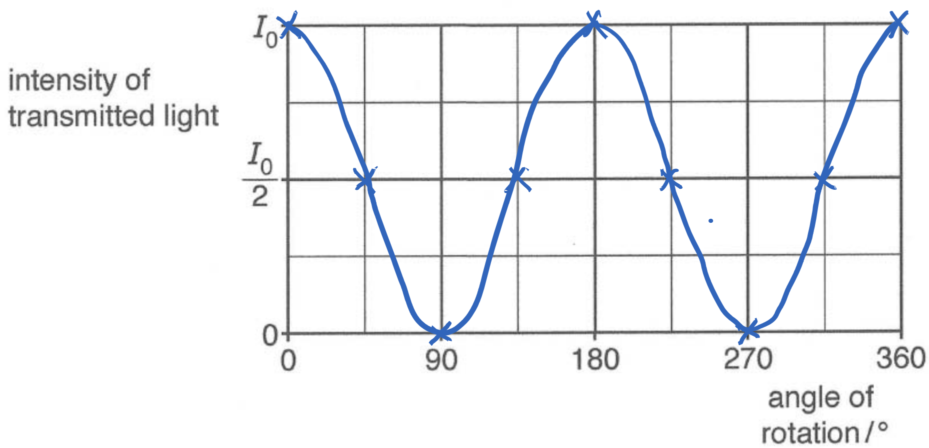
2019 H2 9749 Physics Paper 2

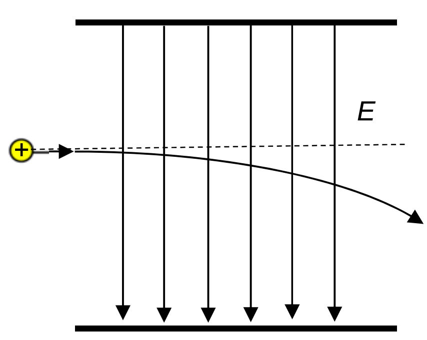
1(a)	1. The resultant force in any direction is zero (translational equilibrium). 2. The resultant torque about any point is zero (rotational equilibrium).	
1(b)	$\sum F_x = 0$ $T_1 \cos 20^\circ = T_2 \cos 10^\circ$ $T_1 = 1.048T_2$ -----------(1) $\sum F_y = 0$ $T_1 \sin 20^\circ + T_2 \sin 10^\circ = 700$ -----------(2) sub (1) into (2) $(1.048T_2)\sin 20^\circ + T_2 \sin 10^\circ = 700$ $T_2 = 1315 \text{ N} \approx 1300 \text{ N (2 s.f.)}$ $T_1 = 1.048T_2 = 1.048(1315) = 1378 \text{ N} \approx 1400 \text{ N (2 s.f.)}$	
1(c)	Taking moments about base of pole, $150\cos 10^\circ(1.8) = T \sin\theta(1.2)$ ----------(1) length of support cable $= \sqrt{1.6^2 + 1.2^2} = 2.0$ m $\frac{2.0}{\sin 90^\circ} = \frac{1.6}{\sin\theta}$ $\theta = 53.1^\circ$ (sub into (1)) $150\cos 10^\circ(1.8) = T \sin 53.1^\circ(1.2)$ $T = 277$ N ≈ 280 N (2 s.f.)	

2(a)(i)	A transverse wave is one in which the direction of oscillation of particles is perpendicular to the direction of energy transfer of the wave. (E.g. electromagnetic waves)	
2(a)(ii)	Plane polarisation occur when particles in the wave oscillate only in a single direction perpendicular to the direction of energy transfer of the wave.	
2(b)(i)	$I_1 = I_0 \cos^2\theta_1 = I_0 \cos^2 30^\circ = 0.75I_0$ $I_T = I_1 \cos^2\theta_2 = 0.75I_0 \cos^2 30^\circ = 0.56I_0$ (2 s.f.)	

2(b)(ii)	$I \propto A^2$ $\frac{I_T}{I_o} = \left(\frac{A_T}{A_o}\right)^2$ $\frac{A_T}{A_o} = \sqrt{\frac{0.5625 I_o}{I_o}}$ $= 0.75$	
2(b)(iii)	$I = I_0 \cos^2 \theta$ 	
2(c)(i)	Sound waves are longitudinal waves and for longitudinal waves, the direction of oscillation is along the direction of travel, hence cannot be polarised.	
2(c)(ii)	$T = \frac{1}{f} = \frac{1}{740} = 0.00135 \text{ s} = 1.35 \text{ ms}$ Time-based setting $= \frac{1.35}{6.8} = 0.1985 \approx 0.20 \text{ ms cm}^{-1}$ (2 s.f.)	

3(a)	The electric potential at a point in an electric field is defined as the work done per unit *positive* charge by an external agent in bringing a small test charge from infinity to that point without a change in the kinetic energy of the charge.	
3(b)(i)	$V = \frac{Q}{4\pi\varepsilon_0 r}$ $= \frac{N_+(q_+)}{4\pi\varepsilon_0 r}$ $780 = \frac{N_+(1.6 \times 10^{-19})}{4\pi\varepsilon_0(1.0 \times 10^{-10})}$ (taking any point from the graph) $N_+ = 54.216$ $= 54$	

3(b)(ii)	Both protons and nucleus have very small diameter (or radius) about 10^{-15} m, hence they behave as point charges.	
3(b)(iii)	$$F = \frac{Qq}{4\pi\varepsilon_0 r^2} = m_p a$$ $$\frac{(54\times1.6\times10^{-19})(1\times1.6\times10^{-19})}{4\pi\varepsilon_0(2.0\times10^{-8})^2} = (1.67\times10^{-27})a$$ $$a = 1.9\times10^{16}\ \text{m s}^{-2}\ \text{(2 s.f.)}$$	
3(b)(iv)	$$E_{initial} = E_{final}$$ $$E_{ki} + E_{pi} = KE_f + E_{pf}$$ $$E_{kf} - E_{ki} = U_i - U_f$$ $$\Delta E_k = \frac{Qq}{4\pi\varepsilon_0 r} - 0$$ $$= \frac{(54\times1.6\times10^{-19})(1\times1.6\times10^{-19})}{4\pi\varepsilon_0(2.0\times10^{-8})}$$ $$= 6.2\times10^{-19}\ \text{J}\quad\text{(2 s.f.)}$$	

4(a)(i)	Applying Fleming's left hand rule on the proton, the magnetic force is upwards. Since no deviation while travelling through the fields, the electric force must be downwards. Thus, Plate P has to be positive.	
4(a)(ii)	$E_k = ½\ m\ v^2$ $E_k = 64 \times 1.60 \times 10^{-19}$ J Speed of proton $v = \sqrt{[(2 \times 64 \times 1.60 \times 10^{-19}) / (1.67 \times 10^{-27})]} = 1.1074 \times 10^5$ ms^{-1} For proton to be not deviated, $F_E = F_B$ $\Rightarrow q\ E = B\ q\ v$ $\Rightarrow E = B\ v = (45 \times 10^{-3})(1.1074 \times 10^5) = 4.98 \times 10^3$ NC^{-1}	
4(a)(iii)	 Lesser $E_k \Rightarrow$ smaller $v \Rightarrow B\ q\ v < q\ E$ Note: Proton starts deviating downwards once it enters the field.	
4(b)	$F_x = B_y\ I_x\ L_x$	

	$\Rightarrow$ force per unit length $F_x / L_x = B_Y I_X = \left(\dfrac{\mu_o I_Y}{2\pi d}\right) I_X$ = (4π x 10-7)(5.5)(8.4) / (2π x 0.12) = 7.7 x 10^{-5} Nm^{-1} Direction is rightward. (Since currents in both wires are in the same direction and apply Fleming's left hand rule.)	

5(a)	The e.m.f. of a source is the energy converted from other forms to electrical energy per unit charge.	
5(b)(i)	The effective resistance of S and T, R = $(1/200 + 1/300)^{-1}$ = 120 Ω When switch is open, voltmeter reads e.m.f. $\Rightarrow E$ = 12.0 V When switch is closed, voltmeter reads terminal p.d. = p.d. across R = 10.8 V Using potential divider method, $V_R = (R \times E) / (R + r)$ $\Rightarrow 10.8 = (120 \times 12.0) / (120 + r)$ Solving, r = 13.3 Ω	
5(b)(ii)	Current flowing through r = current flowing through R = 10.8 /120 = 0.090 A Energy dissipated in the power supply = $(I^2 r)(t)$ = 0.090^2 x 13.3 x 5.0 x 60 = 32.4 J	
5(b)(iii)	When temperature increase, the NTC thermistor's resistance decreases. Thus, the effective resistance of the parallel arrangement of S and Thermistor decreases and given the same e.m.f. E, the p.d. across them also decreases but the p.d. across r increases. Since terminal p.d. decreases, the voltmeter reading will decrease.	

6(a)	Objects in our solar system have much smaller mass compared to neutron star or black hole so the gravitational waves produced in our solar system are not detectable.	[A1]
6(b)(i)	From LIGO Washington graph, maximum fractional change = 1.2×10^{-21} So maximum change in length = $1.2 \times 10^{-21} \times 4000 = 4.8 \times 10^{-18}$ m	 [A1]
6(b)(ii)	This is to produce a large and hence measurable path difference in the two light beams (after they have reflected many times)	[B1] [B1]
6(b)(iii)	The two light beams have phase difference of π which result in destructive interference (and hence zero amplitude)	[B1] [B1]

6(c)(i)	$P = \frac{Nhc}{(1)\lambda} \Rightarrow N = \frac{P\lambda}{hc}$ $= \frac{(100)(1064 \times 10^{-9})}{(6.63 \times 10^{-34})(3.00 \times 10^{8})}$ $= 5.35 \times 10^{20}$	[C1] [C1] [A1]
6(c)(ii)	$F = \frac{\Delta p}{t} = \frac{2Nh}{(1)\lambda}$ $= \frac{2(5.35 \times 10^{20})(6.63 \times 10^{-34})}{(1064 \times 10^{-9})}$ $= 6.67 \times 10^{-7}$ N	[C1] [C1] [A1]
6(c)(iii)	Final momentum is zero, so change in momentum is halved and force is halved	[A1]
6(d)(i)	energy released = $\Delta m\, c^2 = (29 + 36 - 62)(2.0 \times 10^{30})(3.00 \times 10^{8})^2$ $= 5.4 \times 10^{47}$ J	[C1] [A1]
6(d)(ii)	intensity $= \frac{P}{4\pi r^2}$ $= \frac{\frac{E}{t}}{4\pi r^2}$ $= \frac{\frac{5.4 \times 10^{47}}{20 \times 10^{-3}}}{4\pi(1.3 \times 10^{9} \times 9.5 \times 10^{15})^2}$ $= 0.0141$ W m^{-2}	[C1] [C1] [C1] [A1]
6(e)(i)	difference in time of two peaks = 0.435 − 0.423 = 0.012 s	[A1]
6(e)(ii)	speed $= \frac{\text{distance}}{\text{time}} = \frac{3002 \times 10^{3}}{0.012} = 2.5 \times 10^{8}$ m s^{-1}	[A1]
6(e)(iii)	Due to gravitational waves travelling in atmosphere and not in free space	[A1]
6(f)	1. far from disturbances due to vehicle movements or human activity (that can affect the vibration of tube) 2. much less atmosphere (that can affect the waves)	[B1] [B1]