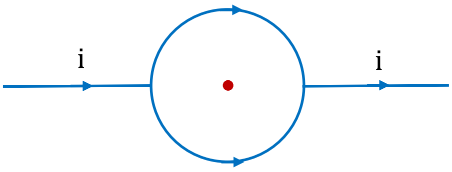
Magnetic Effect of Current and Magnetism

SOLUTIONS

EXERCISE - O

1. **Ans. (A)**



2. **Ans. (A)**

$B_{net} = \sqrt{B_1^2 + B_2^2 + B_3^2}$

$B_1 = B_2 = B_3 = \frac{\mu_0 I}{2R}$

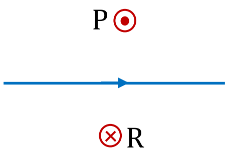
$= \frac{\sqrt{3}\mu_0 I}{2R}$

3. **Ans. (B)**

Magnetic field due to wire at P

$= \frac{\mu_0 i}{2\pi d} \odot$

$= 10\mu T \odot$



At Q, $10\ \mu T \otimes$

Net magnetic field at P

$= 10\ \mu T \odot + 10\ \mu T \odot = 20\ \mu T$

At Q, $10\ \mu T \odot + 10\ \mu T \otimes = 0$

4. **Ans. (B)**

Based on plot of $B = \frac{\mu_0 I}{2\pi r_1} - \frac{\mu_0 I}{2\pi r_2}$

resultant of both wires is taken B at mid-point will be zero. B will approach very high values very close to each wire. (But directions will be opposite)

5. **Ans. (C)**

Field due to CC' and DD' at centre 'O' is zero.

Field due to AB and CD cancel each other.

This only field is due to AA' and BB' = $\frac{\mu_0 i}{4\pi r} \times 2 = \frac{\mu_0 i}{2\pi R}$

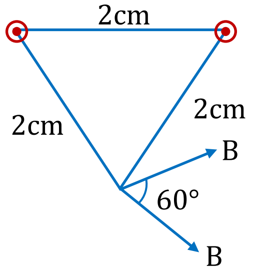
6. Ans. (C)

$B_{net} = \sqrt{3}B$

$= \dfrac{\sqrt{3}\mu_0 i}{2\pi d}$

$= \dfrac{\sqrt{3}\mu_0 \times 10}{2\pi \times 2 \times 10^{-2}}$

$= 1.7 \times 10^{-4}\ T$



7. Ans. (C)

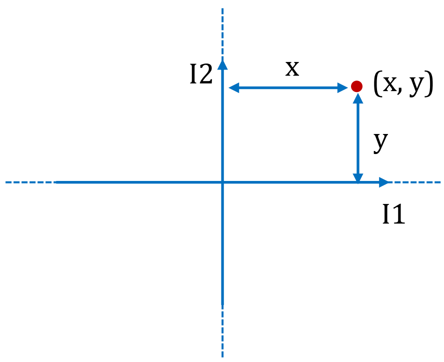
$B_{net} = B_1 - B_2$

$0 = \dfrac{\mu_0 I_1}{2\pi y} - \dfrac{\mu_0 I_2}{2\pi x}$

$\dfrac{\mu_0}{2\pi}\left(\dfrac{I_1 x - I_2 y}{xy}\right) = 0$

$I_1 x = I_2 y \Rightarrow y = \dfrac{I_1}{I_2}x$

So locus is a straight line.



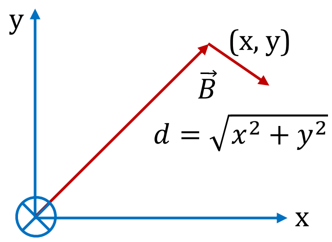
8. Ans. (A)

$B = \dfrac{\mu_0 I}{2\pi\sqrt{x^2+y^2}}$

Unit vector in the direction of magnetic field is

$\hat{B} = \dfrac{y\hat{i} - x\hat{j}}{\sqrt{x^2+y^2}}$

$\vec{B} = B \cdot \hat{B} = \dfrac{\mu_0 I\left(y\hat{i} - x\hat{j}\right)}{2\pi\left(x^2+y^2\right)}$



9. Ans. (A)

$B = \dfrac{\mu_0 I}{4\pi r}(\sin\alpha + \sin\beta)$

$B = 10^{-7} \times \dfrac{2}{7} \times \dfrac{1}{\sqrt{2}} \times 2$

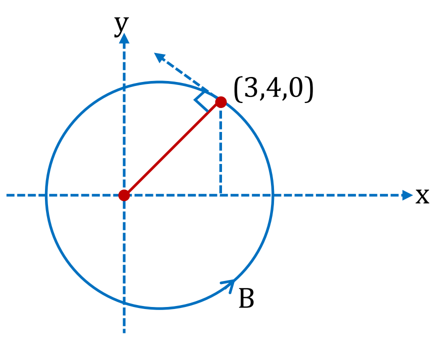
$B = \dfrac{2\sqrt{2}}{5} \times 10^{-7}$ tesla

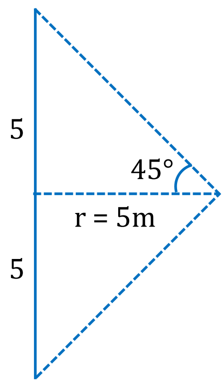
Direction

$\hat{B} = \dfrac{-4\hat{i} + 3\hat{j}}{5}$

Hence,

$\vec{B} = \dfrac{2\sqrt{2}}{25} \times 10^{-7}\left(-4\hat{i} + 3\hat{j}\right)T$





10. Ans. (A)

$$B=\frac{\mu_0 IR^2}{2(x^2+R^2)^{3/2}}=\frac{1}{2\sqrt{2}}\left(\frac{\mu_0 I}{2R}\right)$$

$$\Rightarrow \quad R^3=\frac{1}{\sqrt{8}}\left(x^2+R^2\right)^{3/2}$$

$$\Rightarrow \quad R^6=\frac{1}{8}\left(x^2+R^2\right)^3$$

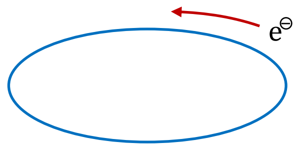
$$\Rightarrow \quad 2R^2=x^2+R^2\Rightarrow \boxed{x=R}$$

$$\therefore \quad \boxed{x=1m}$$

11. Ans. (A)

Average current in the loop

$$i=\frac{e}{T}=e\cdot f \qquad \{\text{where } f=\text{frequency}\}$$



Magnetic field at the centre of circle

$$=\frac{\mu_0 i}{2R}=\frac{\mu_0 e\cdot f}{2R}$$

12. Ans. (D)

MF due to a moving charge

$$B=\frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

MF due to all the charges are in same direction

$$B=\frac{\mu_0}{4\pi}\frac{qv}{a^2}+\frac{\mu_0}{4\pi}\frac{qv}{a^2}+\frac{\mu_0}{4\pi}\frac{2qv}{a^2}$$

$$B=\frac{\mu_0}{4\pi}\left(\frac{4qv}{a^2}\right)$$

13. Ans. (B)

$\int \vec{B}.\vec{d\ell}=\mu_0\Sigma i_{in}$ (Amper's law)

14. Ans. (C)

Use Ampere's circuital law.

15. Ans. (C)

MF inside such wires is given by $B_1=\frac{\mu_0 I}{2\pi R^2}x$ where x is the distance from the axis of wire

For outside point

$$B_2=\frac{\mu_0 I}{2\pi x}$$

$$B_1=\frac{\mu_0 I}{2\pi a^2}\frac{a}{2}=\frac{\mu_0 I}{4\pi a}$$

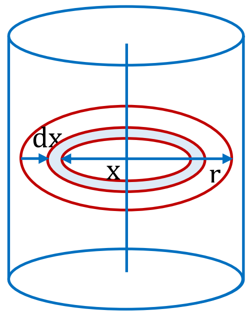
And $\quad B_2=\frac{\mu_0 I}{2\pi(2a)}=\frac{\mu_0 I}{4\pi a}$

$$B_1/B_2=1$$

16. Ans. (D)

Value of *MF* is not same along different positions parallel to wire. Hence ampere law is not useful.

17. Ans. (D)



$$\oint B d\ell = \mu_0 I_{en}$$

$$\oint B_0 r^3 d\ell = \mu_0 I_{en}$$

or $$B_0 r^3 \int_0^{2\pi r} d\ell = \mu_0 I_{en}$$

[**Note** : B_0r^3 is taken out of integration because it is not varying along $d\ell$]

or $B_0r^3(2\pi r) = \mu_0 I_{en}$

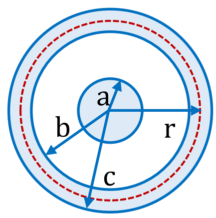
or $$I_{en} = \frac{2\pi B_0 r^4}{\mu_0}$$

18. Ans. (D)

By Ampere's law

$B(2\pi r) = \mu_0(i - i')$

Now, current density in the outer wire is constant



$$\frac{i}{\pi(c^2 - b^2)} = \frac{i'}{\pi(r^2 - b^2)}$$

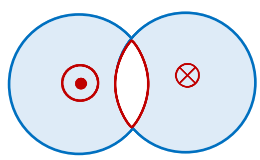
$$i' = i\left(\frac{r^2 - b^2}{c^2 - b^2}\right)$$

$$\therefore \quad B = \frac{\mu_0 i}{2\pi r}\left[1 - \frac{r^2 - b^2}{c^2 - b^2}\right] = \frac{\mu_0 i}{2\pi r}\left(\frac{c^2 - r^2}{c^2 - b^2}\right)$$

19. Ans. (A)

Just assume current is flowing in complete conductor. Because direction of current is in opposite direction in both conductors. So current in non-shaded part is anyways zero.

$B_A = B_1 + B_2$



$$= \frac{\mu_0 J \times \pi\left(\frac{d}{2}\right)^2 (\hat{j})}{2\pi\frac{d}{2}} + \frac{\mu_0 J \pi\left(\frac{d}{2}\right)^2 (\hat{j})}{2\pi\frac{d}{2}}$$

$$B_A = \left(\frac{\mu_0 \pi J d}{2\pi}\right)\hat{j}$$

20. Ans. (D)

Magnetic field insider long solenoid

$B_0 = \mu_0 n I$

Frequency of rotation in magnetic field

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

$$f = \frac{q\mu n I}{2\pi m}$$

$$n = \frac{f \times 2\pi m}{q\mu I}$$

21. **Ans. (C)**

$V = g \sin\theta \cdot t$

$F_m = q(g \sin\theta \cdot t)B$

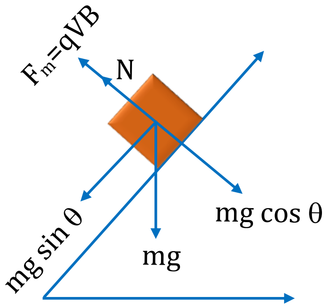
$F_m + N = mg \cos\theta$

It will loose contact when $N = 0$

$F_m = mg \cos\theta$

$q(g \sin\theta \cdot t)B = mg \cos\theta$

$$t = \frac{m\cot\theta}{qB}$$



22. **Ans. (C)**

Radius of curvature

$$r = \frac{mV}{qB\sin\theta}$$

$q = 90°$ angle between B and V

$r = \infty$

23. **Ans. (A)**

Initially magnetic force on charge is in $+x$ direction.

$$\vec{F} = q\left(v\hat{j}\right) \times B_1\hat{k}$$

$$\vec{F} = qvB\hat{i}$$

So, $q > 0$

Radius of circular path

$$r = \frac{mv}{qB}$$

$$r \propto \frac{1}{B}$$

$r_1 > r_2$

So $|B_1| < |B_2|$

24. **Ans. (A)**

I^st case:

$$-2\hat{j} = q2\hat{\imath} \times \left(B_x\hat{\imath} + B_y\hat{j} + B_z\hat{k}\right)$$

$$-2\hat{j} = 2qB_y\hat{k} - 2qB_z\hat{j}$$

So $B_y = 0$

II^nd case:

$$+2\hat{\imath} = q(2\hat{j}) \times \left(B_x\hat{\imath} + B_y\hat{j} + B_2\hat{k}\right)$$

$$2\hat{\imath} = 2qB_x\left(-\hat{k}\right) + 2qB_2\hat{\imath}$$

So $B_x = 0$

$\vec{B}$ is parallel to $\hat{k}$

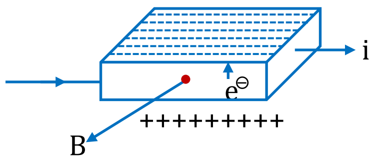
So $\vec{V} || \vec{B}$

So $\vec{F} = 0$

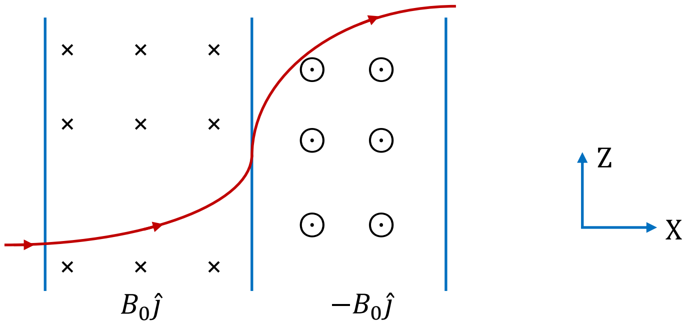
25. Ans. (A)

$$eV_dB = \frac{e(V_B - V_A)}{C}$$

$V_B - V_A = BV_d \cdot C$



26. Ans. (A)



Force can be found using $q(\vec{v} \times \vec{B})$, where q is positive.

27. Ans. (C)

Net work done on the particle.

$W = QE_0x_0$ {Only work done by the electric force}

$W = \Delta k.E.$

$$QE_0x_0 = \frac{1}{2}mv_0^2$$

$$QE_0x_0 = \frac{1}{2}m25$$

$$x_0 = \frac{25}{2E_0}\left(\frac{m}{Q}\right) = \frac{25}{2E_0\alpha}$$

28. Ans. (B)

Unit vector along diameter = $\dfrac{(\hat{i}+\hat{j})}{\sqrt{2}}$

$\therefore \quad F = i\vec{\ell} \times \vec{B}$

29. Ans. (A)

Force on wire Q due to wire P is

$$F_P = 10^{-7} \times \frac{2 \times 30 \times 10}{0.1} \times 0.1 = 6 \times 10^{-5} N \text{ (Towards left)}$$

Force on wire Q due to wire R is

$$F_R = 10^{-7} \times \frac{2 \times 20 \times 10}{0.02} \times 0.1 = 20 \times 10^{-5} N \text{ (Towards right)}$$

Hence $F_{net} = F_R - F_P = 14 \times 10^{-5} N = 1.4 \times 10^{-4} N$ (Towards right)

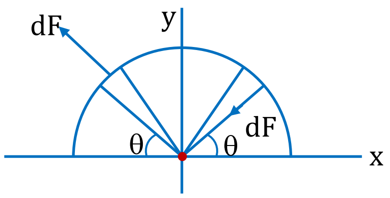
30. Ans. (A)

If we take two small segments on ring as shown in figure. Net force on both segments is in $-x$ direction.

$$F_x = I\int_0^{\pi} \frac{B_0(R\cos\theta)\cdot Rd\theta\cdot\cos\theta}{2R}$$

$$= -\frac{IB_0R}{2}\int_0^{\pi}\cos^2\theta\, d\theta = -\frac{\pi IB_0R}{4}$$

$$F_y = \frac{IB_0R}{2}\int_0^{\pi}\sin\theta\cos\theta\, d\theta = 0$$



Net force will be

$$\vec{F} = \frac{\pi IB_0R}{4}(-\hat{\imath})$$

31. Ans. (D)

Since $\vec{B}$ is constant in the region

The net magnetic force experienced by the conducting wire MN is

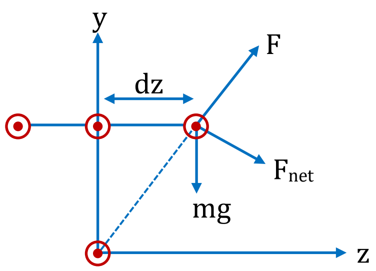
$$\vec{F} = I(\vec{L}_{eff}\times\vec{B})$$

Where, $\vec{L}_{eff} = 6R\hat{\imath}$

$$\vec{F} = I[6R\hat{\imath}\times B(-\hat{k})]$$

$$\vec{F} = 6BIR(\hat{\jmath})$$

32. Ans. (B)



When displaced along z-axis net force on wire will be away from equilibrium.

But when displaced along y-axis F_{net} will be towards equilibrium position.

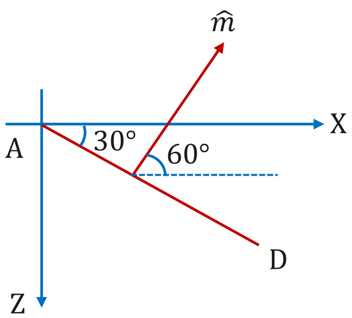
33. Ans. (A)

$$|\vec{m}| = IA = 10\times\left(\frac{10}{100}\right)^2 = \frac{1}{10}Am^2$$

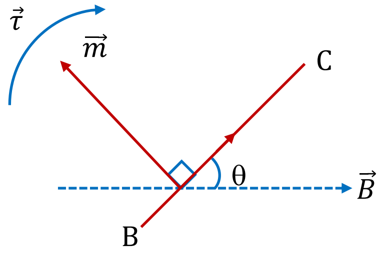
To get the direction :-

$$\vec{m} = \left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{k}\right)\left(\frac{1}{10}\right)$$

$$\vec{m} = (0.05)(\hat{i} - \sqrt{3}\hat{k})$$



34. Ans. (C)



For torque to become zero, $\vec{m}$ vector turns clockwise and gets aligned with $\vec{B}$

Angle turned = 90° + θ

35. Ans. (D)

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

$$\Rightarrow \quad M=\frac{q}{2m}\times\frac{mr^2}{2}\omega$$

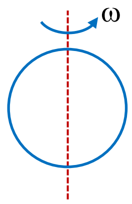
$$\Rightarrow \quad \tau=\vec{M}\times\vec{B}=\frac{q\omega r^2 B\sin\theta}{4}(\text{clockwise})$$

36. Ans. (A)

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

$\tau = IAB$

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



$$\alpha=\frac{\tau}{I}=\frac{IAB}{\frac{mR^2}{2}}$$

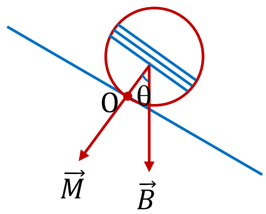
37. Ans. (B)

$\tau = MB \sin\theta$

$\tau_{net} = 0$

So $\quad i\pi R^2 B \sin\theta - mg\sin\theta \cdot R = 0$

$$B=\frac{mg}{\pi iR}$$



38. Ans. (D)

Current sensitivity, $\quad CS = \dfrac{\theta}{I}=\dfrac{10}{10^{-3}}\dfrac{div}{A}$

$CS = 10^4\ div/A$

Voltage sensitivity, $\quad VS = \dfrac{\theta}{V}=2000\dfrac{div}{A}$

Galvanometer resistance $R = \dfrac{CS}{VS}=\dfrac{10000}{2000}=5\Omega$

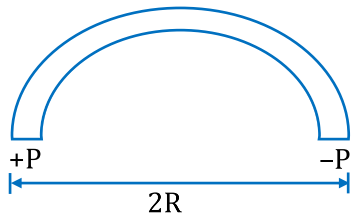
New resistance = $R' = \dfrac{10000}{1}=10000\Omega$

Hence, resistance required to be added in series = 9995 Ω

39. **Ans. (B)**

Pole strength $P = \dfrac{\text{Magnetic moment}}{\text{Length}}$

$P = \dfrac{M}{L}$, pole strength doesn't change on bending. $M' = P(2R)$

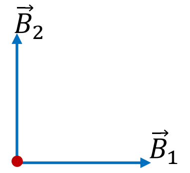


$M' = \dfrac{M}{L}\left(2\times\dfrac{L}{\pi}\right)$

$M' = \dfrac{2M}{\pi}$ $\qquad (\pi R = L)$

40. **Ans. (A)**

$B = \dfrac{\mu_0}{4\pi}\dfrac{2m}{r^3}$



$B_1 = 10^{-7}\left(\dfrac{2\times2}{27\times10^{-3}}\right) = \dfrac{4}{27}\times10^{-4}$

$B_2 = \dfrac{10}{64}\times10^{-4} = \dfrac{5}{32}\times10^{-4}$

$B_{net} = \sqrt{\left(\dfrac{4}{27}\right)^2+\left(\dfrac{5}{32}\right)}\left(10^{-4}\right) = 2.15\times10^{-5}T$

41. **Ans. (B)**

Force on a dipole in non-uniform magnetic field

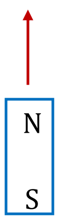
$F = m\left(\dfrac{dB}{dr}\right)$

$\Rightarrow \quad F_{12} = m_1\dfrac{d}{dr}\left(\dfrac{\mu_0}{4\pi}\dfrac{2m_2}{r^3}\right)$

$\Rightarrow \quad F_{12} \propto \dfrac{1}{r^4}$

42. **Ans. (C)**

$1.5\times10^{-4} + \dfrac{2\mu_0 M}{4\pi(0.1)^3} = B$



$= 1.5\times10^{-4} + \dfrac{2\times10^{-7}\times10}{10^{-3}}$

$= 21.5\times10^{-4}\ T$

43. **Ans. (C)**

$B\cos\theta = B_H \Rightarrow B = \dfrac{B_H}{\cos\theta} = \dfrac{0.6}{3/5} = 1G$

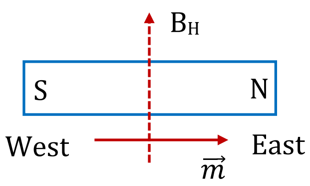
44. **Ans. (B)**

$U = -\vec{m}.\vec{B}$

$U_1 = 0$

$U_2 = -mB$

$|\Delta U| = KE \Rightarrow KE = mB = 2\times25\mu J = 50\ \mu J$



45. Ans. (C)

Torque due to twist (torsional) is balanced by the torque due to magnetic field.

$$\tau = k\phi = mB\sin\theta$$

Where ϕ is the angle of twist and θ is the angle between magnetic field and magnetic moment

$$\frac{\phi_1}{\phi_2} = \frac{m_1}{m_2}\frac{\sin\theta_1}{\sin\theta_2}$$

$$\Rightarrow \quad \frac{m_1}{m_2} = \left(\frac{180-30}{270-30}\right)\left(\frac{1/2}{1/2}\right) = \frac{150}{240} = \frac{5}{8}$$

(ϕ = Angle turned by upper end – Angle turned by lower end)

46. Ans. (B)

$B_H = B\cos 30°$

$B_v = B\sin 30°$

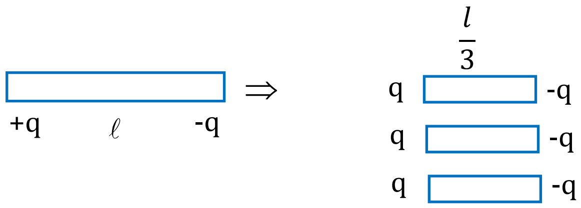
$B_{NS} = B\cos^2 30°$

$$\tan\phi = \frac{B\sin 30}{B\cos^2 30} = \frac{\frac{1}{2}}{\frac{3}{4}} = \frac{2}{3}$$

47. Ans. (D)

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

There is no change in pole strength.



$$m' = \frac{q\ell}{3} = \frac{m}{3}$$

$$I' = \frac{1}{12}\times\frac{M}{3}\left(\frac{\ell}{3}\right)^2\times 3 = \frac{I}{9}$$

$$T' = 2\pi\sqrt{\frac{1}{9}\times 3\frac{I}{mB_H}} = \frac{2}{\sqrt{3}}$$

48. Ans. (B)

$B = \mu H$

$$\Rightarrow \quad \left(8\times10^{-3}\right)(160) = 1.28\,wb/m^2$$

49. Ans. (D)

By definition curie temperature is that temperature above which a ferromagnet transforms into a paramagnet. Due to increased random motion domain formation doesn't happen.

50. Ans. (A)

Ferromagnetic substance is strongly attached by magnetic field.

51. Ans. (A)

$M = \dfrac{CB}{T}$ and $M = m \times$ volume

M = Magnetisation, m = magnetic moment

$$\Rightarrow \quad \frac{m_1}{m_2} = \frac{T_2B_1}{T_1B_2} \qquad \Rightarrow \quad m_2 = \left(\frac{T_1B_2}{T_2B_1}\right)m_1$$

$$m_2 = \frac{15}{100}\times\left(2\times10^{24}\right)\times\left(1.5\times10^{-23}\right)\left(\frac{4.2}{2.8}\right)\left(\frac{0.98}{0.84}\right) = 7.875\,JT^{-1}$$

52. Ans. (B)

Theoretical concept

53. Ans. (C)

Theoretical concept

54. Ans. (D)

$B = \mu_0(H+M) = 0$ is for a perfect diamagnet (super conductor)

$\chi = -1$

55. Ans. (B)

$B = \mu H \Rightarrow \frac{dB}{dH} = \mu$

Slope of the curve first increases then decreases.

56. Ans. (C)

$k\theta = NIAB$

$\Rightarrow \quad \frac{\theta}{I} = \frac{NAB}{k}$

Sensitivity $\propto B = \mu n I$

Hence, statement 1 is correct.

Soft iron can be easily magnetised and demagnetised.

Statement 2 is incorrect.

57. Ans. (B)

Because electromagnets need to be magnetised and demagnetised again and again. These are temporary magnets.

58. Ans. (B)

Paramagnetic substance moves from weaker magnetic field to stronger magnetic field.

59. Ans. (C)

$x_m \propto \frac{1}{T}$ Curie law

60. Ans. (B)

$B = \mu H$

or $B = \left[\frac{0.4}{H} + 12\times10^{-4}\right]H$

or $1 = 0.4 + 12\times10^{-4} H$

$\therefore \quad H = 500\ A/m$

61. Ans. (A)

Atomic magnetic dipole moment is zero for diamagnetic atom have permanent magnetic moment-paramagnetic.

62. Ans. (B)

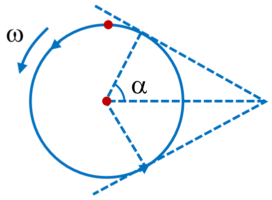
Particle empty subshell contain by ferromagnetic substance.

63. **Ans. (ACD)**

$\cos\alpha = \frac{R}{2R} = \frac{1}{2}$

$\therefore \quad \alpha = \frac{\pi}{3}$

$\therefore \quad \omega t_1 = \frac{\pi}{3}$ and $\omega t_2 = \frac{5\pi}{3}$



64. **Ans. (AD)**

To get zero magnetic field, magnetic field due to ring and solenoid must be opposite to each other and equal in magnitude.

$B_{\text{solenoid}} = B_{\text{ring}}$

$$\mu_0 n i_{\text{solenoid}} = \frac{\mu_0 i_{\text{ring}}}{2R}$$

$$4\pi\times10^{-7}\times\frac{1300}{0.65}\times I = \frac{4\pi\times10^{-7}\times8}{2\times0.02}$$

$20\,I = 2$

$$I = \frac{1}{10}\text{ Amp} = 100\ mA$$

If current is revered then direction of magnetic field changes and $B_{net} = B_1 + B_2$

$$B_{net} = 2B \Rightarrow \frac{\mu_0 i}{R} = \frac{4\pi\times10^{-7}}{0.02}\times8$$

$= 16\pi \times 10^{-5}$ Tesla

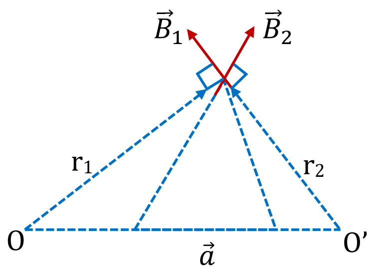
65. **Ans. (ACD)**

Assuming equal and opposite current density in the region of cavity we can calculate MF in the cavity region

$\hat{e}_1 \perp \vec{r}_1$

$\hat{e}_2 \perp \vec{r}_2$

$\hat{e}_1 = \frac{\hat{z}\times\vec{r}_1}{r_1}$ and $\hat{e}_2 = \frac{-\hat{z}\times\vec{r}_2}{r_2}$



Hence,

$$\vec{B}_1 = \frac{\mu_0 j r_1}{2}\hat{e}_1 = \frac{\mu_0 j}{2}(\hat{z}\times\vec{r}_1)$$

And $\vec{B}_2 = -\frac{\mu_0 j}{2}(\hat{z}\times\vec{r}_2)$

Hence,

$$\vec{B}_1 + \vec{B}_2 = \frac{\mu_0 j}{2}\hat{z}\times(\vec{r}_1 - \vec{r}_2)$$

$$\Rightarrow \quad \vec{B}_1 + \vec{B}_2 = \frac{\mu_0 j}{2}\hat{z}\times\vec{a}$$

Hence, net *MF* is constant. It is independent of position inside cavity.

Also, *MF* is perpendicular to $\vec{a}$

If an electron is projected along *y* direction it will be parallel to *MF* and hence will not experience any magnetic force.

66. **Ans. (AC)**

$$\frac{\mu_0 i}{2\pi a} = \frac{\mu_0 J_0}{6}(3a-2a)$$

$$i = \frac{J_0 \pi a^2}{3}$$

67. **Ans. (BCD)**

For no deflection

$F_m = F_e \Rightarrow qV_0B = qE$

For charge to hit below hole in the screen s_2

$F_m < F_e$

$\Rightarrow$ $qvB < qE \Rightarrow vB < E$

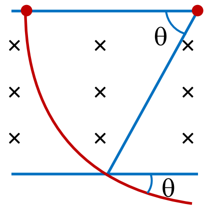
If E is increased and v decreased this is certainly possible

(B) is incorrect because that does not always lead to desired change

(C) is incorrect for the same reason as stated above

(D) is incorrect because it will definitely deflect the particle upwards.

68. **Ans. (AB)**

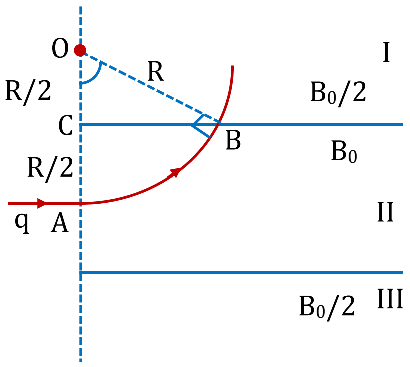


$$\tan\theta = \frac{\sqrt{3}v'}{v'} = \sqrt{3}$$

$\theta = 60$

69. **Ans. (AB)**

Case (1) If $q > 0$



$\theta = 60°$

At $t = \frac{1}{6}\frac{2\pi m}{qB}$

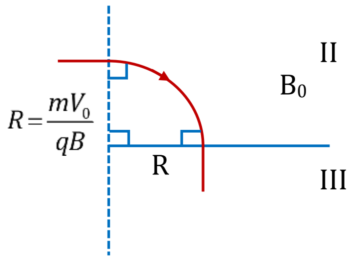
$$t = \frac{\pi m}{3qB}$$

Hence particle will enter region I from II for first time at

$$t = \frac{\pi m}{3qB}$$

Option (A) is correct option (C) is incorrect

Case (2) $q < 0$



$$t = \frac{1}{4}\frac{2\pi m}{|q|B}$$

$$t = \frac{\pi m}{2|q|B}$$

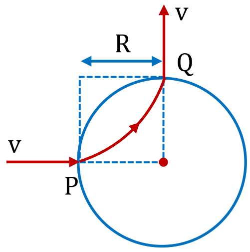
Hence option (B) is correct.

70. Ans. (ABC)

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

$$\Rightarrow \quad B=\frac{mv}{qR}$$

$$T=\frac{\frac{2\pi R}{4}}{v}=\frac{\pi m}{2qB}$$



71. Ans. (BD)

$r=\frac{mv}{qB}$ $\Rightarrow$ if B is greater radius will be small.

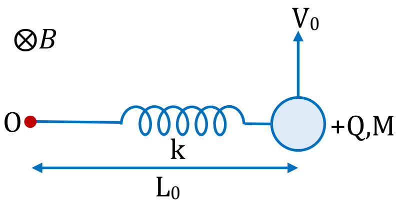
Also $W_{\text{magnetic force}}$ on free particle moving in the field = 0 $\Rightarrow$ speed remains same.

72. Ans. (ABCD)

Magnetic force = $BQv_0=\frac{Mv_0}{QL_0}\times v_0\times Q$

Magnetic force = $\frac{Mv_0^2}{L_0}$

Which is equal to centripetal force so block is circular motion about O & radius L_0. So, spring forces is zero, So potential energy is constant only magnetic force will work, so kinetic energy is constant



73. Ans. (ABD)

$$d\vec{F}_{AB}=Idy\hat{j}\times\vec{B}$$

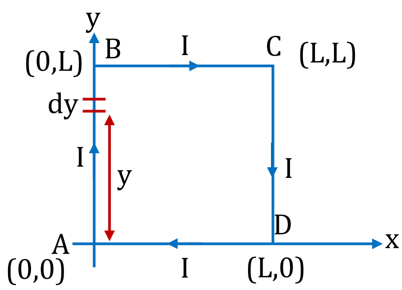
$$\vec{B}=\frac{B_0}{L}(0)\hat{j}+\frac{B_0}{L}y\hat{k}$$

$$d\vec{F}_{AB}=I\left[dy\hat{j}\times\frac{B_0}{L}y\hat{k}\right]$$

$$\int d\vec{F}_{AB}=\int I\frac{B_0}{L}ydy(\hat{i})$$

$$\vec{F}_{AB}=\left(\frac{IB_0}{L}\right)\left(\int_0^L ydy\right)\hat{i}$$

$$\vec{F}_{AB}=\left(\frac{IB_0}{L}\right)\left(\frac{L^2}{2}\right)\hat{i}=\frac{IB_0L}{2}\hat{i}$$



$$d\vec{F}_{BC}=Id\vec{l}\times\vec{B}$$

$$\vec{B}=\frac{B_0}{L}(0)\hat{j}+\frac{B_0}{L}(L)\hat{k}$$

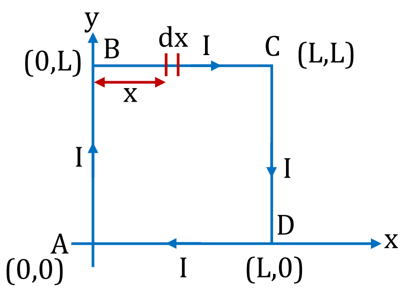
$$\vec{B}=B_0\hat{k}$$

$$d\vec{F}_{BC}=Idx\hat{i}\times B_0\hat{k}$$

$$=IB_0dx\left(\hat{i}\times\hat{k}\right)$$

$$\int d\vec{F}_{BC}=IB_0\left(-\hat{j}\right)\int_0^L dx$$

$$\vec{F}_{BC}=-IB_0L\hat{j}$$



$\vec{F}_{BC} = -(IB_0L)\hat{j}$

$d\vec{F}_{CO} = I(-dy)\hat{j} \times \left(\frac{B_0(0)}{L}\hat{j} + \frac{B_0(y)}{L}\hat{k}\right)$

$= -I\frac{B_0}{L}\int_0^L ydy\hat{i}$

$\vec{F}_{CD} = -\frac{IB_0L}{2}\hat{i}$

For AD $\vec{B} = \frac{B_0}{L}(0)\hat{j} + \frac{B_0}{L}(0)\hat{k} = 0$

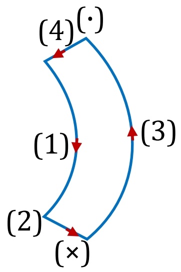
$\vec{F}_{AD} = 0$

$\vec{F}_{net} = -IB_0L\hat{j}$

74. Ans. (B)

Consider an element of length dl ,the force on it $dF = Bi(dl)\sin 90° = Bi(dl)$ and perpendicular to $d\vec{l}$ and $\vec{B}$ that is along z- axis. For any of the element of the loop, the direction is along z-axis. Therefore force on entire loop $\vec{F} = \int_0^{2\pi a} Bi(dl)\hat{k} = Bi\int_0^{2\pi a} dl\hat{k} = Bi(2\pi a)\hat{k}$

75. Ans. (AC)



The net force on the loop = O.

Force on (1) & (3) = 0.

Force on 4 + force on 2 = 0.

So, net force = 0.

If rotates clockwise seen from O.

76. Ans. (ABCD)

(A) $\tau = \vec{M} \times \vec{B} = I\alpha$

$i\ell^2 B\sin 90° = \frac{2}{3}m\ell^2\alpha \Rightarrow a = \frac{3Bi}{2m}$

(B) Initial potential energy

$= -\vec{M}.\vec{B} = MB\cos 90° = 0$

Final potential energy

$= -\vec{M}\vec{B} = -M.B\cos 60^\circ = \frac{-MB}{2} = \frac{-i\ell^2 B}{2}$

Change in potential energy = Change in rotational kinetic energy

$\frac{Bi\ell^2}{2} = \frac{1}{2} \times \frac{2}{3}m\ell^2 \times \omega^2$

$\omega = \sqrt{\frac{3Bi}{2m}}$

(C) $\tau = \vec{M} \times \vec{B} = i\ell^2 B\sin 30^\circ = \frac{Bi\ell^2}{2}$

(D) $\tau = MB\sin\theta = I\alpha$

$\alpha = \frac{MB\sin\theta}{I}$

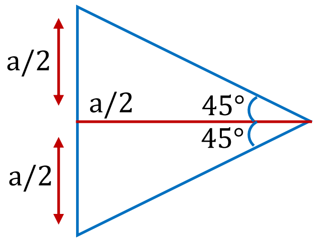
θ increases 90° to 180°

$\Rightarrow$ $\sin\theta$ decreases from 1 to 0

$\therefore$ α decreases

77. Ans. (ABD)

$$B_{centre} = \frac{\sqrt{2}\mu_0 I}{\pi d}$$



$$\sqrt{3}B = \sqrt{B^2 + \frac{2\mu_0^2 I^2}{\pi^2 d^2}}$$

$$3B^2 - B^2 = \frac{2\mu_0^2 I^2}{\pi^2 d^2}$$

$$B = \frac{\mu_0 I}{\pi d}$$

$$I^2 = \frac{B^2\pi^2 d^2}{\mu_0^2} \Rightarrow I = \frac{B\pi d}{\mu_0} = \frac{B\pi a}{2\mu_0}\left(d = \frac{a}{2}\right)$$

(A) $\text{torque} = Ia^2B = a^2B \times \frac{B\pi a}{2\mu_0}$

$$= \frac{\pi B^2 a^3}{2\mu_0}$$

(B) $PE = -\vec{\mu}.\vec{B}$ $\left(\text{Here } \theta = 90^\circ\right)$

$\therefore$ $PE = 0$

(C) If aligned parallel

$$B_{net} = \sqrt{2}B + B$$

(D) If aligned anti-parallel than

$$B_{net} = \left(\sqrt{2} - 1\right)B$$

78. Ans. (A)

79. Ans. (B)

Solution for Question No. 78 and 79

$$y = \frac{1}{2}at^2 = \frac{1}{2}(\alpha E_0)\left(\frac{2\pi}{\alpha B_0}\right)^2$$

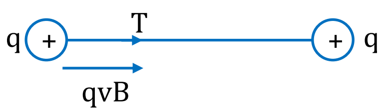
$$v_y = at = (\alpha E_0)\left(\frac{2\pi}{\alpha B_0}\right)$$

$$\theta = \tan^{-1}\left(\frac{v_x}{v_y}\right)$$

where $v_x = v_0$

80. Ans. (B)

$$T + qvB = \frac{mv^2}{L}$$



$$T = 0; \Rightarrow q\left(\frac{qB_0L}{m}\right)B = \frac{mv^2}{L}$$

$\Rightarrow$ $B = B_0$

81. **Ans. (C)**

$$T + \frac{qvB_0}{2} = \frac{mv^2}{R}$$

$$T = \frac{m(qB_0L)^2}{m^2R} - \frac{q(qB_0L)}{m} \times \frac{B_0}{2} = \frac{q^2B_0^2L}{2m}$$

82. **Ans. (B)**

$$\tau = K\theta \Rightarrow K = \frac{\vec{\tau}}{\theta} = \frac{\vec{M} \times \vec{B}}{\theta} = \frac{niAB}{\theta}$$

$$\Rightarrow \quad K = \frac{250 \times 100 \times 10^{-6} \times 2.1 \times 1.2 \times 10^{-4} \times 0.23}{28}$$

$= 5.2 \times 10^{-8}\ Nm/\text{degree}$

83. **Ans. (B)**

$$\theta = \frac{\tau}{K} = \frac{niAB \times 2}{5.2 \times 10^{-8}} \simeq 56°$$

84. **Ans. (B)**

$$\theta' = \frac{niAB'}{K'}, \ B' = 3B, K' = 3K$$

$\Rightarrow \quad \theta' = 28°$

85. **Ans. (A-P,R), (B-S), (C-P,Q,R), (D-P,R)**

Use right hand curl rule to predict the direction of magnetic fields.

(A) B is along $+ve$ × and $+ve\ z$.

(B) B is along $-ve\ x$.

(C) B is along $+ve\ x$, $+ve\ y$ and $+ve\ z$.

(D) B is along $+ve\ x$ and $+\ ve\ z$.

86. **Ans. (A-Q,S), (B-P,S), (C-Q,S), (D-P,S)**

Use ampere circuital law $\oint \vec{B}, \vec{d\ell} = \mu\, i_{\text{enclosed}}$ Also, magnetic force on a charged particle act perpendicular to velocity. Hence work done by magnetic force is zero.

87. **Ans. (A-P,R,T), (B-P,Q), (C-S), (D-P)**

$E = 0$ & $B \neq 0$

$F = qvB \sin\theta$

$F = 0$ if $\theta = 0°$

Path straight line

Path helical if $\theta \neq 90°$ & $0° < 0° < 180°$

Path circular if $\theta = 90°$

$E \neq 0, B = 0$

then a constant force $\vec{F} = q\vec{E}$ will act on charged particle

So path will be straight line if $\vec{F} \,||\, \vec{v}$

& path will be parabola if angle between $\vec{F}$ & $\vec{v}$ is not 0° or 180°.

88. Ans. (A-S), (B-S), (C-Q), (D-R), (E-P)

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

where m = magnetic moment

L = Angular momentum

(A) $\mu=\frac{q}{2m}(I\omega)=\frac{q}{2m}(mr^2\omega)=q\frac{\omega r^2}{2}$

(B) $\mu=\frac{q}{2m}(mr^2\omega)=q\frac{\omega r^2}{2}$

(C) $\mu=\frac{q}{2m}\left(\frac{mr^2}{2}\omega\right)=q\frac{\omega r^2}{4}$

(D) $\mu=\frac{q}{2m}\left(\frac{2}{3}mr^2\omega\right)=q\frac{\omega r^2}{3}$

(E) $\mu=\frac{q}{2m}\left(\frac{2}{5}mr^2\omega\right)=q\frac{\omega r^2}{5}$

EXERCISE – S

1. Ans. 1

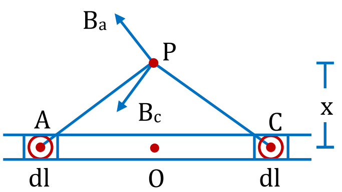
$$\frac{\mu_0 i\pi}{4\pi R_1}-\frac{\mu_0 i\pi}{4\pi R_1\times\alpha}+\frac{\mu_0 i\pi}{4\pi R_1\alpha^2}....$$

$$=\frac{\mu_0 i}{4R_1}\left[1-\frac{1}{\alpha}+\frac{1}{\alpha^2}....\right.$$

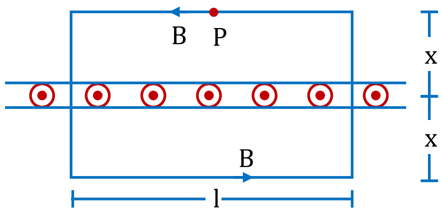
$$=\frac{\mu_0 i}{4R_1}\left[\frac{\alpha}{1+\alpha}\right]$$

2. Ans. $B=\frac{1}{2}\mu_0 K$

Consider two strips A and C of the sheet situated symmetrically on the two sides of P (figure). The magnetic field at P due to the strip A is B_a perpendicular to AP and that due to the strip C is B_c perpendicular to CP. The resultant of these two is parallel to the width AC of the sheet. The field due to the whole sheet will also be in this direction. Suppose this field has magnitude B.



(a)



(b)

The field on the opposite side of the sheet at the same distance will also be B but in opposite direction. Applying Ampere's law to the rectangle show in figure.

$$2Bl=\mu_0 Kl$$

or $$B=\frac{1}{2}\mu_0 K$$

Note that it is independent of x.

3. **Ans.** $V = \frac{\mu_0 qkd}{2m}$

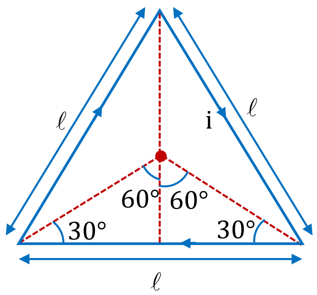
As the magnetic field is uniform and the particle is projected in a direction perpendicular to the field, it will describe a circular path. The particle will not hit the metal sheet if the radius of this circle is smaller than *d*. For the maximum velocity, the radius is just equal to *d*. Thus,

$$qvB = \frac{mv^2}{d}$$

or $$qv\frac{\mu_0 K}{2} = \frac{mv^2}{d}$$

or $$v = \frac{\mu_0 qKd}{2m}$$

4. **Ans.** 18



$$B = 3\left(\frac{\mu_0 i}{4\pi\frac{\ell}{2}\tan 30°}\right)[\sin 60° + \sin 60°] = \frac{\mu_0}{4\pi}\left(\frac{18i}{\ell}\right)$$

5. **Ans.** 5

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 i_{net}$$

$$B \times 2\pi r = \mu_0 \int_0^r \left(J_0 \frac{r}{a}\right) 2\pi r dr$$

$$\Rightarrow \quad 2\pi r B = \frac{\mu_0 J_0}{a}\frac{2\pi r^4}{4}$$

$$\Rightarrow \quad B = \frac{\mu_0 J r^3}{4a}$$

6. **Ans.** 7 μT

We consider a circular element of radius *r* and thickness *dr*.

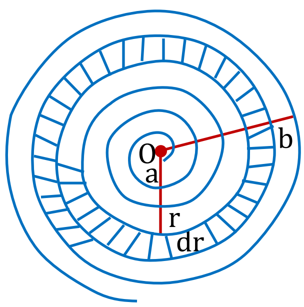
The number of turns in the considered element is

$$dN = \frac{N}{b-a}dr$$

The magnetic field as its Centre due to considered element is

$$dB = \frac{dN\mu_0 I}{2r}$$

$$B = \frac{N\mu_0 I}{2(b-a)}\int_a^b \frac{dr}{r} = \frac{N\mu_0}{2(b-a)} In\frac{b}{a} = 7\mu T$$



7. **Ans.** $\dfrac{\mu_0 I\sqrt{2}}{4\pi^2 R}$

Assuming current is going into the plane

Magnetic field at the centre of a long pipe due to a current *dl* is

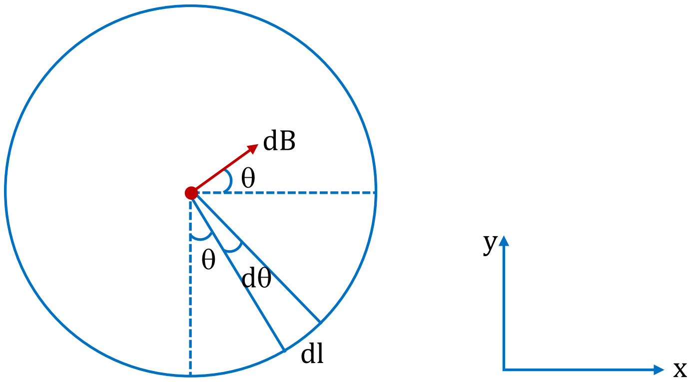
$$\Rightarrow \quad dB = \frac{\mu_0}{2\pi}\times\frac{dl}{R}$$

$$dl = \frac{I}{2\pi R}\times R d\theta$$

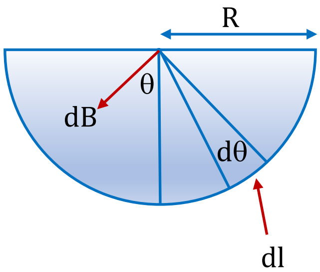
$$dl = \frac{I}{2\pi R}\times R d\theta$$

$$\vec{B} = \int d\vec{B} = \int_0^{\pi/2} dB\cos\theta\hat{i} + \int_0^{\pi/2}\sin\theta\hat{j}$$

$$|\vec{B}| = \frac{\mu_0 I}{4\pi^2 R}\times\sqrt{2}$$



8. **Ans.** $\left(\dfrac{\mu_0 I}{\pi^2 R}\right)$



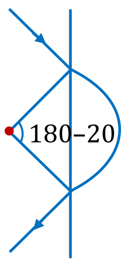
9. **Ans.** $\dfrac{\pi+2\theta}{\pi-2\theta}$

Fraction of circular path in the magnetic field

$$=\left(\frac{\pi+2\theta}{2\pi}\right)$$

Time taken = $\left(\dfrac{\pi+2\theta}{2\pi}\right)T$

$$T_2 = \left(\frac{\pi-2\theta}{2\pi}\right)\cdot T$$



10. **Ans.** 5

Absence of magnetic field

$$N_2 - mg = \frac{mv_1^2}{R}$$

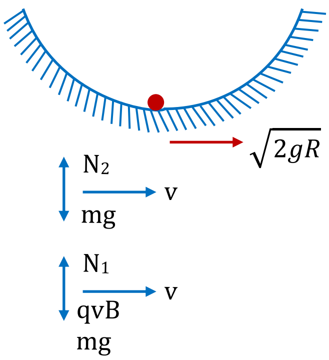
In the presence of magnetic field

$$N_1 - mg - qvB = \frac{mv_2^2}{R}$$

$$v_1 = v_2 = \sqrt{2gR}$$

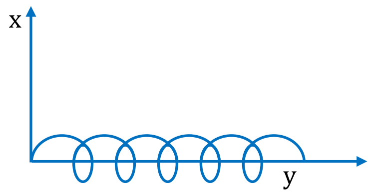
So $\quad N_1 - N_2 = B_2\sqrt{2gR}$

So $\quad k = 5$



11. **Ans.** 5

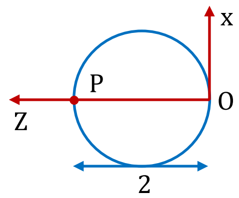
The particle will move in a non-uniform helical path with increasing pitch as shown:



Its time period will be :

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

Changing the view, the particle is seemed to move in a circular path in $(x - z)$ plane as below



After π-seconds the particle will be at point 'P', hence x coordinate will be 0

For linear motion along y-direction.

$$y(\pi) = 0(\pi) + \frac{1}{2}\frac{Eq}{m}(\pi)^2$$

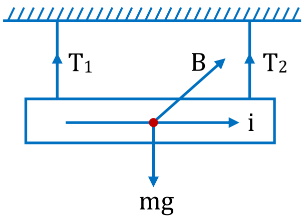
$$y(\pi) = \frac{\pi^2}{2} \text{ and } OP = 2$$

Hence the coordinate $\left(0, \frac{\pi^2}{2}, 2\right)$.

12. **Ans.** (a) A horizontal magnetic field of magnitude 0.26 T normal to the conductor in such a direction that Fleming's left-hand rule gives a magnetic force upward.

(b) 1.176 N.

(a) $i\ell B = mg$



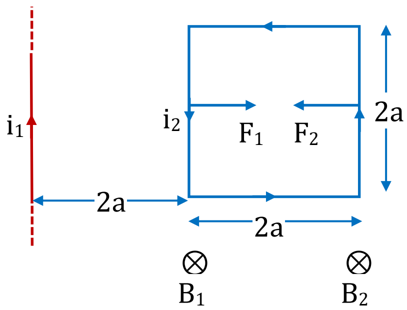
$$B = \frac{mg}{i \times \ell} = \frac{60 \times 10^{-3} \times 9.8}{5 \times 0.45}$$

$= 0.26\ T$

(b) $T_{net} = T_1 + T_2 = mg + i\ell B$

$= 1.176\ N$

13. **Ans.** 1



$F_{net} = F_1 - F_2$

$= i_2B_1(2a) - i_2(B_2)(2a)$

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

$$= \frac{2\mu_0}{4\pi} - \frac{\mu_0}{4\pi} = \frac{\mu_0}{4\pi}$$

$\therefore\ \beta = 1$

14. **Ans.** (a) zero (b) $|\vec{\tau}| = 20\sqrt{2}Nm, \vec{\tau} = 20\hat{\imath} - 20\hat{\jmath}$

(a) Net force is zero on a current carrying loop placed in uniform magnetic field

$$\vec{F} = i\int (d\vec{l} \times \vec{B}) = i\left(\int d\vec{l}\right) \times \vec{B}$$

$\because$ $\int d\vec{l} = 0$ for a closed loop, $\vec{F} = 0$

(b) $\vec{m} = IA\hat{k}$

$\vec{\tau} = \vec{m} \times \vec{B} = 5(2)\hat{k} \times (2\hat{i} + 2\hat{j} - 4\hat{k})$

$\vec{\tau} = 20\hat{j} - 20\hat{i}$

$\vec{\tau} = 20\sqrt{2}Nm$

15. **Ans.** Use $\tau = I(A \times B)$ and $F = I(l \times B)$

(a) 1.8×10^{-2} $N\,m$ along $-y$ direction, (b) Same as in (a)

(c) 1.8×10^{-2} $N\,m$ along $-x$ direction, (d) 1.8×10^{-2} $N\,m$ at an angle of 240° with the $+x$ direction

(e) Zero, (f) Zero

Force is zero in each case. Case (e) corresponds to stable, and case (f) corresponds to unstable equilibrium.

16. **Ans.** $T_0 = 2\pi\sqrt{\dfrac{m}{6IB}} = 0.57s$

$\tau = mB\sin\theta$

$$\Rightarrow \quad \alpha = \left(\frac{mB}{I}\right)\theta \qquad \{\because \sin\theta \approx \theta\}$$

$$\omega = \sqrt{\frac{mB}{I}}$$

Here I is the moment of inertia of the loop

$$I = \frac{m}{4}\left(\frac{a}{2}\right)^2 \times 2 + \frac{1}{12}\left(\frac{m}{4}\right)a^2 \times 2 = \frac{ma^2}{6}$$

And magnetic moment = $m = ia^2$

$$\omega = \sqrt{\frac{6ia^2B}{ma^2}} = \sqrt{\frac{6iB}{m}}$$

Hence, $T = 2\pi\sqrt{\dfrac{m}{6iB}}$ where i = current, m = mass of loop

17. **Ans.** (a) $\dfrac{\mu_0\sigma\omega R}{2}$, (b) $\dfrac{\sigma\omega\pi R^4}{4}$

Let us take a ring element of radius r and thickness dr, then charge on the ring element.

$$dq = \sigma 2\pi r dr$$

Current due to this element

$$di = \frac{(\sigma 2\pi r dr)\omega}{2\pi} = \sigma\omega r dr$$

So, magnetic induction at the center, due to this element

$$dB = \frac{\mu_0 di}{2r}$$

And, From symmetry

$$B = \int dB = \int_0^R \frac{\mu_0\sigma\omega r dr}{2r} = \frac{\mu_0}{2}\sigma\omega R$$

(b) Magnetic moment of element, considered,

$$dP_m = (di)\pi r^2 = \sigma\omega dr \pi r^2 = \sigma\pi\omega r^3 dr$$

Magnetic moment

$$P_m = \int dP_m = \int_0^R \sigma\pi\omega r^3 dr = \sigma\omega\pi\frac{R^4}{4}$$

18. **Ans.** $29pT$

$$B = \frac{2}{3}\mu_0\sigma\omega R = 29pT$$

EXERCISE - JEE (Main) PYQ

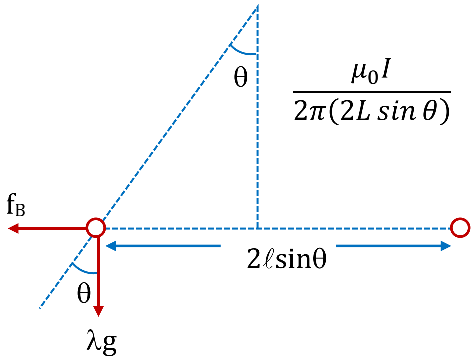
1. **Ans. (1)**

Coercivity = $\frac{B}{\mu_0}$ = 3 × 10³ = nI

3 × 10³ = 1000 I

I = 3A

2. **Ans. (4)**



$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi(2L\sin\theta)}$$

$\tan\theta = \frac{f_B}{\lambda g}$ where f_B is force per unit length (Bi)

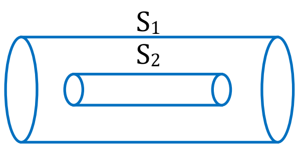
$$\lambda g \tan\theta = \frac{\mu_0 I}{2\pi(2L\sin\theta)} \times I$$

On solving

$$I = 2\sin\theta\sqrt{\frac{\pi\lambda g L}{\mu_0\cos\theta}}$$

3. **Ans. (3)**

Field due to solenoid 2 outside the solenoid is zero



$\therefore \quad \vec{f}_1 = 0$

Due to action reaction $\vec{f}_2 = 0$

or solenoid 2 behave as magnetic dipole

$$\vec{f}_2 = \frac{M\,dB}{dx}$$

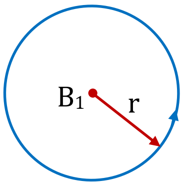
field of 1 is uniform $\therefore \frac{dB}{dx} = 0$

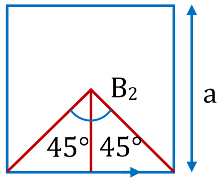
$f_2 = 0$

4. **Ans. (1)**

For electromagnet and transformers, we require the core that can be magnetised and demagnetised quickly when subjected to alternating current. From the given graphs, graph B is suitable.

5. Ans. (1)





$B_1 = \frac{\mu_0 i}{2r}$

$B_2 = 4 \times \frac{\mu_0}{4\pi} \times \frac{i}{\left(\frac{a}{2}\right)} \left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right)$

$\frac{B_1}{B_2} = \frac{\pi a}{4\sqrt{2} r}$

$\ell = 2\pi r = 4a$

$\frac{B_1}{B_2} = \frac{\pi}{4\sqrt{2}} \frac{\pi}{2}$

$\frac{a}{r} = \frac{2\pi}{4} = \frac{\pi}{2}$

$= \frac{\pi^2}{8\sqrt{2}}$

6. Ans. (3)

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

$I = 7.5 \times 10^{-6}\ kg - m^2$

$M = 6.7 \times 10^{-2}\ Am^2$

By substituting value in the formula

$T = 0.665$ sec

for 10 oscillation, time taken will be

Time = 10 T = 6.65 sec

7. Ans. (2)

Dipole moment of circular loop is m

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

$B_1 = \frac{\mu_0 I}{2R}$

Moment becomes double

$\Rightarrow$ R becomes $\sqrt{2}R$ (keeping current constant)

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

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

$\frac{B_1}{B_2} = \sqrt{2}$

8. Ans. (3)

$x \, \alpha \, \frac{1}{T_C}$

Curie law for paramagnetic substance

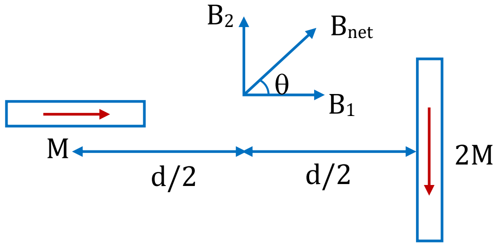
$$\frac{x_1}{x_2} = \frac{T_{C_2}}{T_{C_1}}$$

$$\frac{2.8\times10^{-4}}{x_2} = \frac{300}{350}$$

$$x_2 = \frac{2.8\times350\times10^{-4}}{300}$$

$$= 3.266 \times 10^{-4}$$

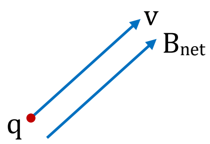
9. Ans. (4)



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

$B_1 = B_2$

$\Rightarrow$ B_{net} is at 45° (θ = 45°)

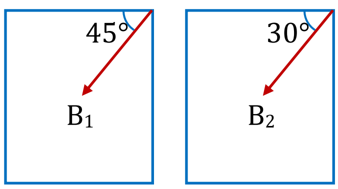


Velocity of charge and B_{net} are parallel so by $\vec{F} = q\left(\vec{v}\times\vec{B}\right)$ force on charge particle is zero.

10. Ans. (3)

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{\mu B_1 \cos 45°}{I}} \quad f_2 = \frac{1}{2\pi}\sqrt{\frac{\mu B_2 cos 30°}{I}}$$

$$\frac{f_1}{f_2} = \sqrt{\frac{B_1 \cos 45°}{B_2 \cos 30°}} \quad \therefore \frac{B_1}{B_2} \simeq 0.7$$



11. Ans. (1)

$\because M = NIA$

$dq = \lambda dx$ & $A = \pi x^2$

$$\int dm = \int (n)\frac{\rho_0 x}{\ell} dx.\pi x^2$$

$$M = \frac{n\rho_0\pi}{\ell}.\int_0^{\ell} x^3.dx = \frac{n\rho_0\pi}{\ell}.\left[\frac{L^4}{4}\right]$$

$$M = \frac{n\rho_0\pi\ell^3}{4} \text{ or } \frac{\pi}{4}n\rho\ell^3$$

12. Ans. (1)

$R_g = 20\Omega$

$N_L = N_R = N = 30$

$FOM = \frac{I}{\phi} = 0.005\ A/\text{Div.}$

Current sentivity = $CS = \left(\frac{1}{0.005}\right) = \frac{\phi}{I}$

$Ig_{max} = 0.005 \times 30$

$= 15 \times 10^{-2} = 0.15$

$15 = 0.15\ [20 + R]$

$100 = 20 + R$

$R = 80$

13. Ans. (4)

$\vec{F}_{net} = q\vec{E} + q(\vec{v} \times \vec{B})$

$= (2q\hat{i} + 3q\hat{j}) + q(\vec{v} \times \vec{B})$

$W = \vec{F}_{net}.\vec{S}$

$= 2q + 3q$

$= 5q$

14. Ans. (2)

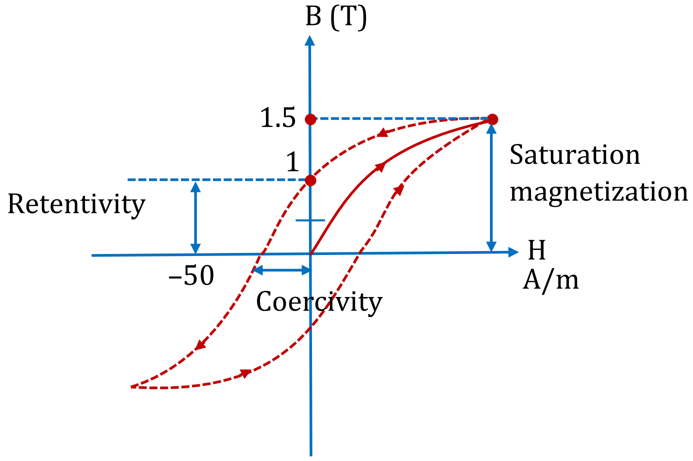
$|\vec{\tau}| = |\vec{M} \times \vec{B}|$

$\tau = NI \times A \times B \times \sin 45°$

$\tau = 0.27\ Nm$

Option (2)

15. Ans. (2)



Retentivity = 1.0 T

Coercivity = 50 A/m

Saturation = 1.5 T

16. **Ans. (2)**

For paramagnetic material

According to curies law

$\chi \propto \frac{1}{T}$ $\qquad\qquad$ $\chi \propto \frac{1}{T} \Rightarrow \chi_1 T_1 = \chi_2 T_2$

$$\Rightarrow \quad \frac{6}{0.4} \times 4 = \frac{I}{0.3} \times 24$$

$$I = \frac{0.3}{0.4} = 0.75\ A/m$$

17. **Ans. (1)**

A perfect diamagnetic substance will completely expel the magnetic field. Therefore, there will be no magnetic field inside the cavity of sphere. Hence the paramagnetic substance kept inside the cavity will experience no force.

18. **Ans. (3)**

$(2V_0)^2 = v_0^2 + \upsilon_x^2$

$v_x = \sqrt{3}\ v_0$

$\sqrt{3}\, v_0 = 0 + \frac{qE_0}{m} t$

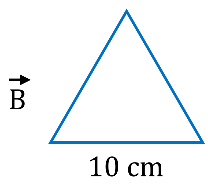
$$t = \frac{\sqrt{3} v_0 m}{qE_0}$$

19. **Ans. (3)**

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

$= MB = \frac{i\sqrt{3}\ell^2}{4} B$

$= \sqrt{3} \times 10^{-5} N - m$



Ans. 3

20. **Ans. (3)**

$$B_C = B = \frac{\mu_0 I}{2r}, B_a = \frac{\mu_0 I r^2}{2(x^2 + r^2)^{3/2}}$$

At $x = \frac{r}{2}$

$$B_a = \frac{\mu_0 I r^2}{2\left(\frac{r^2}{4} + r^2\right)^{3/2}}$$

$$= \frac{\mu_0 I r^2}{2\left(\frac{5}{4} r^2\right)^{3/2}} = \frac{\mu_0 I}{2r}\left(\frac{4}{5}\right)^{3/2}$$

$$B_a = \frac{\mu_0 I}{2r}\left(\frac{2}{\sqrt{5}}\right)^3 = B\left(\frac{2}{\sqrt{5}}\right)^3$$

21. **Ans. (6)**

$I = H$

Given, $I = 2.4 \times 10^3\, A/m$

$2.4 \times 10^3 = H = ni$

$n = \frac{N}{\ell}$

$2.4 \times 10^3 = \frac{60}{15\times10^{-2}}\, i$

$i = \frac{2.4\times15\times10}{60} = \frac{36}{6} = 6A$

22. **Ans. (2)**

$\ell = 50\ cm$

$t = 1\ sec$

$\therefore \quad V = \frac{0.05}{1} = 0.05 m/s.$

$i = \frac{40\times0.05\times0.05}{10} = 0.01A$

$\therefore \quad F = B_i\ell = 40 \times 0.01 \times 0.05$

$F = 0.02\ N$

$\therefore \quad W = 0.02 \times \ell = 0.02 \times .05$

$\therefore \quad W = 1 \times 10^{-3} J$

23. **Ans. (4)**

$d \tan 60° = 2\sqrt{3}$

$d = 2\ cm$

$B = 3 \times \frac{\mu_0 i}{2\pi d} \sin 60°$

$= 3 \times \frac{2\times10^{-7}\times2}{2\times10^{-2}} \times \frac{\sqrt{3}}{2}$

$= 3\sqrt{3} \times 10^{-5}$

EXERCISE - JEE (Advanced) PYQ

1. Ans. (3)

If current is in same direction, then magnetic field at point P will be

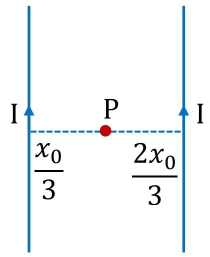
$$B_1 = \frac{\mu_0 I}{2\pi\left(\frac{x_0}{3}\right)} - \frac{\mu_0 I}{2\pi\left(\frac{2x_0}{3}\right)}$$

$$B_1 = \frac{3\mu_0 I}{4\pi x_0}$$

If current is in opposite direction, then magnetic field at point P will be

$$B_2 = \frac{\mu_0 I}{2\pi\left(\frac{x_0}{3}\right)} + \frac{\mu_0 I}{2\pi\left(\frac{2x_0}{3}\right)}$$

$$B_2 = \frac{9\mu_0 I}{4\pi x_0}$$



Radius of curvature, $R = \frac{mu}{qB} \Rightarrow R \propto \frac{1}{B}$

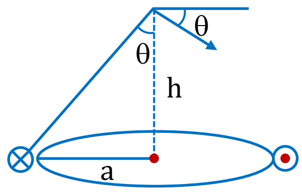
So, $\frac{R_1}{R_2} = \frac{B_2}{B_1} = 3$

2. Ans. (C)

$$B_{\text{wire}} = \frac{\mu_0 i}{2\pi\sqrt{a^2+h^2}} \; 2\sin\theta$$

$$= \frac{\mu_0 ia}{\pi(a^2+h^2)}$$

$$B_{\text{loop}} = \frac{\mu_0 ia^2}{2(a^2+h^2)^{3/2}}$$



Loop

$B_{\text{wire}} = B_{\text{loop}}$

$$\frac{\mu_0 ia}{\pi(a^2+h^2)} = \frac{\mu_0 ia^2}{2(a^2+h^2)^{3/2}}$$

$$\sqrt{a^2+h^2} = \frac{\pi a}{2}$$

$a^2 + h^2 = 2.5\, a^2$

$h^2 = 1.5a^2$

$h \approx 1.2\, a$

3. Ans. (B)

$|\vec{\tau}| = |\vec{M} \times \vec{B}| = MB\sin 30°$

where $M = (\pi a^2)I$ and $B = 2\times\frac{\mu_0 I}{2\pi d} = \frac{\mu_0 I}{\pi d}$

Therefore $\tau = \left(\frac{\mu_0 I}{\pi d}\right)(\pi a^2 I)\left(\frac{1}{2}\right) = \frac{\mu_0 I^2 a^2}{2d}$

4. **Ans. (ABC)**

$\vec{F} = I\left(\overrightarrow{\text{Displacement}}\right) \times \vec{B}$

As magnetic field is uniform

$$\vec{F} = I(2L + 2R)\hat{i} \times \vec{B}$$

When $\vec{B}$ is along y or z axis

$$F \propto (L + R)$$

When $\vec{B}$ is along x-axis

$$F = 0$$

$\therefore$ (A,B,C)

5. **Ans. (A)**

$\vec{F}_{net} = \vec{F}_e + \vec{F}_B = q\vec{E} + q\vec{v} \times \vec{B}$

For particle to move in straight line with constant velocity, $\vec{F}_{net} = 0$

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

6. **Ans. (C)**

For path to be helix with axis along $+ve$ z-direction, particle should experience a centripetal acceleration in x-y plane.

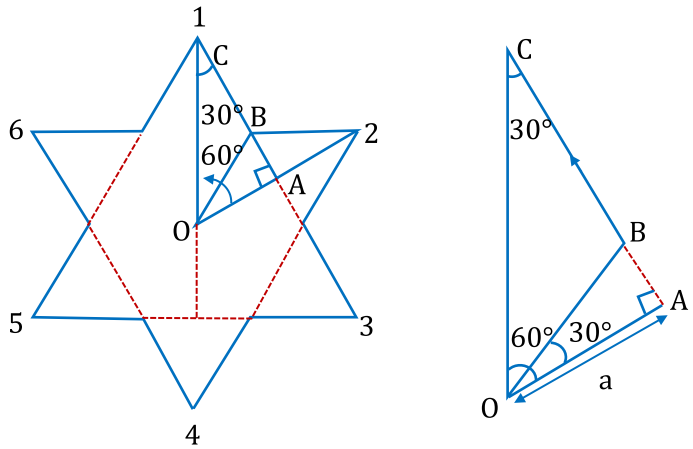
For the given set of options only option (C) satisfy the condition. Path is helical with increasing pitch.

7. **Ans. (D)**

For particle to move in $-ve$ y-direction, either its velocity must be in $-ve$ y-direction (if initial velocity $\neq 0$) and force should be parallel to velocity or it must experience a net force in $-ve$ y-direction only (if initial velocity = 0)

8. **Ans. (B)**

The given points (1, 2, 3, 4, 5, 6) makes 360° angle at 'O'. Hence angle made by vertices 1 and 2 with 'O' is 60°.



Direction of magnetic field at 'O' due to each segment is same. Since it is symmetric star shape, magnitude will also be same.

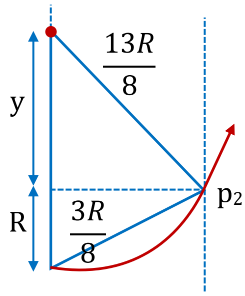
Magnetic field due to section BC.

$$(B_1) = \frac{ki}{a}\left(\sin(+60) - \sin 30\right) = \frac{ki}{2a}\left(\sqrt{3} - 1\right)$$

$$B_{\text{net}} = 12 \times B_1 = \frac{6ki}{a}\left(\sqrt{3} - 1\right) \& \left(k = \frac{\mu_0}{4\pi}\right)$$

9. Ans. (AB)

For $B = \frac{8}{13}\frac{p}{QR}$, radius of path



$R' = \frac{p}{Q.B} = \frac{p \times 13QR}{Q8p} = \frac{13}{8}R$

Using Pythagoras theorem, $y = \frac{5R}{8}$

$\therefore$ Particle will enter region 3 through point P_2

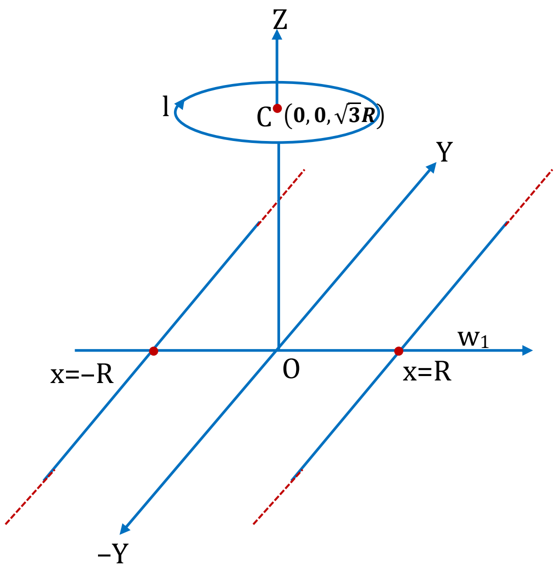
For $B > \frac{2}{3}\frac{p}{QR}$

Radius of path < $\frac{3PQR}{Q2p} = \frac{3}{2}R$

$\therefore$ Particle will not enter in region 3 and will re-enter region 1.

Change in momentum $=\sqrt{2}p$, when particle enters region 1 between entry point and farthest point from y-axis.

10. Ans. (ABD)

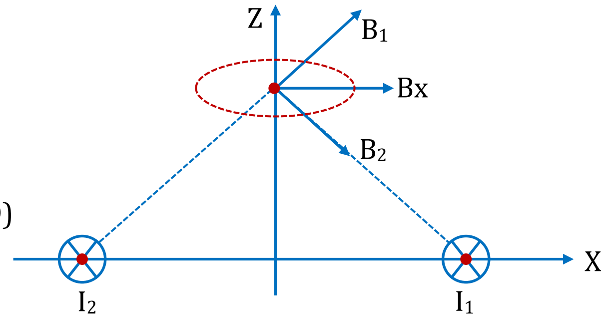


(A) At origin, $\vec{B} = 0$ due to two wires if $I_1 = I_2$, hence $(\vec{B}_{net})$ at origin is equal to $\vec{B}$ due to ring, which is non-zero.

(B) If $I_1 > 0$ and $I_2 < 0$, $\vec{B}$ at origin due to wires will be along $+\hat{k}$ direction and $\vec{B}$ due to ring is along $-\hat{k}$ direction and hence $\vec{B}$ can be zero at origin.

(C) If $I_1 < 0$ and $I_2 > 0$, $\vec{B}$ at origin due to wires is along $-\hat{k}$ and also along $-\hat{k}$ due to ring, hence $\vec{B}$ cannot be zero.

(D)



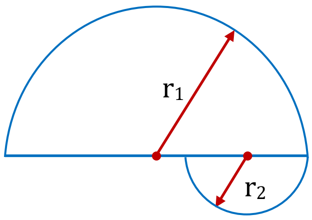
At centre of ring, $\vec{B}$ due to wires is along x-axis,

hence z-component is only because of ring which $\vec{B} = \frac{\mu_0 i}{2R}(-\hat{k})$

11. Ans. (2) [1.99, 2.01]

(1) Average speed along x-axis

$$\langle v_x \rangle = \frac{\int |\vec{v}_x| dt}{\int dt} = \frac{d_1 + d_2}{t_1 + t_2}$$



(2) We have,

$$r_1 = \frac{mv}{qB_1}, r_2 = \frac{mv}{qB_2}$$

Since $B_1 = \frac{B_2}{4}$

$\therefore \quad r_1 = 4r_2$

Time in $B_1 \Rightarrow \frac{\pi m}{qB_1} = t_1$

Time in $B_2 \Rightarrow \frac{\pi m}{qB_2} = t_2$

Total distance along x-axis $d_1 + d_2 = 2r_1 + 2r_2 = 2\,(r_1 + r_2) = 2\,(5r_2)$

Total time $T = t_1 + t_2 = 5t_2$

$\therefore$ Average speed = $\frac{10r_2}{5t_2} = 2\frac{mv}{qB_2} \times \frac{qB_2}{\pi m} = 2$

12. Ans. (B)

Torque experienced by circular loop = $\vec{M} \times \vec{B}$

where $\vec{M}$ is magnetic moment

$\vec{B}$ is magnetic field

$\therefore \quad \tau = i\pi R^2 N B_0$ [at the instant shown $\theta = \pi/2$]

$\therefore \quad \tau dt = dL = i\pi R^2 N B_0\, dt = Q\pi R^2 N B_0$ [$idt = Q$]

13. Ans. (4)

$$r=\frac{mv}{qB}=\frac{\sqrt{2mqV}}{qB}\quad\left\{\because\ \frac{p^2}{2m}=K.E=qV\right\}$$

$$\frac{r_S}{r_\alpha}=\sqrt{\frac{32}{1}\times\frac{2}{4}}=4$$

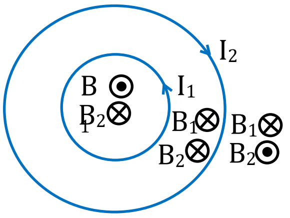
$$\frac{r_S}{r_\alpha}=4$$

14. Ans. (AB)

(A) $d\vec{B}=\frac{\mu_0 i d\vec{\ell}\times\vec{r}}{4\pi r^3}$

$\vec{d\ell}$ is in *xy* plane & $\vec{r}$ is also in *xy* plane

so $d\vec{B}$ is perpendicular to *xy* plane



(B) Due to symmetry it depends only on $r=\sqrt{x^2+y^2}$

(C) At centre $B_1=\frac{\mu_0 I_1}{2R}$; $B_2=\frac{\mu_0 I_2}{4R}\Rightarrow B_2>B_1$

but 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.

15. Ans. (C)

$$\vec{B}=\frac{\mu_0 I}{4\pi L}\sin 45^\circ\left(-\hat{k}\right)+\frac{\mu_0 I\pi}{4\pi\frac{L}{2}}\left(-\hat{k}\right)+\frac{\mu_0 I}{4\pi\frac{L}{4}}\times\frac{\pi}{2}\left(-\hat{k}\right)$$

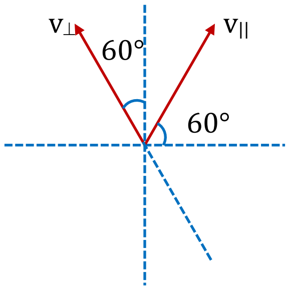
$$\vec{B}=\frac{-\mu_0 I}{L}\left(\frac{1}{4\sqrt{2}\pi}+\frac{1}{2}+\frac{1}{2}\right)$$

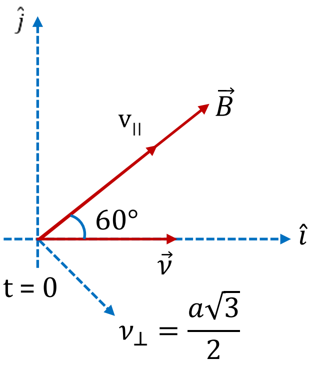
JEE (Main) Practice Paper

SECTION–A

1. Ans. (2)

When Z – coordinate is maximum,





$$v_y=\frac{a\sqrt{3}}{2}\cos 60^\circ+\frac{a}{2}\sin 60^\circ$$

$$v_y=\frac{a\sqrt{3}}{4}+\frac{a\sqrt{3}}{4}=\frac{a\sqrt{3}}{2}$$

2. **Ans. (1)**

At point A direction of magnetic field due to wires is opposite to each other.

$$B_P = \frac{\mu_0 I}{2\pi(10)} \odot$$

$$B_Q = \frac{2\mu_0 I}{2\pi(20)} \otimes$$

$$\vec{B}_P + \vec{B}_Q = 0$$

3. **Ans. (3)**

N become double and radius become half.

4. **Ans. (4)**

$B = \mu_0 ni$

$$= 4\pi \times 10^{-7} \times \frac{1}{0.1 \times 10^{-3}} \times 1$$

$= 4\pi \times 10^{-3}\, J$

5. **Ans. (4)**

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

$$R_M < R_N \Rightarrow \left(\frac{m}{q}\right)_M < \left(\frac{m}{q}\right)_N$$

$$\left(\frac{m}{q}\right)_M = \frac{m}{e} \text{ for proton}$$

$$\left(\frac{m}{q}\right)_N = \frac{4m}{2e} = \frac{2m}{e} \text{ for } \alpha\text{-particle}$$

6. **Ans. (2)**

Theoretical.

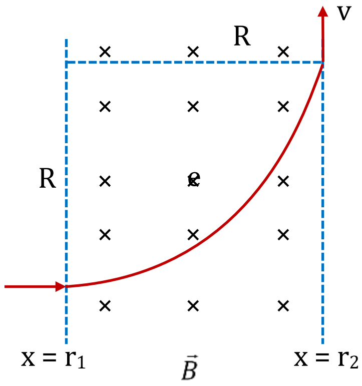
7. **Ans. (1)**

Since magnetic force can not charge speed of charged particle $\therefore\ 2 = |\hat{i} + \hat{j} + m\hat{k}|$ or $m = \pm\sqrt{2}$

8. **Ans. (3)**

$$r = \frac{\sqrt{2mkE}}{qB} = \frac{\sqrt{2mqV}}{qB}$$

9. Ans. (3)



$$R=\frac{mv}{qB}=\frac{v}{\sigma B}$$

$$r_2-r_1=\frac{v}{\sigma B}$$

$\Rightarrow \quad v = \sigma(r_2 - r_1)B$

10. Ans. (4)

Magnetic field can do no work

$\therefore \quad KE_f = KE_i$

$v = v_0$

11. Ans. (3)

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

$V_\perp$ gets reversed

$\vec{v} = 2\hat{\imath} - 3\hat{\jmath} - 4\hat{k}$

$q(\vec{E} + \vec{v} \times \vec{B}) = 0$

$\vec{E} = -(\vec{v} \times \vec{B})$

$= -(2\hat{\imath} - 3\hat{\jmath} - 4\hat{k}) \times 2\hat{\imath}$

$= -6\hat{k} + 8\hat{\jmath}$

12. Ans. (4)

Magnetic force on positive and negative particles will be opposite direction.

13. Ans. (4)

Clearly $F = Bi\ell = Bi \times (2b)$

$\therefore \quad a = \frac{F}{m}=\frac{2ibB}{m}$

14. Ans. (4)

Positive particles experience magnetic force $\vec{F}_m = q\ v\left(\hat{j}\times B\hat{i}\right)=-qvB\hat{k}$

Hence a layer of positive particle gets deposited at the bottom of slab.

Hence, $\vec{E}$ is towards positive z-axis.

15. Ans. (2)

Magnetic moment of current carrying triangular loop $M = IA$

$$M = 0.2\left(\frac{1}{2}\times 5\times 10^{-2}\times \frac{\sqrt{3}\times 5\times 10^{-2}}{2}\right)$$

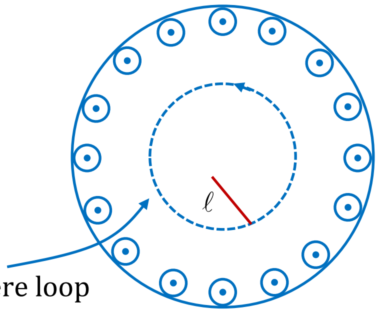
$$= 2.2 \times 10^{-4}\ A\text{-}m^2$$

16. Ans. (3)

We know that $\dfrac{\text{Magnetic moment }(\text{M})}{\text{Angular momentum}(\text{L})} = \dfrac{q}{2m}$

17. Ans. (3)

By using ampere circuital law



Ampere loop

$$\oint \vec{B}.\vec{d\ell} = \mu_0 i_{en} = o$$

$$B(2\pi r) = 0$$

$$\Rightarrow \quad B = 0$$

18. Ans. (1)

$$T' = 2\pi\sqrt{\frac{\ell}{g_{eff}}}$$

ℓ = length of threads

$$T' = \frac{T}{\sqrt{2}}$$

where $T = 2\pi\sqrt{\dfrac{\ell}{g}}$

$$g_{eff} = 2g = (g + a)$$

$\therefore$ Net downwards force = $2mg = mg + iBL$

$$\therefore \quad i = \frac{mg}{BL}$$

19. Ans. (1)

$$\frac{\mu_0 i}{4\pi r}\left(-\hat{j}\right) - \frac{\mu_0 i}{4R}\left(-\hat{k}\right)$$

20. Ans. (2)

By $B = \dfrac{\mu_0}{4\pi}\dfrac{I}{r}(\theta_R)$

SECTION–B

1. **Ans. (1)**

Consider unit length of cylinder charge = $\sigma 2\pi R \times 1$

Time = $2\pi/\omega$

So $ni = \dfrac{2\pi R\sigma\omega}{2\pi} = \sigma R\omega$

Now $B = \mu_0 ni$

$B = \mu_0 \sigma R\omega$

2. **Ans. (6)**

$F = Bi\,(2R) \times 12$

$= 24\,B\,i\,r$

$\therefore \quad \alpha + \beta = 6$

3. **Ans. (2)**

$\vec{B}_{net} = \vec{B}_x + \vec{B}_y$

$B_{net} = \dfrac{\mu_0 i_1}{2R_1}$ (Towards east)

$+ \dfrac{\mu_0 i_2}{2R_2}$ (towards west)

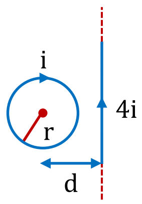
$\dfrac{\mu_0}{2}\left(\dfrac{i_2}{R_2} - \dfrac{i_1}{R_1}\right)$ (towards west)

$B_{net} = 5\pi \times 10^{-4}\,T = 1.6 \times 10^{-3}\,T$

4. **Ans. (4)**

$\dfrac{\mu_0 i}{2r} - \dfrac{\mu_0 \times 4\hat{i}}{2\pi d} = 0$

$d = \dfrac{4r}{\pi}$ from centre of ring

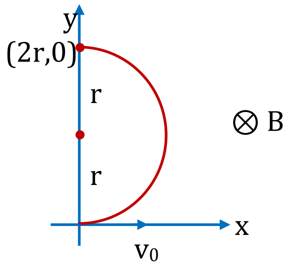


5. **Ans. (2)**

$\oint B \cdot d\ell = \mu_0 I_{enclosed}$

$= \mu_0(6 - 5) = \mu_0$ weber/m

6. **Ans. (4)**



$r = \dfrac{mv_0}{qB}$

By coordinate

$= 2r = \dfrac{2mv_0}{qB}$

7. Ans. (44)

$$r=\frac{m_p v\sin\theta}{qB}=\frac{1.67\times10^{-27}\times4\times10^{5}\times\sqrt{3}}{1.6\times10^{-19}\times0.3\times2}=1.2\times10^{-2}m$$

Time period = $\frac{2\pi r}{v\sin\theta}$

Pitch = (v cos θ) × time period = $v\cos\theta\times\frac{2\pi r}{v\sin\theta}$

= $\frac{2\pi r}{\tan}$

= 4.37 × 10^{-2} m

8. Ans. (14)

Current sensitivity $\left(\frac{\theta}{i}\right)=\frac{nAB}{C}$

9. Ans. (4)

$$\tan\theta'=\frac{B'_V}{B'_H}=\frac{B_V}{B_H\cos\alpha}=\frac{\tan\theta}{\cos\alpha}$$

$\Rightarrow$ $\tan\theta=(\cos\alpha)\tan\theta'=(\cos37°)(\tan45°)=\frac{4}{5}$

10. Ans. (2600)

Coercivity = $H=\frac{B}{\mu_0}$

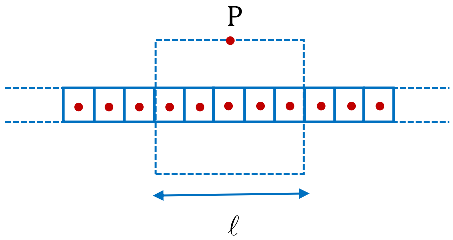
= ni $=\frac{N}{\ell}i=\frac{100}{0.2}\times5.2$

= 2600 A/m

JEE (Advanced) Practice Paper

1. Ans. (C)

Magnetic field due to whole plate



$$\oint B\cdot d\ell=\mu_0 J\times\ell$$

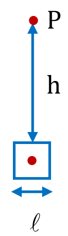
$B\cdot2\ell$ = $\mu_0 J\ell$

$$B=\frac{\mu_0 J}{2}\left(-\hat{i}\right)$$

Magnetic field due to small segment of width a.

Since small segment will behave like a long infinite wire carring current $I = J\cdot a$

So $B=\frac{\mu_0(Ja)}{2\pi h}\left(-\hat{i}\right)$



So magnetic field due to plate after removing small segment

$$B=\frac{\mu_0 J}{2}-\frac{\mu_0 Ja}{2\pi h}$$

$$=\frac{\mu_0 J}{2}\left(1-\frac{a}{\pi h}\right)\left(-\hat{i}\right)$$

2. Ans. (B)

$$B_{net} = \frac{\mu_0 I}{2\sqrt{3}\pi a} - \frac{\mu_0 I}{4\sqrt{3}\pi a} + \frac{\mu I}{6\sqrt{3}\pi a} + \ldots\ldots\ldots\ldots\ldots\ldots \infty$$

$$= \frac{\mu_0 I}{2\sqrt{3}\pi a}\left(1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \ldots\ldots\ldots\ldots\ldots\ldots\infty\right)$$

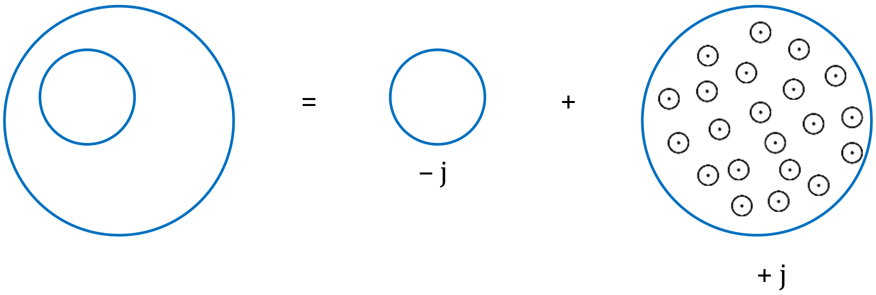
$$\ell n(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} + \ldots\ldots\ldots\ldots\infty$$

$$\ell n(2) = 1 - \frac{1}{2} + \frac{1}{3} + \ldots\ldots\ldots\ldots\infty$$

$$B_{net} = \frac{\mu_0 I \cdot \ell n2}{2\sqrt{3}\pi a} = \frac{\mu_0 I \ell n4}{4\sqrt{3}\pi a}$$

3. Ans. (B)

We can imagine a reverse current in the cavity region



MF due to +*j* at a distance *r* from the axis

$$B(2\pi r) = \mu_0 j(\pi r^2)$$

$$\Rightarrow \quad B = \frac{\mu_0 jr}{2}$$

Similarly *MF* due to –*j* at a distance r from the axis of smaller cylinder

$$\Rightarrow \quad B = \frac{-\mu_0 jr}{2}$$

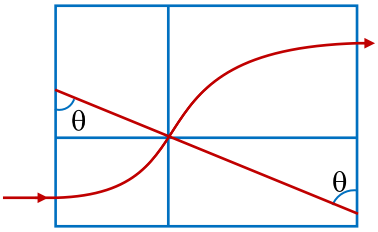
∴ $B = O$ on the axis of smaller cylinder Hence total *MF* on the axis of smaller cylinder is only due to +*j*.

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

Now, $i = \left(\pi b^2 - \pi a^2\right) j \Rightarrow j = \frac{i}{\pi\left(b^2 - a^2\right)}$

$$\therefore \quad B = \frac{\mu_0 ic}{2\pi\left(b^2 - a^2\right)}$$

4. **Ans. (A)**



$$\sin\theta = \frac{d_1}{r_1} = \frac{d_2}{r_2}$$

5. **Ans. (A)**

Magnetic field is circular loop due to straight current carrying wire and there super position is shown in option (A).

6. **Ans. (BCD)**

If $\vec{v}\cdot\vec{B} \neq 0$ then path will be helical

If $\vec{v}\cdot\vec{B} = 0$ then path will be circular

If $\vec{v}\times\vec{B} = 0$ then force on charge will be zero, so path will be straight line.

Distance travelled depends on speed of particle and magnetic force connot change speed of the particle.

7. **Ans. (ABC)**

$E = \dfrac{Qx}{4\pi\epsilon_0\left(R^2+x^2\right)^{3/2}}$; Equivalent current = i = $\left(\dfrac{\omega}{2\pi}\right)Q$

$B = \dfrac{\mu_0 i R^2}{2\left(R^2+x^2\right)^{3/2}} = \dfrac{\mu_0 Q\omega R^2}{4\pi\left(R^2+x^2\right)^{3/2}}$ $\therefore \dfrac{B}{E} = \dfrac{\omega R^2}{xc^2}$

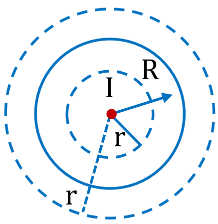
8. **Ans. (ABD)**

Only for option (3); $B = 0$ at $d/2$ between two wires.

9. **Ans. (C)**

Inside the cylinder

$$B = \frac{\mu_0 I}{2\pi R^2} r \qquad \text{...(i)}$$



Outside the cylinder

$$\therefore \quad B = \frac{\mu_0 I}{2\pi r} \qquad \text{...(ii)}$$

Inside cylinder $B \propto r$ and outside $B \propto \dfrac{1}{r}$

So, from surface of cylinder nature of magnetic field changes.

Hence it is clear from the graph that wire 'c' has greatest radius.

10. **Ans. (A)**

Inside the wire $B(r)=\frac{\mu_0}{2\pi}\frac{I}{R^2}r$; $\frac{dB}{dr}=\frac{\mu_0}{2\pi}\frac{I}{R^2}$ i.e. slope $\propto \frac{I}{\pi R^2}$ $\propto$ current density.

It can be seen that slope of curve for wire a is greater than wire *c*.

11. **Ans. (B)**

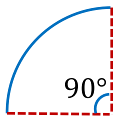
$P_{diss} = i^2R$

$\Delta H = i^2R\Delta t = 10^8 \times 10^{-3} = 10^5\ J$

12. **Ans. (A)**

$R = 10m = \frac{mv}{qB}$

$\Rightarrow \quad B = \frac{0.1\times 50}{1\times 10} = 0.5T$



13. **Ans. (6)**

$x_0 = \frac{1}{2}\frac{qE}{m}(3T)^2$; $T = \frac{2\pi m}{qB}$

14. **Ans. (3)**

Considering the upper half of the area :-

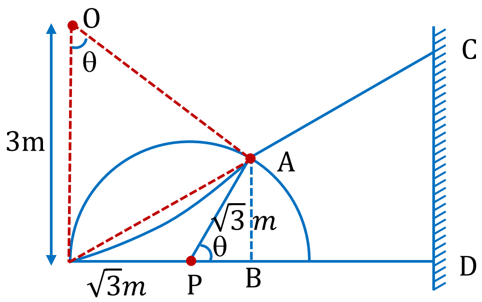
Radius of particle in circular motion = $\frac{mv}{qB}$ = 3 meter.

Radius of circular region = $\sqrt{3}$ meter

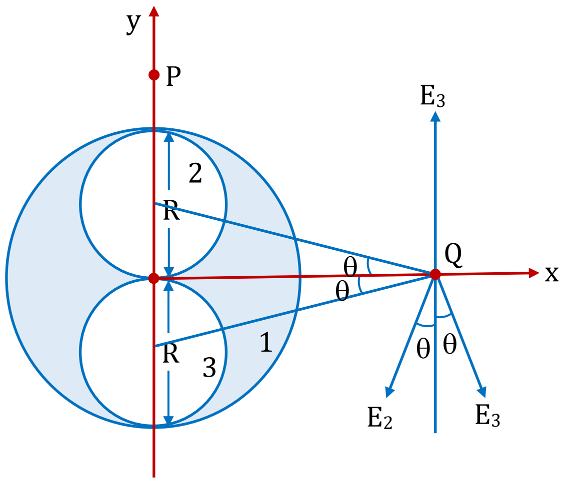
from trigonometry, $\theta = \frac{\pi}{3}$.

$\therefore \quad CD = 6m$

Distance between the points where charges will strike after deflection = (6 + 6) = 12*m*.



15. **Ans. (9)**



$\tan\theta = \frac{1}{4}$

Assume hollow cylinders as current density ± *J* and find E_1, E_2 and E_3 individually finally add all of them.

16. **Ans. (15)**

$$\int F dt = mv$$

$$\int (i\ell B) = mv$$

$$\int i dt = \frac{mv}{\ell B} = \frac{m\sqrt{2gh}}{\ell B} = \frac{10^{-2}\sqrt{2\times10\times3}}{0.2\times0.1} = \sqrt{15}C$$

17. **Ans. (4)**

$mg - qE = mg_{eff.}$

$g - \frac{qE}{m} = g_{eff.}$

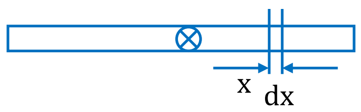
$$T = 2\pi\sqrt{\frac{\ell}{g - q\frac{E}{m}}}$$

$$T = 2\pi\sqrt{\frac{1}{10 - \frac{10^{-6}\times7.5}{10^{-6}}}} = 4 \text{ sec}$$

18. **Ans. (4)**

Current due to rotation of rod at a distance

$x = (dq)f = \left(\frac{2q}{\ell}\right)\cdot dx\frac{\omega}{2\pi}$



$$\therefore \quad dM = \left(\frac{2q}{\ell}\frac{\omega}{2\pi}dx\right)\pi x^2$$

$$\therefore \quad M = \int dM = \frac{2q}{\ell}\frac{\omega}{2}\cdot\left[\frac{x^3}{3}\right]_0^{\frac{\ell}{2}} = \frac{q\omega}{3\ell}\cdot\frac{\ell^3}{8} = \frac{q\omega\ell^2}{24}$$