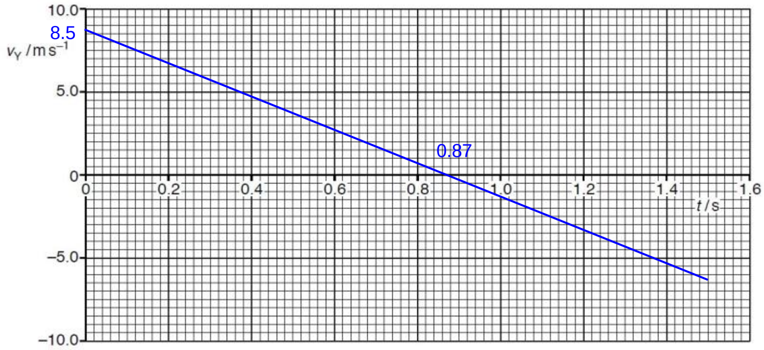
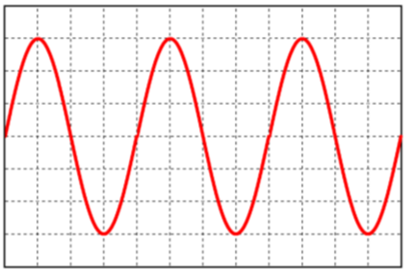
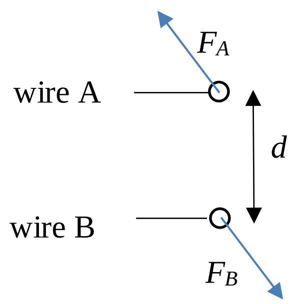
Annotations used in marking BOD - Benefit of doubt ECF - Error carried forward POT - Powers of ten error TE - Transfer error CE - Calculation error XP - Wrong physics ENG - Generally bad english, phrasing and expression PP - Poor presentation of answers Note: For POT and TE, we can award the M mark, not the A mark.	
Qn	**Suggested MS**
1	
(a)(i)	$\frac{\Delta v}{v} = \frac{1}{2}\left(\frac{\Delta T}{T}\right) + \frac{1}{2}\left(\frac{\Delta l}{l}\right) + \frac{1}{2}\left(\frac{\Delta m}{m}\right)$ $= \frac{1}{2}\left[\frac{0.1}{1.8} + \frac{2}{126} + \frac{0.2}{5.1}\right]$
	$= 0.055$ $= 5.5\%$
	OR
	Find max and min value
	Take average and correct answer
(a)(ii)	$v = \sqrt{\frac{(1.8)(1.26)}{(5.1\times10^{-3})}}$ $= 21.08805 \text{ m s}^{-1}$
	$\frac{\Delta v}{v} = 0.055$ $\Delta v = 0.055(21.00805)$ $= 1 \text{ m s}^{-1}$ $v = (21 \pm 1) \text{ m s}^{-1}$
(b)(i)	Average value of 20.7 m s^{-1} falls within the range due to experimental error.
(b)(ii)	Random error
	Repeat the experiment more times so that the average value will tend towards the true value.

2	
(a)	$v_x = \frac{s_x}{t}$ $= \frac{24}{1.5}$
	$= 16 \text{ m s}^{-1}$
(b)	$\tan 28° = \frac{v_y}{v_x}$ $v_y = (16)\tan 28°$ $= 8.51$
	$= 8.5 \text{ m s}^{-1}$
(c)(i)	
	Straight line with negative gradient
	Gradient = 9.81 m s^{-2} →, t = 0.87 s → cut at 0.84 s < t < 0.90 s
	Stop at t = 1.5 s, magnitude of v_y must be less than initial
(c)(ii)	maximum height = area under the v-t graph
	$= \frac{1}{2}(0.866)(8.5)$ $= 3.7 \text{ m}$
(c)(iii)	$\frac{\text{k.e.}}{\text{g.p.e}} = \frac{(1/2)mv_x^2}{mgh}$ $= \frac{(1/2)(16)^2}{(9.81)(3.7)}$
	$\frac{\text{k.e.}}{\text{g.p.e}} = 3.5$
(iv)	Steeper initial gradient, which decreases over time. Area above and below must be the same.
	Tangent to curve where it cuts the time-axis is parallel to original graph and must be the correct shape.

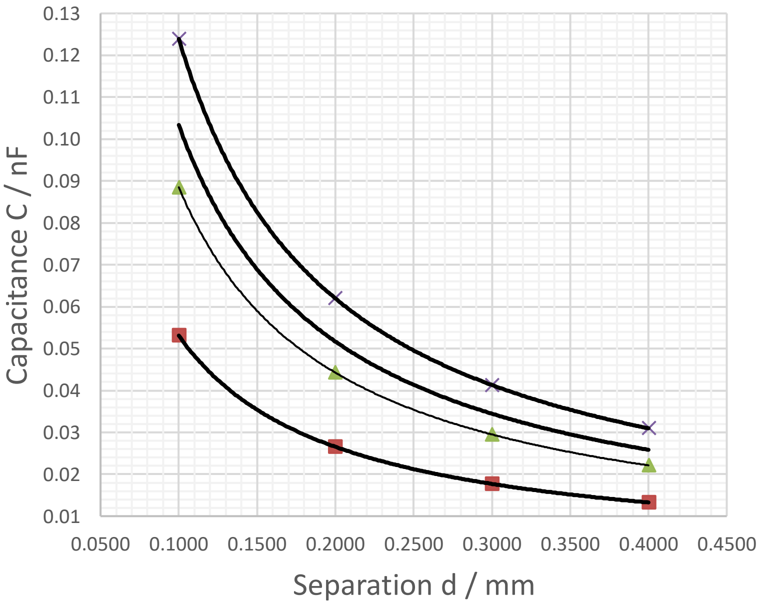
3	
(a)	Upthrust is a force on a partially or fully submerged object , acting in the opposite direction to weight
	Equal in magnitude to the weight of the fluid displaced
(b)	Upthrust $= \rho_{water} V g$ $= (1000)(0.40)(0.50)(9.81)$ $= 1962$ N
	$T_{BE} = \text{weight} - \text{upthrust}$ $= (950)(9.81) - 1962$ $= 7357.5$ N
	$= 7360$ N (shown)
(c)(i)	Beam is in equilibrium. Taking moments about A, Total clockwise moment = total anticlockwise moment $T_{BE}(3.00\cos 58°) + m_{beam} g \left(\frac{3.00}{2}\cos 58°\right) = T_{CD}(1.24\sin 32°)$ where 1.24 sin 32° = perpendicular distance from CD to O
	$T_{CD} = \frac{(7360)(3.00\cos 58°) + (80.0)(9.81)(1.50\cos 58°)}{1.24\sin 32°}$ $= 18\ 700$ N
(c)(ii)	Net force on bar must be zero in all directions for translational equilibrium
	Possible justification includes • *F* must have an upward component to cancel out the net downward force from T_{CD}, T_{BE}, and the weight of the beam. • *F* must have a rightward component to cancel out the leftward force from T_{CD}.
(c)(iii)	Beam is in equilibrium. Taking moments about D, T_{BE} provides clockwise moment.
	Hence, *F* must provide anticlockwise moment, so the direction of *F* is below AB.

4	
(a)(i)	When the voltmeter reading is zero, the p.d. across AB is equal to the p.d. across the 100 Ω resistor.
	$\frac{x}{l_{AC}} = \frac{100}{100+160}$ $x = \left(\frac{100}{100+160}\right)\left(90\times10^{-2}\right)$ $= 34.6\times10^{-2}$ m ≈ 35 cm
(ii)	$R_{eff} = \frac{\varepsilon}{I}$ $= \frac{3.0}{0.234}$ $= 12.82\ \Omega$
	$\frac{1}{R_{eff}} = \frac{1}{R_{AC}} + \frac{1}{R+160}$ $\frac{1}{12.82} = \frac{1}{R_{AC}} + \frac{1}{100+160}$ $R_{AC} = 13.49$ $\approx 13.5\ \Omega$
(iii)	If the battery has internal resistance, the terminal potential difference across the battery will be smaller. With the same current, the effective resistance of the external circuit is smaller.
	Hence, the resistance of the resistance wire AC will be a smaller value.

(b)(i)	For half wave rectification, $V_{\text{rms}} = \sqrt{\dfrac{\dfrac{V_0^2}{2}\left(\dfrac{T}{2}\right)}{T}}$ $= \dfrac{V_0}{2}$
	$P_{\text{ave}} = \dfrac{V_{\text{rms}}^2}{R}$ $= \left(\dfrac{V_0}{2}\right)^2\left(\dfrac{1}{R}\right)$ $= \left(\dfrac{12}{2}\right)^2\left(\dfrac{1}{13.5}\right)$ $= 2.7 \text{ W}$
(ii)	Sinusoidal waveform with an amplitude of three divisions since the peak voltage is 12 V.
	$T = \dfrac{1}{f}$ $= \dfrac{1}{50}$ $= 0.020 \text{ s}$ $= 20 \text{ ms}$ Period of each cycle is 4 divisions and three cycles are drawn.
	

5	
(a)(i)	Out of the page
(a)(ii)1.	B_E = 35 μT
(a)(ii)2.	As the d increases (and 1/d tends to zero), the magnetic field due to the wire decreases to 0. Hence the y-intercept is only due to the magnetic field due to the Earth.
(a)(ii)3.	From graph, (140, 80) So this implies $B = B_W + B_E$ at this position.
	So B_W = 80 – 35 = 45 μT
	Apply $B_w = \frac{\mu_0 I}{2\pi d}$ $I_W = 2\pi(\frac{1}{140})(45\times10^{-6})(4\pi\times10^{-7})^{-1}$ = 1.6 A
(a)(iii)	 Arrows must be labelled in the opposite direction and of the same magnitude. Within 2nd and 4th quadrant.
(b)	Direct current in electromagnet sets up an external magnetic field on the disc
	By Faraday's law, since disc is rotating, there is a rate of change in magnetic flux linkage as the disc enters the region of the external magnetic field.
	This results in an induced emf and a corresponding induced eddy currents in the disc.
	By Lenz's law, these eddy currents will results in a force that oppose the change that is causing it. Hence the velocity of the disc will decrease.

6	
(a)(i)	A photon has an energy which is dependent on its frequency (E = *hf*), which is lower than the work function, hence not sufficient emit the electrons.
	For waves, the energy is dependent on the amplitude/intensity of the wave.
(a)(ii)	A single photon is absorbed by a single electron and the interaction is almost instantaneous.
	For waves, it will take time for the photon to absorb and accumulate sufficient energy to be ejected.
(b)(i)1.	$E = \frac{hc}{\lambda}$ $= \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(680\times10^{-9})}$
	$E = 2.9\times10^{-19}$ J
(b)(i)2.	$I = \frac{P}{A} = \frac{\left(\frac{N}{t}\right)\left(\frac{hc}{\lambda}\right)}{\pi\left(\frac{d}{2}\right)^2}$ $\frac{N}{t} = \frac{(3.2\times10^{3})\pi\left(\frac{1.5\times10^{-3}}{2}\right)^2}{2.9\times10^{-19}}$
	$\frac{N}{t} = 1.9\times10^{16}\ \text{s}^{-1}$
(b)(ii)	$p_i = \frac{h}{\lambda}\cos 30^\circ$ $= \frac{(6.63\times10^{-34})}{(680\times10^{-9})}\cos 30^\circ$ $= 8.4\times10^{-28}\ \text{kg m s}^{-1}$
	$F_{\text{on one photon}} = \frac{p_f - p_i}{t} = \frac{(-8.4\times10^{-28})-(8.4\times10^{-28})}{t}$
	$F_{\text{on surface by one photon}} = -\left(\frac{p_f - p_i}{t}\right) = \frac{1.7\times10^{-27}}{t}$
	total force on surface by photons $= -N\left(\frac{p_f - p_i}{t}\right)$ $= (1.9\times10^{16})(1.7\times10^{-27})$ $= 3.3\times10^{-11}$ N
(b)(iii)	The reflected photons will have a <u>smaller change in momentum</u>, hence the force will be smaller.

7	
(a)i)	$\frac{C_{0.3}}{C_{0.1}} = \frac{d_{0.1}}{d_{0.3}}$ $C_{0.3} = \frac{0.1}{0.3}(0.089) = 0.030nF$
ii)	
	B1 – plot correctly plotted B1 – smooth curve plotted passing through all points
iii)	$C = 0.082nF$
iv)	$C = \varepsilon\frac{A}{d}$ $\varepsilon = \frac{Cd}{A} = \frac{(0.082\times10^{-9})(0.15\times10^{-3})}{1.0\times10^{-4}}$
	$\varepsilon = 1.23\times10^{-10}Fm^{-1}$
b)(i)	When time increases $e^{-t/RC}$ becomes very small, V_c will be very close to V_s
	This will result in an almost zero potential difference and zero current flow
(ii)	$I_R = \frac{V_R}{R}$ $= \frac{V_s}{R}e^{-t/RC}$
(c)(i)	Current flowing in the resistor determine how fast the charge is being discharged
	As the charges decreases, voltage decreases, current decreases and the rate of decrease in charge decreases.
(ii)	- Capacitor can be recharged - Capacitor can release their charge at a much faster rate

	- Capacitor do not lose their charge storage capacity over time
(d)(i)	$C = \frac{Q}{V}$ $Q = CV = (20\times10^{-6})(8) = 1.6\times10^{-4}C$
ii)	$V_c = V_s(1-e^{-t/RC})$ $8 = 12(1-e^{-t/(5)(20\times10^{-6})})$
	$t = 1.10\times10^{-4}s$
iii)	$F = \frac{1}{T}$ $= \frac{1}{1.10\times10^{-4}} = 9.09kHz$
iv) 1.	The lower the resistance, the lower the amount of time the capacitor will take to reach 8.0 V
	Lowering the resistance will decrease the period and increase the frequency
2.	$2000 \le \frac{1}{T}$ $T \le 0.0005s$
	R = 10 and 20 Ω