=\dfrac{1}{2}Mv^2$ kinetic energy of one star $=0.289\dfrac{GM^2}{R}$ kinetic energy of trinary star system $=3\times0.289\dfrac{GM^2}{R}$ $=0.866\dfrac{GM^2}{R}$

(c)(ii)	
(c)(iii)	To escape the gravitational field of the trinary star system, the total energy of the space probe of mass *m* must be minimally equal to zero
	$\frac{1}{2}mv^2 + \left[-\frac{G(3M)m}{d}\right] \geq 0$ $v^2 \geq \frac{2G(3M)}{d}$ $v \geq \sqrt{\frac{2G(3M)}{d}}$ $v \geq \sqrt{\frac{2(6.67\times10^{-11})(3\times1.39\times10^{30})}{1.05\times10^{11}}}$ $v \geq 7.278\times10^{4}\ \text{m s}^{-1}$
	$v = 7.28\times10^{4}\ \text{m s}^{-1}$