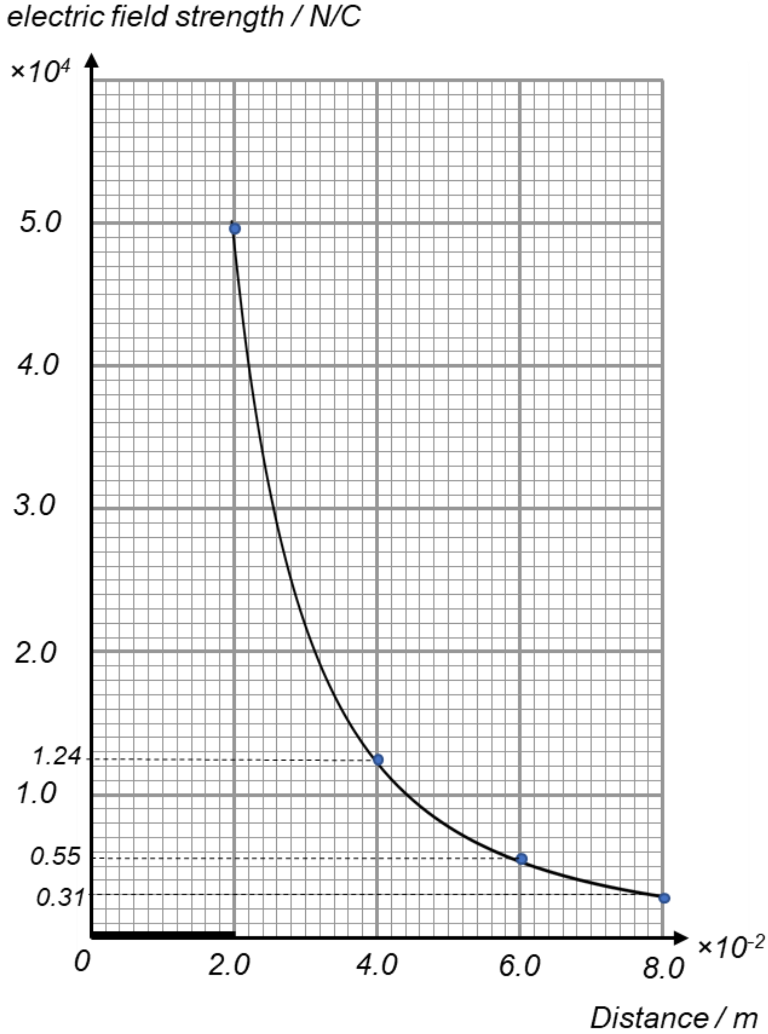
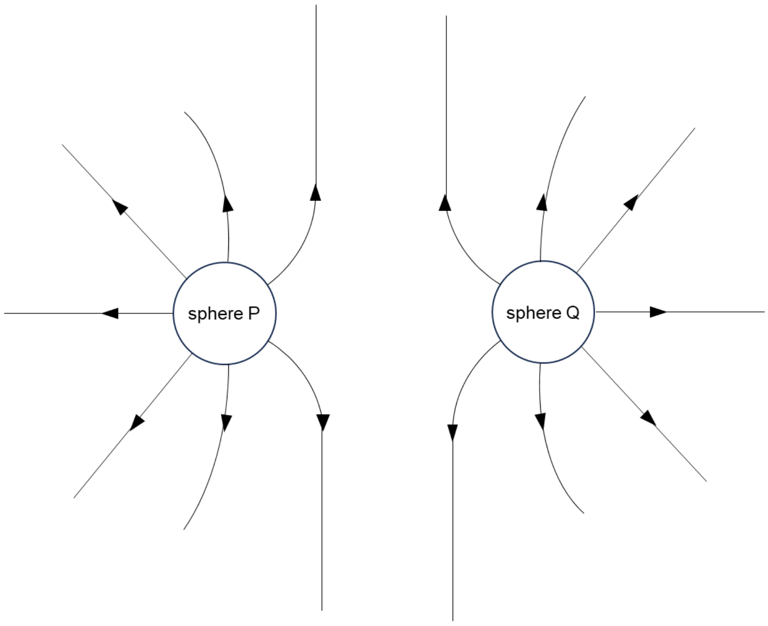
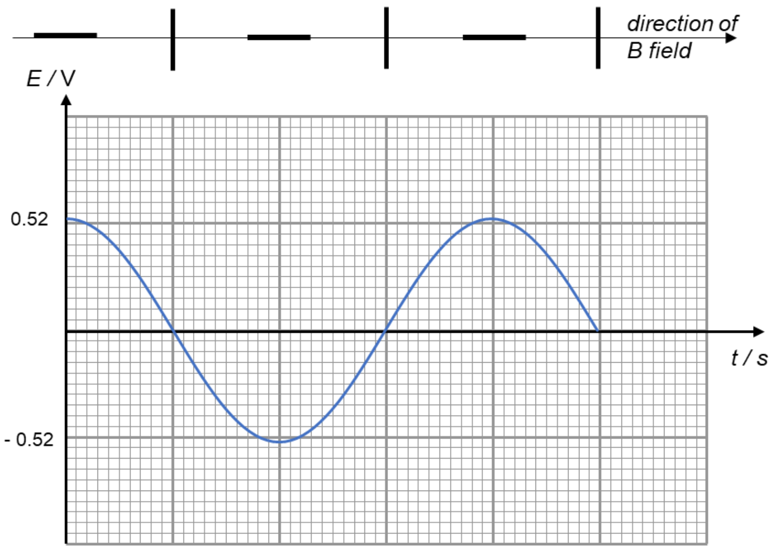
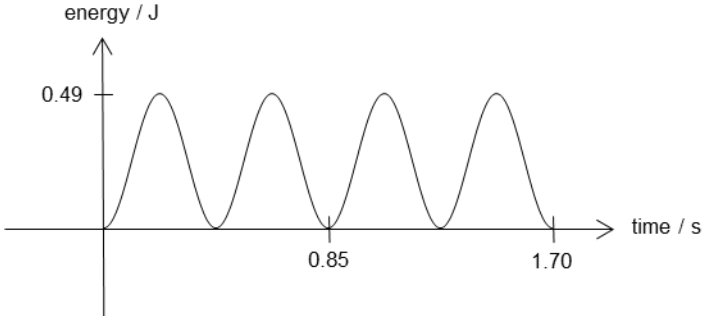
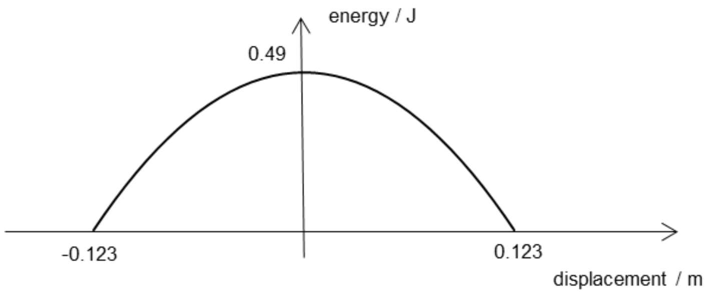
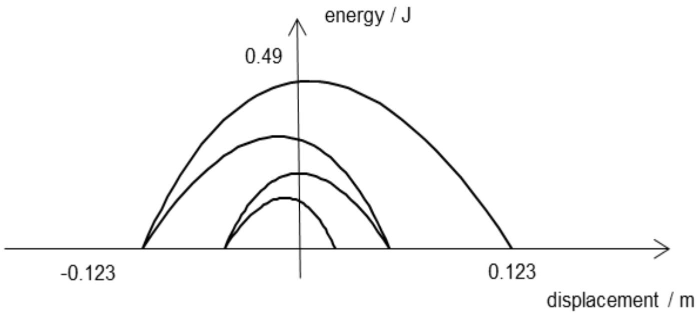
Qn	Suggested MS
1)a)	If sphere A is to move in the opposite direction, speed of sphere B will have to be higher than the initial speed of sphere A
	which will mean that total kinetic energy after collision has increased, which is not possible
b)i)	$m_{2.5}u_{2.5} + 0 = m_{2.5}v_{2.5} + m_{2.0}v_{2.0}$ $2.5(3.6) + 0 = 2.5v_{2.5} + 2.0v_{2.0}$ $9 = 2.5v_{2.5} + 2.0v_{2.0}$
	Relative speed of approach = relative speed of separation $3.6 = v_{2.0} - v_{2.5}$
	$9 = 2.5v_{2.5} + 2.0(3.6 + v_{2.5})$ $v_{2.5} = \frac{9-7.2}{4.5} = 0.4$
ii)	$F_{ave,2.5kg} = \frac{\Delta p}{t} = \frac{p_f - p_i}{t} = \frac{2.5(0.4) - 2.5(3.6)}{0.5} = 16.0N$
	Using N3L, the force on the 2.0 kg crate is also 16.0 N
c)i)	$KE_i + gpe_i = KE_f + gpe_f + WD_f$
	$\frac{1}{2}(3.0)(1.5)^2 + (3.0)(9.81)(2.0) = \frac{1}{2}(3.0)v^2 + 0 + 15.0(\frac{2.0}{\sin 30°})$
	$3.4 + 58.9 = 1.5v^2 + 60$ $v = 1.24ms^{-1}$
ii)	The crate will reach the bottom of the slope with a much higher speed
	The will result in it experiencing a much larger vertical force as it moves from the slope onto the vertical surface, potentially damaging the tomatoes.

2	
(a)	Electric field strength E at a point is defined as the electric force exerted per unit positive charge
	on a small stationary test charge placed at that point in the electric field.
(b)(i)	$E = \dfrac{Q}{4\pi \varepsilon_0 r^2}$ $= \dfrac{2.2\times10^{-9}}{4\pi(8.85\times10^{-12})(\frac{4.0\times10^{-2}}{2})^2}$
	$= 4.94 \times 10^{4}$ N C^{-1}
(ii)	

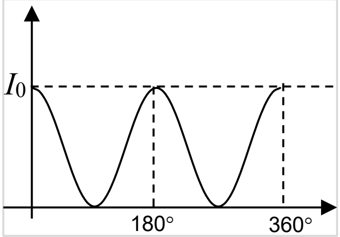
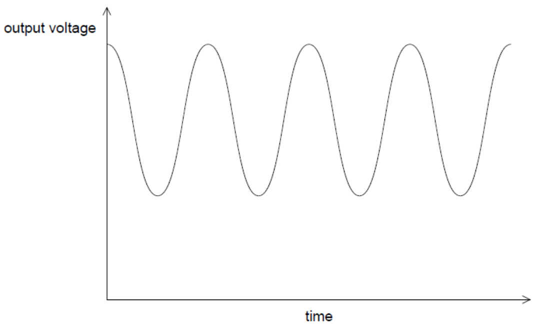
(c)(i)	
(ii)	Electric field strength is the negative potential gradient
	Gradient points in the direction of the greatest change of potential which is the (opposite) direction of the electric field. There is no component of the electric field strength (electric force) parallel to the equipotential line as this will cause a change in electric potential

3(a)	The magnetic flux linkage through a whole coil of N turns is the sum of the magnetic flux through the individual turns
(b)(i)	As the coil rotates, the area of the coil perpendicular to the field changes sinusoidally
	causing the magnetic flux linkage to change sinusoidally and a sinusoidal e.m.f. is induced,
	Since the circuit forms a closed loop, a sinusoial current will now follow
(ii)	$E = -\frac{d\Phi}{dt} = -\frac{d}{dt}NBA\cos(\omega t) = \omega NBA\sin(\omega t)$
	$E_{max} = \omega NBA = 2\pi(\frac{30}{60})(6.2)(265\times 100^{-2})$ = 0.516 V
	= 0.52 V
(iii)	orientation of coil seen from the top view 
(c)(i)	$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{0.516}{\sqrt{2}} = 0.365\,V$
(ii)	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$ $0.25 = \frac{V_s}{V_p}$ $V_s = 0.25\times 0.365 = 0.09125\,V$
	$I_s = \frac{V_s}{R} = \frac{0.09125}{10} = 9.13\times 10^{-3}\,A$

4)a)	$F = kx$ $8.0 = 65x$
	$x = 0.123m$
b)i)	$\mathrm{KE_{max}} = \mathrm{PE_{max}}$
	$KE_{\max} = PE_{\max} = \frac{1}{2}kx^2 = \frac{1}{2}(65)(0.123)^2 = 0.49J$
ii)	$KE_{\max} = \frac{1}{2}mv_o{}^2 = \frac{1}{2}m(\omega x_o)^2 = 0.49J$
	$\frac{1}{2}(1.2)(\frac{2\pi}{T}(0.123))^2 = 0.49$ $T = 0.855s$
iii)	
iv)	
v)	

5(a)	A photon is a quantum of electromagnetic radiation
	whose energy is given by the product of the Planck's constant and its frequency.
(b)(i)	$p = \frac{h}{\lambda}$ $= \frac{6.63 \times 10^{-34}}{656 \times 10^{-9}}$ $= 1.01 \times 10^{-27}$ kg m s^{-1}
(ii)	$\Delta x = c\Delta t$ $= \left(3.00 \times 10^{8}\right)\left(9.00 \times 10^{-15}\right)$ $= 2.70 \times 10^{-6}$ m
	$\Delta x \Delta p \gtrsim h$ minimum $\Delta p \approx \frac{h}{\Delta x}$ $= \frac{6.63 \times 10^{-34}}{2.70 \times 10^{-6}}$ $= 2.46 \times 10^{-28}$ kg m s^{-1}
(c)	When isolated gas atoms are in the excited state, electrons occupying the higher energy levels will spontaneously transit from the higher energy levels to lower energy levels.
	Each transition produces a photon whose energy is equal to the energy difference of the two electron energy levels involved in the transition.
	Discontinuous/discrete coloured lines are produced on a dark background implying only photons of specific energy/wavelength/frequency is emitted, indicating that the energy levels in an isolated atom are discrete.
(d)	$\Delta E = hf$ $= \left(6.63 \times 10^{-34}\right)\left(3.19 \times 10^{15}\right)$ $= 2.115 \times 10^{-18}$ J $= \frac{2.115 \times 10^{-18}}{1.60 \times 10^{-19}}$ eV $= 13.22$ eV
	$E_{\text{higher}} - E_{\text{lower}} = 13.22$ $E_{\text{higher}} = 13.22 + (-13.6)$ $= -0.38$ eV
(e)(i)	$\frac{hc}{\lambda} = \phi + eV_s$
(Ii)	$V_s = \frac{hc}{e}\left(\frac{1}{\lambda}\right) - \frac{\phi}{e}$ Plotting V_s against $\frac{1}{\lambda}$, $\frac{hc}{e}$ is equal to the gradient.
	gradient of graph $= \frac{1.80 - 0.70}{(3.00 - 2.10) \times 10^{6}}$ $= 1.222 \times 10^{-6}$ V m

	$\dfrac{hc}{e} = 1.222 \times 10^{-6}$ $h = \dfrac{\left(1.222 \times 10^{-6}\right)\left(1.60 \times 10^{-19}\right)}{3.00 \times 10^{8}}$ $= 6.52 \times 10^{-34}$ J s

6(a)(i)	The light is polarised in the same direction as the filter's polarising direction / polarised in the vertical direction.
(a)(ii)	
(a)(iii)	$\cos\theta = \sqrt{0.179}$ → $\theta = 65.0°$
	$I_0 \cos^2(65.0° - 30°) = 0.67 I_0$
(b)(i)	Light from both slits arrive in phase, it would result in constructive interference; if arrive in π rad out of phase, it would result in destructive interference.
	This corresponds to maximum voltage for constructive and minimum for destructive.
	As the train moves, it would detect alternating high and low voltages / interference pattern.
	Peak decreases due to diffraction.
(b)(ii)1.	$x = \frac{\lambda D}{d}$ $= \frac{(630\times10^{-9})(5.0)}{1.5\times10^{-3}}$
	$x = 2.1\times10^{-3}$ m
(b)(ii)2.	Time between two peaks = $\frac{0.01}{5} = 2\times10^{-3}$ s
	$v = \frac{2.1\times10^{-3}}{2\times10^{-3}}$ $v = 1.05$ m s^{-1}
(c)(i)	$\frac{\lambda}{b} = \frac{0.13}{5.0}$ $b = (630\times10^{-9})\left(\frac{5.0}{0.13}\right)$
	$b = 2.4\times10^{-5}$ m
(c)(ii)	Peak voltages will be higher.
	Width of the central bright fringe will be smaller.
(d)	
	Reflected waves and incidence waves interfere.

	Same frequency, opposite direction, hence a stationary wave is formed.

7(a)	Work done to move the masses
	from infinity to the distance of separation/to that point.
(b)(i)	A geostationary orbit is one where the satellite will remain in the same position in the sky relative to the Earth's surface
(b)(ii)	The orbital period of the moon is not 24 hours
(b)(iii)	$T = 27.3 \times 24 \times 60 \times 60 = 2358720$ s
	$\omega = \frac{2\pi}{T} = \frac{2\pi}{2358720} = 2.66 \times 10^{-6}$ rad s^{-1}
(b)(iv)	The gravitational force by the Earth on the Moon provides for the centripetal force.
	$\frac{GM_{Earth}M_{Moon}}{r^2} = M_{Moon}a_{Moon}$ $\frac{GM_{Earth}}{r^2} = r\omega^2$ $M_{Earth} = \frac{r^3\omega^2}{G}$
	$M_{Earth} = \frac{r^3\omega^2}{G}$ $M_{Earth} = \frac{(3.84 \times 10^8)^3 \times (2.6638 \times 10^{-6})^2}{(6.67 \times 10^{-11})}$ $M_{Earth} = 6.02 \times 10^{24}$ kg
(b)(v)1	The gravitational force by the Earth on the Moon provides for the centripetal force. $\frac{GM_eM_m}{x^2} = M_m\frac{v^2}{x}$ $\frac{GM_eM_m}{2x} = \frac{1}{2}M_mv^2$ Kinetic energy $= \frac{GM_eM_m}{2x}$
(b)(v)2	Gravitational potential energy $= -\frac{GM_eM_m}{x}$ Total energy $= -\frac{GM_eM_m}{x} + \frac{GM_{eh}M_m}{2x}$ Total energy $= -\frac{GM_eM_m}{2x}$
(b)(v)3	When the total energy is zero (or more), this implies the Moon is able to escape from the Earth's gravitational field.
(b)(vi)1	As the Moon moves further from the Earth, its orbital radius/x increases
	The total energy increases.
	The potential energy will increase more than the decrease in kinetic energy
(b)(vi)2	Since this is an Earth-Moon system, the Earth loses energy while the Moon gains energy.
(b)(vi)3	As the Earth loses energy, the orbital speed about the Earth axis decreases. Since angular velocity is smaller, the period will be longer.
(b)(vi)	The position where the maximum gravitational potential is between M and N
	The direction of the gravitational field strength at N will be towards the moon

	It will accelerate towards the Moon instead.