MAHESH TUTORIALS SCIENCE

00 – 00		Q. Booklet Serial No: 090815	
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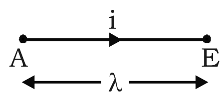
Hints & Solutions

PART A - PHYSICS

1. **d)** **Force is λ aBI, if $\vec{B}$ is in the x-direction.**

conductor ABCDE can be replaced by a straight wire from A to E



If $\vec{B}$ is in x direction , $\vec{B} \parallel \vec{dl}$, so Force will be zero

2. **c)** **distance moved by particle in time t = $\frac{\pi}{B_0\alpha}$ is $\frac{\pi V_0}{B_0\alpha}$**

As $\vec{V} \perp \vec{B}$: path will be circular and speed will be constant.

As speed is constant so distance

= speed × time

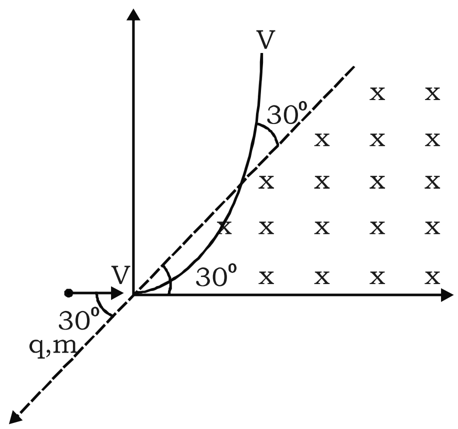
$= V_0 \times \frac{\pi}{B_0\alpha} = \frac{\pi V_0}{B_0\alpha}$

3. **d)** **distance travelled by the particle in time t does not depend on the angle between $\vec{V}$ and $\vec{B}$**

If $\vec{V} \times \vec{B} = 0$ then angle between $\vec{V}$ and $\vec{B}$ will be either 0° or 180°, so particle will move undeviated on straight line.

If $\vec{V} \times \vec{B} = 0$, $\vec{V} \perp \vec{B}$: path will be circular distance travelled by particle depends on speed and time only.

4. **d)** **all of these**



$\vec{V}$ will make angle 60° from x axis when it comes out from field, magnitude will be same

$\vec{V_0} = (V\cos 60)\hat{i} + (V\sin 60)\hat{j}$

As angle of deviation = 60°

$\therefore$ time $= \frac{\pi m}{3qB}$

distance = speed × time = $V\left(\frac{\pi m}{3qB}\right)$

5. **b)** **A and C**

A and C are equidistant , B and D are also equidistant from wire.

6. **a)** **$B = \frac{\mu_0 i}{2\sqrt{2}\pi}$**

Perpendicular distance of point D = $\sqrt{2}$

$\therefore$ $B = \frac{\mu_0 i}{2\pi d} = \frac{\mu_0 i}{2\sqrt{2}\pi}$

7. **b)** **E_z = – 100 V/m**

Proton will go undeviated if force by electric field and magnetic field are equal and opposite.

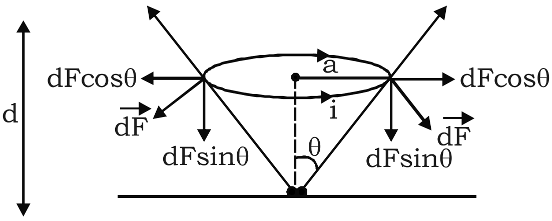
Direction of magnetic force is in + Z direction.

$F_B = F_E \Rightarrow q\,v\,B = qE \Rightarrow E = vB$

$= (10 \times 1000)(0.01)$

$= 100$ v/m

8. **a)** $\dfrac{\mathbf{2\,B\,i\,\pi\,a^2}}{\sqrt{\mathbf{a^2+d^2}}}$



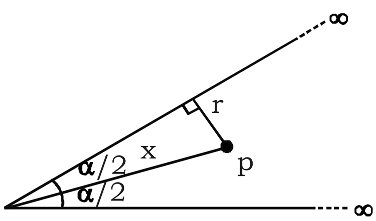
dF cos θ will be cancelled out

$F = \int dF\sin\theta = \int (B\,i\,dl)\sin\theta = Bi\sin\theta\int dl$

$= Bi\sin\theta\,(2\pi a)$

$= Bi\left(\dfrac{a}{\sqrt{a^2+d^2}}\right)(2\pi a)$

9. **c)** $\dfrac{\mathbf{\mu_0 I}}{\mathbf{2\pi x}}\,\mathbf{\cot \alpha/4}$



$r = x\sin\dfrac{\alpha}{2}$

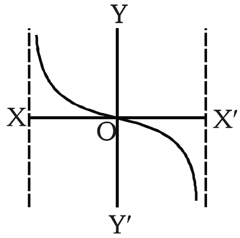
$B_p = 2\,B_{onewire}$

$= 2\left[\dfrac{\mu_0 I}{4\pi\left(x\sin\dfrac{\alpha}{2}\right)}.(\cos\alpha+\cos 0)\right]$

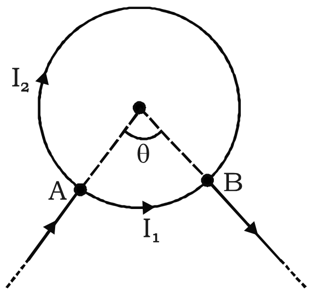
on solving : $B_p = \dfrac{\mu_0 I}{2\pi x}\cot\dfrac{\alpha}{4}$

direction :

10. **a)**



11. **d)** **zero**



$R \propto l \propto q$

In parallel : $I \propto \dfrac{1}{R} \propto \dfrac{1}{\theta}$

$\therefore\quad I_1 : I_2 = \dfrac{1}{\theta_1} : \dfrac{1}{\theta_2} = \dfrac{1}{\theta} : \dfrac{1}{2\pi-\theta}$

$\therefore\quad I_1 : I_2 = (2\pi-\theta) : \theta$

$\therefore\quad I_1 = \left(\dfrac{2\pi-\theta}{2\pi}\right)I,\ I_2 = \left(\dfrac{\theta}{2\pi}\right)I$

$\therefore\quad B_1 = \dfrac{\mu_0 I_1}{4\pi r}\theta = \dfrac{\mu_0 I}{4\pi r}\left(\dfrac{2\pi-\theta}{2\pi}\right)I\theta$

direction(×)

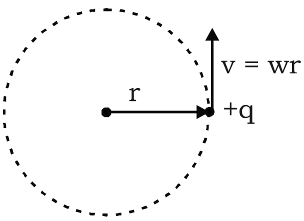
$\therefore\quad B_2 = \dfrac{\mu_0 I_2}{4\pi r}(2\pi-\theta) = \dfrac{\mu_0}{4\pi r}\left(\dfrac{\theta}{2\pi}\right)I\,(2\pi-\theta)$

direction (.)

$\vec{B_1} = -\vec{B_2}$

$\therefore\quad B_{net} = 0$

12. **a)** $\dfrac{\mathbf{\mu_0 q\omega}}{\mathbf{4\pi r}}$



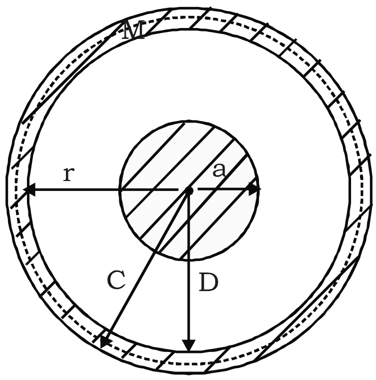
$$B = \frac{\mu_0}{4\pi}\frac{qv\sin 90}{r^2} = \frac{\mu_0 q v}{4\pi r^2}$$

As $V = \omega r$

$$B = \frac{\mu_0 q\omega}{4\pi r}$$

13. **a)** $\frac{\mu_0 I}{2\pi r}\left(\frac{c^2 - r^2}{c^2 - b^2}\right)$

Cross section of cable :



Using Ampere's law on path M :

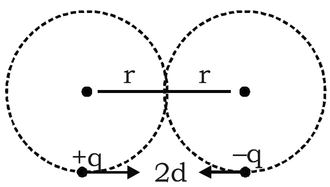
$$\oint_M \vec{B}.\vec{dl} = \mu_0\left[I - \frac{I(r^2 - b^2)}{(c^2 - b^2)}\right]$$

$\Rightarrow$ $$B(2\pi r) = \mu_0 I\left[\frac{c^2 - b^2 - r^2 + b^2}{c^2 - b^2}\right]$$

$\Rightarrow$ $$B = \frac{\mu_0 I}{2\pi r}\left[\frac{c^2 - r^2}{c^2 - b^2}\right]$$

14. **c)** $\frac{\mathbf{qBd}}{\mathbf{m}}$

For no collision $2r < 2d$ or $r < d$



$\Rightarrow$ $\frac{mu}{qB} < d$

$\Rightarrow$ $u < \frac{qBd}{m}$

$\therefore$ Maximum speed = $\frac{qBd}{m}$

15. **c)** **I, IV**

For just tipping off.

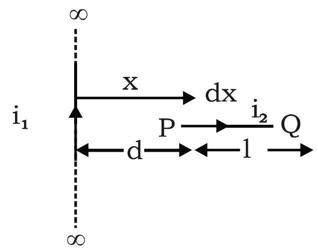
16. **a)** $\mathbf{I = \frac{mg}{\pi RB}}$

Torque due to mg = torque due to external field.

$\Rightarrow$ $mgR = I(\pi R^2)\, B \sin 90$

$\Rightarrow$ $I = \frac{mg}{B(\pi R)}$

17. **a)** $\mathbf{F_{12} = 0, F_{21} = [(2 \times 10^{-7}) \ln 2]\ N}$



$$B \text{ (at x)} = \frac{\mu_0 i}{2\pi x}\left(-\hat{k}\right)$$

Force on element

$$dF = i_2\left[(dx)\,\hat{i} \times \frac{\mu_0\, i_1}{2\pi x}\left(-\hat{k}\right)\right]$$

$\therefore$ Force on PQ = $\int \vec{dF}$

$$= \frac{\mu_0 i_1 i_2}{2\pi}\int \frac{dx}{x}\left(\hat{j}\right)$$

$$= \frac{\mu_0 i_1 i_2}{2\pi}\ln\frac{(d + l)}{d}\hat{j}$$

Force on infinite long wire due to PQ wire = Zero (By symmetry)

[Newton's 3rd law is not valid]

18. **b)** $\mathbf{F_1 = F_2 = 0}$

Due to long wire along z direction, magnetic field lines will be in x-y plane. So

$\vec{B}_1 \parallel \left(\vec{dl}_2\right)$ $\therefore$ $F_2 = 0$

Length of wire 1 is along with magnetic field produce by circular loop

$\therefore$ $F_1 = 0$

[It is coincidence that $F_1 = F_2$: Newtons 3rd law is not valid]

19. **b)** $\left(\frac{4\pi}{3}\right)R^4\sigma\omega$

$\frac{M}{L} = \frac{q}{2m}$

$\Rightarrow M = \frac{qL}{2m} = \frac{4\pi R^2\sigma}{2m}\times\frac{2}{3}mR^2\omega$

$= \frac{4\pi}{3}R^4\sigma\omega$

20. **b)** **1.4**

Current sensitivity $= \frac{BNA}{C}$

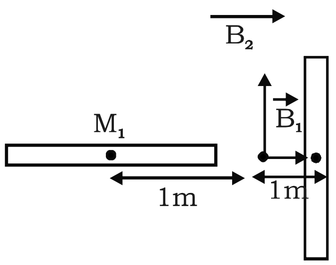
C = same (given)

$\frac{S_2}{S_1} = \left(\frac{B_2}{B_1}\right)\times\left(\frac{N_2}{N_1}\right)\times\left(\frac{A_2}{A_1}\right)$

$= \left(\frac{0.50}{0.25}\right)\times\left(\frac{42}{30}\right)\times\left(\frac{1.8\times10^{-3}}{3.6\times10^{-3}}\right)$

= 1.4

21. **d)** $\sqrt{5}\times10^{-7}$ **T**



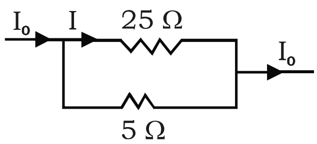
$B_1 = \frac{\mu_0}{4\pi}\frac{2M}{r^3} = (10^{-7})\frac{(2)(1)}{(1)^3} = 2\times10^{-7}\,T$

$B_2 = \frac{\mu_0}{4\pi}\frac{M}{r^3} = (10^{-7})\frac{(1)}{(1)^3} = 1\times10^{-7}\,T$

$\therefore B_{net} = \sqrt{B_1^2+B_2^2}$

$= \sqrt{5}\times10^{-7}\,T$

22. **b)** $\frac{I}{I_0} = \frac{1}{6}$



$I = \left(\frac{5}{25+5}\right)I_0 = \frac{I_0}{6}$

$\therefore \frac{I}{I_0} = \frac{1}{6}$

23. **b)** $\frac{\pi}{3}$

$\frac{B_V}{B_H} = \tan\theta$ (θ = angle of dip)

24. **a)** **the angle of dip is zero**

Aclinic line : It is a circle on earth surface at every point of which dip angle is zero.

25. **a)** $\mu_r > 1, X_m > 1$

26. **a)** $\pi\times10^{-4}$

$\mu = \mu_0(1+x) = (4\pi\times10^{-7})(1+249)$

$= \pi\times10^{-4}$

27. **b)** **2sec**

$T = 2\pi\sqrt{\frac{I}{MB}}$

$I = \frac{ml^2}{12}$, $M = m'(l)$

$\Rightarrow T = 2\pi\sqrt{\frac{ml^2}{12\times m'lB}}$

$= 2\pi\sqrt{\frac{ml}{12m'B}}$

$\therefore T\propto\sqrt{ml}$

On cutting magnet half

$m_2 = \frac{m_1}{2}$,

$l_2 = \frac{l_1}{2}$, $m'B$ = constant

$\frac{T_2}{T_1} = \sqrt{\frac{m_2l_2}{m_1l_1}}$

$= \sqrt{\frac{1}{4}} = \frac{1}{2}$

$\Rightarrow \quad T_2 = \frac{T_1}{2} = \frac{4\,\text{sec}}{2}$

$= 2\ \text{sec}$

28. **a)** **BIAN**

$W_{ext} = I(\phi_i - \phi_f)$

$\phi_i = BNA \quad , \quad \phi_f = 0$

$\therefore \quad W_{ext} = I(BNA)$

29. **b)** $\mathbf{r_\alpha = r_p < r_d}$

$r = \frac{mv}{qB} = \frac{\sqrt{2mk}}{qB}$

or

$r \propto \frac{\sqrt{m}}{q^2}$

30. **b)** **40π rad/s**

$t = I\alpha$

$\Rightarrow \quad MB = I\alpha$

$\Rightarrow \quad i(\pi r^2)B = \frac{1}{2}mr^2\alpha$

$\Rightarrow \quad \alpha = \frac{2iB\pi}{m}$

$= \frac{2 \times 4 \times 10 \times \pi}{2}$

$= 40\pi\ \text{rad/s}^2$