Magnetism solution

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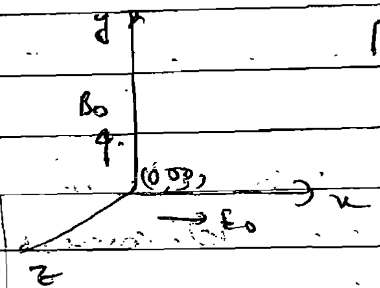
Theory

Set 1

(1)

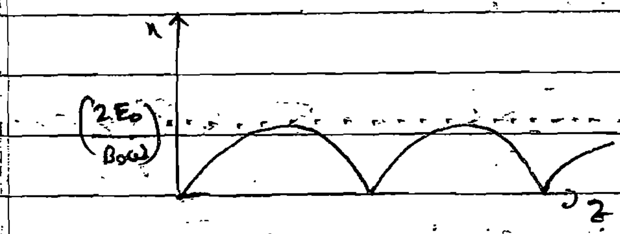


$\boxed{A}$ is correct

Particle is released from rest.

$$v_x = \frac{E_0}{B_0}\sin\omega t \quad \left(\omega = \frac{qB_0}{m}\right)$$

$$v_z = \frac{E_0}{B_0}(1-\cos\omega t)$$



$\vec{v} \neq$ const so $\boxed{B}$ wrong

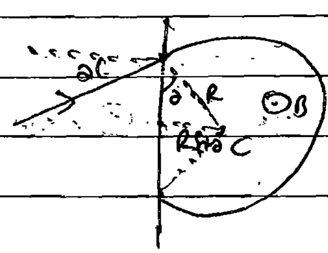
$$a_x = \frac{q}{m}(E_0 - v_z B_0)$$

$$a_z = \frac{q}{m} v_x B_0$$

$v_x = v_z = 0$ at $\omega t = 0, 2\pi$ etc so $\boxed{C}$ is correct

$\boxed{D}$ is correct

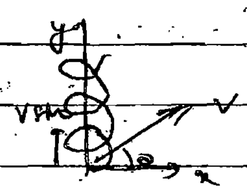
(2)



$0 < \theta < \pi/2$

$R\sin\theta \to R$ if $\theta \to \frac{\pi}{2}$ so particle can't do a complete circular path $\boxed{A}$

(3)



$\boxed{A}$ is correct.

(4) $P = \bar{F}\cdot\bar{V}$ & $\bar{F} = q\bar{v}\times\bar{B}$ so $\bar{F} \perp \bar{V}$

So $P = 0$ $\boxed{A}$ is correct.

(5) If $\cancel{q}VB = \cancel{q}E$ i.e. $E = VB$ so path will st. line

otherwise non circular path.

so $\boxed{A}$ & $\boxed{C}$ will correct.

(6) $\frac{1}{2}mv^2 = KE = qV$ so as q is same for both the isotopes so, KE will equal for both the isotops so $\boxed{A}$ is correct. (1)

As $\bar{F} \perp \bar{v}$ so, KE cont $\boxed{B}$ is correct

they trace circular arc so $\boxed{C}$ is correct, $\boxed{D}$ is correct like logic of Q(7).

(7) $R = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$ $R \propto \sqrt{m}$ so $\boxed{C}$ is correct (2)

$\boxed{A}$ is wrong

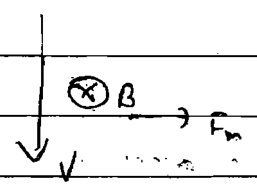
$W = \frac{V}{R} = \frac{qB}{m}$ $\therefore W \propto \frac{1}{m}$ so $\boxed{B}$ is wrong

$\frac{R_1}{R_2} = \frac{P_1}{P_2}$ so $\boxed{D}$ is correct

(8) If $qvB = qE \therefore \vec{E} = \vec{v}B$, $\vec{V} = $ cont $\boxed{A}$ is correct (3)

If $E = 0$ then $W = 0$ so $KE = $ cont $\boxed{C}$ is correct

(9)



so $\boxed{C}$ is correct

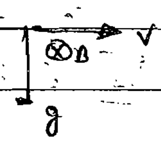
$\boxed{B}$ is correct due to deacc of particle

(10) If E horizontally it will deflect (4)

$\boxed{B}$ is correct

$\boxed{C}$ is correct ($\vec{F}_m = 0$ for C option)

Consider a case when particle is projected horizontally



$mg = qvB$ then $F = 0$

& $V = $ cont

so $\boxed{D}$ is correct

[redacted]

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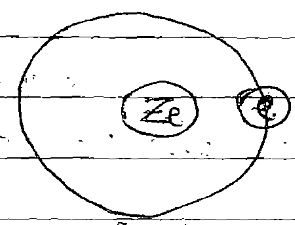
Set 2

(1)



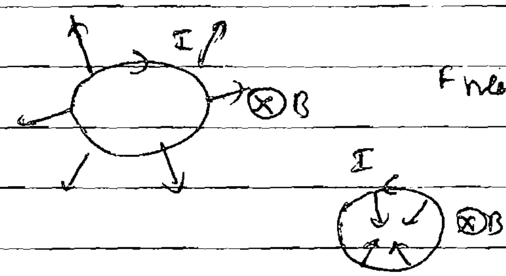
[A] is Correct according to action-reaction pair.

[B] is Correct as C_L is mostly.

[C] is correct as I exists.

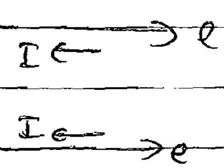
[D] is correct $U \propto \frac{1}{r}$

(2)



$F_{net} = 0$ [A] [B] [C] are correct

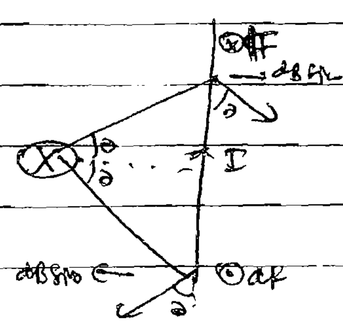
(3)



electrostatic
due to repulsion initially beam tends to spread but due to mag attraction narrow down later.

[B] [D] are Correct.

(4)



⇒ ⊗ ⊗

(after rotation)

so, they approach (attract) each other

so, [C] is alone correct

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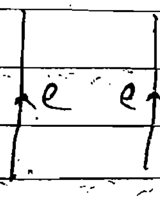
(5)



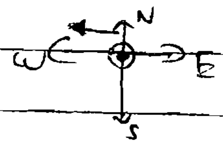
Initially - repulsion & then attⁿ like Q(3).

$\boxed{a}$ $\boxed{b}$ are correct

(6) $\boxed{B}$ is correct for circle area is maximum

$M = IA$ $\boxed{M \propto A}$

Set3 :

①  $\boxed{C}$

② $$B_P = \frac{\mu_0 I}{4\pi d}\left(\sin(90-\theta_2) + \sin(90-\theta_1)\right) = \frac{\mu_0 I}{4\pi d}\left(\cos\theta_1 + \cos\theta_2\right) \quad \boxed{A}$$

③ $\boxed{D}$

④ $\boxed{A}$ for any symmetrical loop $B_{centre} = 0$ if current enter at a point & leave from other point

⑤ $$B_0 = \frac{\mu_0 I}{4\pi a} \odot + \frac{\mu_0 I}{4\pi a} \odot = \frac{\mu_0 I}{2\pi a} \quad \boxed{C}$$

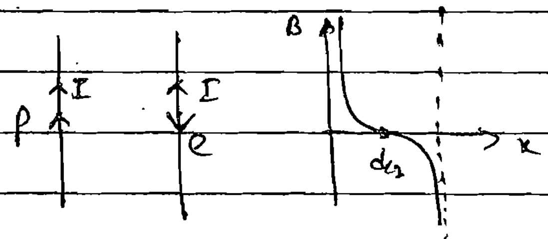
⑥ $\boxed{C}$

⑦ $$B = \frac{\mu_0 I}{4\pi d_2} + \frac{\mu_0 I}{4\pi d_2} = \frac{\mu_0 I}{2\pi d} + \frac{\mu_0 I}{2\pi d} = \frac{\mu_0 I}{\pi d} \quad \boxed{D}$$

⑧ $\boxed{C}$ Hold cursor using right hand rule there will get direction of B.

⑨ $$\left(\frac{\mu_0 I}{4\pi r}\right)\left(\frac{\pi}{2}\right) = \frac{\mu_0 I}{8r} \quad \boxed{C}$$

⑩ $$\left(\frac{\mu_0 I}{4R_1} - \frac{\mu_0 I}{4R_2}\right) = \frac{\mu_0 I}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \boxed{D}$$

⑪ 

$\boxed{C}$

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Set 4

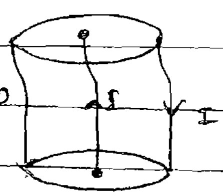
(1) $B\, 2\pi r = \mu_0 I_{in}$ $\quad I_{in} = 0$

$\therefore B = 0 \quad$ for $0 \le x < r$

$\boxed{C}$

(2) $B_{out} = 0 \ni B_2 = 0$

$B_{in} \neq 0 \ni B_1 \neq 0$



$\boxed{C}$

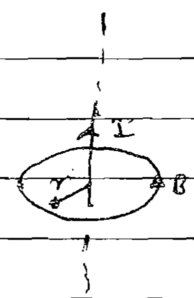
(3) $B_{in} \neq 0$ so $B_1 \neq 0$

$B_{out} \neq 0 \quad B_2 \neq 0 \quad \boxed{A}$

(4) $B_1 = \frac{\mu_0 I}{2\pi x}$ $\quad B_2 = \frac{\mu_0 \cancel{2}I}{2\pi \cancel{2}x} = \frac{\mu_0 I}{2\pi x}$

$\Rightarrow B_1 = B_2 \quad \boxed{A}$

(5)



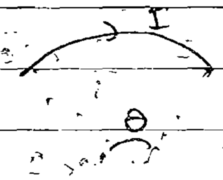
$\vec{F} \neq 0$ if $\vec{R} \parallel \vec{dl}$

so $\boxed{D}$

Exercise 1

Single option is correct:

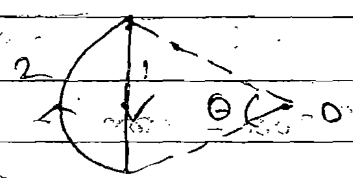
(1) Use $B = \frac{\mu_0 i (\theta)}{4\pi r}$



$$B_{center} = \frac{\mu_0 I}{4\pi R}\left(\frac{\pi}{2}\right) \otimes + \frac{\mu_0 I}{4\pi R'}\left(\frac{3\pi}{2}\right) \otimes$$

$$\therefore B_{center} = \frac{\mu_0 I}{8}\left(\frac{1}{R} + \frac{3}{R'}\right) \otimes \quad \boxed{(D)}$$

(2)



$$B_1 = \frac{\mu_0 I}{4\pi R \cos\theta/2}\left[\sin\frac{\theta}{2} + \sin\frac{\theta}{2}\right] \odot$$

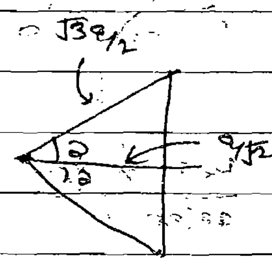
$$B_1 = \frac{\mu_0 I}{2\pi R} \tan\frac{\theta}{2} \odot$$

$$\& \; B_2 = \frac{\mu_0 I}{2\pi R}\left(\frac{\theta}{2}\right) \otimes$$

$$B_{net} = \vec{B_1} + \vec{B_2} = \frac{\mu_0 I}{2\pi R}\left(\tan\frac{\theta}{2} - \frac{\theta}{2}\right) \odot \quad \boxed{C}$$

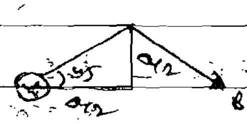
$(\tan\theta/2 > \theta/2)$

(3)



$$B = \frac{\mu_0 I}{4\pi a/\sqrt{2}}(2\sin\theta) = \frac{\mu_0 I}{4\pi a/\sqrt{2}} \frac{2}{\sqrt{3}}$$

$$\cos\theta = \frac{a \cdot 2}{\sqrt{2}\sqrt{3} a} = \sqrt{\frac{2}{3}} \quad B = \frac{\mu_0 I}{(\sqrt{2}\pi a)(\sqrt{3})}$$



$$B_{net} = 4B\cos 45 = \frac{\mu_0 I}{\sqrt{2}\pi a\sqrt{3}} \frac{4}{\sqrt{2}} = \frac{2\mu_0 I}{\sqrt{3}\pi a}$$

$\boxed{C}$

(4) $B = \frac{\mu_0 q(\vec{v}\times\vec{r})}{4\pi r^3}$

$= 10^{-7}\times 2\times \frac{100\times \cancel{2}\,\sin 30}{(2)^3}$

$= \frac{1}{4}\times 10^{-5} = 2.5\times 10^{-6} = 2.5\,\mu T$ (A)

(5) $\vec{B} = \frac{\mu_0 I}{2R}(\hat{i}+\hat{j}+\hat{k}) \Rightarrow |\vec{B}| = \frac{\sqrt{3}\mu_0 I}{2R}$ $\boxed{A}$

(6) $B_{net} = \left|\frac{\mu_0 I_1 N_1}{2R_1} - \frac{\mu_0 I_2 N_2}{2R_2}\right|$ N, W, E, S

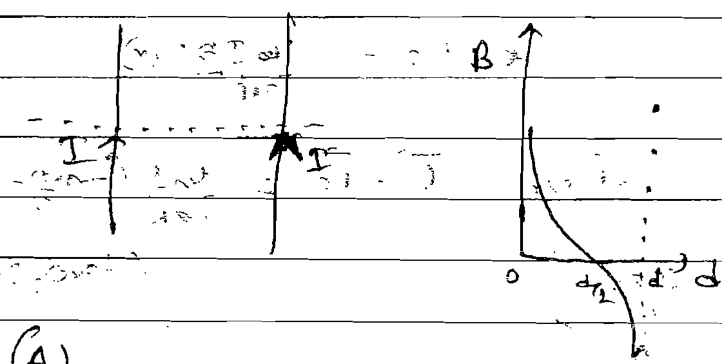
$= \frac{4\pi\times 10^{-7}}{2}\left[\frac{16\times 20}{.16} - \frac{25\times 18}{.10}\right]$

$= |2\pi\times 10^{-7}(2000 - 4500)| = 5000\pi\times 10^{-7}\,T$

$= 5\pi\times 10^{-4}\,T$

$\boxed{A}$

(7)



$\boxed{D}$

(8) (A)

(9) $B_{net} = \left(\frac{\mu_0 I}{4\pi r}\pi + \frac{\mu_0 I}{4\pi(2r)}\pi\right)\otimes$

$= \frac{\mu_0 I}{4r}\left(1+\frac{1}{2}\right) = \left(\frac{3\mu_0 I}{8r}\right)\otimes$ $\boxed{A}$

(10) $B_{net} = \frac{\mu_0 I}{4\pi a\cos 30}2\sin 30 - \frac{\mu_0 I}{8\pi a\cos 30}2\sin 30 + \frac{\mu_0 I}{12\pi a\cos 30}2\sin 30$

$= \frac{\mu_0 I\tan 30}{}\left(1 - \frac{1}{2} + \frac{1}{3} - \infty\right)$

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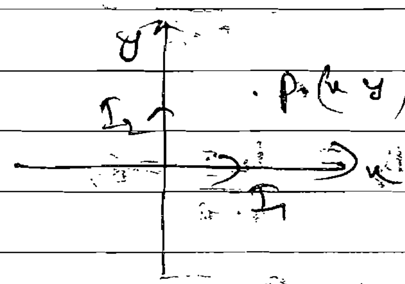
(11) $B_2 = \frac{\mu_0 I}{\cancel{2}r} \times \cancel{2} = \frac{2\mu_0 I}{R}$, $B_1 = \frac{\mu_0 I}{2R}$

$\frac{\cancel{4\pi r}}{2\pi} = \cancel{2\pi R}\ R \quad \therefore r = \frac{R}{2}$

$\frac{B_2}{B_1} = \frac{4}{1}$ $\boxed{B}$

$\boxed{A}$ (12)



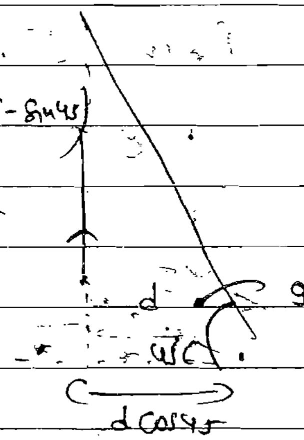
$B_P = 0$

so $\frac{\cancel{\mu_0} I_2}{\cancel{2\pi} x} = \frac{\cancel{\mu_0} I_1}{\cancel{2\pi} y}$

$y = x\left(\frac{I_1}{I_2}\right)$ $\boxed{C}$

(13) $B_{net} = \frac{\mu_0 I}{4\pi d\cos 45}(\sin 90 - \sin 45)$

$\times 2$

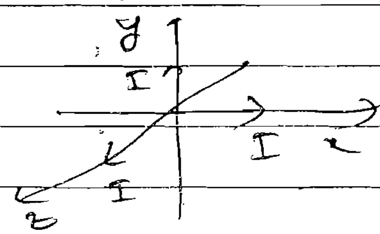


$= \left(\frac{\mu_0 I}{4\pi d/\sqrt{2}}\right)\left(1 - \frac{1}{\sqrt{2}}\right) 2$

$B_{net} = \frac{\mu_0 I}{\sqrt{2}\pi d}\left(1 - \frac{1}{\sqrt{2}}\right)$ (x)

$\boxed{A}$

(14) $B_{net} = \frac{\mu_0 I}{2\pi a}\hat{j}$

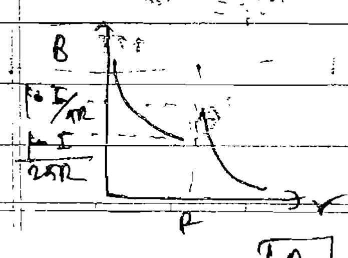


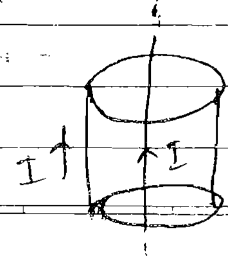
$\frac{\mu_0 I}{2\pi a}\hat{i}$

$\therefore B_{net} = \frac{\mu_0 I}{2\pi a}(\hat{j} - \hat{i})$ $\boxed{A}$

2 sin 30

(15)



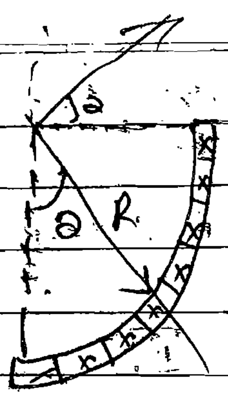


$0 < r < R$

$B = \frac{\mu_0 I}{2\pi r}$

$r > R \quad B = \frac{\mu_0 I}{2\pi r}$

[16]



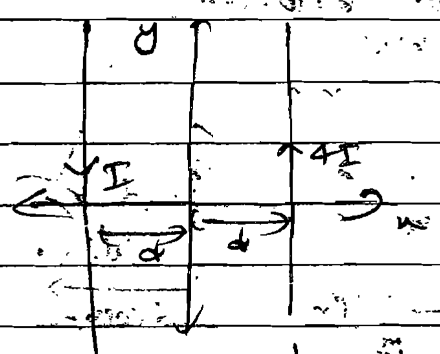
$$\vec{B}_H = \int_0^{\pi/2} dB\cos\theta$$

$$= \int_0^{\pi/2} \frac{\mu_0\left(\frac{I\,d\theta}{2\pi}\right)}{2\pi R}\cos\theta$$

$$B_H = \frac{\mu_0 I}{4\pi^2 R} = B_V$$

$$B_{net} = \sqrt{2}\,B_H = \frac{\mu_0 I\sqrt{2}}{4\pi^2 R} \quad \boxed{A}$$

(17)

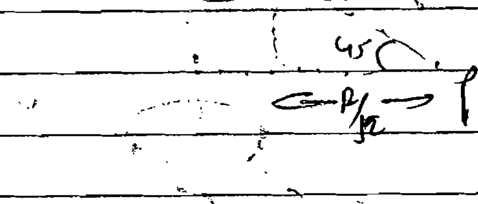


(i) dirⁿ of B is const $(\hat{k})$

(ii) B will tend to zero close to left

So, $\boxed{C}$

(18)



$$B_P = \frac{\mu_0 I}{4\pi R/\sqrt{2}}\left(\sin 90 - \sin 45\right)$$

$$= \frac{\mu_0 I}{4\pi R/\sqrt{2}}\left(1 - \frac{1}{\sqrt{2}}\right)$$

$$\boxed{B_P = \frac{\mu_0 I(\sqrt{2}-1)}{4\pi R}}$$

$\boxed{A}$

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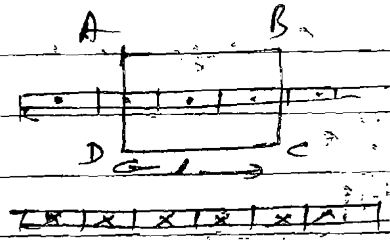
(19) Ampere's law:



$B_{AB}=0$, $\bar{B} \perp \bar{AD}$ & $\bar{BC}$ it is like solenoid

∴ $B\ell = \mu_0 \lambda \ell$ ∴ $B = \mu_0 \lambda$ $\boxed{B}$

(20) Use Principle of superposition

$$B_{cavity} = B_{(+)} + B_{(-)} \quad \text{— (1)}$$

$$B_{(-)} = 0, \quad B_{+} = \frac{\mu_0 I}{2\pi c} = \frac{\mu_0}{2\pi c}\left(\frac{I c^2}{b^2-a^2}\right) = \frac{\mu_0}{2\pi(b^2}$$

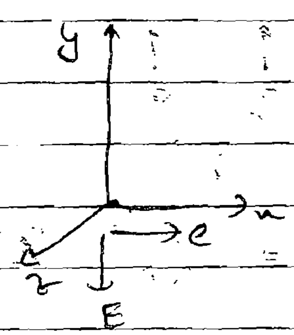
$\boxed{B}$

(21) $$\bar{B} = \bar{B}_{left} + \bar{B}_{right} = \left(\frac{\mu_0 I_{left}}{2\pi d_1}\hat{j} + \frac{\mu_0 I_{right}}{2\pi d_2}\right)\hat{j}$$

$$= \left(\frac{\mu_0}{2\pi}\frac{J\pi d_1^{\cancel{2}}}{\cancel{d_1}} + \frac{\mu_0}{2\pi}\frac{J\pi d_2^{\cancel{2}}}{\cancel{d_2}}\right)\hat{j}$$

$$= \frac{\mu_0}{2\pi}\left(J\frac{\pi}{?}d\right)\hat{j} \quad \boxed{A}$$

(22)



$F_E = \uparrow$

$F_B = \downarrow$ B show ⊗ $\boxed{B}$

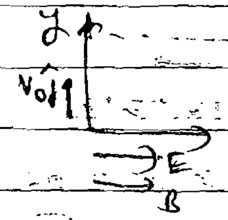
(23) By work energy theorem $\Delta KE = W$

$$\Rightarrow \frac{1}{2}m(2v_0)^2 - \frac{1}{2}mv_0^2 = E_0 d$$

$$\Rightarrow \frac{3}{2}mv_0^2 = E_0 d$$

(23) Change in velocity $= \bar{v}_f - \bar{v}_i$

$= \left(\bar{v}_{yz} + \bar{v}_x - v_0\hat{j}\right)$



$v_{yz}^2 + v_x^2 = 4v_0^2$

$v_{yz}^2 = v_0^2$

$\therefore v_x^2 = 3v_0^2 \quad \therefore v_x = \sqrt{3}v_0$

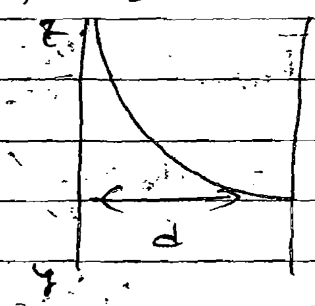
So $\left(\frac{qE}{m}\right) t = \sqrt{3}v_0 \quad \therefore t = \frac{\sqrt{3}\,m v_0}{qE}$ $\boxed{D}$

(24) $qE = \frac{mv^2}{r_1}, \quad q\cancel{v}B = \frac{mv^{\cancel{2}}}{r_2}$

$r_1 = \frac{mv^2}{qE}, \quad r_2 = \left(\frac{mv}{qB}\right)$

$\frac{r_1}{r_2} = \frac{\cancel{m}v^{\cancel{2}}}{\cancel{q}E} \frac{\cancel{q}B}{\cancel{mv}} = \frac{vB}{E}$ $\boxed{D}$

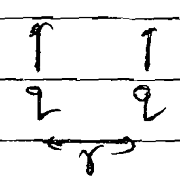
(25)



$d = R = \frac{mv}{qB}$

$\boxed{v = \frac{dqB}{m}}$ $\boxed{B}$

(26) $F_E = \frac{q^2}{4\pi\varepsilon_0 r^2}$ — (1)



$F_B = \frac{\mu_0 q^2 v^2}{4\pi\ r^2}$ — (2)

$\frac{F_E}{F_B} = \frac{\cancel{q^2}}{\cancel{4\pi}\varepsilon_0 \cancel{r^2}} \frac{\cancel{4\pi} \cancel{r^2}}{\mu_0 \cancel{q^2} v^2} = \left(\frac{c^2}{v^2}\right)$ $\boxed{A}$

(27) $t = \frac{\pi}{B_0\alpha} = \frac{m\pi}{B_0 q} = \frac{T}{2}, \quad T = \frac{2\pi m}{qB}$

St line motion : displacement $= v_0 \frac{T}{2}$

$= \frac{v_0 \pi}{\alpha B}$

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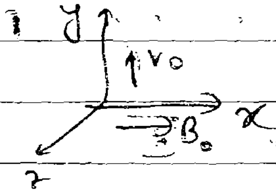

$y = 0, \; z = -2R = -2\left(\frac{mv}{qB}\right)$

$= \frac{-2v}{B\alpha}$

So coordinate $= \left(\frac{v_0 \pi}{B_0 \alpha}, 0, -\frac{2v_0}{B_0\alpha}\right)$ $\boxed{D}$

(28) $R = \frac{mv}{qB}$, H^+ $q=1, m=1$

He^+ $q=1, m=4$

$R = \frac{\sqrt{2mK}}{qB}$ O^{+2} $q=2, m=16$

$R \propto \sqrt{m}/q$ $R_{H^+} \propto 1, R_{He^+} \propto 2, R_{O^{+2}} \propto 2$ $\boxed{B}$

(29) $R = \frac{\sqrt{2mK}}{qB}$ $R \propto \frac{\sqrt{K}}{B} \Rightarrow \frac{R_1}{R_2} = \left(\sqrt{\frac{K_1}{K_2}}\right)\left(\frac{B_2}{B_1}\right)$

$\Rightarrow \frac{R}{R_2} = \frac{1}{\sqrt{2}} \frac{3}{1}$ $\therefore R_2 = R\sqrt{\frac{2}{9}}$ $\boxed{C}$

(30) $\cancel{q}E = \cancel{q}vB$ $\therefore \boxed{E = vB}$ $\therefore v = \frac{E}{B}$

$R = \left(\frac{mv}{qB}\right) = \left(\frac{mE}{qB^2}\right)$

$= \frac{9\times10^{-31} \times 3.2\times10^{5}}{1.6\times10^{-19} \times 4\times10^{-5}} = 4.5\times10^{-1} = 0.45\,m$

$\boxed{C}$

(31) As $V_{initial}$ along B & $\perp$ to B so Helical $\boxed{C}$

(32) $\overline{B} \uparrow\uparrow (-\overline{v})$ also $qvB = F$

$5\times10^{-13} = 1.6\times10^{-19} \times 2.5\times10^{5} \times B$

$B = \frac{8 \cdot 2}{2.5 \times 1.6} = \frac{2}{1.6} = \frac{5}{4} = 1.25$

Also $\overline{B} \uparrow\uparrow -\overline{v}$ So $\boxed{A}$

(33)

$2R = d = \frac{2mv}{qB}$ $qV_0 = \frac{1}{2}mv^2 \therefore v = \sqrt{\frac{2qV_0}{m}}$

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(34) $qvB = \frac{m\cancel{v^2}}{R}$ $\therefore R = \frac{mv}{qB}$; $R \propto v$ $\boxed{B}$ 1

(35) $T = \frac{2\pi R}{v} = \left(\frac{2\pi m}{qB}\right)$ $\boxed{A}$

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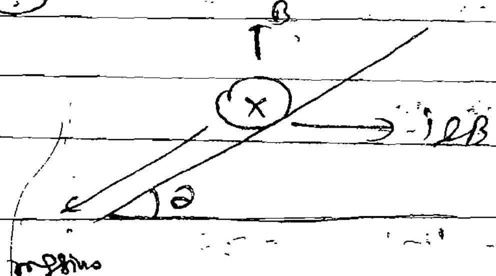
Exercise 2 (Moe tion on i Co

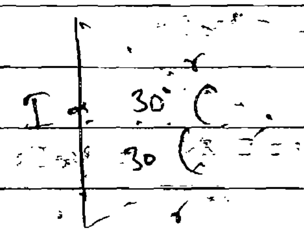
(1)



$i l B \cos\theta = mg \sin\theta$

$\tan\theta = \left(\frac{i l B}{mg}\right)$ $\boxed{D}$

(2)



$B = \left(\frac{\mu_0 I}{4\pi r \cos 30}(\sin 30 + \sin 30)\right) \times 6$

$= \frac{\mu_0 I \sqrt{3}}{\pi r} = \frac{\mu_0 I \sqrt{3}}{\pi l}$ $\boxed{A}$

$(r = l)$ As equilateral Δ.

(3) $F = \int_{l/2}^{3l/2} \frac{\mu_0 I_2}{2\pi x} I_1 dx = \frac{\mu_0 I_1 I_2}{2\pi} \ln 3$ $\boxed{B}$

(4) $B_0 = \frac{\mu_0 I}{4\pi r \cos 45}(\sin 45 + \sin 45) + \frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}\right)$

$= \frac{\mu_0 I}{2\pi r} + \frac{3\mu_0 I \pi}{8\pi r} = \frac{\mu_0 I}{8\pi r}(3\pi + 4)$ $\boxed{D}$

(5) (A), $F_m = 0$

(6) (A) when q is Projected along E, $V \neq$ Const

(B) when q is Projected along B, V = Const

(C) $E = 0$, $B = 0$, V = Const

(D) $E \neq 0$, $B \neq 0$, when ~~qE~~ = qvB i.e. when $E = vB$

(7) Ampere's law $\boxed{B}$ $\boxed{C}$ $\boxed{D}$

(8) Radius $a = \frac{mv}{qB} \Rightarrow K = \frac{P^2}{2m} \Rightarrow P = \sqrt{2mK}$

$a = \frac{\sqrt{2mK}}{qB}$, $B = \frac{\sqrt{2mK}}{qa}$ $\boxed{D}$

(9) $W_{\text{all forces}} = \Delta KE \Rightarrow \frac{1}{2} m (13)^2 = qE_0 x$

$\frac{169m}{2} = qE_0 x$

$\therefore x = \left(\frac{169m}{2qE_0}\right)$ $\boxed{A}$

[redacted]

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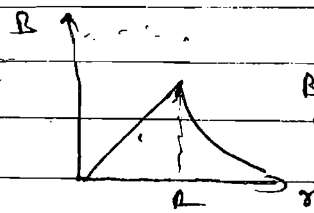
(10) $F = \int_{a/2}^{3a/2} \frac{\mu_0 I}{2\pi x} I' dx = \frac{\mu_0 I I'}{2\pi} \ln 3 \, (-\hat{i})$

$\boxed{B}$ $\boxed{D}$

(11)



$B_{out} = \frac{\mu_0 I}{2\pi r}$ $\quad r \geq R$

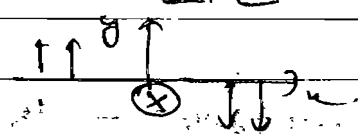
$B_{in} = \frac{\mu_0 I r}{2\pi R^2}$

for In: $B \, 2\pi r = \mu_0 I \frac{\cancel{\pi} r^2}{\cancel{\pi} R^2} = \frac{\mu_0 I r^2}{R^2}$

$B = \frac{\mu_0 I r K}{2\pi R^2 \cancel{r}} = \left(\frac{\mu_0 I r}{2\pi R^2}\right)$

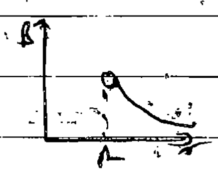
$\boxed{A}$ $\boxed{B}$

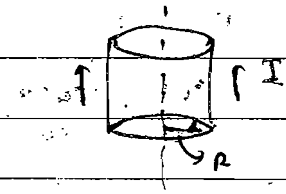
(12)



$\boxed{B}$ $\boxed{C}$ $\boxed{D}$

(13)





$B_{in} = 0$

$B_{out} = \frac{\mu_0 I}{2\pi r}$

(14) $\boxed{C}$ $\boxed{D}$ its Biot-Savart law.

(15) $R = \left(\frac{mv}{qB}\right)$ $\quad R_M > R_N$

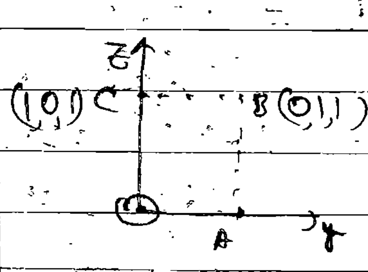
$R \propto m/q$ $\quad R_{He^{+2}} = 2K$ $\quad \boxed{A}$ $\boxed{B}$

$R_{HP} = K$

(16) As O rest w.r.t. F_1 so, No $\vec{B}$ is observed.

$\boxed{A}$ $\boxed{D}$

(17)

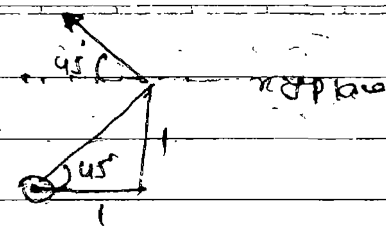


B at B(0,1,1) & D(1,1,1) same

as distance same

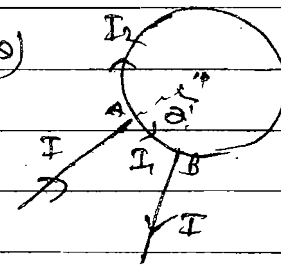
B at A(0,1,0) & C(1,0,1) same

(18) $B = \frac{\mu_0 I}{2\pi d} = \left(\frac{\mu_0 I}{2\sqrt{2}\pi}\right)$



$\boxed{A}$ $\boxed{D}$

(19) $B_C = \frac{\mu_0 I_1 \theta}{4\pi R} - \frac{\mu_0 I_2 (2\pi - \theta)}{4\pi R}$



$V_{AB} = 0$

$I_1 R_{AB}\theta = I_2 R_{AB} 2$

$R \propto l$ So $I_1 \theta = I_2 (2\pi - \theta)$

So $B_C = 0$

(20) $B_1 = \left(\frac{\mu_0 I \pi}{4\pi b} + \frac{\mu_0 I \pi}{4\pi a}\right) = \left(\frac{\mu_0 I}{4b} + \frac{\mu_0 I}{4a}\right)$

$B_2 = \left(\frac{\mu_0 I}{4a} - \frac{\mu_0 I}{4b}\right)$, $B_3 = \frac{\mu_0 I}{4a} - \frac{\mu_0 I}{8b} - \frac{\mu_0 I}{8c}$

$B_4 = \left(\frac{\mu_0 I}{4a} + \frac{\mu_0 I}{8b} + \frac{\mu_0 I}{8c}\right)$ $(a > b > c)$

So $(B)_4$ is max^m $B_4 > B_1 > B_2 > B_3$

$\boxed{A}$ $\boxed{B}$ $\boxed{C}$

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Exercise 3

Comprehension-1

(1.) $NIAB = K\theta$

$250 \times 100 \times 10^{-6} \times \frac{2.1}{100} \times \frac{1.2}{100} \times 0.23 = K \times 28$

$K = 5.2 \times 10^{-8}$ Nm/ degree $\boxed{B}$

(2) $K_1\theta_1 = K_2\theta_2 \Rightarrow K \times 28 = \frac{K}{2}\theta_2$

$\theta_2 = 56^\circ$ $\boxed{B}$

(3) $NIAB = K\theta$

$\cancel{3}NIAB = \cancel{3}K\theta_0 \therefore \theta_0 = 28^\circ$ $\boxed{B}$

Comprehension-2

(4) $T.K.E = 200 \times 100 \times 10^3$ eV $= 20$ MeV $\boxed{B}$

(5) $qB = 2\pi m f_{osc}$

$B = \frac{2\pi m f_{osc}}{q} = \left(\frac{2\pi \times 2 \times 1.6726 \times 10^{-27} \times 24 \times 10^6}{1.6 \times 10^{-19}}\right)$

$= 3.14$ T $\boxed{B}$

(6) $KE = \frac{P^2}{2m} = \frac{(rqB)^2}{2m} = \frac{(0.265 \times 1.6 \times 10^{-19} \times 3.14)^2}{2 \times 2 \times 1.6726 \times 10^{-27}}$

$= 2.2 \times 10^{-12}$ J $\boxed{B}$

Comprehension-3

(7) $i = nqAV_d$ $\quad V_d$ = drift velocity

$V_d = \left(\frac{i}{nqA}\right) = \frac{120}{5.85 \times 10^{28} \times 1.6 \times 10^{-19} \times 11.8 \times 0.23 \times 10^{-6}}$

$= \frac{120}{5.85 \times 1.6 \times 11.8 \times 0.23 \times 10^{3}} = \frac{120}{5.85 \times 1.6 \times 11.8 \times 23}$

$= 4.7$ mm/sec $\boxed{B}$

(8) $E = \Delta V/\Delta d$ $\quad \therefore E = \frac{53 \times 10^{-6}}{11.8 \times 10^{-3}} = 4.5 \times 10^{-3}$ V/m $\boxed{A}$

$\Delta V = IB/qnd = \left(\frac{120 \times 0.95}{1.6 \times 10^{-19} \times 5.85 \times 10^{28} \times 0.23 \times 10^{-3}}\right)$

(9) $= 53 \mu V$

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Matrix Match Type

(10.) $I = \frac{q}{T} = \frac{q^2 B}{2\pi m}$ $T = \frac{2\pi R}{v}$ $qvB = \frac{mv^2}{R}$ $\therefore R = \left(\frac{mv}{qB}\right)$

$= \frac{2\pi}{v} \times \frac{mv}{qB}$

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

(A) → (r)

$M = IA$

$M = I(\pi R^2) \propto v^2$

(B) → (q)

$B = \frac{\mu_0 I \pi}{2\pi R} = \left(\frac{\mu_0 I \times \pi}{2\pi mv/qB}\right) = \left(\frac{\mu_0 I qB}{2mv}\right)$ $B \propto v^{-1}$ So (C) → (S)

(D) → (P)

(11.) $\tau = NIAB$ (A) → (r)

$\tau = C\theta \therefore \theta = \left(\frac{NIAB}{C}\right)$ (B) → (S)

Current sensitivity $= \frac{\theta}{I} = \frac{N\cancel{I}AB}{C\cancel{I}} = \frac{NAB}{C}$ (C) (P)

Voltage sensitivity $= \frac{\theta}{IR} = \frac{N\cancel{I}AB}{C\cancel{I}R} = \frac{NAB}{CR}$ (D) → (q)

(12) (D)

(13) (C)

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Exercise 4

Subjective Qo

(4)

(1) (a) $B = \left(\frac{\mu_0 I}{4\pi a}\right)$ [redacted] $+ \frac{\mu_0 I \phi}{4\pi b}$

$B = \frac{\mu_0 I}{4\pi}\left(\frac{2\pi - \phi}{a} + \frac{\phi}{b}\right)$

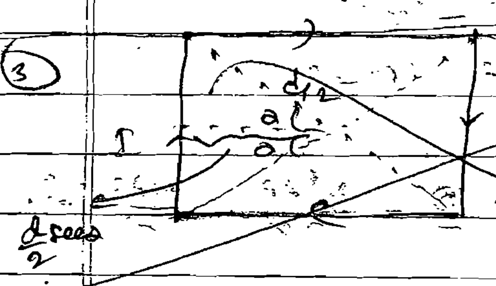
(b) $B = \left(\frac{\mu_0 I}{4\pi a}\right)\left(\frac{3\pi}{4}\right) + \frac{\mu_0 I}{4\pi b}(\sin 45 + \sin 0) \times 2$

$B = \frac{\mu_0 I}{4\pi}\left(\frac{3\pi}{4a} + \frac{\sqrt{2}}{b}\right)$

(2) $B = \frac{\mu_0 I}{4\pi R}(2\pi - 2\phi) + \frac{\mu_0 I}{4\pi R\cos\phi}(2\sin\phi)$

$B = \frac{\mu_0 I}{2\pi R}\left[(\pi - \phi) + \tan\phi\right] = 28\,\mu T$

(3)



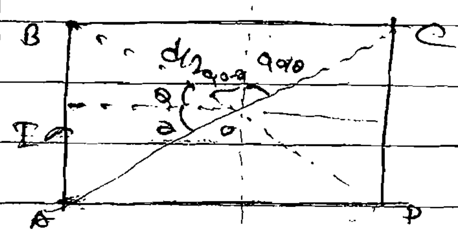
$B_0 = \frac{\mu_0 I}{4\pi d_1 (\cos\theta)}\left[\sin\theta + \sin\theta\right] \times 4$

$B_0 = 4\frac{\mu_0 I \sin\theta}{\pi d(\cos\theta)^{-1}}$ [redacted]

$= \frac{4\mu_0 I \sin\theta\cos\theta}{\pi d}$

(5)

(3)



(6)

$B_0 = 2\left[\frac{\mu_0 I(\sin\theta + \sin\theta)}{4\pi d_{1/2}\cos\theta}\right] + 2\left[\frac{\mu_0 I}{4\pi d_{1/2}\sin\theta}(\cos\theta + \cos\theta)\right]$

$= \frac{2\mu_0 I}{\pi d}\left[\tan\theta + \cot\theta\right] = \frac{4\mu_0 I}{\pi d \sin 2\theta} = 0.1\,mT$

(4) (a) $B = -\left(\frac{\mu_0 I}{4\pi d}\right) 2\hat{k} - \frac{\mu_0 I}{4R}\hat{i}$

$(d = R)$

$\therefore B = \frac{\mu_0 I}{4\pi R}\left[4 + \pi^2\right]^{1/2}$

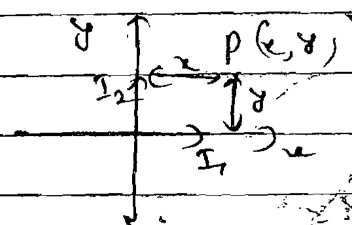
(b) $B_1 = \frac{\mu_0 I}{4\pi R}(-\hat{k})$, $B_2 = \frac{\mu_0 I}{4R}(-\hat{i})$, $B_3 = \frac{\mu_0 I}{4\pi R}(-\hat{i})$

$B_{net} = \frac{\mu_0 I}{4\pi R}\sqrt{1 + (\pi+1)^2} = \frac{\mu_0 I}{4\pi R}\sqrt{\pi^2 + 2 + 2\pi}$

(c) $B_{\text{circle loop}} = 0$, $B_{\text{straight wire}} = \frac{\mu_0 I}{4\pi R}(-\hat{k}) + \frac{\mu_0 I}{4\pi R}(-\hat{j})$

$B_{net} = \frac{\mu_0 I\sqrt{2}}{4\pi R}$

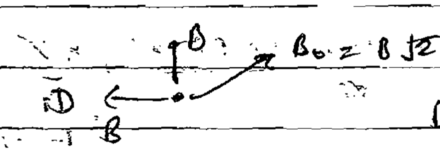
(5)



$B_p = 0$, $\left(\frac{\cancel{\mu_0} I_1}{\cancel{2\pi} y}\right) = \left(\frac{\cancel{\mu_0} I_2}{\cancel{2\pi} x}\right)$

$\boxed{y = (I_1/I_2)x}$

(6) (b)



$B_0 = B\sqrt{2}$

$B_{net} = \sqrt{B^2 + B^2 + 2B^2 + 2B^2\cos 90 + 2\sqrt{2}B^2\cos + 2\sqrt{2}B^2\cos 135}$

$B_{net} = (4B^2 + 2B^2 + -2B^2)^{1/2} = 2B = 2\left(\frac{\mu_0 I}{4\pi a}\right)$

$B_{net} = \frac{\mu_0 I}{2\pi a}$ $\therefore F/\ell = \left(\frac{\mu_0 I^2}{2\pi a}\right)$

(a) $B_{net} = 4\left(\frac{\mu_0 I}{\ldots}\right)\cos 45 = \left(\frac{\mu_0 I}{\ldots}\right)$

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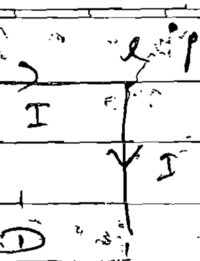
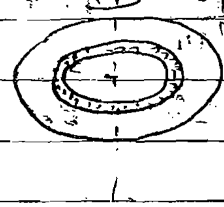
(7) $B_{net} = \frac{\mu_0 I \sqrt{2}}{4\pi R}$ (10)



(8) (9)



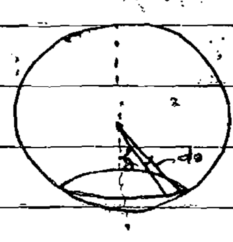
$$B = \int_0^R \frac{\mu_0\, dI}{2x}$$

$$= \frac{\mu_0}{2}\int_0^R \left(\frac{\sigma \cancel{2\pi x}\, dx\, \omega}{\cancel{2\pi x}}\right) = \frac{\mu_0 \sigma \omega R}{2}$$

(6) $P_m = \int_0^R dI\, \pi x^2 = \int_0^R \frac{\sigma \cancel{2\pi} x\, dx\, \omega\, \pi x^2}{\cancel{2\pi}}$ (11)

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

(9) $B_{ring\,(axis)} = \frac{\mu_0 I a^2}{2(a^2+d^2)^{3/2}}$



$dI = \frac{\sigma \cancel{2\pi} R\sin\theta\, R\, d\theta\, \omega}{\cancel{2\pi}}$

$dI = \sigma R^2 \omega \sin\theta\, d\theta$

$$B = \left(\int_0^{\pi/2} \frac{\mu_0\, \sigma R^2 \omega \sin\theta\, d\theta\, (R\sin\theta)^2}{2R^3}\right) \times 2$$

(for upper & lower half)

$$= \mu_0 \sigma \omega R \int_0^{\pi/2} \sin^3\theta\, d\theta = \frac{2\mu_0 \sigma \omega R}{3}$$

$$I = \int_0^{\pi/2} \sin^3\theta\, d\theta = \int_0^1 (1-x^2)\, dx = 1 - \frac{1}{3} = \frac{2}{3}$$

$(x = \cos\theta)$

[redacted]

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(10) (a) $B = \frac{2}{3}\mu_0 \sigma \omega R$ (See sol^n 9)

$= \frac{2}{3}\mu_0 \frac{Q}{4\pi R^2}\omega R = \left(\frac{2}{3}\right)\left(\frac{\mu_0}{4\pi}\right)\left(\frac{Q\omega}{a}\right)$

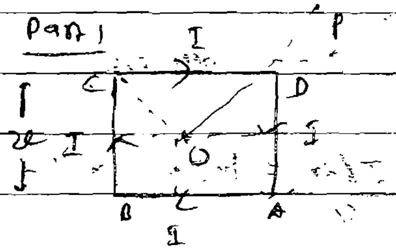
(b) $P_m = 2\int_0^{\pi/2} dI\,(\pi (R\sin\theta)^2) = 2\int_0^{\pi/2} \sigma \omega a^2 \sin\theta\, d\theta\; \pi a^2 \sin^2$

$(R = a)$ $= \frac{2\sigma\omega\pi a^4}{1}\int_0^{\pi/2} \sin^3\theta\, d\theta$

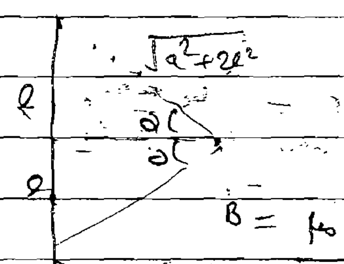
$= \frac{4\sigma\omega\pi a^4}{3} = \frac{4\omega\pi a^4}{3}\frac{Q}{4\pi a^2}$

$= \left(\frac{Q\omega a^2}{3}\right)$

(11) Part 1



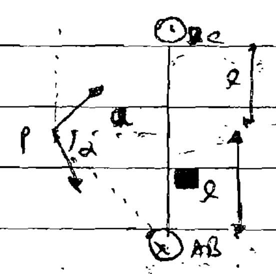
$OP = a$



$B = \frac{\mu_0 I}{4\pi\sqrt{a^2+l^2}}(\sin\theta + \sin\theta)$

$B = \frac{\mu_0 I}{4\pi(a^2+l^2)^{1/2}}\; \frac{2l}{\sqrt{a^2+2l^2}} = \frac{\mu_0 I l}{2\pi\sqrt{a^2+l^2}\sqrt{a^2+2l^2}}$

Part 2



$B_{net} = 4B\sin\alpha$

$= \frac{4\mu_0 I l}{2\pi\sqrt{a^2+l^2}\sqrt{a^2+2l^2}}\;\frac{l}{\sqrt{a^2+l^2}}$

$B_{net} = \frac{2\mu_0 I l^2}{\pi(a^2+l^2)\sqrt{a^2+2l^2}}$

Put $I = 10$, $l = 3$ cm, $a = 2.65$ cm

$B = 2.2\times10^{-4}$ T

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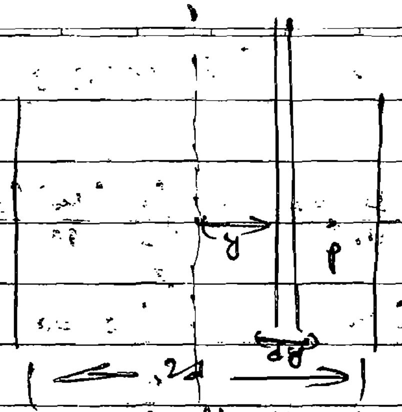
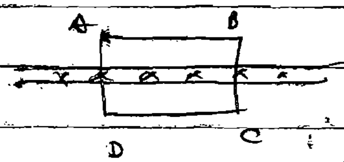
(12)



median plane
(Central part)

Use



$\mu_0 \lambda l = 2Bl$

$B = \mu_0 \lambda/2$

(λ = current/len)

$$\underset{\text{inside}}{B} = \int_{-x}^{x} \mu_0 \left(\frac{I}{l}\right)/2 = \int_{-x}^{x} \frac{\mu_0 J\, dx}{2} = \mu_0 J x \quad (x < d)$$

We have to integrate from $-x$ to x as $(d-x)$ on left & right will cancelled out

(13) Using amper's law

(b) $B = 0 \quad r < a$

$$B = \frac{\mu_0 I_{in}}{2\pi r} \quad a < r \leq b$$

$$I_{in} = \frac{I(r^2-a^2)\cancel{\pi}}{\cancel{\pi}(b^2-a^2)} = \frac{I(r^2-a^2)}{(b^2-a^2)}$$

$$B = \frac{\mu_0 I (r^2-a^2)}{2\pi r(b^2-a^2)}$$

$$B = \frac{\mu_0 I}{2\pi r} \quad r > b$$

(14)

$B = \frac{\mu_0 n}{2}$

(14)

[redacted]

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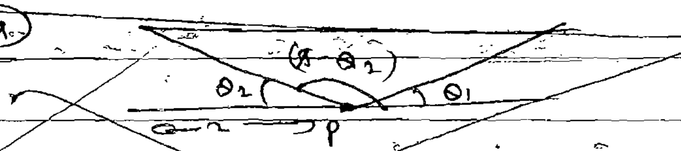
(c) $qvB = \frac{mv^2}{R} \quad \therefore R = \frac{mv}{qB}$

$T = \frac{2\pi R}{v} = \left(\frac{2\pi m}{qB}\right), \quad \omega = \frac{v}{R} = \frac{qB}{m}$

$\theta = \omega t = \left(\frac{qB}{m}\right)\left(\frac{L}{v}\right) = \left(\frac{qBL}{mv}\right)$

$= \left(\frac{qL}{mv}\right)\left(\frac{\mu_0 I}{2\pi r}\right) = \left(\frac{\mu_0 I q L}{2\pi m v r}\right)$

(14) (a)

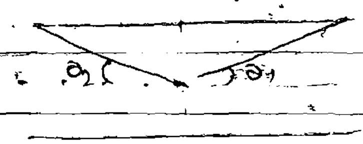


$B = \frac{\mu_0 n I}{2}(\cos\theta_1 - \cos\theta_2)$; $B = \frac{\mu_0 n I}{2}(-\cos\theta_2 + \cos\theta_1)$

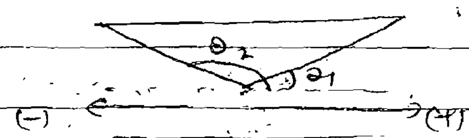
$\cos(\pi-\theta_2) = x/\sqrt{R^2+x^2}$ $\cos\theta_2 = +x/\sqrt{R^2}$

for semi infinite $\theta_1 = 0$, $B = \frac{\mu_0 n I}{2}\left(1 - \frac{x}{\sqrt{R^2+x^2}}\right.$

(14) (a)



$B = \frac{\mu_0 n I}{2}(\cos\theta_1 + \cos\theta_2)$



$B = \frac{\mu_0 n I}{2}(\cos\theta_1 - \cos\theta_2)$.

$\theta_1 = 0 \quad \cos\theta_1 = \cos 0 = \cos 0 = 1 \quad \cos(\pi - \theta_2) = -x/\sqrt{x^2+R^2} \therefore \cos\theta_2 = x/\sqrt{x^2+R^2}$

(semi infinite)

$B = \frac{\mu_0 n I}{2}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$

(b) $\frac{B_0 - B}{B_0} = 1 - \frac{B}{B_0} = 1 - \eta$, $B_0 = \mu_0 n I$, $B = \frac{\mu_0 n I}{2}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$

$1 - \frac{\cancel{\mu_0 n I}}{\left(\frac{\cancel{\mu_0 n I}}{2}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)\right)^{-1}} = 1 - \eta$

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(19)

$$\frac{x}{\sqrt{x^2+R^2}} = 1-2\eta$$

$$x^2 = (x^2+R^2)(1-2\eta)^2$$

$$4\eta x^2 - 4\eta^2 x^2 = \text{[redacted]}(R^2)(1-2\eta)^2$$

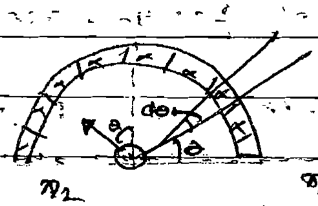
$$4\eta(1-\eta)x^2 = R^2(1-2\eta)^2$$

$$x = \frac{R(1-2\eta)}{2\sqrt{\eta(1-\eta)}} \simeq 5R \quad (\eta = 0.01)$$

(15) $$F = \int_a^{a+l} \frac{\mu_0 I_0}{2\pi x} I\,dx = \frac{\mu_0 I I_0}{2\pi}\ln\left(\frac{a+l}{a}\right)$$

$$F = \frac{\mu_0 I I_0}{2\pi}\ln\left(1+\frac{l}{a}\right)$$

(16)

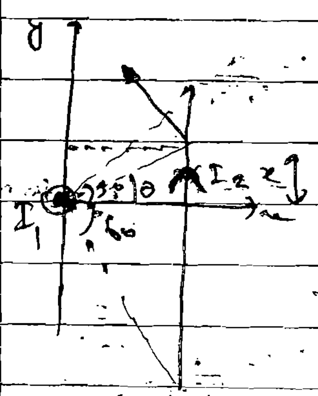


$$B_{net} = \int 2\,dB\sin\theta = 2\int_0^{\pi/2} \frac{\mu_0\left(\frac{I}{\pi}d\theta\right)}{2\pi R}\sin\theta = \frac{\mu_0 I}{\pi^2 R}$$

$$\frac{F}{l} = \left(\frac{\mu_0 I^2}{\pi^2 R}\right)$$

(17) $$\frac{F}{l} = \int_a^{a+b} \frac{\mu_0 I_1}{2\pi x}\frac{I_2\,dx}{b} = \frac{\mu_0 I_1 I_2}{2\pi b}\ln\left(\frac{a+b}{a}\right)$$

(18)



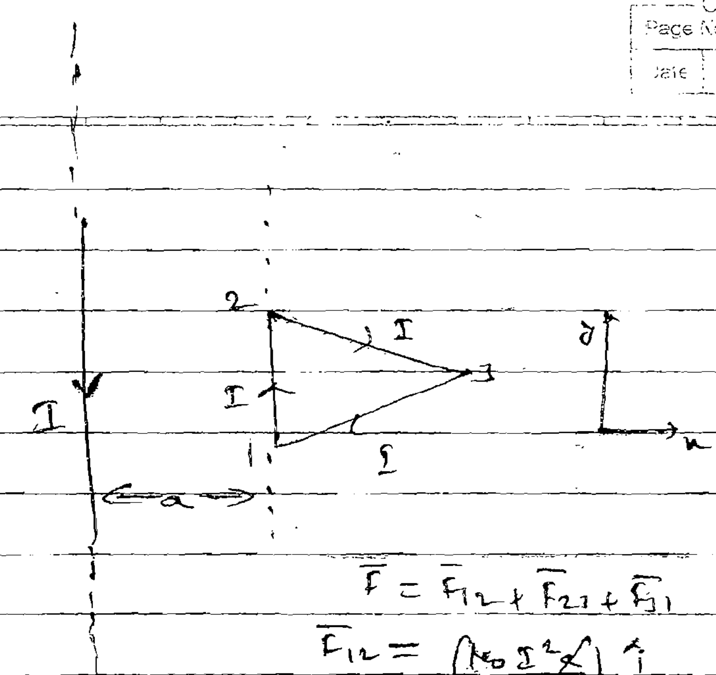
$$F = \int (dB\sin\theta)\, I_2\,dx$$

$$F = \int_{-\sqrt{3}a}^{a/\sqrt{3}} \frac{\mu_0 I_1 I_2}{2\pi\sqrt{a^2+x^2}}\frac{x\,dx}{\sqrt{a^2+x^2}}$$ (20)

$$F = \int_{-\sqrt{3}a}^{a/\sqrt{3}} \frac{\mu_0 I_1 I_2\, 2x\,dx}{4\pi(a^2+x^2)}$$ (21)

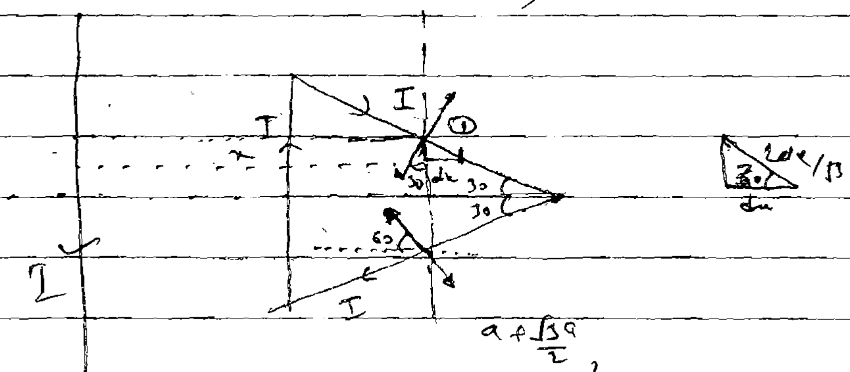
$$= \frac{\mu_0 I_1 I_2}{4\pi}\left(\ln\frac{4}{3} - \ln 4\right)\hat{x}$$

(19)



$$\bar{F} = \bar{F}_{12} + \bar{F}_{23} + \bar{F}_{31}$$

$$\bar{F}_{12} = \left(\frac{\mu_0 I^2 \cancel{a}}{2\pi \cancel{a}}\right)\hat{i}$$



$$F = \int_a^{a+\frac{\sqrt{3}a}{2}} \frac{\mu_0 I\left(\frac{2dx}{\sqrt{3}}\right)}{2\pi x} \frac{\sqrt{3}}{2} \times 2 = \frac{\mu_0 I^2}{\pi} \ln($$

$$\boxed{B = \frac{\mu_0 I^2}{2\pi}\hat{i} + \frac{\mu_0 I^2}{\pi}\ln\left(\frac{2+\sqrt{3}}{2}\right)(-\hat{i})}$$

(20) form 3 loop by adding four additional wires:

$$\bar{M} = \cancel{I\ell^2\hat{k}} + \cancel{I\ell^2 - \hat{k}} \; [illegible]$$

$$+ I\ell^2\hat{j}$$

$$\boxed{\vec{M} = I\ell^2\hat{j}}$$

(21) $B = \int_0^R \frac{\mu_0 dI}{2x} = \frac{\mu_0}{2}\int($ [illegible]

$M = \int$ [illegible]

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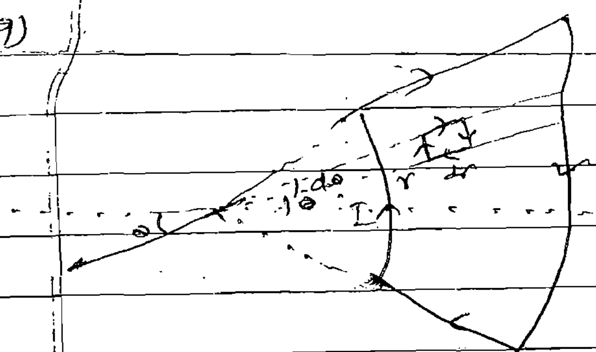
(29)



(31)

$$dA = (r\,d\theta)(dr)$$

$$dM = r I (d\theta)(dr) \quad ; \quad B = \frac{\mu_0 I_0}{2\pi r}$$

$$d\tau = dM\, B \sin 90^\circ$$

$$d\tau = \cancel{r} I\, d\theta\, dr \frac{\mu_0 I_0}{2\pi \cancel{r}} = \frac{\mu_0 I I_0\, d\theta\, dr}{2\pi}$$

towards center

$$\tau_{net} = \int d\tau \cos\theta$$

$$\tau_{net} = \frac{\mu_0 I I_0}{2\pi} \int_{-\alpha}^{\alpha} \cos\theta\, d\theta \int_a^b dr = \frac{\mu_0 I I_0 (2\sin\alpha)(b-a)}{2\pi}$$

$$\tau_{net} = \frac{\mu_0 I I_0 \sin\alpha (b-a)}{\pi} \quad \text{(towards left)}$$ (32)

(30) (a) $\overline{M} = I_2 \overline{A} \qquad \overline{A} = (\overrightarrow{B-A}) \times (\overrightarrow{A-D})$

$$\overline{A} = (2d\hat{i} - 2a\hat{j}) \times 2b\,\hat{k}$$ (33)

$$= 4b\,(d\hat{i} - a\hat{j}) \times \hat{k}$$

$$\overline{A} = -4b\,(d\hat{j} + a\hat{i})$$

$$\overline{M} = -I_2 4b\,(d\hat{j} + a\hat{i})$$

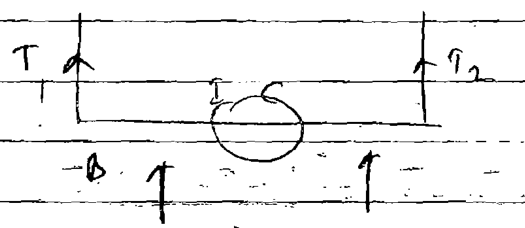
(b) $$B = \frac{\mu_0 I_1}{2\pi a}\,\hat{j}$$

$$U = -\overline{M}\cdot\overline{B} = \frac{I_2 4b\,\mu_0 I_1 d}{2\pi a}$$

$$F = -\frac{dU}{dx}\hat{i} = \left(\frac{2\mu_0 b d I_1 I_2}{\pi x_0^2}\right)\hat{i}$$

Use $\boxed{\bar{F} = -\left(\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right)}$

(31)



Moment about 1

$$\tau_{wt} = \tau_{T_2} + \tau_B$$

$$T_0 L = T_2 L + I\pi r^2 B$$

$$T_2 = \left(T_0 - \frac{I\pi r^2 B}{L}\right)$$

Moment about 2

$$\tau_{T_1} = \tau_B + \tau_{wt}$$

$$T_1 L = T_0 L + I\pi r^2 B$$

$$\boxed{T_1 = T_0 + \frac{I\pi r^2 B}{L}}$$

(32) $\tau_B = \tau_{wt} \Rightarrow \cancel{\lambda} \lambda a g \frac{a}{\cancel{2}} \sin 60 = M B \sin 60$

$$\Rightarrow \lambda \cancel{a^2} g = I \cancel{a^2} B \frac{\sqrt{3}}{2} \quad \therefore B = \frac{2\lambda g}{\sqrt{3} I}$$

(33) By conservation of angular momentum about common diameter!

$$\frac{m r^2 \omega_1}{\cancel{2}} = \frac{M R^2 \omega_2}{\cancel{2}} \quad \therefore \omega_2 = \frac{m}{M}\left(\frac{r^2}{R^2}\right)\omega_1 \quad —(1)$$

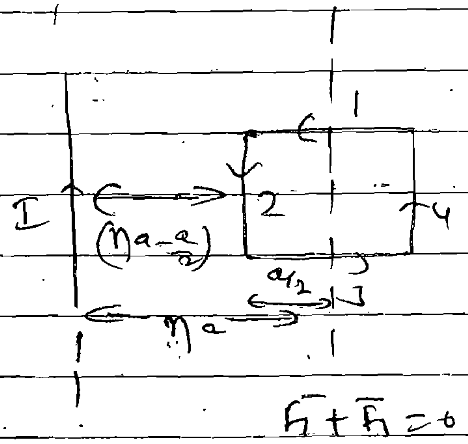
By COE $\frac{1}{2}\frac{m r^2}{2}\omega_1^2 + \frac{1}{2}\frac{M R^2}{2}\omega_2^2 = -\bar{p}\cdot\bar{B}$

$$= \frac{\mu_0 I_1 I_2 \pi r^2}{2R} \quad —(2)$$

Solving (1) & (2)

$$\frac{1}{2}\left(\frac{m r^2}{2}\right)\omega_1^2 = \mu_0 \pi r^2 I_1 I_2 M R$$

(34) (a) (35)



$$\bar{F}_1 + \bar{F}_3 = 0$$

$$\bar{F}_{net} = \bar{F}_2 + \bar{F}_4 = \left[\left(\frac{\mu_0 I_0}{2\pi\left(\eta a - \frac{a}{2}\right)}\right)(Ia) - \frac{\mu_0 I_0}{2\pi(\eta a + a/2)}(Ia)\right]\hat{i}$$

$$= \frac{\mu_0 I_0 I \cancel{a} \times \cancel{2}}{\cancel{2}\pi \cancel{a}}\left(\frac{1}{2\eta - 1} - \frac{1}{2\eta + 1}\right)$$ (36)

$$= \frac{\mu_0 I_0 I}{\pi}\,\frac{2}{4\eta^2 - 1} = \left[\frac{2\mu_0 I I_0}{\pi(4\eta^2 - 1)}\right]\hat{i}$$

(b)

$$W = \Delta P E$$

$$= 2\,P_m B$$ (37)

$$= 2\int_{\eta a - a/2}^{\eta a + a/2} \frac{\mu_0 I}{2\pi x}(I_0 a\,dx)$$

$$W = \frac{\mu_0 I I_0 a}{\pi}\ln\left(\frac{2\eta + 1}{2\eta - 1}\right)$$

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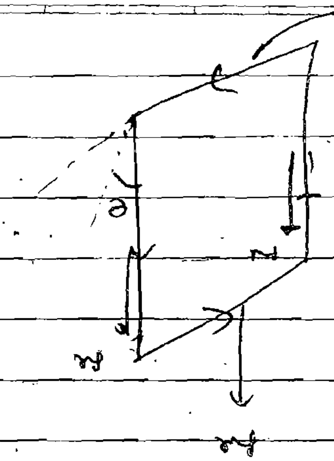
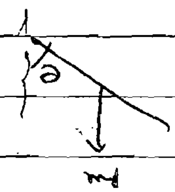
(35) $(\tau = 0)$



$$\tau_B = I l^2 B \sin(90-\theta)$$

$$\therefore \tau_B = I l^2 B \cos\theta$$

$$\tau_{mg} = mg\frac{l}{2}\sin\theta + mg\frac{l}{2}\sin\theta + mgl\sin\theta$$



$$\therefore \tau_{mg} = 2mgl\sin\theta = 2(Sl\rho)gl\sin\theta$$
$$= 2(\rho S l^2 g\sin\theta)$$

for eq^n $\tau_{mg} = \tau_B$

$$I\cancel{l^2}B\cos\theta = 2\rho S\cancel{l^2}g\sin\theta$$

$$\boxed{B = \frac{2S\rho g\tan\theta}{I}}$$

(36) (a) $F = 0$

(b) $$U = -\vec{p}_m\cdot\vec{B} = -p_m\frac{\mu_0 I}{2\pi r}$$

$$F = -\frac{dU}{dr} = \frac{p_m\mu_0 I}{2\pi r^2} = \frac{\mu_0}{4\pi}\left(\frac{2Ip_m}{r^2}\right)$$

(c) $\parallel$ to (B)

(37)

$$B = \frac{\mu_0}{4\pi}\frac{2p_{m_1}}{r^3}$$

$$U = -\vec{p}_{m_2}\cdot\vec{B} = \left(\frac{\mu_0 p_{m_1}p_{m_2}}{2\pi r^3}\right)$$

$$F = -\frac{dU}{dr} = \left.\frac{3\mu_0 p_{m_1}p_{m_2}}{2\pi r^4}\right|_{r=l} = \left(\frac{3\mu_0 p_{m_1}p_{m_2}}{2\pi l^4}\right)$$

(38) $\tau = I l^2 B \sin\theta$ (41)

$\simeq I l^2 B \theta = I_M \alpha$

$\cancel{I l^2 B \theta} = \left[\frac{m}{4}\frac{l^2}{12} \times 2 + \frac{m l^2}{16} \times 2\right] \omega^2 \cancel{\theta}_{\,SHM}$

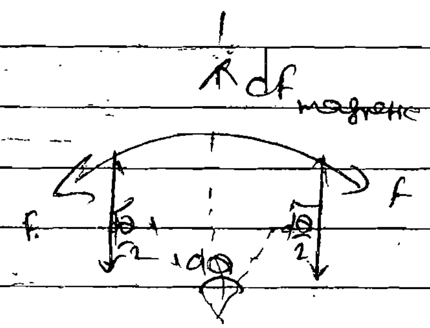
$IB = \frac{m\omega^2}{6}_{SHM} \quad \omega_{SHM} = \sqrt{\frac{6IB}{m}} = \frac{2\pi}{T}$

$T = 2\pi\sqrt{\frac{m}{6IB}} = 2\pi\sqrt{\frac{0.01}{6 \times 2 \times 0.1}}$

$= 2\pi\sqrt{\frac{1}{120}} = \frac{2\pi}{11} = \frac{2 \times 22}{11 \times 7} = \frac{4}{7}$

$= 0.57$ sec (42)

(39)



$2F\sin\left(\frac{d\theta}{2}\right) = F d\theta$

$F d\theta = df_{magnetic}$ (43)

$IR\, d\cancel{\theta} B = F d\cancel{\theta}$

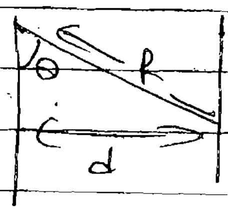
$F = IRB$

$l = 2\pi R$

$dl = 2\pi (dR)$ (44)

$\frac{F}{K} = 2\pi dR \Rightarrow dR = \frac{F}{2\pi K} = \left(\frac{IRB}{2\pi K}\right)$

(40)



$\sin\theta = \frac{d}{R}$

$\omega t = \sin^{-1}(d/R) - \alpha$

(41) $\frac{1}{2}mv^2 = q.V_0 \Rightarrow p = \sqrt{2mqV_0}$

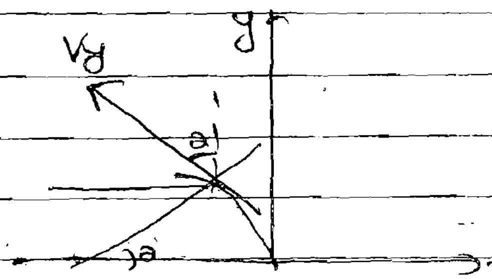
$R = \frac{mv}{qB} = \frac{p}{qB} \quad \therefore \quad 2R = \left(\frac{2p}{qB}\right)$

$l + d = \frac{2}{qB}\sqrt{2m_1 q V_0}$

$l = \frac{2}{qB}\sqrt{2m_2 q V_0} \quad \therefore \left(\frac{l+d}{l}\right)^2 = \frac{m_1}{m_2}$

$\therefore \boxed{\frac{m_1}{m_2} = \left(1 + \frac{d}{l}\right)^2}$

(42)



$\overline{V} = V_x\hat{i} + V_y \cos\omega t\,\hat{j} + V_y \sin\omega t\,(-\hat{k})$

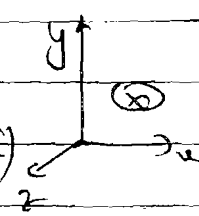
where $\omega = qB/m$

$T = \cancel{2\pi}/\omega = \cancel{2\pi} m/qB \quad \therefore \omega = qB/m$

(43) By COE $\quad \frac{1}{2}mv^2 = qE_0 z$

$\therefore v = \sqrt{\frac{2qE_0 z}{m}}$

(44) $\overline{F} = F_e + F_m = q\overline{E} + q(\overline{v} \times \overline{B})$



$\overline{F} = qE\hat{j} + q(v_x\hat{i} + v_y\hat{j}) \times B(-\hat{k})$

$F = -qE\hat{j} + qBv_x\hat{j} - qv_yB\hat{i}$

$f_x = ev_yB, \quad f_y = (eE - eBv_x)$

$m\frac{dv_x}{dt} = ev_yB \quad -(1) \qquad m\frac{dv_y}{dt} = eE - eBv_x \quad -(2)$

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So diff (2) we get (45.)

$$m\frac{d^2v_y}{dt^2} = -eB\frac{dv_x}{dt}$$

$$m\frac{d^2v_y}{dt^2} = -eB\cdot\frac{eB}{m}v_y$$

$$\frac{d^2v_y}{dt^2} = -\left(\frac{eB}{m}\right)^2 v_y$$

$$v_y = A\sin\left(\frac{eB}{m}t+\phi\right) \quad (46)$$

At $t=0$ $v_y=0$ $\therefore \phi=0$

$$v_y = A\sin\left(\frac{eB}{m}t\right)$$

when $\bar{v}\perp\bar{E}$ $v_y=0$ $\therefore \frac{eBt}{m} = 0, \pi, 2\pi$ etc

$$\frac{dv_y}{dt} = A\frac{eB}{m}\cos\left(\frac{eB}{m}t\right) \quad (47)$$

$$\frac{\cancel{e}E}{\cancel{m}} = \frac{A\cancel{e}B}{\cancel{m}} \quad \text{At } t=0$$

$$A = E/B$$

$$v_y = \frac{E}{B}\sin\left(\frac{eB}{m}t\right) \quad \left(\frac{eB}{m}=\omega\right)$$

$$v_x = \frac{E_0}{B_0}(1-\cos\omega t)$$

So $$y = \frac{E_0}{B_0\omega}(1-\cos\omega t)$$

So, $$y_{(t=m\pi/eB)} = \frac{E_0}{B_0\omega}(1-\cos\pi) = \frac{2E_0m}{B_0eB_0}$$

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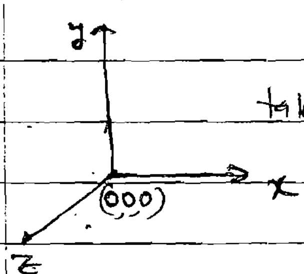
(45.)



take $\alpha = 60°$, Pitch $= 0.05\,m = 5\,cm$

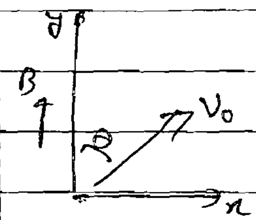
$$\left(\frac{2\pi m}{qB}\right)(V_0 \cos\alpha) = d$$

$$\frac{1}{2} m v_0^2 = qV \quad \therefore V_0 = \sqrt{\frac{2qV}{m}}$$

$$\text{So } \left(\frac{2\pi m}{qB}\right)\sqrt{\frac{2qV}{m}} \cos 60 = d \quad \therefore B = 6.9 \times 10^{-3} T$$

Substituting values.

(46)



Part 1:

$V_0 \cos\theta = V_{second}$

By CoE:

$$\frac{1}{2} m v_0^2 = qV \quad \therefore V_0 = \sqrt{\frac{2qV}{m}}$$

$$V_{second} = \left(\sqrt{2qV/m}\right)\cos\theta$$

Part 2:

distance = pitch = $(V_{second})(T)$

$$= \sqrt{\frac{2qV}{m}} \cos\theta \left(\frac{2\pi m}{qB}\right)$$

(47) Initially $\cancel{q} V \cos\theta B = \cancel{q} E$

$$V = \left(\frac{E}{B\cos\theta}\right)$$

When E off: Pitch $= P = T(V\sin\theta)$

$$= \left(\frac{2\pi R}{V_n}\right)(V\sin\theta)$$

$$= \frac{2\pi m \cancel{V_n}}{\cancel{V_n}\, qB} V\sin\theta$$

$$= \frac{2\pi m}{qB} \frac{E}{B\cos\theta} \sin\theta$$

$$= \left(\frac{2\pi m E \tan\theta}{qB^2}\right)$$

$\frac{q E_0 m}{B_0 q B_0}$

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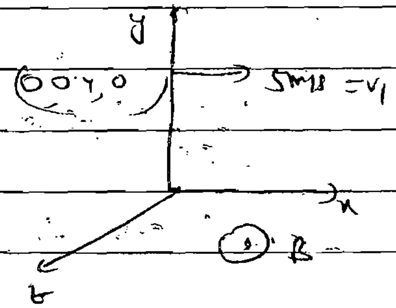
(48)



Radius of circular path by this particle = 0.4

but $r_1 = \left(\frac{m_1 v_1}{q_1 B}\right)$

$B = \left(\frac{m_1 v_1}{q_1 r}\right) = 0.5\,T$

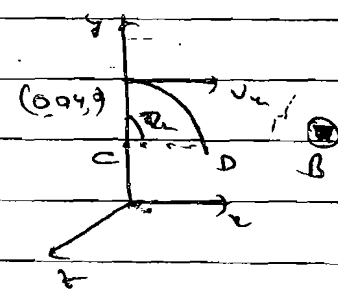
For 1st & 2nd particle use CLM (Conservation of linear momentum)

$(m_1 + m_2)\vec{v}_c = m_1\vec{v}_1 + m_2\vec{v}_2$

$(40\times10^{-3} + 10\times10^{-3})\vec{v} = (40\times10^{-3})5\hat{i} + (10\times10^{-3})40\hat{k}$

So $v_x = 4$ m/s

$v_z = 8$ m/s



due to v_x circular motion

$R = \frac{(m_1 + m_2)v_x}{(q_1 + q_2)B} = 0.2$ m

$T = \frac{2\pi(m_1 + m_2)}{(q_1 + q_2)B} = \frac{\pi}{10}$ sec

angular displacement due to circular motion

$\theta = \omega t = \frac{\pi}{2}$

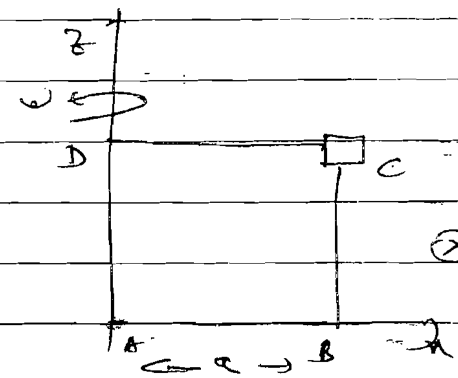
$x_{coordinate} = R\sin\theta = 0.2$

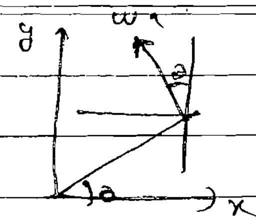
$y_{coordinate} = OC + R\cos\theta = 0.2 + 0 = 0.2$

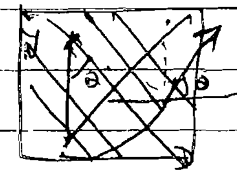
$z_{coordinate} = v_z t = 0.2$

So position = (0.2, 0.2, 0.2)

(49)







V_{speed} of block = ωa in xy plane

$$\bar{v} = \omega a(-\sin\theta\,\hat{i} + \cos\theta\,\hat{j} + v_z\,\hat{k})$$

$$\bar{F} = q\bar{v}\times\bar{B} = \omega a(-\sin\theta\,\hat{i} + \cos\theta\,\hat{j} + v_z\,\hat{k}) \times B_0\hat{j}$$

$$\bar{F}_z = \omega a B_0 \sin\theta(-\hat{k})$$

$$a_z = \frac{\omega a B_0 \sin\theta}{m}(-\hat{k}) = \frac{dv_z}{dt}$$

$$v_z = \int dv_z = -\int_0^t \frac{\omega a B_0 \sin\omega t\,dt}{m}$$

$$v_z = -\frac{\cancel{\omega} a B_0}{m\cancel{\omega}}(1-\cos\omega t)$$

$$v_z = -\frac{a B_0}{m}(1-\cos\omega t) = \frac{dz}{dt}$$

$$\int dz = -\frac{a B_0}{m}\int_0^t (1-\cos\omega t)\,dt$$

$$z = -\frac{\cancel{a} B_0}{m}\left(t - \frac{\sin\omega t}{\omega}\right) = -\cancel{a}$$

$$\boxed{B_0 = \left(\frac{m\omega}{\omega t - \sin\omega t}\right)}$$

$\otimes$ B

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(30) (a) $\frac{1}{2}mv^2 = qV_0$

$(V_0 = \text{p.d})$ (1)

$v = \sqrt{\frac{2qV_0}{m}}$

$d = \frac{1}{2}\frac{qE}{m}t^2 = \frac{1}{2}\frac{qE}{m}\left(\frac{a}{V}\right)^2$ (2)

$= \frac{1}{2}\frac{\cancel{q}E}{\cancel{m}}\frac{a^2\cancel{m}}{2\cancel{q}V_0} = \frac{Ea^2}{4V_0}$

(b) $\text{Pitch} = T\left(\frac{qE}{m}\right)t$

$= \left(\frac{2\pi \cancel{m}}{\cancel{q}B}\right)\left(\frac{\cancel{q}E}{\cancel{m}}\right)\left(\frac{a}{V}\right)$ (3)

$= \frac{2\pi E}{B}\sqrt{\frac{a^2 m}{2qV_0}}$

$\text{Pitch} = \frac{\pi E a}{B}\sqrt{\frac{2m}{qV_0}}$

(4)

(5)

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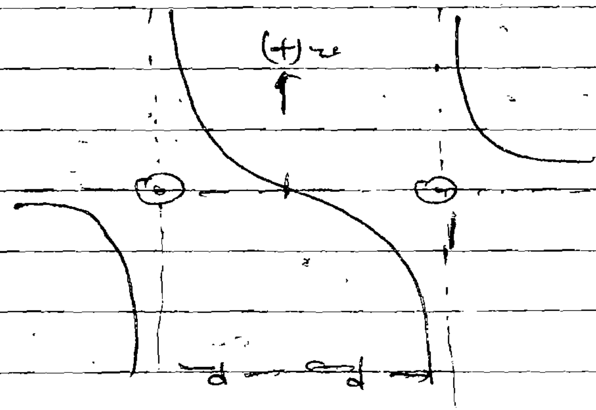
Jee Problems

Single choice

(1) $\frac{M}{L} = \frac{\frac{q\pi r^2}{T}}{mr^2\omega} = \frac{q\cancel{\pi}\cancel{r^2}\cancel{\omega}}{2\cancel{\pi}\, m\cancel{r^2}\cancel{\omega}} = \frac{q}{2m}$ $\boxed{C}$

(2)



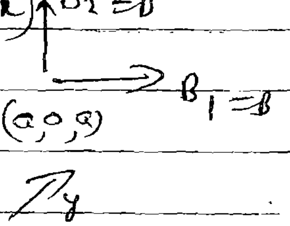
$\boxed{B}$

(3) $h_1 = \frac{\mu_0 I}{4\pi d}$

$h_2 = \frac{\mu_0 I}{4\pi d} + \frac{\mu_0 I}{8\pi d} = \frac{\mu_0 I}{4\pi d}\left(\frac{3}{2}\right) = h_1\frac{3}{2}$

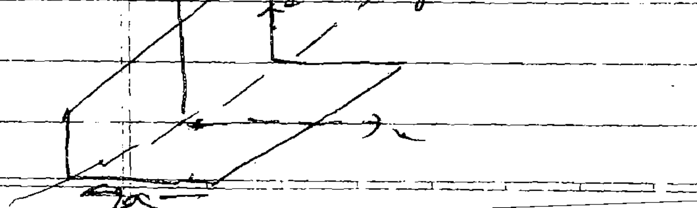
$\frac{h_1}{h_2} = \frac{2}{3}$ $\boxed{C}$

(4)



$\boxed{C}$

(5)



$\therefore B_{net} = \frac{\hat{i}+\hat{k}}{\sqrt{2}}$

$\boxed{D}$

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(6) $R_A > R_B$

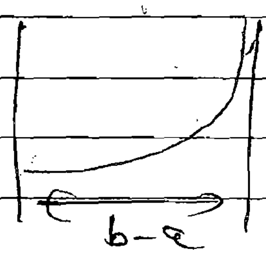
$\frac{m_A v_A}{qB} > \frac{m_B v_B}{qB}$ ∴ $m_A v_A > m_B v_B$ (11)

$\boxed{B}$

(7) $B = \int_a^b \frac{\mu_0 I}{2\pi x} \frac{N}{b-a}\, dx$ (12)

∴ $B = \frac{\mu_0 N I}{2\pi(b-a)} \ln\left(\frac{b}{a}\right)$ $\boxed{C}$

(8) (13)



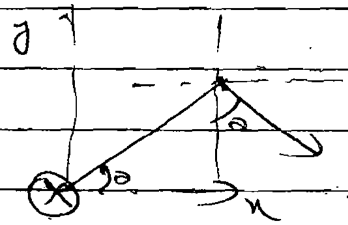
$\frac{mv}{qB} = R = (b-a)$

$\frac{mV}{qB} = (b-a)$ (14)

$V = \frac{q(b-a)B}{m}$ $\boxed{B}$ (15)

(15

(9)



$B = \frac{\mu_0 I}{2\pi\sqrt{x^2+y^2}}\left(\hat{i}\sin\theta - \hat{j}\cos\theta\right)$

∴ $B = \frac{\mu_0 I (y\hat{i} - x\hat{j})}{2\pi(x^2+y^2)}$ $\boxed{A}$

(17)

(10) $\boxed{D}$ Closed loop

N to S out

S to N in

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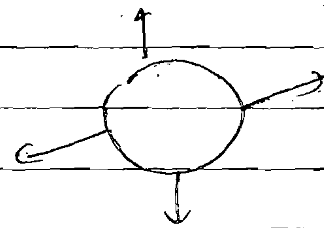
(11) B_{mult} have $\hat{i}$ not alg $\hat{j}$

So $\boxed{B}$

(12)



$\boxed{B}$

(13) $(MB)_{I}$, $(MB\cos\theta)_{IV}$, $(0)_{II}$, $(-MB\cos\theta)_{III}$

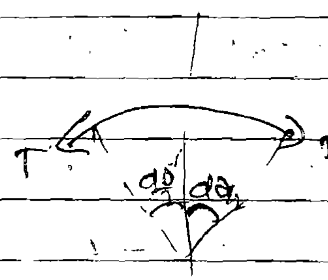
$\therefore$ $\boxed{C}$ $I > IV > II > III$

(14) speed const ey co as q lo

$\boxed{B}$

(15) direction will conclude opt circle down so $\boxed{A}$

(16)



$2T\sin d\theta/2 = I\,dl\,B$

$T\,d\theta = IR\,d\theta\,B$

$\therefore\ T = IRB$ $L = 2\pi R$

$\boxed{T = \frac{IBL}{2\pi}}$ $R = \frac{L}{2\pi}$

$\boxed{C}$

Multiple choice

(17) $F_{AB} = 0 = F_{CD}$, $\overline{F}_{BC} = -\overline{F}_{DA}$

So $F_{net} = 0$

τ F_{BC} F_{DA} — $\boxed{A}$ $\boxed{C}$

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(18) $\frac{mv}{qB} = R > l$ (21)

$v > \frac{qBl}{m}$ [a]

[C] [D] Time period $= \frac{2\pi m}{qB}$

Independent of v

Subjective Problem

(19) In eq^m $2T_0 = mg$ $\therefore T_0 = \frac{mg}{2}$ —(i), $\tau = MB\sin 90°$

$\therefore \tau = (IA)B = \left(\frac{\omega Q}{2\cancel{\pi}}\right)\cancel{\pi}R^2 B = \frac{\omega BQR^2}{2}$

let T_1 & T_2 tension in string when magnetic field is switched on $(T_1+T_2) = mg$ —(ii) $(T_1 > T_2)$ for Rotational eq^m about CM

$(T_1 - T_2)\frac{D}{2} = \frac{\omega BQR^2}{2} \Rightarrow T_1 - T_2 = \frac{\omega BQR^2}{D}$ —(iii)

$\therefore T_1 = \frac{mg}{2} + \frac{\omega BQR^2}{2D} = T_0 + \frac{\omega BQR^2}{2D} = \frac{3T_0}{2}$ $\therefore \omega_{max} = \left(\frac{DT_0}{BQR^2}\right)$

(20) $\frac{R_p}{R_\alpha} = \frac{\cancel{m_p} v_p q_\alpha \cancel{2}}{q_p \cancel{m_\alpha} v_\alpha \cancel{4}\,2} = \frac{1}{2}\left(\frac{v_p}{v_\alpha}\right)$ —(1)

also, $q_\alpha V = \frac{1}{2} m_\alpha v_\alpha^2$ —(A)

$q_p V = \frac{1}{2} m_p v_p^2$ —(B)

(22)

(A)/(B)

$\frac{2\cancel{q_\alpha}}{\cancel{q_p}} = \frac{\overset{4}{\cancel{m_\alpha}}}{\cancel{m_p}}\left(\frac{v_\alpha}{v_p}\right)^2$

$\frac{1}{2} = \left(\frac{v_\alpha}{v_p}\right)^2 \therefore \frac{v_p}{v_\alpha} = \sqrt{2}$

By (1) $\frac{R_p}{R_\alpha} = \frac{1}{\ldots}$

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(21) (a) $NIAB = k i$

$k = \frac{N\cancel{I}AB}{\cancel{I}} = NAB$

$k = NAB$

(b) $NI_0 AB = \tau_k \left(\frac{\pi}{2}\right)$

$\tau_k = \left(\frac{2NI_0AB}{\pi}\right)$ = Torsional const

(c) $\tau = BiNA$

$\int_0^t \tau\, dt = I\omega \Rightarrow BNAQ = I\omega$

$\omega = \frac{BNAQ}{I}$

By COE At max^m deflection total KE is converted into P.E
(Just like is converted to circular)

$\frac{1}{2} I\omega^2 = \frac{1}{2} k\theta_{max}^2 \Rightarrow \cancel{\frac{1}{2}} I\left(\frac{BNAQ}{I}\right)^2$

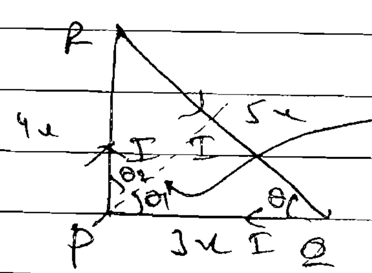
$= \cancel{\frac{1}{2}} \frac{2BiNA}{\pi} \theta_{max}^2$

$I \frac{B^2N^2A^2Q^2}{I^2} = \frac{2BiNA}{\pi} \theta_{max}^2$

$\theta_{max} = \sqrt{\frac{\pi BNAQ^2}{2I}} = Q\sqrt{\frac{BN\pi A}{2I}}$

... is switched
... about cm
$= \frac{BQl^2}{2}$ — (iii)
$\omega_{max} = \left(\frac{DI_0}{BQl^2}\right)$

(22)



$\sin\theta = \frac{d}{3a} = \frac{4}{5} \therefore d = \frac{12a}{5}$

$B_p = \frac{\mu_0 I}{4\pi\left(\frac{12a}{5}\right)}\left[\cos\theta + \sin\theta\right]$

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(23) P to Q as $\vec{M} \uparrow\uparrow -\hat{k}$

$MB = \frac{mga}{2} \Rightarrow I\cancel{a}bB = \frac{mg\cancel{a}}{2}$

$\therefore B = \left(\frac{mg}{2Ib}\right) = 3B_0$

$F_{RS} = -Ib\hat{j} \times (3\hat{i} + 4\hat{k})B_0$

$= IbB_0(3\hat{k} - 4\hat{i})$ $I = \left(\frac{mg}{6bB_0}\right)$

(24) $B_{centre} = \left(\frac{\mu_0 I_1}{4R_1} + \frac{\mu_0 I_2}{4R_2}\right) = \frac{\pi \times 10^{-7}}{4\pi \times 4}\left[\frac{10}{0.02} + \frac{10}{0.03}\right]$

$= 6.54 \times 10^{-5}\,T$

$F_{centre} = 6.54 \times 10^{-5} \times 10 \times \sin 0°$

$\therefore F_{centre} = 0$

$F_{AB} = 0$

also $F_{CD} = \int_{r_1}^{r_2} \frac{\mu_0 I^2 dx}{2\pi x} = \frac{\mu_0 I^2}{2\pi} \ln\left(\frac{r_2}{r_1}\right)$

$= \frac{\mu_0 I^2}{2\pi} \ln\left(\frac{3}{2}\right) = 8 \times 10^{-5} N$

(25) $\boxed{D}$

(26) $\boxed{D}$

(27) $\boxed{B}$

(28) $\boxed{C}$