DEFINATION AND PROPERTIES OF THE MAGNETIC FIELD.

An electron is accelerated through 2400 V and then enters a region where there is a uniform 1.7-T magnetic field. What are (a) the maximum and (b) the minimum values of the magnetic force this charge can experience?

Given

$V = 2400$, $m_e = 9.11 \times 10^{-31}$ Kg

$B = 1.7\ T$, $e = q = 1.602 \times 10^{-19}$ C

$F = ?$

Let first find v in order to find F

Sey angle called Tesla

$\therefore \quad \frac{1}{2} m v^2 = q V$

$$v^2 = \frac{2qV}{m} = \frac{1.602 \times 10^{-19} \times 2400 \times 2}{9.11 \times 10^{-31}}$$

$$v^2 = 8.44 \times 10^{14}\ m^2/s^2$$

$$\therefore \boxed{v = 2.9 \times 10^{7}\ m/s}$$

(a) $F = q v B \sin\theta$ since $\sin 90^\circ = 1$

$\therefore F = 1.602 \times 10^{-19} \times 2.9 \times 10^{7} \times 1.7 \sin 90$ maximum force

$$\boxed{F = 7.91 \times 10^{-12}\ N}$$

(b) since $\sin 0$ and $\sin 180 = 0$

$F = q v B \sin 0$ $\therefore$ the minimum force will be

$\boxed{F = 0}$

and $F = q v B \sin 180$ $0^\circ, 180^\circ, = 0$

$\boxed{F = 0}$

MAGNETIC FORCE ON CURRENT-CARRYING CONDUCTOR $102 \frac{29}{2}$

A wire carries a steady current of 2.4 A. A straight section of the wire, with a length of 0.75 m along the x-axis, lies within a uniform magnetic field $B = (1.6\hat{k})T$. If the current flows in the +x direction, what is the magnetic force on the section of the wire?

Given $l = 0.75$ m

$I = 2.4$ A

$B = (1.6\hat{k})T$

$F = ?$

$dF = I\, dl \times B$ 29.06

$dF = I\, dx\, i \times B$

Since the current flows in +x-direction

$dF = (2.4)\, dx\, i \times 1.6k$

$= -3.84\, dx\, j$

Integrate both side

$$F = -\int_0^{0.75} 3.84\, dx\, j$$

$$= -3.84 \Big| x \Big|_0^{0.75} j$$

$$= -3.8 \times 0.75\, j$$

$$\boxed{F = -2.88\, j\, N}$$

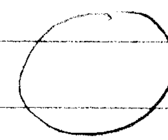
TORQUE ON A CURRENT LOOP IN A UNIFORM MAGNETIC FIELD. 102 $\frac{29}{3}$

A current of 17 mA is maintained in a single circular loop of 2 m circumference. An external magnetic field of 0.8 T is directed parallel to the plane of the loop. (a) Calculate the magnetic moment of the current loop. (b) What is the magnitude of the torque exerted on the loop by the magnetic field.

Given $I = 17 \text{ mA} = 17\times10^{-3} A$

$B = 0.8 T$

circumference $= 2$ m



Lets find r first

circumference $= 2\pi r$

$\therefore \quad 2\pi r = 2$

$\therefore \quad r = \frac{1}{\pi} = 0.318$ m

(a) $\mu = IA$

$= 17\times10^{-3} \times \pi(0.318)^2$ since $A = \pi r^2$

$\mu = \boxed{5.4\times10^{-3} \text{ A.m}^2}$

(b) $\tau = \mu \times B = 5.4\times10^{-3} \times 0.8$

$\tau = \boxed{4.33\times10^{-3} \text{ N.m}}$

TORQUE ON A CURRENT LOOP IN A UNIFORM MAGNETIC FIELD.

A rectangular coil of 225 turns and area $0.45\ m^2$ is in a uniform magnetic field of $0.21T$. Measurement indicate that the maxi. torque exerted on the loop by the field is 8×10^{-3} N.m. (a) Calculate the current in the coil. (b) Would the value found for the required current be different if the 225 turns of wire were used to form a single-turn coil with the same shape of larger area? Explain

given $\quad N = 225$ turn , $B = 0.21T$

$\tau = 8\times10^{-3}$ N.m , $A = 0.45\ m^2$

(a) $\quad \tau = NABI \qquad$ eq 29.11

$$\Rightarrow \quad I = \frac{8\times10^{-3}}{225\times0.21\times0.45} = \boxed{3.76\times10^{-4}\ A}$$

(b) Yes the value would be different.

Now $A = 0.45 = \pi r^2 \Rightarrow r = \sqrt{\frac{0.45}{3.14}} = \underline{0.378\ m}$

$\Rightarrow$ length $l = N(2\pi r)$

$\Rightarrow \quad l = 225\times2\times3.14\times(0.378) = \underline{534.4\ m}$

Now $\quad l = 2\pi R$ (for single turn)

$$\Rightarrow \quad \frac{534.4}{2\times3.14} = R \Rightarrow R = \underline{85.05\ m}$$

$$\Rightarrow \quad I = \frac{\tau}{NAB} = \frac{8\times10^{-3}}{1(0.21)\pi(85.05)^2} = \boxed{1.67\times10^{-6}\ A}$$

MOTION OF A CHARGED PARTICLE IN A MAGNETIC FIELD.

A 2keV electron moving perpendicular to the earth's magnetic field of 50 μT has circular trajectory. Determine (a) the radius of the trajectory and (b) the time required for the electron to complete one circle. (C) Show that your answer to (b) is consistent with the cyclotron frequency of the electron.

$$\varsigma = \frac{2\pi m}{qB}$$

Given

$V = 2 \times 10^{3}$ V

$T = 50 \times 10^{-6}$ T

$r = ?$, $t = ?$

(a) we know

$$① \leftarrow \frac{mv^2}{r} = qvB$$

and $\frac{1}{2}mv^2 = qV$

$\therefore = 1.602 \times 10^{-19} \times 2 \times 10^{3}$

$\frac{1}{2}mv^2 = 3.2 \times 10^{-16}$ J

$\therefore v = 2.65 \times 10^{7}$ m/s

$\therefore$ eq ① can be written

$$mv^{\cancel{2}} = q\cancel{v}Br$$

$$\therefore r = \frac{mv}{qB} = \frac{9.11 \times 10^{-31} \times 2.65 \times 10^{7}}{1.602 \times 10^{-19} \times 50 \times 10^{-6}}$$

$$\boxed{= 3.02 \text{ m}}$$

(b) $t = \frac{2\pi r}{v} = \frac{2 \times 3.14 \times 3.02}{2.65 \times 10^{7}}$

$t = \boxed{7.16 \times 10^{-7} \text{ s}}$

$f = \frac{1}{t} = \boxed{1.4 \times 10^{6} \text{ Hz}}$

(C) cyclotron frequency.

$f = \frac{qB}{2\pi m} = \frac{1.602 \times 10^{-19} \times 50 \times 10^{-6}}{2 \times \pi \times 9.11 \times 10^{-31}}$

$f = \boxed{1.4 \times 10^{6} \text{ Hz}}$

APPLICATION OF THE MOTION OF CHARGED PARTICLES IN A MAGNETIC FIELD. $102 \frac{29}{5}$

Singly charged uranium ions are accelerated through a potential difference of 2KV and enter a uniform magnetic field of 1.2T directed perpendicular to their velocities. Determine the radius of the circular path followed by these ions assuming that they are (a) U^{238} ions and (b) U^{235} ions. How does the ratio of these path radii depend on the accelerating voltage and the magnetic field strength?

Given $V = 2000\,V$, $B = 1.2\,T$

$r = ?$ for U^{238} and U^{235}

$$K = \tfrac{1}{2}mv^2 = qV$$

$$\therefore\ v = \sqrt{\frac{2qV}{m}} \longrightarrow ①$$

and $F = \frac{mv^2}{r}$ $\quad \left(\frac{mv^{\cancel{2}}}{r} = qvB \text{ OR } r = \frac{mv}{qB}\right)$

$$\therefore\ r = \frac{mv}{qB} \quad \text{Substituting } v \text{ from } ①$$

$$\therefore\ r = \frac{m}{q}\frac{\sqrt{2qV/m}}{B} \text{ OR } r = \frac{1}{B}\sqrt{\frac{m^2}{q^2}(2qV/m)} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

a) $\therefore\ r_{238} = \frac{1}{1.2}\sqrt{\frac{2\times 238\times 1.66\times 10^{-27}\times 2000}{1.6\times 10^{-19}}} = \boxed{8.28\times 10^{-2}\,m}$

b) $r_{235} = \frac{1}{1.2}\sqrt{\frac{2\times 235\times 1.66\times 10^{-27}\times 2000}{1.6\times 10^{-19}}} = \boxed{8.23\times 10^{-2}\,m}$

ratio $\frac{r_{238}}{r_{235}} = \frac{8.28}{8.23} = \boxed{1.006}$ OR similarly $\sqrt{\frac{m_{238}}{m_{235}}} = \boxed{1.006}$ Independent of all other variables