

## CHAPTER – 34 MAGNETIC FIELD

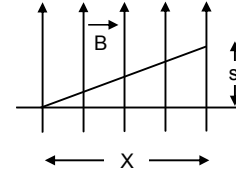
- $q = 2 \times 1.6 \times 10^{-19} \text{ C}$ ,  $v = 3 \times 10^4 \text{ km/s} = 3 \times 10^7 \text{ m/s}$   
 $B = 1 \text{ T}$ ,  $F = qvB = 2 \times 1.6 \times 10^{-19} \times 3 \times 10^7 \times 1 = 9.6 \times 10^{-12} \text{ N}$  towards west.
- $KE = 10 \text{ Kev} = 1.6 \times 10^{-15} \text{ J}$ ,  $\vec{B} = 1 \times 10^{-7} \text{ T}$   
(a) The electron will be deflected towards left

(b)  $(1/2)mv^2 = KE \Rightarrow v = \sqrt{\frac{KE \times 2}{m}}$   $F = qvB$  &  $accln = \frac{qVB}{m_e}$

Applying  $s = ut + (1/2)at^2 = \frac{1}{2} \times \frac{qVB}{m_e} \times \frac{x^2}{v^2} = \frac{qBx^2}{2m_e v}$

$$= \frac{qBx^2}{2m_e \sqrt{\frac{KE \times 2}{m}}} = \frac{1}{2} \times \frac{1.6 \times 10^{-19} \times 1 \times 10^{-7} \times x^2}{9.1 \times 10^{-31} \times \sqrt{\frac{1.6 \times 10^{-15} \times 2}{9.1 \times 10^{-31}}}}$$

By solving we get,  $s = 0.0148 \approx 1.5 \times 10^{-2} \text{ cm}$



- $B = 4 \times 10^{-3} \text{ T}$  ( $\hat{K}$ )  
 $F = [4\hat{i} + 3\hat{j}] \times 10^{-10} \text{ N}$ .  $F_x = 4 \times 10^{-10} \text{ N}$   $F_y = 3 \times 10^{-10} \text{ N}$   
 $Q = 1 \times 10^{-9} \text{ C}$ .

Considering the motion along x-axis :-

$$F_x = quv_y B \Rightarrow v_y = \frac{F}{qB} = \frac{4 \times 10^{-10}}{1 \times 10^{-9} \times 4 \times 10^{-3}} = 100 \text{ m/s}$$

Along y-axis

$$F_y = qv_x B \Rightarrow v_x = \frac{F}{qB} = \frac{3 \times 10^{-10}}{1 \times 10^{-9} \times 4 \times 10^{-3}} = 75 \text{ m/s}$$

Velocity =  $(-75\hat{i} + 100\hat{j}) \text{ m/s}$

- $\vec{B} = (7.0\hat{i} - 3.0\hat{j}) \times 10^{-3} \text{ T}$   
 $\vec{a} = \text{acceleration} = (-i + 7j) \times 10^{-6} \text{ m/s}^2$   
Let the gap be x.

Since  $\vec{B}$  and  $\vec{a}$  are always perpendicular

$$\vec{B} \times \vec{a} = 0$$

$$\Rightarrow (7x \times 10^{-3} \times 10^{-6} - 3 \times 10^{-3} \times 7 \times 10^{-6}) = 0$$

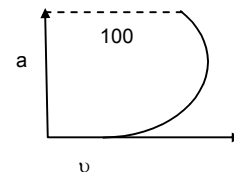
$$\Rightarrow 7x - 21 = 0 \Rightarrow x = 3$$

- $m = 10 \text{ g} = 10 \times 10^{-3} \text{ kg}$   
 $q = 400 \text{ mc} = 400 \times 10^{-6} \text{ C}$   
 $v = 270 \text{ m/s}$ ,  $B = 500 \mu\text{T} = 500 \times 10^{-6} \text{ Tesla}$   
Force on the particle =  $quB = 4 \times 10^{-6} \times 270 \times 500 \times 10^{-6} = 54 \times 10^{-8} \text{ (K)}$   
Acceleration on the particle =  $54 \times 10^{-6} \text{ m/s}^2 \text{ (K)}$

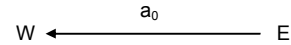
Velocity along  $\hat{i}$  and acceleration along  $\hat{k}$   
along x-axis the motion is uniform motion and  
along y-axis it is accelerated motion.

Along - X axis  $100 = 270 \times t \Rightarrow t = \frac{10}{27}$

Along - Z axis  $s = ut + (1/2)at^2$   
 $\Rightarrow s = \frac{1}{2} \times 54 \times 10^{-6} \times \frac{10}{27} \times \frac{10}{27} = 3.7 \times 10^{-6}$



6.  $q_p = e, \quad m_p = m, \quad F = q_p \times E$   
 or  $ma_0 = eE$  or,  $E = \frac{ma_0}{e}$  towards west



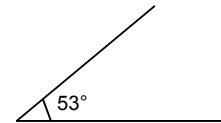
The acceleration changes from  $a_0$  to  $3a_0$

Hence net acceleration produced by magnetic field  $\vec{B}$  is  $2a_0$ .

Force due to magnetic field  
 $= \vec{F}_B = m \times 2a_0 = e \times V_0 \times B$

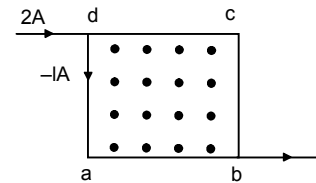
$\Rightarrow B = \frac{2ma_0}{eV_0}$  downwards

7.  $l = 10 \text{ cm} = 10 \times 10^{-3} \text{ m} = 10^{-1} \text{ m}$   
 $i = 10 \text{ A}, \quad B = 0.1 \text{ T}, \quad \theta = 53^\circ$   
 $|F| = i l B \sin \theta = 10 \times 10^{-1} \times 0.1 \times 0.79 = 0.0798 \approx 0.08$   
 direction of  $F$  is along a direction  $\perp$  to both  $l$  and  $B$ .



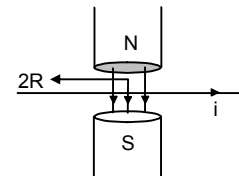
8.  $\vec{F} = i l B = 1 \times 0.20 \times 0.1 = 0.02 \text{ N}$

For  $\vec{F} = i l \times B$   
 So, For  
 $da$  &  $cb \rightarrow l \times B = l B \sin 90^\circ$  towards left  
 Hence  $\vec{F} = 0.02 \text{ N}$  towards left  
 For

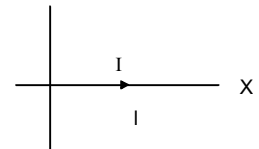


$dc$  &  $ab \rightarrow \vec{F} = 0.02 \text{ N}$  downward

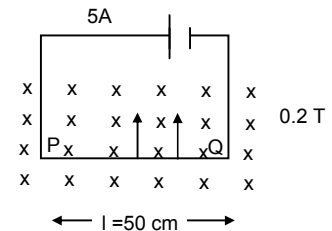
9.  $F = i l B \sin \theta$   
 $= i l B \sin 90^\circ$   
 $= i 2RB$   
 $= 2 \times (8 \times 10^{-2}) \times 1$   
 $= 16 \times 10^{-2}$   
 $= 0.16 \text{ N}.$



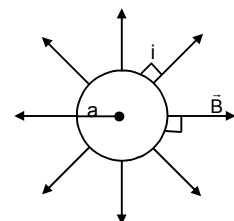
10. Length =  $l$ , Current =  $I \hat{i}$   
 $\vec{B} = B_0(\hat{i} + \hat{j} + \hat{k}) \text{ T} = B_0\hat{i} + B_0\hat{j} + B_0\hat{k}$   
 $F = I l \times \vec{B} = I l \hat{i} \times B_0\hat{i} + B_0\hat{j} + B_0\hat{k}$   
 $= I l B_0 \hat{i} \times \hat{i} + I B_0 \hat{i} \times \hat{j} + I B_0 \hat{i} \times \hat{k} = I l B_0 \hat{k} - I l B_0 \hat{j}$   
 or,  $|\vec{F}| = \sqrt{2I^2 l^2 B_0^2} = \sqrt{2} I l B_0$



11.  $i = 5 \text{ A}, \quad l = 50 \text{ cm} = 0.5 \text{ m}$   
 $B = 0.2 \text{ T},$   
 $F = i l B \sin \theta = i l B \sin 90^\circ$   
 $= 5 \times 0.5 \times 0.2$   
 $= 0.05 \text{ N}$   
 $(\hat{j})$



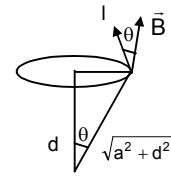
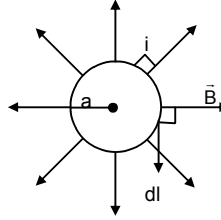
12.  $l = 2\pi a$   
 Magnetic field =  $\vec{B}$  radially outwards  
 Current  $\Rightarrow 'i'$   
 $F = i l \times B$   
 $= i \times (2\pi a \times \vec{B})$   
 $\otimes = 2\pi a i B$  perpendicular to the plane of the figure going inside.



13.  $\vec{B} = B_0 \vec{e}_r$   
 $\vec{e}_r$  = Unit vector along radial direction

$$F = i(\vec{l} \times \vec{B}) = i l B \sin \theta$$

$$= \frac{i(2\pi a) B_0 a}{\sqrt{a^2 + d^2}} = \frac{i 2\pi a^2 B_0}{\sqrt{a^2 + d^2}}$$



14. Current anticlockwise  
 Since the horizontal Forces have no effect.

Let us check the forces for current along AD & BC [Since there is no  $\vec{B}$ ]  
 In AD,  $F = 0$

For BC

$$F = iaB \text{ upward}$$

Current clockwise

Similarly,  $F = -iaB$  downwards

Hence change in force = change in tension

$$= iaB - (-iaB) = 2 iaB$$

15.  $F_1 =$  Force on AD =  $i l B$  inwards

$$F_2 =$$
 Force on BC =  $i l B$  inwards

They cancel each other

$$F_3 =$$
 Force on CD =  $i l B$  inwards

$$F_4 =$$
 Force on AB =  $i l B$  inwards

They also cancel each other.

So the net force on the body is 0.

16. For force on a current carrying wire in an uniform magnetic field

We need,  $l \rightarrow$  length of wire

$i \rightarrow$  Current

$B \rightarrow$  Magnitude of magnetic field

$$\text{Since } \vec{F} = i l B$$

Now, since the length of the wire is fixed from A to B, so force is independent of the shape of the wire.

17. Force on a semicircular wire

$$= 2iRB$$

$$= 2 \times 5 \times 0.05 \times 0.5$$

$$= 0.25 \text{ N}$$

18. Here the displacement vector  $d\vec{l} = \lambda$

$$\text{So magnetic for } i \rightarrow \int d\vec{l} \times \vec{B} = i \times \lambda B$$

19. Force due to the wire AB and force due to wire CD are equal and opposite to each other. Thus they cancel each other.

Net force is the force due to the semicircular loop =  $2iRB$

20. Mass =  $10 \text{ mg} = 10^{-5} \text{ kg}$

Length =  $1 \text{ m}$

$$I = 2 \text{ A,}$$

$$B = ?$$

Now,  $Mg = i l B$

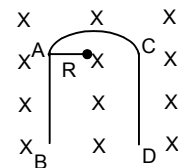
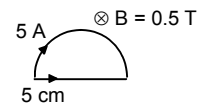
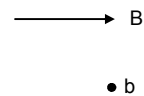
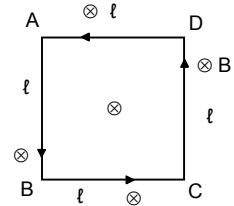
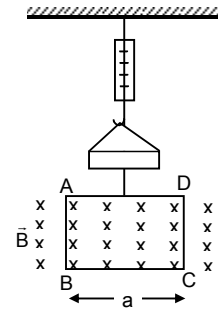
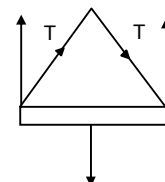
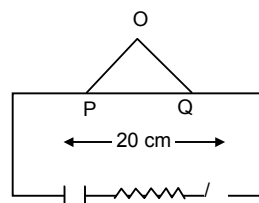
$$\Rightarrow B = \frac{mg}{il} = \frac{10^{-5} \times 9.8}{2 \times 1} = 4.9 \times 10^{-5} \text{ T}$$

21. (a) When switch S is open

$$2T \cos 30^\circ = mg$$

$$\Rightarrow T = \frac{mg}{2 \cos 30^\circ}$$

$$= \frac{200 \times 10^{-3} \times 9.8}{2 \sqrt{3/2}} = 1.13$$



(b) When the switch is closed and a current passes through the circuit = 2 A

Then

$$\Rightarrow 2T \cos 30^\circ = mg + i l B$$

$$= 200 \times 10^{-3} \times 9.8 + 2 \times 0.2 \times 0.5 = 1.96 + 0.2 = 2.16$$

$$\Rightarrow 2T = \frac{2.16 \times 2}{\sqrt{3}} = 2.49$$

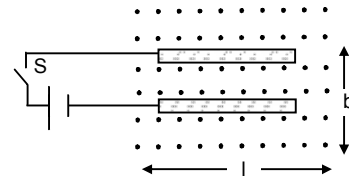
$$\Rightarrow T = \frac{2.49}{2} = 1.245 \approx 1.25$$

22. Let 'F' be the force applied due to magnetic field on the wire and 'x' be the dist covered.

So,  $F \times l = \mu mg \times x$

$$\Rightarrow i b l B = \mu mg x$$

$$\Rightarrow x = \frac{i b l B}{\mu mg}$$

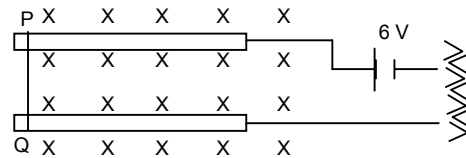


23.  $\mu R = F$

$$\Rightarrow \mu \times m \times g = i l B$$

$$\Rightarrow \mu \times 10 \times 10^{-3} \times 9.8 = \frac{6}{20} \times 4.9 \times 10^{-2} \times 0.8$$

$$\Rightarrow \mu = \frac{0.3 \times 0.8 \times 10^{-2}}{2 \times 10^{-2}} = 0.12$$



24. Mass = m

length = l

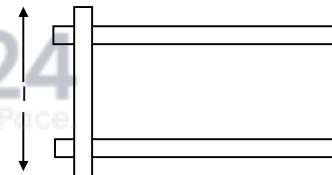
Current = i

Magnetic field = B = ?

friction Coefficient =  $\mu$

$$i l B = \mu mg$$

$$\Rightarrow B = \frac{\mu mg}{i l}$$



25. (a)  $F_{dl} = i \times dl \times B$  towards centre. (By cross product rule)

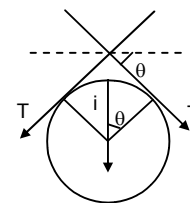
(b) Let the length of subtends an small angle of  $2\theta$  at the centre.

$$\text{Here } 2T \sin \theta = i \times dl \times B$$

$$\Rightarrow 2T\theta = i \times a \times 2\theta \times B \quad [\text{As } \theta \rightarrow 0, \sin \theta \approx \theta]$$

$$\Rightarrow T = i \times a \times B \quad dl = a \times 2\theta$$

Force of compression on the wire =  $i \times a \times B$



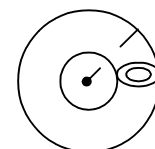
$$26. Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\left(\frac{F}{\pi r^2}\right)}{\left(\frac{dl}{L}\right)}$$

$$\Rightarrow \frac{dl}{L} Y = \frac{F}{\pi r^2} \Rightarrow dl = \frac{F}{\pi r^2} \times \frac{L}{Y}$$

$$= \frac{i a B}{\pi r^2} \times \frac{2\pi a}{Y} = \frac{2\pi a^2 i B}{\pi r^2 Y}$$

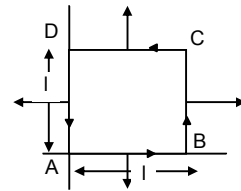
$$\text{So, } dp = \frac{2\pi a^2 i B}{\pi r^2 Y} \text{ (for small cross sectional circle)}$$

$$dr = \frac{2\pi a^2 i B}{\pi r^2 Y} \times \frac{1}{2\pi} = \frac{a^2 i B}{\pi r^2 Y}$$



27.  $\vec{B} = B_0 \left( 1 + \frac{x}{l} \right) \hat{k}$

$f_1 = \text{force on AB} = iB_0[1 + 0]l = iB_0l$   
 $f_2 = \text{force on CD} = iB_0[1 + 0]l = iB_0l$   
 $f_3 = \text{force on AD} = iB_0[1 + 0/1]l = iB_0l$   
 $f_4 = \text{force on BC} = iB_0[1 + 1/1]l = 2iB_0l$   
 Net horizontal force =  $F_1 - F_2 = 0$   
 Net vertical force =  $F_4 - F_3 = iB_0l$



28. (a) Velocity of electron =  $v$   
 Magnetic force on electron

$F = evB$   
 (b)  $F = qE$ ;  $F = evB$   
 or,  $qE = evB$

$\Rightarrow eE = evB$  or,  $\vec{E} = vB$

(c)  $E = \frac{dV}{dr} = \frac{V}{l}$

$\Rightarrow V = IE = l v B$

29. (a)  $i = V_0 n A e$

$\Rightarrow V_0 = \frac{i}{n A e}$

(b)  $F = i l B = \frac{i B l}{n A} = \frac{i B}{n A}$  (upwards)

(c) Let the electric field be  $E$

$E e = \frac{i B}{A n} \Rightarrow E = \frac{i B}{A e n}$

(d)  $\frac{dv}{dr} = E \Rightarrow dV = E dr$

$= E \times d = \frac{i B}{A e n} d$

30.  $q = 2.0 \times 10^{-8} \text{ C}$        $\vec{B} = 0.10 \text{ T}$

$m = 2.0 \times 10^{-10} \text{ g} = 2 \times 10^{-13} \text{ g}$

$v = 2.0 \times 10^3 \text{ m/s}$

$R = \frac{mv}{qB} = \frac{2 \times 10^{-13} \times 2 \times 10^3}{2 \times 10^{-8} \times 10^{-1}} = 0.2 \text{ m} = 20 \text{ cm}$

$T = \frac{2\pi m}{qB} = \frac{2 \times 3.14 \times 2 \times 10^{-13}}{2 \times 10^{-8} \times 10^{-1}} = 6.28 \times 10^{-4} \text{ s}$

31.  $r = \frac{mv}{qB}$

$0.01 = \frac{mv}{e \cdot 0.1}$  ... (1)

$r = \frac{4m \times V}{2e \times 0.1}$  ... (2)

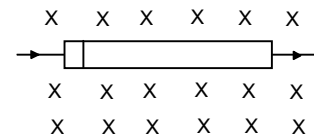
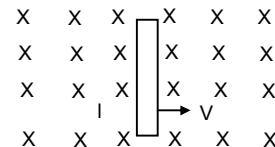
(2)  $\div$  (1)

$\Rightarrow \frac{r}{0.01} = \frac{4mVe \times 0.1}{2e \times 0.1 \times mv} = \frac{4}{2} = 2 \Rightarrow r = 0.02 \text{ m} = 2 \text{ cm}$

32.  $KE = 100ev = 1.6 \times 10^{-17} \text{ J}$

$(1/2) \times 9.1 \times 10^{-31} \times V^2 = 1.6 \times 10^{-17} \text{ J}$

$\Rightarrow V^2 = \frac{1.6 \times 10^{-17} \times 2}{9.1 \times 10^{-31}} = 0.35 \times 10^{14}$



$$\text{or, } v = 0.591 \times 10^7 \text{ m/s}$$

$$\text{Now } r = \frac{mv}{qB} \Rightarrow \frac{9.1 \times 10^{-31} \times 0.591 \times 10^7}{1.6 \times 10^{-19} \times B} = \frac{10}{100}$$

$$\Rightarrow B = \frac{9.1 \times 0.591}{1.6} \times \frac{10^{-23}}{10^{-19}} = 3.3613 \times 10^{-4} \text{ T} \approx 3.4 \times 10^{-4} \text{ T}$$

$$T = \frac{2\pi m}{qB} = \frac{2 \times 3.14 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19} \times 3.4 \times 10^{-4}}$$

$$\text{No. of Cycles per Second } f = \frac{1}{T}$$

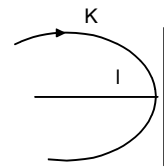
$$= \frac{1.6 \times 3.4}{2 \times 3.14 \times 9.1} \times \frac{10^{-19} \times 10^{-4}}{10^{-31}} = 0.0951 \times 10^8 \approx 9.51 \times 10^6$$

Note:  $\therefore$  Putting  $\vec{B}$   $3.361 \times 10^{-4} \text{ T}$  We get  $f = 9.4 \times 10^6$

33. Radius =  $l$ , K.E =  $K$

$$L = \frac{mV}{qB} \Rightarrow l = \frac{\sqrt{2mk}}{qB}$$

$$\Rightarrow B = \frac{\sqrt{2mk}}{ql}$$



34.  $V = 12 \text{ KV}$        $E = \frac{V}{l}$       Now,  $F = qE = \frac{qV}{l}$       or,  $a = \frac{F}{m} = \frac{qV}{ml}$

$$v = 1 \times 10^6 \text{ m/s}$$

$$\text{or } v = \sqrt{2 \times \frac{qV}{m} \times l} = \sqrt{2 \times \frac{q}{m} \times 12 \times 10^3}$$

$$\text{or } 1 \times 10^6 = \sqrt{2 \times \frac{q}{m} \times 12 \times 10^3}$$

$$\Rightarrow 10^{12} = 24 \times 10^3 \times \frac{q}{m}$$

$$\Rightarrow \frac{m}{q} = \frac{24 \times 10^3}{10^{12}} = 24 \times 10^{-9}$$

$$r = \frac{mV}{qB} = \frac{24 \times 10^{-9} \times 1 \times 10^6}{2 \times 10^{-1}} = 12 \times 10^{-2} \text{ m} = 12 \text{ cm}$$

35.  $V = 10 \text{ Km/s} = 10^4 \text{ m/s}$

$$B = 1 \text{ T}, \quad q = 2e.$$

$$(a) F = qVB = 2 \times 1.6 \times 10^{-19} \times 10^4 \times 1 = 3.2 \times 10^{-15} \text{ N}$$

$$(b) r = \frac{mV}{qB} = \frac{4 \times 1.6 \times 10^{-27} \times 10^4}{2 \times 1.6 \times 10^{-19} \times 1} = 2 \times \frac{10^{-23}}{10^{-19}} = 2 \times 10^{-4} \text{ m}$$

$$(c) \text{Time taken} = \frac{2\pi r}{V} = \frac{2\pi mV}{qB \times v} = \frac{2\pi \times 4 \times 1.6 \times 10^{-27}}{2 \times 1.6 \times 10^{-19} \times 1}$$

$$= 4\pi \times 10^{-8} = 4 \times 3.14 \times 10^{-8} = 12.56 \times 10^{-8} = 1.256 \times 10^{-7} \text{ sec.}$$

36.  $v = 3 \times 10^6 \text{ m/s}, \quad B = 0.6 \text{ T}, \quad m = 1.67 \times 10^{-27} \text{ kg}$

$$F = qvB \quad q_p = 1.6 \times 10^{-19} \text{ C}$$

$$\text{or, } \vec{a} = \frac{F}{m} = \frac{qvB}{m}$$

$$= \frac{1.6 \times 10^{-19} \times 3 \times 10^6 \times 0.6}{1.67 \times 10^{-27}}$$

$$= 17.245 \times 10^{13} = 1.724 \times 10^{14} \text{ m/s}^2$$

37. (a)  $R = 1 \text{ n}$ ,  $B = 0.5 \text{ T}$ ,  $r = \frac{mv}{qB}$

$$\Rightarrow 1 = \frac{9.1 \times 10^{-31} \times v}{1.6 \times 10^{-19} \times 0.5}$$

$$\Rightarrow v = \frac{1.6 \times 0.5 \times 10^{-19}}{9.1 \times 10^{-31}} = 0.0879 \times 10^{10} \approx 8.8 \times 10^{10} \text{ m/s}$$

No, it is not reasonable as it is more than the speed of light.

(b)  $r = \frac{mv}{qB}$

$$\Rightarrow 1 = \frac{1.6 \times 10^{-27} \times v}{1.6 \times 10^{-19} \times 0.5}$$

$$\Rightarrow v = \frac{1.6 \times 10^{-19} \times 0.5}{1.6 \times 10^{-27}} = 0.5 \times 10^8 = 5 \times 10^7 \text{ m/s.}$$

38. (a) Radius of circular arc =  $\frac{mv}{qB}$

(b) Since MA is tangent to arc ABC, described by the particle.

Hence  $\angle MAO = 90^\circ$

Now,  $\angle NAC = 90^\circ$  [ $\because$  NA is  $\perp$ r]

$\therefore \angle OAC = \angle OCA = \theta$  [By geometry]

Then  $\angle AOC = 180 - (\theta + \theta) = \pi - 2\theta$

(c) Dist. Covered  $l = r\theta = \frac{mv}{qB} (\pi - 2\theta)$

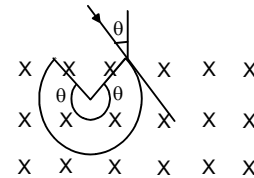
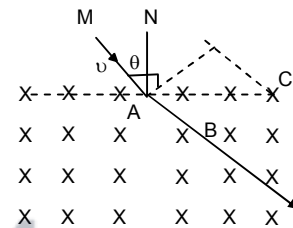
$$t = \frac{l}{v} = \frac{m}{qB} (\pi - 2\theta)$$

(d) If the charge 'q' on the particle is negative. Then

(i) Radius of Circular arc =  $\frac{mv}{qB}$

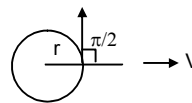
(ii) In such a case the centre of the arc will lie with in the magnetic field, as seen in the fig. Hence the angle subtended by the major arc =  $\pi + 2\theta$

(iii) Similarly the time taken by the particle to cover the same path =  $\frac{m}{qB} (\pi + 2\theta)$



39. Mass of the particle =  $m$ , Charge =  $q$ , Width =  $d$

(a) If  $d = \frac{mV}{qB}$



The  $d$  is equal to radius.  $\theta$  is the angle between the radius and tangent which is equal to  $\pi/2$  (As shown in the figure)

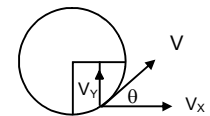
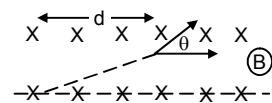
(b) If  $\approx \frac{mV}{2qB}$  distance travelled = (1/2) of radius

Along x-directions  $d = V_x t$  [Since acceleration in this direction is 0. Force acts along  $\hat{j}$  directions]

$$t = \frac{d}{V_x} \quad \dots(1)$$

$$V_y = u_y + a_y t = \frac{0 + qu_x B t}{m} = \frac{qu_x B t}{m}$$

From (1) putting the value of  $t$ ,  $V_y = \frac{qu_x B d}{mV_x}$

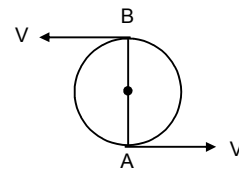


$$\tan \theta = \frac{V_y}{V_x} = \frac{qBd}{mV_x} = \frac{qBmV_x}{2qBmV_x} = \frac{1}{2}$$

$$\Rightarrow \theta = \tan^{-1} \left( \frac{1}{2} \right) = 26.4 \approx 30^\circ = \pi/6$$

$$(c) d \approx \frac{2mu}{qB}$$

Looking into the figure, the angle between the initial direction and final direction of velocity is  $\pi$ .



40.  $u = 6 \times 10^4 \text{ m/s}$ ,  $B = 0.5 \text{ T}$ ,  $r_1 = 3/2 = 1.5 \text{ cm}$ ,  $r_2 = 3.5/2 \text{ cm}$

$$r_1 = \frac{mv}{qB} = \frac{A \times (1.6 \times 10^{-27}) \times 6 \times 10^4}{1.6 \times 10^{-19} \times 0.5}$$

$$\Rightarrow 1.5 = A \times 12 \times 10^{-4}$$

$$\Rightarrow A = \frac{1.5}{12 \times 10^{-4}} = \frac{15000}{12}$$

$$r_2 = \frac{mu}{qB} \Rightarrow \frac{3.5}{2} = \frac{A' \times (1.6 \times 10^{-27}) \times 6 \times 10^4}{1.6 \times 10^{-19} \times 0.5}$$

$$\Rightarrow A' = \frac{3.5 \times 0.5 \times 10^{-19}}{2 \times 6 \times 10^4 \times 10^{-27}} = \frac{3.5 \times 0.5 \times 10^4}{12}$$

$$\frac{A}{A'} = \frac{1.5}{12 \times 10^{-4}} \times \frac{12 \times 10^{-4}}{3.5 \times 0.5} = \frac{6}{7}$$

Taking common ratio = 2 (For Carbon). The isotopes used are  $C^{12}$  and  $C^{14}$

41.  $V = 500 \text{ V}$   $B = 20 \text{ mT} = (2 \times 10^{-3}) \text{ T}$

$$E = \frac{V}{d} = \frac{500}{d} \Rightarrow F = \frac{q500}{d} \Rightarrow a = \frac{q500}{dm}$$

$$\Rightarrow u^2 = 2ad = 2 \times \frac{q500}{dm} \times d \Rightarrow u^2 = \frac{1000 \times q}{m} \Rightarrow u = \sqrt{\frac{1000 \times q}{m}}$$

$$r_1 = \frac{m_1 \sqrt{1000 \times q_1}}{q_1 \sqrt{m_1 B}} = \frac{\sqrt{m_1} \sqrt{1000}}{\sqrt{q_1} B} = \frac{\sqrt{57 \times 1.6 \times 10^{-27} \times 10^3}}{\sqrt{1.6 \times 10^{-19} \times 2 \times 10^{-3}}} = 1.19 \times 10^{-2} \text{ m} = 119 \text{ cm}$$

$$r_1 = \frac{m_2 \sqrt{1000 \times q_2}}{q_2 \sqrt{m_2 B}} = \frac{\sqrt{m_2} \sqrt{1000}}{\sqrt{q_2} B} = \frac{\sqrt{1000 \times 58 \times 1.6 \times 10^{-27}}}{\sqrt{1.6 \times 10^{-19} \times 20 \times 10^{-3}}} = 1.20 \times 10^{-2} \text{ m} = 120 \text{ cm}$$

42. For K - 39 :  $m = 39 \times 1.6 \times 10^{-27} \text{ kg}$ ,  $B = 5 \times 10^{-1} \text{ T}$ ,  $q = 1.6 \times 10^{-19} \text{ C}$ ,  $K.E = 32 \text{ KeV}$ .  
Velocity of projection :  $= (1/2) \times 39 \times (1.6 \times 10^{-27}) v^2 = 32 \times 10^3 \times 1.6 \times 10^{-27} \Rightarrow v = 4.050957468 \times 10^5$   
Through out ht emotion the horizontal velocity remains constant.

$$t = \frac{0.01}{40.50957468 \times 10^5} = 24 \times 10^{-9} \text{ sec. [Time taken to cross the magnetic field]}$$

Accln. In the region having magnetic field =  $\frac{qvB}{m}$

$$= \frac{1.6 \times 10^{-19} \times 4.050957468 \times 10^5 \times 0.5}{39 \times 1.6 \times 10^{-27}} = 5193.535216 \times 10^8 \text{ m/s}^2$$

$V$ (in vertical direction) =  $at = 5193.535216 \times 10^8 \times 24 \times 10^{-9} = 12464.48452 \text{ m/s}$ .

Total time taken to reach the screen =  $\frac{0.965}{40.50957468 \times 10^5} = 0.000002382 \text{ sec}$ .

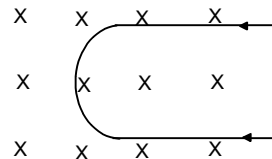
Time gap =  $2383 \times 10^{-9} - 24 \times 10^{-9} = 2358 \times 10^{-9} \text{ sec}$ .

Distance moved vertically (in the time) =  $12464.48452 \times 2358 \times 10^{-9} = 0.0293912545 \text{ m}$

$V^2 = 2as \Rightarrow (12464.48452)^2 = 2 \times 5193.535216 \times 10^8 \times S \Rightarrow S = 0.1495738143 \times 10^{-3} \text{ m}$ .

Net displacement from line =  $0.0001495738143 + 0.0293912545 = 0.0295408283143 \text{ m}$

For K - 41 :  $(1/2) \times 41 \times 1.6 \times 10^{-27} v = 32 \times 10^3 \times 1.6 \times 10^{-19} \Rightarrow v = 39.50918387 \text{ m/s}$ .



$$a = \frac{qvB}{m} = \frac{1.6 \times 10^{-19} \times 395091.8387 \times 0.5}{41 \times 1.6 \times 10^{-27}} = 4818.193154 \times 10^8 \text{ m/s}^2$$

$$t = (\text{time taken for coming outside from magnetic field}) = \frac{0.1}{39501.8387} = 25 \times 10^{-9} \text{ sec.}$$

$$V = at \text{ (Vertical velocity)} = 4818.193154 \times 10^8 \times 25 \times 10^{-9} = 12045.48289 \text{ m/s.}$$

$$\text{(Time total to reach the screen)} = \frac{0.965}{395091.8387} = 0.000002442$$

$$\text{Time gap} = 2442 \times 10^{-9} - 25 \times 10^{-9} = 2417 \times 10^{-9}$$

$$\text{Distance moved vertically} = 12045.48289 \times 2417 \times 10^{-9} = 0.02911393215$$

$$\text{Now, } V^2 = 2as \Rightarrow (12045.48289)^2 = 2 \times 4818.193151 \times S \Rightarrow S = 0.0001505685363 \text{ m}$$

$$\text{Net distance travelled} = 0.0001505685363 + 0.02911393215 = 0.0292645006862$$

$$\text{Net gap between K-39 and K-41} = 0.0295408283143 - 0.0292645006862 = 0.0001763276281 \text{ m} \approx 0.176 \text{ mm}$$

43. The object will make a circular path, perpendicular to the plane of paper  
Let the radius of the object be  $r$

$$\frac{mv^2}{r} = qvB \Rightarrow r = \frac{mV}{qB}$$

Here object distance  $K = 18 \text{ cm.}$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ (lens eqn.)} \Rightarrow \frac{1}{v} - \left(\frac{1}{-18}\right) = \frac{1}{12} \Rightarrow v = 36 \text{ cm.}$$

Let the radius of the circular path of image =  $r'$

$$\text{So magnification} = \frac{v}{u} = \frac{r'}{r} \text{ (magnetic path} = \frac{\text{image height}}{\text{object height}}) \Rightarrow r' = \frac{v}{u}r \Rightarrow r' = \frac{36}{18} \times 4 = 8 \text{ cm.}$$

Hence radius of the circular path in which the image moves is 8 cm.

44. Given magnetic field =  $B$ ,  $Pd = V$ , mass of electron =  $m$ , Charge =  $q$ ,

$$\text{Let electric field be 'E' } \therefore E = \frac{V}{R}, \quad \text{Force Experienced} = eE$$

$$\text{Acceleration} = \frac{eE}{m} = \frac{eV}{Rm} \quad \text{Now, } V^2 = 2 \times a \times S \quad [\because x = 0]$$

$$V = \sqrt{\frac{2 \times e \times V \times R}{Rm}} = \sqrt{\frac{2eV}{m}}$$

$$\text{Time taken by particle to cover the arc} = \frac{2\pi m}{qB} = \frac{2\pi m}{eB}$$

Since the acceleration is along 'Y' axis.

Hence it travels along x axis in uniform velocity

$$\text{Therefore, } r' = v \times t = \sqrt{\frac{2em}{m}} \times \frac{2\pi m}{eB} = \sqrt{\frac{8\pi^2 mV}{eB^2}}$$

45. (a) The particulars will not collide if

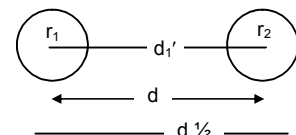
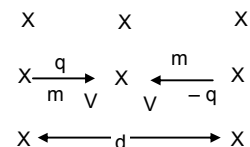
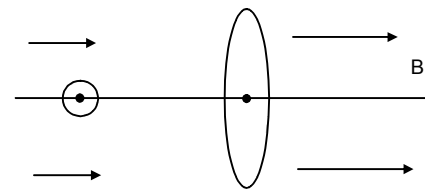
$$d = r_1 + r_2$$

$$\Rightarrow d = \frac{mV_m}{qB} + \frac{mV_m}{qB}$$

$$\Rightarrow d = \frac{2mV_m}{qB} \Rightarrow V_m = \frac{qBd}{2m}$$

$$(b) V = \frac{V_m}{2}$$

$$d_1' = r_1 + r_2 = 2 \left( \frac{m \times qBd}{2 \times 2m \times qB} \right) = \frac{d}{2} \text{ (min. dist.)}$$



Max. distance  $d_2' = d + 2r = d + \frac{d}{2} = \frac{3d}{2}$

(c)  $V = 2V_m$

$r_1' = \frac{m_2 V_m}{qB} = \frac{m \times 2 \times qBd}{2n \times qB}$ ,  $r_2 = d$   $\therefore$  The arc is  $1/6$

(d)  $V_m = \frac{qBd}{2m}$

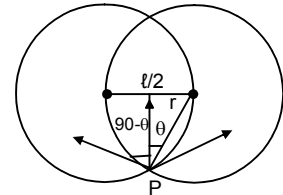
The particles will collide at point P. At point p, both the particles will have motion m in upward direction. Since the particles collide inelastically the stick together.

Distance l between centres = d,  $\sin \theta = \frac{l}{2r}$

Velocity upward =  $v \cos 90 - \theta = V \sin \theta = \frac{Vl}{2r}$

$\frac{mv^2}{r} = qvB \Rightarrow r = \frac{mv}{qB}$

$V \sin \theta = \frac{Vl}{2r} = \frac{Vl}{2 \frac{mv}{qB}} = \frac{qBd}{2m} = V_m$



Hence the combined mass will move with velocity  $V_m$

46.  $B = 0.20 \text{ T}$ ,  $v = ?$   $m = 0.010\text{g} = 10^{-5} \text{ kg}$   $q = 1 \times 10^{-5} \text{ C}$

Force due to magnetic field = Gravitational force of attraction

So,  $qvB = mg$

$\Rightarrow 1 \times 10^{-5} \times v \times 2 \times 10^{-1} = 1 \times 10^{-5} \times 9.8$

$\Rightarrow v = \frac{9.8 \times 10^{-5}}{2 \times 10^{-6}} = 49 \text{ m/s.}$

47.  $r = 0.5 \text{ cm} = 0.5 \times 10^{-2} \text{ m}$

$B = 0.4 \text{ T}$ ,  $E = 200 \text{ V/m}$

The path will straighten, if  $qE = qvB \Rightarrow E = \frac{rqB \times B}{m}$  [ $\therefore r = \frac{mv}{qB}$ ]

$\Rightarrow E = \frac{rqB^2}{m} \Rightarrow \frac{q}{m} = \frac{E}{B^2 r} = \frac{200}{0.4 \times 0.4 \times 0.5 \times 10^{-2}} = 2.5 \times 10^5 \text{ c/kg}$

48.  $M_p = 1.6 \times 10^{-27} \text{ Kg}$

$v = 2 \times 10^5 \text{ m/s}$

$r = 4 \text{ cm} = 4 \times 10^{-2} \text{ m}$

Since the proton is undeflected in the combined magnetic and electric field. Hence force due to both the fields must be same.

i.e.  $qE = qvB \Rightarrow E = vB$

Won, when the electric field is stopped, then it forms a circle due to force of magnetic field

We know  $r = \frac{mv}{qB}$

$\Rightarrow 4 \times 10^2 = \frac{1.6 \times 10^{-27} \times 2 \times 10^5}{1.6 \times 10^{-19} \times B}$

$\Rightarrow B = \frac{1.6 \times 10^{-27} \times 2 \times 10^5}{4 \times 10^2 \times 1.6 \times 10^{-19}} = 0.5 \times 10^{-1} = 0.005 \text{ T}$

$E = vB = 2 \times 10^5 \times 0.05 = 1 \times 10^4 \text{ N/C}$

49.  $q = 5 \mu\text{F} = 5 \times 10^{-6} \text{ C}$ ,

$m = 5 \times 10^{-12} \text{ kg}$ ,

$V = 1 \text{ km/s} = 10^3 \text{ m/s}$

$\theta = \sin^{-1}(0.9)$ ,  $B = 5 \times 10^{-3} \text{ T}$

We have  $mv'^2 = qv'B$

$r = \frac{mv'}{qB} = \frac{mv \sin \theta}{qB} = \frac{5 \times 10^{-12} \times 10^3 \times 9}{5 \times 10^{-6} + 5 \times 10^3 + 10} = 0.18 \text{ metre}$

Hence diameter = 36 cm.,

$$\text{Pitch} = \frac{2\pi r}{v \sin \theta} v \cos \theta = \frac{2 \times 3.1416 \times 0.1 \times \sqrt{1-0.51}}{0.9} = 0.54 \text{ metre} = 54 \text{ mc.}$$

The velocity has a x-component along with which no force acts so that the particle, moves with uniform velocity. The velocity has a y-component with which it accelerates with acceleration a. with the Vertical component it moves in a circular crosssection. Thus it moves in a helix.

50.  $\vec{B} = 0.020 \text{ T}$   $M_p = 1.6 \times 10^{-27} \text{ Kg}$

Pitch = 20 cm =  $2 \times 10^{-1} \text{ m}$

Radius = 5 cm =  $5 \times 10^{-2} \text{ m}$

We know for a helical path, the velocity of the proton has got two components  $\theta_{\perp}$  &  $\theta_H$

$$\text{Now, } r = \frac{m\theta_{\perp}}{qB} \Rightarrow 5 \times 10^{-2} = \frac{1.6 \times 10^{-27} \times \theta_{\perp}}{1.6 \times 10^{-19} \times 2 \times 10^{-2}}$$

$$\Rightarrow \theta_{\perp} = \frac{5 \times 10^{-2} \times 1.6 \times 10^{-19} \times 2 \times 10^{-2}}{1.6 \times 10^{-27}} = 1 \times 10^5 \text{ m/s}$$

However,  $\theta_H$  remains constant

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

$$\text{Pitch} = \theta_H \times T \text{ or, } \theta_H = \frac{\text{Pitch}}{T}$$

$$\theta_H = \frac{2 \times 10^{-1}}{2 \times 3.14 \times 1.6 \times 10^{-27}} \times 1.6 \times 10^{-19} \times 2 \times 10^{-2} = 0.6369 \times 10^5 \approx 6.4 \times 10^4 \text{ m/s}$$

51. Velocity will be along x – z plane

$$\vec{B} = -B_0 \hat{j} \quad \vec{E} = E_0 \hat{k}$$

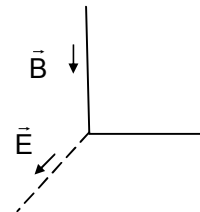
$$F = q (\vec{E} + \vec{v} \times \vec{B}) = q [E_0 \hat{k} + (u_x \hat{i} + u_z \hat{k})(-B_0 \hat{j})] = (qE_0 \hat{k} - (u_x B_0) \hat{k} + (u_z B_0) \hat{i})$$

$$F_z = (qE_0 - u_x B_0)$$

Since  $u_x = 0$ ,  $F_z = qE_0$

$$\Rightarrow a_z = \frac{qE_0}{m}, \text{ So, } v^2 = u^2 + 2as \Rightarrow v^2 = 2 \frac{qE_0}{m} Z \text{ [distance along Z direction be z]}$$

$$\Rightarrow V = \sqrt{\frac{2qE_0 Z}{m}}$$



52. The force experienced first is due to the electric field due to the capacitor

$$E = \frac{V}{d} \quad F = eE$$

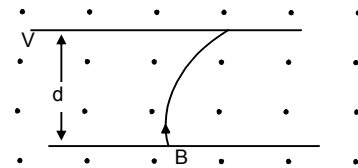
$$a = \frac{eE}{m_e} \quad [\text{Where } e \rightarrow \text{charge of electron } m_e \rightarrow \text{mass of electron}]$$

$$v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times \frac{eE}{m_e} \times d = \frac{2 \times e \times V \times d}{dm_e}$$

$$\text{or } v = \sqrt{\frac{2eV}{m_e}}$$

Now, The electron will fail to strike the upper plate only when d is greater than radius of the are thus formed.

$$\text{or, } d > \frac{m_e \times \sqrt{\frac{2eV}{m_e}}}{eB} \Rightarrow d > \frac{\sqrt{2m_e V}}{eB^2}$$



53.  $\tau = ni \vec{A} \times \vec{B}$

$$\Rightarrow \tau = ni AB \sin 90^\circ \Rightarrow 0.2 = 100 \times 2 \times 5 \times 4 \times 10^{-4} \times B$$

$$\Rightarrow B = \frac{0.2}{100 \times 2 \times 5 \times 4 \times 10^{-4}} = 0.5 \text{ Tesla}$$

54.  $n = 50, r = 0.02 \text{ m}$   
 $A = \pi \times (0.02)^2, \quad B = 0.02 \text{ T}$   
 $i = 5 \text{ A}, \quad \mu = niA = 50 \times 5 \times \pi \times 4 \times 10^{-4}$   
 $\tau$  is max. when  $\theta = 90^\circ$   
 $\tau = \mu \times B = \mu B \sin 90^\circ = \mu B = 50 \times 5 \times 3.14 \times 4 \times 10^{-4} \times 2 \times 10^{-1} = 6.28 \times 10^{-2} \text{ N-M}$   
 Given  $\tau = (1/2) \tau_{\text{max}}$   
 $\Rightarrow \sin \theta = (1/2)$   
 or,  $\theta = 30^\circ = \text{Angle between area vector \& magnetic field.}$   
 $\Rightarrow \text{Angle between magnetic field and the plane of the coil} = 90^\circ - 30^\circ = 60^\circ$

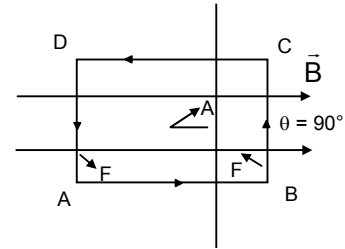
55.  $l = 20 \text{ cm} = 20 \times 10^{-2} \text{ m}$   
 $B = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$

$i = 5 \text{ A}, \quad B = 0.2 \text{ T}$

(a) There is no force on the sides AB and CD. But the force on the sides AD and BC are opposite. So they cancel each other.

(b) Torque on the loop

$\tau = ni \vec{A} \times \vec{B} = niAB \sin 90^\circ$   
 $= 1 \times 5 \times 20 \times 10^{-2} \times 10 \times 10^{-2} \times 0.2 = 2 \times 10^{-2} = 0.02 \text{ N-M}$   
 Parallel to the shorter side.



56.  $n = 500, \quad r = 0.02 \text{ m}, \quad \theta = 30^\circ$   
 $i = 1 \text{ A}, \quad B = 4 \times 10^{-1} \text{ T}$   
 $i = \mu \times B = \mu B \sin 30^\circ = niAB \sin 30^\circ$   
 $= 500 \times 1 \times 3.14 \times 4 \times 10^{-4} \times 4 \times 10^{-1} \times (1/2) = 12.56 \times 10^{-2} = 0.1256 \approx 0.13 \text{ N-M}$

57. (a) radius = r

Circumference =  $L = 2\pi r$

$\Rightarrow r = \frac{L}{2\pi}$

$\Rightarrow \pi r^2 = \frac{\pi L^2}{4\pi^2} = \frac{L^2}{4\pi}$

$\tau = i \vec{A} \times \vec{B} = \frac{iL^2B}{4\pi}$

(b) Circumference = L

$4S = L \Rightarrow S = \frac{L}{4}$

Area =  $S^2 = \left(\frac{L}{4}\right)^2 = \frac{L^2}{16}$

$\tau = i \vec{A} \times \vec{B} = \frac{iL^2B}{16}$

58. Edge = l, Current = i Turns = n, mass = M

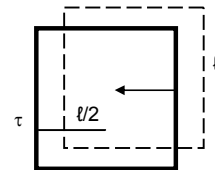
Magnetic field = B

$\tau = \mu B \sin 90^\circ = \mu B$

Min Torque produced must be able to balance the torque produced due to weight

Now,  $\tau B = \tau \text{ Weight}$

$\mu B = \mu g \left(\frac{l}{2}\right) \Rightarrow n \times i \times l^2 B = \mu g \left(\frac{l}{2}\right) \Rightarrow B = \frac{\mu g}{2nil}$



59. (a)  $i = \frac{q}{t} = \frac{q}{(2\pi/\omega)} = \frac{q\omega}{2\pi}$

(b)  $\mu = n i a = i A [\because n = 1] = \frac{q\omega\pi r^2}{2\pi} = \frac{q\omega r^2}{2}$

(c)  $\mu = \frac{q\omega r^2}{2}, L = I\omega = mr^2\omega, \frac{\mu}{L} = \frac{q\omega r^2}{2mr^2\omega} = \frac{q}{2m} \Rightarrow \mu = \left(\frac{q}{2m}\right)L$

60. dp on the small length  $dx$  is  $\frac{q}{\pi r^2} 2\pi x dx$ .

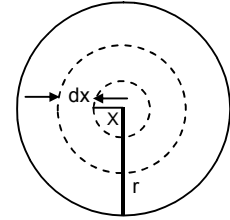
$$di = \frac{q2\pi \times dx}{\pi r^2 t} = \frac{q2\pi x dx \omega}{\pi r^2 q 2\pi} = \frac{q\omega}{\pi r^2} x dx$$

$$d\mu = n di A = di A = \frac{q\omega x dx}{\pi r^2} \pi x^2$$

$$\mu = \int_0^r d\mu = \int_0^r \frac{q\omega}{r^2} x^3 dx = \frac{q\omega}{r^2} \left[ \frac{x^4}{4} \right]_0^r = \frac{q\omega r^4}{r^2 \times 4} = \frac{q\omega r^2}{4}$$

$$I = I \omega = (1/2) m r^2 \omega \quad [\because \text{M.I. for disc is } (1/2) m r^2]$$

$$\frac{\mu}{I} = \frac{q\omega r^2}{4 \times \left(\frac{1}{2}\right) m r^2 \omega} \Rightarrow \frac{\mu}{I} = \frac{q}{2m} \Rightarrow \mu = \frac{q}{2m} I$$



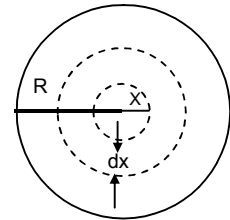
61. Considering a strip of width  $dx$  at a distance  $x$  from centre,

$$dq = \frac{q}{\left(\frac{4}{3}\right)\pi R^3} 4\pi x^2 dx$$

$$di = \frac{dq}{dt} = \frac{q4\pi x^2 dx}{\left(\frac{4}{3}\right)\pi R^3 t} = \frac{3qx^2 dx \omega}{R^3 2\pi}$$

$$d\mu = di \times A = \frac{3qx^2 dx \omega}{R^3 2\pi} \times 4\pi x^2 = \frac{6q\omega}{R^3} x^4 dx$$

$$\mu = \int_0^R d\mu = \int_0^R \frac{6q\omega}{R^3} x^4 dx = \frac{6q\omega}{R^3} \left[ \frac{x^5}{5} \right]_0^R = \frac{6q\omega R^5}{R^3 \times 5} = \frac{6}{5} q\omega R^2$$



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