04 MOVING CHARGES AND MAGNETISM

1. Biot Savart's Law and Ampere's Circuital Law

1.Ans.**(c)**

Explanation

The magnitude of magnetic field due to circular coil of N turns is given by

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

$$= \frac{4\pi \times 10^{-7} \times 7 \times 100}{2 \times 0.1}$$

$$= 4.4 \times 10^{-3}\ \mathrm{T}$$

$$= 4.4\mathrm{mT}$$

2.Ans. **(b)**

Explanation

$$\mathrm{B} = \frac{\mu_0}{4\pi}\frac{\mathrm{I}}{\mathrm{R}}(\pi) - \frac{\mu_0}{4\pi}\frac{2\mathrm{I}}{\mathrm{R}}$$

$$= \frac{\mu_0 \mathrm{I}}{4\mathrm{R}}\left[1 - \frac{2}{\pi}\right]$$ outward i.e. away from page.

3.Ans.**(b)**

Explanation

Magnetic field at the axis of a current carrying circular loop

$$|B| = \frac{\mu_0 i a^2}{2[a^2 + d^2]^{3/2}} \Rightarrow |B| = \frac{4\pi \times 10^{-7} \times \sqrt{2} \times 1}{2[1+1]^{3/2}}$$

$$|B| = \frac{4\pi \times 10^{-7} \times \sqrt{2}}{2.(2)^{3/2}} = \frac{4\pi \times 10^{-7}}{(2)^{3/2} \times (2)^{1/2}} = 3.14 \times 10^{-7}\ \mathrm{T}$$

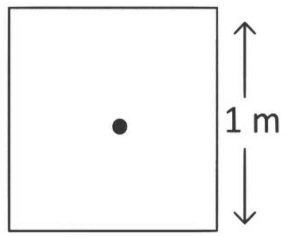
4.Ans.**(c)**

Explanation

According to Biot-Savart's law $\vec{d} = \frac{\mu_0}{4\pi}\frac{I\overrightarrow{dl}\vec{r}}{r^3}$ which is applicable for infinitesimal element. It is analogous to Coulomb's law, where $I\overrightarrow{dl}$ is vector source and electric field is produced by scalar source q. Here statement I is correct and statement II is incorrect.

5.Ans. **(b)**

Explanation



Magnetic flux $(\phi_\mathrm{B}) = \vec{B} \cdot \vec{A}$

$\vec{B}$ and $\vec{A}$ are in same direction, therefore

$$\phi_\mathrm{B} = \mathrm{B} \cdot \mathrm{A} = 0.5 \times 1^2$$

$$= 0.5\ \mathrm{Wb}$$

6.Ans.**(c)**

Explanation

For solid wire

Inside point

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

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

$$B \propto r$$

Outside point

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

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

7.Ans. **(b)**

Explanation

We know, magnetic field at centre of solenoid

$$B = \mu_0 \frac{N}{l} l = \mu_0 n l \left[n = \frac{N}{l}\right]$$

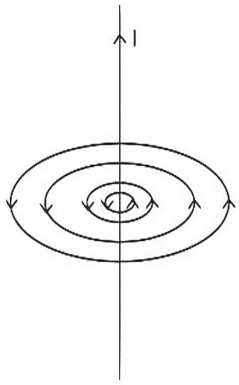
$$= 4\pi \times 10^{-7} \times 100 \times 10^3 \times 1 \left[n = \frac{100}{10^{-3}}\right]$$

$$= 4\pi \times 10^{-2} T$$

$$B = 12.56 \times 10^{-2} T$$

8.Ans. **(c)**

Explanation



From the right hand curl rule, the shape of magnetic field lines due to long current carrying wire is circular (concentric circles)

9.Ans. **(c)**

Explanation

Magnetic field inside the conducting cylindrical cable,

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

Here, R is the radius of the cylindrical cable,

r is the distance from the axis of the cylinder

I is the current carrying in the cylindrical cable.

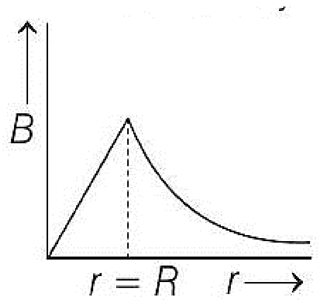
$$\Rightarrow B \propto r$$

$\therefore$ The graph of magnetic field B with r is a straight line passing through origin.

For a point outside the cylinder,

$$B = \frac{\mu_0 I}{2\pi R} \Rightarrow B \propto \frac{1}{R}$$

The graph of magnetic field (B) with r is a rectangular hyperbola passing through the outer surface of the cylinder.



$\therefore$ The variation of the magnetic field B due to the cable with the distance rfrom the axis of the cylindrical cable is as shown in the figure.

10. Ans.**(d)**

Explanation

Given, $I = 50 \text{ cm} = 0.5 \text{ m}, N = 100$ turns and $I = 2.5$ A

$\therefore$ Magnetic field at the centre of solenoid is

$$= \mu_0 n l = \mu_0 \frac{\text{N}}{\text{l}} \cdot l$$

$$= 4\pi \times 10^{-7} \times \frac{100}{0.5} \times 2.5$$

$$= 6.28 \times 10^{-4} \text{ T}$$

Hence, correct option is (d).

11.Ans.**(a)**

Explanation

The magnetic field within the turns of toroid is

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

where, $N =$ number of turns, $I =$ current in loops and

$r =$ radius of each turn

Here, $N_1 = 200, N_2 = 100, r_1 = 40$ cm, $r_2 = 20$ cm

and current / is same, then

$$\frac{B_1}{B_2} = \frac{\mu_0 N_1 I}{2\pi r_1} \times \frac{2\pi r_2}{\mu_0 N_2 l}$$

Substituting the given values in the above relation, we get

$$\frac{B_1}{B_2} = \frac{N_1}{N_2}\frac{r_2}{r_1}$$

$$= \frac{200}{100}\frac{20}{40} = 2 \times \frac{1}{2} = 1$$

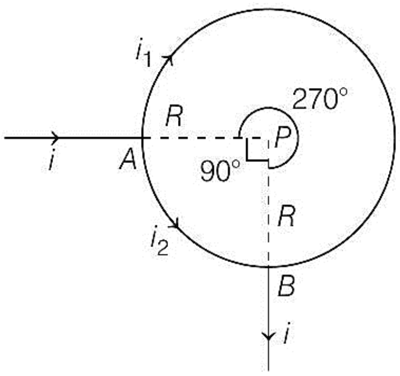
$$\therefore B_1 : B_2 = 1 : 1$$

12. Ans.**(a)**

Explanation

The magnetic field at the centre of an arc subtended at an angle θ is given by

$$B = \frac{\mu_0 i}{2R} \times \frac{\theta}{2\pi}$$



Then, the magnetic field due to larger arc AB is

$$B_1 = \frac{\mu_0 i_1}{2R} \times \frac{270}{2\pi} \qquad (i)$$

which acts in inward direction according to right hand thumb rule. And magnetic field due to smaller arc AB is

$$B_2 = \frac{\mu_0 i_2}{2R} \times \frac{90}{2\pi} \qquad (ii)$$

which acts in outward direction.
The resultant magnetic field

$$B_R = B_1 + B_2$$

$$= -\frac{\mu_0 i_1 \times 270}{4\pi R} + \frac{\mu_0 i_2 \times 90}{4\pi R}$$ [From Eq.(i) and (ii)]

which acts in inward direction as $B_1 > B_2$.
Two arcs can also be seen as the two resistances in parallel combination.
So, the potential across them will be same i.e.

$$V_1 = V_2$$

where, R_1 and R_2 = Resistance of respective segments
The wire is uniform so

$$\frac{R_1}{R_2} = \frac{L_1}{L_2} = \frac{R \times 270}{R \times 90}$$

[$\because$ length of arc = radius × angle]
From Eq. (iv), we get

$$\Rightarrow \quad \frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{90}{270} = \frac{1}{3} \qquad (v)$$

or $\quad 3i_1 = i_2$

From Eq. (iii) and (v), we get

$$B_R = \frac{\mu_0}{4\pi R}(-270 i_1 + 90 i_2)$$

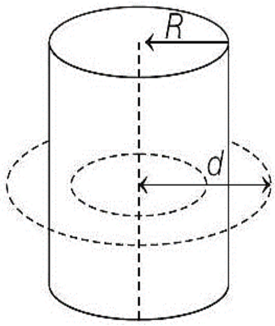
$$= \frac{\mu_0}{4\pi R}[-270 i_1 + 90(3 i_1)]$$

$$= \frac{\mu_0}{4\pi R}(-270 i_1 + 270 i_1) = 0$$

13. Ans.**(b)**

Explanation

The cylinder can be considered to be made from concentric circles of radius R.



(i) The magnetic field at point outside cylinder, i.e. $d > R$
From Ampere's circuital law,

$$\oint B \cdot dl = \mu_0 l$$

$$\Rightarrow \quad B \int dl = \mu_0 l$$

$$B(2\pi d) = \mu_0 l \Rightarrow B = \frac{\mu_0 l}{2\pi d}$$

where, μ_0 = permeability of free space.
(ii) The magnitude field at surface, i.e. $d = R$

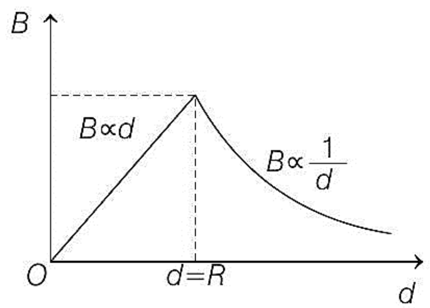
$$B = \frac{\mu_0 I}{2\pi R}$$

(iii) The magnetic field at inside point. The current for a point inside the cylinder is given by I' = current per unit cross-sectional area of cylinder X cross-section of loop

$$= \frac{1}{\pi R^2} \pi d^2 = \frac{I d^2}{R^2}$$

$$\therefore \; B = \frac{\mu_0 I'}{2\pi d} = \frac{\mu_0 l d^2}{2\pi R^2 d} = \frac{\mu_0 I}{2\pi R^2} d$$

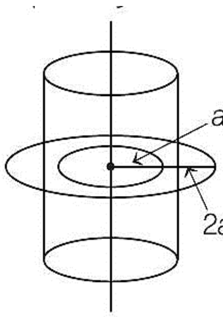
So, the variation of magnetic field can be plotted as



14. Ans.**(b)**

Explanation

Consider two amperian loops of radius $\frac{a}{2}$ and $2a$ as shown in the diagram.
Applying Ampere's circuital law for these loops we get,



$$\oint \mathbf{B}.\mathbf{d}L = \mu_0 I_{enclosec}$$

For the smaller loop

$$\Rightarrow B \times 2\pi \frac{a}{2} = \mu_0 \times \frac{1}{\pi a^2} \times \pi \frac{a^2}{2}$$
$$= \mu_0 I \times \frac{1}{4} = \frac{\mu_0 I}{4}$$
$$\Rightarrow B_1 = \frac{\mu_0 I}{4\pi a}, \text{ at distance } \frac{a}{2} \text{ from}$$

the axis of the wire

Similarly, for bigger amperian loop.

$B' \times 2\pi(2a) = \mu_0 I$[total current enclosed by Amperian loop is 2]

$$\Rightarrow B' = \frac{\mu_0 l}{4\pi a}$$

at distance $2a$ from the axis of the wire.

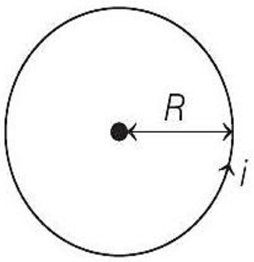
So, ratio of, $\frac{B}{B'} = \frac{\mu_0 l}{4\pi a} \times \frac{4\pi a}{\mu_0 l} = 1$

15. Ans.**(b)**

Explanation

Key Idea $B_{\text{centre}} = \frac{n \cdot \mu_0 i}{2R}$ (For a circular coil)

where, n : Number of turns in circular coil

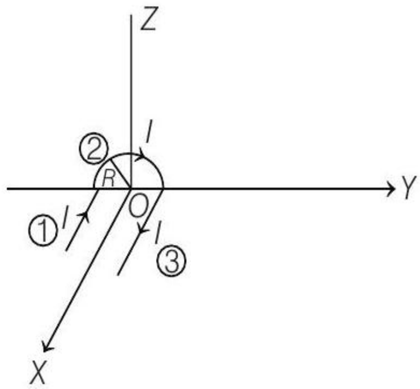


$$B = \frac{\mu_0 j}{2R} = \frac{\mu_0 i(2\pi)}{2(I)} = \frac{\mu_0 \pi i}{l}$$
$$= \frac{\mu_0 n i}{2\frac{1}{2n\pi}} = \frac{n^2 \mu_0 \pi i}{l} = n^2 B$$

16. Ans.**(a)**

Explanation

The magnetic field in the different regions is given by



$\mathbf{B}_1 = \frac{\mu_0}{4\pi} \times \frac{l}{R}(\hat{\mathbf{k}})$

$\mathbf{B}_3 = \frac{\mu_0 I}{4\pi R}(\hat{\mathbf{k}})$

$$\mathbf{B}_2 = \frac{\mu_0 I}{4\pi R}(-\hat{\imath})$$

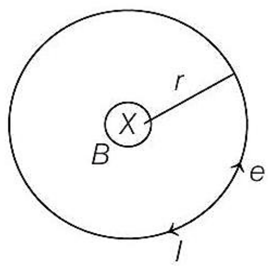
The net magnetic field at the centre 0 is

$$\mathbf{B} = \mathbf{B}_1 + \mathbf{B}_2 + \mathbf{B}_3$$
$$= \frac{\mu_0 I}{4\pi R}(-2\hat{\mathbf{k}}) + \frac{\mu_0 I}{4R}(-\hat{\mathbf{i}})$$
$$= -\frac{\mu_0 I}{4\pi R}(2\hat{\mathbf{k}} + \pi\hat{\mathbf{i}})$$

17. Ans.**(d)**

Explanation

As I $= \frac{q}{t}$. So, for an electron revolving in a circular orbit of radius r



$q = e$ and $t = T$

$\Rightarrow$

$I = \frac{e}{T} = \frac{e}{2\pi/\omega} = \frac{\omega e}{2\pi} = \frac{2\pi n e}{2\pi} = ne$

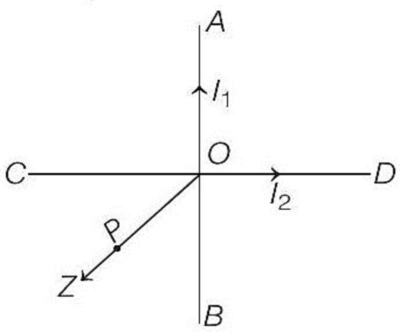
The magnetic field produced at the centre is

$$B = \frac{\mu_0 I}{2R} = \frac{\mu_0 n e}{2r}$$

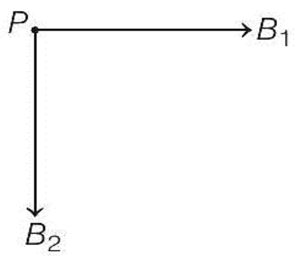
18. Ans.**(d)**

Explanation

As from question



The point P is lying at a distanced along the Z-axis.



As magnetic field B_1 is given by $= \frac{\mu_0}{2\pi}\frac{l_1}{d}$

and magnetic field B_2 is given by $= \frac{\mu_0}{2\pi}\frac{l_2}{d}$

B_1 and B_2 are $\perp$ to each other

So, B_{net} is given by

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

$$B_{\text{net}} = \frac{\mu_0}{2\pi}\frac{1}{d}(l_1^2 + l_2^2)^{1/2}$$

19. Ans.**(b)**

Explanation

Initial acceleration is given by

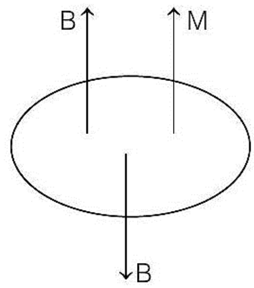
$a_0 = \frac{eE}{m}$

$\Rightarrow\ E = \frac{a_0 m}{e}$

$\therefore\ \frac{ev_0 B + eE}{m} = 3a_0$

or $(F = eE)$

$v_0 B + eE = 3a_0 m$



$\therefore\ ev_0 B = 3ma_0 - eE$

$\Rightarrow\ = 3ma_0 - ma_0$ [from Eq. (i)]

$\therefore B = \frac{2ma_0}{ev_0}$, in vertically downward direction

20. Ans.**(a)**

Explanation

The magnetic field (B) at the centre of circular current carrying coil of radius R and current / is $B = \frac{\mu_0 I}{2R}$

Similarly, if current is 21 , then

Magnetic field $= \frac{\mu_0 21}{2R} = 2B$

So, resultant magnetic field

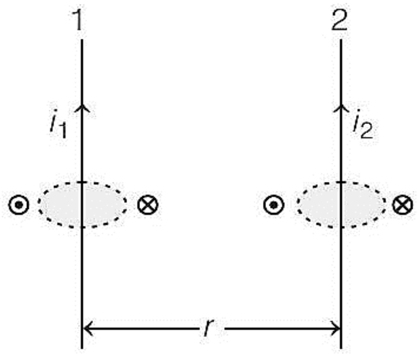
$$= \sqrt{B^2 + (2B)^2} = \sqrt{5B^2}$$

$$= \sqrt{5}B = \frac{\mu_0/\sqrt{5}}{2R}$$

21. Ans.**(b)**

Explanation

According to Maxwell's right handed screw rule, the magnetic field at right hand of wire 1 is perpendicular to the current carrying wire in plane of paper going inwards shown by $\otimes$. Similarly, the magnetic field at left hand of wire 2 is perpendicular to current carrying wire in plane of paper opposite to first wire shown by $\odot$. Thus, the two fields are opposite to each other.



Therefore, net magnetic field

$$B = B_1 - B_2 = \frac{\mu_0 i_1}{2\pi r_1} - \frac{\mu_0 i_2}{2\pi r_2}$$

At mid-point, $r_1 = r_2 = \frac{r}{2} = \frac{5}{2} = 2.5$ cm

Hence, $B = \frac{\mu_0}{2\pi}\frac{i_1}{r/2} - \frac{i_2}{r/2}$

$$= \frac{\mu_0}{2\pi}\frac{5}{2.5} - \frac{2.5}{2.5}$$

$$= \frac{\mu_0}{2\pi}(2-1) = \frac{\mu_0}{2\pi}\text{T}$$

22. Ans.**(b)**

Explanation

Magnetic field at the centre of a circular coil is

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

where, i is current flowing in the coil and r is radius of coil.

At the centre of coil-1,

$$B_1 = \frac{\mu_0}{2\pi} \times \frac{i_1}{r_1} \qquad (i)$$

At the centre of coil-2

$$B_2 = \frac{\mu_0}{2\pi} \times \frac{i_2}{r_2}$$

but $B_1 = B_2$

$$\therefore \frac{\mu_0}{2\pi}\frac{i_1}{r_1} = \frac{\mu_0}{2\pi}\frac{i_2}{r_2} \qquad (iii)$$

or $\frac{i_1}{r_1} = \frac{i_2}{r_2}$

As given $r_1 = 2r_2$

$$\therefore \frac{i_1}{2r_2} = \frac{i_2}{r_2} \text{ or } i_1 = 2i_2$$

Now, ratio of potential differences

$$\frac{V_2}{V_1} = \frac{i_2 \times R_2}{i_1 \times R_1} = \frac{i_2 \times R_2}{2i_2 \times 2R_2} = \frac{1}{4}\ [R \propto r]$$

$$\therefore \frac{V_1}{V_2} = \frac{4}{1}$$

Note If wires are made of same material, then resistance of coil is proportional to the radius of coil i.e., $R \propto I$ so, $R \propto 2\pi r$

23. Ans.**(d)**

Explanation

For a solenoid magnetic field is given by $B = \mu_0 ni$

where, $n =$ number of turns per unit length and $i =$ current through the coil or so for two different cases $B \propto ni$

$$\therefore \frac{B_1}{B_2} = \frac{n_1 i_1}{n_2 i_2}$$

Here, $n_1 = n, n_2 = \frac{n}{2}$

$i_1 = i_1 i_2 = 2i,\ B_1 = B$

Hence, $\frac{B^2}{B_2} = \frac{n}{n/2} \times \frac{i}{2i} = 1$ or $B_2 = B$

24.Ans.**(d)**

Explanation

Magnetic field at the centre of circular coil carrying current i with N number of turns is given by

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

Case I $N = 1, L = 2\pi r \Rightarrow r = \frac{L}{2\pi}$

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

Case II $N = 2, L = 2 \times 2\pi r'$

$$\Rightarrow r' = \frac{L}{4\pi} = \frac{r}{2} \therefore B' = \frac{\mu_0 \times 2 \times i}{2r'}$$

Putting the value of r'

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

Note Magnetic field at the centre of circular coil is maximum and decreases as we move away from the centre (on the axis of coil).

25. Ans.**(c)**

Explanation

At the centre of current carrying, circular coil, the magnetic field is,

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

where, $N =$ number of turns in the coil

$i =$ current flowing

$r =$ radius of the coil

Given, $N = 1000, i = 0.1$ A, $r = 0.1$ m

Substituting the values, we have

$$B = \frac{4\pi \times 10^{-7} \times 1000 \times 0.1}{2 \times 0.1}$$
$$= 2\pi \times 10^{-4} = 6.28 \times 10^{-4} \text{ T}$$

26. Ans.**(b)**

Explanation

According to Ampere's circuital law,

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

So, $B(2\pi r) = \mu_0 \times 0 \; [i_{\text{enclosed}} = 0]$

$\therefore \; B = 0$

So, inside a hollow metallic (copper) pipe there is no current inside the Ampere's surface so, 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.

27. Ans.**(b)**

Explanation

Magnetic induction at the centre of current carrying coil of N turns carrying current is given by

$$B = \frac{\mu_0 N i}{2r} \qquad (i)$$

Suppose the length of the wire be L.

Case I For coil of one turn, let radius be r_1.

$\therefore \; L = 2\pi r_1 \times N$

or $r_1 = \frac{L}{2\pi \times N} = \frac{L}{2\pi} \; (\because N = 1)$

Case II For coil of two turns, let radius be r_2.

$\therefore \; L = 2\pi r_2 \times N$

or $r_2 = \frac{L}{2\pi \times N} = \frac{L}{2\pi \times 2} \; (\because N = 2)$

or $r_2 = \frac{r_1}{2}$

By comparing two different cases from Eq. (i),

$$\frac{B_1}{B_2} = \frac{N_1}{r_1} \times \frac{r_2}{N_2} \text{ or } \frac{B_1}{B_2} = \frac{1 \times \frac{r_1}{2}}{r_1 \times 2}$$

$$\therefore \; \frac{B_1}{B_2} = \frac{1}{4}$$

28. Ans.**(a)**

Explanation

Applying right hand grip rule and considering AB, the direction of magnetic field due to one current is upwards and that due to other is downwards. Both the magnetic fields cancel out each other and the resultant magnetic field is zero.

Considering CD and applying right hand grip rule for the two currents, the direction of magnetic field is in the same direction in both the cases giving non-zero resultant.

29. Ans.**(d)**

Explanation

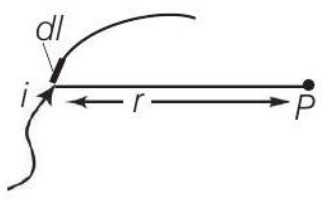
According to Biot-Savart law, the magnetic field induction **dB** (also called magnetic flux density) at a point P due to current element depends upon the factors as stated below.

(i) $dB \propto i$

(ii) $dB \propto dl$

(iii) $dB \propto \sin\theta$

(iv) $dB \propto \frac{1}{r^2}$



Combining these factors, we get magnitude of **dB**

i.e., $\mathbf{dB} = \frac{\mu_0}{4\pi} \cdot \frac{i dl \sin\theta}{r^2}$

In vector form,

$$\mathbf{dB} = \frac{\mu_0}{4\pi} i \frac{(\mathbf{dl} \times \mathbf{r})}{r^3} \quad \frac{\mu_0}{4\pi} = 10^{-7} \text{ T} - \text{m/A}$$

30. Ans.**(a)**

Explanation

Total magnetic field due to current carrying straight wire at any point P is given by

$$B=\frac{\mu_0 i}{4\pi r}(\sin\ \varphi_1+\sin\ \varphi_2)$$

When the conductor is of infinite length and point P lies near the centre of conductor, then $\varphi_1=\varphi_2=90^\circ$

$$\therefore\ B=\frac{\mu_0 i}{4\pi r}(\sin\ 90^\circ+\sin\ 90^\circ)$$

$$=\frac{\mu_0}{4\pi}\cdot\frac{2i}{r}\Rightarrow r=\frac{\mu_0 i}{2\pi B}$$

Here, current $(i)=12$ A,

magnetic field $(B)=3\times10^{-5}\ \mathrm{Wb/m^2}$

$\therefore$ Perpendicular distance from wire to the point, $r=\frac{4\pi\times10^{-7}\times12}{2\times\pi\times(3\times10^{-5})}$

$=8\times10^{-2}$ m

31. Ans.**(b)**

Explanation

Magnetic field due to straight wire is given by

$$B=\frac{\mu_0}{4\pi}\frac{2i}{r}$$

From above expression magnetic field due to current carrying conductor doesn't depends on the diameter of wire, it only depends on distance of wire from the point and current in the wire so, magnetic field remaining same for both wires.

32. Ans.**(c)**

Explanation

Sl unit of magnetic induction is tesla(T). Magnetic field induction at a point is said to be one tesla if a charge of one coulomb while moving at right angle to a magnetic field, with a velocity of 1 $\mathrm{ms^{-1}}$ experiences a force of 1 N , at that point.

$\therefore$

$$1\ \mathrm{T}=1\mathrm{NA^{-1}\ m^{-1}}$$

2.Magnetic Force on Charged Particle in Magnetic Field

1.Ans.**(b)**

Explanation

Given, velocity, $\mathbf{v}=2\hat{\mathbf{i}}+4\hat{\mathbf{j}}+6\hat{\mathbf{k}}$

Force, $\mathbf{F}=4\hat{\mathbf{i}}-20\hat{\mathbf{j}}+12\hat{\mathbf{k}}$

As we know,

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

Here, $q=1$

Substituting the values in the above equation, we get

$$4\hat{\mathbf{i}}-20\hat{\mathbf{j}}+12\hat{\mathbf{k}}=(1)[(2\hat{\mathbf{i}}+4\hat{\mathbf{j}}+6\hat{\mathbf{k}})\times\left(B\hat{\mathbf{i}}+B\hat{\mathbf{j}}+B_0\hat{\mathbf{k}}\right)]$$

$$4\hat{\mathbf{i}}-20\hat{\mathbf{j}}+12\hat{\mathbf{k}}=\begin{matrix}\hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}}\\ 2 & 4 & 6\\ \mathrm{B} & B & B_0\end{matrix}$$

$$\Rightarrow 4\hat{\mathbf{i}}-20\hat{\mathbf{j}}+12\hat{\mathbf{k}}=\hat{\mathbf{i}}(4\ \mathrm{B}_0-6\ \mathrm{B})-\hat{\mathbf{j}}(2B_0-6B)+\hat{\mathbf{k}}(2B-4B)$$

Comparing the LHS and RHS of the above equation, we get

$\hat{\mathbf{i}}$ terms:

$$4B_0-6B=4 \qquad (i)$$

$\hat{\mathbf{j}}$ terms:

$$2B_0-6B=20 \qquad (ii)$$

$\hat{\mathbf{k}}$ terms:

$$2B-4B=12$$

$$\Rightarrow\ B=-6$$

Substituting the value of B in the Eq. (ii), we get

$$2B_0-6(-6)=20\ \Rightarrow\ B_0=-8$$

Thus, the magnetic field vector,

$$B=-6\hat{\mathbf{i}}-6\hat{\mathbf{j}}-8\hat{\mathbf{k}}$$

2.Ans.**(d)**

Explanation

The centripetal force required for circular motion is provided by magnetic force

$$\Rightarrow\ \frac{mv_p^2}{r}=Bqv_p$$

$$\Rightarrow\ r=\frac{mv_p}{qB} \qquad (i)$$

where, v_p = perpendicular velocity of particle and

q = charge on particle.

As, momentum, $p = mv_p$

$$\therefore\ r = \frac{p}{qB}$$

[from Eq. (i)]

According to the question, moment of both particle is same.

$$\Rightarrow\ r \propto \frac{1}{q}$$

For ionised hydrogen atom, $q_{\mathrm{H}} = e$ and for α-particle, $q_\alpha = 2e$

$$\Rightarrow\ \frac{r_H}{r_\alpha} = \frac{q_\alpha}{q_H} = \frac{2e}{e} = \frac{2}{1} \text{ or } 2:1$$

3.Ans.**(a)**

Explanation

As we know that, radius of a charged particle in a magnetic field B is given by

$$r = \frac{mv}{qB} \qquad (i)$$

where, r = charge on the particle

v = speed of the particle

$\therefore$ The time taken to complete the circle,

$$T = \frac{2\pi r}{v} \Rightarrow \frac{T}{2\pi} = \frac{m}{qB} \text{ [from Eq. (i)]}$$

$$\therefore\ \omega = \frac{2\pi}{T} = \frac{qB}{m}$$

$$\because\ q = e \text{ and } \frac{e}{m} = 1.76 \times 10^{11}\mathrm{C/kg}$$

$$\Rightarrow\ B = 3.57 \times 10^{-2}\ \mathrm{T}$$

$$\Rightarrow\ \frac{2\pi}{T} = \frac{eB}{m} f = \frac{1}{2\pi}\frac{e}{m}B\ \because \frac{1}{T} = f$$

$$= \frac{1}{2\pi} \times 1.76 \times 10^{11} \times 3.57 \times 10^{-2}$$

$$= 1.0 \times 10^{9}\ \mathrm{Hz} = 1\mathrm{GHz}$$

4.Ans.**(c)**

Explanation

Frequency, $v = \frac{eB}{2\pi m}$

$KE = \frac{1}{2}mv^2$ and radius $R = \frac{mv}{eB}$

Here, velocity, $v = \frac{\pi R}{TR} = \frac{2\pi R}{T} = 2\pi R v$

$\therefore$ Radius, $R = \frac{m(2\pi R v)}{eB}$

Magnetic field, $B = \frac{2\pi m v}{e}$

Kinetic energy, $K = \frac{1}{2}m(2\pi R v)^2$

$$= 2m\pi^2 v^2 R^2$$

5.Ans.**(a)**

Explanation

Magnetic field (B) will not apply any force. Only electric field E will apply a force opposite to velocity of the electron hence, speed decreases.

6.Ans.**(d)**

Explanation

As the electron beam is not deflected, then $F_m = F_e$ or Bev $= Ee$

$$\text{or } v = \frac{E}{B} \qquad (i)$$

As the electron moves from cathode to anode, its potential energy at the cathode appears as its kinetic energy at the anode. If V is the potential difference between the anode and cathode, then potential energy of the electron at cathode $= eV$. Also, kinetic energy of the electron at anode $= \frac{1}{2}mv^2$. According to law of conservation of energy,

$$\frac{1}{2}mv^2 = eV \text{ or } v = \sqrt{\frac{2eV}{m}} \qquad (ii)$$

From Eqs. (i) and (ii), we have

$$\sqrt{\frac{2eV}{m}} = \frac{E}{B} \text{ or } \frac{e}{m} = \frac{E^2}{2VB^2}$$

7.Ans.**(a)**

Explanation

Magnetic Lorentz force, $\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$

$$= -2 \times 10^{-6}\{(2\hat{\mathbf{i}} + 3\hat{\mathbf{j}}) \times 10^{6} \times 2\hat{\mathbf{j}}\}$$

$$= -2 \times 10^{-6}[2 \times 2 \times 10^{6}\hat{\mathbf{k}}]$$

= 8 Nalong negative Z-axis

8.Ans.**(c)**

Explanation

Magnetic field can never increase the energy of a charged particle so, its kinetic energy will remain same.

9.Ans.**(b)**

Explanation

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

But if electric field becomes zero, then only force due to magnetic field exists. And **E** is perpendicular to the **B** so the charge moves along a circle.

10. Ans.**(c)**

Explanation

When magnetic field is perpendicular to motion of charged particle, then particle performs circular motion. So, centripetal force = magnetic force i.e. $\frac{mv^2}{R} = Bqv$ or $R = \frac{mv}{Bq}$

Further, time period of the motion

$$\mathrm{T} = \frac{2\pi \mathrm{R}}{\mathrm{v}} = \frac{2\pi \frac{\mathrm{mv}}{\mathrm{Bq}}}{\mathrm{v}} \text{ or } \mathrm{T} = \frac{2\pi \mathrm{m}}{\mathrm{Bq}}$$

11. Ans.**(c)**

Explanation

When a charged particle q is moving in a uniform magnetic field **B** with velocity **v** such that angle between **v** and **B** is θ then the chargeq experiences a force which is given by

$$F = q(\mathbf{v} \times \mathbf{B}) = qvB\sin\ \theta$$

If $\theta = 0°$ or $180°$, then $\sin\ \theta = 0$

$$\therefore\ F = qvB\sin\ \theta = 0$$

Since, force on charged particle is non-zero, so angle between **v** and **B** can have any value other than 0° and 180°.

Note Force experienced by the charged particle is the Lorentz force.

12. Ans.**(c)**

Explanation

The time period of electron moving in a circular orbit,

$$T = \frac{\text{Circumference of circular path}}{\text{Speed}}$$

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

Now, equivalent current due to flow of electron is given by

$$i = \frac{q}{T} = \frac{e}{(2\pi r/v)} = \frac{ev}{2\pi r}\ [q = e]$$

Magnetic field at centre of circle

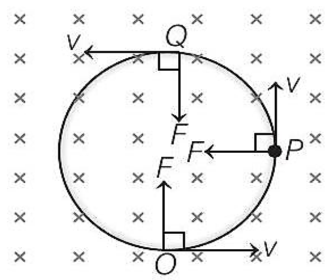
$$B = \frac{\mu_0 i}{2r} = \frac{\mu_0 ev}{4\pi r^2}\ i = \frac{eV}{2\pi r}$$

$$\Rightarrow r \propto \sqrt{\frac{V}{B}}$$

13. Ans.**(c)**

Explanation

When a charged particle moves through a perpendicular magnetic field, then a magnetic force acts on it which changes the direction of particle but does not alter the magnitude of its velocity (i.e., speed).



So, speed of charged particle remains unchanged i.e., of velocity magnitude remains constant.

Note If a charged particle moves at 45° to magnetic field, then path of the particle will be a helix whose circular part has radius according to relation $r = \frac{mv\sin\ \theta}{qB}$

14. Ans.**(b)**

Explanation

If **E** is the electric field strength and **B** is the magnetic field strength and q is the charge on a particle, then electric force on the charge

$$\mathbf{F}_e = q\mathbf{E}$$

and magnetic force on the charge

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

The net force on the charge

$$\mathbf{F} = \mathbf{F}_e + \mathbf{F}_m = q\mathbf{E} + q(\mathbf{v} \times \mathbf{B})$$

Alternative

According to Lorentz force if a charged particle is in both electric field (**E**) and magnetic field (**B**), force is given by

$$\mathbf{F} = q[\mathbf{E} + (\mathbf{v} \times \mathbf{B})]$$

15. Ans.**(b)**

Explanation

Magnetic force = centripetal force

i.e. $qvB = \dfrac{mv^2}{r}$

or $qvB = mr\omega^2$

or $\omega^2 = \dfrac{qvB}{mr} = \dfrac{q(r\omega)B}{mr}$

Angular frequency, $\omega = \dfrac{qB}{m}$

If v is the frequency of rotation, then

If ν is the frequency of rotation, then

$$\omega = 2\pi v \Rightarrow v = \frac{\omega}{2\pi}$$

$$\therefore\ v = \frac{qB}{2\pi m}$$

Note In the resultant expression $\frac{q}{m}$ is known as specific charge. It is sometimes denoted by α. So, in terms of α, the above formula can be written as

$$\omega = B\alpha \text{ and } v = \frac{B\alpha}{2\pi}$$

16. Ans.**(b)**

Explanation

According to the question, the magnetic field is perpendicular to the direction of motion of charged particle.

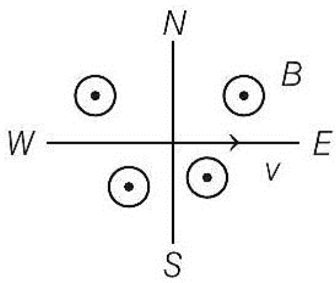
Force on the charged particle is given by

$F = qvB\sin\ \theta = q(\mathbf{v} \times \mathbf{B})$

where, $q =$ charge on charged particle $v =$ velocity of charged particle

$B =$ magnetic field

$\theta =$ angle between **v** and $\mathbf{B} = 90°$



According to Fleming's left hand rule, the force acts perpendicular to the velocity of the particle. This force in magnitude remains same but the direction of charged particle goes on changing and always perpendicular to the velocity of the particle, so the particle will move in a circular orbit. The magnetic force does not make any change in its kinetic energy which implies that speed is constant or unchanged

17. Ans.**(c)**

Explanation

According to Lorentz force,

$$\mathbf{F}_{\text{net}} = q[\mathbf{E} + (\mathbf{v} \times \mathbf{B})]$$

When $\mathbf{v}, \mathbf{E}$ and **B** are mutually perpendicular to each other, in this situation if **E** and **B** are such that $\mathbf{F} = \mathbf{F}_e + \mathbf{F}_m = 0$, then acceleration in the particle, $\mathbf{a} = \frac{\mathbf{F}}{\mathrm{m}} = 0$. It means particle will pass undeflected.

Here, $F_e = F_m$

So, $qE = qvB\ F_e = qE$

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

Given, $E = 20\mathrm{Vm}^{-1}$

$B = 0.5\ \mathrm{T}$

$\therefore\ v = \dfrac{20}{0.5} = 40\ \mathrm{m/s}$

18. Ans.**(c)**

Explanation

If charged particle is moving perpendicular to the direction of **B**, it experiences a maximum force which acts perpendicular to the direction of **B** as well as v. Hence, this force will provide the required centripetal force and the charged particle will describe a circular path in the magnetic field of radius r and is given by

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

Now, KE of electron = 10eV

$$\Rightarrow \frac{1}{2}mv^2 = 10\text{eV}$$

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

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

$$\Rightarrow v^2 = 3.52 \times 10^{12}$$

or $v = 1.88 \times 10^6$ m

Now, radius of circular path

$$r = \frac{mv}{qB} = \frac{9.1 \times 10^{-31} \times 1.88 \times 10^6}{1.6 \times 10^{-19} \times 10^{-4}}$$
$$= 11 \text{ cm}$$

19. Ans.**(d)**

Explanation

The force experienced by a charged particle moving in space where both electric and magnetic fields exist is called Lorentz force.

Due to both electric and magnetic fields, the total force experienced by the charged particle will be given by,

$$\mathbf{F} = \mathbf{F}_e + \mathbf{F}_m = q\mathbf{E} + q(\mathbf{v} \times \mathbf{B})$$
$$= q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

When $\mathbf{v}, \mathbf{E}$ and $\mathbf{B}$ are mutually perpendicular to each other. In this situation, if $\mathbf{E}$ and $\mathbf{B}$ are such that $\mathbf{F} = \mathbf{F}_e + \mathbf{F}_m = 0$, then acceleration in the particle, $\mathbf{a} = \frac{\mathbf{F}}{m} = 0$.

It means particle will go undeflected.

20. Ans.**(a)**

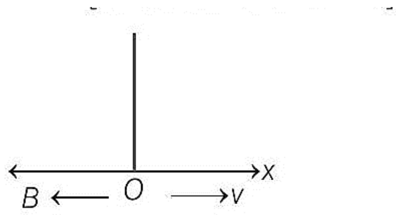
Explanation

Force on a charged particle in the magnetic field is

$$|\mathbf{F}| = q|\mathbf{v} \times \mathbf{B}| \text{ or } F = qvB\sin\theta$$

when angle between velocity v and magnetic induction B is 180° or 0°, then

$$F = qvB\sin 180° = 0$$
$$[\text{as } \sin 180° \text{ or } \sin 0° = 0]$$



So, the charged particle remains unaffected.

21. Ans.**(c)**

Explanation

The force F on the charged particle due to external magnetic field provides the required centripetal force $(= mv^2/r)$ necessary for motion along the circular path of radius r.

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

$$\therefore r \propto v \; \frac{m}{qB} = \text{constant}$$

$As v$ is doubled, the radius also becomes double. Hence, radius $= 2 \times 2 = 4$ cm.

22. Ans.**(d)**

Explanation

When charged particle move on circular path, the force F on the charged particle due to magnetic field provides the required centripetal force $(= mv^2/r)$ necessary for motion along the circular path.

$$\text{So, } \frac{mv^2}{r} = qvB$$

where, m = mass of particle

v = velocity of particle

q = charge on particle

B = external magnetic field

r = radius of circular path

$mv^2 = Bqvr$

$\therefore$ Kinetic energy $E_K = \frac{1}{2}mv^2 = \frac{1}{2}$ Bqvr

$$= Bq \cdot \frac{r}{2}\frac{Bqr}{m} = \frac{B^2q^2r^2}{2m}$$

For deutron, $E_1 = \frac{B^2q^2r^2}{2\times(2m)}$ (mass $= 2m$)

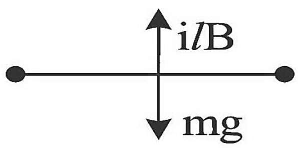
For proton, $E_2 = \frac{B^2q^2r^2}{2m}$ (mass $= m$)

$$\therefore \quad \frac{E_1}{E_2}=\frac{1}{2} \Rightarrow \frac{50\text{keV}}{E_2}=\frac{1}{2}$$

or $\quad E_2 = 100\text{keV}$

3.Force and Torque on Current Carrying Conductor

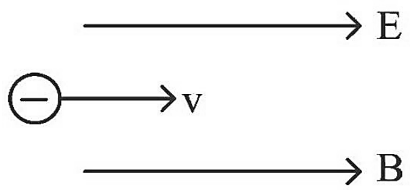
1.Ans.**(d)**
Explanation



$\text{mg} = \text{i}\ell\text{B}$
$250 \times 10^{-3} \times 9.8 = \text{i} \times 2 \times 0.7$
$\text{i} = \frac{0.250 \times 9.8}{2 \times 0.7} = 0.250 \times 7$
$\text{i} = 1.75 \text{ A}$

2.Ans.**(c)**

Explanation
Speed of electron will decrease due to electric force magnetic force of electron is zero.



3.Ans.**(b)**

Explanation

$$\vec{F} = I(\vec{\ell} \times \vec{B})$$
$$= I[(L\hat{\imath}) \times (2\hat{\imath} + 3\hat{\jmath} - 4\hat{k})]$$
$$= I(4L\hat{\jmath} + 3L\hat{k})$$
$$|\vec{F}| = 5 \text{ L}$$

4.Ans.**(d)**

Explanation
Force per unit length between two long current carrying wires $= \frac{\mu_0 I_1 I_2}{2\pi d}$

$$F = \frac{4\pi \times 10^{-7} \times 5 \times 10}{2\pi \times 10 \times 10^{-2}} = 10^{-4}\text{Nm}^{-1}$$

⇒ The force is attractive as direction of current in two conductors is same
Hence, required force is $1 \times 10^{-4}\text{Nm}^{-1}$ and it is attractive.

5.Ans.**(d)**

Explanation
Key Concept Firstly, make a free body diagram of the system and indicate the magnitude and direction of all the forces acting on the body. Then, choose any two mutually perpendicular axes say X and Y in the plane of forces in case of coplanar forces
As, the system is in equilibrium,

$$\Sigma F_x = 0$$

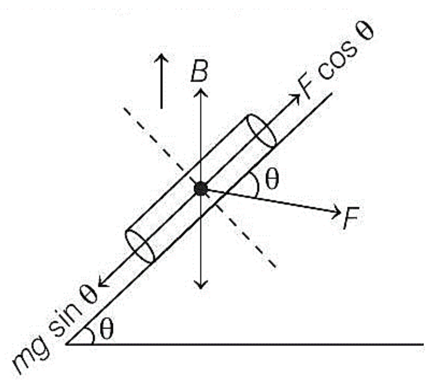
where, F is the magnitude of force experienced by the rod when placed in a magnetic field and current I is flowing through it.
But the force experienced by the given rod in a uniform magnetic field is

$$F = ILB$$

∴ Eq. (i)becomes,

$$mg\sin\ \theta = ILB\cos\ \theta$$
$$\Rightarrow\ I = \frac{mg\sin\ \theta}{LB\cos\ \theta} = \frac{mg}{LB}\tan\ \theta$$

According to the question,



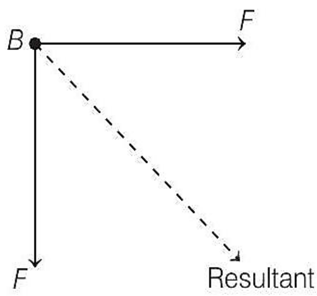
Here, $\frac{m}{L} = 0.5 \text{ kg m}^{-1}, g = 9.8 \text{ ms}^{-2}$,
$\theta = 30^\circ, B = 0.25T$
Substituting the given values in Eq. (ii), we get

$$I=\frac{0.5\times 9.8}{0.25}\tan\ 30^{\circ}$$
$$=\frac{0.5\times 9.8}{0.25}\times\frac{1}{\sqrt{3}}$$
$$=11.32\ \mathrm{A}$$

6.Ans.**(d)**

Explanation

As force on wire B due to A and C are attractive, so we have following condition



$$F=\frac{\mu_0 1^2}{2\pi d}$$

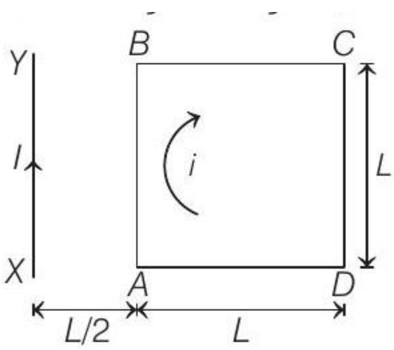
Resultant force on B

$$=\sqrt{F_1^2+F_2^2}=\sqrt{2}F=\sqrt{2}\times\frac{\mu_0 I^2}{2\pi d}$$
$$=\frac{\mu_0 I^2}{\sqrt{2}\pi d}$$

7.Ans.**(d)**

Explanation

Consider the given figure,



From the above figure, it can be seen that the direction of currents in a long straight conductor XY and arm AB of a square loop $ABCD$ are in the same direction. So, there exist a force of attraction between the two, which will be experienced by F_{BA} as

$$F_{BA}=\frac{\mu_0 liL}{2\pi\frac{L}{2}}$$

In the case of XY and arm CD, the direction of currents are in the opposite direction. So, there exist a force of repulsion which will be experienced by CD as $F_{CD}=\frac{\mu_0\ \mathrm{liL}}{2\pi\frac{3L}{2}}$

Therefore, net force on the loop ABCD will be

$$F_{\text{loop}}=F_{BA}-F_{CD}=\frac{\mu_0\ \mathrm{liL}}{2\pi}\frac{1}{(L/2)}-\frac{1}{(3L/2)}$$

$$F_{\text{loop}}=\frac{2\mu_0 il}{3\pi}$$

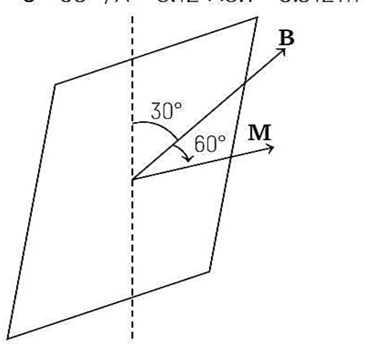
8.Ans.**(b)**

Explanation

Given, $N=50$

$B=0.2\ \mathrm{Wb/m^2}, I=2\ \mathrm{A}$

$\theta=60^{\circ}, A=0.12\times 0.1=0.012\ \mathrm{m}^2$



Thus, torque required to keep the coil in stable equilibrium, i.e.

$$\tau=NIAB\sin\ \theta$$
$$=50\times 2\times 0.012\times 0.2\times\sin\ 60^{\circ}$$
$$=50\times 2\times 0.12\times 0.2\times\frac{\sqrt{3}}{2}=0.20$$

Nm

9.Ans.**(d)**

Explanation

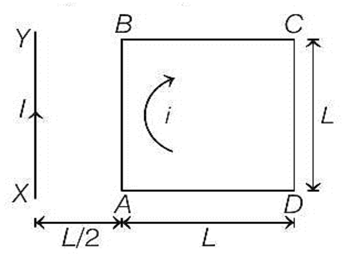
For parallel, Mis stable and for antiparallel, it is unstable.

10. Ans.**(a)**

Explanation

Force on AB is given by, $\mathbf{F}_{AB}=0$

According to the question,



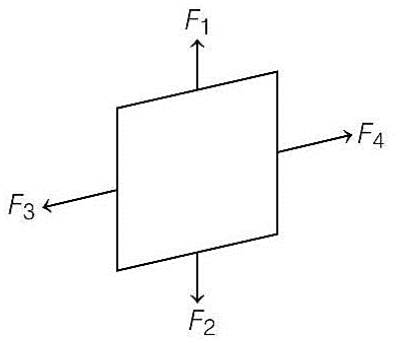
$$\mathbf{F}_{AB} = 0$$
$$\Rightarrow \mathbf{F}_{AB} + \mathbf{F}_{BC} + \mathbf{F}_{CA} = 0$$
$$\mathbf{F}_{BC} + \mathbf{F}_{CA} = 0$$
$$\mathbf{F}_{CA} = -\mathbf{F}_{BC} = -\mathbf{F}$$

11. Ans.**(b)**

Explanation

When a current carrying loop is placed in a magnetic field, the coil experiences a torque given by $\tau = NBiA\sin\,\theta$. Torque is maximum when $\theta = 90°$, i.e., the plane of the coil is parallel to the field.

$$\tau_{\max} = \text{NBiA}$$



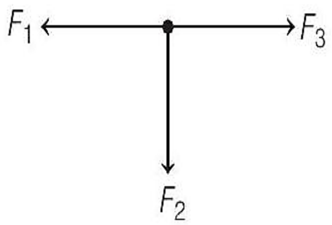
Forces $\mathbf{F}_1$ and $\mathbf{F}_2$ acting on the coil are equal in magnitude and opposite in direction. As the forces $\mathbf{F}_1$ and $\mathbf{F}_2$ have the same line of action, their resultant effect on the coil is zero.

The two forces $\mathbf{F}_3$ and $\mathbf{F}_4$ are equal in magnitude and opposite in direction. As the two forces have different lines of action, they constitute a torque. Thus, if the force on one arc of the loop is **F**, the net force on the remaining three arms of the loop is ***F***.

12. Ans.**(b)**

Explanation

As the net force on closed loop is equal to zero. So, force on QP will be equal and opposite to sum of forces on other 3 sides.



So, from vector laws,

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

13. Ans.**(c)**

Explanation

Torque acting on equilateral triangle in a magnetic field **B** is

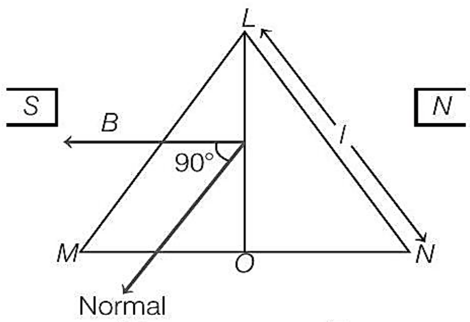
$$\tau = \mathbf{M} \times \mathbf{B}, \tau = iAB\sin\,\theta\ [iA = \mathbf{M}]$$

Area of $\triangle\ LMN$

$$A = \frac{\sqrt{3}}{4} l^2 \text{ and } \theta = 90°$$

[I =sides of triangle]

Substituting the given values in the expression for torque, we have



$$\tau = i \times \frac{\sqrt{3}}{4} l^2\ B \sin 90° = \frac{\sqrt{3}}{4} il^2\ B$$

$(\because \sin 90° = 1)$

Hence, $l = 2\left(\frac{\tau}{\sqrt{3}\,Bi}\right)^{1/2}$

14. Ans.**(a)**

Explanation

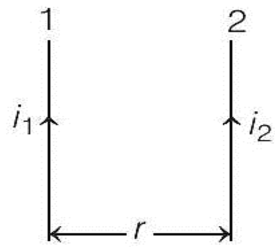
If there are N turns in a coil, i is the current flowing and A is the area of the coil, then magnetic dipole moment or simply magnetic moment of the coil is
$M = NiA$
As we know when velocity of charged particle entering to magnetic field region is perpendicular to **B**, then it follows circular path.

15. Ans.**(a)**

Explanation

Magnetic force between parallel wires per unit length is given by

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



where, i_1 and i_2 are the currents in wires 1 and 2 respectively and r is the distance between them. Since, it is given that between two wires there is a force of attraction, so, the direction of currents in both will be the same.

Given, $i_1 = i_2 = 1$ A, $r = 1$ m

$\mu_0 = 4\pi \times 10^{-7}$ T − m/A

$$\therefore \quad \frac{F}{l} = \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{1 \times 1}{1} = 2 \times 10^{-7} \text{ N/m}$$

Note When current is in same direction in both the wires there will be attraction and if current in opposite direction there is repulsion.

16. Ans. **(b)**

Explanation

Force on a current carrying conductor placed in a magnetic field is given by

$$F = i(\mathbf{I} \times \mathbf{B}) = ilB\sin\,\theta$$

where, $\theta =$ angle between current elements and magnetic field.

If linear conductor carrying current is placed perpendicular to the direction of magnetic field, $(\theta = 90°)$ it will experience maximum force.

i.e., $F_{\max} = ilB$

Given, $i = 1.2$ A, $I = 0.5$ m and $B = 2$ T

$\therefore\ F = 2 \times 1.2 \times 0.5 = 1.2$ N

17. Ans.**(c)**

Explanation

The coil must orient so that its magnetic moment becomes parallel to the field. So that the magnetic force on the coil is zero.

4.Moving Coil Galvanometer

1.Ans.**(a)**

Explanation

Current sensitivity of a moving coil galvanometer is the deflection (θ) per unit current (I) flowing through it, i.e.

$$I_s = \frac{\theta}{I} = \frac{NAB}{k} \qquad (i)$$

where, $N =$ number of turns in the coil,

$A = Area$ of each turn of coil,

$B =$ magnetic field

$k = restoring$ torque per unit twist of the fibre strip.

Similarly, voltage sensitivity is the deflection per unit voltage, i.e.

$$V_s = \frac{\theta}{V} = \frac{NAB}{k}\frac{I}{V} = \frac{NAB}{kR_G} \qquad (ii)$$

where, R_G is the resistance of the galvanometer.

From Eqs. (i) and (ii), we get

$$R_G = \frac{I_S}{V_S} \qquad (iii)$$

Here, $I_s = 5\text{div/mA} = 5 \times 10^{-3}\text{div/A}$

and $V_S = 20\text{div/V}$

Substituting the given values in Eq. (iii), we get

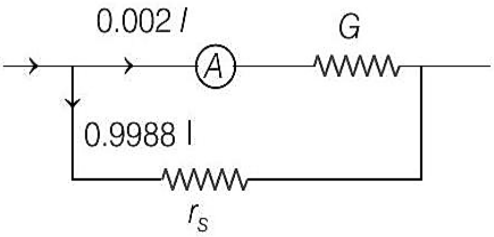
$$R_G = \frac{5 \times 10^3}{20} = 250$$

$\therefore$ The resistance of the galvanometer is 250Ω.

2.Ans.**(c)**

Explanation

For ammeter



$$0.002I \times G = 0.998I \times r_s$$

$$r_s = \frac{0.002}{0.998}G$$

$$\Rightarrow \quad r_s = 0.002004\,G = \frac{1}{499} \times G$$

Equivalent resistance of ammeter,

$$\frac{1}{R} = \frac{1}{G} + \frac{1}{r_s}$$

$$\therefore \frac{1}{R} = \frac{1}{G} + \frac{1}{G/499} \Rightarrow R = \frac{G}{500}$$

3.Ans.**(a)**

Explanation

The full scale deflection current

$$i_g = \frac{25\text{mV}}{G}\ \text{A}$$

where, G is the resistance of the meter.
The value of shunt required for converting it into ammeter of range 25 A

$$\text{is } S = \frac{i_g G}{i - i_g} \Rightarrow S = i_g \frac{G}{i}\ (\text{as} i \gg i_g)$$

So that

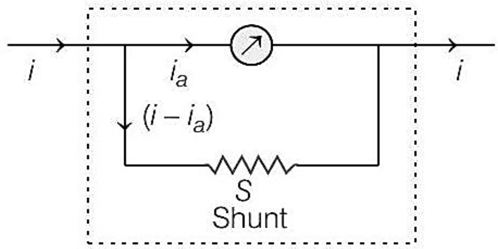
$$S \approx \frac{25\text{mV}}{G} \cdot \frac{G}{i} = \frac{25\text{mV}}{25} = 0.001\Omega$$

4.Ans.**(b)**

Explanation

Let i_a be the current flowing through ammeter and i be the total current. So, a current $i - i_0$ will flow through shunt resistance.
Potential difference across ammeter and shunt resistance is same.

i.e. $\quad i_a \times R = (i - i_a) \times S$



High reading ammeter

or $\quad S = \dfrac{i_a R}{i - i_a}$

Given, $i_a = 100\,A, i = 750\,A, R = 13\,\Omega$

Hence, $S = \dfrac{100 \times 13}{750 - 100} = 2\,\Omega$