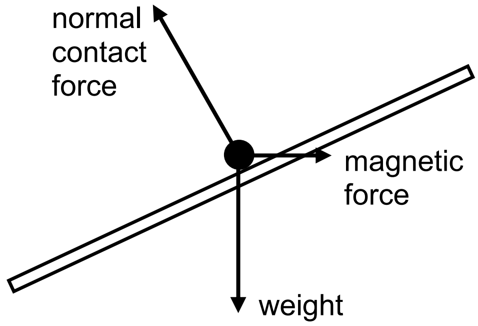
8 **(a)** the force per unit length per unit current exerted on a long straight conductor placed perpendicular to the magnetic field.

(b) **(i)**



M1 – all forces shown
A1 – all arrows labelled

(ii)

$$V = IR$$
$$6.0 = I \times 5.0$$
$$I = 1.2 \text{ A}$$

(iii)

$$F_{net} = 0$$
$$mg\sin\theta = BIL\cos\theta$$
$$m \times 9.81 \times \sin 30° = 0.021 \times 1.2 \times 1.5 \times \cos 30°$$
$$m = 6.67 \times 10^{-3} \text{ kg}$$

B1 – component of weight along slope
B1 – component of magnetic force along slope

(iv) When the cross-sectional area is doubled, the resistance will be halved, and the current will be doubled. Hence, the magnetic force will be doubled. However, the volume will also be doubled, and the mass will be doubled. There is no net force acting on rod XY and the rod remains at rest.

(c) **(i)** As the rod move down the slope, there is magnetic flux cutting, resulting in an induced e.m.f. across the rod.

(ii)

$$mgh = \frac{1}{2}mv^2$$
$$m \times 9.81 \times 0.020 \times \sin 30° = \frac{1}{2}mv^2$$
$$v = 0.44294 \text{ m s}^{-1}$$
$$\varepsilon = BLv\cos\theta$$
$$= (0.021)(1.5)(0.44294)\cos 30°$$
$$= 0.0121 \text{ V}$$

(iii) **1.** As the rod moves down the slope, the area and magnetic flux linkage decreases.
By Lenz's law, the direction of the induced current will be from P to Q to increase the magnetic flux linkage.

2. When the switch is closed, there will an induced current in the rod.
By conservation of energy, the loss in gravitational potential energy of the rod is equal to the gain in kinetic energy of the rod and heat generated by resistive heating.
Hence, there is a smaller gain in kinetic energy and a lower speed, resulting in smaller e.m.f. and the answer in **(c)(ii)** to be smaller.

9 **(a)** **(i)** Diffraction of light when passes through a single slit / Double-slit interference / Diffraction of light through a diffraction grating.

(ii) Photoelectric effect / Compton effect (not in syllabus)

(b) **(i)** The energies of the hydrogen atoms are quantized into discrete levels. When an atom transits from a higher energy level to a lower energy level, photons of energy equal to the difference in the two energy levels are emitted. Energy of photon is given by $E = \frac{hc}{\lambda}$. Hence, only photons of specific wavelengths are emitted.

(ii)

$$\text{Energy of photon of blue light} = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{4.86 \times 10^{-7}} = 4.093 \times 10^{-19}\ \text{J} = 2.6\ \text{eV}$$

Since the energy of the photon is higher than the work function energy photoemission will be observed.

(iii) **1.** Power of red light = Intensity × Area
= $6.80 \times 10^{3} \times 3.00 \times 10^{-4}$
= 2.04 W

2.

$$\text{Number of photons per second} = \frac{\text{Power}}{\text{Energy per photon}} = \frac{2.04}{hc/\lambda} = \frac{2.04 \times 4.86 \times 10^{-7}}{6.63 \times 10^{-34} \times 3.0 \times 10^{8}} = 4.98 \times 10^{18}$$

$$\text{Momentum of each photon} = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{4.86 \times 10^{-7}} = 1.364 \times 10^{-27}\ \text{kg m s}^{-1}$$

$$\text{Total force} = 1.364 \times 10^{-27} \times 4.98 \times 10^{18} = 6.80 \times 10^{-9}\ \text{N}$$

(c) **(i)** **1.**

$$\frac{1}{\lambda_n} = R\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

$$\frac{1}{6.56 \times 10^{-7}} = 1.097 \times 10^{7}\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

$$n = 3$$

2.

$$\frac{1}{\lambda_n} = R\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

$$\frac{1}{4.86 \times 10^{-7}} = 1.097 \times 10^{7}\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

$$n = 4$$

(ii) For shortest wavelength, $n = \infty$.

$$\frac{1}{\lambda_{\text{min}}} = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$\lambda_{\text{min}} = 3.65 \times 10^{-7} \text{ m}$$

(iii)

$$E_n - E_2 = \frac{hc}{\lambda_n}$$

$$E_n - E_2 = hcR\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

$$E_n - E_2 = \frac{hcR}{2^2} - \frac{hcR}{n^2}$$

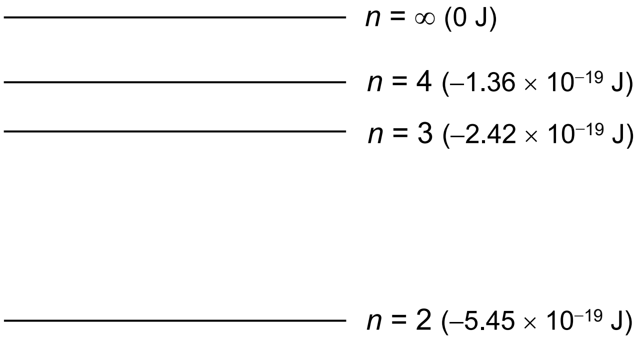
$$E_n - E_2 = -\frac{hcR}{n^2} - \left(-\frac{hcR}{2^2}\right)$$

$$\therefore E_n - \frac{hcR}{n^2} \quad \& \quad E_2 = -\frac{hcR}{2^2}$$

$$E_n = -\frac{1}{n^2}\left(6.63 \times 10^{-34}\right) \times \left(3.0 \times 10^{8}\right) \times \left(1.097 \times 10^{7}\right) = -\frac{2.18 \times 10^{-18}}{n^2}$$

Hence, the energy values are:

n = 2: -5.45×10^{-19} J
n = 3: -2.42×10^{-19} J
n = 4: -1.36×10^{-19} J



Alternative method

From E_∞ to E_2, $\Delta E = -\frac{hc}{\lambda} = -\frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{3.646 \times 10^{-7}} = -5.455 \times 10^{-19}$ J

From E_3 to E_2, $\Delta E = -\frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{6.56 \times 10^{-7}} = -3.032 \times 10^{-19}$ J

From E_4 to E_2, $\Delta E = -4.093 \times 10^{-19}$ J