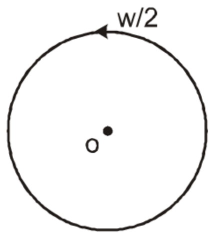
Exercise-1

Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

Section (A) : Magnet and Magnetic field due to a moving charge

A-1. Sol. $B = \frac{\mu_0 i}{2R}$



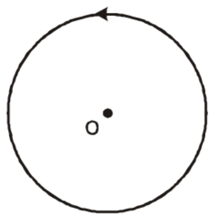
$= \frac{\mu_0 qf}{2R}$

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

or $B = \frac{\mu_0 100 \times 1.6 \times 10^{-19} \times 10^{11} \times 2\pi}{4\pi \times 0.8}$

$B = 10^{-6}\ \mu_0$

A-2. Sol. $B = \frac{\mu_0 i}{2R}$



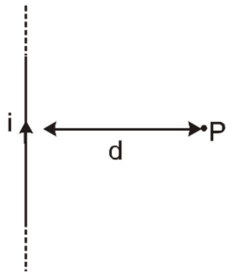
$B_0 = \frac{\mu_0 qf}{2R}$

$= \frac{\mu_0}{2R.}\frac{q\omega}{2\pi}$

$B_0 = 10^{-7} \times \frac{q\omega}{R}$

Section (B) : Magnetic field due to a circular loop, straight wire, solenoid, toroid, cylinder, Ampere's law

B-1. Sol.

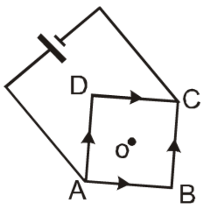


$B_P = \dfrac{\mu_0 i}{2\pi d}$

$B = \dfrac{\mu_0 i}{2\pi(d/2)}, \left(\text{at } x = \dfrac{d}{2}\right) \quad \Rightarrow \quad B_{(d/2)} = 2B$

B-2.

Sol.



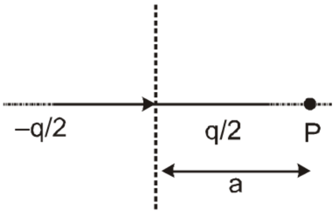
$B_0 = B_{AB} + B_{BC} + B_{AD} + B_{DC}$

Now $B_{AB} = -B_{DC}$

and $B_{AD} = -B_{BC}$

then $B_0 =$ zero

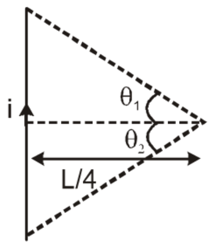
B-3. **Sol.**



Point P on the extended part of line thus

B_P = zero = 0

B-4. **Sol.** $B = \dfrac{\mu_0 i}{4\pi R}(\sin\theta_1 + \sin\theta_2)$

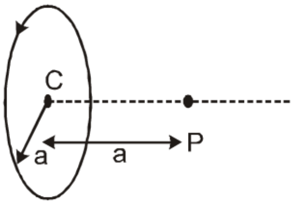


$\sin\theta_1 = \dfrac{L/2}{\sqrt{(L/2)^2 + (L/2)^2}} = \dfrac{1}{2\left(\sqrt{1/4 + 1/16}\right)} = \dfrac{4}{2\sqrt{5}}$

$\Rightarrow \qquad B = \dfrac{\mu_0 i}{4\pi R}\left(\dfrac{2 \times 4}{2\sqrt{5}}\right)$

$B = \dfrac{4\mu_0 i}{\sqrt{5}\pi R}$

B-5. Sol.



$$\frac{B_C}{B_P} = \frac{\mu_0 i / 2a}{\mu_0 i a^2 / 2(a^2 + a^2)^{3/2}} = \frac{2\sqrt{2}}{1}$$

B-6.

Sol. $B_0 = B_1 \odot B_2 \otimes$

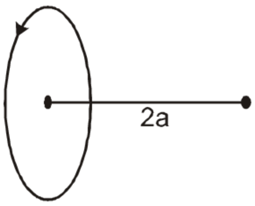
as B zero due to QP and RS at "O"

$= \dfrac{\mu_0 i}{4\pi}\left(\dfrac{1}{r_1}\right) - \dfrac{\mu_0 i}{4\pi}\left(\dfrac{1}{r_2}\right)$

$= \dfrac{\mu_0 i}{4\pi}\left(\dfrac{1}{r_1} - \dfrac{1}{r_2}\right)$

B-7.

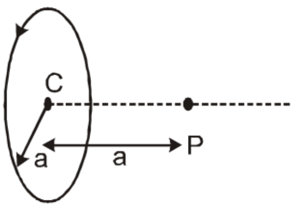
Sol.



$B = \dfrac{\mu_0 i\, a^2}{2(a^2 + (2a)^2)^{3/2}} = \dfrac{\mu_0 i}{10\sqrt{5}a}$

$B = \dfrac{\mu_0 i}{10\sqrt{5}a}$

B-8. Sol.

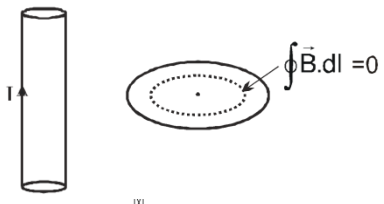


$$\frac{B_C}{B_P} = \frac{\mu_0 i / 2a}{\mu_0 i a^2 / 2(a^2 + a^2)^{3/2}} = \frac{2\sqrt{2}}{1}$$

B-9. Sol. $B = \mu_0 \mu_r n i$

$= 10^{-7} \times 4\pi \times 4000 \times 1000 \times 5$
$= 8\pi$ T
$= 25.12$ T Ans. (4)

B-14.
Ans. B
Sol.



$\oint \vec{B}.dl = 0$
B = 0 Ans. (2)

Section (C) : Magnetic force on a charge

C-2. **Sol.** $R = \dfrac{mV}{qB}$

$$\frac{R_1}{R_2} = \frac{\frac{mV}{qB}}{\frac{mV_2}{qB}} = \frac{V_1}{V_2} = 1.3$$

C-3. **Sol.** $R_P = \dfrac{mV}{qB} = \dfrac{\sqrt{2mK}}{qB}$ or $K = \dfrac{1}{2}mV^2$ and K = q Volt
or qE or $K = qV_0$

$$= \frac{\sqrt{2m_P eV_0}}{eB} = 8 \text{ cm}$$

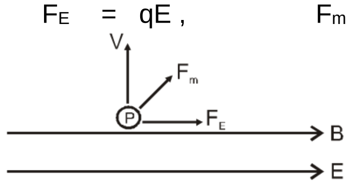
$R_D = \dfrac{\sqrt{2m_D 2eV_0}}{2eB} = \sqrt{2}\, R_P$ and $m_P = \dfrac{m_D}{2}$

$= \sqrt{2} \times 8 = 11.31$ cm

C-4. **Sol.** $T = \dfrac{2\pi m}{qB}$

$$\frac{T_\alpha}{T_P} = \frac{2\pi 4m_P / 2eB}{2\pi m_P / eB} = 2$$

C-6. **Sol.** $F_E = qE$, $F_m = qvB$



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

Pitch $p = V_{||} T$

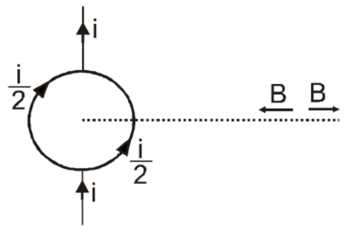
$T = \dfrac{2\pi R}{V}$

$V_{||} = 0 + \dfrac{qE\,t}{m}$ Ans. (4)

C-8. **Sol.** $F = qVB$

$F_{Max} = q_{Max}VB$ Ans. (4)

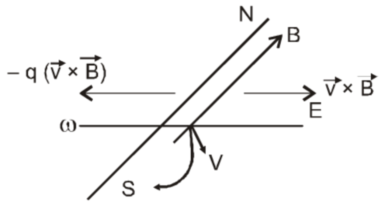
C-9. **Sol.**



Ans. (4)

C-10 **Ans.** B

Sol.

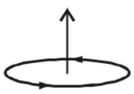


F towards west

So particle will be deflected towards west **Ans. (2)**

Section (E) : Magnetic force on a current carrying wire

E-5 **Sol.**



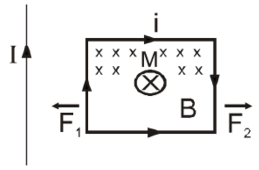
In uniform magnetic filed force acting on a closed loop = 0.

Ans. (3)

E-6

Ans. C

Sol. $\vec{M} \times \vec{B} = 0$



$\tau = 0$

Loop will Not rotate

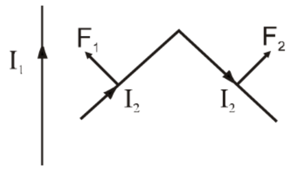
$F_1 > F_2$

So loop move towards the wire

Ans. (3)

E-8

Sol.



Resulted force will be at on angle with x as well as y axis

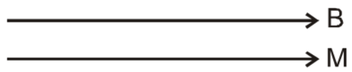
Ans. (4)

Section (F) : Magnetic force and torque on a current carrying loop and magnetic dipole moment

F-1. **Ans.** B

Sol. $U_i = -MB$

$U_f = MB$

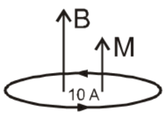


$W = U = 2\,MB$

$= 2 \times 2.5 \times 0.2$

$= 1\ J$ Ans. (2)

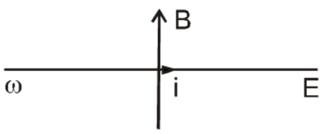
F-2 **Sol.**



$\vec{\tau} = \vec{M} \times \vec{B} = 0$ Ans. (1)

Section (G) : Magnetic field due to a magnet and earth

G-2. **Sol.**



$F = BiL$

$= 10^{-4} \times 10 \times 1$

$= 10^{-3}$ N Ans. (3)

Exercise-2

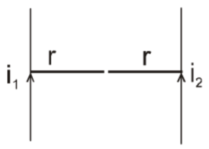
Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

1. **Sol.** Charge the rest produces only electric field but charge in motion produces both electric and magnetic field.

Ans. (3)

2. **Sol.**



$i_1 > i_2$

$\frac{\mu_0}{2r}(i_1 - i_2) = 10$

$\frac{\mu_0}{2r}(i_1 + i_2) = 30$

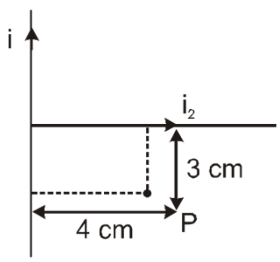
$\frac{i_1 + i_2}{i_1 - i_2} = \frac{3}{1} \Rightarrow \frac{i_1}{i_2} = \frac{2}{1}$ **Ans.(3)**

3. **Sol.** In observer frame of refernece

$B = \frac{\mu_0 i}{2\pi r}$ **Ans.(1)**

4.

Sol.



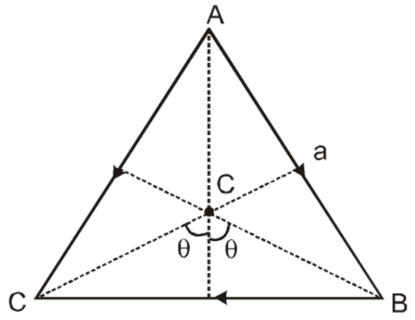
$B_P = B_1 \odot + B_2 \odot$

$= \frac{\mu_0 i_1}{2\pi r_1} + \frac{\mu_0 i_2}{4\pi r_2}$

$= \frac{2 \times 10^{-7} \times 2}{4 \times 10^{-2}} + \frac{10^{-7} \times 1.5}{3 \times 10^{-2}}$

$= 2 \times 10^{-5}$ N/A–m

5. Sol.



$\theta = 60^\circ$

Perpendicular distance of C from any side

$B = 3B_1$ as $B_{AB} = B_{BC} = B_{CA} = B_1$

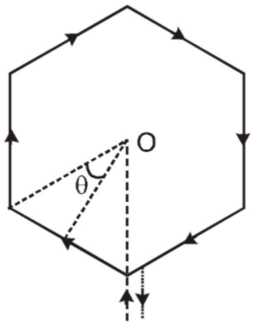
$= \frac{3 \times \mu_0 i}{4\pi r}(\sin\theta_1 + \sin\theta_2)$

$r = \frac{a}{2\sqrt{3}}$ and $\theta_1 = 60^\circ = \theta_2$

$B_C = \frac{3 \times \mu_0 i\, 2\sqrt{3}}{4\pi\, a} \times \frac{2 \times \sqrt{3}}{2}$

$B_C = \frac{9\mu_0 i}{2\pi\, a}$

6.
Sol.



Perpencicular distance from side of "O" is a cos 30º

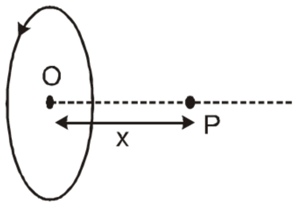
$r = \frac{\sqrt{3}a}{2}$

$B_{net} = 6.B,$

$= 6 \times \frac{\mu_0 i}{4\pi r}$ (sin 30º + sin 30º)

$= \frac{6 \times \mu_0 i \times 2}{4\pi.\sqrt{3}a} \times \frac{2 \times 1}{2} = \frac{\sqrt{3}\mu_0 i}{\pi a}$

7. **Sol.**



$B_P = \frac{B_0}{8}$

$\frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}} = \frac{\mu_0 i}{2R \times 8}$, R = a (given)

$8R^3 = (R^2 + x^2)^{3/2}$

$2R = (R^2 + x^2)^{1/2}$

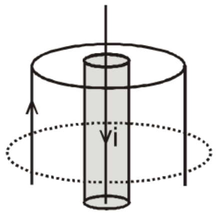
$x^2 = 3R^2$

$x = \sqrt{3}\ R = \sqrt{3}\ a$

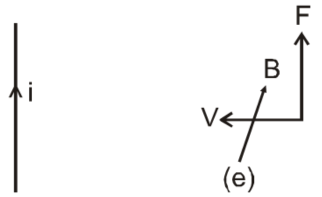
8.

Sol. **(1)** $B\,(2\pi r) = \mu_0\,(i - i) = 0$

$B = 0$



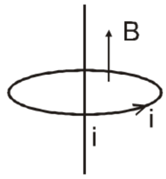
9. **Sol.** **(3)** F_{up}



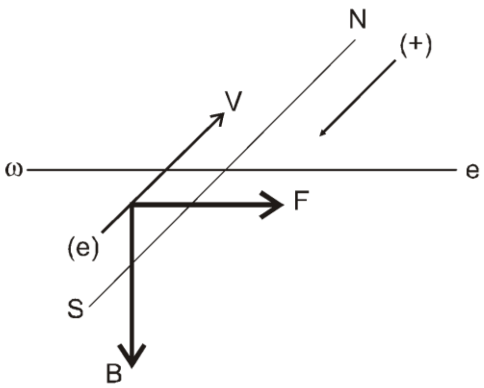
10. Sol. (3)

Field produced by loop at the centre will be along the axis of the loop i.e. || to st. wire .

So $F = i(\vec{i} \times \vec{B}) = 0$

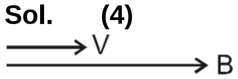


11. Sol. (1)



Electron beam will experience force towards east that is towards proton beam.

12. Sol. (4)

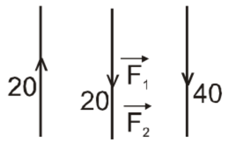


V || B

F = 0

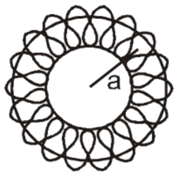
13. Sol. (2) $F_1 = \dfrac{\mu_0(20 \times 20)}{2\pi l}$

$F_2 = \dfrac{\mu_0(20 \times 40)}{2\pi l}$



F_1 and F_2 both points in the same direction towards 40 A wire.

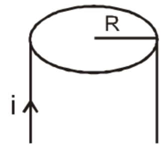
14. Sol. (1)

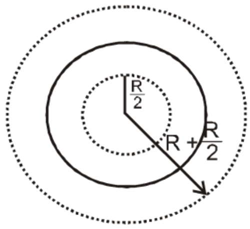


$\Sigma \vec{M} = 0$

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

15. **Sol.** **(4)** $B_{inside} = \dfrac{\mu_0 \dfrac{i}{\pi R^2} \times \dfrac{\pi R^2}{4}}{2\pi \dfrac{R}{2}} = \dfrac{\mu_0 i}{4\pi R}$





$B_{Outside} = \dfrac{\mu_0 i}{2\pi \dfrac{3R}{2}}$

$= \dfrac{\mu_0 i}{3\pi R}$

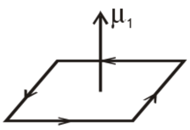
Energy density $\propto$ B^2

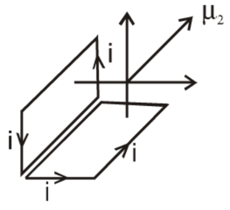
$\dfrac{\varepsilon_1}{\varepsilon_2} = \left[\dfrac{B_1}{B_2}\right]^2 = \dfrac{9}{16}$

16. **Sol.** **(3)**

$\mu_1 = L^2$

$\mu_2 = \sqrt{2} \times L \times \dfrac{L}{2}$

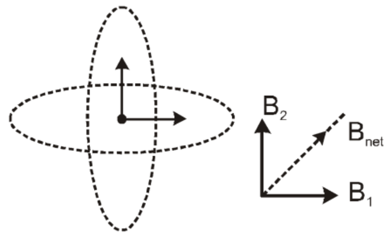




$\mu_2 = \dfrac{L^2}{\sqrt{2}}$

$\dfrac{\mu_1}{\mu_2} = \sqrt{2}$

17. **Sol.**



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

$B_2 = \frac{\mu_0 \sqrt{3}\, iN}{2R}$

$B_{net} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0\, iN}{2R}(1+3)^{1/2} = \frac{\mu_0\, iN}{2R}.2$

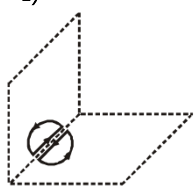
$B_{net} = \frac{\mu_0\, iN}{R}$

18.

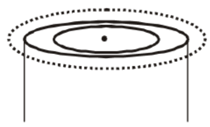
Sol. $\oint_{ABCDA} \vec{B}.d\vec{l} = \oint_{ABCA} \vec{B}.d\vec{l} + \oint_{CDAC} \vec{B}.d\vec{l}$

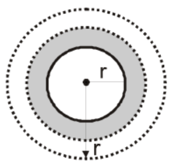
$= \mu_0 (i_1 + i_3) + \mu_0 (i_2 - i_3)$

$= \mu_0 (i_1 + i_2)$ Ans. (4)



19. **Sol.** $\oint \vec{B}.d\vec{l} = \mu_0 \frac{i}{\pi R^2} \times \pi r^2$





$= \frac{\mu_0 ir^2}{R^2}$ Ans. (2)

$\oint \vec{B}.d\vec{l} = \mu_0 i$

22. **Sol.** $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$

\` If does not deflect then, resultant force must be zero.

PART - II : MISCELLANEOUS QUESTIONS

1. **Sol.** The current through solid metallic cylinder also produces magnetic field inside the cylinder. Hence statement-1 is false

2. **Sol.** **[Easy]**
A force which always acts perpendicular to velocity of the particle does no work on the particle, but changes the direction of momentum of the particle. Hence statement 2 is correct explanation of the statement 1.

3. **Sol.** Since both charged particles move along same straight line, the magnetic field due to one particle at location of other is zero. Hence there is no magnetic interaction amongst the charged particles.

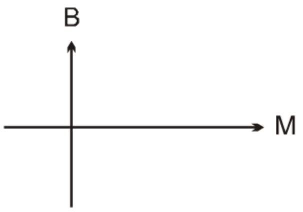
Section (B) : Match The Column

B-1. **Ans.** **(1) p, q (2) p, r, s (3) p, s (4) p, q, r, s**
Sol. **[Moderate]** (A) Uniform electric field exerts constant force on the charged particle, hence the particle may move in straight line or a parabolic path.
(B) Under action of uniform magnetic field, the charged particle may move in straight line when projected along or opposite to direction of magnetic field. The charged particle moves in circle when it is projected perpendicular to the magnetic field. If the initial velocity of the charged particle makes an angle between 0^o and 180^o (except 90^o) with magnetic field, the particle moves along a helical path of uniform pitch.
(C) If charged particle is shot parallel to both fields it moves along a straight line. If the charged particle is shot at any angle with both the field (except 0° and 180°) , the particle moves along a helix with non-uniform pitch.
(D) from results of A and B all the given paths are possible.

B-2.
Ans. (a) Q (b) P (c) S (d) R

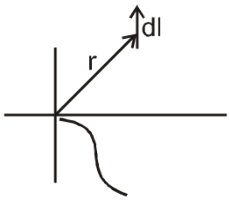
Section (C) : One or More Than One Options Correct

C-1*. **Ans.** ABC
Sol. $\vec{\tau} = \vec{M} \times \vec{B}$
$\vec{F} = m\vec{B}$



couple of force may give torque but not force is zero.
m = pole strength depending on angle
$\tau = 0$ $\tau \neq 0$, & $F = 0$ $F \neq 0$
(ABC) **Ans.**

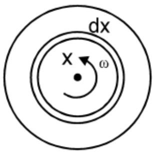
C-2.* **Sol.** $B = \frac{\mu_0}{4\pi} i \left(\frac{\vec{r} \times dl}{r^3}\right)$
$B = \frac{\mu_0}{4\pi} - i \left(\frac{dl \times \vec{r}}{r^3}\right)$



C-3. Sol. (A), (D)

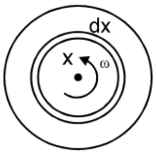
Consider a ring of radius x and thickness dx.

Equivalent current in this ring = $\frac{\omega}{2\pi}$ × charge on ring = $\frac{\omega}{2\pi} \times (2\pi \times dx)\frac{Q}{\pi R^2}$



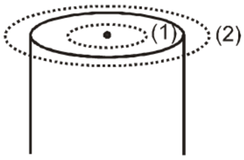
dB (due to this ring) = $\frac{\mu_0}{2x}\left(\frac{\omega}{2\pi}\frac{2xQ}{R^2}dx\right)$ $\therefore$ B = $\int_0^R \frac{\mu_0\omega}{2\pi}\frac{Q}{R^2}dx.$

$= \frac{\mu_0\omega\theta}{2\pi R^2}.R = \frac{\mu_0\omega\theta}{2\pi R}$



$= \frac{\mu_0\omega Q}{2\pi R^2}.R = \frac{\mu_0\omega Q}{2\pi R}$

C-4.* Sol.



Loop (1)
B (2πr) = 0
B = 0
Loop (2)
B (2πr) = μ_0i
B $\propto \frac{1}{r}$ **Ans. (B, C, D)**

C-5.*#

Sol. (A) B(2πr) = μ_0 (i – i) = 0
B = 0

C-6.

Ans. A, B, D

Sol. **A, B, D**

$\omega_E + \omega_B = \Delta k$

$\Rightarrow \quad qE\,(2a) = \frac{1}{2}m\,(2v)^2 - \frac{1}{2}mv^2$

$= \frac{3}{2}mv^2$

$E = \frac{3}{4}\frac{mv^2}{qa}$

At P Rate of work done by E = qEv = $\frac{3}{4}\frac{mv^3}{a}$

At Q Rate of work done by E = qE (2v) cos90° = 0

At Q Rate of work done by B = 0

Exercise-3

Marked Questions can be used as Revision Questions.

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. **Sol.** Magnetic field at centre of circular coil A is

$B_A = \frac{u_0 Ni}{2R}$

R is radius and i is current flowing in coil.

Similarly $B_B = \frac{\mu_0 N(2i)}{2.(2R)}$

$= \frac{\mu_0 Ni}{2R} = \frac{B_A}{B_B} = 1$

2. **Sol.** Since, electron and proton have same momenta so, the same force will act on them by the magnetic field.

F = qvB sin θ

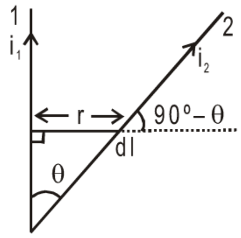
= qvB (∵ θ = 90º)

Hence, both will move on same trajectory (curved path)

3. **Sol.** Due to flow of current in same direction in two adjacent sides, an attractive magnetic force will be produced due to which spring will get compressed. '

4.

Sol. Magnetic field on dl element due ot current i_1 is



$B = \frac{\mu_0}{2\pi}\frac{i_1}{r}$ ...... (i)

Unit force acting on dl element

$\frac{F}{dl} = i_2 B \sin(90^o - \theta)$ ......(ii)

Thus, () $\frac{F}{dl} = \frac{\mu_0}{2\pi}\frac{i_1 i_2}{r}\cos\theta$

$F = \frac{\mu_0 i_1 i_2\, dl \cos\theta}{2\pi r}$

5. **Sol.** Electrons, protons, and helium atoms are deflected in magnetic field so, the compound can emit electrons, protons and He^{2+} .

6. **Sol.** $\Rightarrow$ $W = MB(1 - \cos\theta)$

$\Rightarrow$ $W = \frac{MB}{2}$

$\therefore$ $MB = 2W$

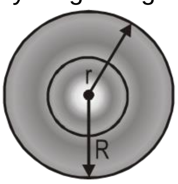
Torque, $\tau = MB \sin 60^o$

$= \frac{MB\sqrt{3}}{2} = \frac{2W\sqrt{3}}{2}$

$= W\sqrt{3}$

7. **Sol.** Inside bar magnet, lines of force are from south to north.

8. **Sol.** Let R be radius of a long thin cylindrical shell.
To calculate the magnetic induction at a distance r (r < R) from the axis of cylinder, a circular loop of radius r is shown :
Since, no current is enclosed in the circle so, from Ampere's circuital law, magnetic induction is zero at every point of circle. Hence, the magnetic induction at any point
inside the infinitely long straight thin walled tube (cylindrical) is zero.



9. **Sol.** The magnetic field at the centre of circular coil is

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

where r = radius of circle = $\frac{l}{2\pi}$ $(\because l = 2\pi r)$

$\therefore \quad B = \frac{\mu_0 i}{2} \times \frac{2\mu}{l}$

$= \frac{\mu_0 i \pi}{l}$ ....(i)

when wire of length l bents into a circular loops of n turns, then

$l = n \times 2\pi r'$

$\Rightarrow \quad r' = \frac{1}{n \times 2\pi}$

Thus, new magnetic field

$B' = \frac{\mu_0 n i}{2r'} = \frac{\mu_0 n i}{2} \times \frac{n \times 2\pi}{l}$

$= \frac{\mu_0 i \pi}{l} \times n^2$

$= n^2 B$ [from eq (i)

10. **Sol.** The magnetic field at a point on the axis of a circular loop at distance x from the centre is

$B = \frac{\mu_0 i R^2}{2\left(R^2 + x^2\right)^{3/2}}$

Given : $B = 54\ \mu T$, $x = 4$ cm, $R = 3$cm

Putting the given values we get

$\therefore \quad 54 = \frac{\mu_0 i \times (3)^2}{2\left(3^2 + 4^2\right)^{3/2}}$

$\Rightarrow \quad 54 = \frac{9\mu_0 i}{2(25)^{3/2}} = \frac{9\mu_0 i}{2 \times (5)^3}$

$\therefore \quad \mu_0 i = \frac{54 \times 2 \times 125}{9}$

$\mu_0 i = 1500$

Now, putting x = 0 in equation (i), magnetic field at the centre of loop is

$B = \frac{\mu_0 i R^2}{2 \times 3} = \frac{\mu_0 i}{2R}$

$= \frac{1500}{2 \times 3} = 250\ \mu T$

11. **Sol.** Force acting between two current carrying conductors

$F = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{d} l$ ....(i)

where d = distance between the conductors,

l = length of each conductor

Again $F' = \frac{\mu_0}{2\pi} \frac{(-2I_1)(I_2)}{(3d)} . l$

$= -\frac{\mu_0}{2\pi} . \frac{2I_1 I_2}{3d} l$

Thus, from equations (i) and (ii)

$\frac{F'}{F} = -\frac{2}{3}$ $\Rightarrow$ $F' = \frac{2}{3}F$

12. **Sol.** The time period of oscillations of magnet

$T = 2\pi\sqrt{\left(\frac{I}{MH}\right)}$

where I = moment of inertia of magnet

$= \frac{mL^2}{12}$

(m, being the mass of magnet)

M = pole strength × L

When the three equal parts of magnet are placed on one another with their like poles together, then

$I' = \frac{1}{12}\left(\frac{m}{3}\right) \times \left(\frac{L}{3}\right)^2 \times 3$

$= \frac{1}{12}\frac{mL^2}{9}$

$= \frac{I}{9}$

and M' = pole strength × $\frac{L}{3}$ × 3 = M

Hence, $T' = 2\pi\sqrt{\left(\frac{I/9}{MH}\right)}$

$\Rightarrow$ $T' = \frac{1}{3} \times T$

$T' = \frac{2}{3}$ sec

13. **Sol.** Electromagnets are made of soft iron. The soft iron has high retentivity and low coercivity.

14. **Sol.** The force per unit length between the two wires is

$\frac{F}{1} = \frac{\mu_0}{4\pi}, \frac{2i_2}{d} = \frac{\mu_0 i^2}{2\pi d}$

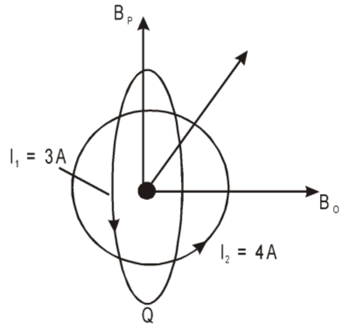
The force will be attractive as current directions in both are same.

15. **Sol.** $B_P = \frac{\mu_0 I_2}{2R} = \frac{4\pi \times 10^{-7} \times 4}{2 \times 0.02\pi} = 4\times10^{-5}$ Wb/m^2

$B_Q = \frac{\mu_0 I_1}{2R}$

$= \frac{4\pi \times 10^{-7} \times 3}{2 \times 0.2\pi} = 3 \times 10^{-5}$ Wb/m^2 $\therefore$ $B = \sqrt{B_P^2 + B_Q^2}$

$= \sqrt{\left(4 \times 10^{-5}\right)^2 + \left(3 \times 10^{-5}\right)^2} = 5 \times 10^{-5}$ Wb/m^2



16. **Sol.** When electron is projected in an electric field, then velocity of electron will decrease.

17. **Sol.** Magnetic force $F = q\upsilon B$ .... (i)

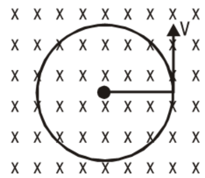
Centripetal force

$F = \frac{m\upsilon^2}{r}$ .... (ii)

From Eq. (i) and (ii),

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

The time taken by the particle to complete one revolution,



$T = \frac{2\pi r}{\upsilon} = \frac{2\pi m\upsilon}{qB} = \frac{2\pi m}{qB}$

18. **Sol.** Magnetic needle is placed in non-uniform magnetic field. It experiences force and torque both due to unequal forces acting on poles.

19. **Sol.** Straight line

20. **Sol.** Attracts N_1 strongly, N_2 weakly and Repel N_3 weakly.

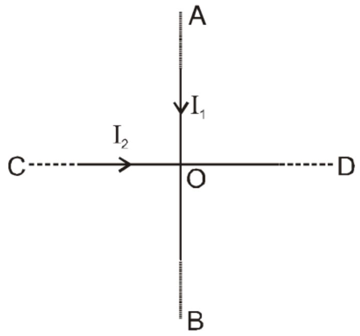
22. **Sol.** $B_1 = \frac{\mu_0 i}{2\pi a^2}r$ where $0 \le r \le a$, $B_1 = \frac{\mu_0 i}{2\pi a^2}.\frac{a}{2}$ $\left(\text{at } r = \frac{a}{2}\right)$

$B_1 = \frac{\mu_0 i}{4\pi a^2}$, $B_2 = \frac{\mu_0 i}{2\pi(2a)}$ (at r = 2a), $\frac{B_1}{B_2} = 1$

23. **Sol.** Magnetic field inside the infinitely long pipe is zero at all points.

25. **Sol.** Magnetic force can not do any work, so kinetic energy remains constant. Since initial velocity is perpendicular to magnetic field, hence momentum will change.

26. **Sol.** Magnetic field due to AB and CD are $\frac{\mu_0 I_1}{2\pi d}$ and $\frac{\mu_0 I_2}{2\pi d}$ respectively



$B_{net} = \frac{\mu_0}{2\pi d}\sqrt{I_1^2 + I_2^2}$

29. **Sol.** **Ans. (1)**

Magnetic field due to loop ABCD

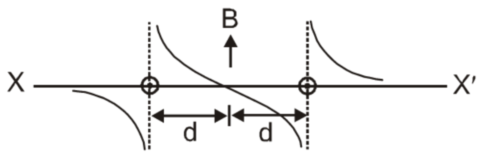
$$= \frac{\mu_0 I}{4\pi}\left(\frac{\pi}{6}\right) \times \left[\frac{1}{a} - \frac{1}{b}\right] = \frac{\mu_0 I}{24}\left[\frac{b-a}{ab}\right]$$

30. **Sol.** **Ans. (1)** $\vec{F} = i\,(\vec{\ell} \times \vec{B})$

Magnetic field due to I_1 is parallel to AD and BC. So that force On AD and BC is zero.

31. **Ans.** **(1)**

Sol.



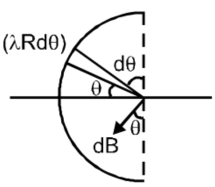
Towards left of both wires direction of B is downward and at mid point between two wires, magnetic field is zero

32. **Ans.** **(1)**

Sol. $v = \frac{I}{\pi R}$

$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{2I}{R}$ $\quad\quad$ $I = \lambda R\, d\theta$

$\therefore \quad B = \int_{-\pi/2}^{\pi/2} dB\cos\theta$



$$= \frac{\mu_0\lambda}{2\pi}\int_{-\pi/2}^{\pi/2}\cos\theta\, d\theta$$

$$= \frac{\mu_0\lambda}{\pi} = \frac{\mu_0 I}{\pi^2 R}$$ **Ans.**

33. Ans. (1)

Sol. $\vec{F} = q[\vec{E} + \vec{v} \times \vec{B}]$

$= q\left[3\hat{i} + \hat{j} + \hat{k} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 4 & 1 \\ 1 & 1 & -3 \end{vmatrix}\right]$

$= q\ [3\hat{i} + \hat{j} + 2\hat{k} + \hat{i}) - 12 - 1) - \hat{j}(-9 - 1) + \hat{k}(3 - 4)]$

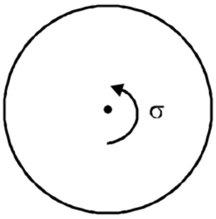
$= q\ [3\hat{i} + \hat{j} + 2\hat{k} - 13\hat{i} + 10\hat{j} - \hat{k}]$

$= q\ [-10\hat{i} + 11\hat{j} + \hat{k}]$

$= F_y = 11q.\hat{j}$

34. Sol. $\frac{q}{2M} = \frac{\text{Magnetic dipole moment}}{\text{Angular momentum}}$

$\therefore$ Magnetic dipole moment(M)



$M = \frac{q}{2M} \cdot \left(\frac{MR^2}{2}\right) \cdot \omega$

$= \frac{1}{4}\sigma.\pi R^4\omega.$

35. Ans. (1)

Sol. $dB = \frac{\mu_0(dq)}{2r}\left(\frac{\omega}{2\pi}\right)$

$B = \int dB = \frac{\mu_0\omega}{4\pi} \cdot \frac{Q}{\pi R^2} 2\pi \int_0^R \frac{rdr}{r}$

$B = \frac{\mu_0\omega Q}{2\pi R^2}.R$

$B = \frac{\mu_0\omega Q}{2\pi R}$

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

36. Ans. (2)

Sol. $r = \frac{\sqrt{2mE}}{3q}$

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

$r_p = k\frac{\sqrt{m}}{q}$

$r_D = k\frac{\sqrt{2m}}{q}$

$r_\alpha = k\frac{\sqrt{4m}}{2q} = \frac{k\sqrt{m}}{q}$

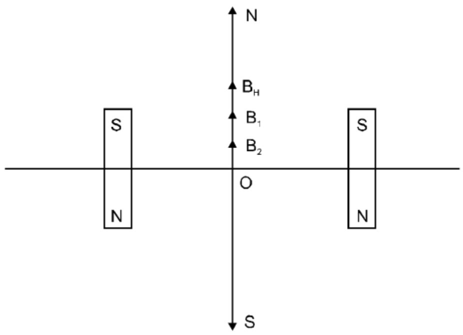
$\therefore$ $r_p = r_\alpha < r_d$.

37. Sol. $B_{net} = B_1 + B_2 + B_H$

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

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

Ans. (2)



38.

Ans. (2)

Sol. $F_{ext.} = B(x)\,IL$

$P = \frac{1}{t}\int_0^2 F_{ext.} \cdot dx = \frac{1}{t}\int_0^2 B(x) IL\, dx = \frac{1}{5\times10^{-3}}\int_0^2 3\times10^{-4} e^{-0.2x} \times 10 \times 3\, dx$

$= 9\,[1 - e^{-0.4}]$

$= 9\left[1 - \frac{1}{e^{0.4}}\right] = 2.96$

39. Ans. (3)

Sol. For solenoid

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

$B = \mu_0 nI$

$H = nI$

$\Rightarrow$ $3 \times 10^3 = \frac{100}{0.1} \times I$

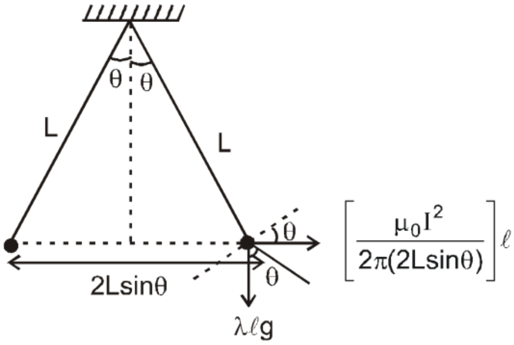
$I = 3A$

40. Ans. (1)

Sol. $\vec{F}_1 = \vec{F}_2 = 0$

Because net resultant will be zero. and equal because of action and reaction pair

41.
Ans. **(2)**
Sol.

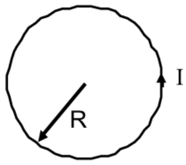


$\lambda \ell g \sin\theta = \frac{\mu_0 I^2}{2\pi(2L\sin\theta)} \ell\cos\theta$

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

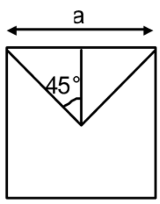
42.
Ans. **(3)**
Sol. For stable equilibrium angle should be zero and for unstable equilibrium angle between $\vec{M}$ and $\vec{B}$ should be π.

43. **Ans.** **(3)**
Sol.



Magnetic field at centre of circle

$B_A = \frac{\mu_0 I}{2R} = \frac{m_0 I \pi}{\ell}$ [Also $\ell = 2\pi R$]



Magnetic field at centre = $\frac{4\mu_0 I}{4\pi \frac{a}{2}}(2\sin 45°)$

$= \frac{16\mu_0 I}{\sqrt{2}\pi\ell}$ [Also $4a = \ell$]

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

44. **Ans.** **(3)**
Sol. Since area of hysterics curve of (B) is smaller it is suitable for electromagnet and transformer.

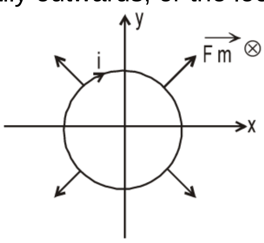
45. **Ans.** **(2)**
Sol. $M = 6.7 \times 10^{-2}$ A – m^2
$I = 7.5 \times 10^{-6}$ kgm^2
$T = 2\pi\sqrt{\frac{I}{MB}}$
$= 2\pi\sqrt{\frac{7.5 \times 10^{-6}}{6.7 \times 10^{-2} \times 10 - 2}}$
$= 2\pi\sqrt{\frac{7.5}{6.7} \times 10^{-2}}$
$= 2 \times 10^{-1}\sqrt{\frac{75}{67}}$
$t = 10T$
$= 2\pi\sqrt{\frac{75}{67}}$ = 6.65 sec.

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. **Ans.** A
Sol. $U = \vec{M}\cdot\vec{B} = -MB\cos\theta$
Here $\vec{M}$ = magnetic moment of the loop
θ = angle between $\vec{M}$ and $\vec{B}$
U is maximum when $\theta = 180^o$ and minimum when $\theta = 0^o$. So as θ decrease from 180^o to 0^o its P.E. also decreases.

2.
Ans. D
Sol. Net force on a current carrying loop in uniform magnetic field is zero. Hence the loop can't translate. So, options (c) and (d) are wrong. From Flaming's left hand rule we can see that if magnetic field is perpendicular to paper inwards and current in the loop is clockwise (as shown) the magnetic force $\vec{F}_m$ on each element of the loop is radially outwards, or the loops will have a tendency to expand.



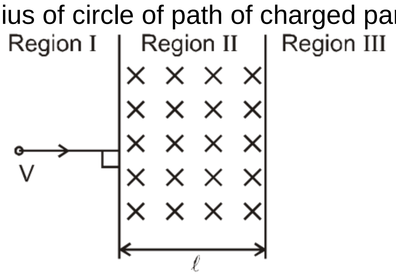
3.
Sol. Magnetic force does not change the speed of charged particle. Hence, v = u. Further magnetic field on the electron in the given condition is along negative y–axis in the starting. Or it describes a circular path in clockwise direction. Hence, when it exists from the field, y < 0.
Therefore, the correct option is (D).

4.*

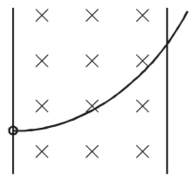
Sol. **(A, C)**
Magnetic force on wire BC would be perpendicular to the plane of the loop along the outward direction and on wire DA the magnetic force would be along the inward normal, so net force on the wire loop is zero and torque on the loop would be along the clockwise sence as seen from O.

5. **Sol.** Magnetic field in the region a < x < 2a will turn the particle towards positive Z-axis while the magnetic field in the region 2a < x < 3a will exert force in opposite direction. The turning is smooth because the magnetic force is NOT impulsive.

6. **Sol.** The radius of circle of path of charged particle is $R = \frac{mV}{qB}$

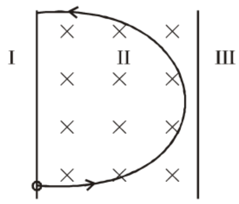


For particle to enter region III $R > \ell$. or $\frac{mV}{qB} > \ell$



For path length of particle in region II to be maximum

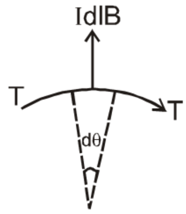
$\ell = R$ or $V = \frac{q\ell B}{m}$

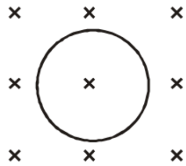


The period of revolution of charged particle is $\omega = \frac{qB}{m}$

The time spent in region II is $t = \frac{\pi}{\omega} = \frac{\pi m}{qB}$, which is same for all the cases when it returns to region II.
Ans. (A), (C) and (D)

7.
Ans. (C)
Sol.

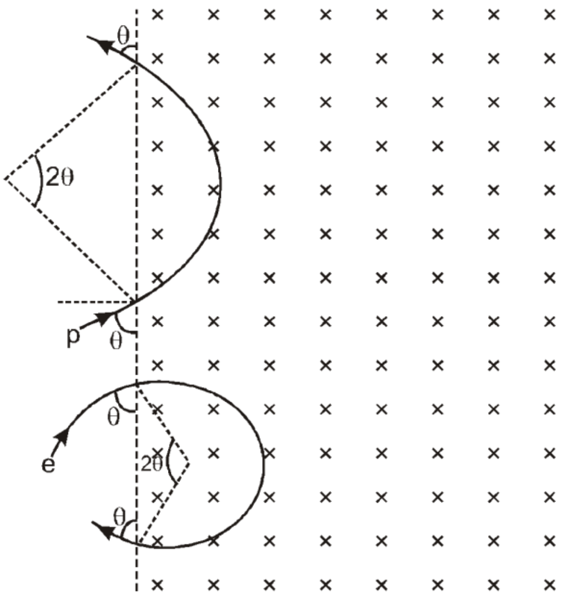




$2T\sin\left(\frac{d\theta}{2}\right) = IdlB \quad \Rightarrow \quad 2T\frac{d\theta}{2} = IRdlB \quad \Rightarrow \quad T = BIR = \frac{BIL}{2\pi}$

8*. **Ans. (B), (D)**

Sol.



$t_p = \frac{2\theta \times R_P}{v} = \frac{2\theta \times m_p v}{eBv} = \frac{2\theta m_p}{eB}$

$t_e = \frac{(2\pi - 2\theta) \times R_e}{v} = \frac{(2\pi - 2\theta)m_e v}{eBv} = \frac{(2\pi - 2\theta)m_e}{eB}$

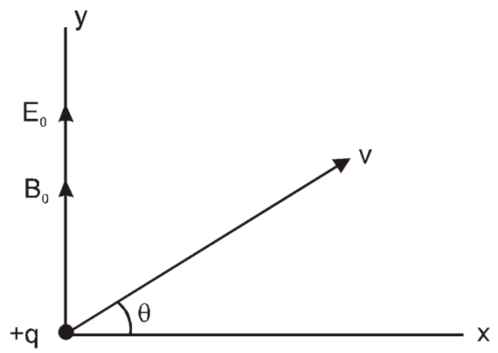
$\because t_e \neq t_p$

9.

Sol. $B = \int \frac{\mu_0 dNi}{2x} = \int \frac{\mu_0\left(\frac{N}{b-a}dx\right)i}{2x} = \frac{\mu_0 Ni}{2(b-a)}\ell n\frac{b}{a}$

10. **Ans. (C), (D)**

Sol.



If $\theta = 0°$ then due to magnetic force path is circular but due to force qE_0 (↑) q will have accelerated motion along y–axis. So combined path of q will be a helical path with variable pitch so (A) and (B) are wrong.
If $\theta = 10°$ then due to $v\cos\theta$, path is circular and due to qE_0 and $v\sin\theta$**,** q has accelerated motion along y-axis so combined path is a helical path with variable pitch (C) is correct.
If $\theta = 90°$ then $F_B = 0$ and due to qE_0 motion is accelerated along y-axis. (D)

11.

Ans. **(B)**

Sol. Area = $a^2 + 4 \times \frac{\pi\left(\frac{a}{2}\right)^2}{2}$

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

$A = \left(1 + \frac{\pi}{2}\right) a^2 \hat{k}$

12. **Ans.** **(D)**

Sol. **Case-I** $x < \frac{R}{2}$

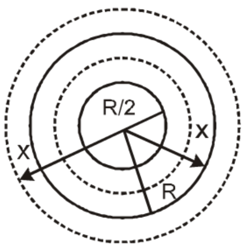
$|B| = 0$

Case-II $\frac{R}{2} \le x < R$

$\int \vec{B}.d\vec{\ell} = \mu_0 I$

$|B|\, 2\pi x = \mu_0 \left[\pi x^2 - \pi\left(\frac{R}{2}\right)^2\right] J$

$|B| = \frac{\mu_0 J}{2x}\left(x^2 - \frac{R^2}{4}\right)$



Case-III $x > R$

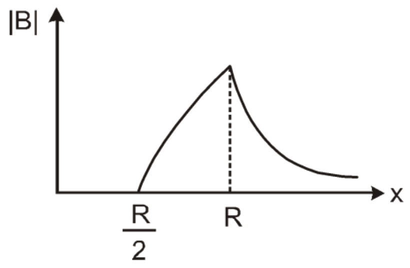
$\oint \vec{B}.\, d\vec{\ell} = \mu_0 I$

$|B|\, 2\pi x = \mu_0 \left[\pi R^2 - \pi\left(\frac{R}{2}\right)^2\right] J$

$|B| = \frac{\mu_0 J}{2x}\, \frac{3}{2}\, R^2$

$|B| = \frac{3\mu_0 J R^2}{8x}$

so



13*. **Ans. (A,C)**

Sol. Component of final velocity of particle is in positive y direction.

Centre of circle is present on positive y axis. so magnetic field is present in negative z-direction

Angle of deviation is 30° because

$\tan\theta = \frac{v_y}{v_x} = \frac{1}{\sqrt{3}}$

$\theta = \frac{\pi}{6}$

$\omega t = \theta$

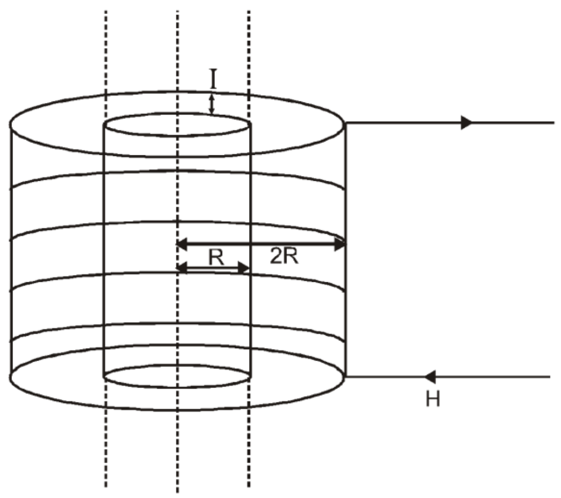
$\theta = \frac{QB}{M} t$

$B = \frac{M\theta}{Qt}$

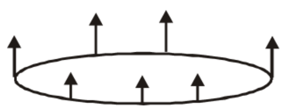
$B = \left(\frac{50M\pi}{3Q}\right)$

14. **Ans. (A, D)**

Sol.



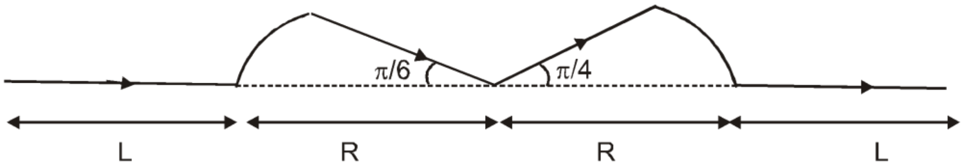
(A) For $0 < r < R \Rightarrow B \neq 0$



(D) For $r > 2R \Rightarrow B \neq 0$

15.

Ans. **(A, B, C)**



$\vec{F} = i\left(\vec{\ell} \times \vec{B}\right)$ = i{2(L + R) $\hat{i}$ × $\vec{B}$}

If $\vec{B}$ is along $\hat{z}$

$\vec{F}$ = [i 2(L + R)B] $\left(-\hat{j}\right)$

If $\vec{B}$ is along $\hat{x}$

$\vec{F}$ = 0

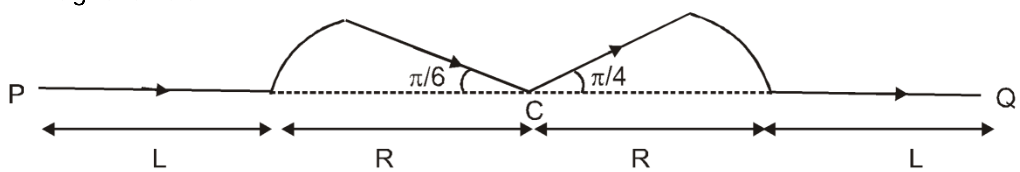
If $\vec{B}$ is along $\hat{y}$

$\vec{F} = i\left\{2(L+R)B)\hat{k}\right\}$

Alternate solution :

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

In unfirom magnetic field



$\int d\vec{F} = \int i\left(d\vec{\ell} \times \vec{B}\right) = i\left(\int d\vec{\ell} \times \vec{B}\right) \Rightarrow \vec{F} = i\left(\overrightarrow{PQ} \times \vec{B}\right)$

(A) F = [i 2(L + R)B] = 2iB (L + R)

(B) F = 0

(C) F = [i 2(L + R)B] = 2iB (L + R)

(D) F = [i 2(L + R)B] = 2iB (L + R)

Additional Problems For Self Practice (APSP)

PART-I: PRACTICE TEST PAPER

1. **Sol.** force on a moving charge
$F = qvB \sin\theta$
$\therefore$ $\theta = 0$ then rc $\sin\theta = 0$
$\therefore$ $F = 0$

2. **Sol.** Work done in rotating the dipole
$W = MH(1 - \cos\theta)$

3. **Sol.** Energy density in magnetic field is directly proportional to B.

4. **Sol.** Co(cobalt) is a ferromagnetic substance.

5. **Sol.** Positive charged particle are deviated towards north pole in magnetic field.

6. **Sol.** For paramagnetic materials, magnetic suspectibility is inversely proportional to the temperature i.e,, proportional to T^{-1}.

7. **Sol.** When a loop (of anysize)is placed in a magnetic field, then the force acting on the loop is iRB.

8. **Sol.** Magneticfield is produced by moving charges, (current carrying loop) and changing electric field.

9. **Sol.** Magnetic field atcentre of a circular coil,

$$B = \frac{\mu_0 ni}{2r}$$

Here $N = \frac{1}{2}$

$$\therefore \quad B = \frac{\mu_0\left(\frac{1}{2}\right)i}{2r} = \frac{\mu_0 i}{4r}$$

10. **Sol.** In a parallel wires, similar currents attract and opposite currents repel.

11.

Sol. For parallel wires, same direction currents attract and opposite currents repel.

The magnetic force between two parallel wires $\propto \frac{1}{r}$
AB and CD are symmetrical relative to wire EF, so, they exert equal and opposite forces on EF.
As wire BC is nearer to EF as compared to AD and current in both wires is same, so wire BC exerts larger force than that of AD. So, wire EF will be attracted towards the loop.

12. **Sol.** Magnetic field at the centre ofsolenoid = $\mu_0 ni$

13. **Sol.** The magnetic field at the centre of circular coil

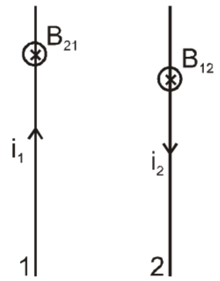
$$B = \frac{\mu_0 nI}{2r}$$

where r = radius of coil
I = current flowing in the coil
n = number of turns in a coil

Therefore, magnetic field in a circuflar coil does not depend on area of coil

14. **Sol.** In a uniform magnetic field, the torque acts on a magnetic needle but forcedoes not. Therefore $\tau \neq 0$, $F = 0$

15. **Sol.** The crosses in the figure denote that the direction of magnetic field is



perpendicular to the page away from reader. Now let's take case of wire one. Magnetic field at wire (1)due to wire (2), i.e., B_{21} is vertically downwards, into the page current in wire (1) is flowing upwards. So force acts to left side i.e., it is repulsive.
Similarly, on wire(2) it is one right side.
Directions of magnetic fields are opposite so both wires will repel each other.

16. **Sol.** Suppose the magnetic field produced due to each coil is B.
The two coils are kept perpendicular hence, the angle between these is 90° therefore , the resultant magnetic field is given by

$= \sqrt{B^2 + B^2 + 2B.B.\cos 90^\circ}$

$= \sqrt{2B^2 + 2B^2 \times 0} = \sqrt{2B^2} = B\sqrt{2}$

Hence, the ratio of magnetic field due to one coil and the resultant magnetic field is given by

$= \frac{B}{\sqrt{2}B} = 1 : \sqrt{2}$

17. **Sol.** The formula for radius of circular path is

$r = \frac{mv}{eB} = \frac{v}{\left(\frac{e}{m}\right)B}$

Given : $\frac{e}{m}$ of electron = 1.7×10^{11} C/kg, $v = 6 \times 10^7$ m/s and $B = 1.5 \times 10^{-2}$ T

∴ $r = \frac{6 \times 10^7}{1.7 \times 10^{11} \times 1.5 \times 10^{-2}} = 2.35 \times 10^{-2}$ m = 2.35 cm

18. **Sol.** Torque acting on the magnet is given by

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

Here $\vec{M}$ = magnetic moment

$\vec{B}$ = magnetic field, pqEcdh; {ks=k

19. **Sol.** When a charged particle enters a magnetic field perpendicularly, it moves on a circular path. The required centripetal force is provided by magnetic force.
i.e., magnetic force = Centripetal force

or $qvB = \frac{mv^2}{r}$

∴ $r = \frac{mv}{qB}$

Now kinetic energy of the particle,

$K = \frac{1}{2}mv^2$

$\Rightarrow \quad mv = \sqrt{2mK}$

Therefore, Eq. (i) becomes

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

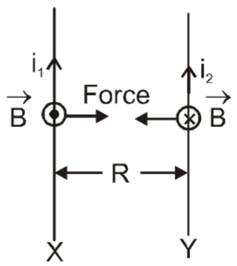
or $\quad r \propto \sqrt{m}$

$\therefore \quad \frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}}$

As $m_e < m_p$; so $r_e < r_p$

Hence, trajectory of electron is less curved.

20. **Sol.** As shown in the figure, let the conductor Y carry current i_2, situated in a magnetic field $\vec{B}$ perpendicular to its length. t therefore, experiences a magnetic force, the magnitude ofthe force acting on a length l of Y is



$F = i_2Bl = i_2\left(\frac{\mu_0}{2\pi}\frac{i_2}{R}\right)l$

From Fleming's left hand rule the direction of this force is towards X. Similarly, force per unit length of X due to Y is directed opposite to Y. Hence, the conductors attract each other.

$F = i_2Bl = i_2\left(\frac{\mu_0}{2\pi}\frac{i_2}{R}\right)l$

21. **Sol.** Key Idea To move on circular path in a magnetic field, a centripetal force is provided by the magnetic force.

When magnetic field is perpendicular to motion of charged particle, then

Centripetal force = magnetic force

ie $\frac{mv^2}{R} = Bqv$

or $\quad R = \frac{mv}{Bq}$

Further, time period of the motion

$T = \frac{2\pi R}{v} = \frac{2\pi\left(\frac{mv}{Bq}\right)}{v}$ or $T = \frac{2\pi m}{Bq}$

It is independent of both R and v.

22. **Sol.** As revolving charge is equivalent to a current, so

$I = qf = q \times \frac{\omega}{2\pi}$

But $\omega = \frac{v}{R}$

where R is radius of circle and v is uniform speed of charged particle.

Therefore $I = \frac{qv}{2\pi R}$

Now, magnetic moment associated with charged particle is given by

$\mu = IA = I \times \pi R^2$

$\mu = \frac{qv}{2\pi R} \times \pi R^2$

$= \frac{1}{2}qvR$

23. **Sol.** When particle describes circular path in a magnetic field, its velocity is always perpendicular to the magnetic force.

Power $P = \vec{F}.\vec{v} = Fv\cos\theta$

Here $\theta = 90°$

$P = 0$

But $P = \frac{W}{t}$

$\Rightarrow$ $W = P.t$

Hence, work done W = 0 (everywhere)

24. **Sol.** Given $q_y = 2q_x$

radius of circular path in a magnetic field is given by

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

$v = \frac{Brq}{m}$

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

or $mv^2 = \frac{B^2r^2q^2}{m}$

$\therefore$ $KE = \frac{1}{2}mv^2 = \frac{B^2r^2q^2}{2m}$ ...(i)

When charged particle is accelerated by potential V, then its kinetic energy

$KE = Vq$ ...(ii)

From Eqs. (i) and (ii)

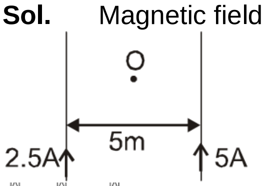
$Vq = \frac{B^2r^2q^2}{2m}$

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

$\therefore$ $m \propto r^2q$

$\therefore$ $\frac{m_1}{m_2} = \frac{r_1^2q_1}{r_2^2q_2} = \frac{R_1^2}{R_2^2} \times \frac{q}{2q} = \frac{R_1^2}{2R_2^2}$

25. **Sol.** Magnetic field at mid point O,



$\vec{B} = \vec{B}_1 + \vec{B}_2$

$= \frac{\mu_0}{2\pi}\frac{I_1}{r} - \frac{\mu_0}{2\pi}\frac{I_2}{r} = \frac{\mu_0}{2\pi}\frac{(2.5-5)}{2.5} = \frac{\mu_0}{2\pi}$

26. Sol. Given N = 50 turns/cm = 5000 turns/m

I = 4A

Magnetic field at an internal point $= \mu_0 nI$

$= 4\pi \times 10^{-7} \times 5000 \times 4$

$= 8\pi \times 10^{-3}$

$= 25.12 \times 10^{-3}$ Wb/m^2

Magnetic field at one end $= \frac{\mu_0 nI}{2}$

$= \frac{25.12 \times 10^{-3}}{2}$

$= 12.56 \times 10^{-3}$ Wb/m^2

Magnetic field at an internal point $= \mu_0 nI$

27. Sol. Biot–Savart's law,

$dB = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{r^2}$

In vector form $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{l} \times \hat{r}}{r^2}$

28. Sol. As particle is moving without deviation, therefore

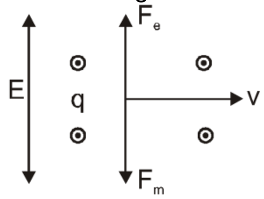
Eq = Bqv

$B = \frac{E}{v} = \frac{10^4}{10}$

$= 10^3$ Wb/m^2

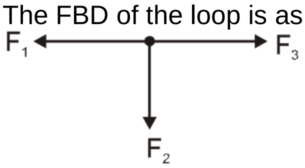
29. Sol. If both electric and magnetic fields are present and perpendicular to each other and the particle is moving perpendicular to both of them with $F_e = F_m$. In this situation $\vec{E} \neq 0$ and $\vec{B} \neq 0$

But if electric field becomes zero, then only force due to magnetic field exists. Under this force, the charge moves along a circle.



30.

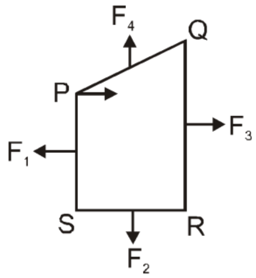
Sol. The FBD of the loop is as shown

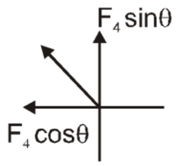


Therefore, force on QP will be equal and opposite to sum of forces on other sides.

Thus, $F_{QP} = \sqrt{(F_3 - F_1)^2 + F_2^2}$

Alternative :





$F_4 \sin\theta = F_2$

$F_4 \cos\theta = (F_3 - F_1)$

$\therefore \quad F_4 = \sqrt{(F_3 - F_1)^2 + F_2^2}$

PART - II : PRACTICE QUESTIONS

31. **Sol.** After passing through a magnetic field, the magnitude of its mass and velocity of the particle remain same, so its energy does not change, ie., kinetic energy will remain T.

32. **Sol.** For electron to pass undeflected,
electric force on electron = magnetic force on electron
i.e. $eE = evB$

or $v = \frac{E}{B}$

or $v = \frac{|\vec{E}|}{|\vec{B}|}$

33. **Sol.** According to Ampere's circuital law
$B(2\pi r) = \mu_0 \times 0$
or $B = 0$
So, inside a hollow metallic (copper) pipe carrying current, the magnetic field is zero.
But for external points, the whole current behaves as if it were concentrated at the axis only, so outside

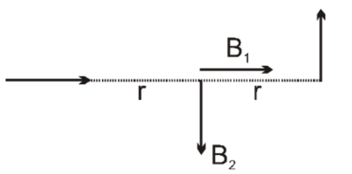
$B_0 = \frac{\mu_0 i}{2\pi r}$

Thus, the magnetic field is produced outside the pipe only

34. **Sol.** For external points the current carrying wire behaves as if thewhole current were concentrated at theaxis, so malgnetic field at far points from axis $B = \frac{\mu_0 i}{2\pi r}$ remains unaffected if diameter of wire is changed.

35. **Ans.** B

Sol. $B_1 = \frac{2\mu_0}{4\pi}\frac{M}{r^3}$



$= \frac{10^{-7} \times 1 \times 2}{(1)^3}$

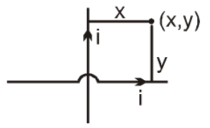
$= 2 \times 10^{-7}$ T

$B_2 = \frac{\mu_0}{4\pi}\frac{M}{r^3} = 10^{-7}$ T

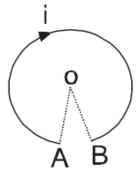
$B_{net} = \sqrt{5} \times 10^{-7}$ T (2) **Ans.**

36. **Sol.** $\frac{\mu_0 i}{2\pi x} = \frac{\mu_0 i}{2\pi y}$

y = x Ans. (1)



37.
Sol.

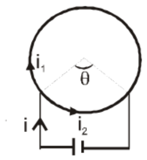


$B = \frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)^2$ **Ans. (1)**

38.

Ans. B

Sol. $B_{\text{at centre}} = \frac{\mu_0 i_1}{2R}\frac{[2\pi-\theta]}{2\pi} - \frac{\mu_0 i_2}{2R}\left[\frac{\theta}{2\pi}\right]$



$i_1R_1 = i_2R_2 = \varepsilon$

$i_1\,(2\pi - \theta) = i_2\,(\theta)$

So $B_{\text{at centre}} = 0$ **Ans. (2)**

39. **Solution :** $B = \frac{1}{2}\mu_0 ni\,[\cos\theta_1 - \cos\theta_2]$

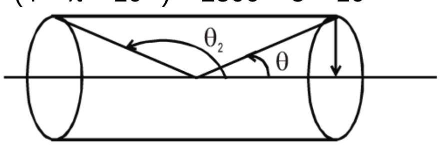
$\Rightarrow$ $n = \frac{1000}{0.4} = 2500$ per meter

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

(i) $\cos\theta_1 = \frac{0.2}{\sqrt{(0.3)^2+(0.2)^2}} = \frac{0.2}{\sqrt{0.13}}$

$\cos\theta_2 = \frac{-0.2}{\sqrt{0.13}}$

$\Rightarrow$ $B = \frac{1}{2} \times (4 \times \pi \times 10^{-7}) \times 2500 \times 5 \times 10^{-3}\,\frac{2\times 0.2}{\sqrt{0.13}} = \frac{\pi\times 10^{-5}}{\sqrt{13}}\,T$



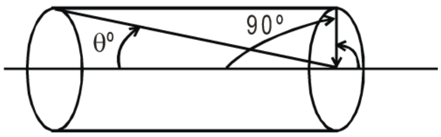
(ii) At the end

$\cos\theta_1 = \dfrac{0.4}{\sqrt{(0.3)^2 + (0.4)^2}} = 0.8$

$\cos\theta_2 = \cos 90^o = 0$

$B = \dfrac{1}{2} \times (4 \times \pi \times 10^{-7}) \times 2500 \times 5 \times 10^{-3} \times 0.8$

$\Rightarrow \quad B = \dfrac{\pi \times 10^{-5}}{\sqrt{13}} T$



40. **Ans.** C

Sol.

$qV = \dfrac{1}{2} mv^2$

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

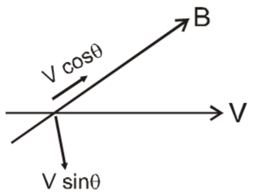
$= \dfrac{m\sqrt{\dfrac{2qV}{m}}}{qB}$

$= \sqrt{\dfrac{2mv}{qB^2}}$

$\dfrac{R_1}{R_2} = \sqrt{\dfrac{m_1}{m_2}}$

$\dfrac{m_1}{m_2} = \left(\dfrac{R_1}{R_2}\right)^2$ **Ans. (3)**

41.
Sol.



$\dfrac{mv^2}{R} = q\,v\,(B \sin\theta)$

$R = \dfrac{mv}{qB\sin\theta}$ **Ans. (3)**

42. **Sol.** $B_H \tan\theta = \dfrac{\mu_0 Ni}{2r}$

$i = \dfrac{0.34 \times 10^{-4} \times 2 \times .2}{4\pi \times 10^{-7} \times 20}$

$= \dfrac{17}{10\pi}$ Ans. (1)

43. **Sol.** Magnetic field at the centre of circular coil

$B = \frac{\mu_0 Ni}{2r}$

Ist case : N = 1, L = 2πr ⇒ r = $\frac{L}{2\pi}$

∴ $B = \frac{\mu_0 \times 1 \times i}{2r} = \frac{\mu_0 i}{2r}$

IInd case : N = 2, L = 2 × 2πr'

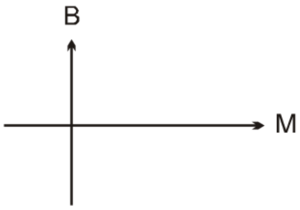
⇒ $r' = \frac{L}{4\pi} = \frac{r}{2}$

∴ $B' = \frac{\mu_0 \times 2 \times i}{2r'} = \frac{\mu_0 \times 2i}{2 \times (r/2)} = \frac{4\mu_0 i}{2r} = 4B$

48*. **Ans.** ABC

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

$\vec{F} = m\vec{B}$



couple of force may give torque but not force is zero.

m = pole strength depending on angle /kzqo {kerk dks.k ij fuHkZj djsxkA

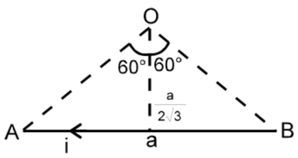
$\tau = 0$ $\tau \neq 0$, & $F = 0$ $F \neq 0$

(ABC) **Ans.**

49.

Sol. **(B)**

The magnetic field at the centroid (or circumcentre) because of side AB of triangular loop is



$\frac{\mu_0}{4\pi} \frac{i(\sin 60° + \sin 60°)}{\frac{a}{2\sqrt{3}}} = \frac{3\,\mu_0\,I}{2\,\pi a}$

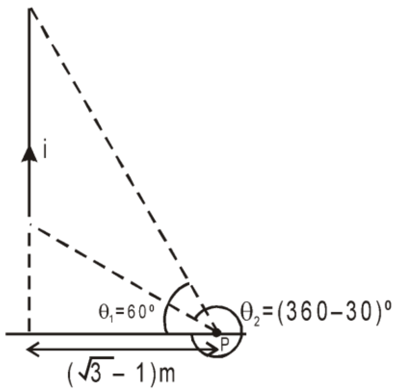
hence the net magnetic field due to all 3 sides is 3 × $\frac{9\,\mu_0\,I}{2\,\pi a}$

51. **Sol.** **[Easy]**

The magnetic lines of forces due to a straight current carrying wire (of any size) in a plane perpendicular to wire are circular in nature.

52. **Sol.** $B = \frac{\mu_0 . i}{4\pi d}(\sin\theta_1 + \sin\theta_2) = \frac{10^{-7} \times 100}{\sqrt{3}-1}\left[\frac{\sqrt{3}}{2} - \frac{1}{2}\right]$

$= 5 \times 10^{-6}$ T



54. **Sol.** The values of B_1, B_2 and B_3 are

B_1, B_2 B_3

$$B_1 = \frac{\mu_0}{4\pi}\frac{i}{a}(1 + \sin 45°) = \frac{\mu_0}{4\pi}\frac{i}{a}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$$

$$B_2 = \frac{\mu_0}{4\pi}\frac{i}{a}$$

$$B_3 = \frac{\mu_0}{4\pi}\frac{i}{a}(1 - \sin 45°) = \frac{\mu_0}{4\pi}\frac{i}{a}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$$

$\therefore B_1 : B_2 : B_3 = \sqrt{2}+1 : \sqrt{2} : \sqrt{2}-1$