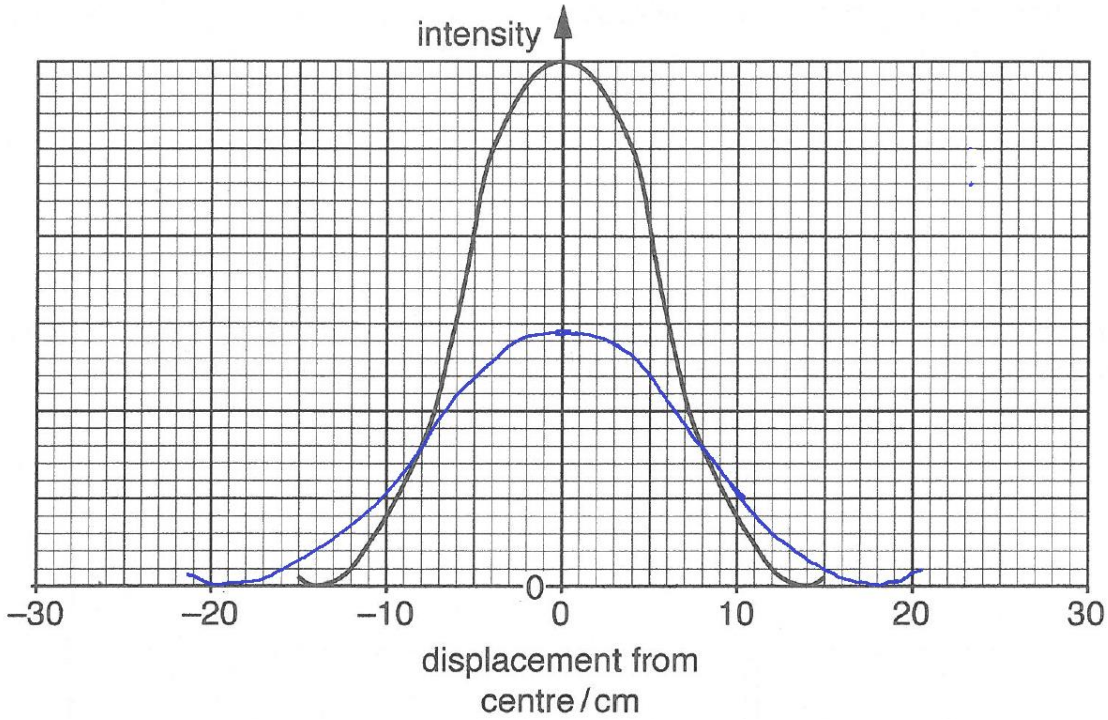
2018 H2 9749 Physics Paper 2

1(a)	Principle of moments states that for an object to be in equilibrium, the **sum** of clockwise moments about any axis of rotation (or pivot) must equal the **sum** of anti-clockwise moments about that (same) axis (or pivot). **Note:** both conditions for equilibrium and sum of moments must be stated.	
1(b)(i)	Weight of sign = 4.5 x 9.81 = 44.1 N Tension in support at A $= \frac{7}{10} \times 44.1 = 30.9$ N [B1] Tension in support at B $= \frac{3}{10} \times 44.1 = 13.2$ N [B1] **Note:** By inspection, the tension at A is larger (closer to the centre of mass)	
1(b)(ii)	Taking moments about the centre of mass, $T_A \times (d - 0.20) = T_B \times (1.00 - 0.20 - d)$ [M1] $(d - 0.20) = \frac{T_B}{T_A} \times (1.00 - 0.20 - d)$ $(d - 0.20) = \frac{3}{7} \times (1.00 - 0.20 - d)$ $d = 0.38$ m [A1]	
1(c)	The supports has to provide a horizontal force (towards the left) to maintain the sign in equilibrium (no net force) due to the wind force acting on the right. **Note:** Do not repeat the question without using key words. Also, there is no horizontal component of weight. Newton 3rd law cannot be used to describe.	

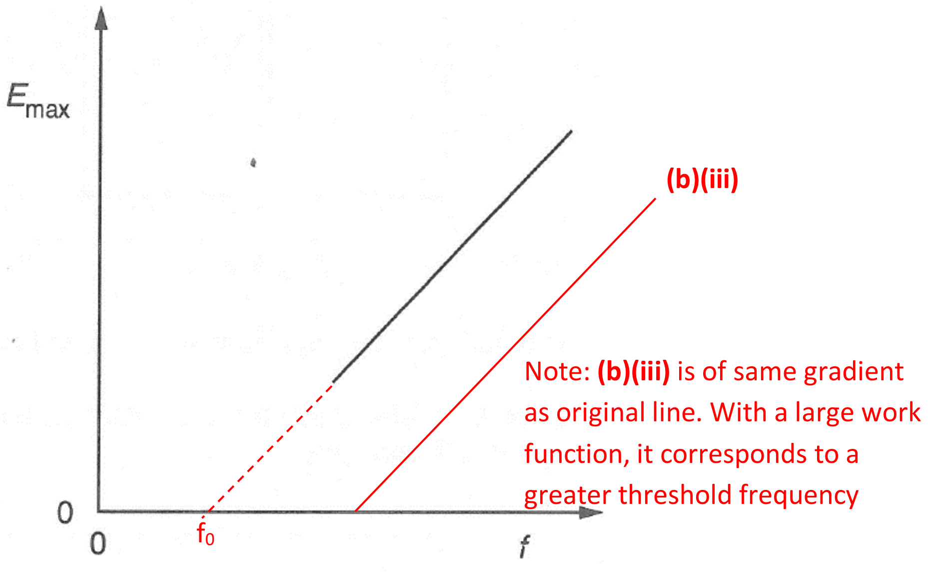
2(a)(i)	Hooke's law states that the force is proportional to the extension if the limit of proportionality is not exceeded.	
2(a)(ii)	Area under the graph $= \frac{1}{2}(6.8)(85 \times 10^{-3})$ [M1] $= 0.289$ J [A1]	
2(b)	By conservation of energy, Elastic Potential Energy at start = Gravitational Potential Energy at P + Kinetic Energy at P $= mgh + \frac{1}{2}mv^2$ [C1] $0.289 = (0.042)(9.81)(0.40) + \frac{1}{2}(0.042)v^2$ [C1] $v = 2.43$ m s^{-1} [A1]	

2(c)(i)	At minimum speed, the weight of the ball is just sufficient to provide for the centripetal force required to keep the ball in circular motion. The ball is just about to lose contact with the track and normal contact force, N, is zero. [M1] Hence, $W + N = \frac{mv^2}{r}$ At minimum speed, N is zero. $\mathrm{mg} = \frac{mv_{min}^2}{r}$ $v_{min} = \sqrt{gr}$ $= \sqrt{(9.81)(0.20)}$ [C1] $= 1.4 \text{ m s}^{-1}$ [A1]	
2(c)(ii)	v_{min} is independent of mass, hence, it will not change when the ball is replaced with one of greater mass. [A1]	

3(a)	Diffraction is the spreading of waves after they pass through an aperture or around an obstacle. Note: Examples of unaccepted answers - diffraction is the spreading of waves through an obstacle, or bending of waves after they pass through an aperture.	
3(b)	sin θ = λ/b where b = slit width Since θ is small, sin θ ≈ tan θ ≈ θ $\lambda = (14 \times 10^{-2}/2.7)\ (12 \times 10^{-6}) = 6.2 \times 10^{-7}$ m Note: Do not mix up other formula like Young's double slit or diffraction grating formula.	

3(c)		
3(d)(i)	The equation sin θ = λ/b gives the angle θ where the first minimum is observed. If the wavelength of light is larger, the angle θ is larger, hence the position of the first minimum will be further away from the centre.	
3(d)(ii)	White light consists of light over a range of wavelengths. The amount of spreading depends on the wavelength of light. The central region is white because all wavelengths of light superpose. The edges are coloured because only some frequencies are present as different wavelengths will drop to zero intensity at different positions. Note: Use scientific terms to answer this question.	

4(a)	The threshold frequency is the <u>minimum</u> frequency of incident light required <u>for photoemission</u> to occur.	[B2]

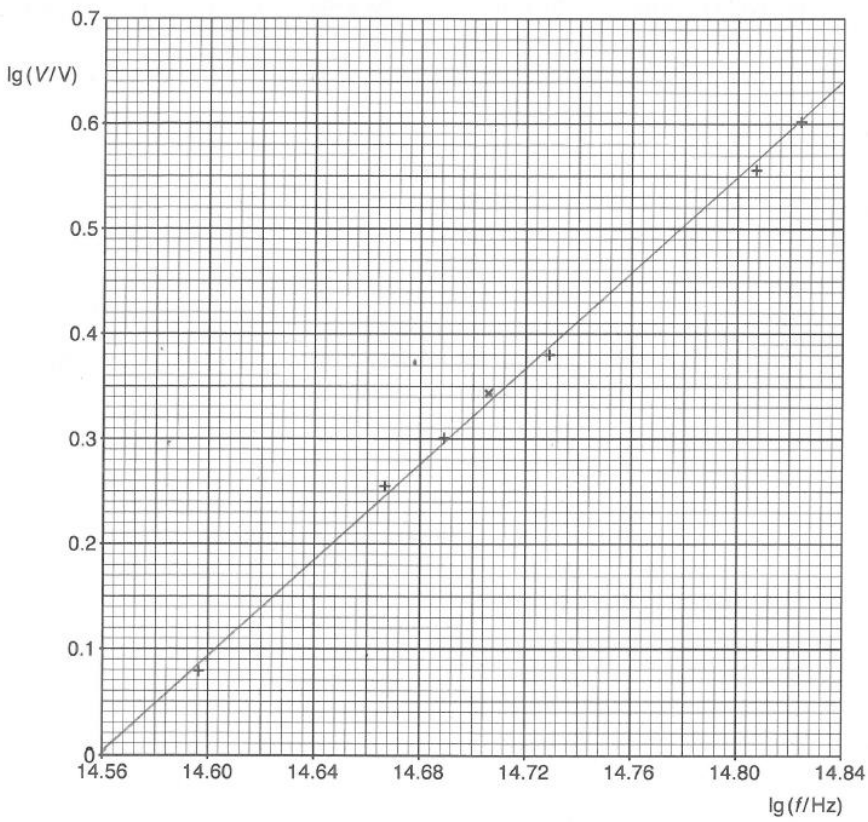
4(b)(i) **4(b)(iii)**	 **Fig. 4.1** Note for (b)(i): When light of threshold frequency is incident, the maximum kinetic energy of photoelectrons produced is 0 J. Hence Fig. 4.1 should be extrapolated to cut x-axis (i.e. maximum kinetic energy is 0)	**(b)(i)** [B1] **(b)(iii)** [B1]
4(b)(ii)	The gradient of the line gives the Planck constant *h*. Note: $E_{max} = hf - \Phi$ is in the y = mx + c form. Hence the gradient is *h*.	[B1]
4(c)(i)	$\frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{490\times10^{9}}$ $=4.0592\times10^{-19}$ [C1] $\frac{hc}{\lambda} = \Phi + E_{k\max}$ $E_{k\max} = 4.0592\times10^{-19} - (2.5)(1.60\times10^{-19})$ [C1] $= 5.9184\times10^{-21}$ J $\frac{1}{2}m_e v^2 = 5.9184\times10^{-21}$ $v = \sqrt{\frac{(2)(5.9184\times10^{-21})}{9.11\times10^{-31}}}$ [C1] $=1.1\times10^{5}$ m s^{-1} [A1] Note: Try not to lump the calculation into a single step. Know how to convert nm and eV into their respective SI units.	
4(c)(ii)1	<u>Blue light is above the threshold frequency</u> of europium. When it is incident on europium, <u>photoemission occurs</u>. <u>Negative charge is reduced</u> and hence the <u>gold leaf and metal rod repels less</u>, leading to the leaf to fall. As <u>red light is below the threshold frequency</u>, no photoemission occurs. Note: Use scientific terms to answer this question.	[B1]

4(c)(ii)2	If the frequency of the light is above the threshold frequency, photoemission occurs and europium becomes less negatively charged (i.e. more positive), causing a larger repulsion. Otherwise if frequency is below the threshold, nothing happens. Hence the leaf will not fall under any wavelength of light. Note: A metal is positively charged as a result of losing electrons and not in gaining positive charges. Hence it becomes less negatively charged.	[B1] [B1]

5(a)	Volume of 1 mole of copper = $\frac{m}{\rho} = \frac{0.0635}{8960} = 7.09 \times 10^{-6} m^3$ No of charge carries in 1 m^3 of copper = $\frac{6.02 \times 10^{23}}{7.09 \times 10^{-6}} = 8.49 \times 10^{28}$ Number density of charge carriers in copper = 8.49×10^{28}	
5(b)	$P = I^2 R$ $5.0 = I^2 (30)$ $I = 0.4082 A$ Cross sectional area A $= \frac{\pi d^2}{4}$ $= \frac{\pi (0.36 \times 10^{-3})^2}{4}$ $= 1.018 \times 10^{-7} m^2$ I = nAvq $0.4082 = (3.4 \times 10^{28})(1.018 \times 10^{-7})(v)(1.6 \times 10^{-19})$ $v = 7.4 \times 10^{-4} ms^{-1}$ Note: Do not mixed up the number density of copper with that of tungsten. Learn equation I = nAvq fully.	[C1] [C1] [C1] [A1]
5(c)	The length of the wire is doubled, hence resistance of the wire will also be doubled. With the same potential difference across the wire, current will be halved. By the equation I=navq, when I is halved, drift velocity v will halved as n,a and q remains constant.	[B1] [B1] [B1]

6(a)(i)	$V_{out} = IR$ $V_{out} = (27 \times 10^{-3})90 = 2.43V$	[A1]
6(a)(ii)	Effective resistance across Q and thermistor $= \left(\frac{1}{90} + \frac{1}{120}\right)^{-1} = 51.43\ \Omega$ Resistance of P = $\frac{9.0 - 2.43}{2.43} \times 90 = 243.3\ \Omega$ $V_{out} = \frac{51.43}{51.43 + 243.3} \times 9.0 = 1.57$ V	[C1] [C1] [A1]
6(a)(iii)	As the temperature of the thermistor increases, the resistance of the thermistor decreases. Hence the effective resistance across Q and thermistor decreases. By potential divider principle, V_{out} will decrease.	[M1] [M1] [A1]
6(b)	Length AB $= \frac{92}{360} \times 2\pi r$ $= \frac{92}{360} \times 2\pi(0.012)$ $= 0.01927$ m $V_{out} = \frac{0.01927}{0.065} \times 9.0 = 2.67$ V	[C1] [C1] [A1]

7(a)(i)	The p.d. V increases at an increasing rate with respect to the frequency f as f increases. Note: This relationship is not directly proportional. If that is true, then V = kf, so V/f should be a constant. This is not true however, if you check for pairs of V and f data in the table. In fact, V/f increases as V increases, meaning V increases at a faster rate compared to f.	

7(b)(i), (ii)		
7(b)(iii)	V = kf^n, so equation of line is lg V = n lg f + lgk n = gradient of line = (0.64 – 0) / (14.84 – 14.56) = 2.29 Note: “Determine” means that you need to show your workings clearly.	
7(c)(i)	f = c / λ λ = (3.0 x 10^8) / (520 x 10^{-9}) = 5.769 x 10^{14} Hz lg f = 14.76 From Fig 7.1, this corresponds to lg V = 0.46 So V = 2.88 V	
7(c)(ii)	P = (N/t) E where P is power of LED, N/t is the number of photons released per unit time, E is the energy of each photon. 10 = (N/t) (3.8 x 10^{-19}) N/t = 2.631 x 10^{19} s^{-1} So in 1 second, 2.631 x 10^{-19} photons are released. In 1 minute, 2.631 x 10^{19} x 60 = 1.58 x 10^{21} photons are released.	

7(c)(iii)	The potential difference (p.d.) across the LED for emitting photons of wavelength 520 nm is 2.88 V, found in (c)(i). Hence the p.d across series resistor = 4.5 – 2.88 = 1.62 V Passage mentioned that the safe normal operating current through LED is 20mA, hence Resistance of resistor = 1.62 / (20 x 10^{-3}) = 81 Ω Note: The e.m.f. of the power supply is not the p.d. across the series resistor.	
7(d)	730 mAh means that the total amount of charge available from the power supply is equal to that provided by a 730 mA current in 1 hour (since Q = It)	
7(e)	Passage mentioned that 60W incandesecent lamp produces an illumination of 840 lumens, while 10W power for LED produces an illuminatin of 800 lumens. Hence, Efficiency of LED / Efficiency of incandescent lamp = (800/ 10) / (840/ 60) = 5.7	
7(f)(i)	LEDs and CFLs consume less power than incandescent lamps to produce the same illumination, hence more cost effective in terms of electrical consumption. LEDs and CFLs are also less likely to be damaged than incandescent lamps, since they require smaller currents to operate, hence have longer life spans. Thus less frequent replacements are required.	
7(f)(ii)	Consider 50000 hrs of use for a traffic light <u>LED</u> Cost of lamp = \$35.95 Total electrical energy consumption = 50000 h x 10 W= 500000 Wh = 500 kWh Cost of electricity= 500 x \$0.22 = \$110 So total cost = \$145.95 <u>CFL</u> Cost of lamp = 5 x \$3.95 = \$19.75 Total electrical energy consumption = (5 x 10000) h x 14W = 700000 Wh = 700 kWh Cost of electricity = 700 x \$0.22 = \$154 So total cost = \$173.75 So in the long run, the total cost is still cheaper for LED. Considering that traffic lights are operating continuously all day long, the long term cost should be considered, hence the decision by LTA should be supported. Note: You need to show that the LED lamps were cost effective over the long term (of a period of 50 000 hours). You should not be considering only the cost of buying the lamps over this period, but not the cost of electrical consumption.	

7(f)(iii)	The significant amount of thermal energy produced by incandesecent lamps can melt the snow falling on the traffic light, preventing them from being covered from sight.	