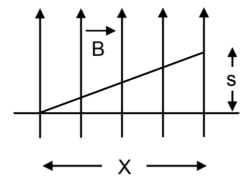
CHAPTER – 34
MAGNETIC FIELD

1. $q = 2 \times 1.6 \times 10^{-19}$ C, $\quad \upsilon = 3 \times 10^4$ km/s $= 3 \times 10^7$ m/s
   $B = 1$ T, $F = qB\upsilon = 2 \times 1.6 \times 10^{-19} \times 3 \times 10^7 \times 1 = 9.6\ 10^{-12}$ N. towards west.

2. KE = 10 Kev $= 1.6 \times 10^{-15}$ J, $\quad \vec{B} = 1 \times 10^{-7}$ T

   (a) The electron will be deflected towards left

   (b) $(1/2)\ mv^2 = KE \Rightarrow V = \sqrt{\dfrac{KE \times 2}{m}}$ $\quad F = qVB$ & accln $= \dfrac{qVB}{m_e}$



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

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

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

3. $B = 4 \times 10^{-3}$ T $(\hat{K})$

   $F = [4\,\hat{i} + 3\,\hat{j} \times 10^{-10}]$ N. $\quad F_X = 4 \times 10^{-10}$ N $\quad F_Y = 3 \times 10^{-10}$ N

   $Q = 1 \times 10^{-9}$ C.

   Considering the motion along x-axis :–

   $F_X = quV_YB \Rightarrow V_Y = \dfrac{F}{qB} = \dfrac{4 \times 10^{-10}}{1 \times 10^{-9} \times 4 \times 10^{-3}} = 100$ m/s

   Along y-axis

   $F_Y = qV_XB \Rightarrow V_X = \dfrac{F}{qB} = \dfrac{3 \times 10^{-10}}{1 \times 10^{-9} \times 4 \times 10^{-3}} = 75$ m/s

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

4. $\vec{B} = (7.0\ i - 3.0\ j) \times 10^{-3}$ T

   $\vec{a}$ = acceleration = $(\text{---}i + 7j) \times 10^{-6}$ m/s^2

   Let the gap be x.

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

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

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

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

5. $m = 10$ g $= 10 \times 10^{-3}$ kg

   $q = 400$ mc $= 400 \times 10^{-6}$ C

   $\upsilon = 270$ m/s, $\quad B = 500\ \mu t = 500 \times 10^{-6}$ Tesla

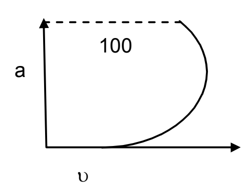
   Force on the particle $= quB = 4 \times 10^{-6} \times 270 \times 500 \times 10^{-6} = 54 \times 10^{-8}$ (K)

   Acceleration on the particle $= 54 \times 10^{-6}$ m/s^2 (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.



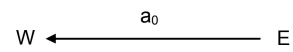
   Along – X axis $100 = 270 \times t \Rightarrow t = \dfrac{10}{27}$

   Along – Z axis $s = ut + (1/2)\ at^2$

   $\Rightarrow s = \dfrac{1}{2} \times 54 \times 10^{-6} \times \dfrac{10}{27} \times \dfrac{10}{27} = 3.7 \times 10^{-6}$

6. $q_P = e$, $m_P = m$, $F = q_P \times E$

or $ma_0 = eE$ or, $E = \dfrac{ma_0}{e}$ 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

$= \overrightarrow{F_B} = m \times 2a_0 = e \times V_0 \times B$

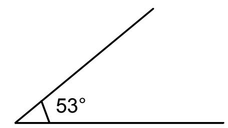
$\Rightarrow B = \dfrac{2ma_0}{eV_0}$ downwards

7. $l = 10$ cm $= 10 \times 10^{-3}$ m $= 10^{-1}$ m

$i = 10$ A, $B = 0.1$ T, $\theta = 53°$

$|F| = iL\,B \sin\theta = 10 \times 10^{-1} \times 0.1 \times 0.79 = 0.0798 \approx 0.08$

direction of F is along a direction $\perp$r to both l and B.



8. $\vec{F} = ilB = 1 \times 0.20 \times 0.1 = 0.02$ N

For $\vec{F} = il \times B$

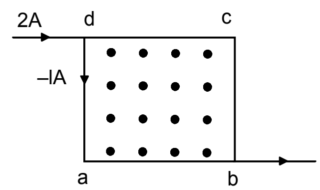
So, For

da & cb $\rightarrow l \times B = l\,B \sin 90°$ towards left

Hence $\vec{F}$ 0.02 N towards left

For

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



9. $F = ilB \sin\theta$

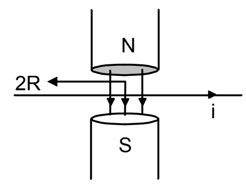
$= ilB \sin 90°$

$= i\,2RB$

$= 2 \times (8 \times 10^{-2}) \times 1$

$= 16 \times 10^{-2}$

$= 0.16$ N.



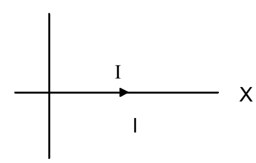
10. Length = l, Current = $l\,\hat{i}$

$\vec{B} = B_0(\hat{i} + \hat{j} + \hat{k})T = B_0\hat{i} + B_0\hat{j} + B_0\hat{k}T$

$F = I\,l \times \vec{B} = I\,l\,\hat{i} \times B_0\hat{i} + B_0\hat{j} + B_0\hat{k}$

$= I\,l\,B_0\,\hat{i} \times \hat{i} + lB_0\,\hat{i} \times \hat{j} + lB_0\,\hat{i} \times \hat{k} = I\,l\,B_0\hat{K} - I\,l\,B_0\,\hat{j}$

or, $|\vec{F}| = \sqrt{2I^2l^2{B_0}^2} = \sqrt{2}\,I\,l\,B_0$



11. $i = 5$ A, $l = 50$ cm $= 0.5$ m

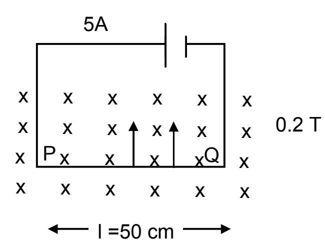
$B = 0.2$ T,

$F = ilB \sin\theta = ilB \sin 90°$

$= 5 \times 0.5 \times 0.2$

$= 0.05$ N

$(\hat{j})$



12. $l = 2\pi a$

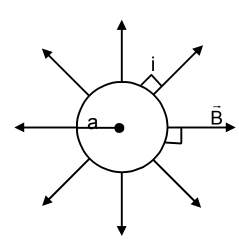
Magnetic field = $\vec{B}$ radially outwards

Current $\Rightarrow$ 'i'

$F = i\,l \times B$

$= i \times (2\pi a \times \vec{B})$

$\otimes = 2\pi ai\,B$ perpendicular to the plane of the figure going inside.

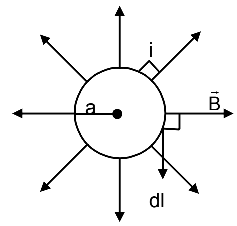


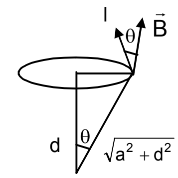
13. $\vec{B} = B_0 \vec{e_r}$

$\vec{e_r}$ = Unit vector along radial direction

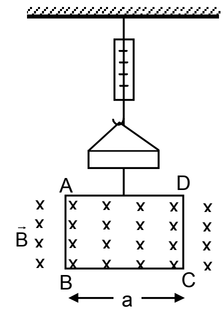
$F = i(\vec{I} \times \vec{B}) = ilB \sin\theta$

$= \dfrac{i(2\pi a)B_0 a}{\sqrt{a^2 + d^2}} = \dfrac{i2\pi a^2 B_0}{\sqrt{a^2 + d^2}}$

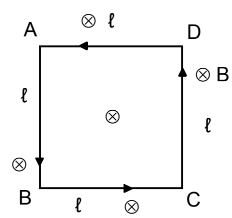




14. Current anticlockwise
Since the horizontal Forces have no effect.
Let us check the forces for current along AD & BC [Since there is no $\vec{B}$]
In AD, F = 0
For BC
F = iaB upward
Current clockwise
Similarly, F = – iaB downwards
Hence change in force = change in tension
= iaB – (–iaB) = 2 iaB

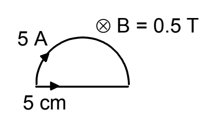


15. F_1 = Force on AD = iℓB inwards
F_2 = Force on BC = iℓB inwards
They cancel each other
F_3 = Force on CD = iℓB inwards
F_4 = Force on AB = iℓB inwards
They also cancel each other.
So the net force on the body is 0.



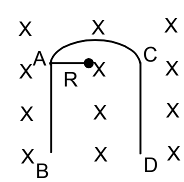
16. For force on a current carrying wire in an uniform magnetic field
We need, $l \to$ length of wire
$i \to$ Current
$B \to$ Magnitude of magnetic field
Since $\vec{F} = i\ell B$
Now, since the length of the wire is fixed from A to B, so force is independent of the shape of the wire.

17. Force on a semicircular wire
= 2iRB
= 2 × 5 × 0.05 × 0.5
= 0.25 N



18. Here the displacement vector $\vec{dl} = \lambda$
So magnetic for $i \to t\,\vec{dl} \times \vec{B} = i \times \lambda B$

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



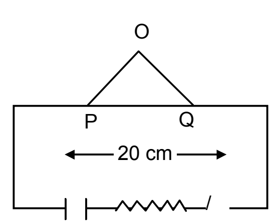
20. Mass = 10 mg = 10^{-5} kg
Length = 1 m
I = 2 A, B = ?
Now, Mg = ilB

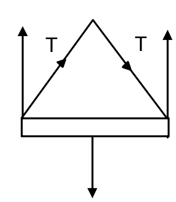
$\Rightarrow B = \dfrac{mg}{il} = \dfrac{10^{-5} \times 9.8}{2 \times 1} = 4.9 \times 10^{-5}$ T

21. (a) When switch S is open
2T Cos 30° = mg

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

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





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

Then

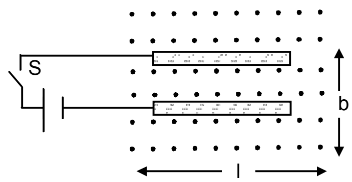
$\Rightarrow$ 2T Cos 30° = mg + ilB

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

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

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

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

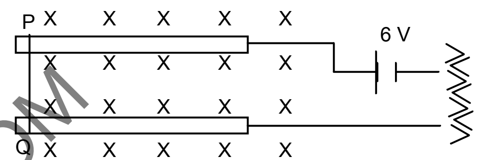


So, $F \times l = \mu mg \times x$

$\Rightarrow ibBl = \mu mgx$

$\Rightarrow x = \dfrac{ibBl}{\mu mg}$

23. $\mu R = F$

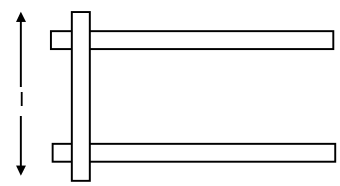


$\Rightarrow \mu \times m \times g = ilB$

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

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

24. Mass = m



length = l

Current = i

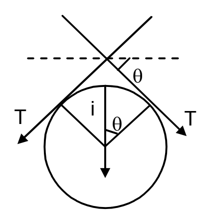
Magnetic field = B = ?

friction Coefficient = μ

$iBl = \mu mg$

$\Rightarrow B = \dfrac{\mu mg}{il}$

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 20 at the centre.

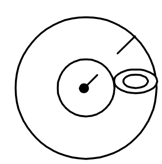
Here $2T \sin \theta = i \times dl \times B$

$\Rightarrow 2T\theta = i \times a \times 2\theta \times B$ [As $\theta \to 0$, $\sin \theta \approx 0$]

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

Force of compression on the wire = i a B

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



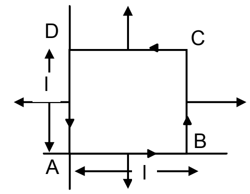
$\Rightarrow \dfrac{dl}{L} Y = \dfrac{F}{\pi r^2} \Rightarrow dl = \dfrac{F}{\pi r^2} \times \dfrac{L}{Y}$

$= \dfrac{iaB}{\pi r^2} \times \dfrac{2\pi a}{Y} = \dfrac{2\pi a^2 iB}{\pi r^2 Y}$

So, $dp = \dfrac{2\pi a^2 iB}{\pi r^2 Y}$ (for small cross sectional circle)

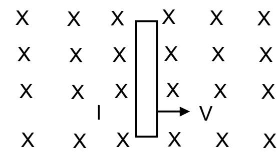
$dr = \dfrac{2\pi a^2 iB}{\pi r^2 Y} \times \dfrac{1}{2\pi} = \dfrac{a^2 iB}{\pi r^2 Y}$

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



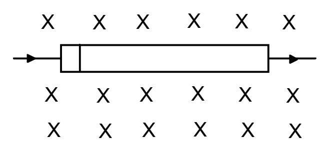
f_1 = force on AB = $iB_0[1 + 0]l = iB_0l$
f_2 = force on CD = $iB_0[1 + 0]l = iB_0l$
f_3 = force on AD = $iB_0[1 + 0/1]l = iB_0l$
f_4 = force on AB = $iB_0[1 + 1/1]l = 2iB_0l$
Net horizontal force = $F_1 - F_2 = 0$
Net vertical force = $F_4 - F_3 = iB_0l$

28. (a) Velocity of electron = υ



Magnetic force on electron
$F = e\upsilon B$
(b) $F = qE$; $F = e\upsilon B$
or, $qE = e\upsilon B$
$\Rightarrow eE = e\upsilon B$ or, $\vec{E} = \upsilon B$
(c) $E = \frac{dV}{dr} = \frac{V}{l}$
$\Rightarrow V = lE = l\upsilon B$

29. (a) $i = V_0nAe$



$\Rightarrow V_0 = \frac{i}{nae}$
(b) $F = ilB = \frac{iBl}{nA} = \frac{iB}{nA}$ (upwards)
(c) Let the electric field be E
$Ee = \frac{iB}{An} \Rightarrow E = \frac{iB}{Aen}$
(d) $\frac{dv}{dr} = E \Rightarrow dV = Edr$
$= E\times d = \frac{iB}{Aen}d$

30. $q = 2.0 \times 10^{-8}$ C $\vec{B} = 0.10$ T
$m = 2.0 \times 10^{-10}$ g $= 2 \times 10^{-13}$ g
$\upsilon = 2.0 \times 10^{3}$ m/′
$R = \frac{m\upsilon}{qB} = \frac{2\times10^{-13}\times2\times10^{3}}{2\times10^{-8}\times10^{-1}} = 0.2$ m = 20 cm
$T = \frac{2\pi m}{qB} = \frac{2\times3.14\times2\times10^{-13}}{2\times10^{-8}\times10^{-1}} = 6.28 \times 10^{-4}$ s

31. $r = \frac{mv}{qB}$
$0.01 = \frac{mv}{e0.1}$ …(1)
$r = \frac{4m\times V}{2e\times0.1}$ …(2)
(2) ÷ (1)
$\Rightarrow \frac{r}{0.01} = \frac{4mVe\times0.1}{2e\times0.1\times mv} = \frac{4}{2} = 2 \Rightarrow r = 0.02$ m = 2 cm.

32. KE = 100ev = 1.6×10^{-17} J
$(1/2) \times 9.1 \times 10^{-31} \times V^2 = 1.6 \times 10^{-17}$ J
$\Rightarrow V^2 = \frac{1.6\times10^{-17}\times2}{9.1\times10^{-31}} = 0.35 \times 10^{14}$

or, V = 0.591 × 10^7 m/s

Now r = $\frac{m\upsilon}{qB} \Rightarrow \frac{9.1\times10^{-31}\times0.591\times10^{7}}{1.6\times10^{-19}\times B} = \frac{10}{100}$

$\Rightarrow$ B = $\frac{9.1\times0.591}{1.6}\times\frac{10^{-23}}{10^{-19}}$ = 3.3613 × 10^{-4} T ≈ 3.4 × 10^{-4} T

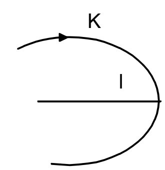
T = $\frac{2\pi m}{qB} = \frac{2\times3.14\times9.1\times10^{-31}}{1.6\times10^{-19}\times3.4\times10^{-4}}$

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

= $\frac{1.6\times3.4}{2\times3.14\times9.1}\times\frac{10^{-19}\times10^{-4}}{10^{-31}}$ = 0.0951 × 10^8 ≈ 9.51 × 10^6

Note: ∴ Puttig $\vec{B}$ 3.361 × 10^{-4} T We get f = 9.4 × 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 KV E = $\frac{V}{l}$ Now, F = qE = $\frac{qV}{l}$ or, a = $\frac{F}{m} = \frac{qV}{ml}$

υ = 1 × 10^6 m/s

or V = $\sqrt{2\times\frac{qV}{ml}\times l} = \sqrt{2\times\frac{q}{m}\times12\times10^{3}}$

or 1 × 10^6 = $\sqrt{2\times\frac{q}{m}\times12\times10^{3}}$

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

$\Rightarrow \frac{m}{q} = \frac{24\times10^{3}}{10^{12}}$ = 24 × 10^{-9}

r = $\frac{mV}{qB} = \frac{24\times10^{-9}\times1\times10^{6}}{2\times10^{-1}}$ = 12 × 10^{-2} m = 12 cm

35. V = 10 Km/′ = 10^4 m/s
B = 1 T, q = 2e.
(a) F = qVB = 2 × 1.6 × 10^{-19} × 10^4 × 1 = 3.2 × 10^{-15} N

(b) r = $\frac{mV}{qB} = \frac{4\times1.6\times10^{-27}\times10^{4}}{2\times1.6\times10^{-19}\times1}$ = 2 × $\frac{10^{-23}}{10^{-19}}$ = 2 × 10^{-4} m

(c)Time taken = $\frac{2\pi r}{V} = \frac{2\pi mv}{qB\times v} = \frac{2\pi\times4\times1.6\times10^{-27}}{2\times1.6\times10^{-19}\times1}$

= 4π × 10^{-8} = 4 × 3.14 × 10^{-8} = 12.56 × 10^{-8} = 1.256 × 10^{-7} sex.

36. υ = 3 × 10^6 m/s, B = 0.6 T, m = 1.67 × 10^{-27} kg
F = qυB q_P = 1.6 × 10^{-19} C

or, $\vec{a} = \frac{F}{m} = \frac{q\upsilon B}{m}$

= $\frac{1.6\times10^{-19}\times3\times10^{6}\times10^{-1}}{1.67\times10^{-27}}$

= 17.245 × 10^{13} = 1.724 × 10^4 m/s^2

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

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

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

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

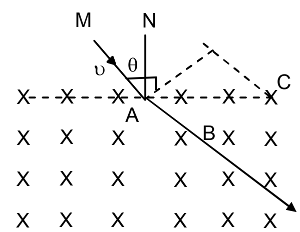
(b) $r = \frac{m\upsilon}{qB}$

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

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

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

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



Hence $\angle MAO = 90°$

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

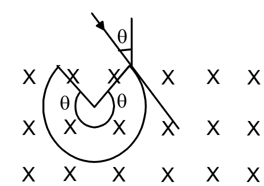
$\therefore \angle OAC = \angle OCA = \theta$ [By geometry]

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

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

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

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

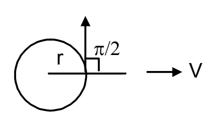


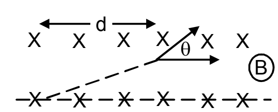
(i) Radius of Circular arc = $\frac{m\upsilon}{qB}$

(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

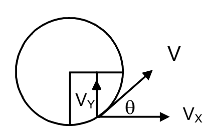




(a) If $d = \frac{mV}{qB}$

The d is equal to radius. θ 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



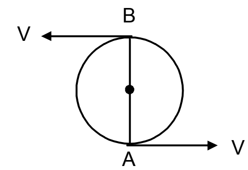
Along x-directions $d = V_X t$ [Since acceleration in this direction is 0. Force acts along $\hat{j}$ directions]

$t = \frac{d}{V_X}$ …(1)

$V_Y = u_Y + a_Y t = \frac{0 + qu_X Bt}{m} = \frac{qu_X Bt}{m}$

From (1) putting the value of t, $V_Y = \frac{qu_X Bd}{mV_X}$

Tan θ = $\frac{V_Y}{V_X} = \frac{qBd}{mV_X} = \frac{qBmV_X}{2qBmV_X} = \frac{1}{2}$

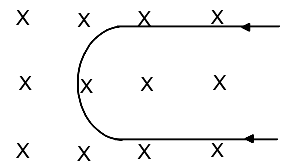


$\Rightarrow \theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.4 \approx 30° = \pi/6$

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

Looking into the figure, the angle between the initial direction and final direction of velocity is π.

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



$r_1 = \frac{mv}{qB} = \frac{A\times(1.6\times10^{-27})\times6\times10^4}{1.6\times10^{-19}\times0.5}$

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

$\Rightarrow A = \frac{1.5}{12\times10^{-4}} = \frac{15000}{12}$

$r_2 = \frac{mu}{qB} \Rightarrow \frac{3.5}{2} = \frac{A'\times(1.6\times10^{-27})\times6\times10^4}{1.6\times10^{-19}\times0.5}$

$\Rightarrow A' = \frac{3.5\times0.5\times10^{-19}}{2\times6\times10^4\times10^{-27}} = \frac{3.5\times0.5\times10^4}{12}$

$\frac{A}{A'} = \frac{1.5}{12\times10^{-4}}\times\frac{12\times10^{-4}}{3.5\times0.5} = \frac{6}{7}$

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

41. V = 500 V B = 20 mT = (2×10^{-3}) T

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

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

$r_1 = \frac{m_1\sqrt{1000\times q_1}}{q_1\sqrt{m_1}B} = \frac{\sqrt{m_1}\sqrt{1000}}{\sqrt{q_1}B} = \frac{\sqrt{57\times1.6\times10^{-27}\times10^3}}{\sqrt{1.6\times10^{-19}}\times2\times10^{-3}} = 1.19 \times 10^{-2}$ m = 119 cm

$r_1 = \frac{m_2\sqrt{1000\times q_2}}{q_2\sqrt{m_2}B} = \frac{\sqrt{m_2}\sqrt{1000}}{\sqrt{q_2}B} = \frac{\sqrt{1000\times58\times1.6\times10^{-27}}}{\sqrt{1.6\times10^{-19}}\times20\times10^{-3}} = 1.20 \times 10^{-2}$ m = 120 cm

42. For K – 39 : m = $39 \times 1.6 \times 10^{-27}$ kg, B = 5×10^{-1} T, q = 1.6×10^{-19} C, K.E = 32 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.

$t = \frac{0.01}{40.50957468\times10^5} = 24 \times 10^{-19}$ sec. [Time taken to cross the magnetic field]

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

$= \frac{1.6\times10^{-19}\times4.050957468\times10^5\times0.5}{39\times1.6\times10^{-27}} = 5193.535216 \times 10^8$ m/s^2

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

Total time taken to reach the screen = $\frac{0.965}{40.50957468\times10^5} = 0.000002382$ sec.

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

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

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

Net displacement from line = 0.0001495738143 + 0.0293912545 = 0.0295408283143 m

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

$a = \frac{qvB}{m} = \frac{1.6\times10^{-19}\times395091.8387\times0.5}{41\times1.6\times10^{-27}}$ = 4818.193154 × 10^8 m/s^2

t = (time taken for coming outside from magnetic field) = $\frac{00.1}{39501.8387}$ = 25 × 10^{-9} sec.

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

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

Time gap = 2442 × 10^{-9} – 25 × 10^{-9} = 2417 × 10^{-9}

Distance moved vertically = 12045.48289 × 2417 × 10^{-9} = 0.02911393215

Now, V^2 = 2as ⇒ $(12045.48289)^2$ = 2 × 4818.193151 × S ⇒ S = 0.0001505685363 m

Net distance travelled = 0.0001505685363 + 0.02911393215 = 0.0292645006862

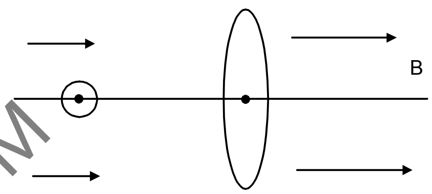
Net gap between K– 39 and K– 41 = 0.0295408283143 – 0.0292645006862

= 0.0001763276281 m ≈ 0.176 mm

43. The object will make a circular path, perpendicular to the plance 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 cm.

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

Let the radius of the circular path of image = r′

So magnification = $\frac{v}{u} = \frac{r'}{r}$(magnetic path = $\frac{\text{image height}}{\text{object height}}$) ⇒ r′ = $\frac{v}{u}r$ ⇒ r′ = $\frac{36}{18}\times4$ = 8 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,

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

Acceleration = $\frac{eE}{m} = \frac{eE}{Rm}$ Now, V^2 = 2 × a × S [∵ x = 0]

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

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

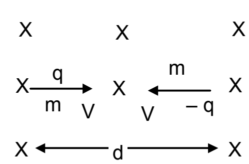
Since the acceleration is along 'Y' axis.

Hence it travels along x axis in uniform velocity

Therefore, ′ = υ × 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

$d = r_1 + r_2$

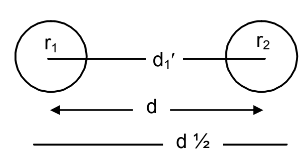


$\Rightarrow d = \frac{mV_m}{qB} + \frac{mV_m}{qB}$

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

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

$d_1' = r_1 + r_2 = 2\left(\frac{m\times qBd}{2\times2m\times qB}\right) = \frac{d}{2}$ (min. dist.)



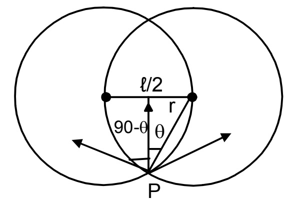
Max. distance $d_2' = d + 2r = d + \frac{d}{2} = \frac{3d}{2}$

(c) $V = 2V_m$

$r_1' = \frac{m_2 V_m}{qB} = \frac{m \times 2 \times qBd}{2n \times qB}$, $\quad r_2 = d \quad \therefore$ 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. $B = 0.20$ T, $\quad \upsilon = ?$ $\quad m = 0.010g = 10^{-5}$ kg, $\quad q = 1 \times 10^{-5}$ C

Force due to magnetic field = Gravitational force of attraction

So, $q\upsilon B = mg$

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

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

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

$B = 0.4$ T, $\quad E = 200$ V/m

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

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

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

$\upsilon = 2 \times 10^5$ m/s $\quad r = 4$ cm $= 4 \times 10^{-2}$ 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. $qE = q\upsilon B \Rightarrow E = \upsilon B$

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

We know $r = \frac{m\upsilon}{qB}$

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

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

$E = \upsilon B = 2 \times 10^5 \times 0.05 = 1 \times 10^4$ N/C

49. $q = 5\ \mu F = 5 \times 10^{-6}$ C, $\quad m = 5 \times 10^{-12}$ kg, $\quad V = 1$ km/s $= 10^3$ m/′

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

We have $mv'^2 = qv'B$ $\quad r = \frac{mv'}{qB} = \frac{mv\sin\theta}{qB} = \frac{5 \times 10^{-12} \times 10^3 \times 9}{5 \times 10^{-6} + 5 \times 10^3 + 10} = 0.18$ metre

Hence dimeter = 36 cm.,

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 metre = 54 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 is 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 T $\qquad$ M_P = 1.6 × 10^{-27} Kg

Pitch = 20 cm = 2 × 10^{-1} m

Radius = 5 cm = 5 × 10^{-2} m

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

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 × 10^5 m/s

However, θ_H remains constant

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

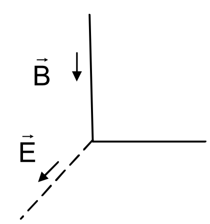
Pitch = θ_H ×T or, $\theta_H = \frac{\text{Pitch}}{T}$

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

51. Velocity will be along x – z plane

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

$F = q\left(\vec{E} + \vec{V} \times \vec{B}\right) = q\left[E_0\hat{k} + (u_x\hat{i} + u_x\hat{k})(-B_0\hat{j})\right] = (qE_0)\hat{k} - (u_xB_0)\hat{k} + (u_zB_0)\hat{i}$



$F_z = (qE_0 - u_xB_0)$

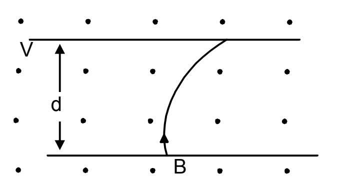
Since $u_x = 0$, $F_z = qE_0$

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

$\Rightarrow V = \sqrt{\frac{2qE_0Z}{m}}$

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

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



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

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

or $\upsilon = \sqrt{\frac{2eV}{m_e}}$

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

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

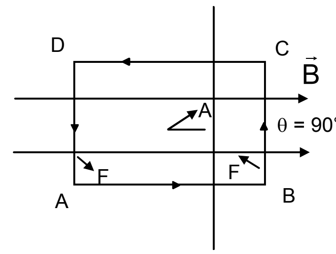
53. $\tau = ni\,\vec{A} \times \vec{B}$

$\Rightarrow \tau$ = ni AB Sin 90° ⇒ 0.2 = 100 × 2 × 5 × 4 × 10^{-4} × B

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

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

55. $l = 20 \text{ cm} = 20 \times 10^{-2}$ m
$B = 10 \text{ cm} = 10 \times 10^{-2}$ m
$i = 5$ A, $B = 0.2$ 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°
$= 1 \times 5 \times 20 \times 10^{-2} \times 10 \times 10^{-2}\ 0.2 = 2 \times 10^{-2} = 0.02$ N-M
Parallel to the shorter side.

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

57. (a) radius = r
Circumference $= L = 2\pi r$

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

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

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

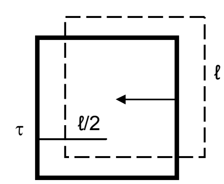
(b) Circumfernce = L

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

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

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

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



$\tau = \mu B \text{ Sin } 90° = \mu B$
Min Torque produced must be able to balance the torque produced due to weight
Now, $\tau B = \tau$ Weight

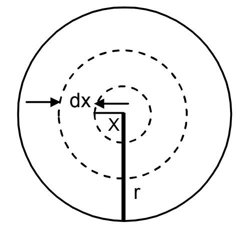
$$\mu B = \mu g\left(\frac{l}{2}\right) \Rightarrow n \times i \times l^2\, B = \mu g\left(\frac{l}{2}\right) \qquad \Rightarrow B = \frac{\mu g}{2nil}$$

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

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

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

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



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

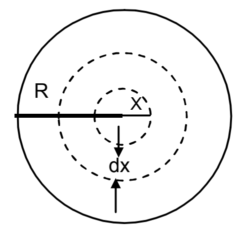
$$d\mu = n\ di\ A = di\ A = \frac{q\omega x dx}{\pi r^2} \pi x^2$$

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

$I = I\ \omega = (1/2)\ mr^2\ \omega$ [$\therefore$ M.I. for disc is $(1/2)\ mr^2$]

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

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



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

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

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

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

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