JEE Main Exercise

1. (C)

$\mathbf{a} \perp \mathbf{b}$

$\Rightarrow \mathbf{a} \cdot \mathbf{b} = \left(-5\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + a^2\hat{\mathbf{k}}\right) \cdot \left(2\hat{\mathbf{i}} + a\hat{\mathbf{j}} + \hat{\mathbf{k}}\right) = 0$

$\Rightarrow -10 + 3a + a^2 = 0$

$\Rightarrow a = 2$ and $a = -5$

2. (A)

$F_B = mg = qvB\sin 90° = mg$

$$\Rightarrow qv\left(\frac{\mu_0 i}{2\pi r}\right)\sin 90° = mg$$

$$\Rightarrow q(10)\left(\frac{4\pi \times 10^{-7} \times 1}{2\pi(0.01)}\right)(1) = 1 \times 10^{-6} \times 10$$

$\Rightarrow q = 50 \times 10^{-3}\,\text{C} = 50\,\text{mC}$

3. (A)

$$R = \frac{mv}{qB} = \frac{2 \times 10^5}{5 \times 10^7 \times 4 \times 10^{-2}} = 0.10\text{ m}$$

4. (C)

$$T_p = \frac{2\pi m_p}{q_p B} \text{ and } T_\alpha = \frac{2\pi(4m_p)}{(2q_p)B} = 2T_p$$

$$\Rightarrow T_p = \frac{25\mu s}{5} = 5\mu s \Rightarrow T_\alpha = 2 \times 5 = 10\mu s$$

5. (A)

$$f = \frac{qB}{2\pi m} \Rightarrow f \propto \frac{1}{m}$$

6. (B)

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

$$\Rightarrow v \geq \frac{q(b-a)B}{m}$$

$$\Rightarrow \quad v_{\min} = \frac{q(b-a)B}{m}$$

7. (B)

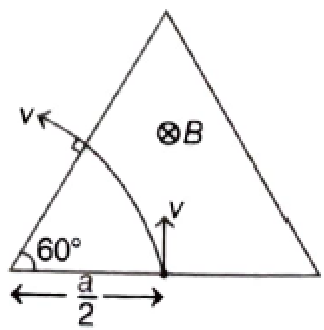
$$K = \frac{q^2B^2R^2}{2m} \text{ and } f = \frac{qB}{2\pi m}$$

$$\Rightarrow \quad K = \frac{(2\pi mf)^2 R^2}{2m} = 2\pi^2 mf^2R^2$$

$$\Rightarrow \quad K = 2\times(3.14)^2 \times 1.67\times 10^{-27}\times\left(10^7\right)^2 (0.6)^2$$

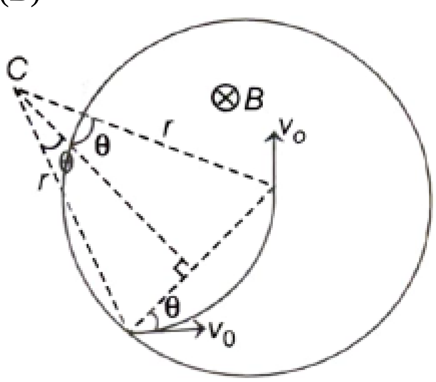
$$\Rightarrow \quad K = 1.2\times 10^{-12} \text{ J}$$

8. (B)



$$R = \frac{mv}{qB} \Rightarrow \frac{a}{2} = \frac{mv}{qB} \Rightarrow B = \frac{2mv}{qa}$$

9. (B)



$$2r\sin\theta = R$$

$$\Rightarrow \quad 2\left(\frac{mv_0}{qB}\right) = \sin\theta = R \quad \Rightarrow v_0 = \frac{qBR}{2m\sin\theta}$$

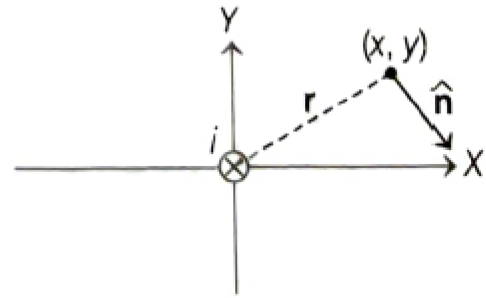
10. (A)

$$B=\frac{\mu_0 i}{2\pi r}=\frac{\mu_0 i}{2\pi\sqrt{x^2+y^2}}$$

$$\mathbf{r}=x\hat{\mathbf{i}}+y\hat{\mathbf{j}}$$

$$\hat{\mathbf{n}}\perp\mathbf{r}\Rightarrow\hat{\mathbf{n}}=\frac{y\hat{\mathbf{i}}-x\hat{\mathbf{j}}}{\sqrt{x^2+y^2}}$$

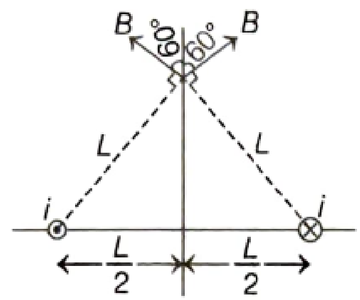
$$\mathbf{B}=B\hat{\mathbf{n}}\frac{\mu_0 i}{2\pi\sqrt{x^2+y^2}}\left(\frac{y\hat{\mathbf{i}}-x\hat{\mathbf{j}}}{\sqrt{x^2+y^2}}\right)=\frac{\mu_0 i\left(y\hat{\mathbf{i}}-x\hat{\mathbf{j}}\right)}{2\pi(x^2+y^2)}$$



11. (C)

$$B=\frac{\mu_0 i}{2\pi L}$$

$$B_{\text{net}}=2B\cos 60^\circ=\frac{\mu_0 i}{2\pi L}$$



12. (A)

$$B_{\text{net}}=2\left(B_{AB}+B_{BC}\right)$$

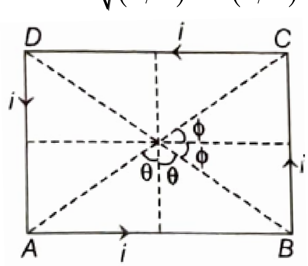
$$=2\left(\frac{\mu_0 i}{4\pi\left(\frac{b}{2}\right)}(\sin\theta+\sin\theta)\right)+2\left(\frac{\mu_0 i}{4\pi\left(\frac{a}{2}\right)}(\sin\phi+\sin\phi)\right)$$

$$=\frac{2\mu_0 i}{\pi}\left[\frac{1}{b}\left(\frac{a/2}{\sqrt{(a/2)^2+(b/2)^2}}\right)+\frac{1}{a}\left(\frac{b/2}{\sqrt{(a/2)^2+(b/2)^2}}\right)\right]$$

$$=\left(\frac{\mu_0 i}{4\pi}\right)\left(\frac{8\sqrt{a^2+b^2}}{ab}\right)$$

$$\sin\theta=\frac{a/2}{\sqrt{(a/2)^2+(b/2)^2}}$$

$$\sin\phi=\frac{b/2}{\sqrt{(a/2)^2+(b/2)^2}}$$



13. (A)

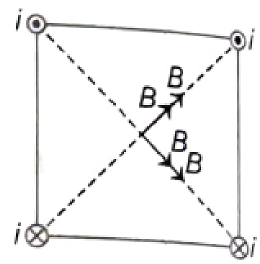
$$\mathbf{B}=\mathbf{B_1}+\mathbf{B_2}+\mathbf{B_3}=\frac{\mu_0 i}{2\pi a}\hat{\mathbf{j}}-\frac{\mu_0 i}{2\pi a}\hat{\mathbf{i}}+0=\frac{\mu_0 i}{2\pi a}(\hat{\mathbf{j}}-\hat{\mathbf{i}})$$

14. (A)

At point (X, Y), $\mathbf{B}=\left(\frac{\mu_0 i_1}{2\pi Y}-\frac{\mu_0 i_2}{2\pi X}\right)\hat{\mathbf{k}}=0$

$$\Rightarrow \quad Y=\left(\frac{i_1}{i_2}\right)X$$

15. (A)



$$B=\frac{\mu_0 i}{2\pi\left(\frac{a}{\sqrt{2}}\right)}$$

$$B_{\text{net}}=\sqrt{(2B)^2+(2B)^2}$$

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

16. (D)

$$B=\frac{\mu_0\left(\frac{2}{3}\right)\frac{i}{3}}{2a}-\frac{\mu_0\left(\frac{1}{3}\right)\left(\frac{2i}{3}\right)}{2a}=0$$

17. (C)

$$\mathbf{B}=\mathbf{B_1}+\mathbf{B_2}+\mathbf{B_3}=\frac{\mu_0\left(\frac{3}{4}\right)i}{2a}-\frac{\mu_0\left(\frac{3}{4}\right)i}{2b}+\frac{\mu_0 i}{2c}=0$$

$$\Rightarrow \quad \frac{\mu_0 i}{2}\left(\frac{3}{4a}-\frac{3}{4b}+\frac{1}{c}\right)=0$$

$$\Rightarrow \quad \frac{3}{4}\left(\frac{1}{a}-\frac{1}{b}\right)+\frac{1}{2a}=0$$

$$\Rightarrow \quad a=\frac{5}{3}b$$

18. (A)

$$B_1=-\frac{\mu_0 i}{4R}+\frac{\mu_0 i}{4\pi R}-\frac{\mu_0 i}{4\pi R}=-\frac{\mu_0 i}{4R}$$

$$B_2=\frac{\mu_0 i}{4R}+0+0=\frac{\mu_0 i}{4R}$$

$$B_3=\frac{\mu_0\left(\frac{3}{4}\right)i}{2R}+0-\frac{\mu_0\pi i}{4R}=\frac{\mu_0 i}{2\pi R}\left(\frac{3\pi}{4}-\frac{1}{2}\right)$$

$$B_1:B_2:B_3=-\frac{\pi}{2}:\frac{\pi}{2}:\left(\frac{3\pi}{4}-\frac{1}{2}\right)$$

19. (C)

$$\oint \mathbf{B}\cdot\mathbf{dl} = \mu_0 i_{\text{enclosed}}$$

loop A; $\oint \mathbf{B}\cdot\mathbf{dl} = +i+i+i-i-i-i=0$

loop B; $\oint \mathbf{B}\cdot\mathbf{dl} = +i+i-i=i$

loop C; $\oint \mathbf{B}\cdot\mathbf{dl} = +i-i-i-i=-i$

loop D; $\oint \mathbf{B}\cdot\mathbf{dl} = -i$

$B > A > C = D$

20. (B)

$$\oint \mathbf{B}\cdot\mathbf{d}l = \mu_0\left(-i_2-i_3+i_4\right)$$

$$=\mu_0\left(-4-6+8\right) = -2\mu_0 \text{ Wb/m}$$

21. (C)

$$\oint \mathbf{B}\cdot\mathbf{dI} = 0$$

$$\Rightarrow \int_A^B \mathbf{B}\cdot\mathbf{dI} + \int_B^C \mathbf{B}\cdot\mathbf{dI} + \int_C^D \mathbf{B}\cdot\mathbf{dI} + \int_D^E \mathbf{B}\cdot\mathbf{dI} + \int_E^A \mathbf{B}\cdot\mathbf{dI} = 0$$

$$\int_E^A \mathbf{B}\cdot\mathbf{dI} = 0 \Rightarrow \mathbf{B}\perp\mathbf{dI}$$

$$\Rightarrow \int_A^B \mathbf{B}\cdot\mathbf{dI} + \int_B^C \mathbf{B}\cdot\mathbf{dI} = -\int_C^D \mathbf{B}\cdot\mathbf{dI} - \int_D^E \mathbf{B}\cdot\mathbf{dI}$$

$$= \int_D^C \mathbf{B}\cdot\mathbf{dI} + \int_E^D \mathbf{B}\cdot\mathbf{dI}$$

22. (A)

Forces on BC and DA cancel out each other.

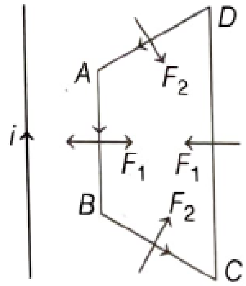
$$F_{AB} = \left[\frac{\mu_0 i_2}{2\pi\left(\frac{l}{2}\right)}\right] i_1 l = \frac{\mu_0 i_1 i_2}{\pi}$$

$$F_{CD} = \left[\frac{\mu_0 i_2}{2\pi\left(\frac{3l}{2}\right)}\right] i_1 l = \frac{\mu_0 i_1 i_2}{3\pi}$$

$$F_{\text{net}} = F_{AB} - F_{CD} = \frac{2\mu_0 i_1 i_2}{3\pi}$$

23. (B)

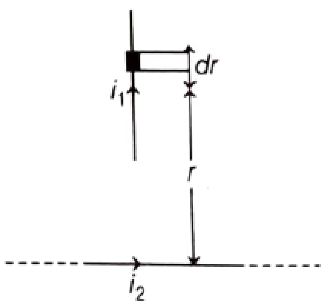
Force on *AB* and *CD* cancel out each other. Resultant of force on *DA* and *BC* will be directed towards right. So, net force on the loop is away from the long wire.



24. (C)

$$\int dF = \int_{x}^{x+l} \left(\frac{\mu_0 i_2}{2\pi r}\right) i_1 dr$$

$$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(\frac{x+l}{x}\right)$$



25. (B)

$$\mathbf{F}_{ABC} = \mathbf{F}_{AC} = I\left(\mathbf{L}_{AC} \times \mathbf{B}\right)$$

$$= 2\left[\left(3\times 10^{-2}\right)\hat{\mathbf{i}} \times \left(-2\hat{\mathbf{k}}\right)\right] = \left(12\times 10^{-2}\right)\hat{\mathbf{j}}$$

$$\mathbf{a} = \frac{\mathbf{F}}{m} = \frac{\left(12\times 10^{-2}\right)\hat{\mathbf{j}}}{\left(10\times 10^{-3}\right)} = 12 \text{ m/s}^2 \left(\hat{\mathbf{j}}\right)$$

26. (A)

$$Bil = ma \Rightarrow BdqI = md\theta$$

$$\Rightarrow Bl\int dq = m\int d\theta$$

$$\Rightarrow q = \frac{mv}{Bl} = \frac{m\sqrt{2gh}}{Bl}$$

27. (C)

$$\tau = i\alpha \Rightarrow (Bil)\frac{I}{2} = \left(\frac{mI^2}{3}\right)\alpha$$

$$\Rightarrow \alpha = \frac{3iB}{2m}$$

28. (D)

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

$$\Rightarrow M = \frac{qL}{2m} = \frac{ql\omega}{2m}$$

$$= \frac{(\lambda l)\left(\frac{ml^2}{3}\right)\omega}{2m} = \frac{\lambda\omega l^3}{6}$$

29. (D)

$\tau = NiAB\sin\theta$

Couple (torque) will be maximum for circular loop as circle has the greatest area for a given parimeter.

30. (A)

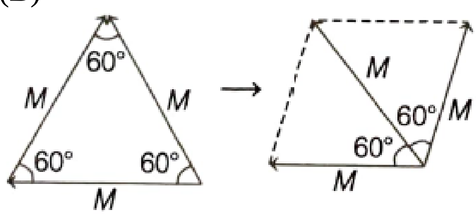
We can put wires carrying equal and opposite currents along CH and DG to complete three loops.

$$\mathbf{M} = \mathbf{M}_{ABCH} + \mathbf{M}_{CDGH} + \mathbf{M}_{DEFG}$$

$$= (1)^2(1)\hat{\mathbf{j}} + (1)^2(1)\hat{\mathbf{i}} + (1)^2(1)(-\hat{\mathbf{j}}) = (1)\hat{\mathbf{i}}$$

$$\tau = \mathbf{M}\times\mathbf{B} = \hat{\mathbf{i}}\times 2\hat{\mathbf{j}} = 2\hat{\mathbf{k}}$$

31. (B)



Resultant of three vectors $= M + M\cos 60° + M\cos 60°$
$= 2M$

32. (A)

For equilibrium of upper magnet, $F = mg$

$$\Rightarrow \left(\frac{\mu_0}{4\pi}\right)\frac{m_1 m_2}{r^2} = mg$$

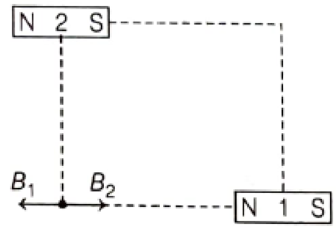
$$\Rightarrow 10^{-7}\frac{m^2}{(3\times10^{-3})^2} = 50\times10^{-3}\times 9.8$$

$$\Rightarrow m = 6.64 \text{ A-m}$$

33. (A)

$$B_1 = \left(\frac{\mu_0}{4\pi}\right)\frac{2M}{r^3}$$

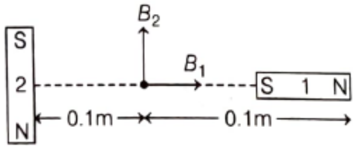
$$B_2 = \left(\frac{\mu_0}{4\pi}\right)\frac{M}{r^3}$$



$$B_{\text{net}} = B_1 - B_2$$

$$= \frac{10^{-7}\times 1000}{(0.1)^3} = 0.1\,\text{T}$$

34. (D)



$$B_1 = \left(\frac{\mu_0}{4\pi}\right)\frac{2M}{r^3};\ B_2 = \left(\frac{\mu_0}{4\pi}\right)\frac{M}{r^3}$$

$$B_{\text{net}} = \sqrt{B_1^2 + B_2^2} = \frac{\sqrt{5}\times 10^{-7}\times 10}{(0.1)^3} = \sqrt{5}\times 10^{-3}\ \text{T}$$

35. (A)

$$W = \Delta U = -MB\cos 60° - (-MB\cos 0°) = \frac{MB}{2}$$

$$\tau = MB\sin 60° = (2W)\left(\frac{\sqrt{3}}{2}\right) = \sqrt{3}W$$

36. (A)

At magnetic North-pole angle of dip is 90°.

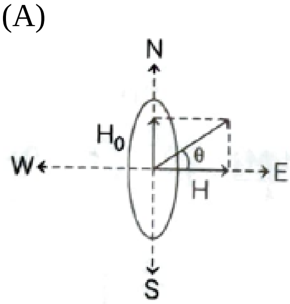
$$B_H = B\cos 90° = 0$$

37. (B)

$$B = \frac{\mu_0}{4\pi}\frac{M}{r^3} \Rightarrow 0.3\times 10^{-4} = 10^{-7}\frac{M}{(6400\times 10^3)^3}$$

$$\Rightarrow\ M = 7.8\times 10^{22}\ \text{A-m}^2$$

38. (A)



$$\tan\theta = \frac{H_0}{H} \Rightarrow \theta = \tan^{-1}\left(\frac{H_0}{H}\right)$$

39. (B)

$$K_1 + U_1 = K_2 + U_2$$

$$\Rightarrow\ 0 - MB\cos 90° = K_2 - MB\cos 0°$$

$$\Rightarrow\ K_2 = MB = 2\times 25 = 50\ \mu\text{J}$$

40. (A)

$$f = \frac{1}{2\pi}\sqrt{\frac{MB}{I}} \Rightarrow f \propto \sqrt{M} \Rightarrow \frac{M_1}{M_2} = \left(\frac{f_2}{f_1}\right)^2 = \frac{4}{9}$$

41. (C)

$$f \propto \sqrt{B_H} \Rightarrow \frac{B_{H_1}}{B_{H_2}} = \left(\frac{f_1}{f_2}\right)^2$$

$$\Rightarrow \frac{B_{H_1}}{36\times10^{-6}} = \left(\frac{40}{20}\right)^2 \Rightarrow B_{H_1} = 144\times10^{-6}\text{ T}$$

42. (B)

In $\tan A$ position, $B_H \tan\theta_1 = \frac{\mu_0}{4\pi}\frac{2m_1 I}{d_1^3}$

In $\tan B$ position, $B_H \tan\theta_2 = \frac{\mu_0}{4\pi}\frac{m_2 I}{d_2^3}$

$$\Rightarrow \frac{\tan\theta_1}{\tan\theta_2} = 2\left(\frac{m_1}{m_2}\right)\left(\frac{d_2}{d_1}\right)^3$$

$$\Rightarrow \tan\theta_2 = \tan 30°$$

$$\Rightarrow \theta_2 = 30°$$

43. (A)

Aluminium is paramagnetic, copper is diamagnetic and Iron and Nickel are ferromagnetic.

44. (C)

Diamagnetic materials are repelled by magnetism field. So, they will be thrown out.

45. (D)

A superconductor exhibits perfect diamagnetism as magnetic field lines don't enter a superconductor.

46. (D)

$$B = B_{\text{ext}} + B_{\text{induced}} \Rightarrow B = \mu_0 H + \mu_0 M$$

$$\Rightarrow B = \mu_0 (H+M)$$

47. (A)

Magnetic susceptibility of paramagnetic substances is independent of the magnetising field.

48. (A)

Magnetic susceptibility of ferromagnetic materials decreases with rise in temperature and the substance becomes paramagnetic above Curie temperature.

49. (A)

$\chi_m = \frac{C}{T} \Rightarrow AC = \text{Slope of } \chi_m$ *versus* $\frac{1}{T}$ graph

$$= \frac{0.4}{7\times10^{-3}} = 57\,\text{K}$$

50. (B)

OQ = Retentivity; *OR* = Coercivity

For making a permanent magnet, both retentivity (*OQ*) and coercivity (*OR*) should be high.

51. (4)

$mvr = L$

$\Rightarrow \quad mv\left(\frac{mv}{qB}\right) = L$

$\Rightarrow \quad v = \sqrt{\frac{qBL}{m^2}}$

$\Rightarrow \quad v = \sqrt{\frac{1.6\times10^{-19}\times1\times10^{-3}\times8.1\times10^{-38}}{81\times10^{-62}}}$

$= 4\ \text{m/s}$

52. (6)

Path of the particle will be helical.

Distance = Speed × time $= 2\times3 = 6\ \text{m}$

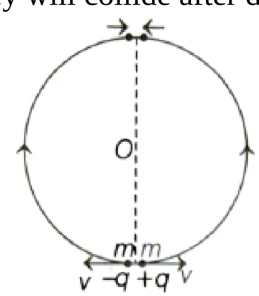
53. (1.21)

$R = \frac{\sqrt{2mqV}}{qB} \quad \Rightarrow \quad m = \frac{qB^2R^2}{2V} \quad \Rightarrow \quad m \propto R^2$

$\Rightarrow \quad \frac{m_{\max}}{m_{\min}} = \left(\frac{R_{\max}}{R_{\min}}\right)^2 = \left(\frac{\frac{l+d}{2}}{\frac{l}{2}}\right)^2 = 1.21$

54. (220)

They will collide after describing semi-circle.



$T = \frac{\pi m}{qB} = \frac{22\times14\times10^{-3}}{7\times3\times10^{-6}\times\left(\frac{200}{3}\right)} = 220\,\text{s}$

55. (70)

Using Work-energy theorem,

$W_{mg} + W_B + W_N = \Delta K$

$\Rightarrow \quad +mgR + 0 + 0 = \frac{1}{2}mv^2 - 0$

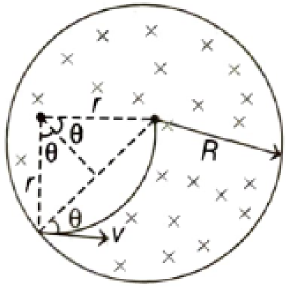
$\Rightarrow \quad v = \sqrt{2gR}$

At P, $N_1 - mg - qvB\sin 90^\circ = \frac{mv^2}{R}$

$\Rightarrow \quad N_1 = 3mg + qvB = 60 + 10 = 70\ \text{N}$

56. (3)

Lets take radius of circle described by the particle in the magnetic field to be r.



$$R = 2r\sin\theta$$

$$\Rightarrow \quad R = 2\left(\frac{mv}{qB}\right)\sin\theta$$

$$\Rightarrow \quad 0.1 = 2\left(\frac{5\times10^{-5}\times\left(1/\sqrt{3}\right)}{5\times10^{-4}\times1}\right)\sin\theta$$

$$\Rightarrow \quad \sin\theta = \frac{\sqrt{3}}{2} \Rightarrow \theta = \frac{\pi}{3}$$

57. (10)

$$\mathbf{n} = \mathbf{dl}\times\mathbf{r} = (-\hat{\mathbf{j}})\times(\hat{\mathbf{i}}+\hat{\mathbf{j}}+\hat{\mathbf{k}}) = \hat{\mathbf{k}}-\hat{\mathbf{i}}$$

$$\hat{\mathbf{n}} = \frac{\hat{\mathbf{k}}-\hat{\mathbf{i}}}{\sqrt{2}}$$

$$\mathbf{B}_{\text{wire}} = \frac{\mu_0 i}{2\pi r}\hat{\mathbf{n}} = \frac{4\pi\times10^{-7}\times8}{2\pi(\sqrt{2})}\left(\frac{\hat{\mathbf{k}}-\hat{\mathbf{i}}}{\sqrt{2}}\right)$$

$$= 0.8\times10^{-6}\left(\hat{\mathbf{k}}-\hat{\mathbf{i}}\right)$$

$$\mathbf{B}_{\text{net}} = \mathbf{B}_{\text{wire}}+\mathbf{B}_{\text{ext}} = (0.6\times10^{-6})\hat{\mathbf{i}}+(0.8\times10^{-6})\hat{\mathbf{k}}$$

$$|B_{\text{net}}| = 10\times10^{-7}\ \text{T}$$

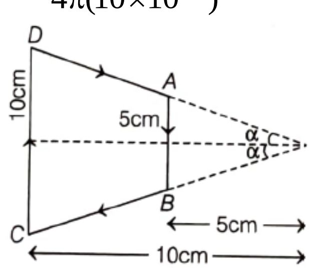
So, $\alpha = 10$

58. (2)

$$\mathbf{B} = \frac{\mu_0 i}{4\pi r}(\sin\alpha+\sin\beta)$$

$$\mathbf{B}_{AB} = \frac{4\pi\times10^{-7}\times\sqrt{2}}{4\pi(5\times10^{-2})}(\sin45^\circ+\sin45^\circ) = 4\times10^{-6}\ \text{T}$$

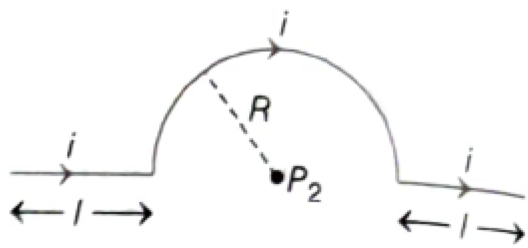
$$\mathbf{B}_{CD} = \frac{4\pi\times10^{-7}\times\sqrt{2}}{4\pi(10\times10^{-2})}(\sin45^\circ+\sin45^\circ) = 2\times10^{-6}\ \text{T}$$



$$\mathbf{B}_{\text{net}} = \mathbf{B}_{AB} + \mathbf{B}_{BC} + \mathbf{B}_{CD} + \mathbf{B}_{DA}$$
$$\mathbf{B}_{\text{net}} = 4\times10^{-6} + 0 - 2\times10^{-6} + 0$$
$$= 2\times10^{-6}\,\text{T} = 2\,\mu\text{T}$$

59. (32)

$$B_1 = B_{PQ} + B_{QR} + B_{RS} + B_{ST} + B_{TU}$$
$$= 0 + \frac{\mu_0 i}{4\pi I}\sin 45^\circ + \frac{\mu_0 i}{4\pi I}(2\sin 45^\circ) + \frac{\mu_0 i}{4\pi I}\sin 45^\circ + 0$$
$$= \frac{\mu_0 i}{\sqrt{2}\pi I}$$



$$2\pi R = 4I \Rightarrow R = \frac{2I}{\pi}$$
$$B_2 = \frac{\mu_0 i}{4\left(\frac{2I}{\pi}\right)} = \frac{\mu_0 i\pi}{8I}$$
$$\frac{B_1}{B_2} = \frac{\sqrt{32}}{\pi^2}$$
So, $n = 32$

60. (4)

$$\int dB = \int_I^{2I} \frac{\mu_0\left[\lambda dx\left(\frac{\omega}{2\pi}\right)\right]}{2x}$$
$$\Rightarrow\; B = \frac{\mu_0\lambda\omega}{4\pi}\ln 2 = \frac{\mu_0\left(\frac{2}{\pi}\right)(2\pi)}{4\pi}\ln 2$$
So, $n = 4$

61. (36)

$$B_{\text{axis}} = \frac{\mu_0 NiR^2}{2(R^2+x^2)^{3/2}}$$
$$= \frac{4\pi\times10^{-7}\times1\times2.5\times(3\times10^{-2})^2}{2[(0.03)^2+(0.04)^2]^{3/2}}$$
$$= 36\pi\times10^{-7}\,\text{T}$$
So, $n = 36$

62. (5880)

$$B = \mu_0 ni \;\Rightarrow\; 0.168 = 4\pi\times10^{-7}\times n\times 2$$
$$n = \frac{21\times10^4}{\pi}$$
$$N = nI = \left(\frac{21\times10^4}{\pi}\right)(1.4)$$

Length of wire $= N(2\pi R)$

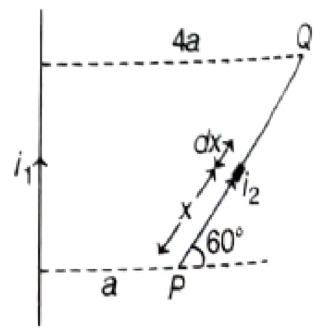
$$= \left(\frac{21\times10^4\times1.4}{\pi}\right)[(2\pi\,(0.01)]$$

$$= 5880 \text{ m}$$

63. (16)

$PQ = 3a\sec 60° = 6a$

Lets take an element dx on wire PQ.



$$\int dF = \int_0^{6a}\left(\frac{\mu_0 i_1}{2\pi(a+x\cos 60°)}\right) i_2\,dx$$

$$F = \frac{\mu_0 i_1 i_2}{2\pi}\left[2\ln(2a+x)\right]_0^{6a}$$

$$= \frac{\mu_0 i_1 i_2}{2\pi}\ln(16)$$

$$= \frac{\mu_0 i_1 i_2}{2\pi}\ln x$$

So, $x = 16$

64. (2)

$F_B = mg \Rightarrow \int(B\sin 30°)\,idl = mg$

$\Rightarrow (B\sin 30°)i(2\pi R) = mg$

$$\Rightarrow B = \frac{mg}{\pi iR} = \frac{40\times10^{-3}\times10\pi}{\pi(10)(2\times10^{-2})} = 2\,\text{T}$$

65. (10)

$F(\Delta p)A = Bil\sin\theta$

$$\Rightarrow eg(\Delta h)A = Bil\sin\theta \Rightarrow \Delta h = \frac{Bil\sin\theta}{egA}$$

$$= \frac{5.44\times10\times4\times10^{-3}\sin 90°}{13.6\times10^3\times10\times(4\times10^{-3})^2} = 10 \text{ cm}$$

1. (A)

Magnetic field at any point lies on axial position of current carrying conductor B = 0

2. (B)

(b) Given : Radius = R

Distance $x = 2\sqrt{2}R$

$$\frac{B_{centre}}{B_{axis}} = \left(1+\frac{x^2}{R^2}\right)^{3/2} = \left(1+\frac{(2\sqrt{2}R)^2}{R^2}\right)^{3/2} = (9)^{3/2} = 27$$

3. (D)

(d) Statements I is false and Statement II is true

For ammeter, shunt resistance, $S = \frac{IgG}{I - Ig}$

Therefore for I to increase, S should decrease, So additional S can be connected across it.

4. (D)

(d) The current that will given full scale deflection in the absence of the shunt is nearly equal to the current through the galvanometer when shunt is connected i.e. I_g

As $I_g = \frac{IS}{G+S} = \frac{5.5\times 1}{120+1} = 0.045$ ampere.

5. (B)

(b) **Given :** $M_1 = 1.20\,Am^2$

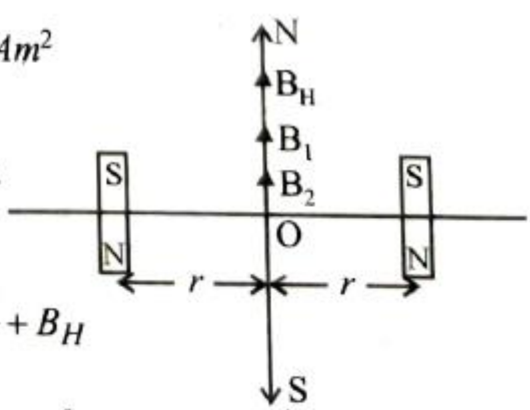
$M_2 = 1.00\,Am^2$

$r = \frac{20}{2}cm = 0.1\,m$

$B_{net} = B_1 + B_2 + B_H$

$B_{net} = \frac{\mu_0}{4\pi}\frac{(M_1+M_2)}{r^3} + B_H$

$= \frac{10^{-7}(1.2+1)}{(0.1)^3} + 3.6\times 10^{-5} = 2.56\times 10^{-4}$ wb/m²



6. (B)

(b) For loop $B = \frac{\mu_0 nI}{2a}$

where, a is the radius of loop.

Then, $B_1 = \frac{\mu_0 I}{2a}$

Now, for coil $B = \frac{\mu_0 I}{4\pi} \cdot \frac{2nA}{x^3}$

at the centre x = radius of loop

$$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2 \times 3 \times (I/3) \times \pi (a/3)^2}{(a/3)^3} = \frac{\mu_0 .3I}{2a}$$

$$\therefore \quad \frac{B_1}{B_2} = \frac{\mu_0 I/2a}{\mu_0 .3I/2a}$$

$$B_1 : B_2 = 1:3$$

7. (C)

(c) Magnetic field in solenoid $B = \mu_0 ni$

$\Rightarrow \quad \frac{B}{\mu_0} = ni$ (Where n = number of turns per unit length)

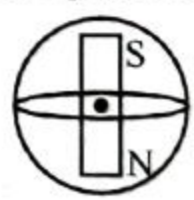
$$\Rightarrow \quad \frac{B}{\mu_0} = \frac{Ni}{L} \Rightarrow 3 \times 10^3 = \frac{100i}{10 \times 10^{-2}} \Rightarrow i = 3\text{A}$$

8. (A)

(a) Dipole moment of the earth M = ?

We will consider a bar magnet inside the earth as shown.
Clearly, field on equator will be same as field on equatorial point of bar magnet

$B = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$, $\quad 4 \times 10^{-5} = \frac{2 \times 4\pi \times 10^{-7} \times M}{4\pi \times (6.4 \times 10^6)^3}$



$\therefore \quad M \cong 2 \times 10^{23}\ \text{Am}^2$

9. (D)

(d) In magnetic dipole

Interaction energy, $U = -\vec{M} \cdot \vec{B}$ and $B \propto \frac{1}{r^3}$

$\therefore F = -\frac{dU}{dr} \propto \frac{1}{r^4}$

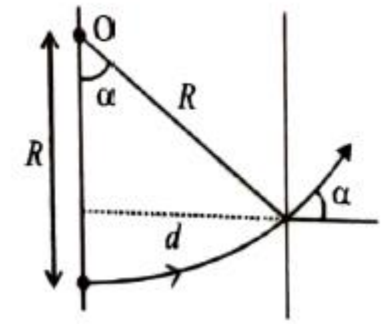
10. (D)

(d) From figure, $\sin\alpha = d/R$

And we know, $\frac{mv^2}{R} = qvB$

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

$\therefore \sin\alpha = \frac{dqB}{mv}$



11. (A)

(a) For stable equilibrium $\vec{M} \parallel \vec{B}$

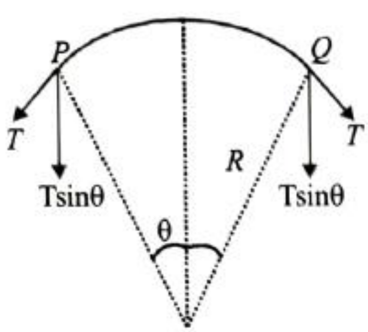
For unstable equilibrium $\vec{M} \parallel (-\vec{B})$

12. (A)

(a) $I_1 I_2 =$ Positive
(attract) $F =$ Negative
$I_1 I_2 =$ Negative
(repell) $F =$ Positive
Hence, option (a) is the correct answer.

13. (C)

(c) For small arc length
$2T \sin\theta = \text{BIR } 2\theta$ (As $F = BIL$ and $L = RZ\theta$)
$T = \text{BIR}$



14. (B)

To measure AC voltage across a resistance a moving coil galvanometer is used.

15. (C)

(c) $\vec{M}$ (mag. moment/volume) $= \frac{NiA}{A\ell}$

$= \frac{Ni}{\ell} = \frac{(500)15}{25\times10^{-2}} = 30000 \text{ Am}^{-1}$

16. (C)

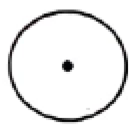
(c) Here, r = 30cm = 0.3cm

we know $\frac{\mu_0 M}{4\pi r^3} = B_H = 3.6\times10^{-5}$

$\Rightarrow M = \frac{3.6\times10^{-5}}{10^{-7}}(0.3)^3$

Hence, M = 9.7 Am^2

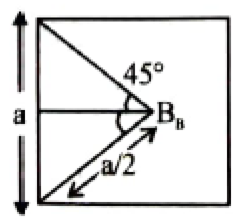
17. (B)

(b) Case (a) : 

$B_A = \frac{\mu_0}{4\pi}\frac{I}{R}\times 2\pi = \frac{\mu_0}{4\pi}\frac{I}{\ell/2\pi}\times 2\pi \; (\because 2\pi R = \ell)$

$= \frac{\mu_0}{4\pi}\frac{I}{\ell}\times(2\pi)^2$

Case (b) :



$B_B = 4\times\frac{\mu_0}{4\pi}\frac{I}{a/2}[\sin 45° + \sin 45°]$

$= 4\times\frac{\mu_0}{4\pi}\times\frac{I}{\ell/8}\times\frac{2}{\sqrt{2}} = \frac{\mu_0}{4\pi}\frac{I}{\ell}\times\frac{64}{\sqrt{2}} = \frac{\mu_0 I}{4\pi\ell}32\sqrt{2} \; [4a = l]$

$\Rightarrow \frac{B_A}{B_B} = \frac{\pi^2}{8\sqrt{2}}$

18. (C)

(c) $I_g G = (I - I_g)s$

$\therefore 10^{-3}\times 100 = (10 - 10^{-3})\times S$

$\therefore S \approx 0.01\Omega$

19. (D)

(d) As we know, $I = \frac{V}{R} = \frac{5}{50} = 0.1$

$I' = 0.099$

When Galvanometer is connected

$R_{eq} = 50 + \frac{100S}{100+S} = \frac{V}{I}$

$$\Rightarrow \frac{100S}{100+S} = \frac{5}{0.099} - 50$$

$$\Rightarrow \frac{100S}{100+S} = 50.50 - 50 \Rightarrow \frac{100S}{100+S} = 0.5$$

$$\Rightarrow 100S = 50 + 0.55 \Rightarrow 99.5S = 50$$

$$\Rightarrow S = \frac{50}{99.05} = 0.5\,\Omega$$

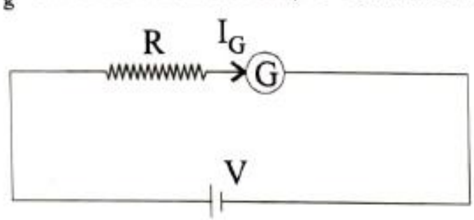
So, shunt of resistance = 0.5Ω is connected in parallel with the galvanometer.

20. (A)

(a) According to Ohm's Law, $I = \frac{V}{R}$

$$I_g = \frac{V}{R+G}$$

where, I_g-Galvanometer current, G-Galvonometer resistance



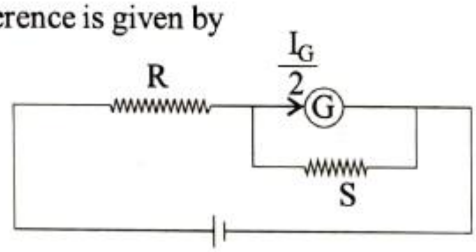
When shunt of resistance S is connected parallel to the Galvanometer then $G = \frac{GS}{G+S}$

$$\therefore\ I = \frac{V}{R + \frac{GS}{G+S}}$$

Equal potential difference is given by

$$I'_g G = (I - I'_g)S$$

$$I'_g(G+S) = IS$$



$$\Rightarrow \frac{I_g}{2} = \frac{IS}{G+S}$$

$$\Rightarrow \frac{V}{2(R+G)} = \frac{V}{R + \frac{GS}{G+S}} \times \frac{S}{G+S}$$

$$\Rightarrow \frac{1}{2(R+G)} = \frac{S}{R(G+S)+GS}$$

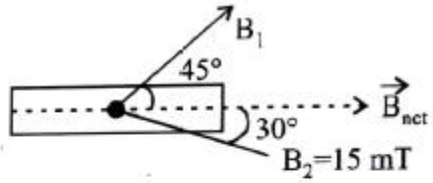
$$\Rightarrow R(G+S) + GS = 2S(R+G)$$

$$\Rightarrow RG + RS + GS = 2S(R+G)$$

$$\Rightarrow RG = 2S(R+G) - S(R+G) \Rightarrow RG = S(R+G)$$

21. (B)

(b)



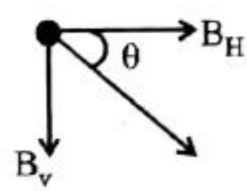
Clearly, $\tan 30° = \dfrac{B_1 \sin 75}{B_2 + B_1 \cos 75°}$

Putting $B_2 = 15$ mT in above equation,
we get $B_1 = 11$ mT

22. (B)
Graph [A] is for material used for making permanent magnets (high coercivity)
Graph [B] is for making electromagnets and transformers.

23. (D)

(d) $\sin\theta = \dfrac{2}{3}$ so, $\cos\theta = \dfrac{\sqrt{5}}{3}$



Wings will cut vertical component of magnetic field so,

$$V_w = B_V \times l_{wing} \times V = 5\times10^{-5} \times \frac{2}{3} \times 15 \times 240 = 120\,\text{mV}$$

whereas, vertical section of plane will cut horizontal component of earth magnetic field.

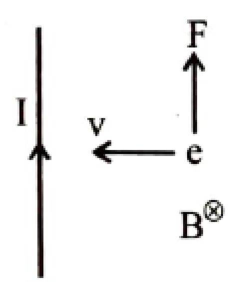
$$V_B = B_H \times 15 \times 240 = 5\times10^{-5} \times \frac{\sqrt{5}}{3} \times 15 \times 240 \simeq 45\,mV$$

24. (B)

(b) The force is parallel to the direction of current in magnetic field,

hence $F = q(v \times \vec{B})$

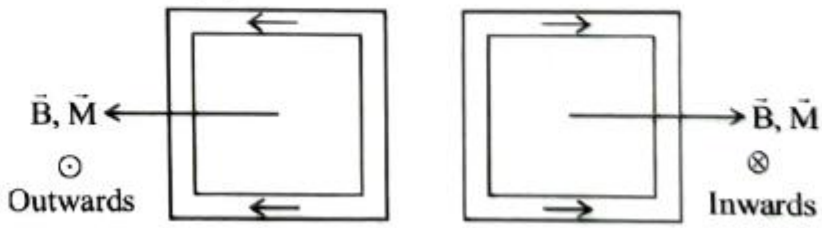
According to Fleming's left hand rule, we have, the direction of motion of charge is towards the wire.



25. (C)

(c) Magnetic moment of current carrying rectangular loop of area A is given by M = NIA

magnetic moment of current carrying coil is a vector and its direction is given by right hand thumb rule, for rectangular loop, $\vec{B}$ at centre due to current in loop and $\vec{M}$ are always parallel.



Hence, (c) corresponds to stable equilibrium.

26. (C)

(c) Given : Current through the galvanometer,

$i_g = 5 \times 10^{-3}\ A$

Galvanometer resistance, $G = 15\Omega$

Let resistance R to be put in series with the galvanometer to convert it into a voltmeter.

$V = i_g (R + G)$

$10 = 5 \times 10^{-3} (R + 15)$

$\therefore \quad R = 2000 - 15 = 1985 = 1.985 \times 10^3\ \Omega$

27. (C)

(c) Potential energy of dipole, $U = -MB\cos\theta$

Torque experienced by dipole $\tau = MB\sin\theta$

Torque will be maximum (τ_{max}) when $\theta = 90°$ then potential energy $U = 0$

28. (C)

(c) Given : Magnetic moment, $M = 6.7 \times 10^{-2}\ Am^2$

Magnetic field, $B = 0.01\ T$

Moment of inertia, $I = 7.5 \times 10^{-6}\ \text{Kgm}^2$

Using, $T = 2\pi\sqrt{\dfrac{I}{MB}}$

$$= 2\pi\sqrt{\frac{7.5\times10^{-6}}{6.7\times10^{-2}\times0.01}} = \frac{2\pi}{10}\times1.06\,s$$

Time taken for 10 complete oscillations

$t = 10T = 2\pi \times 1.06 = 6.6568 \approx 6.65$ s

29. (C)

(c) Magnetic field at the centre of loop, $B_1 = \frac{\mu_0 I}{2R}$

Dipole moment of circular loop is m = IA

$m_1 = I.A = I.\pi R^2$ {R = Radius of the loop}

If moment is doubled (keeping current constant) R becomes $\sqrt{2}R$

$$m_2 = I.\pi\left(\sqrt{2}R\right)^2 = 2.I\pi R^2 = 2m_1$$

$$B_2 = \frac{\mu_0 I}{2\left(\sqrt{2}R\right)} \qquad \therefore \frac{B_1}{B_2} = \frac{\frac{\mu_0 I}{2R}}{\frac{\mu_0 I}{2\left(\sqrt{2}R\right)}} = \sqrt{2}$$

30. (B)

(b) Point *P* is situated at the mid-point of the line joining the centres of the circular wires which have same radii (R). The magnetic fields ($\vec{B}$) at P due to the currents in the wires are in same direction.

Magnitude of magnetic field at point, *P*

$$B = 2\left\{\frac{\mu_0 NIR^2}{2\left(R^2 + \frac{R^2}{4}\right)^{3/2}}\right\} = \frac{\mu_0 NIR^2}{\frac{5^{3/2}}{8}} = \frac{8\mu_0 NI}{5^{3/2}R}$$

31. (A)

(a) Magnetic moment, $\mu = IA = \frac{qv}{2\pi r}(\pi r^2)$

or, $\mu = \frac{qr\omega}{2\pi r}(\pi r^2) = \frac{1}{2}qr^2\omega$

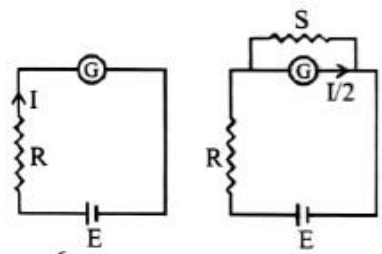
32. (B)

(b) Figure of merit of a galvanometer is the correct required to produce a deflection of one division in the galvanometer i.e., figure of merit $= \frac{I}{\theta}$

$$I = \frac{\varepsilon}{R+G} \qquad G = \frac{1}{9}K\Omega$$

$$\frac{1}{2} = \frac{\varepsilon}{R + \frac{GS}{G+S}} \times \frac{S}{S+G} \Rightarrow \frac{1}{2} = \frac{\varepsilon S}{R(S+G)+GS}$$

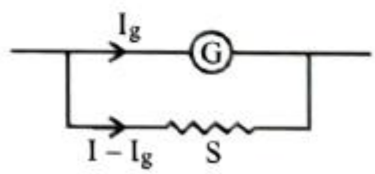
$$S = \frac{RG \times \frac{1}{2}}{\varepsilon - \frac{(R+G)I}{2}}$$



$$S = \frac{11 \times 10^3 \times \frac{1}{2} \times 10^2 \times 270 \times 10^{-6}}{6 - \left(\frac{6}{2}\right)} = 110\Omega$$

33. (D)

(d) According to question, current through galvanometer,
$I_g = 1$ mA
Current through shunt $(I - I_g) = 2$ A
Galvanometer resistance $R_g = 25\Omega$
Resistance of shunt, S = ?
$I_0R_0 = (I - I_g)S$



$$\Rightarrow S = \frac{10^{-3} \times 25}{2}$$

$S \simeq 1.25 \times 10^{-2}\Omega$

34. (B)

(b) Given Number of turns,
$n = 1000$ turns/cm $= 1000 \times 100$ turns/m
Coercivity of ferromagnet, $H = 100$ A/m
Current to demagnetise the ferromagnet, I = ?
Using, $H = nI$
or, $100 = 10^5 \times I$

$$\therefore \quad I = \frac{100}{10^5} = 1 \text{ mA}$$

35. (D)

(d) As particle is moving along a circular path

$$\therefore R = \frac{mv}{qB} \quad ...(i)$$

Path is straight line, then

$qE = qvB$

$$E = vB \Rightarrow v = \frac{E}{B} \quad ....(ii)$$

From equation (i) and (ii)

$$m = \frac{qB^2R}{E} = \frac{1.6\times10^{-19}\times(0.5)^2\times0.5\times10^{-2}}{100}$$

$\therefore$ m = 2.0 × 10^{-24} kg

36. (B)

(b) The radius of the circular path is,

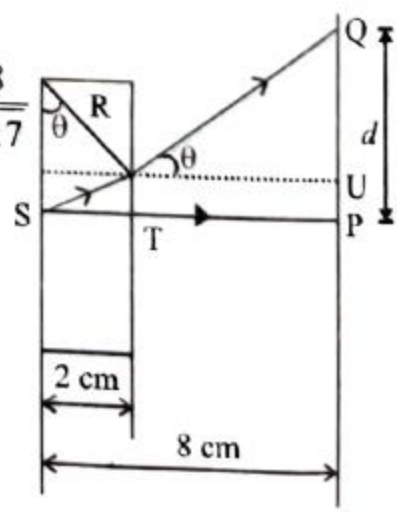
$$R = \frac{mv}{Bq} = \frac{\sqrt{2mE_k}}{Bq}$$

$$\Rightarrow R = \frac{\sqrt{2\times9.1\times10^{-31}\times100\times1.6\times10^{-19}}}{1.5\times10^{-3}\times1.6\times10^{-19}}$$

$\Rightarrow R = 2.25$ cm

$$\text{Now, } \sin\theta = \frac{2}{2.25} = \frac{8}{9}$$

$$\Rightarrow \cos\theta = \frac{\sqrt{17}}{9} \text{ and } \tan\theta = \frac{8}{\sqrt{17}}$$



$PU = R(1 - \cos\theta)$

$$= 2.25 \times \left(1 - \frac{\sqrt{17}}{9}\right)$$

$\Rightarrow$ PU = 1.22 cm

$$\tan\theta = \frac{QU}{6}$$

$$\Rightarrow QU = 6\times\frac{8}{\sqrt{17}} = 11.64\,\text{cm}$$

$\therefore$ PQ = PU + QU = 1.22 + 11.64 = 12.86 cm

37. (B)

(b) As $mvr = qvB \Rightarrow r = \frac{mv}{qB} = \frac{\sqrt{2mK.E.}}{qB}$

[As : $\frac{1}{2}mv^2 = K.E.$

$\Rightarrow \quad m^2v^2 = 2m\,K.E. \Rightarrow \quad mv = \sqrt{2m\,K.E.}$]

For proton, electron and α-particle,
$m_{He} = 4m_p$ and $m_p >> m_e$
Also $a_{He} = 2q_p$ and $q_p = q_e$

$\therefore$ As KE of all the particles is same then, $r \propto \frac{\sqrt{m}}{q}$

$\therefore r_{He} = r_p > r_e$

38. (A)

(a) Radius of the circular path will be $r = \frac{mv}{qB}$

$\Rightarrow r = \frac{\sqrt{2mKE}}{qB} \quad (\because \; p = mv = \sqrt{2mKE})$

$\because \; KE = q\Delta V$

$\therefore \; r = \frac{\sqrt{2mq\Delta V}}{qB} \Rightarrow r \propto \sqrt{\frac{m}{q}} \qquad \therefore \; \frac{r_p}{r_\alpha} = \frac{1}{\sqrt{2}}$

39. (D)

(d) Radius of the path (r) is given by $r = \frac{mv}{qB}$

$r = \frac{\sqrt{2mk}}{eB} \quad \left(\because \; p = mv = \sqrt{2mk}\right)$

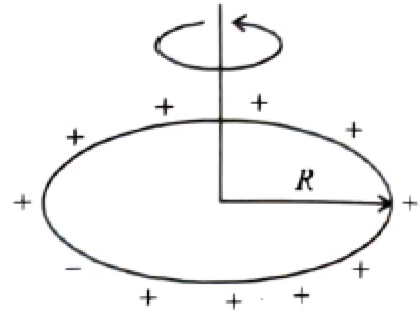
$= \frac{\sqrt{2meV}}{eB} \quad (\because \; k = eV)$

$r = \frac{\sqrt{\frac{2m}{e}V}}{B} = \frac{\sqrt{\frac{2 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}}(500)}}{100 \times 10^{-3}}$

$\Rightarrow r = \frac{\sqrt{\frac{9.1}{0.16} \times 10^{-10}}}{10^{-1}} = \frac{3}{.4} \times 10^{-4} \; = 7.5 \times 10^{-4}$

40. (B)

(b) If q is the charge on the ring, then



$i = \frac{q}{T} = \frac{q\omega}{2\pi}$

Magnetic field,

$$B = \frac{\mu_0 i}{2R} = \frac{\mu_0\left(\frac{q\omega}{2\pi}\right)}{2R}$$

or $\quad 3.8 \times 10^{-9} = \left(\frac{\mu_0}{4\pi}\right)\frac{q\omega}{R} = \left(10^{-7}\right)\frac{q \times 40\pi}{0.10}$

$\therefore \quad q = 3 \times 10^{-5}\,\text{C}.$

41. (B)

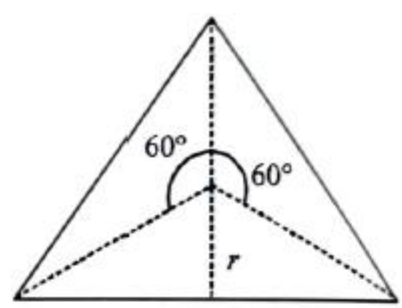
(b) $B = \frac{\mu_0}{4\pi}, \frac{i}{r}(\sin\alpha + \sin\beta)$

Here $r = \sqrt{5^2 - 3^2} = 4\text{ cm}$

$\alpha = \beta = 37°$

$\therefore B = 10^{-7} \times \frac{5}{4} 2\sin 37° = 1.5 \times 10^{-5}\,\text{T}$

42. (A)



(a) $r = \left(\frac{1}{3}\right)(a\sin 60)$

$r = \frac{a}{3} \times \frac{\sqrt{3}}{2} = \left(\frac{a}{2\sqrt{3}}\right)$

$B_0 = 3\left[\frac{\mu_0 I}{4\pi r}(\sin 60° + \sin 60°)\right]$

$= \frac{3\mu_0 I}{4\pi\left(\frac{a}{2\sqrt{3}}\right)} \times (2)\left(\frac{\sqrt{3}}{2}\right) = \frac{9}{2}\left(\frac{\mu_0 I}{\pi a}\right)$

$= \frac{9 \times 2 \times 10^{-7} \times 10}{1} = 18\,\mu\text{T}$

43. (C)

(c) Let I be the current in each wire. (directed inwards)

Magnetic field at 'O' due to LP and QM will be zero.

i.e., $B_0 = B_{PS} + B_{QN}$

$\therefore$ Net magnetic field $B_0 = \frac{\mu_0 i}{4\pi d} + \frac{\mu_0 i}{4\pi d}$

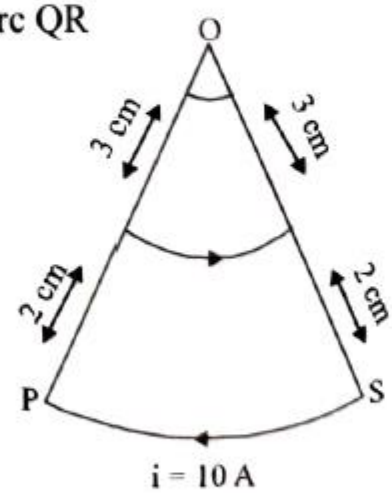
or $10^{-4} = \frac{\mu_0 i}{2\pi d} + \frac{2\times10^{-7}\times i}{4\times10^{-2}}$

$\therefore$ i = 20 A and the direction of magnetic field is perpendicular into the plane

44. (D)

(d) There will be no magnetic field at O due to wire PQ and RS

Magnetic field at 'O' due to arc QR



$= \frac{\mu_0}{4\pi}\frac{\left(\frac{\pi}{4}\right).I}{r_1}$

Magnetic field at 'O' due to are PS

$= \frac{\mu_0}{4\pi}\frac{\left(\frac{\pi}{4}\right).I}{r_2}$

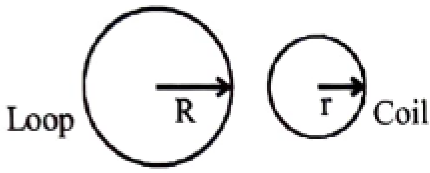
$\therefore$ Net magnetic field at 'O'

$$B = \frac{\mu_0}{4\pi}(\pi/4)\times10\left[\frac{1}{(3\times10^{-2})} - \frac{1}{(5\times10^{-2})}\right]$$

$$\Rightarrow |\vec{B}| = \frac{\pi}{3}\times10^{-5}T \approx 1\times10^{-5}T$$

45. (D)

(d)



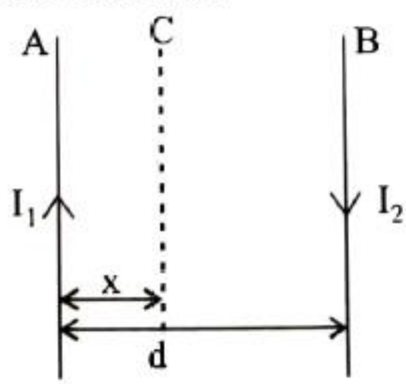
$L = 2\pi R \qquad L = N \times 2\pi r$

$R = Nr \Rightarrow r = \dfrac{R}{N}$

$B_{Loop} = \dfrac{\mu_0 i}{2R}, \; B_{coil} = \dfrac{\mu_0 Ni}{2r} = \dfrac{\mu_0 Ni}{2\left(\dfrac{R}{N}\right)} = \dfrac{\mu_0 N^2 i}{2R} \quad \therefore \; \dfrac{B_L}{B_C} = \dfrac{1}{N^2}$

46. (D)

(d) As net force on the third wire C is zero.



$\Rightarrow \vec{F} = \dfrac{\mu_0 I_1}{2\pi x} + \dfrac{\mu_0 I_2}{2\pi(d - x)} = 0$

$\Rightarrow \dfrac{\mu_0 I_1}{2\pi x} = \dfrac{\mu_0 I_2}{2\pi(x - d)}$

$\Rightarrow \; I_1 x - I_1 d = I_2 x$

$x = \dfrac{I_1 d}{I_1 - I_2}$

Two cases may be possible if $I_1 > I_2$ or $I_2 > I_1$

47. (D)

(d) $\tau = MB \sin 45° = N\,(iA)\,B \sin 45°$

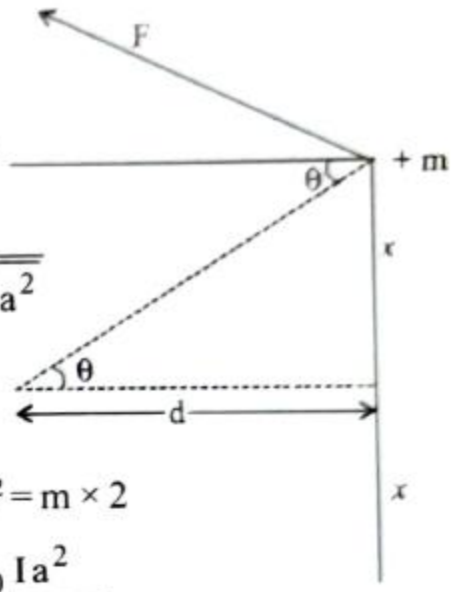
$= 100 \times 3(5 \times 2.5) \times 10^{-4} \times 1 \times \dfrac{1}{\sqrt{2}} = 0.27$ N-m

48. (C)

(c) $F = \dfrac{\mu_0}{2\pi}\left(\dfrac{i_1 i_2}{a} - \dfrac{i_1 i_2}{2a}\right) \times a = \dfrac{\mu_0 i_1 i_2}{4\pi}$

49. (D)

(d) Force on one pole,



$$F = m \times \frac{\mu_0 I}{2\pi\sqrt{d^2 + x^2}}$$

Total force, $F_{total} = 2F \sin\theta$

$$= 2 \times \frac{\mu_0 Im}{2\pi\sqrt{d^2 + a^2}} \times \frac{x}{\sqrt{d^2 + a^2}}$$

$$= \frac{\mu_0 Imx}{\pi(d^2 + a^2)}$$

Magnetic moment, $M = I\pi a^2 = m \times 2$

or, Total force, $F_{total} = \frac{\mu_0 Ia^2}{2(d^2 + a^2)}$

$$= \frac{\mu_0 Ia^2}{2d^2} \left[\because\ d >> a\right]$$

Clearly $F_{total} \propto \frac{a^2}{d^2}$

50. (C)

$$V = i_g(G + R) = 4 \times 10^{-3}(50 + 5000) = 20V$$

51. (D)

(d) $C\theta = NBiA \sin 90°$

or $10^{-6}\left(\frac{\pi}{180}\right) = 175B(10^{-3}) \times 10^{-4}$

$\therefore B = 10^{-3}\,T$

52. (D)

(d) Using, $i_g = i\frac{S}{S+G}$

$$0.002 = 0.5\frac{S}{S+50}$$

On solving, we get

$$S = \frac{100}{498} \simeq 0.2\,\Omega$$

53. (B)

(b) When key K_1 is closed and key K_2 is open

$$i_g = \frac{E}{220 + R_g} = C\theta_0 \qquad \text{... (i)}$$

When both the keys are closed

$$i_g = \left(\frac{E}{220 + \frac{5R_g}{5 + R_g}}\right) \times \frac{5}{(R_g + 5)} = \frac{C\theta_0}{5}$$

$$\Rightarrow \frac{5E}{225R_g + 1100} = \frac{C\theta_0}{5} \qquad \text{... (ii)}$$

$$\Rightarrow \frac{E}{220 + R_g} = C\theta_0$$

Dividing (i) by (ii), we get

$$\Rightarrow \frac{225R_g + 1100}{1100 + 5R_g} = 5$$

$\Rightarrow$ $5500 + 25R_g = 225R_g + 1100$ $\Rightarrow$ $200R_g = 4400$

$\Rightarrow$ $R_g = 22\Omega$

54. (D)

(d) Given,

Resistance of galvanometer, $G = 100\Omega$

Current, $i_g = 1\ mA$

A galvanometer can be converted into voltmeter by connecting a large resistance R in series with it.

Total resistance of the combination = $G + R$

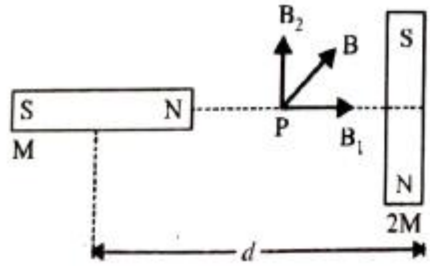
According to Ohm's law, $V = i_g(G + R)$

$\therefore\ 10 = 1 \times 10^{-3}(100 + R_0)$

$\Rightarrow 10000 - 100 = 9900\ \Omega = R_0$

$\Rightarrow R_0 = 9.9\ k\Omega$

55. (B)



(b) $B_1 = \frac{\mu_0}{4\pi}\frac{2M}{(d/2)^3}$

and $B_2 = \frac{\mu_0}{4\pi}\frac{2M}{(d/2)^3}$

$\therefore \quad \tan\theta = \frac{B_2}{B_1} = \frac{\frac{\mu_0}{4\pi}\frac{2M}{(d/2)^3}}{\frac{\mu_0}{4\pi}\frac{2M}{(d/2)^3}} = 1$

or $\theta = 45^\circ$

The resultant field is 45° from B_1. The angle between $\vec{B}$ and $\vec{v}$ zero, so force on the particle is zero.

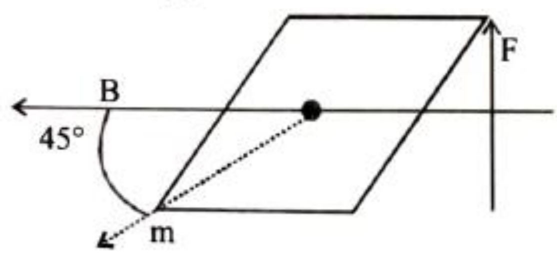
56. (C)

(c) Work done, $W = 2\,m \cdot B$

$= 2 \times 10^{-2} \times 1 \cos(0.125) = 0.02$ J

57. (D)

(d) using, $MB\sin\theta = F\,\ell\,\sin\theta\,(\tau)$



$MB\sin 45^\circ = F\frac{\ell}{2}\sin 45^\circ$

$F = 2MB = 2 \times 1.8 \times 18 \times 10^{-6} = 6.5 \times 10^{-5}N$

58. (B)

(b) Corecivity, $H = \frac{B}{\mu_0}$ and $B = \mu_0 ni\left(n = \frac{N}{\ell}\right)$

or, $H = \frac{N}{\ell}i = \frac{100}{0.2} \times 5.2 = 2600$ A/m

59. (B)

(b) The time period of oscillation of magnetic needle at any place depends on horizontal component of earth's magnetic field.

So, $T = 2\pi\sqrt{\dfrac{I}{MB_H}}$

$$\left(\frac{T_1}{T_2}\right)^2 = \frac{B_{H_2}}{B_{H_1}} \Rightarrow \frac{B_{H_1}}{B_{H_2}} = \left(\frac{T_2}{T_1}\right)^2$$

$$\Rightarrow \frac{B_1 \cos 45}{B_2 \cos 30} = \left(\frac{1.5}{2}\right)^2$$

$$\Rightarrow \frac{B_1}{B_2} = \frac{9\sqrt{6}}{32} \simeq 0.7$$

60. (C)

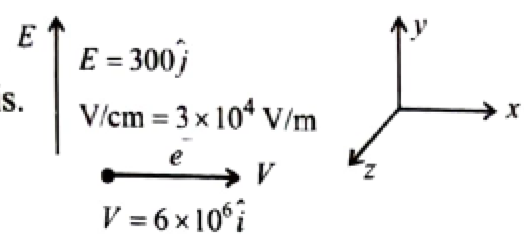
(c) $\vec{E} = 300\hat{j}$ V/cm $= 3\times10^4$ V/m

$\vec{V} = 6\times10^6\hat{i}$

$\vec{B}$ must be in $+z$ axis.

$q\vec{E} + q\vec{V}\times\vec{B} = 0$

$E = VB$



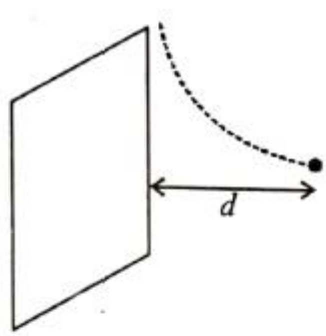
$$\therefore\ B = \frac{E}{V} = \frac{3\times10^4}{6\times10^6} = 5\times10^{-3}\,T$$

Hence, magnetic field $B = 5\times10^{-3}$ T along $+z$ direction.

61. (C)

(c) If $r \le d$, particle will not hit screen

$$r = \frac{mv}{qB_0}\quad\left[\because \frac{mv^2}{r} = qvB_0\right]$$



Hence, minimum value of v for which the particle will not hit the screen.

$$v = \frac{qB_0 d}{m}$$

62. (B)

(b) [Given: $q = 1\mu C = 1\times10^{-6} C$;

$\vec{V} = (2\hat{i} + 3\hat{j} + 4\hat{k})$ m/s and

$\vec{B} = (5\hat{i} + 3\hat{j} - 6\hat{k}) \times 10^{-3}$ T]

$$\vec{F} = q(\vec{V}\times\vec{B}) = 10^{-6}\times10^{-3}\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 2 & 3 & 4\\ 5 & 3 & -6\end{vmatrix}$$

$$= (-30\hat{i} + 32\hat{j} - 9\hat{k})\times10^{-9}\text{ N}$$

$$\therefore \vec{F} = (-30\hat{i} + 32\hat{j} - 9\hat{k})$$

63. (C)

(c) Time period of one revolution of proton, $T = \dfrac{2\pi m}{qB}$

Here, m = mass of proton

q = charge of proton

B = magnetic field.

Linear distance travelled in one revolution,

$p = T(v\cos\theta)$ (Here, v = velocity of proton)

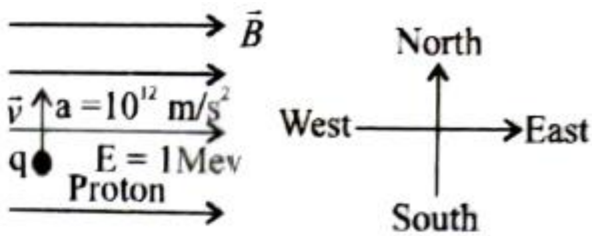
$\therefore$ Length of region, $l = 10\times(v\cos\theta)T$

$$\Rightarrow l = 10\times v\cos60^\circ\times\frac{2\pi m}{qB}$$

$$\Rightarrow l = \frac{20\pi mv}{qB} = \frac{20\times3.14\times1.67\times10^{-27}\times4\times10^{5}}{1.6\times10^{-19}\times0.3}$$

$$\Rightarrow l = 0.44\text{ m}$$

64. (A)

(a) 

As we know, magnetic force $F = qvB = ma$

$$\therefore\ \vec{a} = \left(\frac{qvB}{m}\right) \text{ perpendicular to velocity.}$$

$$\therefore \text{ Also } v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2\times e\times 10^6}{m}}$$

$$\therefore\ a = \frac{qvB}{m} = \frac{eB}{m}\sqrt{\frac{2\times e\times 10^6}{m}}$$

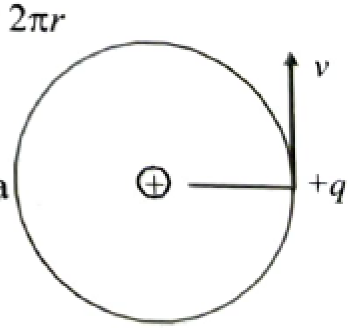
$$\therefore\ 10^{12} = \left(\frac{1.6\times 10^{-19}}{1.67\times 10^{-27}}\right)^{\frac{3}{2}} .\sqrt{2}\times 10^3 B$$

$$\therefore B \simeq \frac{1}{\sqrt{2}}\times 10^{-3} T = 0.71 \text{ mT (approx)}$$

65. (D)

(d) Length of the circular path, $l = 2\pi r$

Current, $i = \dfrac{q}{T} = \dfrac{qv}{2\pi r}$



Magnetic moment M = Current × Area

$$= i\times \pi r^2 = \frac{qv}{2\pi r}\times \pi r^2$$

$$M = \frac{1}{2} q\cdot v\cdot r$$

Radius of circular path in magnetic field, $r = \dfrac{mv}{qB}$

$$\therefore M = \frac{1}{2} qv\times \frac{mv}{qB} \Rightarrow M = \frac{mv^2}{2B}$$

Direction of $\vec{M}$ is opposite of $\vec{B}$ therefore

$$\vec{M} = \frac{-mv^2\vec{B}}{2B^2}$$

(By multiplying both numerator and denominator by B).

66. (D)

(d) Given : $I_A = 2\text{ A}, R_A = 2\text{ cm}, \theta_A = 2\pi - \frac{\pi}{2} = \frac{3\pi}{2}$

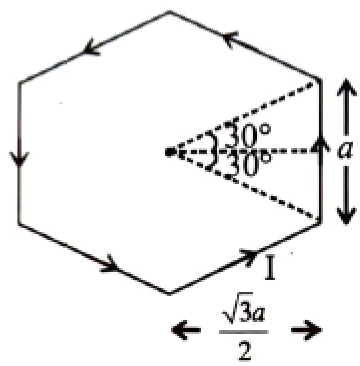
$I_B = 3\text{ A}, R_B = 4\text{ cm}, \theta_B = 2\pi - \frac{\pi}{3} = \frac{5\pi}{3}$

Using, magnetic field, $B = \frac{\mu_0 I\theta}{4\pi R}$

$$\frac{B_A}{B_B} = \frac{I_A}{I_B} \times \frac{\theta_A R_B}{\theta_B R_A} = \frac{2 \times \frac{3\pi}{2} \times 4}{3 \times \frac{5\pi}{3} \times 2} = \frac{6}{5}$$

67. (C)

(c) Magnetic field due to one side of hexagon



$$B = \frac{\mu_0 I}{4\pi \frac{\sqrt{3}a}{2}} (\sin 30° + \sin 30°)$$

$$\Rightarrow B = \frac{\mu_0 I}{2\sqrt{3}a}\left(\frac{1}{2} + \frac{1}{2}\right) = \frac{\mu_0 I}{2\sqrt{3}a\pi}$$

Now, magnetic field due to one hexagon coil

$$B = 6 \times \frac{\mu_0 I}{2\sqrt{3}a\pi}$$

Again magnetic field at the centre of hexagonal shape coil of 50 turns,

$$B = 50 \times 6 \times \frac{\mu_0 I}{2\sqrt{3}a\pi} \qquad \left[\because a = \frac{10}{100} = 0.1\text{ m}\right]$$

or, $B = \frac{150\mu_0 I}{\sqrt{3} \times 0.1 \times \pi} = 500\sqrt{3}\frac{\mu_0 I}{\pi}$

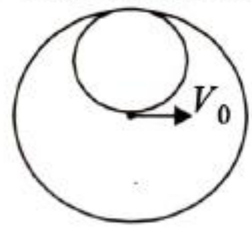
68. (B)

(b) Magnetic field inside the solenoid is given by

$B = \mu_0 nI$ .... (i)

Here, n = number of turns per unit length

The path of charge particle is circular. The maximum possible radius of electron $= \frac{R}{2}$



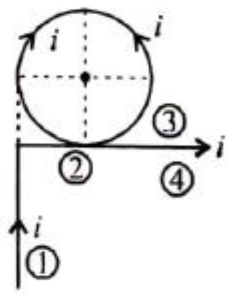
$$\therefore \frac{mV_{max}}{qB} = \frac{R}{2}$$

$$\Rightarrow V_{max} = \frac{qBR}{2m} = \frac{eR\mu_0 nI}{2m} \text{(using (i))}$$

69. (A)

(a) $B_0 = B_1 + B_2 + B_3 + B_4$

$$= \frac{\mu_0 I}{4\pi R}[\sin 90° - \sin 45°] + \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{4\pi R}[\sin 45° + \sin 90°]$$



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

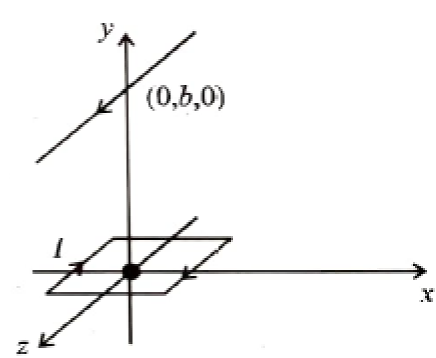
$$\overrightarrow{B_0} = \frac{\mu_0 I}{2\pi R}\left(\pi + \frac{1}{\sqrt{2}}\right)$$

70. (A)

$\vec{\tau} = \vec{M} \times \vec{B} = MB\hat{n}$

$|\vec{\tau}| = I(2a)^2 \times \frac{\mu_0 I}{2\pi b}$

$= \frac{2\mu_0 I^2 a^2}{\pi b}$



71. (C)

(c) Torque on circular loop, $\tau = MB \sin\theta$

where, M = magnetic moment

B = magnetic field

Now, using $\tau = I\alpha$

$$\therefore \quad \tau = MB\sin\theta = I\alpha \quad \Rightarrow \quad \pi R^2 IB\theta = \frac{mR^2\alpha}{2}$$

($\because$ $m = IA$ and moment of inertia of circular loop,

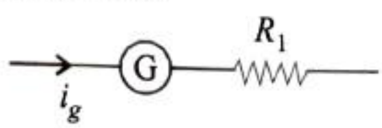
$$I = \frac{mR^2}{2})$$

$$\Rightarrow \quad \pi R^2 IB\,\theta = \frac{mR^2}{2}\omega\theta$$

$$\Rightarrow \quad \omega = \sqrt{\frac{2\pi IB}{m}} \quad \Rightarrow \quad \frac{2\pi}{T} = \sqrt{\frac{2\pi IB}{m}} \quad \Rightarrow \quad T = \sqrt{\frac{2\pi m}{IB}}$$

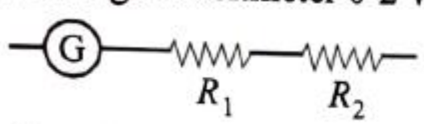
72. (D)

(d) Galvanometer of resistance (G) converted into a voltmeter of range 0-1 V.



$V = 1 = i_g(G + R_1)$ ...(i)

To increase the range of voltmeter 0-2 V



$2 = i_g(R_1 + R_2 + G)$ ...(ii)

Dividing eq. (i) by (ii),

$$\Rightarrow \frac{1}{2} = \frac{G + R_1}{G + R_1 + R_2} \Rightarrow G + R_1 + R_2 = 2G + 2R_1$$

$$\therefore R_2 = G + R_1$$

73. (D)

(d) Given,

Current passing through galvanometer, $I = 6$ mA

Deflection, $\theta = 2°$

Figure of merit of galvanometer

$$= \frac{I}{\theta} = \frac{6\times10^{-3}}{2} = 3\times10^{-3} \text{ A/div.}$$

74. (C)

(c) Here, $\theta = 30°$, $\tau = 0.018$ N-m, $B = 0.06$ T

Torque on a bar magnet :

$\tau = MB\sin\theta \Rightarrow 0.018 = M\times0.06\times\sin 30°$

$\Rightarrow 0.018 = M\times0.06\times\frac{1}{2} \Rightarrow M = 0.6 \text{ A-m}^2$

Position of stable equilibrium ($\theta = 0°$)

Position of unstable equilibrium ($\theta = 180°$)

Minimum work required to rotate bar magnet from stable to unstable equilibrium

$\Delta U = U_f - U_i = -MB\cos180° - (-MB\cos0°)$

$W = 2MB = 2\times0.6\times0.06 \Rightarrow W = 7.2\times10^{-2}$ J

75. (A)

(a) Given,

Moment of inertia of circular coil, $I = 0.8$ kg m^2

Magnetic moment of circular coil, $M = 20$ Am^2

Rotational kinetic energy of circular coil, KE $= \frac{1}{2}I\omega^2$

Here, ω = angular speed of coil

Potential energy of bar magnet = $-MB\cos\phi$

From energy conservation

$$\frac{1}{2}I\omega^2 = U_{in} - U_f = 0 - (-MB\cos60°)$$

$$[\because U_i = -MB\cos90° = 0]$$

$$\Rightarrow \frac{MB}{2} = \frac{1}{2}I\omega^2 \Rightarrow \frac{20\times4}{2} = \frac{1}{2}(0.8)\omega^2$$

$\Rightarrow 100 = \omega^2 \Rightarrow \omega = 10$ rad

76. (B)

(b) Given,

Volume of iron rod, $V = 10^{-3}\ \text{m}^3$

Relative permeability, $\mu_r = 1000$

Number of turns per unit length, $n = 10$

Magnetic moment of an iron core solenoid,

$M = (\mu_r - 1) \times NiA$

$$\Rightarrow M = (\mu_r - 1) \times Ni\frac{V}{l} \Rightarrow M = (\mu_r - 1) \times \frac{N}{l} iV$$

$$\Rightarrow M = 999 \times \frac{10}{10^{-2}} \times 0.5 \times 10^{-3} = 499.5 \approx 500.$$

77. (D)

(d) For paramagnetic material. According to curies law

$$\chi \propto \frac{1}{T}$$

For two temperatures T_1 and T_2, $\chi_1 T_1 = \chi_2 T_2$

But $\chi = \dfrac{I}{B}$ $\quad\therefore \dfrac{I_1}{B_1} T_1 = \dfrac{I_2}{B_2} T_2$

$$\Rightarrow \frac{6}{0.4} \times 4 = \frac{I_2}{0.3} \times 24 \Rightarrow I_2 = \frac{0.3}{0.4} = 0.75\ \text{A/m}$$

78. (B)

When magnetic field is applied to a diamagnetic substance, it produces magnetic field in opposite direction so net magnetic field inside the cavity of sphere will be zero. So, field inside the paramagnetic substance kept inside the cavity is zero.

79. (D)

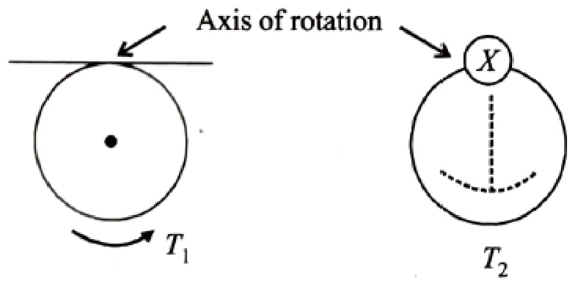
Permanent magnets (P) are made of materials with large retentivity and large coercivity. Transformer cores (T) are made of materials with low retentivity and low coercivity.

80. (A)

(a) Let I_1 and I_2 be the moment of inertia in first and second case respectively.

$I_1 = 2MR^2$

$I_2 = MR^2 + \frac{MR^2}{2} = \frac{3}{2}MR^2$



Time period, $T = 2\pi\sqrt{\frac{I}{mgd}}$

$T \propto I$

$\therefore \frac{T_1}{T_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{2MR^2}{\frac{3}{2}MR^2}} = \frac{2}{\sqrt{3}}$

81. (D)

(d) $F = \frac{mV^2}{r}$ and $F = qVB$

$\therefore \frac{mV^2}{r} = qVB \Rightarrow r = \frac{mV}{qB}$

or, $r = \frac{\sqrt{2mK}}{qB}$ $\qquad (\because p = mV = \sqrt{2mK})$

$\Rightarrow \frac{r^2q^2B^2}{2m} = K$

$K_p = \frac{r_p^2 q_p^2 B^2}{2m_p}$ and $K_\alpha = \frac{r_\alpha^2 q_\alpha^2 B^2}{2m_\alpha}$

$\therefore \frac{K_p}{K_\alpha} = \frac{r_p^2 q_p^2 m_\alpha}{r_\alpha^2 q_\alpha^2 m_p} = \left(\frac{2}{1}\right)^2 \left(\frac{1}{2}\right)^2 \left(\frac{4}{1}\right)$ or, $\frac{K_p}{K_\alpha} = 4:1$

82. (B)

(b) Force on a charge particle of charge q moving with velocity $\vec{v}$ in the magnetic field of strength $\vec{B}$ is given by

$$\vec{F}_m = q\vec{v} \times \vec{B}$$

Since, force on a point charge by magnetic field is always perpendicular to $\vec{v}$. So, work done by magnetic force on the point charge is zero.

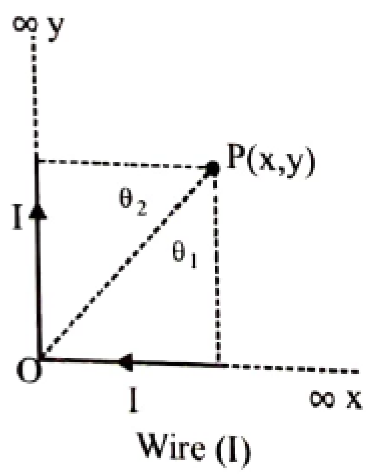
83. (A)

(a) $B_1 = \frac{\mu_0 I}{4\pi y}[\sin 90 + \sin\theta_1]$

$$= \frac{\mu_0 I}{4\pi y}\left(1 + \frac{x}{\sqrt{x^2+y^2}}\right) \quad ...(i)$$

$$B_2 = \frac{\mu_0}{4\pi}\frac{I}{x}(\sin 90 + \sin\theta_2)$$

$$= \frac{\mu_0}{4\pi}\frac{I}{y}\left(1 + \frac{y}{\sqrt{x^2+y^2}}\right) \quad ...(ii)$$



$B_{Net} = B_1 + B_2$

$$B = \frac{\mu_0 I}{4\pi}\left[\frac{1}{y} + \frac{x}{y\sqrt{x^2+y^2}} + \frac{1}{x} + \frac{y}{x\sqrt{x^2+y^2}}\right]$$

$$\Rightarrow B = \frac{\mu_0 I}{4\pi}\left[\frac{x+y}{xy} + \frac{x^2+y^2}{xy\sqrt{x^2+y^2}}\right]$$

$$= \frac{\mu_0 I}{4\pi}\left[\frac{x+y}{xy} + \frac{\sqrt{x^2+y^2}}{xy}\right]$$

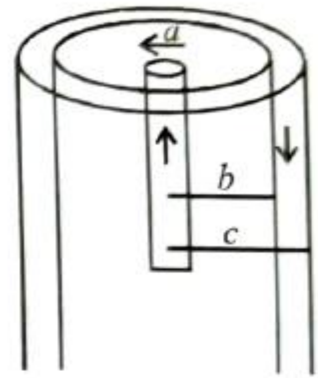
$$\Rightarrow B = \frac{\mu_0 I}{4\pi xy}\left[\sqrt{x^2+y^2} + (x+y)\right]$$

84. (A)

(a) For x < a

Using ampere's circuital lows

$\int B.\,dl = \mu_o$ current enclosed



$$\Rightarrow B_1(2\pi x) = \mu_o\left(\frac{i_o}{\pi a^2}\right)\pi x^2$$

$$\Rightarrow B_1(2\pi x) = \frac{\mu_o i_o x^2}{a^2}$$

$$\Rightarrow B_1 = \frac{\mu_o i_o x}{2\pi a^2} \quad \text{...(i)}$$

For a < x < b

$$B_2(2\pi x) = \mu_o i_o \Rightarrow B_2 = \frac{\mu_o i_o}{2\pi x} \quad \text{...(ii)}$$

$$\therefore \frac{B_1}{B_2} = \frac{\mu_o i_o \dfrac{x}{2\pi a^2}}{\dfrac{\mu_o i_o}{2\pi x}} = \frac{x^2}{a^2}$$

85. (A)

(a) Magnetic field at P,

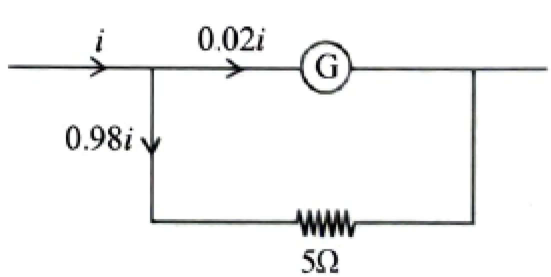
$B_P = 2$ (Magnetic field due to straight wire)

+ (Magnetic field due to semicircle)

$$B_P = 2\left(\frac{\mu_0 I}{4\pi r}\right) + \frac{\mu_0 I}{4r} \quad \therefore B_P = \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{4r} = \frac{\mu_0 I}{4\pi r}(2+\pi)$$

86. (C)

(c)



$0.02i\,R_g = 0.98i \times 5$

$R_g = 245\Omega.$

87. (D)

(d) Given, current sensitivity = 2 dov/mA

Full scale current,

$$I_{max} = \frac{50}{2} = 25\text{mA}$$

$$\therefore \quad \text{Resistance, } R = \frac{V}{I} = \frac{50\,mV}{25mA} = 2\Omega$$

88. (D)

Soft ferromagnetic materials are materials which can be easily magnetised and demagnetised by external magnetic field. When external field is applied, the domains in which magnetic dipole are aligned in the direction of external magnetic field will increase in size. While the domain in which magnetic dipole aligned opposite to magnetic field decrease in size.

89. (B)

(b) Given,

Magnetic field, B = 1T

Radius of cyclotron dees, r = 60 cm = 0.6 m

Kinetic energy of electron in cyclotron

$$= \left[\frac{q^2B^2r^2}{2m}\right] = \frac{(1.6\times10^{-19})^2 \times (1)^2 \times (0.6)^2}{2\times1.6\times10^{-27}}\text{J}$$

$$= \frac{0.288\times10^{-38}}{1.6\times10^{-19}\times10^{-27}} = 0.18\times10^{8}\,\text{eV} = 18\,\text{MeV}$$

90. (B)

(b) Given that uniform magnetic field, $\vec{B} = (2\hat{i} + 3\hat{j})\text{T}$

Acceleration $\vec{a} = (\alpha\hat{i} - 4\hat{j})\text{m/s}^2$

We know that

$$F = q(\vec{v}\times\vec{B}) \Rightarrow m\vec{a} = q(\vec{v}\times\vec{B})$$

Here, $\vec{a} \perp \vec{B}$, so, $\vec{a}.\vec{B} = 0$

$$(\alpha\hat{i} - 4\hat{j})(2\hat{i} + 3\hat{j}) = 0 \Rightarrow 2\alpha - 12 = 0 \Rightarrow \alpha = 6$$

91. (A)

(a) Given, $\vec{E} = E\hat{k}$

$\vec{B} = B\hat{j}$, B = 12 mT = 12×10^{-3} T. Energy = 728 eV

$$\text{Energy} = \frac{1}{2}mv^2$$

$$728\text{ eV} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$$

$$728 \times 1.6 \times 10^{-19} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$$

$$= v = \sqrt{\frac{2 \times 728 \times 1.6 \times 10^{-9}}{9.1 \times 10^{-31}}}$$

we have, $v = 16 \times 10^6$ m/s

$E = vB$

$\Rightarrow E = 16 \times 10^6 \times 12 \times 10^{-3}$

$\Rightarrow E = 192 \times 10^3$ V/m = 192 k Vm^{-1}

92. (B)

(b) As $R = \frac{mv}{qB} = \frac{\sqrt{2m(K.E)}}{qB} \Rightarrow q \propto \frac{\sqrt{m}}{R}$

$$\Rightarrow \frac{q_1}{q_2} = \sqrt{\frac{m_1}{m_2}} \times \frac{R_2}{R_1} = \sqrt{\frac{9}{4}} \times \frac{5}{6} = \frac{3}{2} \times \frac{5}{6} = \frac{5}{4}$$

93. (C)

(c) $f = \frac{1}{T} = \frac{eB}{2\pi m} \quad \left[\because T = \frac{2\pi m}{qB}\right]$

$$= \frac{1.6 \times 10^{-19} \times 10^{-4}}{2\pi \times 9 \times 10^{-31}} = 2.8 \times 10^6 \text{Hz}$$

94. (A)

(a) We know that in cyclotron

$$(K.E)_{max} = \frac{1}{2}mV^2_{max}, V_{max} = \frac{qBR_{dees}}{m}$$

$$= \frac{1}{2} \times m \times \frac{q^2B^2R^2_{dess}}{m^2} = \frac{q^2B^2R^2_{dees}}{2m}$$

$$= \frac{(2\pi mf)^2 R^2_{dees}}{2m}\left[\because f = \frac{qB}{2\pi m}\right] = 2\pi^2 mf^2 R^2_{dess}$$

Putting the values, $(K.E)_{max} = 7.4$ Me V

95. (C)

(c) Radius of particle in cyclotron

$$r = \frac{mV}{qB} = \frac{\sqrt{2m(K.E)}}{qB}$$

So, $\frac{r_1}{r_2} = \frac{\sqrt{K.E_1}}{\sqrt{K.E_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2} \qquad \therefore \frac{r_2}{r_1} = \frac{2}{1}$

96. (C)

(c) As $R = \frac{mv}{qB}$

$$\Rightarrow R \propto \frac{m}{q} \Rightarrow \frac{R_\alpha}{R_P} = \left(\frac{m_\alpha}{m_P}\right) \times \frac{q_P}{q_\alpha} \Rightarrow \frac{R_\alpha}{R_P} = \left(\frac{4}{1}\right) \times \frac{1}{2} = 2$$

97. (D)

(d) Radius of circular path in uniform magnetic field is

given by, $r = \frac{mV}{qB} = \frac{\sqrt{2m(K.E.)}}{qB}$

As $K.E$ = constant

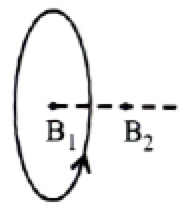
So, $r \propto \frac{\sqrt{m}}{q}$

So, $r_p : r_d : r_\alpha = \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e} = 1 : \sqrt{2} : 1$

98. (C)

(c) $B_1 = \frac{\mu_0 I}{2R}$ ...(i)

$B_2 = \frac{\mu_0 I R^2}{2(R^2 + 3R^2)^{3/2}}$ ...(ii)



$= \frac{1}{8}\left(\frac{\mu_0 I}{2R}\right) = \frac{B_1}{8}$

Dividing (i) by (ii), we get

$\Rightarrow \frac{B_1}{B_2} = \frac{8}{1}$

99. (B)

(b) The magnetic field at the centre of coil, $B = \frac{\mu_0 N i}{2R}$

Given, for coil x

Number of turns, $N_x = 200$

Radius, $R_x = 20$ cm

$\Rightarrow B_x = \frac{\mu_0 N_x i}{2R_x} = \frac{200\mu_0 i}{2 \times 20}$ ..... (i)

For coil y

Number of turns, $N_y = 400$

Radius, $R_y = 20$ cm

$\Rightarrow B_y = \frac{\mu_0 N_y i}{2R_y} = \frac{400\mu_0 i}{2 \times 20}$ ..... (ii)

Divide equation (i) by equation (ii), we have

$\Rightarrow \frac{B_x}{B_y} = \frac{\frac{200\mu_0 i}{2 \times 20}}{\frac{400\mu_0 i}{2 \times 20}} = \frac{1}{2}$

100. (B)

(b) From the given figure. Magnetic moment will be,

$\vec{M}$ = current $(\vec{I}) \times$ Area $(\vec{A})$

$\vec{M} = -I\pi(0.5)^2\hat{k} + I\pi(0.3)^2\hat{k}$

$\vec{M} = -7 \times \frac{22}{7}\left(\frac{25}{100} - \frac{9}{100}\right)\hat{k} = -22\left(\frac{16}{100}\right)\hat{k}$

$\vec{M} = -3.52\,\hat{k}\ \text{Am}^2 = -\frac{7}{2}\hat{k}\ \text{Am}^2$

101. (B)

(b) Magnetic field at centre is given as

$B = \frac{N\mu_0 i}{2R}$

So, $B_1 = \frac{N_1\mu_0 i}{2R_1}$

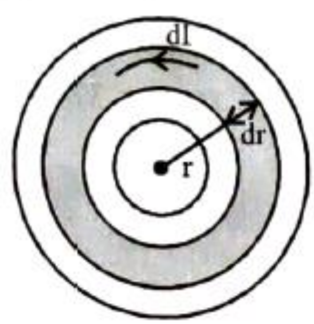
and, $B_2 = \frac{N_2\mu_0 i}{R_2}, R_2 = \frac{N_1 R_1}{N_2}$

$\frac{B_2}{B_1} = \frac{N_2}{N_1}\frac{R_1}{R_2} = \frac{N_2}{N_1} \times \frac{N_2}{N_1} \Rightarrow \frac{B_2}{B_1} = \frac{25}{4}$

102. (D)

(d) Let us consider a circular strip of length 'dr' at distance 'r' from centre

Magnetic field at centre due to this strip is given as



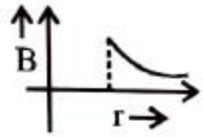
$dB = \frac{\mu_0}{2r}dI = \frac{\mu_0}{2r} \cdot \frac{n}{r_2 - r_1} \cdot dr$

So, $B_{net} = \int dB = \frac{\mu_0 nI}{2(r_2 - r_1)}\int_{r_1}^{r_2}\frac{dr}{r} = \frac{\mu_0 nI}{2(r_2 - r_1)}\ln\left(\frac{r_2}{r_1}\right)$

103. (D)

(d) $\vec{B} = O,\ r < R$

$= \frac{\mu_0 I}{2r}, r \geq R$



So, $B = 0, r < R$

$\propto \frac{1}{2}, r \geq R$. Therefore graph will be as such

104. (A)

(a) $X = 1.2 \times 10^{-5}$

$\mu_r = 1 + X = 1 + 1.2 \times 10^{-5}$

Now, $B = \mu_0 \mu_r n I \Rightarrow \frac{\Delta B}{B} = \frac{\Delta \mu_r}{\mu_r}$

$\Rightarrow \frac{\Delta B}{B} = \frac{\mu_r - 1}{1} = \mu_r - 1 = X = 1.2 \times 10^{-5}$

105. (A)

(a) Magnetic field due to solenoid is given by

$B = \mu_0 n I \quad \Rightarrow B \propto nI \Rightarrow \frac{B_2}{B_1} = \frac{n_2 I_2}{n_1 I_1}$

$\Rightarrow B_2 = \frac{n_2 I_2}{n_1 I_1} \times B_1 \quad \Rightarrow B_2 = \frac{1}{2} \times 2 \times B_1 \ \therefore B_2 = B$

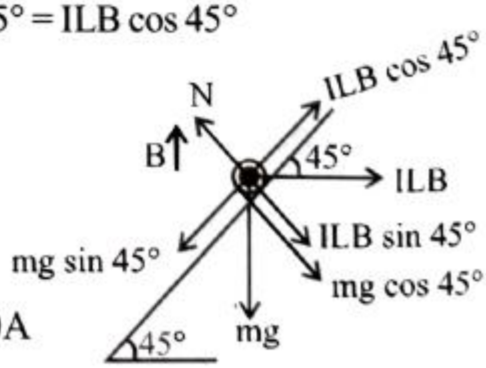
106. (A)

(a) Force, F = ILB sinθ

From figure, mg sin 45° = ILB cos 45°

$\therefore I = \left(\frac{m}{L}\right)\frac{g}{B}$

$= \frac{(0.45)(10)}{0.15} = 30A$



107. (C)

(c) F_M (CD) = $BI\ell_{eff}$

$= 0.5 \times (10) \times (5 \sin 60 \times 10^{-2}) = 0.216$ N

108. (B)

(b) Here, current cannot be in same direction in both wire because then, $B_p = 0$. So current should be in opposite direction.

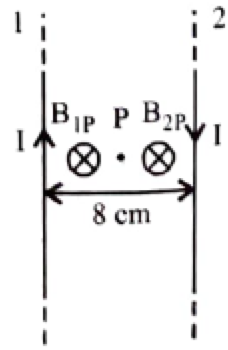
$B_p = B_{1p} + B_{2p}$

$B_p = 2\dfrac{\mu_0 I}{2\pi r}$

$300 \times 10^{-6} = 2 \times 2 \times 10^{-7} \times \dfrac{I}{4\times10^{-2}}$

$3 \times 10^{-4} = 10^{-5} \times I$

$I = 30\ A$



109. (C)

(c) We know that

$\dfrac{F}{l} = \dfrac{\mu_0}{2\pi}\dfrac{I_1 I_2}{d}$

$\Rightarrow 2 \times 10^{-6} = 2 \times 10^{-7} \times \dfrac{x^2}{0.2} \Rightarrow 2 = x^2 \Rightarrow x = \sqrt{2} = 1.4$

110. (C)

(c) We have,

$$B_p = \frac{\mu_0}{2\pi}\left[\frac{I_1}{r_1} - \frac{I_2}{r_2}\right](-\hat{k}) = \frac{2\times10^{-7}}{10^{-2}}\left[\frac{4}{4} - \frac{2}{6}\right](-\hat{k})$$

$$= 2\times10^{-5}\left[1 - \frac{1}{3}\right](-\hat{k}) = \frac{4}{3}\times10^{-5}(-\hat{k})$$

So, $\vec{F} = q(\vec{V}\times\vec{B}) = 3\pi\left[(2\hat{i} + 3\hat{j})\times\left(-\dfrac{4}{3}\times10^{-5}\hat{k}\right)\right]$

$$= 3\pi\left[\frac{8}{3}\hat{j} - 4\hat{i}\right]\times10^{-5}$$

$$= [8\pi\hat{j} - 12\pi\hat{i}]\times10^{-5} = 4\pi[2\hat{j} - 3\hat{i}]\times10^{-5}$$

$$= 4\pi\times10^{-5}[-3\hat{i} + 2\hat{j}]$$

111. (D)

(d) Current $i = \left(\frac{K}{NAB}\right)\theta$

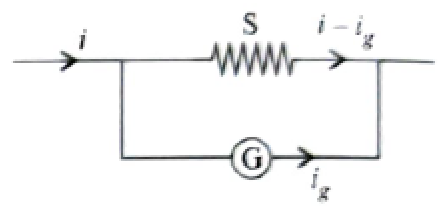
where, K = torsional constant and

B = magnetic fixed

$$\therefore \frac{d\theta}{di} = \frac{NAB}{K}$$

112. (B)

(b) We have, $S(i - i_g) = igG$



$$\Rightarrow S\left(1 - \frac{i_g}{i}\right) = \frac{i_g}{i}G$$

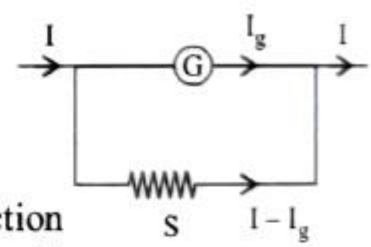
$$\Rightarrow \frac{G}{S} = \frac{i}{i_g} - 1$$

$$\Rightarrow \frac{i}{i_g} = \frac{G}{S} + 1 = \frac{72}{8} + 1 = 10 \Rightarrow \frac{i_g}{i} = \frac{1}{10}$$. So, % $\frac{i_g}{i} = 10\%$

113. (D)

(d) By current division rule

$$I_g = I \times \frac{S}{G+S} \Rightarrow I = \frac{G+S}{S} I_g \quad ...(i)$$



Now, figure of merit $(k) = \frac{I_g}{\theta}$

$\Rightarrow I_g = K\theta$

as, n = actual number of deflection

So, $I_g = kn$, [$\because$ k represent current]

[(ii) corresponding to one scale division]

So, $I = \frac{Kn}{S}(G + S)$ [From (i) & (ii)]

114. (A)

(a) As $\vec{M} = I\vec{A}$

$\Rightarrow |\vec{M}| = \dfrac{e}{\frac{2\pi R}{v}}\pi R^2 \qquad \left[\because I = \dfrac{Q}{T} = \dfrac{e}{\frac{2\pi R}{v}}\right]$

$\Rightarrow |\vec{M}| = \dfrac{1}{2}evR \Rightarrow |\vec{M}| = \dfrac{mvR}{1}\cdot\dfrac{e}{2M}$

$\Rightarrow |\vec{M}| = \dfrac{eL}{2M} \Rightarrow |\vec{M}| = -\dfrac{e\vec{L}}{2M}$

[$\because$ Here $\vec{M}$ and $\vec{L}$ will always be opposite]

115. (A)

(a) Work done is rotating a dipole for $\theta = \theta_1$ to $\theta = \theta_2$ is given by

$W = MB(\cos\theta_1 - \cos\theta_2) = MB(\cos 0° - \cos 60°)$

$= \dfrac{MB}{2} = \dfrac{2\times10^5\times14\times10^{-5}}{2} = 14J$

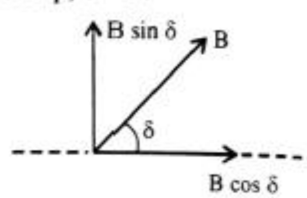
116. (D)

(d) Given that vertical component of the earth's magnetic field $B_V = 6\times10^{-3}$T and angle of dip, $\delta = 37°$

$B_V = B\sin\delta$

$6\times10^{-5} = B\times\dfrac{3}{5}$

$\Rightarrow B = \dfrac{5\times6\times10^{-5}}{3} = 10^{-4}T$



117. (A)

(a) Apparent dip is given as 'δ'

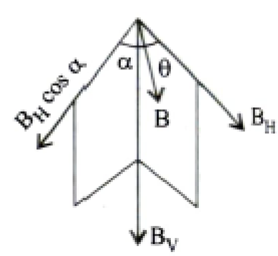
So, $\tan\delta = \dfrac{B_V}{B_H\cos\alpha}$,

Here, $\delta = 45°, \theta = 60°$

$\tan\delta = \dfrac{\tan\theta}{\cos\alpha}$

$\tan\theta = \tan\delta\cos\alpha$

$= \tan 60°\cos 45° = \sqrt{\dfrac{3}{2}}$



118. (A)

(a) We have

$B_H = B_e \cos\theta$, θ = angle of Dip

$B_e = B_H \sec\theta = (0.5 \sec 30)G$

$= \left(0.5 \times \frac{2}{\sqrt{3}}\right)G = \frac{G}{\sqrt{3}}$

119. (C)

$\mu_r = 1 + x = 100$

$\mu = \mu_0 \mu_r = 4\pi \times 10^{-7} \times 100$

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

120. (A)

(a) According to Curie's law, magnetic susceptibility is inversely proportional to temperature for a fixed value of external magnetic field i.e. $X = \frac{C}{T}$

The same is applicable for ferromagnet & the relation is given as

$X = \frac{C}{T - T_C}$ (T_c is curie's Temperature)

Dimagnetism is due to non-cooperative behaviour of orbiting electrons when exposed to external magnetic field.

121. (C)

(c) Soft Iron is used in electromagnet because of

(i) High permeability

As B = μH

So, higher is the value of 'μ', higher will be magnetic field (B) due to electromagnet.

(ii) Low retentivity

We always want that when current (or magnetising field) is removed, then there should be no residual magnetic field due to electromagnet. So retentivity, which is residual magnetic field left after demagnetisation should be zero.

122. (B)

(b) As, $T = 2\pi\sqrt{\frac{I}{MB}}$

$$\Rightarrow T^2 \propto \frac{I}{M} \quad \Rightarrow M \propto \frac{I}{T^2}$$

$$\Rightarrow \frac{M_1}{M_2} = \left(\frac{I_1}{I_2}\right)\left(\frac{T_2}{T_1}\right)^2 = \frac{3}{2}\times\left(\frac{4}{3}\right)^2 = \frac{3}{2}\times\frac{16}{9} = \frac{8}{3}$$

123. (20)

(20) Given,

Area of galvanometer coil, $A = 3 \times 10^{-4}\ \text{m}^2$

Number of turns in the coil, $N = 500$

Current in the coil, $I = 0.5$ A

Torque $\tau = |\vec{M} \times \vec{B}| = NiAB\sin(90°) = NiAB$

$$\Rightarrow B = \frac{\tau}{NiA} = \frac{1.5}{500\times 0.5\times 3\times 10^{-4}} = 20T$$

124. (543)

(543) Given,

Accelerating potential, V = 12 kV

Let number of revolution = n

Then, $\frac{1}{2}m_p \times \left(\frac{C}{6}\right)^2 = (2eV)\times n$

$$\Rightarrow n\left[2\times 1.6\times 10^{-19}\times 12\times 10^3\right]$$

$$= \frac{1}{2}\times 1.67\times 10^{-27}\times\left[\frac{3\times 10^8}{6}\right]^2$$

$$\Rightarrow n\left(38.4\times 10^{-16}\right) = 0.2087\times 10^{-11} \quad \Rightarrow n = 543.6197$$

125. (3)

(3) Given,

Side of triangle, $\ell = 10\text{ cm} = 10 \times 10^{-2}\text{ m}$

Magnetic field, $B = 20\text{ mT} = 20 \times 10^{-3}\text{ T}$

Current, $I = 0.2\text{ A}$

Area of equilateral triangle, $A = \frac{\sqrt{3}}{4}\ell^2$

Torque, $\vec{\tau} = \vec{M} \times \vec{B} = MB\sin 90°$

$= IAB = \frac{i\sqrt{3}\ell^2}{4}B = \frac{0.2 \times \sqrt{3} \times \left(10 \times 10^{-2}\right)^2}{4} \times 20 \times 10^{-3}$

$\therefore\ \tau = \sqrt{3} \times 10^{-5}\text{ Nm}$

126. (250)

(250) $I = \frac{M}{V}$, I = Magnetisation intensity

$\chi H = \frac{M}{V}$, M = Magnetic moment

For solenoid ($H = ni$) and as $\mu_r = 1 + \chi$

So, $(\mu_r - 1)niV = M$

$M \propto \mu_r - 1 \qquad \therefore\ \frac{M_2}{M_1} = \frac{749}{499} \Rightarrow M_2 = \frac{749}{499}M_1$

So, $\frac{M_2 - M_1}{M_1} = \frac{\frac{250}{499}M_1}{M_1} = \frac{250}{499}$

127. (22)

(22) $B = \mu_0\mu_r H = \mu_0(1+\chi)H = B_0(1+\chi)\ [H\mu_0 = B_0]$

$\Rightarrow\ B - B_0 = B_0\chi \Rightarrow \frac{B - B_0}{B_0} = \chi$

Percentage increase in magnetic field,

$\frac{B - B_0}{B_0} \times 100 = 100\chi = 100 \times 2.2 \times 10^{-5} = 2.2 \times 10^{-3} = \frac{22}{10^4}$

$\therefore$ Value of x = 22

128. (10)

(10) We know that

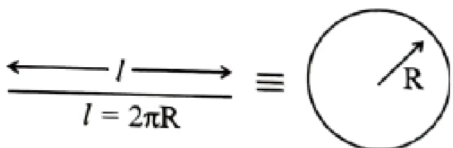
$$r=\frac{mV}{qB}=\frac{\sqrt{2m(KE)}}{qB}$$

$$=\frac{\sqrt{2\times24\times1.67\times10^{-27}\times5000\times1.6\times10^{-19}}}{1.6\times10^{-19}\times0.5}$$

$= 0.1$ m $= 10$ cm

129. (11)

(11)



As, length of wire $= 2\pi R$

$$\Rightarrow \frac{314}{100}=2\pi R \quad \Rightarrow R=0.5\text{ m}$$

Magnetic Moment $= I \times A = 14 \times \pi R^2$

$$=14\times(3.14)\times\frac{1}{4}=10.99\approx11.00$$

130. (3)

(3) Magnetic field at centre of ring/coil is given as,

$$B_{\text{centre}}=\frac{N\mu_0 I}{2R}$$

$$\Rightarrow \quad 37.68\times10^{-4}=\frac{100\times4\pi\times10^{-7}\times I}{2\times5\times10^{-2}} \quad \Rightarrow I=3\text{A}$$

131. (5)

(5) We have

$$\frac{F}{l}=\frac{\mu_0}{2\pi}\frac{i_1 i_2}{r} \quad \Rightarrow \quad r=\frac{\mu_0}{2\pi}i_1 i_2\times\frac{l}{F}$$

$$\Rightarrow r=2\times10^{-7}\times25\times\frac{0.1}{10^{-5}}$$

$= 50 \times 10^{-7} \times 10^4 = 50 \times 10^{-3}$ m $= 5$ cm

Magnetism solution

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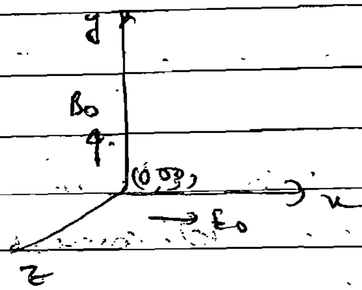
Theory

Set 1

(1)

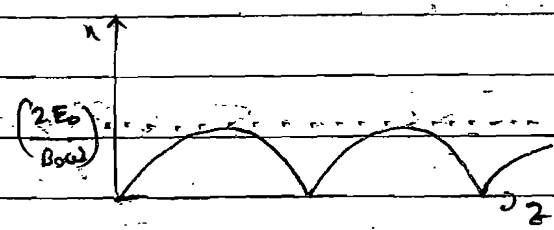


$\boxed{A}$ is Correct

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

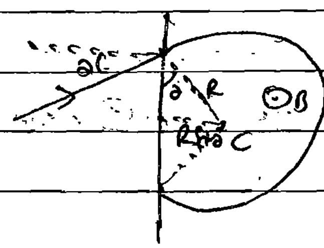
$$a_x = \frac{q}{m}(E_0 - V_z B_0)$$

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

$V_x = V_z = 0$ at $\omega t = 0$, 2π etc so $\boxed{C}$ is correct

$\boxed{D}$ is correct

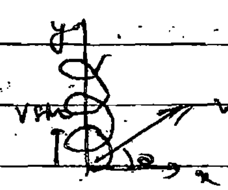
(2)



$0 < \theta < \pi/2$.

$R\sin\theta \to R$ 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.

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

As $\vec{F} \perp \vec{v}$ 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

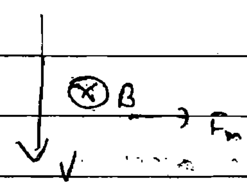
$W = \frac{V}{R} = \frac{qB}{m}$ $\therefore W \propto \frac{1}{m}$ So $\boxed{B}$ is wrong

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

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

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

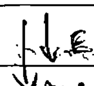
(9)



so $\boxed{C}$ is correct

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

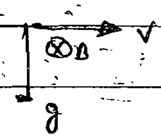
(10) If E horizontally it will deflect ④



$\boxed{B}$ 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

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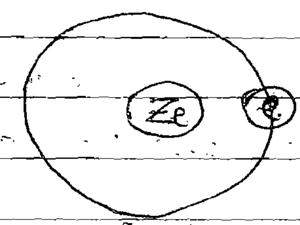
Set 2

(1)



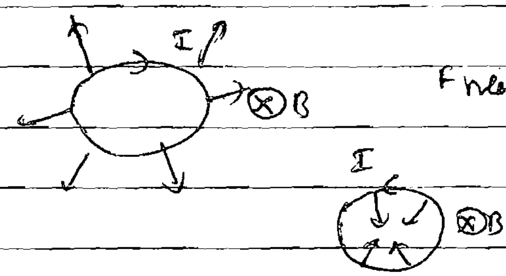
[A] is Correct according to action-reaction pair.

[B] is Correct as q is moving.

[C] is correct as I exists.

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

(2)



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

(3)

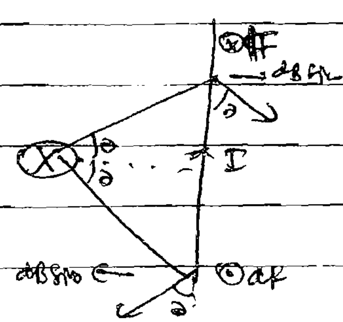
I ← → e

I ← → e

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

[B] [D] are Correct.

(4)



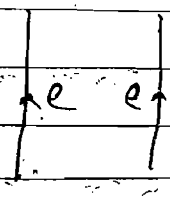
⇒ ⊗ ⊗

(after rotation)

so, they approach (attract) each other

so, [C] is alone correct

(5)



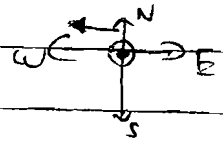
Initially repulsion &
then attrⁿ like O(3),

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

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

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

Set3 :

(1) 

$\boxed{C}$

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

(3) $\boxed{D}$

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

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

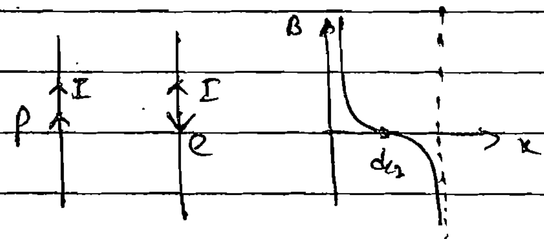
(6) $\boxed{C}$

(7) $B = \frac{\mu_0 I}{4\pi d/2} + \frac{\mu_0 I}{4\pi d/2} = \frac{\mu_0 I}{2\pi d} + \frac{\mu_0 I}{2\pi d} = \frac{\mu_0 I}{\pi d}$ $\boxed{D}$

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

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

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

(11) 

$\boxed{C}$

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Set 4

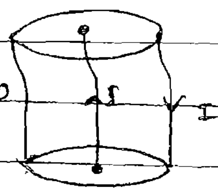
(1) $B\,2\pi x = \mu_0 I_{in}$ $\quad I_{in} = 0$

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

$\boxed{C}$

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

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



$\boxed{C}$

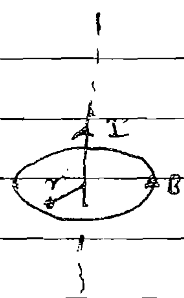
(3) $B_{in} \neq 0$ so $B_1 \neq 0$

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

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

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

(5)



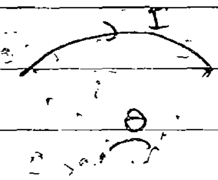
$\vec{F} \neq 0$ if $\vec{B} \parallel \vec{dl}$

so $\boxed{D}$

Exercise 1

Single option is correct:

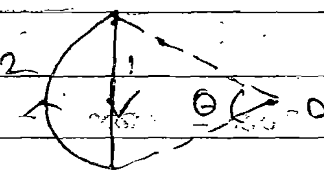
(1) Use $B = \frac{\mu_0 i (\theta)}{4\pi r}$



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

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

(2)



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

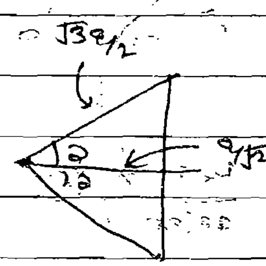
$$B_1 = \frac{\mu_0 I}{2\pi R}\tan\frac{\theta}{2} \odot$$

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

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

$(\tan\theta/_2 > \theta/_2)$

(3)



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

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

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

$\boxed{C}$

(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

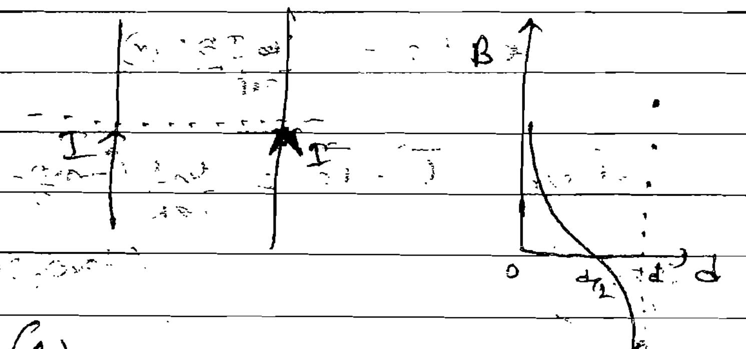
$= \frac{4\pi \times 10^{-7}}{2}\left[\frac{16 \times 20}{.16} - \frac{25 \times 18}{.10}\right]$

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

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

$\boxed{A}$

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

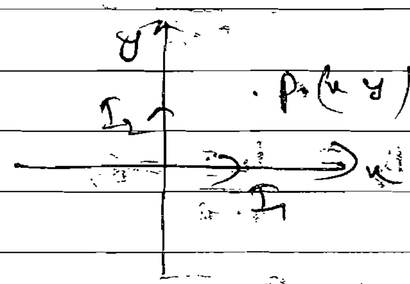
$= \frac{\mu_0 I \tan 30}{\ldots}\left(1 - \frac{1}{\ldots} + \frac{1}{\ldots} - \infty\right)$

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

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

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

$\boxed{A}$ (12)



$B_P = 0$

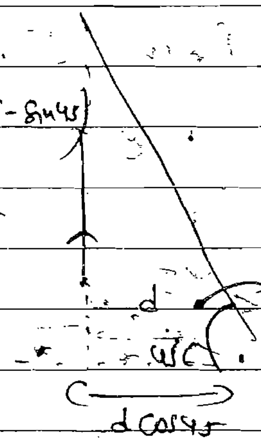
so $\frac{\mu_0 I_2}{2\pi x} = \frac{\mu_0 I_1}{2\pi y}$

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

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

$\times 2$

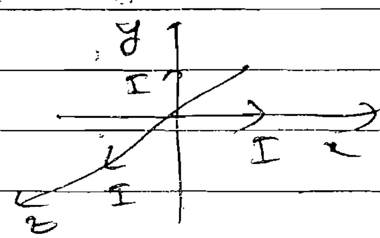
$= \left(\frac{\mu_0 I}{4\pi d/\sqrt{2}}\right)\left(1 - \frac{1}{\sqrt{2}}\right) 2$



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

$\boxed{A}$

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

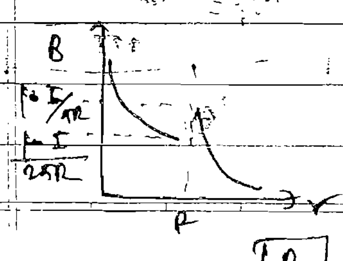


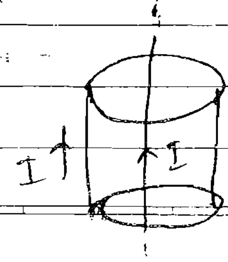
$= \frac{\mu_0 I}{2\pi a}\hat{i}$

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

2 sin 30

(15)



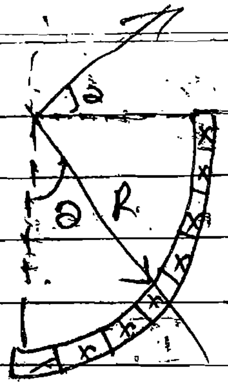


$0 < r < R$

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

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

(16)



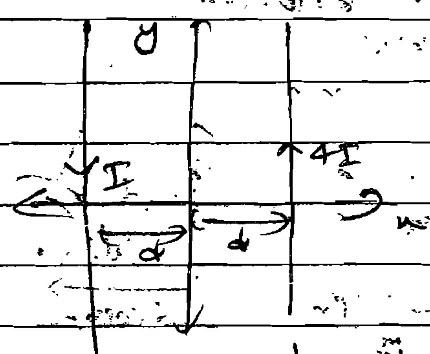
$$B_H = \int_0^{\pi/2} dB\cos\theta$$

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

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

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

(17)

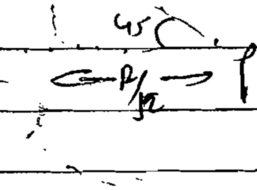


(i) direction of B is const $(\hat{k})$

(ii) B will tend to zero close to left

So, $\boxed{C}$

(18)



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

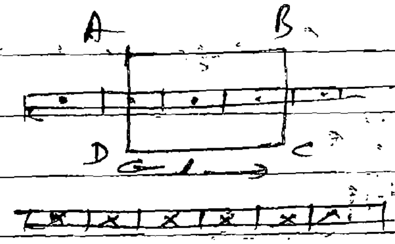
$$= \frac{\mu_0 I}{4\pi R/\sqrt{2}}\left(1 - \frac{1}{\sqrt{2}}\right)$$

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

$\boxed{A}$

[redacted]

(19) Ampere's law:



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

$\therefore B\cancel{l} = \mu_0 \lambda \cancel{l}$ $\therefore B = \mu_0 \lambda$ $\boxed{B}$

(20) Use principle of superposition

$$B_{axis} = B_{(+)} + B_{(-)} \quad (1)$$

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

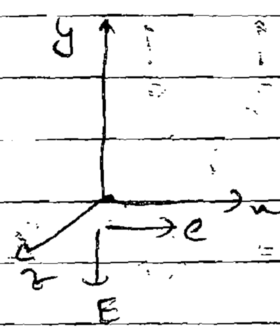
$\boxed{B}$

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

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

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

(22)



$F_E = \uparrow$

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

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

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

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

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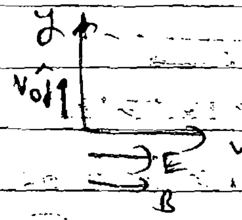
(23) Change in velocity $= \bar{V}_f - \bar{V}_i$

$= \left(\bar{V}_{yz} + \bar{V}_x - V_0\hat{j}\right)$



$V_{yz}^2 + V_x^2 = 4V_0^2$

$V_{yz}^2 = V_0^2$

$\therefore V_x^2 = 3V_0^2 \therefore V_x = \sqrt{3}V_0$

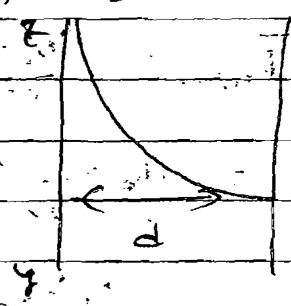
So $\left(\frac{qE}{m}\right)t = \sqrt{3}V_0 \therefore t = \frac{\sqrt{3}mV_0}{qE}$ $\boxed{D}$

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

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

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

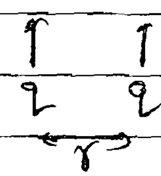
(25)



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

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

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



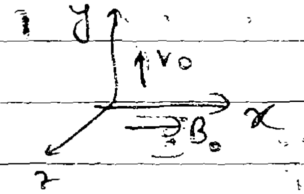
$F_B = \frac{\mu_0 q^2 v^2}{4\pi r^2}$ —(2)

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

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

St line motion : displacement $= V_0\frac{T}{2}$

$= \frac{V_0\pi}{B\alpha}$



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

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

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^+ $q=1, m=4$

O^{+2} $q=2, m=16$

$R = \frac{\sqrt{2mK}}{qB}$

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

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

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

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

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

$= \frac{9\times10^{-31}\times \cancel{3.2}\times10^{5}}{\cancel{1.6}\times10^{-19}\times 4\times10^{-6}}$ $= 4.5\times10^{-1} = 0.45$ m $\boxed{C}$

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

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

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

$B = \frac{8\ 2}{2.5\times1.6} = \frac{2}{1.6} = \frac{5}{4} = 1.25$

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

(33)

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

[redacted]

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

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

(2)

(3)

(4)

(5)

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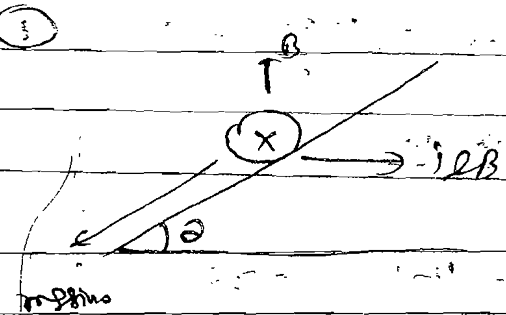
Exercise 2 (Magnetic force on a current...)

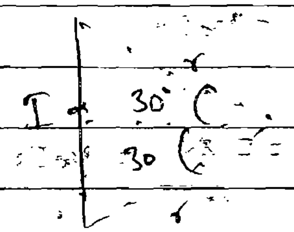
(1)



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

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

(2)



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

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

$(r = \ell)$ As equilateral Δ.

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

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

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

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

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

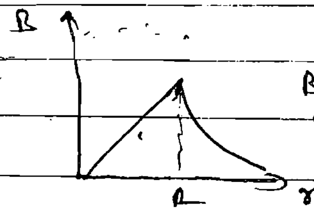
$\therefore v = \left(\frac{169m}{2qE_0}\right)$ $\boxed{A}$

[redacted]

(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)



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

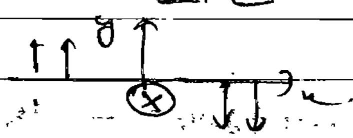
$B_{in} = \frac{\mu_0 I r}{2\pi R^2}$

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

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

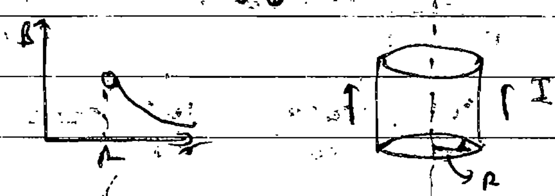
$\boxed{A}$ $\boxed{B}$

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

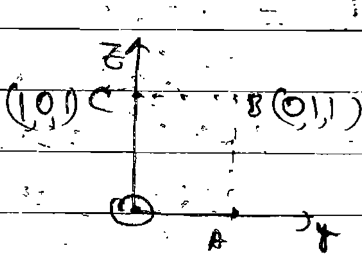
$R \propto m/q$ $\quad R_{He^{+2}} = 2K$ $\quad \boxed{a}$ $\boxed{B}$

$R_{H^+} = K$

(16) As O rest w.r.t. P, 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

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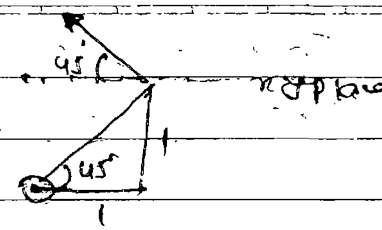
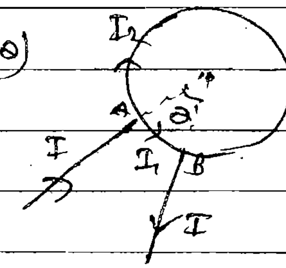
(18) $B = \frac{\mu_0 I}{2\pi d} = \left(\frac{\mu_0 I}{2\sqrt{2}\pi}\right)$



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

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



$V_{AB} = 0$

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

$R \propto l$ 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.) $NIAB = K\theta$

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

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

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

$\theta_2 = 56°$ $\boxed{B}$

(3) $NIAB = K\theta$

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

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) $KE = \frac{P^2}{2m} = \frac{(rqB)^2}{2m} = \frac{(0.265 \times 1.6 \times 10^{-19} \times 3.14)^2}{2 \times 2 \times 1.672 \times 10^{-27}}$

$= 2.7 \times 10^{-12}$ 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) $= 53$ μV

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Matrix Match Type

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

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

(A) $\rightarrow$ (r)

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

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

(B) $\rightarrow$ (q)

$B = \frac{\mu_0 I \pi}{2\pi R} = \left(\frac{\mu_0 I \times \cancel{\pi}}{2\cancel{\pi} mv/qB}\right) = \left(\frac{\mu_0 I q B}{2mv}\right)$ $\qquad B \propto v^{-1}$ So (C) $\rightarrow$ (s)

(D) $\rightarrow$ (p)

(11.) $\tau = NIAB$ $\qquad$ (A) $\rightarrow$ (r)

$\tau = C\theta \therefore \theta = \left(\frac{NIAB}{C}\right)$ $\qquad$ (B) $\rightarrow$ (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) $\rightarrow$ (q)

(12) (D)

(13) (C)

Exercise 4

Subjective Qo

(4)

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

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

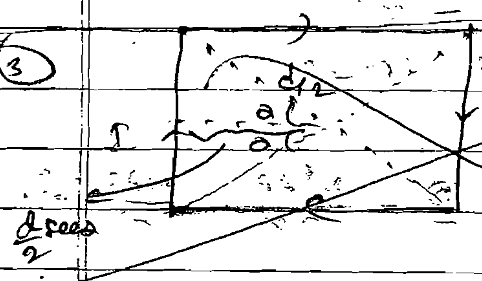
(b) $B = \left(\frac{\mu_0 I}{4\pi a}\right)\left(\frac{3\pi}{4}\right) + \frac{\mu_0 I}{4\pi b}(\sin 45 + \sin 0) \times 2$

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

(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)

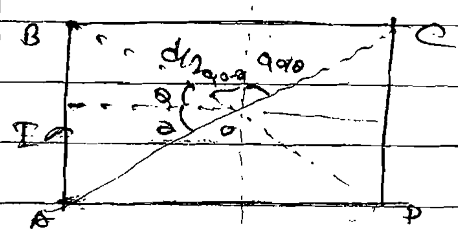


$B_0 = \frac{\mu_0 I}{4\pi \frac{d}{2}(\cos\theta)}\left[\sin\theta + \sin\theta\right] \times 4$

$B_0 = 4\frac{\mu_0 I \sin\theta}{\pi d(\cos\theta)^{-1}}$ [redacted] (5)

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

(3)



(6)

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

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

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

$(d = R)$

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

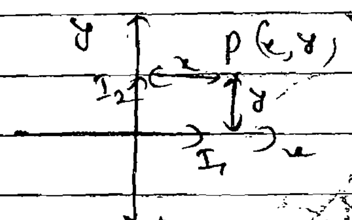
(b) $B_1 = \frac{\mu_0 I}{4\pi R}(-\hat{k})$, $B_2 = \frac{\mu_0 I}{4R}(-\hat{i})$, $B_3 = \frac{\mu_0 I}{4\pi R}(-\hat{i})$

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

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

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

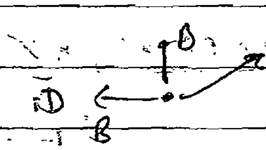
(5)



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

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

(6) (b)



$B_0 = B\sqrt{2}$

$B_{net} = \sqrt{B^2 + B^2 + 2B^2 + 2B^2\cos 90 + 2\sqrt{2}B^2\cos 45 + 2\sqrt{2}B^2\cos 135}$

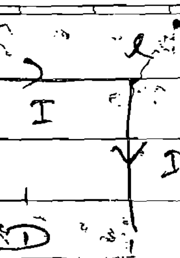
$B_{net} = (4B^2 + 2B^2 - 2B^2)^{1/2} = 2B = 2\left(\frac{\mu_0 I}{4\pi a}\right)$

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

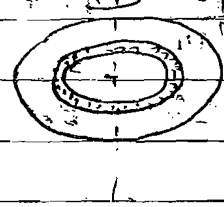
(a) $B_{net} = 4\left(\frac{\mu_0 I}{\quad}\right)\cos 45 = \left(\frac{\mu_0 I}{\quad}\right)$

[redacted]

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



(8) (9)



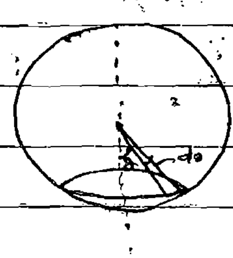
$$B = \int_0^R \frac{\mu_0 \, dI}{2x}$$

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

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

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

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

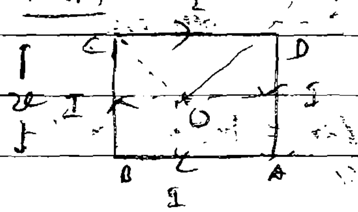
(b) $$P_m = 2\int_0^{\pi/2} dI\left(\pi (R\sin\theta)^2\right) = 2\int_0^{\pi/2} \sigma\omega a^2 \sin\theta\, d\theta\, \pi a^2 \sin^2\theta$$

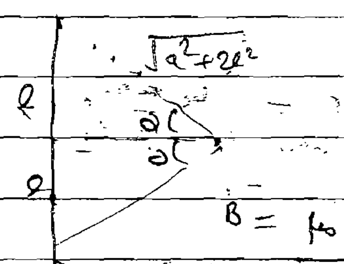
$(R=a)$ $$= \frac{2\sigma\omega\pi a^4}{1}\int_0^{\pi/2}\sin^3\theta\, d\theta$$

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

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

(11) Part 1



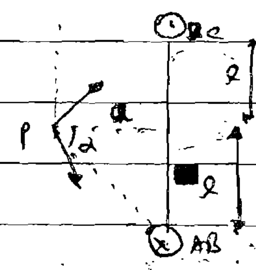


$OP = a$

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

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

Part 2



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

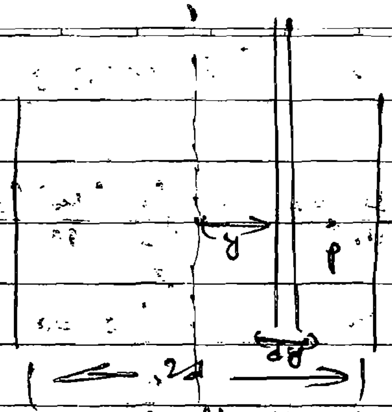
$$= 4\,\frac{\mu_0 I l}{2\pi\sqrt{a^2+l^2}\sqrt{a^2+2l^2}}\,\frac{l}{\sqrt{a^2+l^2}}$$

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

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

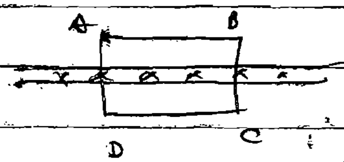
$B = 2.2\times10^{-4}$ T

(12)



median plane
(central part)

Use



$\mu_0 \lambda \ell = 2B\ell$

$B = \mu_0 d/2$

(d = current len)

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

(14)

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

(13) Using ampere's law

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

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

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

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

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

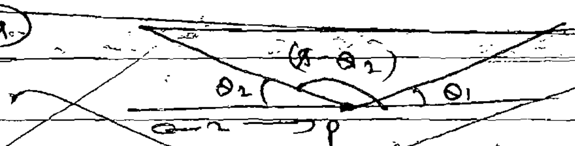
(c) $qvB = \frac{mv^2}{R}$ $\therefore$ $R = \frac{mv}{qB}$

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

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

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

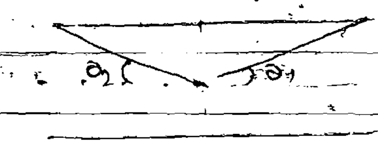
~~(14) (a)~~



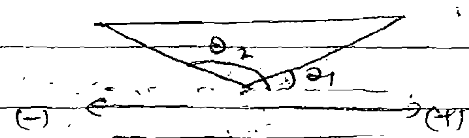
~~$B = \frac{\mu_0 n I}{2}(\cos\theta_1 - \cos\theta_2)$; $B = \frac{\mu_0 n I}{2}(-\cos\theta_2 + \cos\theta_1)$~~ ~~$\cos(\pi-\theta_2) = \dots$~~ ~~$\cos\theta_2 = +x/\sqrt{R^2 \dots}$~~

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

(14) (a)



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



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

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

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

(b) $\frac{B_0 - B}{B_0} = 1 - \frac{B}{B_0} = 1 - \eta$, $B_0 = \mu_0 n I$, $B = \frac{\mu_0 n I}{2}\left(1 - \dots\right)$

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

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(19)

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

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

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

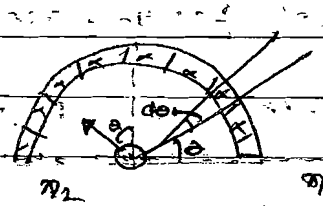
$$4\eta(1-\eta)x^2 = R^2(1-2\eta)^2$$

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

(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)

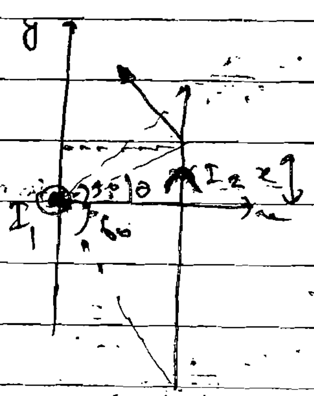


$$B_{net} = \int 2\,dB\sin\theta = 2\int_0^{\pi/2} \frac{\mu_0\left(\frac{I}{\pi}d\theta\right)}{2\pi R}\sin\theta = \frac{\mu_0 I}{\pi^2 R}$$

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

(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)



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

(20)

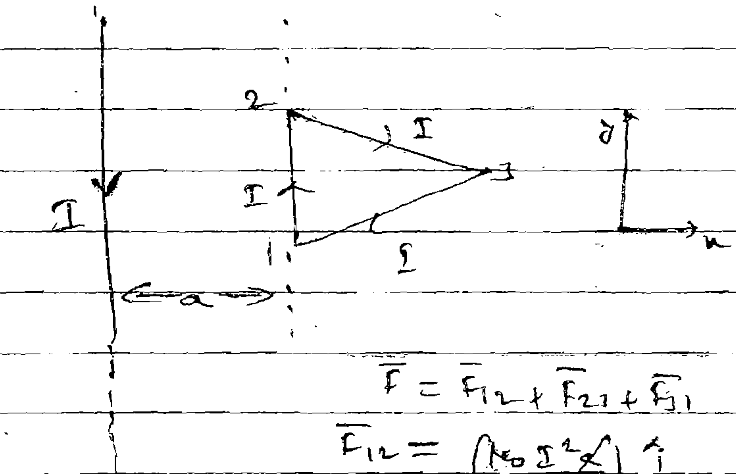
$$F = \int_{-\sqrt{3}a}^{a/\sqrt{3}} \frac{\mu_0 I_1 I_2}{2\pi\sqrt{a^2+x^2}} \frac{x\,dx}{\sqrt{a^2+x^2}}$$

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

(21)

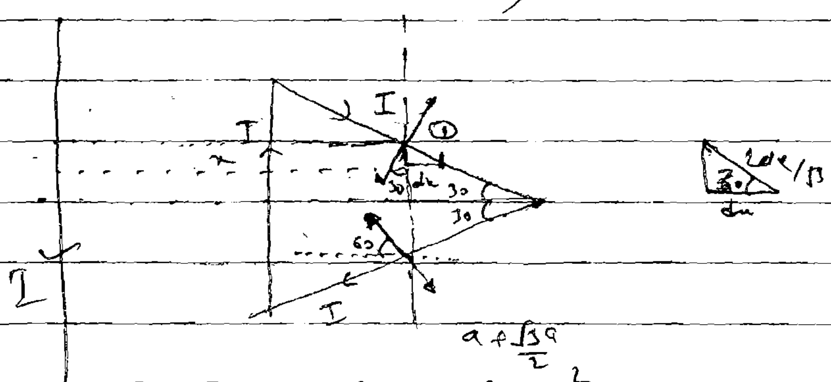
$$= \frac{\mu_0 I_1 I_2}{4\pi}\left(\ln\frac{y}{3} - \ln 1\right)\hat{x}$$

(19)



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

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



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

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

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

$\overline{M} = \cancel{I l^2 \hat{k}} + \cancel{I l^2 (-\hat{k})}$

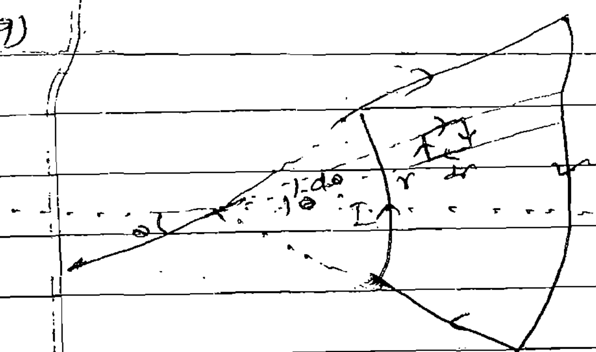
$+ I l^2 \hat{j}$

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

(21) $B = \int_0^R \frac{\mu_0 dI}{2x} = \frac{\mu_0}{2}\int_0^l (\sigma \ldots = \ldots$

$M = \int \ldots$ R

(29)



(31)

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

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

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

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

towards center

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

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

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

(30) (a) $\bar{M} = I_2\bar{A}$ $\bar{A} = (\overrightarrow{B\_A})\times(\overrightarrow{A\_D})$

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

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

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

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

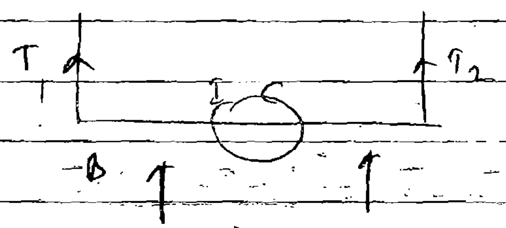
(b) $B = \frac{\mu_0 I_1}{2\pi a}\hat{j}$

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

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

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

(31)



Moment about 1

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

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

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

Moment about 2

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

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

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

(32) $\tau_B = \tau_{ext} \Rightarrow \cancel{4}\lambda a g \frac{a}{\cancel{2}}\sin 30 = MB\sin 60$

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

(33) By Conservation of angular momentum; about common diameter

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

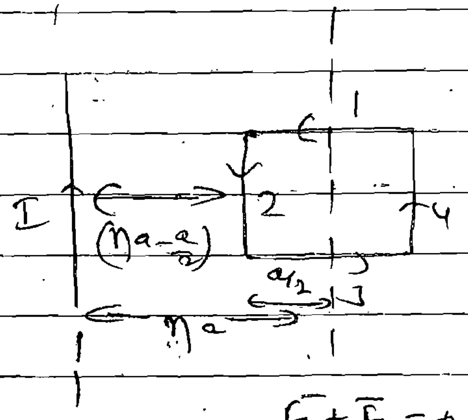
By COE $\frac{1}{2}\frac{mr^2}{2}\omega_1^2 + \frac{1}{2}\frac{MR^2}{2}\omega_2^2 = -\vec{P}\cdot\vec{B}$

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

Solving (1) & (2)

$$\frac{1}{2}\left(\frac{mr^2}{2}\right)\omega_1^2 = \mu_0\pi r^2 I_1 I_2 MR$$

(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)

$$W = \Delta P E$$

$$= 2 P E_m$$ (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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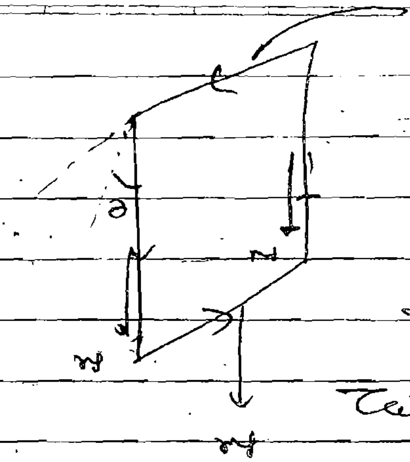
(15)

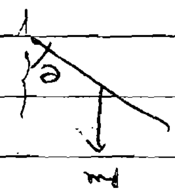


$(\tau = 0)$

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

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

$$\tau_{cof} = mg\frac{\ell}{2}\sin\theta + mg\frac{\ell}{2}\sin\theta + mg\ell\sin\theta$$



$$\therefore \tau_{cof} = 2mg\ell\sin\theta = 2(S\ell\rho)g\ell\sin\theta$$
$$= 2(\rho S\ell^2 g\sin\theta)$$

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

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

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

(16) (a) $F = 0$

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

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

(c) $\parallel$ to (B)

(17)

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

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

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

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(38)

$$\tau = I l^2 B \sin\theta$$

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

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

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

$$T = 2\pi\sqrt{\frac{m}{6IB}} = 2\pi\sqrt{\frac{0.01}{6\times2\times0.1}}$$

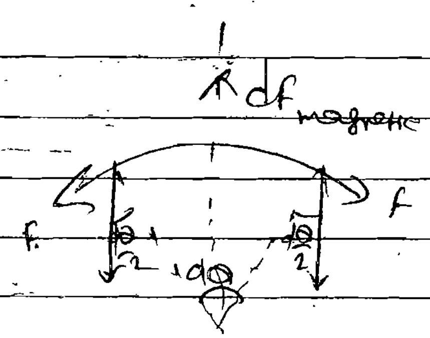
$$= 2\pi\sqrt{\frac{1}{120}} = \frac{2\pi}{11} = \frac{2 \times 22}{11 \times 7} = \frac{4}{7}$$

$$= 0.57 \text{ sec}$$

(41)

(42)

(39)



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

$$F d\theta = df_{magnetic}$$

(43)

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

$$F = IRB$$

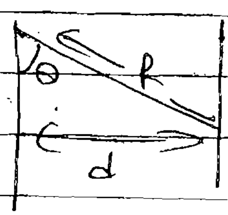
$$l = 2\pi R$$

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

(44)

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

(40)



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

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

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

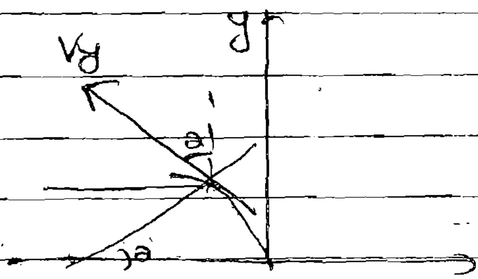
$R = \frac{mv}{qB} = \frac{p}{qB} \therefore 2R = \left(\frac{2p}{qB}\right)$

$l + d = \frac{2}{qB}\sqrt{2m_1qV_0}$

$l = \frac{2}{qB}\sqrt{2m_2qV_0} \therefore \left(\frac{l+d}{l}\right)^2 = \frac{m_1}{m_2}$

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

(42)



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

where $\omega = qB/m$

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

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

$\therefore v = \sqrt{\frac{2qE_0z}{m}}$

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

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

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

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

$m\frac{dv_x}{dt} = eV_yB$ — (1) $\quad m\frac{dv_y}{dt} = eE - eBv_x$ — (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

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

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

$$A = E/B$$

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

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

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

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

[redacted]

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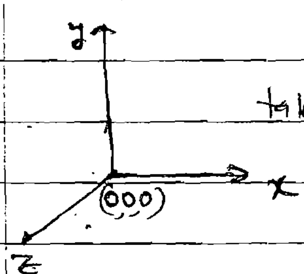
(45.)



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

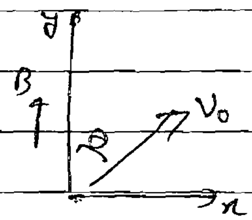
$$\left(\frac{2\pi m}{qB}\right)(V_0 \cos\alpha) = d$$

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

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

Substituting values.

(46.)



Part 1:

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

By CoE:

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

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

Part 2:

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

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

(47) Initially $q V \cos\theta\, B = qE$

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

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

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

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

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

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

$\frac{\epsilon_0 m}{B_0 q_0 \beta_0}$

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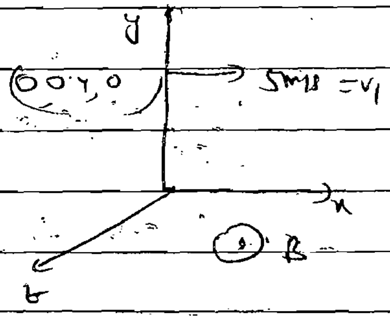
(48)



Radius of circular path by this particle = 0.4

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

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

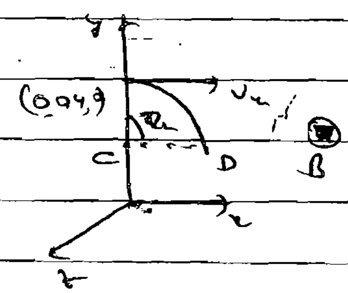
For 1st & 2nd particle use CLM (Conservation of linear momentum)

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

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

So $v_x = 4$ m/s

$v_z = 8$ m/s



due to v_x, circular motion

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

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

angular displacement due to circular motion

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

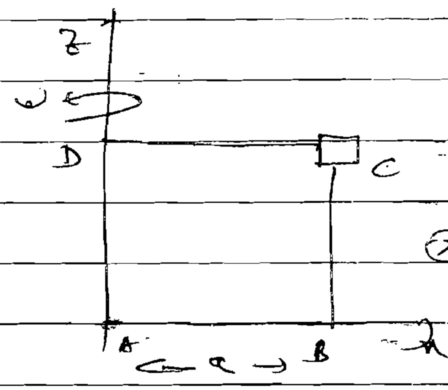
$x_{coordinate} = R\sin\theta = 0.2$

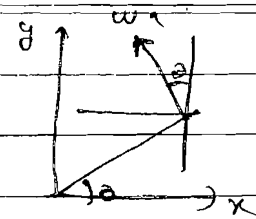
$y_{coordinate} = OC + R\cos\theta = 0.2 + 0 = 0.2$

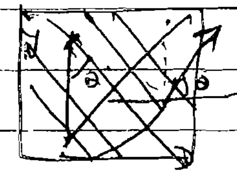
$z_{coordinate} = v_z t = 0.2$

So position = (0.2, 0.2, 0.2)

(49)







V_{speed} of block $= \omega a$ 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 = 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)

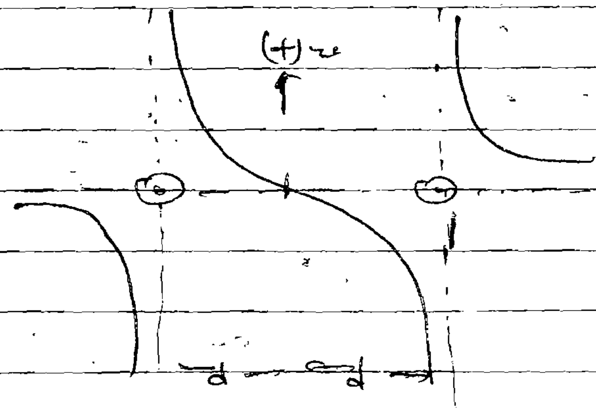
(5)

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)



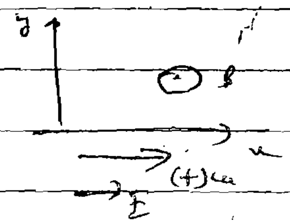
$\boxed{B}$

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

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

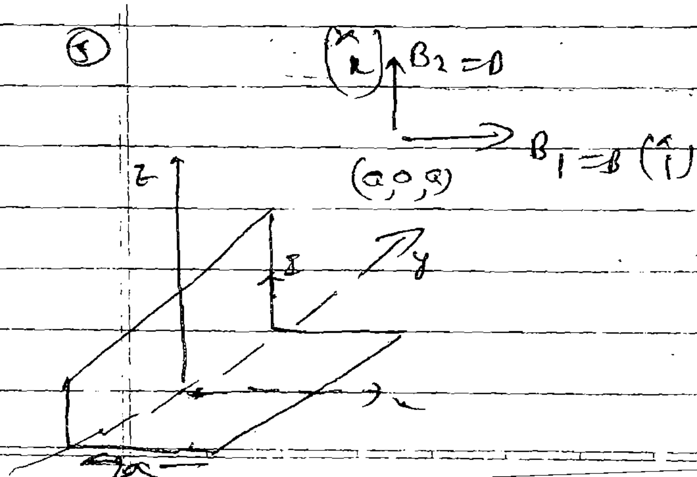
$\frac{h_1}{h_2} = \frac{2}{3}$ $\boxed{C}$

(4)



$\boxed{C}$

(5)



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

$\boxed{D}$

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(6) $R_A > R_B$

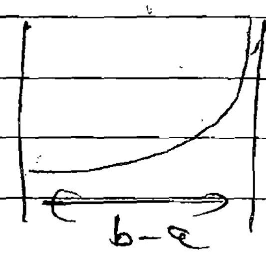
$\frac{m_A v_A}{qB} > \frac{m_B v_B}{qB} \therefore m_A v_A > m_B v_B$ (11)

$\boxed{B}$

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

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

(8) (13)



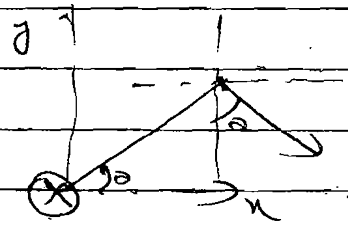
$\frac{mv}{qB} = R = (b-a)$

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

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

(15

(9)



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

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

(17)

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

N to S out

S to N in

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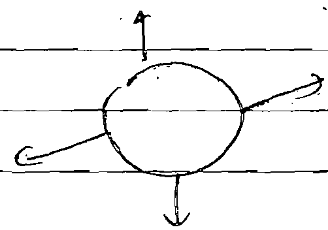
(11) B_{mult} have $\hat{i}$ not alg $\hat{j}$

So $\boxed{B}$

(12)



$\boxed{B}$

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

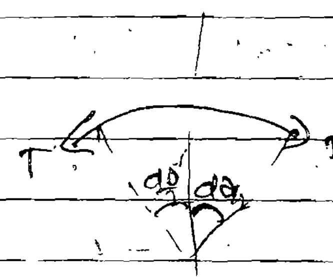
$\therefore$ $\boxed{C}$ $I > IV > II > III$

(14) Speed const ey co ~ q lo

$\boxed{B}$

(15) direction will conclude pt circle down So $\boxed{A}$

(16)



$2T\sin d\theta_{/2} = IdlB$

$Td\cancel{\theta} = IR\cancel{d\theta}B$

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

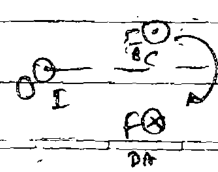
$\boxed{T = \frac{IBL}{2\pi}}$ $\quad R = \frac{L}{2\pi}$

$\boxed{C}$

Multiple choice

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

So $F_{net} = 0$



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

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

$v > \frac{qBl}{m}$ $\boxed{a}$

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

Independent of v

Subjective Problems

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

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

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

$(T_1 - T_2)\frac{D}{2} = \frac{\omega B Q R^2}{2} \Rightarrow T_1 - T_2 = \frac{\omega B Q R^2}{D}$ —(III)

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

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

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

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

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

$\tau_k = \left(\frac{2NI_0AB}{\pi}\right)$ = 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 liner is converted to circular)

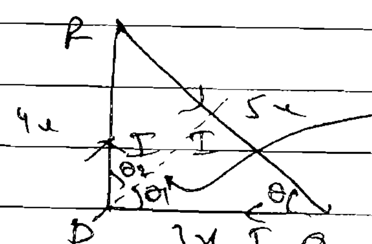
$\frac{1}{2}I\omega^2 = \frac{1}{2}k\theta_{max}^2 \Rightarrow \frac{1}{2}I\left(\frac{BNAQ}{I}\right)^2$

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

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

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

(22)



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

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

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

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

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

$\therefore F_{centr} = 0$

$F_{AB} = 0$

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) $\boxed{D}$

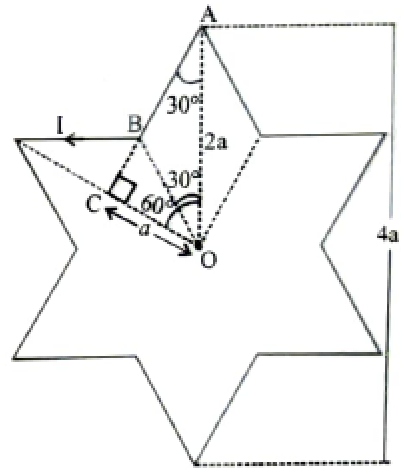
(27) $\boxed{B}$

(28) $\boxed{C}$

Only One Option Correct

1. (A)

(a) From figure,
In Δ OAC,



$$\cos 60° = \frac{OC}{OA} = \frac{OC}{2a}$$

$$\therefore \ OC = 2a \times \frac{1}{2} = a$$

Magnetic field at 'O' due to element AB

$$= \frac{\mu_0}{4\pi}\frac{I}{a}[\sin 60° - \sin 30°]$$

$$= \frac{\mu_0}{4\pi}\frac{I}{a}\left[\frac{\sqrt{3}}{2} - \frac{1}{2}\right] = \frac{\mu_0 I}{4\pi a} \times \frac{1}{2}(\sqrt{3}-1)$$

$\therefore$ Magnetic field at the centre, due to complete loop

$$= \left[\frac{\mu_0}{4\pi}\frac{I}{a} \times \frac{1}{2}(\sqrt{3}-1)\right] \times 12 = \frac{\mu_0}{4\pi}\frac{I}{a} \times 6(\sqrt{3}-1)$$

2. (C)

(c) $$\vec{B} = \frac{\mu_0 I}{4\pi L}\sin 45°(-\hat{k}) + \frac{\mu_0 I\pi}{4\pi\frac{L}{2}}(-\hat{k}) + \frac{\mu_0 I}{4\pi\frac{L}{4}} \times \frac{\pi}{2}(-\hat{k})$$

$$= \frac{-\mu_0 I}{L}\left[\frac{1}{4\pi\sqrt{2}} + 1\right]\hat{k}$$

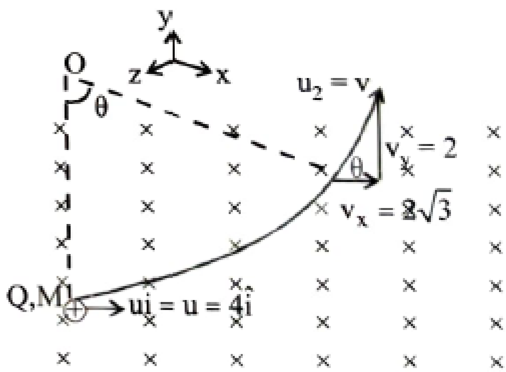
One or More than One Option Correct

1. (A, C)

(a, c) According to Fleming's left hand rule, magnetic field should be in the $-z$ direction.

From figure, $\tan\theta = \frac{v_y}{v_x} = \frac{2}{2\sqrt{3}}$

$$\therefore \ \theta = \frac{\pi}{6}$$



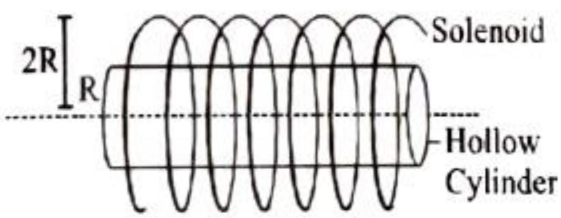
Angle rotated by the particle = $\frac{\text{arc}}{\text{radius}} = \frac{\text{speed} \times \text{time}}{\text{radius}}$

$$\frac{\pi}{6} = \frac{4 \times 10 \times 10^{-3}}{M \times 4 / QB} \qquad \left[\because \text{radius} = \frac{Mv}{QB}\right]$$

$$\therefore \quad B = \frac{50\pi M}{3Q}$$

2. (A, D)

(a, d) In the region $0 < r < R$, the net magnetic field is due to current in solenoid.



In the region $r > 2$ R, the magnetic field is present due to the current in the cylinder.
For the region $R < r < 2R$, the magnetic field is neither along the common axis, nor tangential to the circle of radius r.

3. (A, B, C)

(a, b, c) Magnetic force acting on a current carrying wire, placed in a uniform magnetic field,

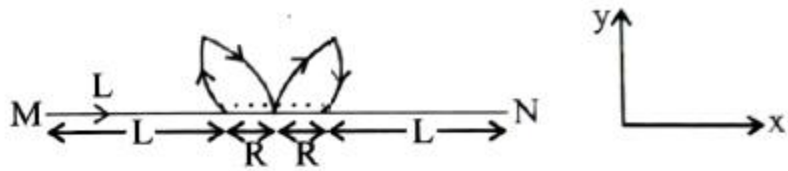
$\vec{F} = I(\vec{l} \times \vec{B})$

Here, $\vec{l}$ = displacement of the wire = $2(L + R)\,\hat{x}$

$\therefore \quad \vec{F} = 2I(L+R)(\hat{x} \times \vec{B})$

If $\vec{B} = B\hat{x}$ then

$\vec{F} = 2I(L+R)(\hat{x} \times \hat{x})\,B = 0$



If $\vec{B} = B\hat{y}$ then

$\vec{F} = 2I(L+R)(\hat{x} \times \hat{y})B = 2IB(L+R)\,\hat{z}$

or $\quad F \propto (L+R)$

If $\vec{B} = B\hat{z}$ then

$\vec{F} = 2I(L+R)(\hat{x} \times \hat{z})B = -2IB(L+R)\hat{y}$

or, $\quad F \propto (L+R)$.

4. (A, C)

(a, c) The range of voltmeter.

$V = I_g(R_{eq} + G)$

$\therefore$ Maximum voltage can be obtained if equivalent resistance of components is maximum, *i.e.* when all the components are connected in series.

The range of ammeter

$$I = I_g\left(1 + \frac{G}{S_{eq}}\right)$$

$\therefore$ Maximum current range can be obtained if equivalent shunt resistance is minimum, *i.e.*, when all the components are connected in parallel.

5. (A, B)

(a, b) (a) For the charge +Q to return region 1.

$$\frac{mv^2}{(3R/2)} = QvB \quad \Rightarrow \frac{2p}{3R} = QB \quad \left[\text{Here, radius } r = \frac{3}{2}R\right]$$

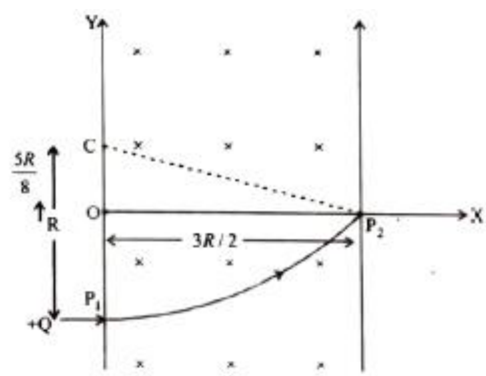
$$\therefore \quad B = \frac{2p}{3QR}$$

Therefore for $B \geq \dfrac{2p}{2QR}$, the particle will re-enter region 1.

(b) When $B = \dfrac{8p}{13QR}$

$$\frac{mv^2}{r} = Qv\left(\frac{8p}{13QR}\right) \qquad \therefore \ r = \frac{13R}{8}$$

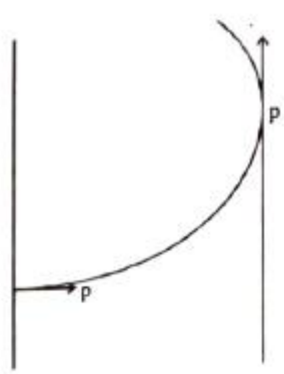
Thus 'C' is the of the centre of circular path of radius $\dfrac{13R}{8}$



Also $CP_2 = \sqrt{CO^2 + OP_2{}^2} = \sqrt{\left(\dfrac{5R}{8}\right)^2 + \left(\dfrac{3R}{2}\right)^2}$

$$\therefore \text{CP}_2 = \frac{13R}{8}$$

Thus the particle will enter region 3 through the point P_1 on X-axis



(c) Change in momentum = $\sqrt{2}p$

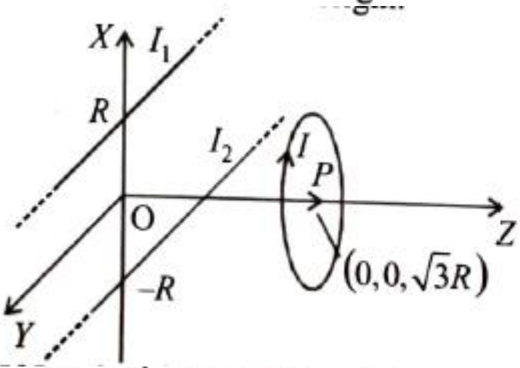
(d) Further $\frac{mv^2}{r} = qvB \ \therefore\ r = \frac{mv}{qB} \ \therefore\ r \propto m$

i.e., Distance is directly proportional to mass.

6. (A, B, D)

(a, b, d) (a) If $I_1 = I_2$, then the magnetic fields due to I_1 and I_2 at origin 'O' will cancel out each other. But the magnetic field at 'O' due to the ring will be present. Therefore B cannot be zero at origin.

(b) If $I_1 > 0$ and $I_2 < 0$, then the magnetic field due to both current will be in $+Z$ direction and add-up. The magnetic field due to current I will be in $-Z$ direction and if its magnitude is equal to the combined magnitudes of I_1 and I_2 then B can be zero at the origin.



(c) If $I_1 < 0$ and $I_2 > 0$ then their net magnetic field at origin will be in $-Z$ direction and the magnetic field due to I at origin will also be in $-Z$ direction. Therefore $\vec{B}$ at origin cannot be zero.

(d) If $I_1 = I_2$ then the resultant of the magnetic field B_R at P is along $+X$ direction. Therefore the magnetic field at P is only due to the current I which is in $-Z$ direction and is equal to $\vec{B} = \frac{\mu_0 I}{2R}(-\hat{k})$.

7. (B, D)

(b, d) Here, $G = 10\Omega$; $I_g = 2 \times 10^{-6}$ A, V = 100 m V = 0.1V, $I = 10^{-3}$A

Using, $V = I_g(G+R)$ [R = resistance connected in series with galvanometer]

$\Rightarrow 0.1 = 2 \times 10^{-6} R_v$

$\therefore R_v = 5 \times 10^4 \Omega$ (Resistance of voltmeter)

Also $I_g G = (I - I_g)s$

$2 \times 10^{-6} \times 10 = (10^{-3} - 2 \times 10^{-6})s$

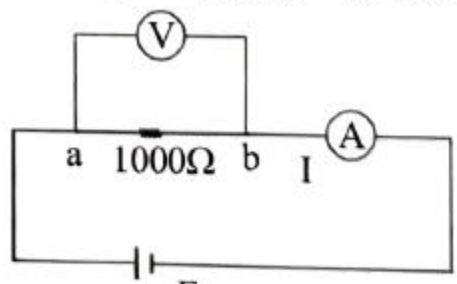
$\therefore S = 2 \times 10^{-2} \Omega$ (Resistance of ammeter)

$$R_A = \frac{GS}{G+S} = \frac{10 \times 0.02}{10 + 0.02} \approx 0.02\Omega$$

$$I = \frac{E}{\frac{50,000 \times 1000}{51000} + 0.02} = \frac{E}{980.41}$$

$$V_{ab} = \frac{E}{980.41} \times \frac{50,000 \times 1000}{51000} = \frac{E}{980.41} \times 980.39$$

$$\therefore R_{measured} = \frac{V_{ab}}{I} = \frac{E}{980.41} \times \frac{980.39}{E/980.41} = 980.39\Omega$$



If the voltmeter shows full scale deflection, then

$$0.1 = \frac{E}{980} \times \left(\frac{1000}{51000}\right) \times 5 \times 10^4$$

$\therefore \quad E = 999.6$ mv.

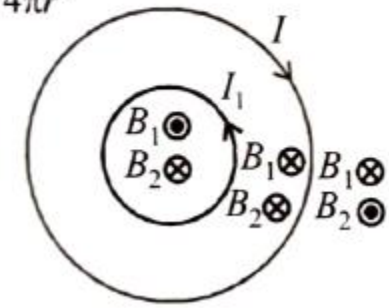
Since $i_A = 10^{-3}$A

$$\therefore \quad \text{Maximum reading of } R = \frac{999.6 \times 10^{-3}}{1 \times 10^{-3}} = 999.6\,\Omega$$

8. (A, B)

(a,b) As per Biot-savart's law,

$$d\vec{B} = \frac{\mu_0 i\overrightarrow{d\ell} \times \vec{r}}{4\pi r^3}$$



i.e., $\vec{B}$ is perpendicular to both $i\overrightarrow{d\ell}$ and $\vec{r}$

$\overrightarrow{d\ell}$ is in xy plane and $\vec{r}$ is also in xy plane

$\therefore$ $d\vec{B}$ is perpendicular to xy plane

Due to symmetry it depends only on distance from centre,

radial distance $r = \sqrt{x^2 + y^2}$

At centre $B_1 = \frac{\mu_0 I_1}{2R}$ and $B_2 = \frac{\mu_0 I_2}{4R}$ clearly, $B_2 > B_1$

As we approach towards first loop B_1 increases to infinity hence B_1 dominates.

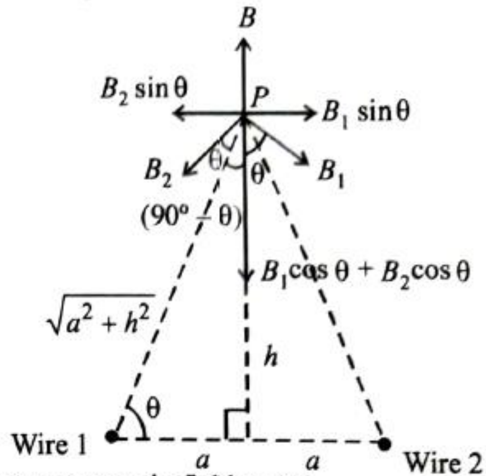
So it would be zero at some point between inner loops and centre.

Field will be in opposite direction inside and outside the loop.

Comprehensions Type

1. (C)

(c) Here $B_1 \sin\theta$ and $B_2 \sin\theta$ cancelled each other.



For zero magnetic field at 'P'

Magnetic field due to current carrying circular loop

= Magnetic field due to straight wires

$B = B_1 \cos\theta + B_2 \cos\theta = 2\, B_1 \cos\theta$

$$\frac{\mu_0 I a^2}{2\left(a^2+h^2\right)^{3/2}} = 2\left[\frac{\mu_0 I}{2\pi\sqrt{a^2+h^2}}\right] \times \frac{a}{\sqrt{a^2+h^2}}$$

Solving we get,

$h \approx 1.2a$

The current is from P to Q and R to S in wire 1 and wire 2 respectively.

2. (B)

(b) We know torque

$\vec{\tau} = \vec{M} \times \vec{B} = MB \sin\theta$

$$= \left(I \times \pi a^2\right) \times \left[2 \times \frac{\mu_0 I}{2\pi d}\right] \sin 30°$$

$$\therefore \quad \tau = \frac{\mu_0 I^2 a^2}{2d}$$

3. (A, D)

(a, d) When megnetic force balances electric force

$F_B = F_E \Rightarrow q v_d B = q E$

$\therefore \quad v_d B = \frac{V}{w} \qquad [\because V = E \times w]$

$\therefore \quad V = w v_d B = w\left[\frac{I}{newd}\right] \times B \qquad \left[v_d = \frac{I}{neA} = \frac{I}{newd}\right]$

$\therefore \quad V = \frac{I}{ned} \times B$

or, $V \propto \frac{1}{d} \quad \Rightarrow \quad V_1 d_1 = V_2 d_2$

If $d_1 = 2d_2, V_2 = 2V_1$

and if $d_1 = d_2, V_2 = V_1$

4. (A, C)

(a, c) $\because V = \frac{I}{ne_d} \times B$

$\therefore V \propto \frac{B}{n} \Rightarrow \frac{V_1 n_1}{B_1} = \frac{V_2 n_2}{B_2}$

If $B_1 = B_2$ and $n_1 = 2n_2 \Rightarrow V_2 = 2V_1$

and vf $B_1 = 2B_2$ and $n_1 = n_2 \Rightarrow V_2 = 0.5V_1$

For Questions No. 5 and 6

5. (A)

6. (C)

Sol. Magnetic flux due to dipole through ring

$$\phi = Li = \frac{\mu_0 m}{2\pi r^3} \times \pi a^2 \Rightarrow i = \frac{\mu_0 m \pi a^2}{2\pi r^3 L}$$

or $i \propto \frac{m}{r^3}$

Magnetic moment, $m' = iA = \pi a^2 i = \frac{\mu_0 m \pi^2 a^4}{2\pi r^3 L}$

$$F = \frac{kmm'}{r^4} = \frac{km^2 \pi^2 a^4}{2\pi r^7 L}$$

Therefore work done in bringing the dipole,

$$W = \int F dr \propto \int \frac{m^2 dr}{r^7} \text{ or, } W \propto \frac{m^2}{r^6}$$

Integer / Numerical Answer Type

1. (3)

(3) $\dfrac{mv^2}{R} = qvB \Rightarrow R = \dfrac{mv}{qB}$

or $R \propto \dfrac{1}{B}$ $\qquad$ [$\because$ m, q, v are the same]

$\therefore \dfrac{R_1}{R_2} = \dfrac{B_2}{B_1}$

or, $\dfrac{R_1}{R_2} = \dfrac{\dfrac{\mu_0}{4\pi} \times 2I \left[\dfrac{1}{X_1} + \dfrac{1}{X_0 - X_1}\right]}{\dfrac{\mu_0}{4\pi} \times 2I \left[\dfrac{1}{X_1} - \dfrac{1}{X_0 - X_1}\right]}$

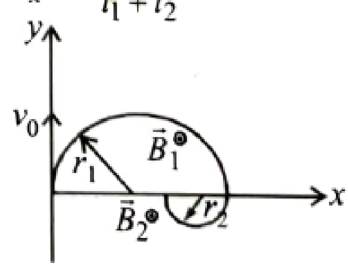
$= \dfrac{X_0 - X_1 + X_1}{X_0 - X_1 - X_1} = \dfrac{X_0}{X_0 - 2X_1}$ $\qquad \left[\text{Given } \dfrac{X_0}{X_1} = 3\right]$

$\therefore \dfrac{R_1}{R_2} = \dfrac{\dfrac{X_0}{X_1}}{\dfrac{X_0}{X_1} - 2} = \dfrac{3}{3-2} = 3$

2. (2)

(2) Average speed along x-axis, $v_x = \dfrac{d_1 + d_2}{t_1 + t_2}$

Here, $r_1 = \dfrac{mv_0}{qB_1}$ and $r_2 = \dfrac{mv_0}{qB_2}$



$\because B_1 = \dfrac{B_2}{4}$ $\qquad \therefore \quad r_1 = 4r_2$

Time spent by charged particle in B_1, $t_1 = \dfrac{\pi m}{qB_1}$

Time spent by charged particle in B_2, $t_2 = \dfrac{\pi m}{qB_2}$

Total distance along x-axis

$d_1 + d_2 = 2r_1 + 2r_2 = 2(r_1 + r_2) = 2(5r_2) = 10r_2$

Average speed $= \dfrac{10r_2}{5t_2} = 2\dfrac{mv_0}{qB_2} \times \dfrac{qB_2}{\pi m}$

$= 2\text{ms}^{-1}$ $\qquad (\because v_0 = \pi\text{ms}^{-1})$

3. (5.56)

(5.56) [Given: $B = 0.02T$, $C = 10^{-4}$ Nm rad^{-1}
$\theta = 0.2$ rad
$N = 50$ and
$A = 2 \times 10^{-4}\ m^2$]
We know, $C\theta = NBA\,I_g$

$$\therefore\quad I_g = \frac{C\theta}{NBA} = \frac{10^{-4} \times 0.2}{50 \times 2 \times 10^{-4} \times 0.02} = 0.1A$$

To convert a galvanometer to ammeter, a shunts is used in parallel to the galvanometer.
$I_g \times G = (I - I_g)\,S$

$$\therefore\quad S = \frac{I_g G}{I - I_g} = \frac{0.1 \times 50}{1 - 0.1} = \frac{50}{9} = 5.56\,\Omega$$

4. (4)

(4) Here, force $F = qVB$ is balanced by centripetal force

$$F_e = \frac{mV^2}{r}$$

$$\therefore\quad qVB = \frac{mV^2}{r}$$

$$\text{or}\quad r = \frac{mV}{qB} = \frac{\sqrt{2mqV}}{qB}$$

$$\frac{P^2}{2m} = \text{K.E.} = qV$$

$$\frac{r_s}{r_\alpha} = \sqrt{\frac{m_s}{q_s}} \times \sqrt{\frac{q_a}{m_a}} = \sqrt{\frac{32}{1} \times \frac{2}{4}} = 4$$

$$\therefore\quad \frac{r_s}{r_\alpha} = \mathbf{4}$$