

JEE Main Exercise

1. (C)
 $\mathbf{a} \perp \mathbf{b}$
 $\Rightarrow \mathbf{a} \cdot \mathbf{b} = (-5\hat{i} + 3\hat{j} + a^2\hat{k}) \cdot (2\hat{i} + a\hat{j} + \hat{k}) = 0$
 $\Rightarrow -10 + 3a + a^2 = 0$
 $\Rightarrow a = 2$ and $a = -5$

2. (A)
 $F_B = mg = qvB \sin 90^\circ = mg$
 $\Rightarrow qv \left(\frac{\mu_0 i}{2\pi r} \right) \sin 90^\circ = mg$
 $\Rightarrow q(10) \left(\frac{4\pi \times 10^{-7} \times 1}{2\pi(0.01)} \right) (1) = 1 \times 10^{-6} \times 10$
 $\Rightarrow q = 50 \times 10^{-3} \text{ C} = 50 \text{ mC}$

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)
 $T_p = \frac{2\pi m_p}{q_p B}$ and $T_\alpha = \frac{2\pi(4m_p)}{(2q_p)B} = 2T_p$
 $\Rightarrow T_p = \frac{25\mu\text{s}}{5} = 5\mu\text{s} \Rightarrow T_\alpha = 2 \times 5 = 10\mu\text{s}$

5. (A)
 $f = \frac{qB}{2\pi m} \Rightarrow f \propto \frac{1}{m}$

6. (B)
 $R = \frac{mv}{qB} \geq (b-a)$
 $\Rightarrow v \geq \frac{q(b-a)B}{m}$

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

7. (B)

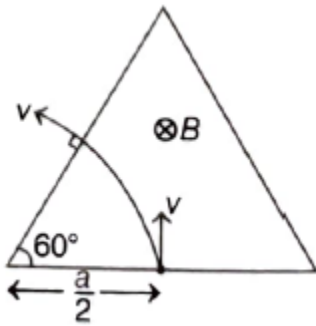
$$K = \frac{q^2 B^2 R^2}{2m} \text{ and } f = \frac{qB}{2\pi m}$$

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

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

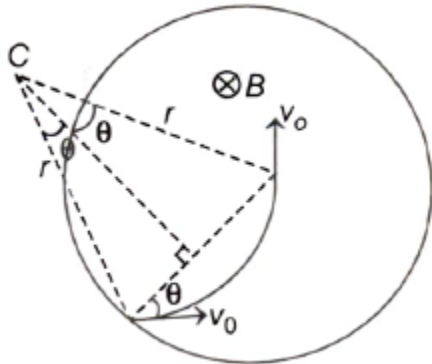
$$\Rightarrow K = 1.2 \times 10^{-12} \text{ J}$$

8. (B)



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

9. (B)



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

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

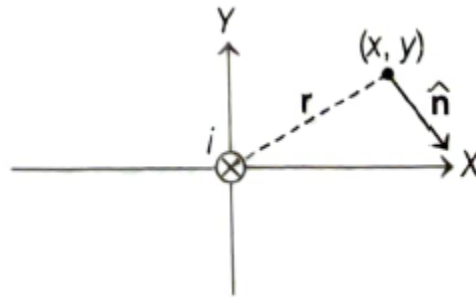
10. (A)

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

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

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

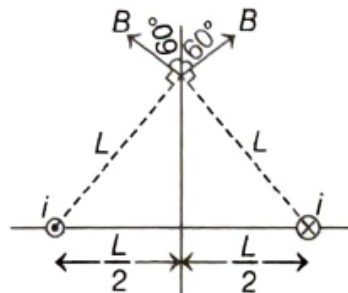
$$\mathbf{B} = B\hat{\mathbf{n}} = \frac{\mu_0 i}{2\pi\sqrt{x^2 + y^2}} \left(\frac{y\hat{\mathbf{i}} - x\hat{\mathbf{j}}}{\sqrt{x^2 + y^2}} \right) = \frac{\mu_0 i (y\hat{\mathbf{i}} - x\hat{\mathbf{j}})}{2\pi(x^2 + y^2)}$$



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)

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

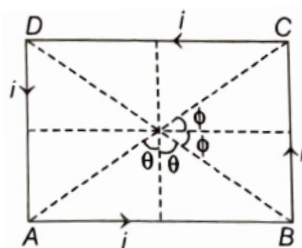
$$= 2 \left[\frac{\mu_0 i}{4\pi \left(\frac{b}{2}\right)} (\sin \theta + \sin \theta) \right] + 2 \left[\frac{\mu_0 i}{4\pi \left(\frac{a}{2}\right)} (\sin \phi + \sin \phi) \right]$$

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

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

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

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



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)

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

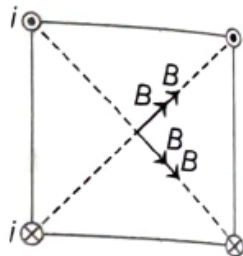
$$\Rightarrow Y = \left(\frac{i_1}{i_2} \right) X$$

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)

$$\mathbf{B} = \mathbf{B}_1 + \mathbf{B}_2 + \mathbf{B}_3 = \frac{\mu_0 \left(\frac{3}{4} \right) i}{2a} - \frac{\mu_0 \left(\frac{3}{4} \right) i}{2b} + \frac{\mu_0 i}{2c} = 0$$

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

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

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

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)

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

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

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

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

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

$$B > A > C = D$$

20. (B)

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

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

21. (C)

$$\oint \mathbf{B} \cdot d\mathbf{l} = 0$$

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

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

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

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

22. (A)

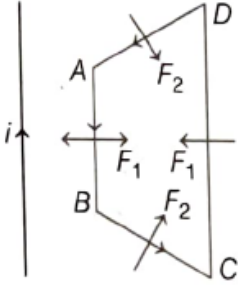
Forces on BC and DA cancel out each other.

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

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

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

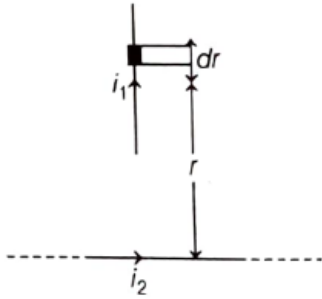
23. (B)
Force on AB and CD cancel out each other. Resultant of force on DA and BC will be directed towards right. So, net force on the loop is away from the long wire.



24. (C)

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

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



25. (B)

$$\begin{aligned} \mathbf{F}_{ABC} &= \mathbf{F}_{AC} = I(\mathbf{L}_{AC} \times \mathbf{B}) \\ &= 2 \left[(3 \times 10^{-2}) \hat{\mathbf{i}} \times (-2 \hat{\mathbf{k}}) \right] = (12 \times 10^{-2}) \hat{\mathbf{j}} \end{aligned}$$

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

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 perimeter.

30. (A)

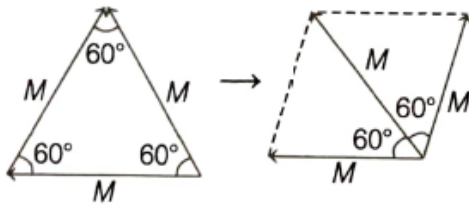
We can put wires carrying equal and opposite currents along CH and DG to complete three loops.

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

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

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

31. (B)



$$\text{Resultant of three vectors} = M + M \cos 60^\circ + M \cos 60^\circ$$

$$= 2M$$

32. (A)

For equilibrium of upper magnet, $F = mg$

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

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

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

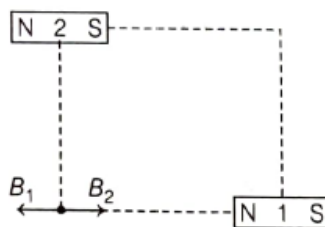
33. (A)

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

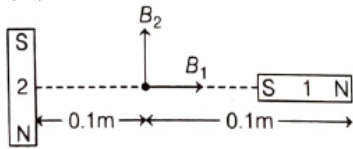
$$B_2 = \left(\frac{\mu_0}{4\pi} \right) \frac{M}{r^3}$$

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

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



34. (D)



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

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

35. (A)

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

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

36. (A)

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

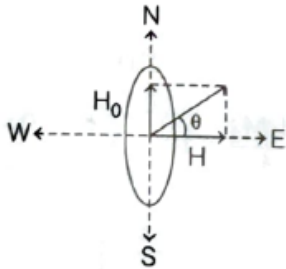
$$B_H = B \cos 90^\circ = 0$$

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)

$$K_1 + U_1 = K_2 + U_2$$

$$\Rightarrow 0 - MB \cos 90^\circ = K_2 - MB \cos 0^\circ$$

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

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)

$$f \propto \sqrt{B_H} \Rightarrow \frac{B_{H_1}}{B_{H_2}} = \left(\frac{f_1}{f_2}\right)^2$$
$$\Rightarrow \frac{B_{H_1}}{36 \times 10^{-6}} = \left(\frac{40}{20}\right)^2 \Rightarrow B_{H_1} = 144 \times 10^{-6} \text{ T}$$

42. (B)

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

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

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

$$\Rightarrow \tan \theta_2 = \tan 30^\circ$$

$$\Rightarrow \theta_2 = 30^\circ$$

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)

$$\chi_m = \frac{C}{T} \Rightarrow AC = \text{Slope of } \chi_m \text{ versus } \frac{1}{T} \text{ graph}$$
$$= \frac{0.4}{7 \times 10^{-3}} = 57 \text{ K}$$

50. (B)

OQ = Retentivity; OR = Coercivity

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

51. (4)

$$mvr = L$$

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

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

$$\Rightarrow v = \sqrt{\frac{1.6 \times 10^{-19} \times 1 \times 10^{-3} \times 8.1 \times 10^{-38}}{81 \times 10^{-62}}}$$

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

52. (6)

Path of the particle will be helical.

$$\text{Distance} = \text{Speed} \times \text{time} = 2 \times 3 = 6 \text{ m}$$

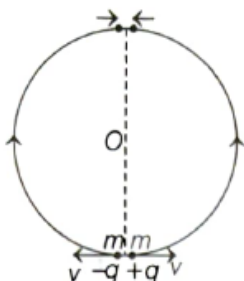
53. (1.21)

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

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

54. (220)

They will collide after describing semi-circle.



$$T = \frac{\pi m}{qB} = \frac{22 \times 14 \times 10^{-3}}{7 \times 3 \times 10^{-6} \times \left(\frac{200}{3} \right)} = 220 \text{ s}$$

55. (70)

Using Work-energy theorem,

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

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

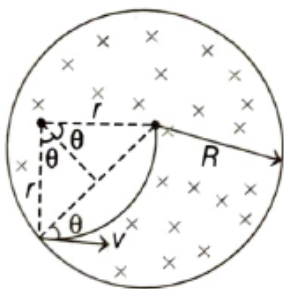
$$\Rightarrow v = \sqrt{2gR}$$

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

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

56. (3)

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



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

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

$$\Rightarrow 0.1 = 2 \left(\frac{5 \times 10^{-5} \times (1/\sqrt{3})}{5 \times 10^{-4} \times 1} \right) \sin \theta$$

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

57. (10)

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

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

$$\begin{aligned} \mathbf{B}_{\text{wire}} &= \frac{\mu_0 i}{2\pi r} \hat{\mathbf{n}} = \frac{4\pi \times 10^{-7} \times 8}{2\pi(\sqrt{2})} \left(\frac{\hat{\mathbf{k}} - \hat{\mathbf{i}}}{\sqrt{2}} \right) \\ &= 0.8 \times 10^{-6} (\hat{\mathbf{k}} - \hat{\mathbf{i}}) \end{aligned}$$

$$\mathbf{B}_{\text{net}} = \mathbf{B}_{\text{wire}} + \mathbf{B}_{\text{ext}} = (0.6 \times 10^{-6})\hat{\mathbf{i}} + (0.8 \times 10^{-6})\hat{\mathbf{k}}$$

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

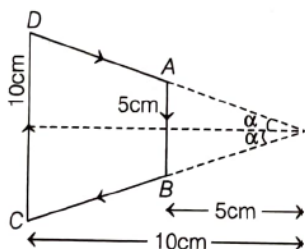
So, $\alpha = 10$

58. (2)

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

$$\mathbf{B}_{AB} = \frac{4\pi \times 10^{-7} \times \sqrt{2}}{4\pi(5 \times 10^{-2})} (\sin 45^\circ + \sin 45^\circ) = 4 \times 10^{-6} \text{ T}$$

$$\mathbf{B}_{CD} = \frac{4\pi \times 10^{-7} \times \sqrt{2}}{4\pi(10 \times 10^{-2})} (\sin 45^\circ + \sin 45^\circ) = 2 \times 10^{-6} \text{ T}$$



$$\mathbf{B}_{\text{net}} = \mathbf{B}_{AB} + \mathbf{B}_{BC} + \mathbf{B}_{CD} + \mathbf{B}_{DA}$$

$$\mathbf{B}_{\text{net}} = 4 \times 10^{-6} + 0 - 2 \times 10^{-6} + 0$$

$$= 2 \times 10^{-6} \text{ T} = 2 \mu \text{ T}$$

59. (32)

$$B_1 = B_{PQ} + B_{QR} + B_{RS} + B_{ST} + B_{TU}$$

$$= 0 + \frac{\mu_0 i}{4\pi I} \sin 45^\circ + \frac{\mu_0 i}{4\pi I} (2 \sin 45^\circ) + \frac{\mu_0 i}{4\pi I} \sin 45^\circ + 0$$

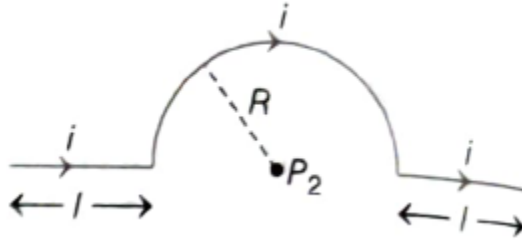
$$= \frac{\mu_0 i}{\sqrt{2}\pi I}$$

$$2\pi R = 4I \Rightarrow R = \frac{2I}{\pi}$$

$$B_2 = \frac{\mu_0 i}{4 \left(\frac{2I}{\pi} \right)} = \frac{\mu_0 i \pi}{8I}$$

$$\frac{B_1}{B_2} = \frac{\sqrt{32}}{\pi^2}$$

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)

$$B_{\text{axis}} = \frac{\mu_0 NiR^2}{2(R^2 + x^2)^{3/2}}$$

$$= \frac{4\pi \times 10^{-7} \times 1 \times 2.5 \times (3 \times 10^{-2})^2}{2[(0.03)^2 + (0.04)^2]^{3/2}}$$

$$= 36\pi \times 10^{-7} \text{ T}$$

So, $n = 36$

62. (5880)

$$B = \mu_0 ni \Rightarrow 0.168 = 4\pi \times 10^{-7} \times n \times 2$$

$$n = \frac{21 \times 10^4}{\pi}$$

$$N = nI = \left(\frac{21 \times 10^4}{\pi} \right) (1.4)$$

$$\begin{aligned} \text{Length of wire} &= N(2\pi R) \\ &= \left(\frac{21 \times 10^4 \times 1.4}{\pi} \right) [(2\pi (0.01))] \\ &= 5880 \text{ m} \end{aligned}$$

63. (16)

$$PQ = 3a \sec 60^\circ = 6a$$

Lets take an element dx on wire PQ .

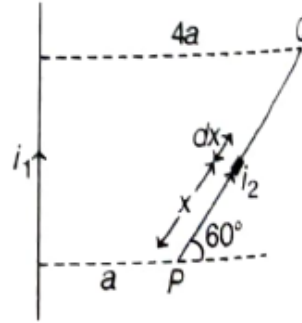
$$\int dF = \int_0^{6a} \left(\frac{\mu_0 i_1}{2\pi(a+x \cos 60^\circ)} \right) i_2 dx$$

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

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

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

So, $x = 16$



64. (2)

$$F_B = mg \Rightarrow \int (B \sin 30^\circ) i dl = mg$$

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

$$\Rightarrow B = \frac{mg}{\pi i R} = \frac{40 \times 10^{-3} \times 10\pi}{\pi(10)(2 \times 10^{-2})} = 2 \text{ T}$$

65. (10)

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

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

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

1. (A)
Magnetic field at any point lies on axial position of current carrying conductor $B = 0$

2. (B)
(b) Given : Radius = R

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

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

3. (D)
(d) Statements I is false and Statement II is true

For ammeter, shunt resistance, $S = \frac{I_g G}{I - I_g}$

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

4. (D)
(d) The current that will give 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.

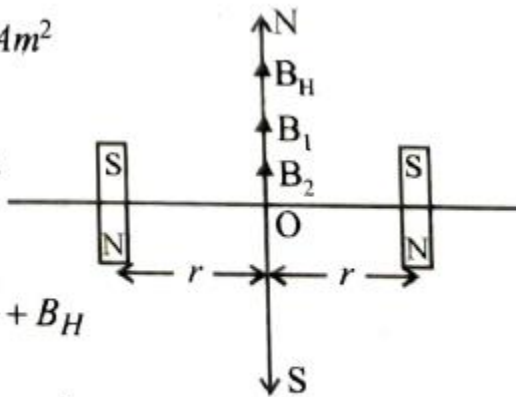
5. (B)
(b) Given : $M_1 = 1.20 \text{ Am}^2$
 $M_2 = 1.00 \text{ Am}^2$

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

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

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

$= \frac{10^{-7} (1.2 + 1)}{(0.1)^3} + 3.6 \times 10^{-5} = 2.56 \times 10^{-4} \text{ wb/m}^2$



6. (B)

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

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

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

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

$$B_1 : B_2 = 1 : 3$$

7. (C)

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

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

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

8. (A)

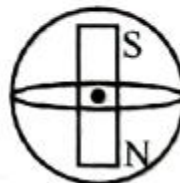
(a) Dipole moment of the earth $M = ?$

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

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

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



9. (D)

(d) In magnetic dipole

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

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

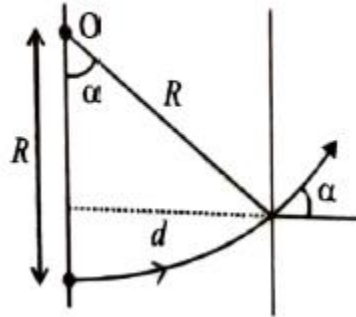
10. (D)

(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) $I_1 I_2 = \text{Positive}$

(attract) $F = \text{Negative}$

$I_1 I_2 = \text{Negative}$

(repell) $F = \text{Positive}$

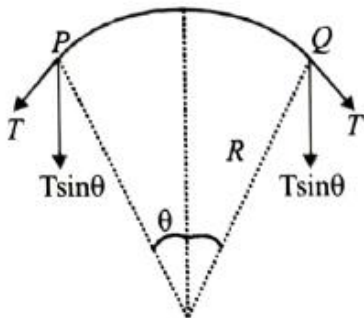
Hence, option (a) is the correct answer.

13. (C)

(c) For small arc length

$$2T \sin \theta = BIR \cdot 2\theta \quad (\text{As } F = BIL \text{ and } L = RZ\theta)$$

$$T = BIR$$



14. (B)

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


15. (C)

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

$$= \frac{Ni}{\ell} = \frac{(500)15}{25 \times 10^{-2}} = 30000 \text{ Am}^{-1}$$

16. (C)
 (c) Here, $r = 30\text{cm} = 0.3\text{m}$
 we know $\frac{\mu_0 M}{4\pi r^3} = B_H = 3.6 \times 10^{-5}$
 $\Rightarrow M = \frac{3.6 \times 10^{-5}}{10^{-7}} (0.3)^3$
 Hence, $M = 9.7 \text{ Am}^2$

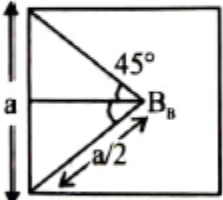
17. (B)

(b) Case (a): 

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

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

Case (b):



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

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

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

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

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

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

$$\Rightarrow 100S = 50 + 0.5S \Rightarrow 99.5S = 50$$

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

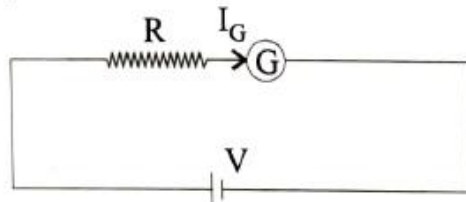
So, shunt of resistance = 0.5Ω is connected in parallel with the galvanometer.

20. (A)

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

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

where, I_g -Galvanometer current, G -Galvanometer resistance



When shunt of resistance S is connected parallel to the

Galvanometer then $G = \frac{GS}{G+S}$

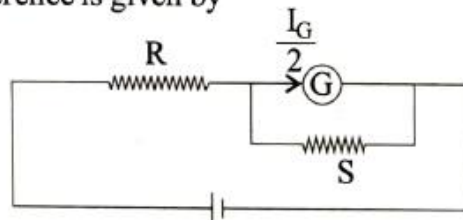
$$\therefore I = \frac{V}{R + \frac{GS}{G+S}}$$

Equal potential difference is given by

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

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

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



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

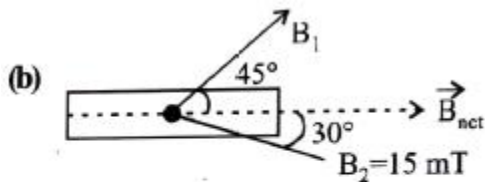
$$\Rightarrow \frac{1}{2(R+G)} = \frac{S}{R(G+S)+GS}$$

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

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

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

21. (B)



Clearly, $\tan 30^\circ = \frac{B_1 \sin 75^\circ}{B_2 + B_1 \cos 75^\circ}$

Putting $B_2 = 15 \text{ mT}$ in above equation, we get $B_1 = 11 \text{ mT}$

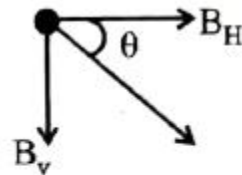
22. (B)

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

23. (D)

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

Wings will cut vertical component of magnetic field so,



$V_w = B_V \times l_{wing} \times V = 5 \times 10^{-5} \times \frac{2}{3} \times 15 \times 240 = 120 \text{ mV}$

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

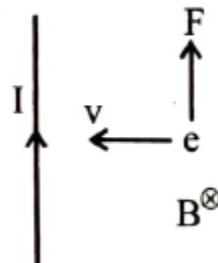
$V_B = B_H \times 15 \times 240 = 5 \times 10^{-5} \times \frac{\sqrt{5}}{3} \times 15 \times 240 \approx 45 \text{ mV}$

24. (B)

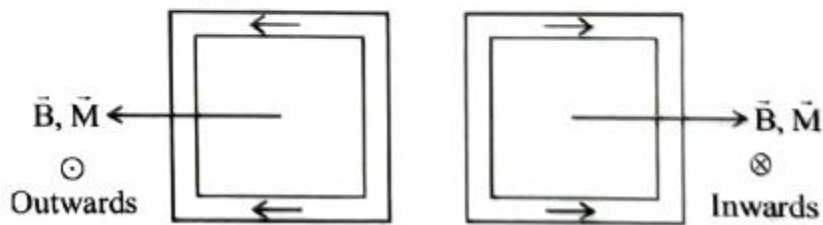
(b) The force is parallel to the direction of current in magnetic field,

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

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.
 $V = i_g (R + G)$
 $10 = 5 \times 10^{-3} (R + 15)$
 $\therefore R = 2000 - 15 = 1985 = 1.985 \times 10^3 \Omega$

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 $\theta = 90^\circ$ 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, $I = 7.5 \times 10^{-6} Kgm^2$

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

$$= 2\pi \sqrt{\frac{7.5 \times 10^{-6}}{6.7 \times 10^{-2} \times 0.01}} = \frac{2\pi}{10} \times 1.06 s$$

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 $\sqrt{2R}$

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

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

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

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

31. (A)

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

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

32.

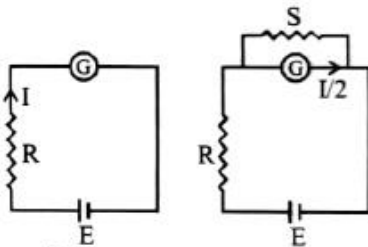
(B)

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

$$I = \frac{\epsilon}{R + G} \quad G = \frac{1}{9} \text{K}\Omega$$

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

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



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

33.

(D)

(d) According to question, current through galvanometer,

$$I_g = 1 \text{ mA}$$

$$\text{Current through shunt } (I - I_g) = 2 \text{ A}$$

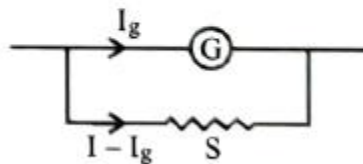
$$\text{Galvanometer resistance } R_g = 25 \Omega$$

$$\text{Resistance of shunt, } S = ?$$

$$I_0 R_0 = (I - I_g) S$$

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

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



34.

(B)

(b) Given Number of turns,

$$n = 1000 \text{ turns/cm} = 1000 \times 100 \text{ turns/m}$$

$$\text{Coercivity of ferromagnet, } H = 100 \text{ A/m}$$

$$\text{Current to demagnetise the ferromagnet, } I = ?$$

$$\text{Using, } H = nI$$

$$\text{or, } 100 = 10^5 \times I$$

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

35. (D)
(d) As particle is moving along a circular path

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

Path is straight line, then
 $qE = qvB$

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

From equation (i) and (ii)

$$m = \frac{qB^2 R}{E} = \frac{1.6 \times 10^{-19} \times (0.5)^2 \times 0.5 \times 10^{-2}}{100}$$

$$\therefore m = 2.0 \times 10^{-24} \text{ kg}$$

36. (B)
(b) The radius of the circular path is,

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

$$\Rightarrow R = \frac{\sqrt{2 \times 9.1 \times 10^{-31} \times 100 \times 1.6 \times 10^{-19}}}{1.5 \times 10^{-3} \times 1.6 \times 10^{-19}}$$

$$\Rightarrow R = 2.25 \text{ cm}$$

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

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

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

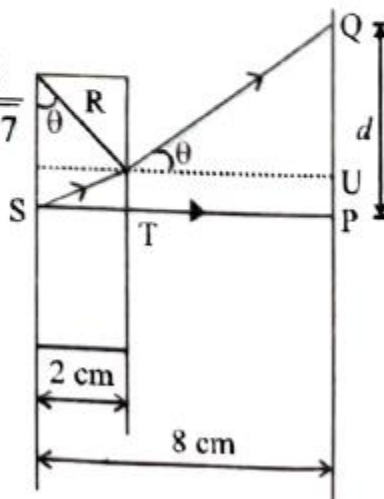
$$= 2.25 \times \left(1 - \frac{\sqrt{17}}{9}\right)$$

$$\Rightarrow PU = 1.22 \text{ cm}$$

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

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

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



37. (B)

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

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

$$\Rightarrow m^2v^2 = 2mK.E. \Rightarrow mv = \sqrt{2mK.E.}]$$

For proton, electron and α -particle,

$$m_{He} = 4m_p \text{ and } m_p \gg m_e$$

$$\text{Also } a_{He} = 2q_p \text{ and } q_p = q_e$$

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

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

38. (A)

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

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

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

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

39. (D)

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

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

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

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

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

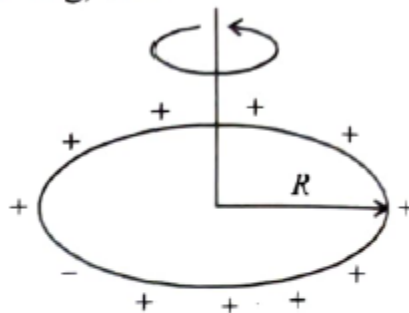
40. (B)

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

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

Magnetic field,

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



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

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

41. (B)

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

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

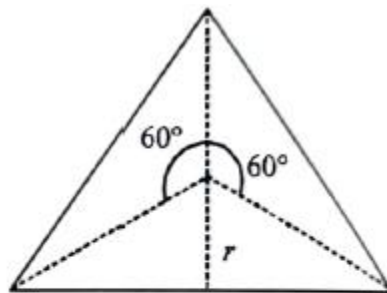
$$\alpha = \beta = 37^\circ$$

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

42. (A)

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

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



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

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

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

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.

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

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

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

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

44. (D)

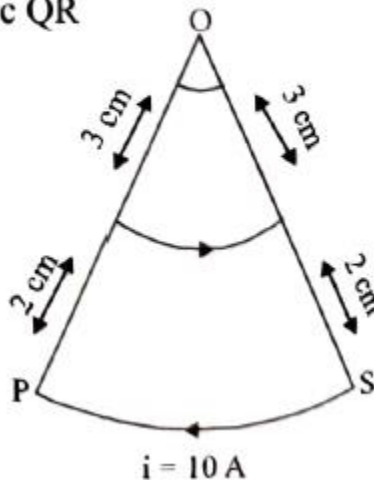
(d) There will be no magnetic field at O due to wire PQ and RS

Magnetic field at 'O' due to arc QR

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

Magnetic field at 'O' due to arc PS

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

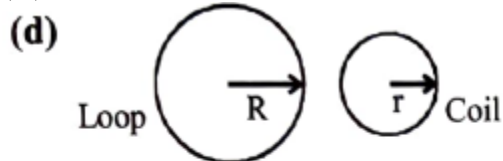


\therefore Net magnetic field at 'O'

$$B = \frac{\mu_0}{4\pi} (\pi/4) \times 10 \left[\frac{1}{(3 \times 10^{-2})} - \frac{1}{(5 \times 10^{-2})} \right]$$

$$\Rightarrow |\vec{B}| = \frac{\pi}{3} \times 10^{-5} \text{ T} \approx 1 \times 10^{-5} \text{ T}$$

45. (D)



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

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

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

46. (D)

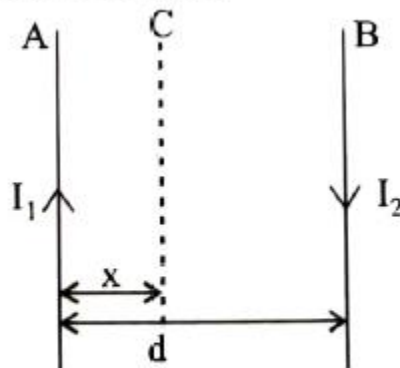
(d) As net force on the third wire C is zero.

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

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

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

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



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

47. (D)

(d) $\tau = MB \sin 45^\circ = N (iA) B \sin 45^\circ$

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

48. (C)

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

49. (D)

(d) Force on one pole,

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

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

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

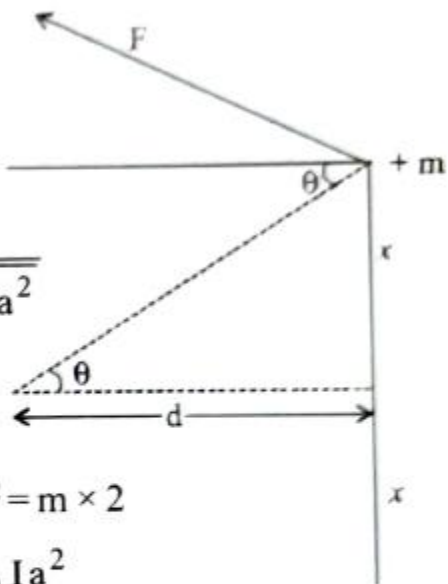
$$= \frac{\mu_0 I m x}{\pi(d^2 + a^2)}$$

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

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

$$= \frac{\mu_0 I a^2}{2d^2} \quad [\because d \gg a]$$

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



50. (C)

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

51. (D)

(d) $C\theta = \tilde{N}BiA \sin 90^\circ$

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

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

52. (D)

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

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

On solving, we get

$$S = \frac{100}{498} \approx 0.2 \Omega$$

53. (B)

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

$$i_g = \frac{E}{220 + R_g} = C\theta_0 \quad \dots (i)$$

When both the keys are closed

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

$$\Rightarrow \frac{5E}{225R_g + 1100} = \frac{C\theta_0}{5} \quad \dots (ii)$$

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

Dividing (i) by (ii), we get

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

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

$$\Rightarrow R_g = 22\Omega$$

54. (D)

(d) Given,

Resistance of galvanometer, $G = 100\Omega$

Current, $i_g = 1 \text{ mA}$

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

Total resistance of the combination = $G + R$

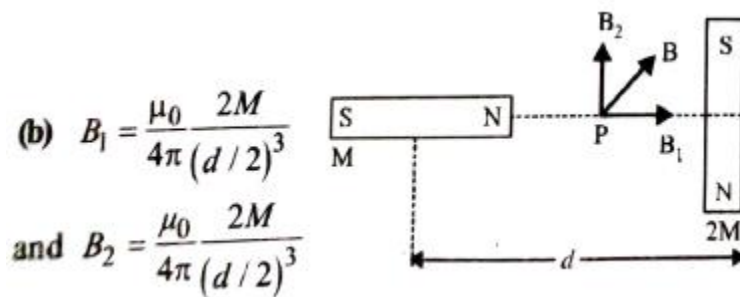
According to Ohm's law, $V = i_g (G + R)$

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

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

$$\Rightarrow R_0 = 9.9 \text{ k}\Omega$$

55. (B)



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

or $\theta = 45^\circ$

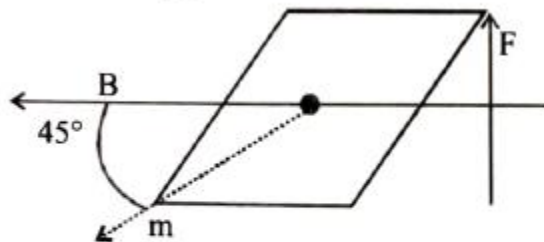
The resultant field is 45° from B_1 . The angle between \vec{B} and \vec{v} zero, so force on the particle is zero.

56. (C)

(c) Work done, $W = 2 \text{ m} \cdot \text{B}$
 $= 2 \times 10^{-2} \times 1 \cos(0.125) = 0.02 \text{ J}$

57. (D)

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



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

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

58. (B)

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

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

59. (B)

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

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

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

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

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

60. (C)

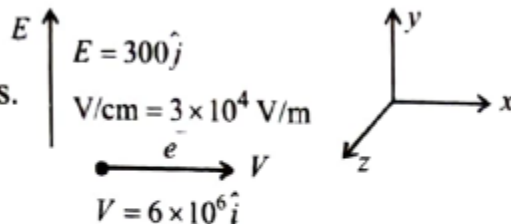
(c) $\vec{E} = 300\hat{j}$ V/cm = 3×10^4 V/m

$$\vec{V} = 6 \times 10^6 \hat{i}$$

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

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

$$E = VB$$



$$\therefore B = \frac{E}{V} = \frac{3 \times 10^4}{6 \times 10^6} = 5 \times 10^{-3} \text{ T}$$

Hence, magnetic field $B = 5 \times 10^{-3}$ T along +z direction.

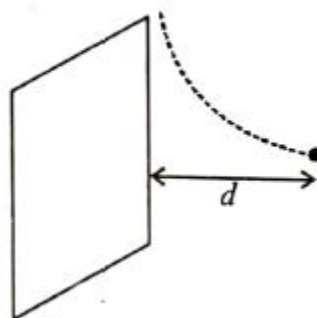
61. (C)

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

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

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

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



62. (B)

(b) [Given: $q = 1\mu\text{C} = 1 \times 10^{-6}\text{C}$;

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

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

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

$$= (-30\hat{i} + 32\hat{j} - 9\hat{k}) \times 10^{-9} \text{ N}$$

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

63. (C)

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

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)

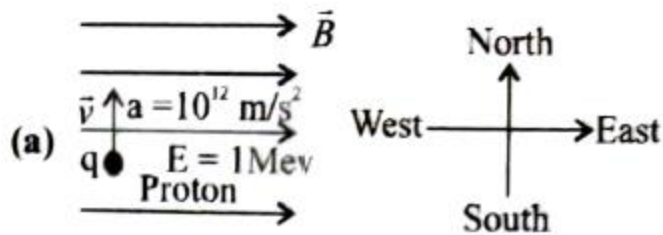
\therefore Length of region, $l = 10 \times (v \cos \theta)T$

$$\Rightarrow l = 10 \times v \cos 60^\circ \times \frac{2\pi m}{qB}$$

$$\Rightarrow l = \frac{20\pi m v}{qB} = \frac{20 \times 3.14 \times 1.67 \times 10^{-27} \times 4 \times 10^5}{1.6 \times 10^{-19} \times 0.3}$$

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

64. (A)



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

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

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

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

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

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

65. (D)

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

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

Magnetic moment $M = \text{Current} \times \text{Area}$

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

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

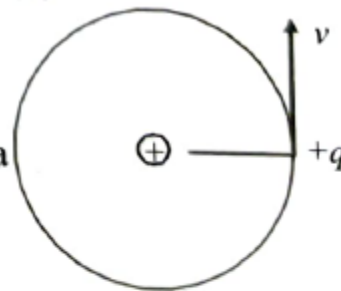
Radius of circular path in magnetic field, $r = \frac{mv}{qB}$

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

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

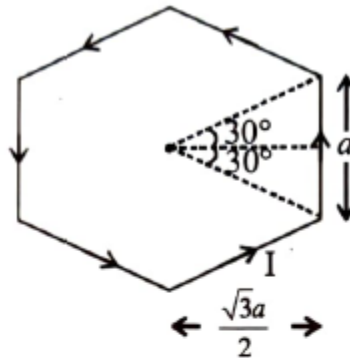
$$\frac{B_A}{B_B} = \frac{I_A}{I_B} \times \frac{\theta_A R_B}{\theta_B R_A} = \frac{2 \times \frac{3\pi}{2} \times 4}{3 \times \frac{5\pi}{3} \times 2} = \frac{6}{5}$$

67. (C)

(c) Magnetic field due to one side of hexagon

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

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



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,

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

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

68. (B)

(b) Magnetic field inside the solenoid is given by

$$B = \mu_0 n I \quad \dots (i)$$

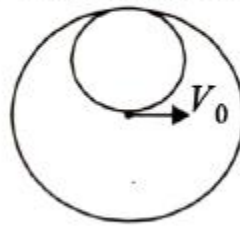
Here, n = number of turns per unit length

The path of charge particle is circular. The maximum

possible radius of electron = $\frac{R}{2}$

$$\therefore \frac{m V_{\max}}{q B} = \frac{R}{2}$$

$$\Rightarrow V_{\max} = \frac{q B R}{2 m} = \frac{e R \mu_0 n I}{2 m} \text{ (using (i))}$$



69. (A)

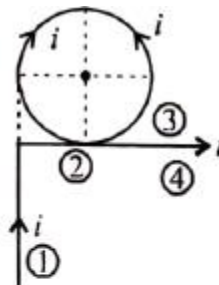
(a) $B_0 = B_1 + B_2 + B_3 + B_4$

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

$$[\sin 45^\circ + \sin 90^\circ]$$

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

$$\vec{B}_0 = \frac{\mu_0 I}{2 \pi R} \left(\pi + \frac{1}{\sqrt{2}}\right)$$

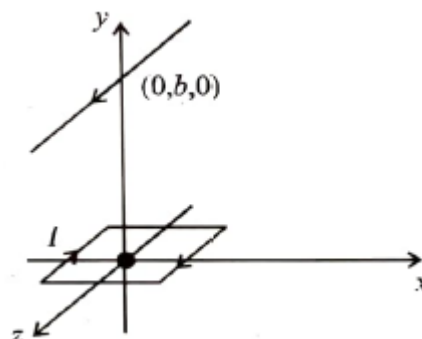


70. (A)

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

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

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



71. (C)
(c) Torque on circular loop, $\tau = MB \sin \theta$
 where, $M = \text{magnetic moment}$
 $B = \text{magnetic field}$

Now, using $\tau = I\alpha$

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

($\because m = IA$ and moment of inertia of circular loop,
 $I = \frac{mR^2}{2}$)

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

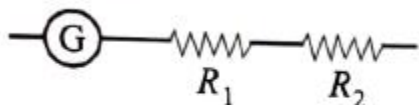
$$\Rightarrow \omega = \sqrt{\frac{2\pi IB}{m}} \Rightarrow \frac{2\pi}{T} = \sqrt{\frac{2\pi IB}{m}} \Rightarrow T = \sqrt{\frac{2\pi m}{IB}}$$

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



$$V = 1 = i_g (G + R_1) \quad \dots(i)$$

To increase the range of voltmeter 0-2 V



$$2 = i_g (R_1 + R_2 + G) \quad \dots(ii)$$

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, $I = 6 \text{ mA}$

Deflection, $\theta = 2^\circ$

Figure of merit of galvanometer

$$= \frac{I}{\theta} = \frac{6 \times 10^{-3}}{2} = 3 \times 10^{-3} \text{ A/div.}$$

74. (C)

(c) Here, $\theta = 30^\circ$, $\tau = 0.018 \text{ N-m}$, $B = 0.06 \text{ T}$

Torque on a bar magnet :

$$\tau = MB \sin \theta \Rightarrow 0.018 = M \times 0.06 \times \sin 30^\circ$$

$$\Rightarrow 0.018 = M \times 0.06 \times \frac{1}{2} \Rightarrow M = 0.6 \text{ A-m}^2$$

Position of stable equilibrium ($\theta = 0^\circ$)

Position of unstable equilibrium ($\theta = 180^\circ$)

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

$$\Delta U = U_f - U_i = -MB \cos 180^\circ - (-MB \cos 0^\circ)$$

$$W = 2MB = 2 \times 0.6 \times 0.06 \Rightarrow W = 7.2 \times 10^{-2} \text{ J}$$

75. (A)

(a) Given,

Moment of inertia of circular coil, $I = 0.8 \text{ kg m}^2$

Magnetic moment of circular coil, $M = 20 \text{ Am}^2$

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

Here, $\omega =$ angular speed of coil

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

From energy conservation

$$\frac{1}{2} I \omega^2 = U_{\text{in}} - U_f = 0 - (-MB \cos 60^\circ)$$

$$\Rightarrow \frac{MB}{2} = \frac{1}{2} I \omega^2 \Rightarrow \frac{20 \times 4}{2} = \frac{1}{2} (0.8) \omega^2 \quad [\because U_i = -MB \cos 90^\circ = 0]$$

$$\Rightarrow 100 = \omega^2 \Rightarrow \omega = 10 \text{ rad}$$

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 Curie's law

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

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

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

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

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.

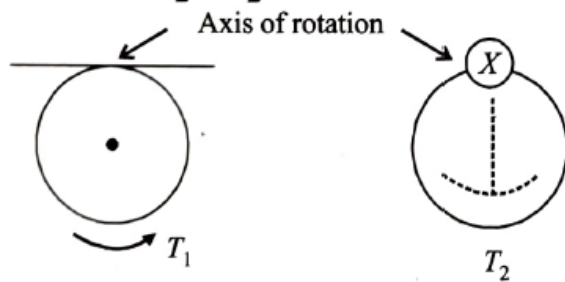
80.

(A)

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

$$I_1 = 2MR^2$$

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



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

$$T \propto I$$

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

81.

(D)

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

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

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

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

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

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

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.

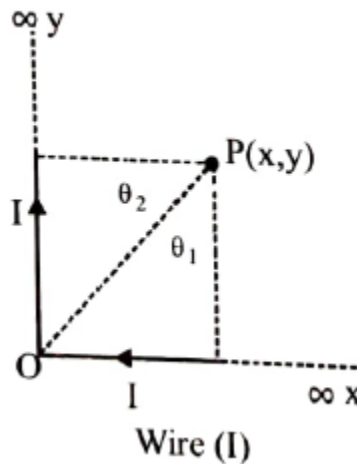
83. (A)

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

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

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

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



$$B_{\text{Net}} = B_1 + B_2$$

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

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

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

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

84.

(A)

(a) For $x < a$

Using ampere's circuital laws

$$\int B \cdot dl = \mu_o \text{ current enclosed}$$

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

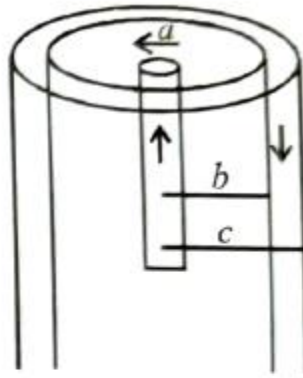
$$\Rightarrow B_1 (2\pi x) = \frac{\mu_o i_o x^2}{a^2}$$

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

For $a < x < b$

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

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



... (i)

... (ii)

85.

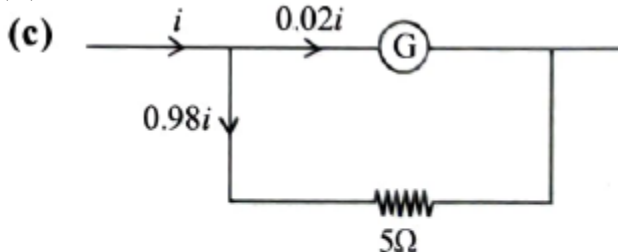
(A)

(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)



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

$$R_g = 245\Omega.$$

87. (D)
(d) Given, current sensitivity = 2 div/mA
 Full scale current,

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

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

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 are aligned opposite to magnetic field decrease in size.

89. (B)
(b) Given,
 Magnetic field, $B = 1\text{T}$
 Radius of cyclotron dees, $r = 60\text{ cm} = 0.6\text{ m}$
 Kinetic energy of electron in cyclotron

$$= \left[\frac{q^2 B^2 r^2}{2m} \right] = \frac{(1.6 \times 10^{-19})^2 \times (1)^2 \times (0.6)^2}{2 \times 1.6 \times 10^{-27}} \text{ J}$$

$$= \frac{0.288 \times 10^{-38}}{1.6 \times 10^{-19} \times 10^{-27}} = 0.18 \times 10^8 \text{ eV} = 18 \text{ MeV}$$

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, $\vec{a} \cdot \vec{B} = 0$

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

91. (A)

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

$\vec{B} = B\hat{j}$, $B = 12 \text{ mT} = 12 \times 10^{-3} \text{ T}$. 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, $v = 16 \times 10^6 \text{ m/s}$

$E = vB$

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

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

92. (B)

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

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

93. (C)

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

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

94. (A)

(a) We know that in cyclotron

$$\begin{aligned} (\text{K.E})_{\max} &= \frac{1}{2} m V_{\max}^2, V_{\max} = \frac{qBR_{dees}}{m} \\ &= \frac{1}{2} \times m \times \frac{q^2 B^2 R_{dees}^2}{m^2} = \frac{q^2 B^2 R_{dees}^2}{2m} \\ &= \frac{(2\pi mf)^2 R_{dees}^2}{2m} \left[\because f = \frac{qB}{2\pi m} \right] = 2\pi^2 m f^2 R_{dees}^2 \end{aligned}$$

Putting the values, $(\text{K.E})_{\max} = 7.4 \text{ MeV}$

95. (C)

(c) Radius of particle in cyclotron

$$\begin{aligned} r &= \frac{mV}{qB} = \frac{\sqrt{2m(\text{K.E})}}{qB} \\ \text{So, } \frac{r_1}{r_2} &= \frac{\sqrt{K.E_1}}{\sqrt{K.E_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2} \quad \therefore \frac{r_2}{r_1} = \frac{2}{1} \end{aligned}$$

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

As $K.E = \text{constant}$

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)

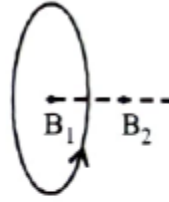
$$(c) B_1 = \frac{\mu_0 I}{2R} \quad \dots(i)$$

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

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

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

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

For coil y

Number of turns, $N_y = 400$

Radius, $R_y = 20$ cm

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

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,

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

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

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

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

101. (B)

(b) Magnetic field at centre is given as

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

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

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

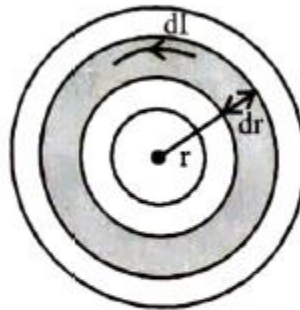
$$\frac{B_2}{B_1} = \frac{N_2 R_1}{N_1 R_2} = \frac{N_2}{N_1} \times \frac{N_2}{N_1} \Rightarrow \frac{B_2}{B_1} = \frac{25}{4}$$

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

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

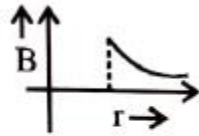


$$\text{So, } B_{\text{net}} = \int dB = \frac{\mu_0 n I}{2(r_2 - r_1)} \int_{r_1}^{r_2} \frac{dr}{r} = \frac{\mu_0 n I}{2(r_2 - r_1)} \ln \left(\frac{r_2}{r_1} \right)$$

103. (D)

(d) $\vec{B} = 0, r < R$

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



So, $B = 0, r < R$

$\propto \frac{1}{r}, r \geq R$. 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

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

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

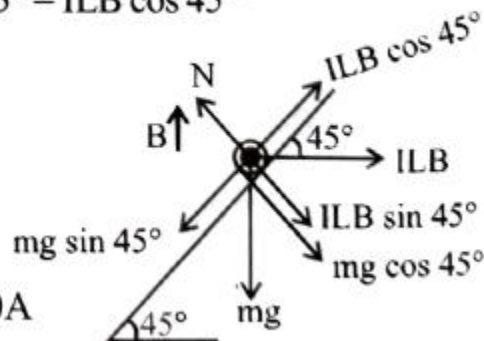
106. (A)

(a) Force, $F = ILB \sin \theta$

From figure, $mg \sin 45^\circ = ILB \cos 45^\circ$

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

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



107. (C)

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

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

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.

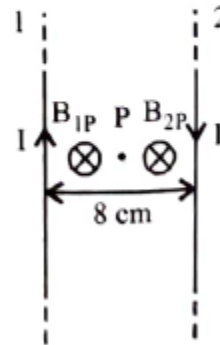
$$B_p = B_{1p} + B_{2p}$$

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

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

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

$$I = 30 \text{ A}$$



109. (C)

(c) We know that

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

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

110. (C)

(c) We have,

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

$$= 2 \times 10^{-5} \left[1 - \frac{1}{3} \right] (-\hat{k}) = \frac{4}{3} \times 10^{-5} (-\hat{k})$$

$$\text{So, } \vec{F} = q(\vec{V} \times \vec{B}) = 3\pi \left[(2\hat{i} + 3\hat{j}) \times \left(-\frac{4}{3} \times 10^{-5} \hat{k} \right) \right]$$

$$= 3\pi \left[\frac{8}{3} \hat{j} - 4\hat{i} \right] \times 10^{-5}$$

$$= [8\pi\hat{j} - 12\pi\hat{i}] \times 10^{-5} = 4\pi[2\hat{j} - 3\hat{i}] \times 10^{-5}$$

$$= 4\pi \times 10^{-5} [-3\hat{i} + 2\hat{j}]$$

111. (D)

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

where, K = torsional constant and
 B = magnetic field

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

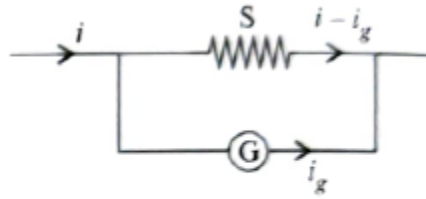
112. (B)

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

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

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

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



113. (D)

(d) By current division rule

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

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

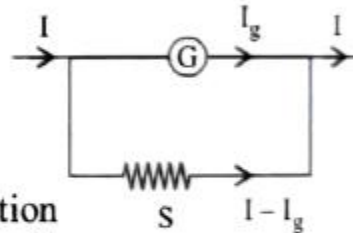
$$\Rightarrow I_g = K\theta$$

as, n = actual number of deflection

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

[(ii) corresponding to one scale division]

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



114. (A)

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

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

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

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

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

115. (A)

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

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

$$= \frac{MB}{2} = \frac{2 \times 10^5 \times 14 \times 10^{-5}}{2} = 14J$$

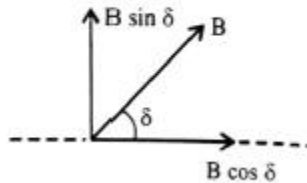
116. (D)

(d) Given that vertical component of the earth's magnetic field $B_V = 6 \times 10^{-5} T$ and angle of dip, $\delta = 37^\circ$

$$B_V = B \sin \delta$$

$$6 \times 10^{-5} = B \times \frac{3}{5}$$

$$\Rightarrow B = \frac{5 \times 6 \times 10^{-5}}{3} = 10^{-4} T$$



117. (A)

(a) Apparent dip is given as ' δ '

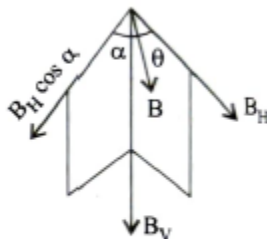
$$\text{So, } \tan \delta = \frac{B_V}{B_H \cos \alpha},$$

$$\text{Here, } \delta = 45^\circ, \theta = 60^\circ$$

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

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

$$= \tan 60^\circ \cos 45^\circ = \sqrt{\frac{3}{2}}$$



118. (A)

(a) We have

$$B_H = B_e \cos \theta, \theta = \text{angle of Dip}$$

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

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

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

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

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 $B = \mu H$

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)

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

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

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

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, $I = 0.5 \text{ A}$

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

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

124. (543)

(543) Given,

Accelerating potential, $V = 12 \text{ kV}$

Let number of revolution = n

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

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

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

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

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, $\vec{\tau} = \vec{M} \times \vec{B} = MB \sin 90^\circ$

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

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

126. (250)

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

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

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

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

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

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

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

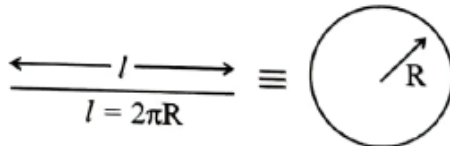
$$r = \frac{mV}{qB} = \frac{\sqrt{2m(KE)}}{qB}$$

$$= \frac{\sqrt{2 \times 24 \times 1.67 \times 10^{-27} \times 5000 \times 1.6 \times 10^{-19}}}{1.6 \times 10^{-19} \times 0.5}$$

$$= 0.1 \text{ m} = 10 \text{ cm}$$

129. (11)

(11)



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

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

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

$$= 14 \times (3.14) \times \frac{1}{4} = 10.99 \approx 11.00$$

130. (3)

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

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

$$\Rightarrow 37.68 \times 10^{-4} = \frac{100 \times 4\pi \times 10^{-7} \times I}{2 \times 5 \times 10^{-2}} \Rightarrow I = 3 \text{ A}$$

131. (5)

(5) We have

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

$$\Rightarrow r = 2 \times 10^{-7} \times 25 \times \frac{0.1}{10^{-5}}$$

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