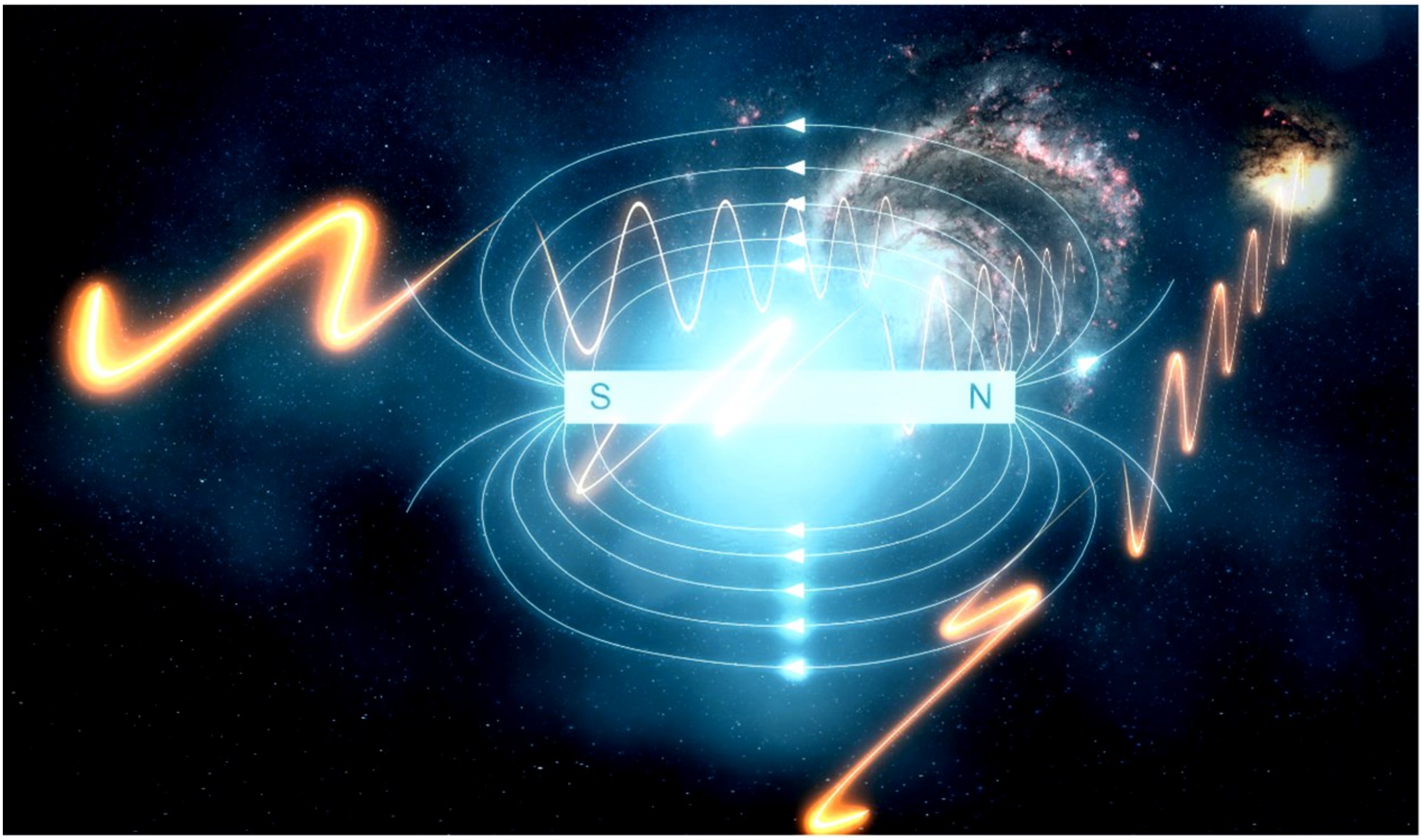
MAGNETIC EFFECTS OF CURRENT AND MAGNETISM



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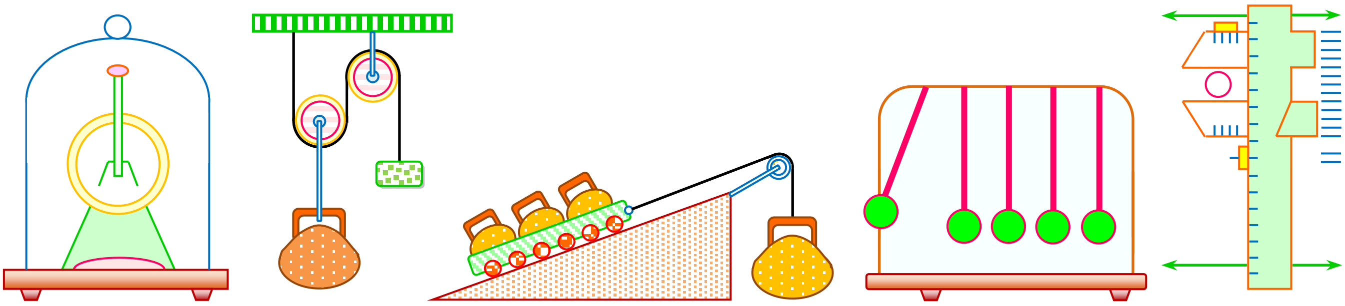
PHYSICS XII



PHYSICS BOOKLET FOR JEE NEET & BOARDS

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MAGNETIC EFFECTS OF CURRENT AND MAGNETISM

1 THE MAGNETIC FIELD

In earlier lessons we found it convenient to describe the interaction between charged objects in terms of electric fields. Recall that an electric field surrounds an electric charge. The region of space surrounding a moving charge includes a magnetic field in addition to the electric field. A magnetic field also surrounds a magnetic substance.

In order to describe any type of field, we must define its magnitude, or strength, and its direction.

Magnetic field is the region surrounding a moving charge in which its magnetic effects are perceptible on a moving charge (electric current). Magnetic field intensity is a vector quantity and also known as magnetic induction vector. It is represented by $\vec{B}$.

Lines of magnetic induction may be drawn in the same way as lines of electric field. The number of lines per unit area crossing a small area perpendicular to the direction of the induction being numerically equal to $\vec{B}$. The number of lines of $\vec{B}$ crossing a given area is referred to as the magnetic flux linked with that area. For this reason $\vec{B}$ is also called magnetic flux density.

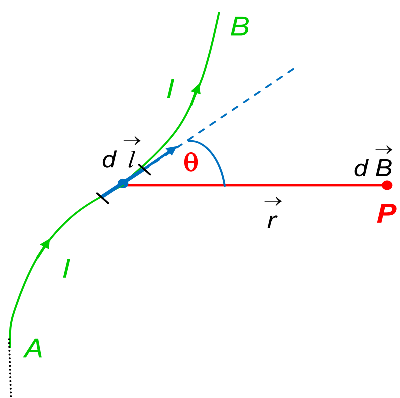
There are two methods of calculating magnetic field at some point. One is **Biot Savart law** which gives the magnetic field due to an infinitesimally small current carrying wire at some point and the another is **Ampere's law,** which is useful in calculating the magnetic field of a symmetric configuration carrying a steady current.

The unit of magnetic field is weber / m^2 and is known as tesla (T) in the SI system.

2 BIOT-SAVART LAW

Biot-Savart law gives the magnetic induction due to an infinitesimal current element.

Let *AB* be a conductor of an arbitrary shape carrying a current *I*, and *P* be a point in vacuum at which the field is to be determined. Let us divide the conductor into infinitesimal current–elements. Let $\vec{r}$ be a displacement vector from the element to the point *P*.



According to 'Biot-Savart Law', the magnetic field induction $d\vec{B}$ at *P* due to the current element $d\vec{l}$ is given by

$$d\vec{B} \propto \frac{I(d\vec{l} \times \vec{r})}{r^3}$$

or, $$d\vec{B} = k\frac{I(d\vec{l}\times\vec{r})}{r^3},$$

where k is a constant of proportionality. Here $d\vec{l}$ vector points in the direction of current I.

In S.I units, $k = \frac{\mu_0}{4\pi} = 10^{-7}\frac{\text{Wb}}{\text{amp}\times\text{metre}}$

$$\therefore \quad d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3} \quad \dots (1)$$

Equation (1) is the vector form of the Biot Savart Law. The magnitude of the field induction at P is given by

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

where θ is the angle between $d\vec{l}$ and $\vec{r}$.

If the medium is other than air or vacuum, the magnetic induction is

$$d\vec{B} = \frac{\mu_0\mu_r}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}, \quad \dots (2)$$

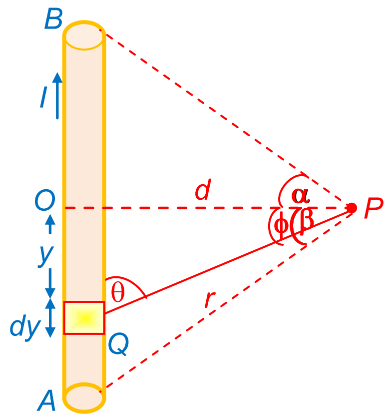
where μ_r is relative permeability of the medium and is a dimensionless quantity.

3 FIELD DUE TO A STRAIGHT CURRENT CARRYING WIRE

3.1 FIELD DUE TO A STRAIGHT WIRE OF FINITE LENGTH

Consider a straight wire segment carrying a current I and there is a point P at which magnetic field is to be calculated is as shown in the figure. This wire segment makes angle α and β at that point with normal OP. Consider an element of length dy at a distance y from O and distance of this element from point P is r and line joining P to Q makes an angle θ with the direction of current as shown in figure. Using Biot-Savart Law magnetic field at point P due to small current element is given by

$$dB = \frac{\mu_0 I}{4\pi}\left(\frac{dy\sin\theta}{r^2}\right)$$



As every element of the wire contributes to $\vec{B}$ in the same direction, we have

$$B = \frac{\mu_0 I}{4\pi}\int_A^B \frac{dy\sin\theta}{r^2} \quad \dots (i)$$

From the triangle OPQ as shown in diagram, we have

$y = d\tan\phi$

or, $dy = d\sec^2\phi\, d\phi$

and in same triangle,

$r = d\sec\phi$ and $\theta = (90° - \phi)$, where ϕ is angle between line OP and PQ

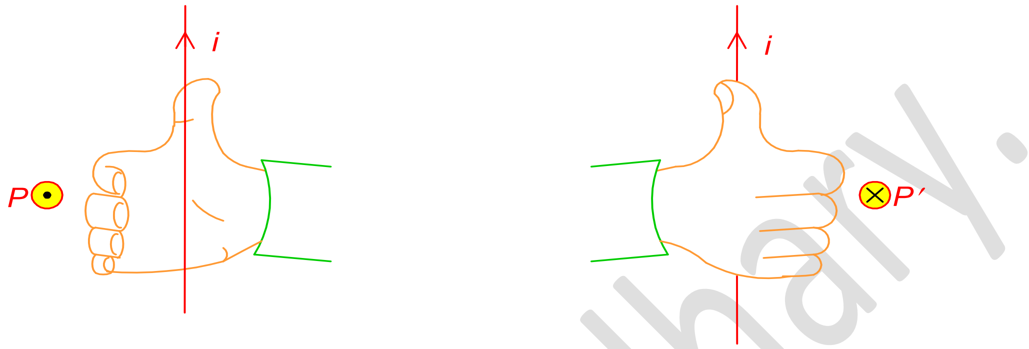
Now equation (i) can be written in this form

$$\therefore \quad B = \frac{\mu_0}{4\pi}\frac{I}{d}\int_{-\beta}^{\alpha}\cos\phi\, d\phi$$

or, $$B = \frac{\mu_0}{4\pi}\frac{I}{d}[\sin\alpha + \sin\beta] \quad \dots (3)$$

Direction of $\vec{B}$: The direction of magnetic field is determined by the cross product of the vector $id\vec{l}$ with $\vec{r}$. Therefore, at point *P*, the direction of the magnetic field due to the whole conductor will be perpendicular to the plane of paper and going into the plane.

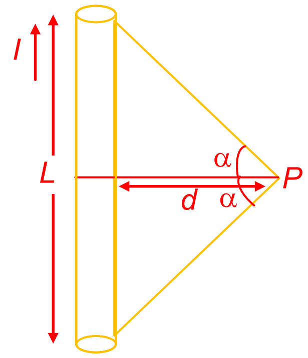
Right-hand Thumb Rule: The direction of *B* at a point *P* due to a long, straight wire can be found by the right-hand thumb rule. The direction of magnetic field is perpendicular to the plane containing wire and perpendicular from the point. The orientation of magnetic field is given by the direction of curl fingers if we stretch thumb along the wire in the direction of current. Refer figure.



Conventionally, the direction of the field perpendicular to the plane of the paper is represented by ⊗ if into the page and by ⊙ if out of the page.

Now consider some special cases involving the application of equation (3)

Case I: When the point *P* is on perpendicular bisector

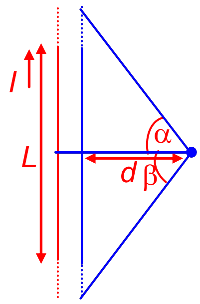


In this case angle $\alpha = \beta$, using result of equation (3) , the magnetic field is

$$B = \frac{\mu_0}{4\pi}\frac{2I}{d}\sin\alpha$$

where $\sin\alpha = \dfrac{L}{\sqrt{L^2 + 4d^2}}$

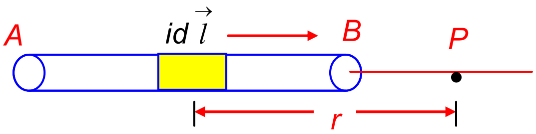
Case II: When wire is of infinite length



In this case $\alpha = \beta = 90°$, using result of equation (3), the magnetic field is

$$B = \frac{\mu_0}{4\pi}\frac{2I}{d}$$

Case III: When the point *P* lies along the length of wire (but not on it):



If the point is along the length of the wire (but not on it), then as $d\vec{l}$ and $\vec{r}$ will either be parallel or antiparallel, i.e., $\theta = 0$ or π, so $id\vec{l} \times \vec{r} = 0$ and hence using equation (1)

$$\vec{B} = \int_A^B d\vec{B} = 0$$

Illustration 1

Question: **Calculate the magnetic field induction at a point distance, $\frac{a\sqrt{3}}{2}$ metre from a straight wire of length a = 10 cm metre carrying a current of $I = \sqrt{3}$ amp. The point is on the perpendicular bisector of the wire.**

Solution:

$$B = \frac{\mu_0}{4\pi}\frac{I}{d}[\sin\alpha + \sin\beta]$$

$$= 10^{-7}\left[\frac{I}{(a\sqrt{3}/2}\left(\frac{1}{2}+\frac{1}{2}\right)\right] = \frac{2I}{\sqrt{3}a}\times 10^{-7}\text{ T},$$

$$= 2\ \mu\text{T}$$

Perpendicular to the plane of figure (inward).

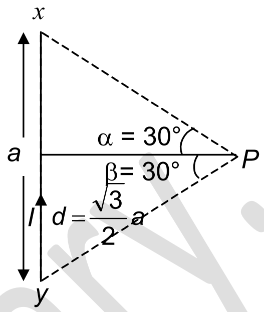
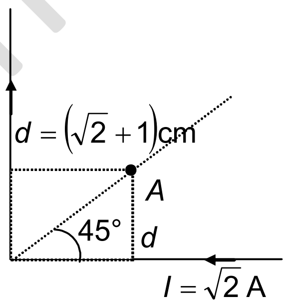


Illustration 2

Question: **A long straight conductor is bent at an angle of 90° as shown in the figure. Calculate the magnetic field induction at *A*.**

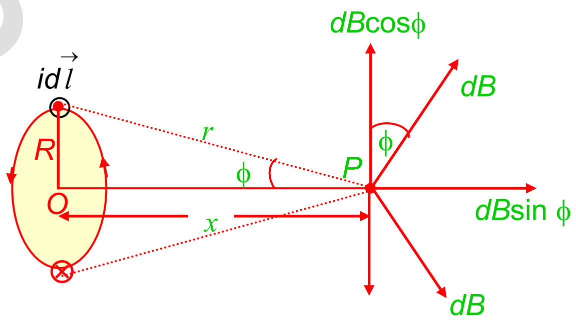


Solution: For each portion, $\beta = 45°$ and $\alpha = 90°$

$$\therefore \text{ total field at } A = \frac{\mu_0}{4\pi}\left[\frac{2I}{d}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)\right] = 20\ \mu\text{T}$$

4 MAGNETIC FIELD AT AN AXIAL POINT OF A CIRCULAR COIL

Consider a circular loop of radius R and carrying a steady current I. We have to find out magnetic field at the axial point P, which is at distance x from the centre of the loop.



Consider an element $Id\vec{l}$ of the loop as shown in figure, and the distance of point P from current element is r. The magnetic field at P due to this current element from the equation (1) can be given by,

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l}\times\vec{r}}{r^3}$$

In case of point on the axis of a circular coil, as for every current element there is a symmetrically situated opposite element, the component of the field perpendicular to the axis cancel each-other while along the axis add up.

$$\therefore \quad B = \int dB \sin\phi = \frac{\mu_0}{4\pi}\int \frac{Idl\sin\theta}{r^2}\sin\phi$$

Here, θ is angle between the current element $Id\vec{l}$ and $\vec{r}$, which is $\frac{\pi}{2}$ everywhere and

$$\sin\phi = \frac{R}{r} = \frac{R}{\sqrt{R^2 + x^2}}$$

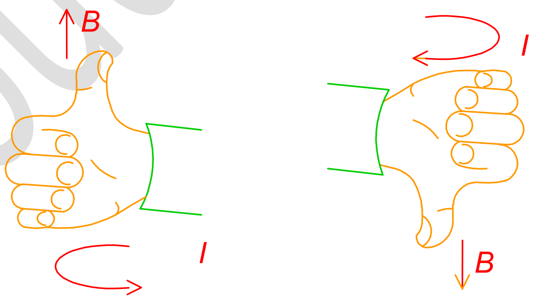
$$\therefore \quad B = \frac{\mu_0}{4\pi}\frac{IR}{(R^2 + x^2)^{3/2}}\int_0^{2\pi R} dL$$

or, $$B = \frac{\mu_0}{4\pi}\frac{IR}{(R^2 + x^2)^{3/2}}(2\pi R)$$

or, $$B = \frac{\mu_0}{4\pi}\frac{2\pi IR^2}{(R^2 + x^2)^{3/2}} \qquad \textbf{... (4)}$$

If the coil has N turns, then $B = \frac{\mu_0}{4\pi}\frac{2\pi NIR^2}{(R^2 + x^2)^{3/2}}$

Direction of $\vec{B}$: Direction of magnetic field at a point the axis of a circular coil is along the axis and its orientation can be obtained by using the right-hand thumb rule. If the fingers are curled along the current, the stretched thumb will point towards the magnetic field.



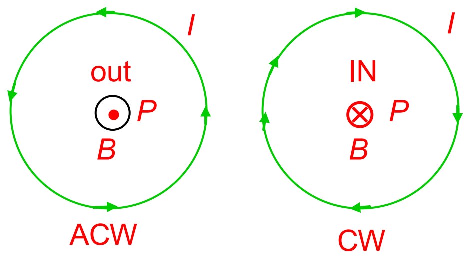
Magnetic field will be out of the page for anticlockwise current while into the page for clockwise current as shown in the figure given.

Now consider some special cases involving the application of equation (4)

Case I: Field at the centre of the coil

In this case distance of the point P from the centre $(x) = 0$, the magnetic field

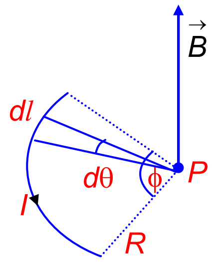
$$B = \frac{\mu_0}{4\pi}\frac{2\pi I}{R} = \frac{\mu_0}{2}\frac{I}{R}$$



Case II: Field at a point far away from the centre

It means $x >> R$, $B = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{x^3}$

5 FIELD AT THE CENTRE OF A CURRENT ARC



Consider an arc of radius R carrying current I and subtending an angle ϕ at the centre.

According to Biot-Savart Law, the magnetic field induction at the point P is given by

$$B = \frac{\mu_0}{4\pi}\int_0^{\phi}\frac{Idl}{R^2}$$

Here, $dl = Rd\theta$

$$\therefore \quad B = \frac{\mu_0}{4\pi}\int_0^{\phi}\frac{IRd\theta}{R^2}$$

or, $$B = \frac{\mu_0}{4\pi}\frac{I\phi}{R} \qquad \text{... (5)}$$

If 'l' is the length of the circular arc, we have

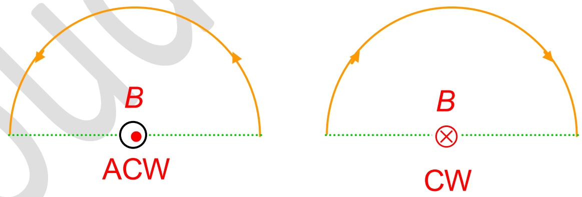
$$B = \frac{\mu_0}{4\pi}\frac{Il}{R^2} \qquad \text{... (6)}$$

Consider some special cases involving the application of equation (5)

Case I: If the loop is the semi-circular,

In this case $\phi = \pi$, so

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

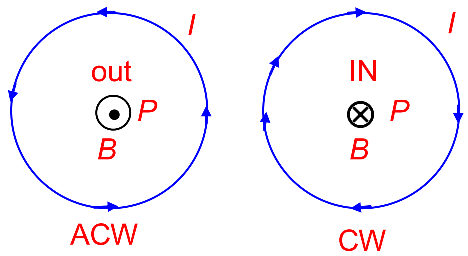


and will be out of the page for anticlockwise current while into the page for clockwise current as shown in the figure.

Case II: If the loop is a full circle with N turns,

In this case $\phi = 2\pi$ so,

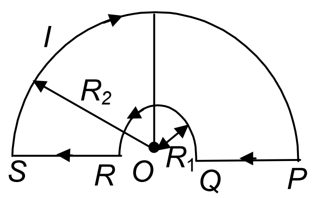
$$B = \frac{\mu_0}{4\pi}\frac{2\pi NI}{R}$$



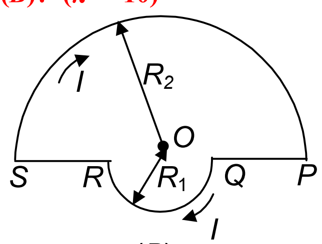
and will be out of the page for anticlockwise current while into the page for clockwise current as shown in the figure.

Illustration 3

Question: **The wire loop *PQRSP* formed by joining two semi-circular wires of radii R_1 = 10cm and R_2 = 20 cm carries a current $I = \pi$ amp as shown in the figure given below. What is the magnetic field induction at the centre *O* in cases (*A*) and (*B*)? ($\pi^2 = 10$)**



(A)



(B)

Solution: (a) As the point O is along the length of the straight wires, so the field at O due to them will be zero and hence magnetic field is only due to semicircular portions.

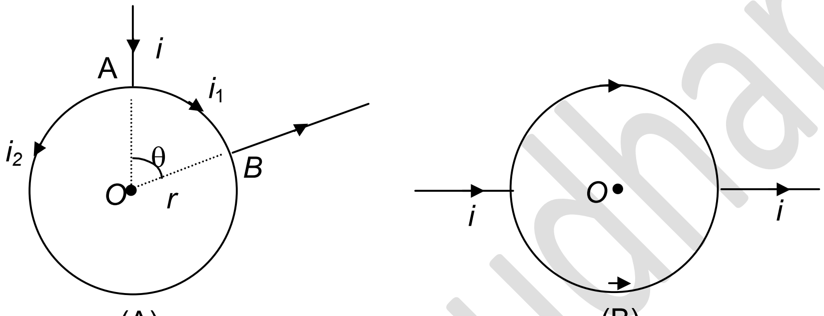
$$\therefore |\vec{B}| = \frac{\mu_0}{4\pi}\left[\frac{\pi I}{R_2}\otimes + \frac{\pi I}{R_1}\odot\right]$$

or, $$|\vec{B}| = \frac{\mu_0}{4\pi}\pi I\left[\frac{1}{R_2} - \frac{1}{R_1}\right]$$ out of the page $= \mathbf{5\ \mu T}$ **out of the page**

(b) $$|\vec{B}| = \frac{\mu_0}{4\pi} I\pi\left[\frac{1}{R_1} + \frac{1}{R_2}\right]$$ in to the page $=$ **15 μT into the page**

Illustration 4

Question: **A battery is connected between two points *A* and *B* on the circumference of a uniform conducting ring of radius *r* and resistance *R* as shown in the figure given below. One of the arcs *AB* of the ring subtends an angle θ at the centre. What is the value of the magnetic field at the centre due to the current in the ring?**



(A) (B)

Solution: (a) As the field due to arc. at the centre is given by

$$B = \frac{\mu_0}{4\pi}\frac{I\phi}{r}$$

$$\therefore \quad B = \frac{\mu_0}{4\pi}\frac{I_1\theta}{r}\otimes + \frac{\mu_0}{4\pi}\frac{I_2(2\pi-\theta)}{r}\odot$$

But $(V_A - V_B) = I_1R_1 = I_2R_2$

or, $$I_2 = I_1\frac{R_1}{R_2} = I_1\frac{L_1}{L_2}\quad [\because R \propto L]$$

$$I_2 = I_1\frac{\theta}{(2\pi-\theta)}\quad [\because L = r\theta]$$

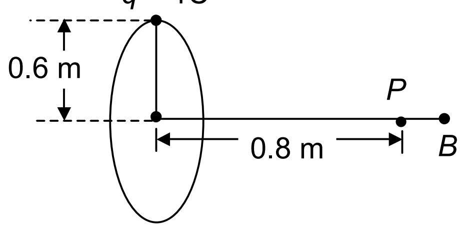
$$\therefore \quad B_R = \frac{\mu_0}{4\pi}\frac{I_1\theta}{r}\otimes + \frac{\mu_0}{4\pi}\frac{I_1\theta}{r}\odot = \mathbf{0}$$

i.e., **the field at the centre of the coil is zero and is independent of θ.**

Illustration 5

Question: **A charge of one Coulomb is placed at one end of a non-conducting rod of length 0.6 m. The rod is rotated in a vertical plane about a horizontal axis passing through the other end of the rod with angular frequency $10^4\ \pi$ rad/s. Find the magnetic field at a point on the axis of rotation at a distance of 0.8 m from the centre of the path.**
Now half of the charge is removed from one end and placed on the other end. The rod is rotated in a vertical plane about horizontal axis passing through the mid-point of the rod with the same angular frequency. Calculate the magnetic field at a point on the axis at a distance of 0.4 m from the centre of the rod.

Solution: As the revolving charge q is equivalent to a current

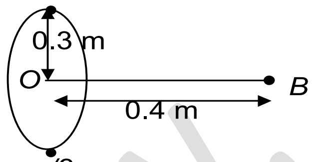


$$i = qf = q \times \frac{\omega}{2\pi} = 1 \times \frac{10^4\pi}{2\pi} = 5 \times 10^3 \text{ A}$$

Now $B = \frac{\mu_0}{4\pi}\frac{2\pi I R^2}{(R^2 + x^2)^{3/2}}$

$$\therefore \quad B = 10^{-7} \times \frac{2\pi \times 5 \times 10^3\,(.6)^2}{[(.6)^2 + (.8)^2]^{3/2}} = \mathbf{1.13 \times 10^{-3}\ T}$$

If half of the charge is placed at the other end and the rod is rotated at the same frequency



$$I' = \left(\frac{q}{2}\right)f + \left(\frac{q}{2}\right)f = qf = I = 5 \times 10^3 \text{ A}$$

In this case, $R' = 0.3$ m and $x' = 0.4$ m

$$\therefore \quad B' = 10^{-7} \times \frac{2\pi \times 1 \times 5 \times 10^3 \times (.3)^2}{[(.3)^2 + (.4)^2]^{3/2}} = \mathbf{2300\ \mu T}$$

6 AMPERE'S LAW

This law is useful in finding the magnetic field due to currents under certain conditions of symmetry. Consider a closed plane curve enclosing some current-carrying conductors.

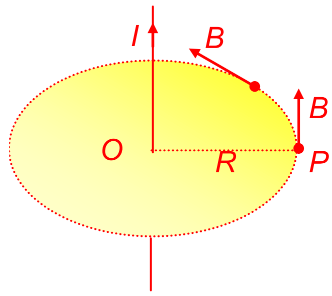
The line integral $\oint \vec{B}.\vec{dl}$ taken along this closed curve is equal to μ_0 times the total current crossing the area bounded by the curve.

i.e., $\oint \vec{B}.\vec{dl} = \mu_0 I$ **… (7)**

where I = total current (algebraic sum) crossing the area.

As a simple application of this law, we can derive the magnetic induction due to a long straight wire carrying current I. Suppose the magnetic induction at point P, distant R from the wire is required.

Draw the circle through P with centre O and radius R as shown in figure.



The magnetic induction $|\vec{B}|$ at all points along this circle will be the same and will be tangential to the circle, which is also the direction of the length element $\vec{dl}$.

The current crossing the circular area is I.

Thus, by Ampere's law, $B \times 2\pi R = \mu_0 I$

$$\Rightarrow \quad B = \frac{\mu_0 I}{2\pi R} \qquad \textbf{… (8)}$$

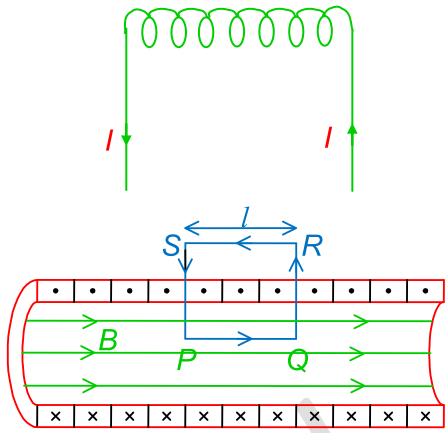
7 THE MAGNETIC FIELD OF A SOLENOID

7.1 MAGNETIC FIELD INSIDE A LONG SOLENOID

A solenoid is a wire wound closely in the form of a helix, such that the adjacent turns are electrically insulated.

The magnetic field inside a very tightly wound long solenoid is uniform everywhere along the axis of the solenoid and is zero outside it.

To calculate the magnetic field at a point P inside the solenoid, let us draw a rectangle $PQRS$ as shown in figure. The line PQ is parallel to the solenoid axis and hence parallel to the magnetic field $\vec{B}$ inside the solenoid.



$$\Rightarrow \quad \int_P^Q \vec{B}\cdot d\vec{l} = Bl$$

On the remaining three sides, $\vec{B}\cdot d\vec{l}$ is zero everywhere as $\vec{B}$ is either zero (outside the solenoid) or perpendicular to $d\vec{l}$ (inside the solenoid).

If n is the number of turns per unit length along the length of solenoid, total nl turns cross the rectangle $PQRS$. Each turn carries a current I.

$\Rightarrow$ Net current crossing $PQRS = nlI$

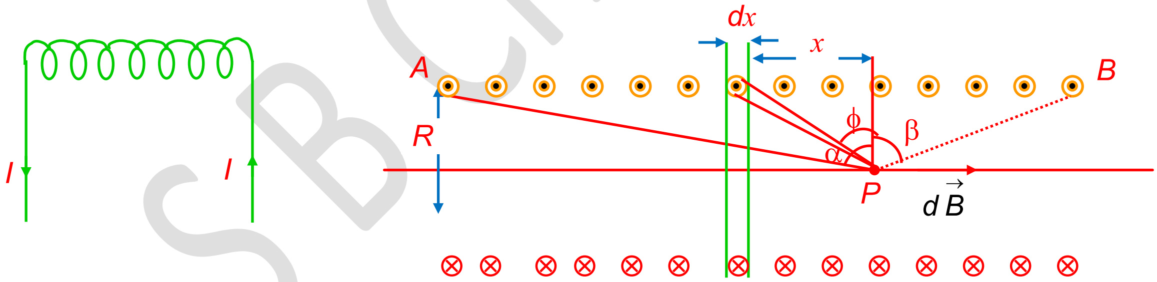
Using Ampere's law,

$\Rightarrow$ $Bl = \mu_0 nlI$

$\Rightarrow$ $\boldsymbol{B = \mu_0 nI}$ ... (9)

7.2 MAGNETIC FIELD AT A POINT ON THE AXIS OF A SHORT SOLENOID

Consider a solenoid of length l and radius r containing N closely spaced turns and carrying a steady current I. We have to find out an expression for the magnetic field at an axial point P lying in the space enclosed by the solenoid as shown in the figure below.



The field at a point on the axis of a solenoid can be obtained by the superposition of fields due to a large number of identical coils all having their centre on the axis of the solenoid.

Let us consider a coil of width dx at a distance x from the point P on the axis of the solenoid as shown in the above diagram.

The field at P due to this coil is given by

$$dB = \frac{\mu_0}{4\pi}\frac{2\pi dNIR^2}{(R^2+x^2)^{3/2}}$$

If n be the number of turns per unit length, $dN = ndx$.

From the above figure,

$x = R\tan\phi$

or, $dx = R\sec^2\phi\, d\phi$

$$\therefore \quad dB = \frac{\mu_0}{4\pi}\frac{2\pi(ndx)IR^2}{(R^2+R^2\tan^2\phi)^{3/2}} = \frac{\mu_0}{4\pi}(2\pi nI)\cos\phi\, d\phi$$

$\therefore \quad B = \frac{\mu_0}{4\pi}(2\pi nI)\int_{-\alpha}^{\beta}\cos\phi\, d\phi$

or, $\quad B = \frac{\mu_0}{4\pi}(2\pi nI)[\sin\alpha + \sin\beta]$ **… (10)**

Now consider some cases involving the application of equation (10)

Case I: If the solenoid is of infinite length and the point is well inside the solenoid,

In this case, $\alpha = \beta = \frac{\pi}{2}$

$\therefore \quad B = \frac{\mu_0}{4\pi}(2\pi nI)[1+1] = \mu_0 nI$

Case II: If the solenoid is of infinite length and the point is near one end

In this case, $\alpha = 0$ and $\beta = \frac{\pi}{2}$

$\therefore \quad B = \frac{\mu_0}{4\pi}(2\pi nI)[1+0] = \frac{1}{2}(\mu_0 nI)$

Case III: If the solenoid is of finite length and the point is on the perpendicular bisector of its axis

In this case, $\alpha = \beta$

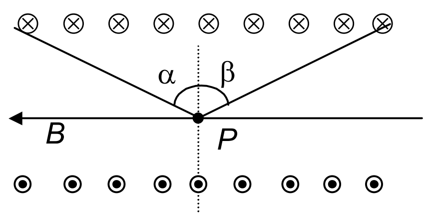
$\therefore \quad B = \frac{\mu_0}{4\pi}(4\pi nI)\sin\alpha$,

where, $\sin\alpha = \frac{L}{\sqrt{L^2 + 4R^2}}$

Illustration 6

Question: **A solenoid of length $\sqrt{\frac{7}{3}}$ m and diameter $2\sqrt{\frac{5}{3}}$ m consists of a single layer of 30000 turns of fine wire carrying a current of π ampere. Calculate the magnetic field on the axis at the middle and at the end of the solenoid. ($\pi^2 = 10$)**

Solution: In case of a solenoid, the field at point on the axis as shown in the above diagram is given by



$B = \frac{\mu_0}{4\pi}(2\pi nI)[\sin\alpha + \sin\beta]$

Here, $n = \frac{N}{L}$

(a) When the point is at the middle on the axis, $\alpha = \beta$ with

$\sin\alpha = \frac{L}{\sqrt{L^2 + 4r^2}}$

$B = \frac{4\pi\times10^{-7}\times2\pi\times30000\times\pi}{4\pi L}\times\frac{2L}{\sqrt{L^2+4r^2}} =$ **40 mT**

(b) When the point is at the end on the axis, $\alpha = 0$

with $\sin\beta = \frac{L}{\sqrt{L^2 + r^2}}$

$B = \frac{4\pi\times10^{-7}\times2\pi\times30000\times\pi}{4\pi L}\times\frac{L}{\sqrt{L^2+r^2}} =$ **30 mT**

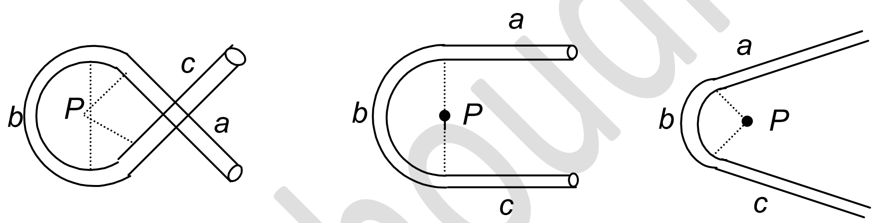
PROFICIENCY TEST– I

The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. Equal currents I are flowing through too infinitely long parallel wires. Will there be a magnetic field at a point exactly half-way between the wires when the currents in them are (i) the same direction and (ii) in the opposite direction?

2. Two infinitely long parallel wires carry equal currents in the same direction. What is the direction of the magnetic field due to one of the wires at any point along the other wire?

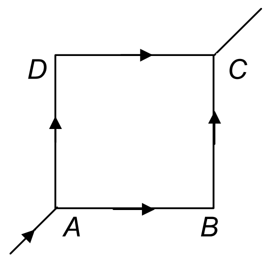
3. Figure shows three sections of a circuit, each section consisting of a wire curved along a circular arc (all with same radius) and two long straight wires that are tangential to the arc. If the straight wires pass each other without touching. The sections carry equal currents. In which case is the magnitude of the magnetic field produced at the centre of curvature P (a) greatest (b) least?



(a) (b) (c)

4. A horizontal overhead power line carries a current of 100 A in east-west direction. What is the magnitude and direction of the magnetic field due to this current 4 m below the line?

5. Figure shows a square loop made from a uniform wire. Find the magnetic field at the centre of the square if a battery is connected between points A and C



6. A current of 10 A is established in a long wire along the positive z-axis. Find the magnetic field $\vec{B}$ at the point (1m, 0, 0).

7. A long solenoid is formed by winding 20 turns/cm. What current is necessary to produce a magnetic field of 20 mT inside the solenoid?

ANSWERS TO PROFICIENCY TEST– I

1. (i) No
(ii) Yes

2. Tangent to the radial distance from the point on the other wire

3. Greatest in case *a* and least in case (*c*)

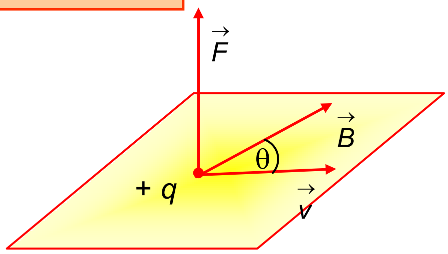
4. 5 μTesla directed from north to south

5. zero

6. 2 μT along the positive *Y*-axis

7. 8 Amp

8 FORCE ON A CHARGED PARTICLE IN A MAGNETIC FIELD



When a charge q moves with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ as shown in the figure, it experiences a magnetic force $\vec{F}$ given by

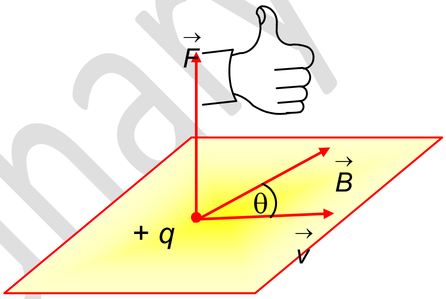
$$\vec{F} = q\,(\vec{v} \times \vec{B}) \qquad \ldots \textbf{(11)}$$

The magnitude of force is given by

$$|\vec{F}| = qvB\sin\theta$$

where θ is the angle between velocity $\vec{v}$ and magnetic field $\vec{B}$. (smaller angle)

The force is directed at right angle to the plane containing the vectors $\vec{v}$ and $\vec{B}$.



The right hand thumb rule: For determining the direction of the cross product $\vec{v} \times \vec{B}$, you point the fore fingers of your right hand along the direction of $\vec{v}$, and palm in the direction of magnetic field $\vec{B}$ then curl the fingers. The thumb then points in the direction of $\vec{v} \times \vec{B}$.

Since $F = q\vec{v} \times \vec{B}$, $\vec{F}$ is in the direction of $\vec{v} \times \vec{B}$ if q is positive and opposite the to direction of $\vec{v} \times \vec{B}$ if q is negative.

Some important points

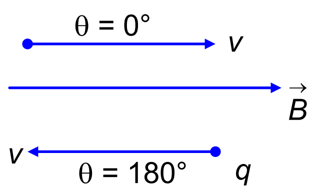
(1) The magnetic force will be maximum when sinθ = 1

⇒ θ = 90°, i.e., the charge is moving perpendicular to the field.

$F_{max} = qvB$

In this situations $\vec{F}$, $\vec{v}$ and $\vec{B}$ are mutually perpendicular to each other.

(2) The magnetic force will be minimum when sinθ = 0, i.e., θ = 0° or 180°. It means the charge is moving parallel to the field.



Thus, $F_{min} = 0$

(3) In case of motion of charged particle in a magnetic field, as the force is always perpendicular to motion,

$$W = \int \vec{F}.d\vec{s} = \int F ds \cos 90° = 0$$

So work done by the force due to magnetic field on a moving charged particle is always zero. According to work-energy theorem,

W = Δ KE, so the kinetic energy will not change and hence the speed v will remain constant. However, in this situation, the force changes the direction of the motion. therefore., the velocity $\vec{v}$ of the charged particle changes.

8.1 DIFFERENCE BETWEEN MAGNETIC FORCE AND ELECTRIC FORCE

(1) Magnetic force is always perpendicular to the field while electric force is collinear with the field.

(2) Magnetic force is velocity dependent, i.e., acts only when the charged particle is in motion while electric force (qE) is independent of the state of rest or motion of the charged particle.

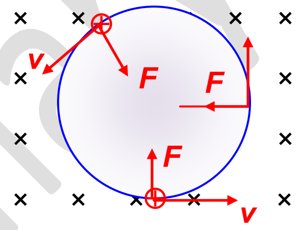
(3) Magnetic force does no work when the charged particle is displaced while the electric force does work in displacing the charged particle.

(4) Magnetic force is always non-central while the electric force may or may not be.

9 MOTION OF A CHARGED PARTICLE IN A UNIFORM MAGNETIC FIELD

9.1 WHEN THE CHARGED PARTICLE IS GIVEN VELOCITY PERPENDICULAR TO THE FIELD

Let a particle of charge q and mass m is moving with a velocity v and enters at right angles to a uniform magnetic field $\vec{B}$ as shown in figure.



The force on the particle is qvB and this force will always act in a direction perpendicular to v. Hence, the particle will move on a circular path. If the radius of the path is r then

$$\frac{mv^2}{r} = Bqv \quad \text{or,} \quad r = \frac{mv}{qB} \qquad \dots (12)$$

Thus, radius of the path is proportional to the momentum mv of the particle and inversely proportional to the magnitude of magnetic field.

Time period: is the time taken by the charge particle to complete one rotation of the circular path which is given by,

$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB} \qquad \dots (13)$$

The time period is independent of the speed v.

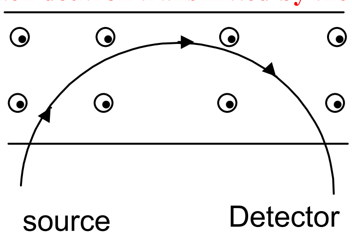
Frequency: The frequency is number of revolution of charged particle in one second, which is given by

$$\nu = \frac{1}{T} = \frac{qB}{2\pi m} \qquad \dots (14)$$

Illustration 7

Question: **A uniform magnetic field with a slit system as shown is to be used as a momentum filter for high-energy charged particles. With a field of B tesla it is found that the filter transmits α-particle each of energy 5.3 MeV. The magnetic field is increased to 2.3 B tesla and deutrons are passed into the filter. What is energy of each deutron transmitted by the filter?**

Solution: $r = \frac{mV}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB} \Rightarrow K = \frac{q^2B^2r^2}{2m}$



$p = mv$

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

$K = \frac{m^2v^2}{2m}$

$p = \sqrt{2} \ mK$

$K_\alpha = \frac{r^2(2e)^2B^2}{2(4m)}$

$K_D = \frac{r^2(e^2)\times(2.3B)^2}{2(2m)}$

$\Rightarrow \quad K_D =$ **14 MeV**

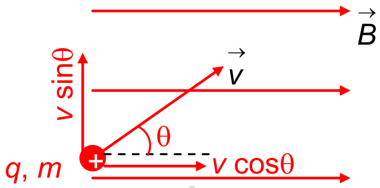
9.2 WHEN THE CHARGED PARTICLE IS MOVING AT AN ANGLE TO THE FIELD

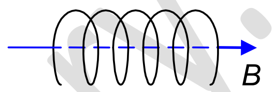
In this case the charged particle having charge q and mass m is moving with velocity v and it enters the magnetic field B at angle θ as shown in figure. Velocity can be resolved in two components, one along magnetic field and the other perpendicular to it. Let these components are $v_{\|}$ and $v_{\perp}$

$$v_{\|} = v \cos\theta$$

and $$v_{\perp} = v \sin\theta$$

The parallel component $v_{\|}$ of velocity remains unchanged as it is parallel to $\vec{B}$. Due to the $v_{\perp}$ the particle will move on a circular path. So the resultant path will be combination of straight-line motion and circular motion, which will be helical as shown in figure.





The radius of path is (r) $= \dfrac{mv_{\perp}}{qB} = \dfrac{mv\sin\theta}{qB}$ … (15)

Time period (T) $= \dfrac{2\pi r}{v_{\perp}} = \dfrac{2\pi mv\sin\theta}{v\sin\theta\, qB} = \dfrac{2\pi m}{qB}$ … (16)

Frequency (f) $= \dfrac{Bq}{2\pi m}$ … (17)

Pitch: Pitch of helix described by charged particle is defined as the displacement of the particle in the time in which it completes one revolution.

Pitch $= (v_{\|})$ (time period)

$$= v\cos\theta \frac{2\pi m}{Bq} = \frac{2\pi mv\cos\theta}{qB} \quad \dots (18)$$

Illustration 8

Question: **A beam of particles with a velocity $10\sqrt{2}$ m/s enters a uniform magnetic field of 1 T at an angle 45° to the magnetic field. Find the time period of the helical path taken by the particle beam. Also find the pitch of the helix ($m = \pi \times 10^{-8}$ kg, $q = 20\ \mu$C, $\pi^2 = 10$)**

Solution: $T = \dfrac{2\pi m}{qB} = 10$ ms

$\therefore\ p = v\cos\theta . T$

$\Rightarrow\ p = 10\sqrt{2} \times \dfrac{1}{\sqrt{2}} \times 10 \times 10^{-3}$ = **10 cm**

10 MOTION OF A CHARGED PARTICL IN COMBINED ELECTRIC AND MAGNETIC FIELD

When the moving charged particle is subjected simultaneously to both electric field $\vec{E}$ and magnetic field $\vec{B}$, the moving charged particle will experience electric force $\vec{F}_e = q\vec{E}$ and magnetic force $\vec{F}_m = q(\vec{v} \times \vec{B})$, so the net force on it will be

$$\vec{F} = q[\vec{E} + (\vec{v} \times \vec{B})] \quad \dots (19)$$

Which is '**Lorentz force equation**'.

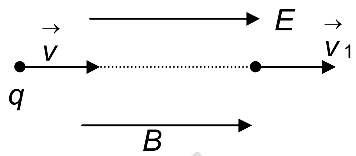
Now let us consider two special cases involving the application of above equation.

Case I: When $\vec{v}$, $\vec{E}$ and $\vec{B}$ all the three are collinear:

In this situation as the particle is moving parallel or anti-parallel to the field, the magnetic force on it will be zero and only electric force will act, so

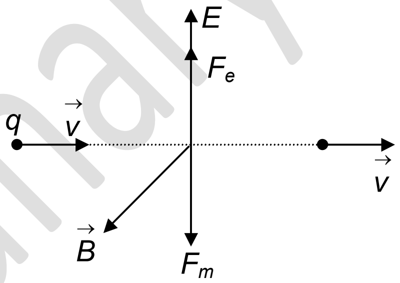
$$\vec{a} = \frac{\vec{F}}{m} = \frac{q\vec{E}}{m}$$

Hence the particle will pass through the field following a straight-line path (parallel to the field) with change in its speed. So in this situation speed, velocity, momentum and kinetic energy all will change without change in direction of motion as shown in the figure given below.



$\vec{v}$, $\vec{E}$ and $\vec{B}$ are collinear.

Case II: $\vec{v}$, $\vec{E}$ and $\vec{B}$ are mutually perpendicular



$\vec{v}$, $\vec{E}$ and $\vec{B}$ are mutually perpendicular. In case situation of $\vec{E}$ and $\vec{B}$ are such that

$$\vec{F} = \vec{F}_e + \vec{F}_m = 0$$

or, $\vec{a} = \left(\frac{\vec{F}}{m}\right) = 0$, then the particle will pass through the field with the same velocity.

In this situation,

$F_e = F_m$ or, $qE = qvB$

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

This principle is used in velocity-selector to get a charged beam having a specific velocity.

Illustration 9

Question: **A particle of mass 1×10^{-26} kg and charge $+ 1.6 \times 10^{-19}$ C travelling with a velocity 1.28×10^6 m/s in + x direction enters a region in which a uniform electric field $\vec{E}$ and a uniform magnetic field $\vec{B}$ are present such that $E_x = E_y = 0$; $E_z = -102.4$ kV/m and $B_x = B_z = 0$; $B_y = 8 \times 10^{-2}$ Wb/m^2. The particle enters in a region at the origin at time $t = 0$. Find the x-coordinate of the particle at $t = 5 \times 10^{-6}$ s.**

Solution: $\vec{F}_e = q\vec{E} = 1.6 \times 10^{-19} \times 102.4 \times 10^3 (-\hat{k})$

$\vec{F}_B = q(\vec{v} \times \vec{B}) = 1.6 \times 10^{-19} \times 1.2 \times 10^6 \times 8 \times 10^{-2} (\hat{k})$

$\therefore \quad \vec{F} = \vec{F}_e + \vec{F}_B = 0$

Hence, the particle will move along + x-axis with constant velocity $\vec{v} = 1.28 \times 10^6 \hat{i}$ m/s

$x_0 = vt$ = **640 cm**

11 CYCLOTRON

The cyclotron is a device used to accelerate positively charged particle to high energies. Such charged particles are required to carry out nuclear reactions.

11.1 PRINCIPLE

It works on the fact that

(i) When a charged particle moves at right angle to a uniform magnetic field it describes a circular path and

(ii) If the charged particle simultaneously and repeatedly crosses an electric field while moving in the direction of the electric field, it gets accelerated to a sufficiently high energy. Such an electric field is called an oscillating electric field.

11.2 CONSTRUCTION

The cyclotron consists of two D shaped hollow metallic semi-cylindrical chambers D_1 and D_2 called the dees, enclosed in an evacuated steel box. The dees are kept horizontally with a small gap separating them. An oscillator which produces an alternating potential difference of the order of 10^3 volts and frequency of the order of mega cycles/sec is applied across the dees. A strong magnetic field produced by a strong electromagnet acts perpendicular to the plane of the dees. A sources S of ions or positively charged particles is kept in the gap between the dees.

11.3 THEORY AND WORKING

Let m and q be the mass and charge of the ion or the particle to be accelerated. Let D_2 be negative and D_1 be positive when source (s) produces the particle.

The particle, therefore, gets attracted towards D_2, the electric field becomes zero. It is because the electric field inside a charged conductor is always zero. Thus, inside D_2,it moves with constant speed v at right angles to the magnetic field acting downward. As a result, the particle takes a semi-circular path inside D_2. Let r be the radius of the semicircular path. Then

$$\frac{mv^2}{r} = qvB \qquad \therefore \qquad r = \frac{mv}{qB}$$

$\therefore$ Time taken by particle to complete the semi-circular path

$$t = \frac{\pi r}{v}. \text{ But } v = \frac{qBr}{m}$$

$$t = \frac{\pi rm}{qBr} = \frac{\pi m}{qB}$$

Above relation shows that t is independent of both the radius of the circular path and the speed of the charged particle.

As the particle reaches the gap just after completing the semi-circular path inside D_2, the polarity of the dees is reversed i.e. D_1 become negative and D_2 positive. The particle accelerates due to the electric field and enters D_1 with greater speed, say v_1. It then moves along a semi-circular path of larger radius inside D_1 due to the magnetic field (B) acting perpendicular to v_1. As it comes out of D_1 after completing the semi-circular path, the polarity of dees again gets reversed. The particle again accelerates and enters D_2 with a greater speed and then describes a semi-circular path of larger radius. The whole process keeps repeating time and again.

As a result, the particle keeps on accelerating every time it crosses the gap between the dees and keeps describing semi-circular paths of increasing radii. The result is that a spiral path is followed by the particle till it comes out of the dees through a window W with a very high speed i.e. high energy. The particles are deflected to come out through the windows by employing an electric field.

11.4 CYCLOTRON FREQUENCY OR MAGNETIC RESONANCE FREQUENCY (ν)

The cyclotron works when the frequency of the applied alternating potential difference (ν_0) is equal to the frequency of the revolving charged particle (ν)

$$\therefore \quad \nu_0 = \nu = \frac{1}{T} = \frac{1}{2\times t} = \frac{qB}{2\pi m}$$

∴ **Cyclotron angular frequency** $\omega = 2\pi\nu = \frac{qB}{m}$ … (20)

11.5 MAXIMUM VELOCITY AND MAXIMUM ENERGY OF THE ACCELERATED PARTICLE

Let v_m be the maximum velocity of the particle when it comes out of the dees following semi-circular path of maximum radius i.e. radius of dees, then

$$v_m = \frac{qBR}{m}$$

∴ Maximum kinetic energy acquired by the particle

$$E_{max} = \frac{1}{2}mv_m^2 = \frac{1}{2}m\left(\frac{qBR}{m}\right)^2$$

$$\therefore \quad E_{max} = \frac{1}{2}\frac{B^2q^2R^2}{m} \quad \dots (21)$$

11.6 LIMITATIONS OF CYCLOTRON

As the positive ion accelerates in the cyclotron, it moves with larger and speed. As this speed becomes comparable with the speed of light, the mass of the ion increases in accordance with the relation.

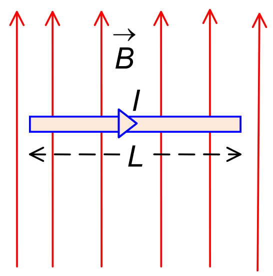
$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$$

where, $m_0 \to$ the rest mass of the ion
$v \to$ velocity of the ion
$m \to$ mass of the ion when it moves with velocity v
$c \to$ velocity of light

Thus, the time taken by the ion to complete a semi-circular path $c = \left(\frac{\pi m}{qB}\right)$ also increases.

It means that the polarity of dees changes before the ion completes the semi-circular path. The ion, therefore, gets out of phase with the oscillating electric field.

12 FORCE ON A CURRENT CARRYING WIRE IN A MAGNETIC FIELD



Let L be the length of a straight conductor carrying a current I and placed perpendicular to a uniform magnetic field of induction B.

A current in a conductor is due to the movement of electrons and the direction of the conventional current is opposite to that of the direction of motion of electrons. If n be the number of moving charges per unit volume, each charge is of q, and travelling with drift velocity v_d, the charge passing through any cross-section per second is nqv_dA

$$I = nqv_dA$$

where A is the cross-sectional area.

The number of charges in length L of a conductor

$$N = nLA$$

The force on each charge

$F = Bqv_d$

The force on all charges i.e., the force on the conductor

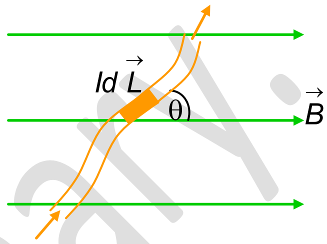
$F = Bqv_d \times nLA$

or $F = BIL$

In vector form $\vec{F} = I(\vec{L} \times \vec{B})$ … (22)

where L is a vector in the direction of the current I; the magnitude of $\vec{L}$ equals the length L of the segment. Note that this expression applies only to a straight segment of wire in a uniform magnetic field.

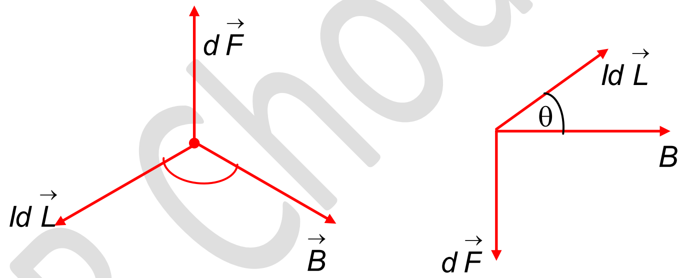
Now consider an arbitrarily shaped wire segment of uniform cross-section in a magnetic field $\vec{B}$, as shown in figure. Then the magnetic force on a very small segment dL in the presence of magnetic field $\vec{B}$ is given by



$$d\vec{F} = I\,d\vec{L} \times \vec{B}$$

The magnitude of force is $dF = BIdL \sin\theta$, where θ is the angle between the vectors $I\,d\vec{L}$ and $\vec{B}$.

Direction of force: The direction of force is always perpendicular to the plane containing $I\,d\vec{L}$ and $\vec{B}$ and is same as that of cross-product of two vectors $(\vec{a} \times \vec{b})$ with $\vec{a} = I d\vec{L}$ and $\vec{b} = \vec{B}$.



The direction of force when current element $I d\vec{L}$ and $\vec{B}$ are perpendicular to each-other can also be determined by applying either of the following rules.

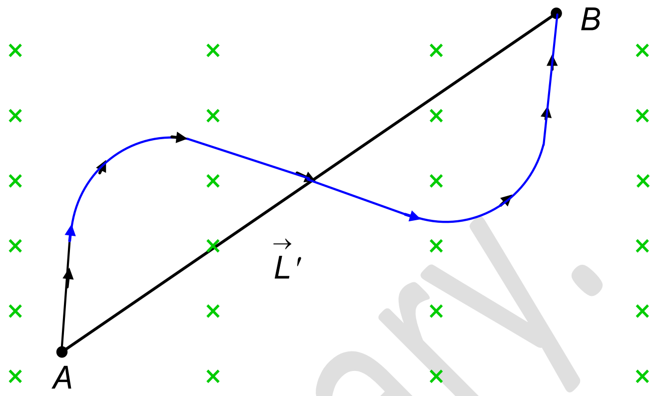
(a) Fleming's Left-hand Rule: Strech the fore-finger, central finger and thumb of the left hand mutually perpendicular. Then if the fore-finger points in the direction of the field ($\vec{B}$) and the central in the direction of current I, the thumb will point in the direction of force (or motion).

(b) Right-hand Palm rule: Stretch the fingers and thumb of the right hand at right angles to each-other. If the fingers point in the direction of current I, and the palm in the direction of the field $\vec{B}$ then thumb will point in the direction of force.

12.1 FORCE ON A CURVED CURRENT CARRYING WIRE

In this case a current-carrying conductor is placed in a uniform magnetic field $\vec{B}$. the force is given by $\vec{F} = \int I d\vec{L} \times \vec{B} = I \int d\vec{L} \times \vec{B}$

and for a conductor $\int d\vec{L}$ represents the vector sum of all the lengths elements from initial to final point, which in accordance with the law of vector addition is equal to the length vector $\vec{L}$ joining initial to the final point. So a current-carrying conductor of any arbitrary shape in a uniform field experiences a force



$$\vec{F} = I\,[\int d\vec{L}] \times \vec{B} = I\,\vec{L} \times \vec{B}$$

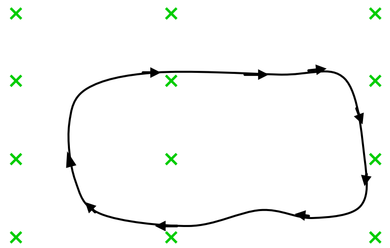
12.2 FORCE ON A CLOSED LOOP OF AN ARBITRARILY SHAPED CONDUCTOR

Consider a current-carrying conductor in the form of a loop of any arbitrary shape is placed in a uniform field $\vec{B}$. In this case the vector sum of the current element must be taken over the closed loop.

for a closed loop, the vector sum of $d\vec{L}$ is always zero.

$\therefore \quad \vec{F} = 0$

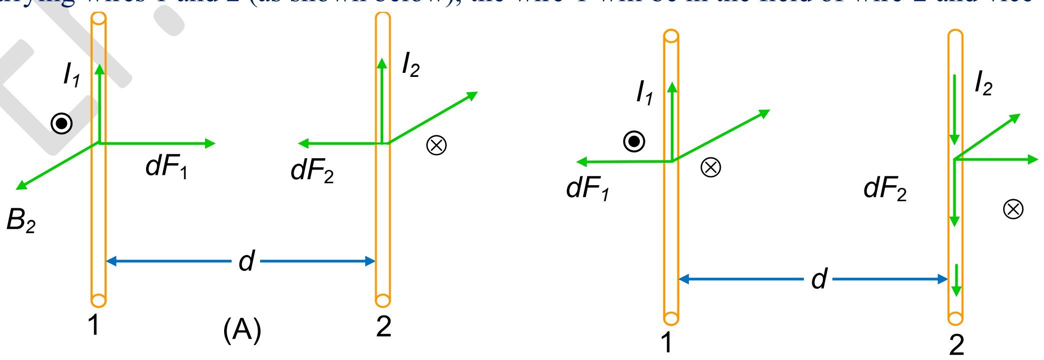
i.e., the magnetic force on a current loop in a uniform magnetic field is always zero.



12.3 FORCE BETWEEN TWO LONG STRAIGHT PARALLEL CURRENT CARRYING CONDUCTORS

Let us consider two very long parallel straight wires carrying currents I_1 and I_2.

Each wire is placed in the region of magnetic induction of other and hence will experience a force. The net force on a current-carrying conductor due to its own field is zero. So if there are two long parallel current-carrying wires 1 and 2 (as shown below), the wire-1 will be in the field of wire-2 and vice-versa.



The force on dl_2 length of wire-2 due to field of wire-1, $dF_2 = I_2\, dL_2\, B_1$

$$= \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}dL_2 \quad [\because B_1 = \frac{\mu_0}{4\pi}\frac{2I_1}{d}]$$

or, $$\frac{dF_2}{dL_2} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$$ … (23)

It will be true for wire-1 in the field of wire-2. The direction of force in accordance with the right-hand screw rule will be as shown above.

So the force per unit length in case of two parallel current-carrying wires separated by a distance '*d*' is

$$\frac{dF}{dL} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$$

If I_1 and I_2 are along the same direction, the forces between the wires is attractive in nature and if I_1 and I_2 are oppositely directed the force is repulsive. The direction of forces is given by Fleming's left hand rule.

Definition of 'ampere'

We have $\frac{dF}{dL} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$

If $I_1 = I_2 = 1A$; $d = 1$m; $dL = 1$m; then

$dF = 2 \times 10^{-7}$ N

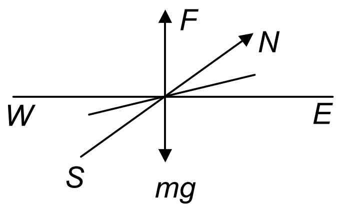
Hence, 'ampere' is defined as the current which when passing though each of two parallel infinitely long straight conductors placed in free space at a distance of 1 m from each-other produces between them force of 2×10^{-7} N for one metre of their length.

***Illustration* 10**

Question: **A straight wire of length 30 cm and mass 60 mg lies in a direction 30° east of north. The earth's magnetic field at this is in horizontal and has a magnitude of 0.8×10^{-4} T . What current must be passed through the wire so that it may float in air? [$g = 10$ m/s^2]**

Solution: $F = BIL \sin\theta$

$$\therefore I = \frac{mg}{BL\sin\theta} = \frac{60\times10^{-6}\times10}{0.8\times10^{-4}\times30\times10^{-2}\times\frac{1}{2}} = \mathbf{50A}$$



13 CURRENT LOOP IN A UNIFORM MAGNETIC FIELD

13.1 MAGNETIC MOMENT

According to magnetic effects of current, in case of current-carrying coil for axial point,

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\pi NIR^2}{(R^2 + x^2)^{3/2}}$$

when $x >> R$, $\vec{B} = \frac{\mu_0}{4\pi}\frac{2\pi NIR^2}{x^3}$

If we compare this result with the field due to a small bar magnet for a distant axial point, i.e.,

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}}{x^3},$$

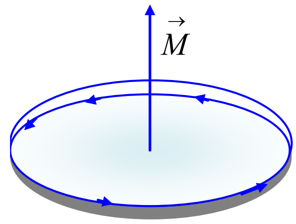
where M is magnetic moment of the bar magnet

we find that a current-carrying coil for a distant point behaves as a magnetic dipole of moment

$$\vec{M} = NI\,\pi R^2 = NIA$$ … (24)

where A is area of the loop. So the magnetic moment of a current carrying coil is defined as the product of current in the coil with the area of coil in the vector form.

Magnetic moment of a current loop is a vector quantity and direction is perpendicular to the plane of the loop. Its dimensions are $[L^2A]$ and units are $A\text{-}m^2$.



Magnetic moment in case of a charged particle having charge q and moving in a circle of radius R with speed v is given by $\frac{1}{2}qvR$

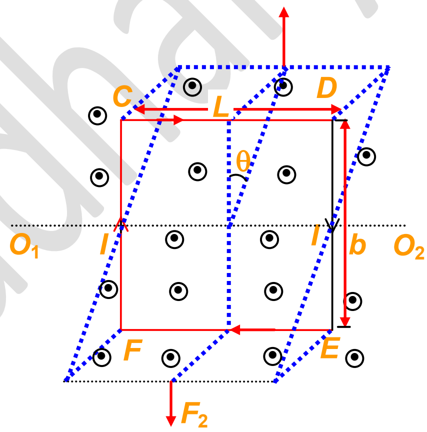
As we know, $I = qf = q\frac{v}{2\pi R}$ and $|A| = \pi R^2$

$$\therefore \quad M = I|\vec{S}| = \frac{1}{2}qvR$$

13.2 TORQUE ON A CURRENT LOOP

Consider a rectangular coil $CDEF$ of length L and width b is placed vertically, while a uniform magnetic induction B passes normally through it as shown. The coil is capable of rotation about an axis O_1O_2.

If the loop is oriented in the magnetic field such that the normal to the plane of the coil makes an angle θ with the direction of $\vec{B}$, then the torque experienced by the loop



$$\tau = \frac{b}{2}(ILB)\sin\theta + \frac{b}{2}(ILB)\sin\theta$$

i.e., $\tau = ILbB\sin\theta = IAB\sin\theta$

where $A = Lb$ is the area of the loop.

The maximum torque experienced is $\tau = IAB$, when $\theta = 90°$

and for a coil of N turns

$$\tau = NIAB$$

Here $NIA = M$ = Magnetic moment of the loop.

In vector notation $\vec{\tau} = \vec{M} \times \vec{B}$ **.** **… (25)**

This result holds good for plane loops of all shapes rectangular, circular or otherwise.

13.3 WORK DONE IN ROTATING A CURRENT LOOP

When a current loop is rotated in a uniform magnetic field through an angle θ about an axis then work done will be

$$\int_0^W dW = \int \tau d\theta = \int_0^\theta MB\sin\theta\, d\theta$$

$$W = -[MB\cos\theta]_0^\theta = MB(1-\cos\theta) \qquad \text{… (26)}$$

Illustration 11

Question: **For a given length $L = \sqrt{\pi}$ m of a wire carrying a current $I = 4$ amp, how many circular turns would produce the maximum magnetic moment and of what value?**

Solution: for a circular coil having N turns,

$$M = \pi R^2 I N$$

Now, $L = (2\pi R)N$

$\therefore \quad R = \dfrac{L}{2\pi N}$

Substituting the above value of R in equation (1), we get

$$M = \pi NI \times \frac{L^2}{4\pi^2 N^2}$$

or, $\quad M = \dfrac{IL^2}{4\pi N}$ … (i)

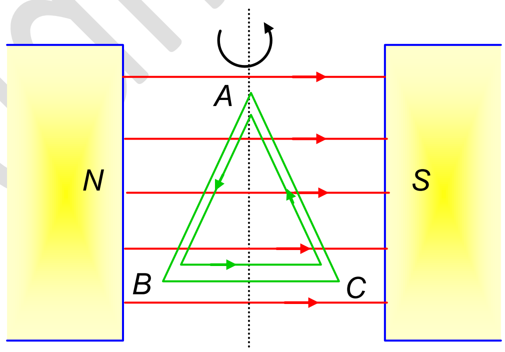
From equation (ii), it is clear that M will be maximum when N = minimum = 1, i.e., the coil has only one turn and

$$(M)_{max} = \frac{1}{4\pi} IL^2 = \mathbf{1\ Am^2}$$

Illustration 12

Question: **A coil in the shape of an equilateral triangle of side 1 m is suspended from a vertex such that it is hanging in a vertical plane in magnetic field of 4 T. Find the couple acting on the coil when a current of $\sqrt{3}$ ampere is passed through it and the magnetic field is parallel to its plane.**

Solution: As the coil is in the form of an equilateral triangle, its area



$$S = \frac{1}{2} \times L x L \sin\ 60°$$

$$= \frac{1}{2} \times (1)^2 \times \frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{4}\ m^2$$

So its magnetic moment

$$M = IA = \sqrt{3} \times \frac{\sqrt{3}}{4}$$

$$= \frac{3}{4}\ A\text{-}m^2$$

Now, the couple on a current – carrying coil in a magnetic field is given by $\tau = MB \sin\theta$

since the plane of the coil is parallel to the magnetic field, the angle between $\vec{M}$ and $\vec{B}$ will be 90° and hence $\tau = MB \sin 90° = MB$

$$\therefore \quad \tau = \frac{3}{4} \times 4 = \mathbf{3\ N\text{-}m}$$

14 MOVING COIL GALVANOMETER

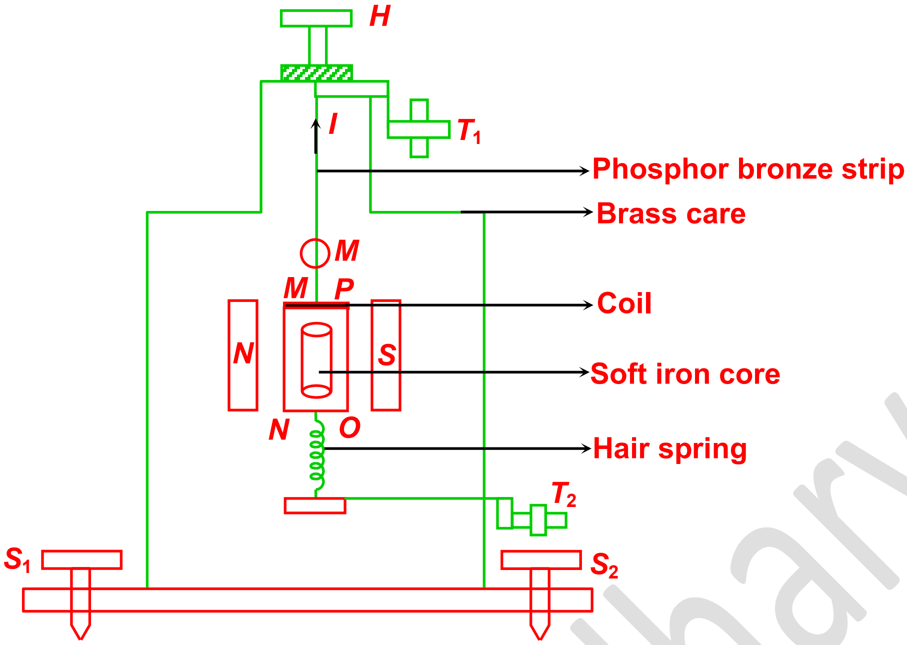
It is a sensitive instrument used for detecting and measuring small electric currents.

Principle " **It works on the fact that when a current carrying coil is kept in a magnetic field, it experiences a torque**"

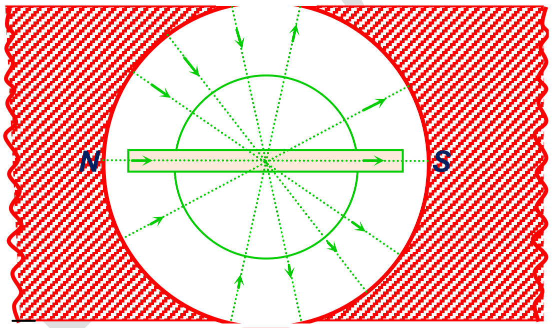
14.1 CONSTRUCTION

It consists of a coil *MNOP* having a larger number of turns of insulated copper wires and wound over a frame made of non-magnetic material such as copper. The coil may be rectangular or circular in shape.

The coil is suspended vertically from a movable screw (called torsion head) *M* by means of a phosphor bronze wire in uniform magnetic field which is produced by strong cylindrical pole pieces *N* and *S* shown in the figure.



A soft iron core is held within the coil in such a manner that the coil rotates without touching the poles and the core. The core is spherical in shape for a circular coil and cylindrical for a rectangular coil. The lower end of the coil is connected to a hair spring (a very light but highly elastic spring made of quartz or phosphor bronze). The other end of the spring is connected to a binding terminal T_2. The torsion head is also connected to binding terminal T_1. A small light mirror M is attached to the suspension wire to measure the deflection of the coil by a lamp and scale arrangement.



The entire apparatus is enclosed in a brass case (with glass window at the front) to avoid disturbances due to air etc.

14.2 THEORY AND WORKING

Let a current I be passed through the coil by connecting a cell between T_1 and T_2. A torque acts on the coil and the coil turns by a certain angle. Therefore, suspension wire gets twisted through the same angle. As a result, a restoring torque comes into play in the suspension wire. The restoring torque tends to oppose the deflecting torque.

As the coil turns more, the restoring torque also increases till stage comes in which it becomes equal to the deflecting torque.

Let θ be the angle by which the suspension wire gets twisted.

This is called the equilibrium position of the coil

$\therefore$ In equilibrium position

Deflecting torque = Restoring torque

or $NIAB\cos\alpha = C\theta$

Here α is the angle which the plane of the coil makes with the direction of the magnetic field.

The soft iron core placed symmetrically between the cylindrical pole pieces produces a radial magnetic field. In such a field, the lines of force pass through the axis of the cylindrical gap between *N* and *S*. Hence, the plane of the coil in all position will remain parallel to the lines of force.

$\therefore \quad \alpha = 0^0$

C is the torsion constant of the suspension wire and θ is the angle of twist.

$\therefore \quad NIAB = C \times \theta$

$\therefore \quad I \propto \theta$

Thus deflection of the coil is directly proportional to the current flowing through the coil.

14.3 CURRENT SENSITIVITY AND VOLTAGE SENSITIVITY OF A GALVANOMETER

Current sensitivity of a galvanometer is defined as the deflection produced in a galvanometer when unit current is passed through it.

From $NIAB = C\theta$

$$\therefore \quad \text{current sensitivity} = \frac{\theta}{I} = \frac{NBA}{C}$$

It is measured in rad A^{-1}.

Voltage sensitivity is defined as the deflection produced in the galvanometer when a unit potential difference is applied across the two terminals of the galvanometer.

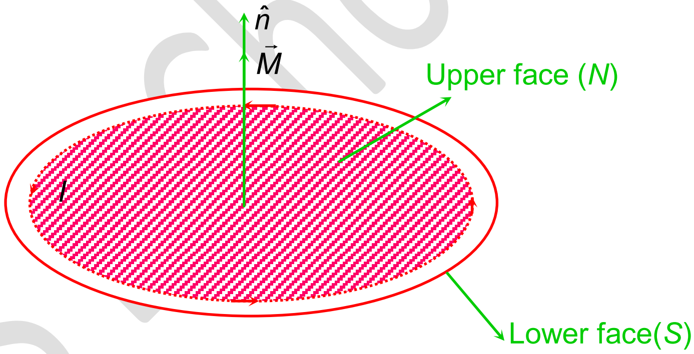
$$\therefore \quad \text{voltage sensitivity} = \frac{\theta}{V} = \frac{\theta}{IG} = \frac{NBA}{CG}$$

$$= \frac{\text{current sensitivity}}{\text{resistance of galvanometer}}$$

The unit of voltage sensitivity is rad/volt.

15 CURRENT LOOP AS A MAGNETIC DIPOLE

ent carrying loop thus behaves as a system of two equal and opposite magnetic poles and hence is a magnetic dipole**.**



The magnetic dipole moment of the current loop (*M*) is directly proportional to (i) strength of current (*I*) through the loop and (ii) area (*A*) enclosed by the loop.

i..e $\quad M \propto I$ and $M \propto A$

$\therefore \quad M = KIA$

where *K* is a constant of proportionality .

If we define unit magnetic dipole moment as that of a small one turn loop of unit area carrying unit current.

$1 = K \times 1 \times 1$ or $K = 1$

$M = IA$

For *N* such turns, $M = NLA$

The SI unit of *M* is ampere metre^2. It is the magnetic moment of one turn loop of area one square meter carrying a current of one ampere.

In vector form, we can rewrite equation as

$\vec{M} = NA\hat{n}$

where $\hat{n}$ is unit vector perpendicular to the plane of the loop in a direction given by right handed screw rule.

16 MAGNETIC DIPOLE MOMENT OF AN ATOM DUE TO REVOLVING ELECTRON

In every atom, electrons revolve around the nucleus. A revolving electron is like a loop of current, which has a definite magnetic dipole moment.

If e is the change on an electron revolving in an orbit of radius r with a uniform angular velocity ω, then equivalent current

$$i = \frac{\text{charge}}{\text{time}} = \frac{e}{T} \text{ where,}$$

T = the period of revolution of electron = $2\pi/\omega$

$$\therefore \quad i = \frac{e}{2\pi/\omega} = \frac{\omega e}{2\pi} \quad \ldots \text{(i)}$$

Area of the orbit $A = \pi r^2$

Magnetic moment of the atom is given by

$$M = iA = \frac{\omega e}{2\pi}\pi r^2$$

or $$M = \frac{1}{2}e\omega r^2 \quad \ldots \text{(ii)}$$

Also $mvr = \frac{nh}{2\pi}$, where n = 1, 2, 3 …… denotes the number of the orbit. Using $v = r\omega$, we get

$$m(r\omega)r = \frac{nh}{2\pi} \text{ or } \omega r^2 = \frac{nh}{2\pi m}$$

Put in (ii)

$$M = \frac{1}{2}e\frac{nh}{2\pi m} = n\frac{eh}{4\pi m} = n(\mu_B) \quad \ldots \text{(iii)}$$

where $\mu_B = eh/4\pi m$

We may define Bohr magneton as the magnetic dipole moment associated with an atom due to orbital motion of an electron in the first orbit of hydrogen atom.

17 BAR MAGNET AS AN EQUIVALENT SOLENOID

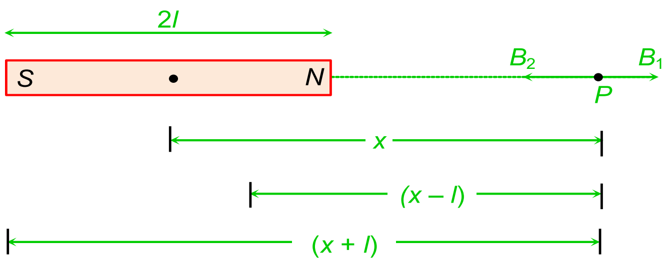
The magnetic field of a bar magnet when mapped using a small compass needle, a pattern of field lines is formed around the magnet

It should be clearly understood that the field lines exist in all the space around the magnet. Comparison of the two field patterns shows that current carrying solenoid from outside resembles a bar magnet. Inside the solenoid, there is a strong magnetic field which can magnetise a specimen. Solenoid is hollow from inside whereas the bar magnet is solid.

18 MAGNETIC FIELD DUE TO A BAR MAGNET (MAGNETIC DIPOLE)

18.1 AT A POINT LYING ON ITS AXIAL LINE

Consider a bar magnet of pole strength m and magnetic length $(2l)$ (distance between poles). Let P be a point on its axial line at a distance x from its centre.



∴ Magnetic field at P due to N pole of the magnet is

$$B_1 = \frac{\mu_0}{4\pi}\frac{m}{(x-l)^2} \text{ (pointing towards right)}$$

Similarly, magnetic field at P due to the S pole

$$B_2 = \frac{\mu_0}{4\pi}\frac{m}{(x+l)^2} \text{ (pointing towards left)}$$

∴ Net magnetic field at P due to the magnet

$$B = B_1 - B_2 = \frac{\mu_0 m}{4\pi}\left(\frac{1}{(x-l)^2} - \frac{1}{(x+l)^2}\right)$$

$$= \frac{\mu_0}{4\pi}\frac{m \times 4lx}{(x^2-l^2)^2}$$

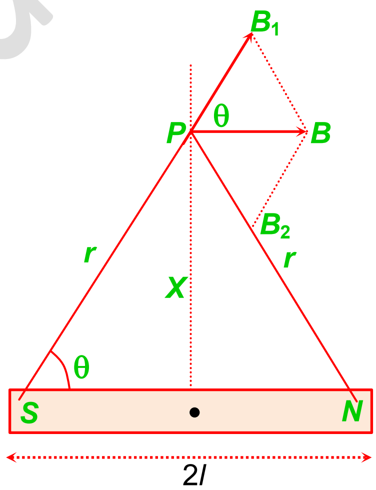
$$B = \frac{\mu_0}{4\pi}\frac{2Mx}{(x^2-l^2)^2} \quad \dots (27)$$

As a far off point, i.e. $x >> 1$

$$B = \frac{\mu_0}{4\pi}\frac{2M}{x^3}$$

18.2 AT A POINT LYING ON ITS EQUATORIAL LINE

Let P be a point at a distance x from the centre of the magnet.



∴ Magnetic field at P due to the north (N) pole of the magnet is

$$B_1 = \frac{\mu_0}{4\pi}\frac{m}{r^2} \text{ (pointing along } NP\text{)}$$

and the field due to the south (S) pole is

$$B_2 = \frac{\mu_0}{4\pi}\frac{m}{r^2} \text{ (pointing along } PS\text{)}$$

∴ $|\vec{B}_1| = |\vec{B}_2| = B_1$

∴ Net field at P due to the bar magnet is

$$B = 2B_1\cos\theta = 2\times\frac{\mu_0}{4\pi}\frac{m}{r^2}\frac{l}{r} = \frac{\mu_0}{4\pi}\frac{2ml}{r^3}$$

or $$B = \frac{\mu_0}{4\pi}\frac{M}{(x^2+l^2)^{3/2}} \quad \text{(As } r = \sqrt{x^2+l^2}\text{)} \quad \dots (28)$$

At a far-off point $x >> l$

$$B = \frac{\mu_0}{4\pi}\frac{M}{r^3}$$

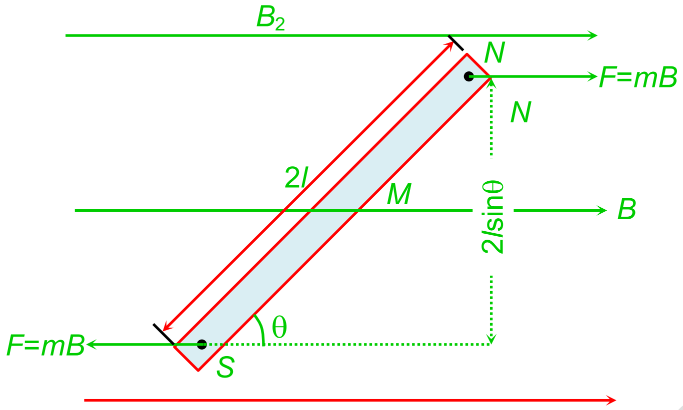
19 TORQUE ON A BAR MAGNET IN A UNIFORM MAGNETIC FIELD

Consider a bar magnet of pole strength m and length $2l$ kept in a uniform magnetic field $\vec{B}$ pointing horizontally from left to right, as shown in figure.

Let θ be the angle between the axis of the magnetic and the magnetic field (the angle between $\vec{M}$ of the magnetic and $\vec{B}$)

∴ Force acting on each pole of the magnetic is

$F = mB$



Since these equal forces act on the magnet in the opposite direction, their resultant force is zero. But these forces constitute a couple which tends to rotate the magnetic in the clock wise direction and brings it along the direction of $\vec{B}$.

∴ Torque due to the couple is

τ = force × perpendicular between the forces

$= mB \times 2l \sin\theta$

$= (m\, 2l)\, B \sin\theta$

or $\tau = MB \sin\theta$

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

The direction of the torque $\vec{\tau}$ is given by the right hand screw rule for the vector product.

If $\theta = 90^0$, $B = 1\ T$, then $\tau = M$

Therefore, magnetic dipole moment of a magnet is numerically equal to the torque acting on the magnet when held perpendicular to a uniform magnetic field of one Tesla.

Illustration 13

Question: **A magnet 10 cm long has a pole strength of 12 A.m. Find the magnitude of magnetic field strength *B* at a point on its at a distance of 20 cm from it. What would be the value of B, if the point were to lie at the same distance on equatorial line of magnet?**

Solution: Here, $2l = 10$ cm = 0.1m, m = 12 Am

B = ? d = 20 cm = 0.2 m

As $B_1 = \frac{\mu_0}{4\pi}\frac{2Md}{(d^2 - l^2)^2} = \frac{\mu_0 1mld}{4\pi(d^2 - l^2)^2}$

$= \frac{10^{-7} \times 4 \times 12 \times 0.05 \times 0.2}{[(0.2)^2 - (0.05)^2]^2}$

∴ $B_1 = \mathbf{34\ \mu T}$

At the same distance, on equatorial line,

$B_2 = \frac{1}{2}B_1$

assuming the magnet to be short

∴ $B_2 = \frac{1}{2} \times 3.4 \times 10^{-5} T = \mathbf{17\ \mu T}$

Illustration 14

Question: **A magnet having a magnetic moment of 1.0×10^4 J/T is free to rotate in a horizontal plane where a magnetic field 4×10^{-5} T exists. Find the work done in rotating the magnet slowly from a direction parallel to the field do a direction 60^0 from the field.**

Solution: Here, $M = 1.0 \times 10^4$ J/T

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

$W = ?\ \theta_1 = 0^0,\ \theta_2 = 60^0$

$W = -MB(\cos\theta_2 - \cos\theta_1)$

$= -1.0 \times 10^4 \times 4 \times 10^{-5} (\cos 60^0 - \cos 0^0)$

$= -0.4\left(\frac{1}{2} - 1\right) = 0.2\ \text{J} = \mathbf{200\ mJ}$

20 EARTH'S MAGNETISM

A freely suspended magnet always aligns itself along north-south direction. If this magnet is turned away from this position and left, it oscillates for some time and finally aligns along, its initial north south direction.

It suggests as if there is a giant magnet inside the earth with its magnetic south pole near the geographic north pole of earth and the magnetic north pole near the geographic north pole.

20.1 DEFINITIONS OF IMPORTANT TERMS

(i) Geographic axis

The axis of rotation of earth is called its geographic axis and the points where it cuts the earth's surface are called its geographic pole (north and south).

(ii) Geographic Meridian

An imaginary vertical plane passing though the geographic axis of earth is called its geographic meridian.

(iii) Geographic equator

The great circle on earth's surface whose plane is perpendicular to the geographic axis is called geographic equator of earth.

(iv) Magnetic axis

The axis of the giant fictitious magnet inside the earth is called earth's magnetic axis and the points where the magnetic axis cuts the earth's surface are called the magnetic north (MN) and magnetic south (MS) pole of earth.

(v) Magnetic meridian

An imaginary vertical plane passing through the magnetic axis of the earth is called magnetic meridian.

(vi) Magnetic equator

The great circle on earth's surface whose plane is perpendicular to earth's magnetic axis is called magnetic equator.

20.2 ELEMENTS OF EARTH'S MAGNETISM

The physical quantities which enables us to completely describe the magnitude and direction of earth's magnetic field at a place are called the elements of earth's magnetism. These are

(i) Magnetic declination or declination (θ)

(ii) Magnetic inclination or dip or angle of dip (δ) and

(iii) Horizontal component of earth's magnetic field.

(i) Magnetic Declination (θ)

Magnetic Declination at a place may be defined as the angle between its magnetic meridian and the earth geographic meridian at the place.

It is due to the fact that the magnetic axis of the earth does not coincide with its geographic axis.

(ii) Magnetic Inclination or Angle of Dip (δ)

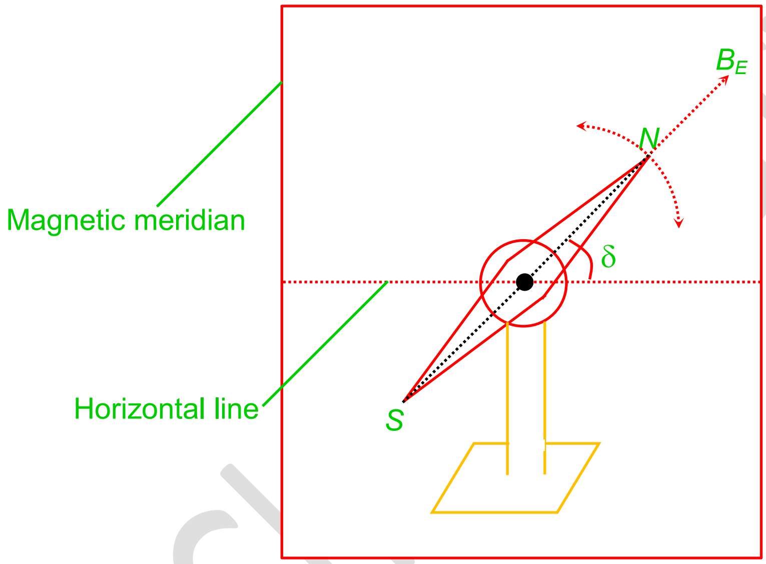
Angle of dip at a place is defined as the angle between the direction of intensity of earth's magnetic field (B_E) and the horizontal direction in magnetic meridian at that place.

Consider a light magnetic needle free to rotate about a horizontal axis passing through its centre. Let the magnet be free to rotate in a vertical plane in the magnetic meridian.

The magnet, therefore, aligns itself along the direction of earth's magnetic field (B_E). The angle (δ) which the magnet makes with the horizontal is the angle of dip at that place.

The instrument consisting of a light magnetic needle mounted on a horizontal axis on a stand and free to turn in a vertical plane can be used to measure the angle of dip. It is therefore, called Dip circle.

Note: The value of dip is 90^0 at pole and zero at the equator.



(iii) Horizontal component of earth's magnetic field

It is defined as the component of earth's magnetic field (B_E) along the horizontal direction in magnetic meridian. It may be represented by B_H or H.

Let B_E is the earth's magnetic field and δ is the angle of dip at that place.

∴ Horizontal component of earth's magnetic field

$$B_H = B_E \cos\delta$$

and vertical component, $B_v = B_E \sin\delta$

$$\therefore \quad B_H^2 + B_V^2 = B_E^2 \quad \text{and} \quad \tan\delta = \frac{B_V}{B_H}$$

The value of B_H can be determined by using vibration magnetometer.

Illustration 15

Question: **The horizontal component of earth's magnetic field at a place is $\sqrt{2}\times 10^{-3}$ T. If angle of dip is 45^0, what is the values of total intensity of earth's field?**

Solution: Here, $H = \sqrt{2}\times 10^{-3}$ T, $\delta = 45^0$

$R = ?$

From $H = R\cos\delta$,

$$R = \frac{H}{\cos\delta} = \frac{\sqrt{2}\times 10^{-3}}{\cos 45^0} = \sqrt{2}\times\sqrt{2}\times 10^{-3}$$

R = **2 mT**

21 CLASSIFICATION OF MAGNETIC MATERIALS

As motioned earlier, all substances, depending upon their behaviour in external magnetic field, can be dividing into following three categories.

(i) Diamagnetic substances
(ii) Paramagnetic substances and
(iii) Ferro magnetic substances

Let us, now understand these substances one by one.

(i) Diamagnetic Substances

The substances which are feebly repelled by a magnet and hence tend to move from stronger the weaker parts of the magnetic field are called diamagnetic substances. For example –zinc, copper, gold, water, etc.

(ii) Paramagnetic substances

The substances which get feebly attracted by a magnet are called paramagnetic substances. Such substances when placed in an external magnetising field, get feebly magnetised along the direction of the field.

For example: Aluminium, platinum, chromium, manganese, copper sulphate and solutions of iron and nickel etc.

(iii) Ferromagnetic substance

The substances which are strongly attracted by a magnet and hence tend to move from weaker to stronger parts of a magnetic field are called Ferromagnetic substances.

Thus, ferromagnetic substances behave like paramagnetic substances but the effect is much more intense.

For example: Iron nickel, cobalt, gadolinium etc.

SELECTION OF MAGNETIC MATERIAL

The hysteresis curves provide us the necessary information for selecting a particular material for a special particle use in various devices. For example

(i) Electromagnets (Temporary Magnets)

The material of the core of an electromagnet should have the following prosperities.

(a) Low retentivity. Because of this, the material will get almost completely demagnetised after the removal of the magnetising field.

(b) High permeability. Because of this, it will have value of magnetic saturation and hence the electromagnet will be very strong.

(c) Low coercivity: Due to this, the core gets easily demagnetised.

Hence soft iron is suitable for making electromagnetics.

(ii) Permanent Magnets

The material used for making permanent magnets should have the following prosperities.

(a) It should have high retentivity so that it remains strongly magnetised after the removal of the magnetising field.

(b) It should soft iron is suitable for making electromagnets.

PROFICIENCY TEST– II

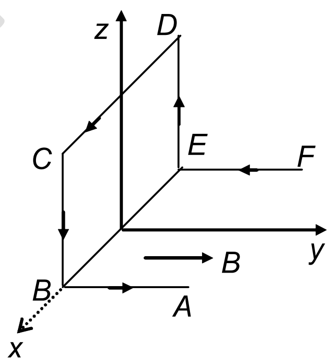
The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. An alpha particle moves on a circular path of radius 0.45 m in a magnetic field of induction $B = 1.2$ Wb/m^2. Calculate its (a) its kinetic energy and (b) the potential difference it would have to accelerate to achieve this energy.
(For alpha particle $q = 3.2 \times 10^{-19}$ C; $m = 4 \times 1.65 \times 10^{-27}$ kg)

2. A charged particle moving in a uniform magnetic field penetrates a layer of lead and thereby loses one half of its kinetic energy. How does the radius of curvature of its path change?

3. If an electron describes half of revolution in a circle of radius r in a magnetic field, what is the energy acquired?

4. A wire *ABCDEF* (with each side of length L= 1m) bent as shown in figure and carrying a current I = 1amp is placed in a uniform magnetic induction B = 1T parallel to positive y direction. What is the force-experienced by the wire?



5. A rectangular current loop is in an arbitary orientation in an external uniform magnetic field. Is any work required to rotate the loop about an axis perpendicular to its plane?

6. Two infinitely long parallel wires carry equal currents in the same direction.
(i) What is the direction of the force on one wire due to the other?
(ii) By what factor does this force change if the current in each wire is doubled?

7. A beam of protons is deflected sideways. Could this deflection be caused (a) by an electric field? (b) by a magnetic field? (c) if either is possible, how can you tell which one is present?

ANSWERS TO PROFICIENCY TEST– II

1. (a) 14 MeV; (b) 7 MV

2. Radius of curvature becomes $\frac{1}{\sqrt{2}}$ (original radius)

3. Zero

4. $F = 1$ N along negative z-axis

5. No work is done in rotating the coil because work done $W = mB(1 - \cos\theta)$. Hence is no change in θ and so no work is done.

6. (i) Attractive force towards each other
(ii) Four

7. (a) Yes, it could be due to an electric field directed perpendicular to the motion. (b) Yes, it could be due to a magnetic field. (c) Stop the proton and keep it stationary. If it still experiences a force in the same direction, it is due to an electric field. If the force vanishes on stopping the motion, there is a magnetic field. Also if path of beam is parabolic it is due to electric field if path of beam is circular it is due to magnetic.

SOLVED OBJECTIVE EXAMPLES

***Example* 1:**

Two circular coils made of similar wires but of radii 20 cm and 40 cm are connected in parallel. The ratio of the magnetic field at their centres is

(a) 4 : 1 **(b) 1 : 4** **(c) 2 : 1** **(d) 1 : 2**

Solution:

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi ni}{r} = \frac{\mu_0}{4\pi}\cdot\frac{2\pi n}{r}\cdot\frac{V}{2\pi rx}$$ (where, x = resistance per metre)

or $B \propto \frac{V}{r^2}$ (the potential difference V is same for both coils)

or $Br^2 = \text{Constant} \Rightarrow \frac{B_1}{B_2} = \frac{r_2^2}{r_1^2} = \left(\frac{40}{20}\right)^2 = \frac{4}{1}$

∴ **(a)**

***Example* 2:**

In a hydrogen atom, the electron is making 6.6 × 10^{15} revolutions per second in a circular orbit of radius 0.53 Å. The field of induction produced at the position of the nucleus is approximately

(a) zero **(b) 3πT** **(c) 4πT** **(d) 0.4πT**

Solution:

$i = Ne = (6.6\times10^{15}\times1.6\times10^{-19})$ amp

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi ni}{r} = 10^{-7}\times2\pi\times(1)\frac{(6.6\times10^{15}\times1.6\times10^{-19})}{0.53\times10^{-10}} = \mathbf{4\pi\ tesla}$$

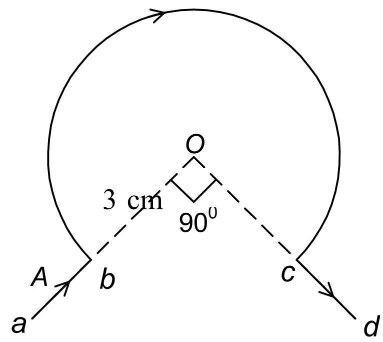
∴ **(c)**

***Example* 3:**

The conductor *abcd* carries a current of 4 *A*. The field at the centre *O* of the circular part of it is

(a) $\frac{8\pi}{3}\times10^{-5}T$ **(b) 2π × 10^{-5} *T***

(c) $\frac{8\pi}{3}\times10^{-4}T$ **(d) 2π × 10^{-4} *T***



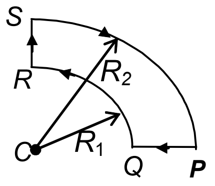
Solution:

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi ni}{r} = 10^{-7}\times\frac{2\pi\times\frac{3}{4}\times4}{3\times10^{-2}} = \mathbf{2\,\pi\times10^{-5}\ T}$$

∴ **(b)**

Example 4:

The wire loop *PQRSP* formed by joining two quarter circular wires of radii R_1 and R_2 carries a current I as shown in figure. The magnitude of magnetic induction at the centre C is



(a) $\frac{\mu_0 I}{4}$ **(b)** $\frac{\mu_0 I}{8}\frac{(R_2-R_1)}{R_1R_2}$

(c) $\frac{\mu_0 I}{4}\frac{R_1}{R_2}$ **(d)** $\frac{\mu_0 I}{2}$

Solution:

Magnetic field at C due to bigger quarter circular coil

$$=\frac{1}{4}\left(\frac{\mu_0}{2}\times\frac{I}{R_2}\right)$$ inwards from the plane of the coil.

Magnetic field at C due to smaller quarter circular coil

$$=\frac{1}{4}\left(\frac{\mu_0}{2}\times\frac{I}{R_1}\right)$$ outwards from the plane of the coil.

Net field (outward) at the centre C

$$=\frac{1}{4}\left(\frac{\mu_0}{2}\times\frac{I}{R_1}\right)-\frac{1}{4}\left(\frac{\mu_0}{2}\times\frac{I}{R_2}\right)$$

$$=\frac{1}{4}\frac{\mu_0 I}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$=\frac{\mu_0 I}{8}\left(\frac{R_2-R_1}{R_1R_2}\right)$$

∴ **(b)**

Example 5:

A copper wire having resistance 0.01 ohm in each metre is used to wind a 400 turn solenoid of radius 1 cm and length 20 cm. Find the e.m.f of the battery which when connected across the solenoid will produce a magnetic field 1×10^{-2} tesla at the centre of solenoid.

(a) 1 volt **(b) 2 volts** **(c) 2.5 volts** **(d) 3 volts**

Solution:

One turn has a length $= 2\pi r = 2\pi\times1\times10^{-2}$ m

No. of turns $= 400$

∴ Total length $= 400\times2\pi\times10^{-2}$ m

Resistance (R) $= 400\times2\pi\times10^{-2}\times0.01$ ohm

$= 800\,\pi\times10^{-4}$ ohm

Magnetic field $= \mu_0 ni$

$$1\times10^{-2} = \mu_0\times\frac{400}{20\times10^{-2}}\times i$$

$$\text{But } i = \frac{E}{R}=\frac{E}{8\pi\times10^{-2}}$$

$$\frac{20\times10^{-2}\times1\times10^{-2}}{400\mu_0}=\frac{E}{10^{-4}\times800\pi}$$

$$E=\frac{800\pi\times10^{-4}\times20\times10^{-4}}{400\times4\pi\times10^{-7}}$$

$=$ **1 volt**

∴ **(a)**

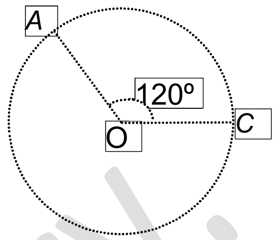
***Example* 6:**

A piece of wire carrying a current 6 amp. is bent in the form of a circular arc of radius 10 cm and it subtends an angle of 120° at centre. Find the flux density at the centre.

(a) 1.26×10^{-5} tesla | **(b) 2.52×10^{-5} tesla**

(c) 0.63×10^{-5} tesla | **(d) 10^{-5} tesla**

Solution:



Flux density due to full circular line $= \frac{\mu_0 i}{2a}$

The arc AC is only $\frac{1}{3}$ of the circular line

$$\therefore \quad B = \frac{1}{3} \times \frac{\mu_0 i}{2a} = \frac{\mu_0 i}{6a} = \frac{4\pi \times 10^{-7} \times 6}{6 \times 10^{-1}}$$

$= 4\pi \times 10^{-6}$

$= 3.14 \times 4 \times 10^{-6}$

$= \mathbf{1.26 \times 10^{-5}}$ **tesla**

$\therefore$ **(a)**

***Example* 7:**

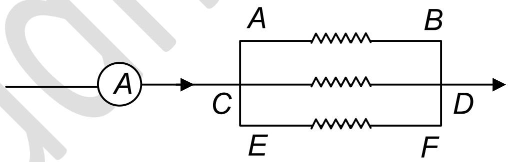


Figure shows a part of electric circuit. The wires *AB*, *CD* and *EF* are long and have identical resistances. The separation between consecutive wires is 1 cm. The wires *AE* and *BF* have negligible resistance. The ammeter reads 30 amps. The force per unit length on wires *AB* and *CD* are

(a) zero, zero

(b) 3×10^{-3} N/m, zero

(c) 2×10^{-3} N/m, 10^{-3} N/m

(d) 10^{-3} N/m, zero

Solution:

Since *AB*, *CD*, *EF* have equal resistances each carry 10 A current, force on *AB* per unit length due to *CD*

$$= \frac{\mu_0}{2\pi} \times \frac{10 \times 10}{1 \times 10^{-2}} = \frac{\mu_0}{2\pi} \times 10^4$$

Force on *AB* per unit length due to *EF*

$$= \frac{\mu_0}{2\pi} \times \frac{10 \times 10}{2 \times 10^{-2}} = \frac{\mu_0}{4\pi} \times 10^4$$

Total force downwards $= \frac{\mu_0}{4\pi} \times 10^4 \times 3$

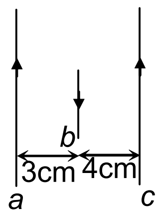
$= \mathbf{3 \times 10^{-3}}$ **N/m**

Force on *CD* due to *AB* and *EF* are equal and opposite and the net force is **zero.**

$\therefore$ **(b)**

***Example* 8:**

Currents of 3 A, 1 A and 2 A flow through the long, straight and parallel conductors *a*, *b* and *c* respectively as shown. A length 0.5 m of wire b experiences a force of



(a) 10.0×10^{-6} N from right to left | **(b) 10.0×10^{-6} N from left to right**

(c) 5.0×10^{-6} N from right to left (d) 5.0×10^{-6} N from left to right

Solution:

Force between the conductors *a* and *b* = $F_1 = \frac{\mu_0}{4\pi} \times \frac{2i_1 i_2}{r} \times 0.5 = 100 \times 10^{-7}$ N/m towards right.

Force between the conductors *c* and *b* = $F_2 = \frac{\mu_0}{4\pi} \times \frac{2 \times 2 \times 1}{4 \times 10^{-2}} \times 0.5 = 50 \times 10^{-7}$ N/m towards left.

$(F_1 - F_2) = \mathbf{50 \times 10^{-7}}$ **N/m towards right**

$\therefore$ **(d)**

***Example* 9:**

Alpha particles (m = 6.7 × 10^{-27} kg, q = + 2e) are accelerated from rest through a potential difference of 6.7 kV. Then they enter a magnetic field B = 0.2 T perpendicular to their direction of motion. The radius of the path described by them is

(a) 8.375 m **(b) 8.375 cm** **(c) infinity** **(d) none of the above**

Solution:

$$r = \frac{mv}{qB} = \frac{\sqrt{2Km}}{qB} = \frac{1}{B}\sqrt{\frac{2V}{q}m}$$

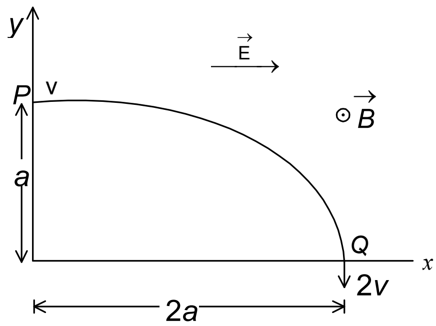
$$= \frac{1}{0.2}\sqrt{\frac{2 \times 6.7 \times 10^{3} \times 6.7 \times 10^{-27}}{2 \times 1.6 \times 10^{-19}}}$$

$= \mathbf{8.375 \times 10^{-2}}$ **m**

$\therefore$ **(b)**

***Example* 10:**

A particle of charge +q and mass m moving under the influence of a uniform electric field $E\,\vec{i}$ and a uniform magnetic field $B\,\vec{k}$ follows a trajectory from P to Q as shown in Figure. The velocity at P and Q are $v\,\vec{i}$ and $-2v\,\vec{j}$. Which of the following statement/s is/are correct?



(a) $E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$

(b) Rate of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$

(c) Rate of work done by the electric field at P is zero.

(d) Rate of work done by both of the fields at Q is different.

Solution:

Work done by electric filed = Gain in kinetic energy

$\Rightarrow$ $(qE) \times (2a) = \frac{1}{2}m[(2v)^2 - v^2]$

$\Rightarrow$ $qE \times 2a = \frac{1}{2}m \times 3v^2 \Rightarrow E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$

$\therefore$ (a)

Rate of work done by electric filed at $P = \vec{F} \cdot \vec{v}$ = $(qE) \cdot v$

$$= qv \times \frac{3}{4}\left(\frac{mv^2}{qa}\right)$$

$$= \frac{3}{4}\left(\frac{mv^2}{a}\right)$$

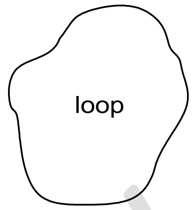
$\therefore$ **(b)**

***Example* 11:**

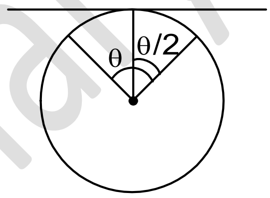
A loop of flexible conducting wire of length 0.5 m lies in a magnetic field of strength 1 tesla perpendicular to the plane of the loop. When a current 1.57 *A* is passed through the loop it opens into a circle with the tension (*T*) developed in the wire, *T* is

(a) 0.125 N **(b) 0.250 N** **(c) 0.0625 N** **(d) 0.375 N**

Solution:



When the loop is closed, $\vec{F} = i d\vec{l} \times \vec{B}$, is perpendicular to both $\vec{B}$ and $i\,\vec{dl}$. $\vec{F}$ is the force acting on a small element, *dl*. There is no translational motion of the loop as a whole. Hence, the net force in any direction is zero. This is possible when the various forces on the various infinitely large number of elements like *dl* nullify one another. i.e., all the forces must be acting along the various radii of a circle. Hence, the loop opens up into a circle for stability.



When the loop opens up into a circle, there is tension in the wire. If *T* is the tension, then $2T\sin\frac{\theta}{2}$ is the component of tension in a radial direction. If we consider an infinitesimally small length *dl* of the element, then θ is very small and $2T\sin\frac{\theta}{2} = 2T\frac{\theta}{2} = T\theta$ = force along radius, i.e. perpendicular to *dl*, i.e., radial force = *idl B*

Hence, $T\theta = idl\,B$

or $T = \frac{iBdl}{\theta}$

But $dl = r\theta$ or $\frac{dl}{\theta} = r$

$T = iBr$, but $r = \frac{l}{2\pi}$

Hence, $T = \frac{iBl}{2\pi} = \frac{(1.57A)\times 1.0\times 0.5}{2\pi}$

= **0.125 N.**

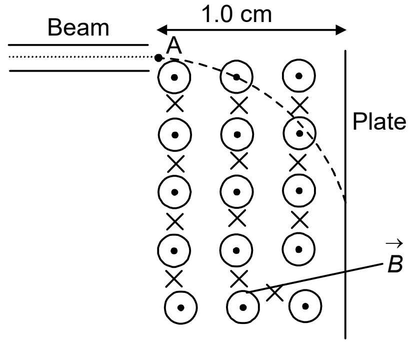
$\therefore$ **(a)**

***Example* 12:**

A beam of charged particles of K.E. = 1 keV and q = 1.6 × 10^{-19} C and two masses 8 × 10^{-22} kg and 16 × 10^{-27} kg come out of an accelerator tube. And strike a plate at distance of 1 cm from the end of the tube, where the particles emerge perpendicularly. The value of the smallest magnetic field which can prevent the beam from striking the plate is

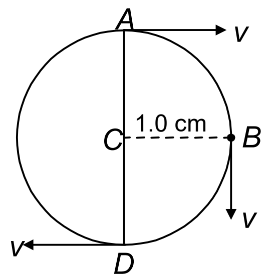
(a) 1.414 T **(b) 2.828 T** **(c) 4.242 T** **(d) 5.656 T**

Solution:



$\vec{B}$ should be out of the paper. Let *F* be the magnetic force acting on the particles, where $F = (mv^2/r) = qvB$ since *v* is perpendicular to *B*. This force does not change the speed of the particles but it bends them into a circular arc of radius *r*, where $r = \left(\frac{mv}{qB}\right)$. The beam will not strike the plate, if the field is minimum, *r* is maximum. Hence $r_{max} = \left(\frac{mv}{qB_{min}}\right)$.

At the point A (see Figure), the beam is horizontal. Hence, the beam must describe a semi-circle, ABD with C as centre. Hence, r_{max} = 1.0 cm = 10^{-2} m.



$$\therefore \quad B_{min} = \frac{mv}{q\times10^{-2}} = \frac{mv}{(1.6\times10^{-19}\times10^{-2})}$$

Now $\frac{1}{2}mv^2$ = K.E. = 1.0 keV = 10^3 eV

$= 10^3 \times 1.6 \times 10^{-19}$ J

or $v = (2 \times 10^3 \times 1.6 \times 10^{-19}\text{ J/m})^{1/2}$.

$$B_{min} = \frac{m\times\left(\frac{2\times10^3\times1.6\times10^{-19}}{m}\right)^{1/2}}{1.6\times10^{-19}\times10^{-2}}$$

$$= \sqrt{m}\sqrt{\frac{2\times10^3\times1.6\times10^{-19}}{(1.6\times10^{-21})^2}} = \sqrt{m}\left[\frac{3.2\times10^{-16}}{2.56\times10^{-42}}\right]^{1/2}$$

$$= \sqrt{m}\times(1.25\times10^{26})^{1/2} = \sqrt{m}\times1.1\times10^{13}$$

Hence, B_{min} is more if m is more. The higher mass can be prevented from striking the plate, if

$$B_{min} = \sqrt{16\times10^{-27}}\,\sqrt{1.25}\times10^{13}$$

$$= (\sqrt{1.6\times1.25}) = (\sqrt{2})\ T = \mathbf{1.414\ T}$$

$\therefore$ **(a)**

***Example* 13:**

A wire of length *l* carrying a current *i* is bent into a circle and placed in a magnetic field *B*. If the coil has only one turn, the maximum torque (τ) is

(a) $2l^2i\,B/\pi$ **(b) $l^2i\,B/2\pi$** **(c) $l^2i\,B/4\pi$** **(d) $l^2i\,B/\pi$**

Solution:

A current carrying closed loop has a magnetic moment, $\mu = iA$ associated with it, where A = area of the coil.

$l = 2\pi r$ or $r = \left(\frac{l}{2\pi}\right)$.

Hence, $A = \pi r^2 = \frac{\pi l^2}{4\pi^2} = \left(\frac{l^2}{4\pi}\right)$

$\therefore \mu = iA = \frac{il^2}{4\pi}$.

If the axis of the circular coil makes an angle θ with the field,

torque = $\mu B \sin\theta$.

So maximum torque when $\theta = 90^\circ$,

i.e., $\mu B = \frac{il^2B}{4\pi}$.

$\therefore$ **(c)**

Example **14:**

An atom consists of a proton and electron separated by a distance of 0.5 Å. Assuming that the electron moves in a circular orbit with a velocity 10^{13} cm/sec find the magnetic flux density at the region of nucleus.

(a) 3.2×10^5 T **(b) 6.4×10^5 T** **(c) 1.28×10^6 T** **(d) 2.0×10^5 T**

Solution:

The current is the rate at which the charge passes any point in the orbit

$$I = \frac{e}{T} \text{ where } T \text{ is the period of revolution}$$

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

$$\therefore \quad I = \frac{ev}{2\pi r}$$

$$B = \frac{\mu_0 I}{2r} = \frac{\mu_0 ev}{4\pi r^2} = \frac{1.6\times10^{-15}}{0.25\times10^{-20}} = \frac{1.6\times10^5}{0.25}$$

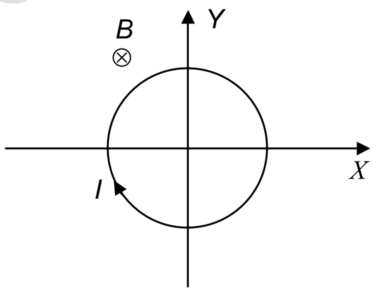
$$= \mathbf{6.4 \times 10^5\ T}$$

$\therefore$ **(b)**

Example **15:**

A conducting loop carrying a current *I* is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to

(a) contract
(b) expand
(c) move towards positive *x* -axis
(d) move towards negative *x*-axis



Solution:

Since force on any section of wire will be outward so the loop will have a tendency to expand.

$\therefore$ **(b)**

SOLVED SUBJECTIVE EXAMPLES

Example 1:

An insulating circular disc of radius a = 20 cm has a uniformly distributed static charge of surface density $\sigma = \pi$ Cm^{-2}. The disc rotates about its centre with an angular velocity ω =100rad/s. Find the magnetic field at the centre of the disc. ($\pi^2 = 10$)

Solution:

The disc may be considered to be made up of concentric circular rings with radius increasing from 0 to a. Consider one such elementary ring of radii r and $r + dr$.

Face area $= 2\pi r dr$

Charge $= 2\pi r dr\sigma$

Angular velocity = ω

Period $T = \dfrac{2\pi}{\omega}$

The elementary charge when the disc rotates to equivalent to a circular current loop. The amount of charge passing through the current loop during $T = 2\pi r dr\sigma$

$$\therefore \quad I = \frac{2\pi r dr\sigma}{T} = \frac{2\pi r dr\sigma\omega}{2\pi}$$

$$= r dr\omega\sigma$$

Magnitude of magnetic field at centre $dB = \dfrac{\mu_0 I}{2r} = \dfrac{\mu_0 r dr\omega\sigma}{2r} = \mu_0 \dfrac{\omega\sigma dr}{2}$

$\therefore$ total magnetic field due to all rings = $B = \int dB = \dfrac{\mu_0\omega\sigma}{2}\int_0^a dr = \mu_0 \dfrac{\omega\sigma a}{2}$ = **40 μT**

Example 2:

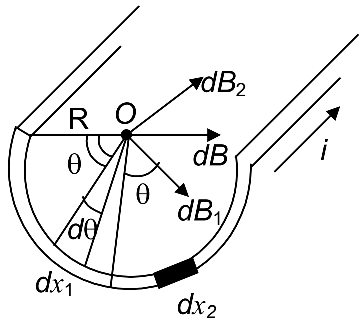
Find the magnetic induction B at a point on the axis due to an infinite thin conductor with semicircular cross-section of radius R = 10 cm carrying a uniform current $i = \pi$ amp.

Solution:

Let R be the radius of semicircular cross-section and O, a point on the axis. Considering an element dx_1 carrying current di_1

$$di_1 = \frac{i dx_1}{\pi R}$$

Induction dB_1 at O due to di_1 is $dB_1 = \dfrac{\mu_o di}{2\pi R}$



This is directed normal to line joining the element to O.

$$dB_1 = \frac{\mu_o i}{2\pi R}\frac{dx_1}{\pi R} = \frac{\mu_o i}{2\pi^2 R^2} R d\theta$$

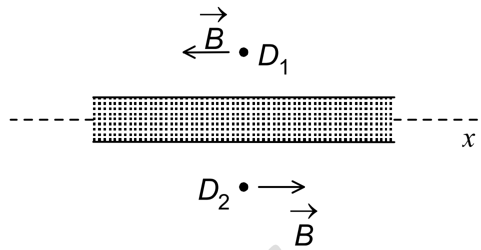
$$= \frac{\mu_o i}{2\pi^2 R} d\theta$$

Field dB_2 due to corresponding element dx_2 points in a direction shown. Resolving $d\vec{B}_1$ and $d\vec{B}_2$, $dB_1 \sin\theta$ and $dB_2 \sin\theta$ acting on same line and $dB_2\cos\theta = dB_1\cos\theta$ acting on opposite direction and hence cancelling each other.

$\therefore \qquad B = \int_0^{\pi} dB_1 \sin\theta = \frac{\mu_0 i}{2\pi^2 R}\int_0^{\pi} \sin\theta d\theta = \frac{\mu_0 i}{\pi^2 R} = 4\ \mu T$

***Example* 3:**

Given Figure shows a cross-section of an infinite conducting sheet carrying a current per unit x-length of λ = π A/m, the current emerges perpendicularly out of the page.



(a) Use the Biot-Savart law and symmetry to prove that for all points D_1 above the sheet, and all points D_2 below it, the magnetic field $\vec{B}$ is parallel to the sheet and directed as shown.

(b) Use Ampere's law, find the value of magnetic field at all points of D_1 and D_2. ($\pi^2 = 10$)

Solution:

(a) Let the field be not parallel to the sheet as shown in figure (I)
Reverse the direction of the current:
According to the Biot-Savart law, the field reverses and will be as shown in figure (ii)
Rotate the sheet by 180º about a line that is perpendicular to the sheet. Then the field will rotate with it to be finally as in figure (iii).
Only if the field is parallel to the sheet, then the final direction of the field be the same as the original direction.
If the current is out of the page, any inifinitesimal portion of the sheet in the form of a long straight wire produces a field that is to the left above the sheet and to the right below the sheet. The field then is framed as in figure given in question.

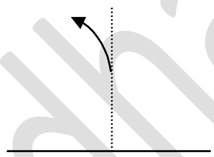


Fig. (i)

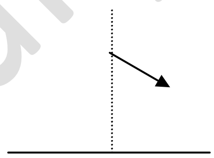
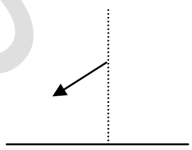
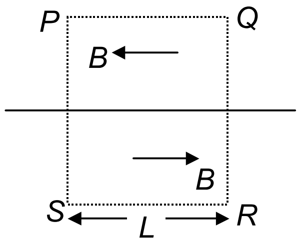


Fig. (ii)


(iii)



(iv)

(b) Integrate the tangential component of the magnetic field around the rectangular loop shown with dotted lines (figure iv).
The upper and lower edges are the same distance from the current sheet and each has length *L*. This means the field has the same magnitude along these edges. It points to the left along the upper edge *PQ* and to the right along the lower edge *SR*.

The contributions to the integral $\oint \vec{B}.d\vec{l}$ are

BL from *PQ*
BL from *RS*
Zero from *PS*
Zero from *QR*

(as *PS* and *QR* are perpendicular to the sides, the cosine term in $\vec{B}.d\vec{S} = |\vec{B}||d\vec{S}|\cos(\angle\vec{B}.d\vec{S})$ is zero).

$\therefore \qquad \oint \vec{B}.d\vec{l} = BL + BL = 2BL$

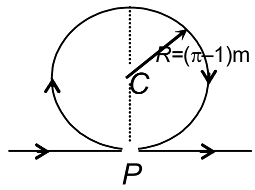
Total current through the loop = λL

Ampere's law $\Rightarrow 2BL = \mu_0 \lambda L$

$\Rightarrow B = (\mu_0 \lambda)/2 = 2\ \mu T$

***Example* 4:**

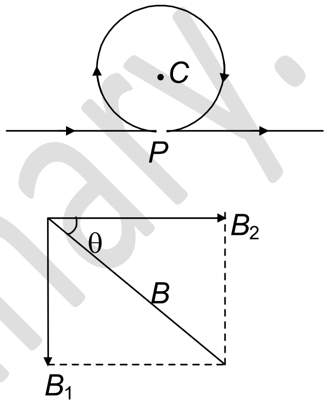
A long wire is bent into the shape shown in the figure without cross contact at *P*. Determine the magnitude and direction of $\vec{B}$ at the centre *C* of the circular portion when the current i = 10 amp flow as indicated.



Solution:

Let *C* be the centre of the circle. The magnetic induction at *C* due to the long straight part of the conductor is

$$B_1 = \frac{\mu_o}{4\pi}\cdot\frac{2i}{R}$$



This field is perpendicular to the plane of the paper and points outwards (towards the reader). The field at *C* due to the circular current loop

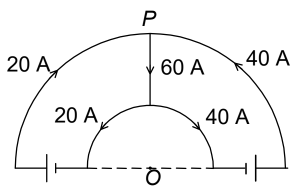
$$B_2 = \frac{\mu_o}{2}\cdot\frac{i}{R}$$

This field is directed opposite to as B_1.

Hence the resultant field $B = B_1 - B_2 = -\frac{\mu_o}{4\pi}\cdot\frac{2i}{R} + \frac{\mu_o}{2}\cdot\frac{i}{R} = \frac{\mu_0 i}{2R}\left(1-\frac{1}{\pi}\right)$ = **2 μT**

***Example* 5:**

Two concentric coplanar semicircular conductors form part of two current loops as shown in the figure. If their radii are 11 cm and 4 cm calculate the magnetic induction at the centre.



Solution:

Magnetic induction at $O = \frac{1}{4}\frac{\mu_o}{2}\left(\frac{40}{r_1}-\frac{40}{r_2}\right) - \frac{1}{4}\frac{\mu_o}{2}\left(\frac{20}{r_1}-\frac{20}{r_2}\right)$

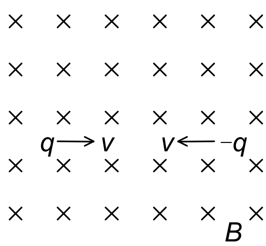
$$= \frac{4\pi\times10^{-7}}{8}\left[20\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\right]$$

$$= \frac{4\pi\times10^{-7}}{8}\left[20\left(\frac{1}{4\times10^{-2}}-\frac{1}{11\times10^{-2}}\right)\right]$$

= **50 μ weber/m² (inward)**

***Example* 6:**

Two particles *P* and *Q*, each having a mass *M* = 1 mg are placed at a separation *D* = 4 m in a uniform magnetic field *B* = 1 T as shown in figure. They have opposite charges of equal magnitude of 200 μC. At time *t* = 0 the particles are projected towards each other, each with a speed *v*. Suppose the coulomb force between the charges is switched off (a) Find the maximum value v_m of the projection speed so that the two particles do not collide (b) What would be the minimum and maximum separation between the

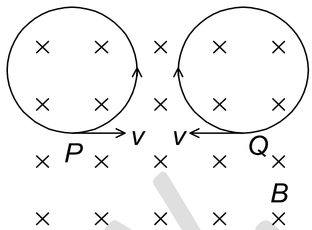


particles if $v = \frac{v_m}{4}$? (c) A collision will occur between the particles if $v = 2v_m$ at $t = \frac{n\pi}{6}$ s. Find the value of n?

Solution:

(a) Force acting on P due to the magnetic field = Bqv.

This particle P will describe a circle in the clockwise direction whose radius is obtained from the equation



$$Bqv = \frac{mv^2}{r_1}$$

$$r_1 = \frac{mv}{qB}$$

The particle Q will describe a circle in the anticlockwise direction $r_2 = \frac{mv}{qB}$

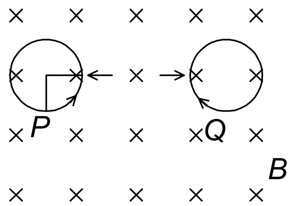
The two particles do not collide if $r_1 + r_2 \le d$

$$\frac{mv}{qB} + \frac{mv}{qB} \le d$$

Maximum value of the projection speed,

$$v_{max} = \frac{qBd}{2m} = \mathbf{40\ cm/s}$$

(b) If $v = \frac{v_{max}}{4}$, then $r_1 = \frac{m}{qB}\left(\frac{qBd}{8m}\right) = \frac{d}{8}$



$$r_2 = \frac{d}{8}$$

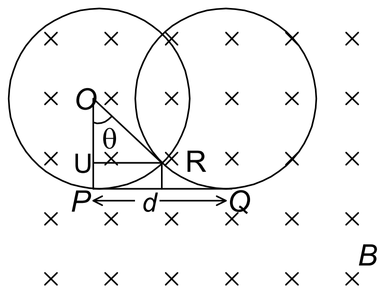
Minimum separation between the two particles

$$= d - r_1 - r_2 = \frac{3d}{4} = \mathbf{3\ m}$$

Maximum separation between the two particles

$$= d + r_1 + r_2 = \frac{5d}{4} = \mathbf{5\ m}$$

(c) If $v = 2v_{max}$, then $r_1 = \frac{m}{qB}\left(\frac{2qBd}{2m}\right) = d$; $r_2 = d$



Angular velocity, $\omega = \frac{qBd}{md} = \frac{qB}{m}$

The particle will collide at point R, $UR = \frac{d}{2}$

$$\sin\theta = \frac{\frac{d}{2}}{d}$$

$$\theta = 30^\circ = \frac{\pi}{6}$$

A collision will occur between the particles at time t

$$t = \frac{\frac{\pi}{6}}{\omega} = \frac{m\pi}{6qB} = \frac{5\pi}{6}$$

$\therefore$ $n = \mathbf{5}$

Example 7:

A fixed horizontal wire carries 200 A current below which another wire of linear density 10 g/m carrying a current is kept at a depth 2 cm and parallel to the first wire. If the second wire hangs in air, find the current in it. If the current in the first wire increases to 220 A, what will be the instantaneous acceleration on the second wire?

Solution:

For the second wire to hang in air without any support its weight acting downwards should be balanced by an upward force of equal magnitude. In this case this upward force is provided by the mutual attractive force between the two parallel conductors carrying current. For this to happen the current should flow in the same direction in both the wires.

Now, $\frac{\mu_0}{4\pi}\cdot\frac{2I_1I_2}{r} = mg$

$$10^{-7}\times\frac{2\times200\times I_2}{2\times10^{-2}} = (10 \times 10^{-3}\text{kg})\ (9.8\ \text{m/s}^2)$$

or $I_2 = 49$ A

The current carried by the second wire = 49 A

If the current carried by the first wire I_1 = 220 A, then the force experienced by 1 m length of the second wire

$$F = \frac{\mu_0}{4\pi}\cdot\frac{2I_1I_2}{r} = \frac{2\times220\times49}{2\times10^{-2}}\times10^{-7}N$$

Considering a metre length of second wire

$F - mg = ma$, where a is the acceleration.

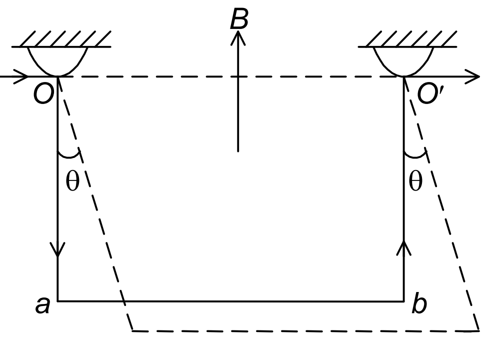
Now,

$$a = \frac{F}{m} - g = \frac{2\times220\times49}{2\times10^{-2}}\times\frac{10^{-7}}{10\times10^{-3}} - 9.8 = 10.78 - 9.8 = 0.98\ \text{m/s}^2$$

The instantaneous acceleration experienced by the second wire = **98 cm/s²** in the upward direction.

Example 8:

A copper wire with cross-sectional area 2.5 mm² and bent to make three sides of a square can turn about a horizontal axis *OO′*. The wire is located in a uniform vertical magnetic field. Find the magnetic induction, if on passing a current *I* = 16 A deflects by an angle θ = 20° (Specific gravity of copper = 8.9).



Solution:

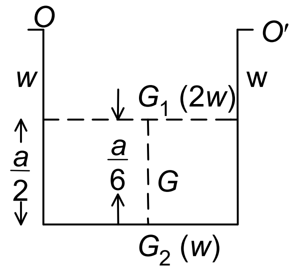
The deflection of the system is due to the force on the wire, due to the magnetic field B and the force is given by = BIa, where a is the side of the square and this force acts in the horizontal direction.

The moment of the force about the axis of rotation OO'

$= BIa \times a\cos\theta = BIa^2\cos\theta$

where $\theta = 20^\circ$.

The weight of the wire is mg and this acts through the centre of gravity of the wire, G lying at a distance of $\frac{a}{2}+\frac{a}{6}=\frac{2a}{3}$ from OO′.



∴ moment of the weight about OO'

$$= mg \cdot \frac{2}{3} a \sin\theta$$

For the equilibrium of the system

$$\frac{2}{3} mga \sin\theta = Bia^2 \cos\theta$$

or $$B = \frac{2}{3}\frac{mga\sin\theta}{Ia^2\cos\theta} = \frac{2}{3}\frac{mg}{Ia} \tan\theta$$

The mass m of the wire is given by

m = Length of the wire × cross-section × density

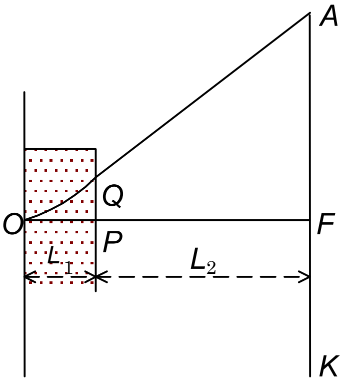
$= 3a \times (2.5 \times 10^{-6}\ m^2)\ (8900\ kg/m^3)$

∴ $$B = \frac{2}{3}\cdot\frac{3a(2.5\times10^{-6})(8900)(9.8)}{16\times a} \tan 20^\circ$$

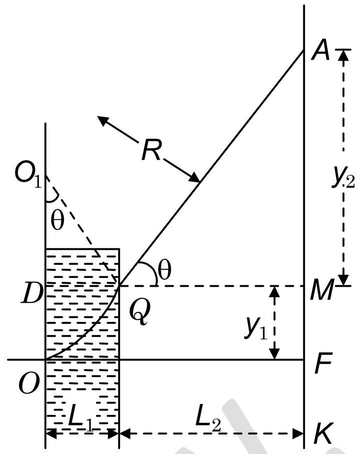
= 9900 μT

Example 9:

A beam of particles accelerated by a potential difference of V flies into a homogeneous magnetic field applied perpendicular to the plane of the paper and towards the observer. The width of the magnetic field is OP. In the absence of the magnetic field the electron beam produces a spot at a point F on fluorescent screen AK, which is at a distance of L_2 from the edge of the magnetic field. When the magnetic field is switched on the spot moves on to A along the path OQA. Find the displacement FA of the spot if the induction of the magnetic field is B. (take B = 1T, $\frac{2Vm}{q} = 1$, $L_1 = \frac{\sqrt{3}}{2}$ m, $L_2 = 3\frac{\sqrt{3}}{2} m$)



Solution:



The path OQ of the particle travelled in the magnetic field B is an arc of the circle of radius R is given by

$$R = \frac{mv}{qB} \quad \ldots \text{(i)}$$

where m and q are mass and charge of a particle and v its velocity.

The velocity gained by the accelerated electron

$$v = \sqrt{\frac{2qV}{m}} \quad \ldots \text{(ii)}$$

where V is the accelerating potential difference.

From equations (i) and (ii),

$$R = \frac{1}{B}\sqrt{\frac{2Vm}{q}} \quad \ldots \text{(iii)}$$

The centre of curvature of the arc OQ lies at O_1 and

$$OO_1 = QO_1 = R$$

QA is a straight line and tangent to the curve at Q.

Displacement $FA = FM + MA = y_1 + y_2$.

To find y_1

$$y_1 = FM = OD = OO_1 - O_1D$$

$$= R - \sqrt{R^2 - DQ^2} = R - \sqrt{R^2 - L_1^2} \quad \ldots \text{(iv)}$$

To find y_2

Triangles AQM and O_1DQ are similar.

$$\frac{AM}{QM} = \frac{DQ}{O_1D}$$

$$\frac{y_2}{L_2} = \frac{L_1}{\sqrt{R^2 - L_1^2}} \quad \text{or} \quad y_2 = \frac{L_1L_2}{\sqrt{R^2 - L_1^2}}$$

Total displacement

$$FA = y_1 + y_2$$

$$= \left(R - \sqrt{R^2 - L_1^2}\right) + \frac{L_1L_2}{\sqrt{R^2 - L_1^2}} \quad \ldots \text{(v)}$$

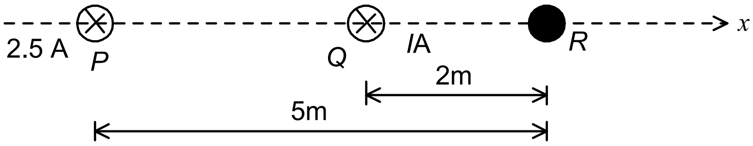
$$R = \frac{1}{B}\sqrt{\frac{2Vm}{q}} = 1\text{m}$$

Now,

$$FA = 1 - \sqrt{1 - \frac{3}{4}} + \frac{\frac{\sqrt{3}}{2}\,\frac{3\sqrt{3}}{2}}{\sqrt{1 - \frac{3}{4}}} = \mathbf{5\ m}$$

***Example* 10:**

Two long parallel wires carrying currents 2.5 ampere and *I* ampere in the same direction (directed into the plane of the paper) are held at *P* and *Q* respectively such that they are perpendicular to the plane of paper. The points *P* and *Q* are located at a distance of 5 metre and 2 metre respectively from a collinear point *R* (see Figure).



(1) **An electron moving with a velocity of 4×10^5 m/s along the positive *x*-direction experiences a force of magnitude 3.2×10^{-20} N at the point *R*. Find the value of *I*.**

(2) **Find all the positions at which a third long parallel wire carrying a current of magnitude 2.5 amperes may be placed so that the magnetic induction at *R* is zero.**

Solution:

(1) Magnetic field B_1 due to *P* at *R*

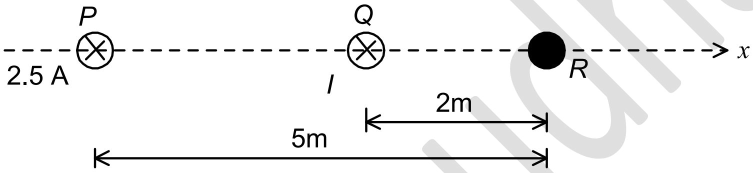
$$B_1 = \frac{\mu_0}{2\pi}\frac{I}{d} = \frac{\mu_0}{2\pi}\left(\frac{2.5}{5}\right)$$

Magnetic field B_2 due to *Q* at *B*

$$B_2 = \frac{\mu_0}{2\pi}\cdot\frac{I}{d} = \frac{\mu_0}{2\pi}\left(\frac{I}{2}\right)$$

Resultant magnetic field at *R*

$$B = B_1 + B_2 = \frac{\mu_0}{2\pi}\left(\frac{2.5}{5} + \frac{I}{2}\right) \quad \text{.... (i)}$$



This field *B* at *R* acts into the plane of the paper and perpendicular to *PX*. Force experienced by electron moving along *PX* is

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

$\vec{F}$ is perpendicular to both $\vec{v}$ and $\vec{B}$. Because of the negative charge of electron (i.e. q = negative) the force *F* acts perpendicular to the plane of paper directed upwards.

Now, $F = evB$

$$\therefore \quad B = \frac{F}{ev} = \frac{3.2 \times 10^{-20}}{1.6 \times 10^{-19} \times 4 \times 10^5} = 0.5 \times 10^{-6} \quad \text{.... (ii)}$$

Equating this to (1), we get

$$\frac{\mu_0}{2\pi}\left[\frac{2.5}{5} + \frac{I}{2}\right] = 0.5 \times 10^{-6}$$

Which gives

$$I = 2\left[\frac{2\pi}{\mu_0}(0.5 \times 10^{-6}) - \frac{2.5}{5}\right] = 2\left[\frac{2\pi \times (0.5 \times 10^{-6})}{4\pi \times 10^{-7}} - \frac{2.5}{5}\right] = 2\left[\frac{2.5}{1} - \frac{2.5}{5}\right] = 4\text{A}$$

(2) In this case, we consider the following alternatives:

(a) When the current 2.5 A is directed into the plane of paper. If *r* is the distance of this current wire from *R*.

we have $B_3 = \left(\frac{\mu_0}{2\pi}\right)\left(\frac{2.5}{r}\right)$

Now since $B_1 + B_2 + B_3 = 0$ we get,

$$\frac{\mu_0}{2\pi}\left(\frac{2.5}{5} + \frac{4}{2} + \frac{2.5}{r}\right) = 0$$

which gives $r = -1$ m

Thus the third wire is located at **1 m** from *R* on *RX*.

(b) When the current 2.5 A is directed out from the plane of paper upwards.

Here $I_3 = -2.5$ A

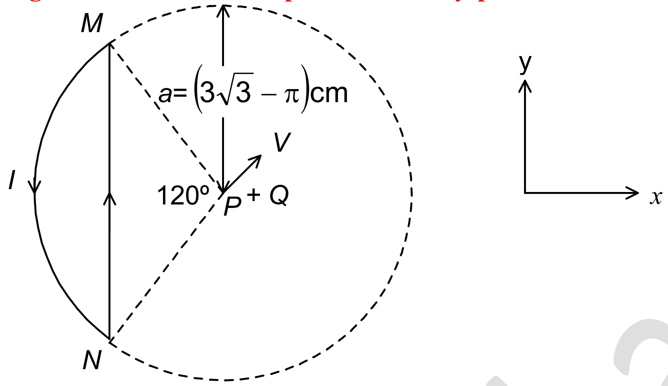
Hence we will similarly have

$$\frac{\mu_0}{2\pi}\left(\frac{2.5}{5}+\frac{4}{2}+\frac{2.5}{r}\right)=0$$

which gives $r = 1$ **m** i.e. the third wire is located 1 m from R on RQ.

***Example* 11:**

A wire loop carrying a current $I = 10$ A is placed in the x-y plane as shown in the figure.



If a particle with charge $+Q = 3000\ \mu$C and mass $m = 1 \times 10^{-5}$ kg is placed at the centre P and given a velocity $\vec{v} = 10$ m/s along NP (see figure), find its instantaneous acceleration.

Solution:

Let us calculate the total magnetic field B at P due to the whole loop. The loop consists of a linear part MN and a circular part MIN, let the fields due to these be B_1 and B_2 respectively.

Then clearly $B = B_1 + B_2$

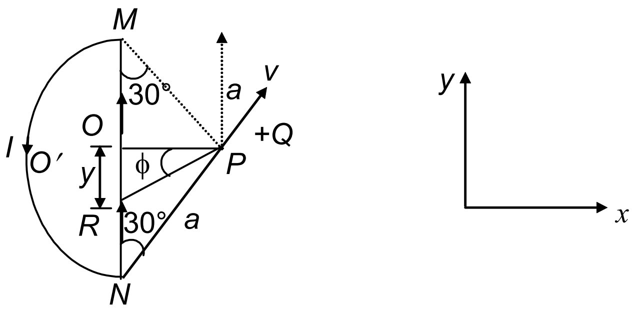
Since the circular part subtends $\lfloor 90°$ with every radius joining it to P, the field

$$B_2 = \frac{\mu_0 i}{6a} \qquad \text{...(i)}$$

For calculating the field B_1, due to the linear part, consider a small element of length dy at R at a distance y form O.

Then the elementary magnetic field due to this element at

$$P = dB = \frac{\mu_0 i dy \cos\phi}{4\pi\left(\frac{a^2}{4}+y^2\right)} \qquad \text{...(ii)}$$



where $\phi = \angle OPR$

From the figure,

$$\left.\begin{aligned} y &= \frac{a}{2}\tan\phi \\ \text{Hence } dy &= \frac{a}{2}\sec^2\phi\, d\phi \end{aligned}\right\} \text{[because } PO = PN \sin 30° = \frac{a}{2} \qquad \text{... (iii)}$$

Substituting for y and dy in (2),

$$dB = \frac{\mu_0 I \cos\phi \frac{a}{2}\sec^2\phi\, d\phi}{4\pi\left(\frac{a^2}{4}+\frac{a^2}{4}\tan^2\phi\right)}$$

or $$dB = \frac{\mu_0 I}{4\pi}\left[\frac{\frac{a}{2}\sec^2\phi\cos\phi\, d\phi}{\frac{a^2}{2}\sec^2\phi}\right] = \frac{\mu_0 I}{2\pi a}\cos\phi\, d\phi$$

Hence the total field due to the whole current line MN at P is

$$B_1 = \int_{-\pi/3}^{+\pi/3} \frac{\mu_0 I}{2\pi a}\cos\phi d\phi = \frac{\mu_0 I}{2\pi a}\left[\sin\phi\Big|_{-\pi/3}^{+\pi/3}\right] = \frac{\mu_0 I}{2\pi a}\left[2x\frac{\sqrt{3}}{2}\right] = \frac{\sqrt{3}\mu_0 I}{2\pi a}$$

The field B_1 is into the plane of paper perpendicular to it, and field B_2 is out of the plane of paper also perpendicular to it. The two have opposite directions. Hence, taking B_1 as +ve, the net field

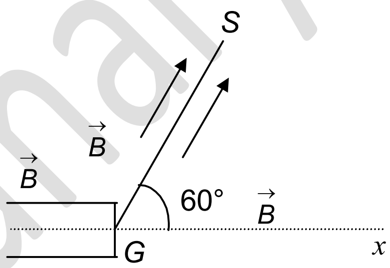
$$B = B_1 - B_2 = \frac{\sqrt{3}\mu_0 I}{2\pi a} - \frac{\mu_0 I}{6a} = \frac{\mu_0 I}{6\pi a}\left[3\sqrt{3} - \pi\right]$$

Hence force on the charge Q, $F = B.Q.v = \frac{\mu_0 IQv}{6\pi a}\left(3\sqrt{3} - \pi\right)$

Hence the acceleration of the charge $= F/m = \frac{\mu_0 IQv}{6\pi ma}\left(3\sqrt{3} - \pi\right)$ **= 20 cm/s²**

***Example* 12:**

An electron gun G emits electrons of energy 2 keV travelling in the positive x-direction. The electrons are required to hit the spot S, where $GS = 0.1$ m and the line GS makes an angle of 60° with x-axis as shown in Figure. A uniform magnetic field $\vec{B}$ parallel to GS exists in the region outside the electron gun. Find the minimum value of B needed to make the electrons hit S.



Solution:

The velocity of electrons can be resolved into the following two components:
Component parallel to the magnetic field, $v_{\parallel} = v\cos 60^0$
Component perpendicular to the magnetic field, $v_{\perp} = v\sin 60^o$
Now the component v will make the electro to revolve in a circular path perpendicular to B such that

$$\frac{mv_{\perp}^2}{r} = qBv_{\perp}$$

$$\therefore \quad r = \frac{mv_{\perp}^2}{qB} \qquad \text{...(i)}$$

The component $v_{\parallel}$ will make the electron to move in the direction of B. Time taken by the electron to cover the distance GS is

$$t = \frac{\text{distance } GS}{v_{\parallel}} = \frac{0.1m}{v\cos 60^\circ} \qquad \text{... (ii)}$$

In order that the electrons hit the spot S, time taken by electron to cover the distance GS must be equal to integral multiples of time period of circular motion

$$t = n(T) \qquad \text{... (iii)}$$

where $T = \frac{2\pi r}{v\sin 60^\circ}$ ... (iv)

Substituting the value of r from (1) in (4)

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

$\therefore$ equation (3) becomes $t = n\left(\frac{2\pi m}{qB}\right)$

Substituting from (2) and rearranging

$$\frac{B}{n}=\frac{2\pi m}{q}\left(\frac{v\cos 60^\circ}{0.1}\right)$$

For $B_{minimum}$ we set $n = 1$,

$$\therefore \qquad B_{minimum}=\frac{2\pi m}{q}\left(\frac{v\cos 60^\circ}{0.1}\right)=\frac{\pi m}{0.1q}v \qquad \ldots (v)$$

But $\quad \frac{1}{2}mv^2=E \quad$ or $\quad v=\sqrt{2E/m}$

$$B_{min}=\frac{\pi m}{0.1q}\sqrt{\frac{2E}{m}}=\frac{\pi\sqrt{(2E/m)}}{q\times 0.1} \quad = 4736\ \mu T$$

MIND MAP

1. Biot-Savart law

It gives the magnetic induction due to an infinitesimal current element

$$dB=\frac{\mu_0}{4\pi}\frac{Id\vec{l}\times\vec{r}}{r^3}$$

2. Field due to straight current carrying wire

(a) When the wire is of finite length

$$B=\frac{\mu_0}{4\pi}\frac{I}{d}[\sin\alpha+\sin\beta]$$

(b) When the wires of infinite length

$$B=\frac{\mu_0}{4\pi}\frac{2I}{d}$$

3. Field due to circular current carrying wire

(a) At an axial point

$$B=\frac{\mu_0}{4\pi}\frac{2\pi IR^2}{(R^2+x^2)^{3/2}}$$

(b) At the centre

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

MAGNETICS

4. Field due to current carrying arc

(a) At the centre making an angle ϕ

$$B=\frac{\mu_0}{4\pi}\frac{I\phi}{R}=\frac{\mu_0}{4\pi}\frac{Il}{R^2}$$

(b) At the centre of semi circular wire

$$B=\frac{\mu_0}{4}\frac{I}{R}$$

5. Field due to solenoid

(a) At a point on the axis of solenoid of finite length

$$B=\frac{\mu_0}{2}nI(\sin\alpha+\sin\beta)$$

(b) At a point inside the solenoid of infinite length

$B = \mu_0 nI$

6. (i) Force on a moving charge

(a) When it is moving in a magnetic field

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

(b) When it is moving in a combined electric and magnetic field

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

(ii) Force on a current carrying straight wire when it is in a uniform magnetic field

$F = I(\vec{l} \times \vec{B})$

7. Motion of charged particle in a uniform magnetic field.

(a) When it enters at right angle to the field, Path will be circular and

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

(b) When it enters at some angle θ with the field, Path will be helical

$r = \frac{mv\sin\theta}{qB}$, $T = \frac{2\pi m}{qB}$

Pitch = $\frac{2\pi m}{qB} v\cos\theta$

8. When a current carrying loop is in a uniform field

(i) Force = 0

(ii) Magnetic moment $\vec{M} = I\vec{A}$

(ii) Torque, $(\vec{\tau}) = \vec{M} \times \vec{B}$

(iii) Wark done = $MB(1 - \cos\theta)$

9. Force between two long straight parallel wire per unit length carrying current I_1 and I_2

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

EXERCISE – I

NEET-SINGLE CHOICE CORRECT

1. A horizontal wire of length 10 cm and mass 0.3 g carries a current of 5A. The minimum magnitude of the magnetic field which can support the weight of the wire is (g = 10 m/s^2)

(a) 3×10^{-3} T (b) 6×10^{-3} T (c) 3×10^{-4} T (d) 6×10^{-4} T

2. A uniformly distributed current I flows through a cylindrical conductor of radius r. The magnetic field at a point x ($< r$) is

(a) $\frac{\mu_0 I}{2\pi x}$ (b) $\frac{\mu_0 I}{2\pi(x-r)}$ (c) $\frac{\mu_0 I x}{2\pi r^2}$ (d) $\frac{\mu_0 I}{2\pi(x-r)^2}$

3. A horizontal cable carries a current from west to east. The direction of the magnetic field produced by the current at a point vertically above the wire is

(a) north to south (b) south to north (c) east to west (d) west to east

4. An electron is moving in a circle of radius r in a uniform magnetic field B. Suddenly the field is reduced to B/2. The radius of the circle now becomes.

(a) r/2 (b) r/4 (c) 2r (d) 4r

5. A 2 MeV proton (mass = 1.6×10^{-27} kg) is moving perpendicular to a uniform magnetic field of 2.5 T. The magnetic force on the proton is

(a) 2.5×10^{-10} N (b) 8×10^{-11} N (c) 2.5×10^{-11} N (d) 8×10^{-12} N

6. An electric charge q moves with a constant velocity v parallel to the lines of force of a uniform magnetic field B. The force experienced by the charge is

(a) qvB (b) qv/B (c) zero (d) Bv/q

7. A positively charged particle moving with velocity $\vec{v}$ enters a region of space having a constant magnetic induction $\vec{B}$. The particle will experience the largest force when the angle between vectors $\vec{v}$ and $\vec{B}$ is

(a) 0° (b) 45° (c) 90° (d) 180°

8. A circular coil of radius 1 m having current $(2/\pi)$ Amp is placed in a uniform magnetic field of 0.2 T with its normal making an angle of 30° with the direction of the field, the torque experienced by the coil is

(a) 0. 2 N m (b) 0. 3 N m (c) 0. 4 N m (d) 0. 5 N m

9. A bar magnet suspended by a silk-thread is vibrating in the earth's magnetic field. If the temperature of the needle is increased by 1500°C then

(a) the time period decreases (b) the time period remains unchanged

(c) the time period increases (d) bar magnet stops vibrating

10. The area enclosed by a hysteresis loop is a measure of

(a) retentivity (b) susceptibility

(c) permeability (d) energy loss per cycle

11. Force between two identical bar magnets whose centres are r m apart is 4.8 N when their axes are in the same line. If separation is increased to $2r$, the force between them is reduced to

(a) 2.4 N (b) 0.6 N (c) 1.2 N (d) 0.3 N

12. A bar magnet of length 10 cm and having the pole strength equal to 10^{-3} Wb is kept in a magnetic field having magnetic induction B ($=4\pi \times 10^{-3}$ T). It makes an angle of 30° with the direction of magnetic induction (B). The value of Torque (in newton-metre) is

(a) $2\pi \times 10^{-7}$ (b) $2\pi \times 10^{-5}$ (c) 0.5 (d) 0.5×10^{-2}

13. A short bar magnet produces magnetic fields of equal induction at two points, one on the axial line and the other on the equatorial line. Then the ratio of their distances is

(a) $1 : 2^{1/3}$ (b) 1 : 2 (c) $2^{1/3} : 1$ (d) 1 : 8

14. The period of oscillation of a vibration magnetometer depends on the following factors:

(a) M and I only (b) I and H only

(c) I, M and H only (d) I and M only

where I is the moment of inertia of the magnet about the axis of suspension, M is the magnetic moment of the magnet and H is the external magnetic field.

15. A circular coil of radius R is placed in a uniform magnetic field such that the plane of the coil is perpendicular to the magnetic field. If a current I is passed through the coil, the magnetic force on the coil is

(a) $2\pi RBI$ (b) $4\pi RBI$ (c) $8\pi RBI$ (d) zero

16. A charged particle enters a region where a uniform electric field E and a uniform magnetic field B exist. If E and B are perpendicular to each other and also perpendicular to the velocity u of the particle, then the particle will move undeviated if u equals

(a) B/E (b) E/B (c) EB (d) E^2/B^2

17. A current of 1 ampere is passed through a straight wire of length 2.0 m. The magnetic field at a point in air at a distance of 3 m from either end of the wire and lying on the axis of wire will be

(a) $\frac{\mu_0}{2\pi}$ (b) $\frac{\mu_0}{4\pi}$ (c) $\frac{\mu_0}{8\pi}$ (d) zero

18. The value of the magnetic field at a distance x from a long straight current-carrying conductor is proportional to

(a) x (b) x^2 (c) $1/x^2$ (d) $1/x$

19. A circular current-carrying coil has a radius R. The distance from the centre of the coil, on the axis, where B will be $1/8^{th}$ of its value at the centre of the coil is

(a) $R/\sqrt{3}$ (b) $\sqrt{3}\,R$ (c) $2\sqrt{3}\,R$ (d) $\frac{2R}{\sqrt{3}}$

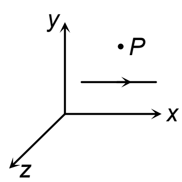
20. Two circular coils have number of turns in the ratio 1 : 2 and radii in the ratio 2 : 1. If the same current flows through them, the magnetic fields at their centres will be in the ratio

(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 1 : 4

21. Two coils are having magnetic field B and $2B$ at their centres and current i and $2i$, then the ratio of their radius is

(a) 1 : 2 (b) 2 : 1 (c) 1 : 1 (d) 4 : 1

22. A straight wire carrying current is parallel to x-axis as shown in the figure. Then



(a) magnetic field at point P is parallel to x-axis
(b) magnetic field at point P is parallel to y-axis
(c) magnetic field at point P is parallel to z-axis
(d) magnetic field at point P is anti-parallel to x-axis

23. The susceptibility of a diamagnetic substance

(a) does not vary with temperature
(b) first decreases and then increases with increase of temperature
(c) increase with temperature

(d) decreases with temperature

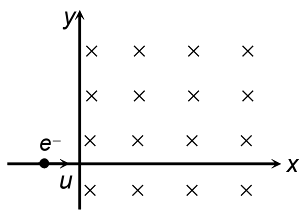
24. The angle of dip at a place on the earth gives
(a) the horizontal component of the earth's magnetic field
(b) the location of the geographic meridian
(c) the vertical component of the earth's field
(d) the direction of the earth's magnetic field

25. In the vibration magnetometer, if the moment of inertia is 1, then time period of vibration is
(a) $\frac{2\pi}{\sqrt{MH}}$ (b) $2\pi\sqrt{MH}$ (c) $2\pi\sqrt{\frac{M}{H}}$ (d) $2\pi\sqrt{\frac{H}{M}}$

EXERCISE – II

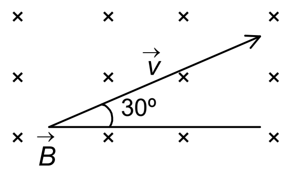
IIT-JEE- SINGLE CHOICE CORRECT

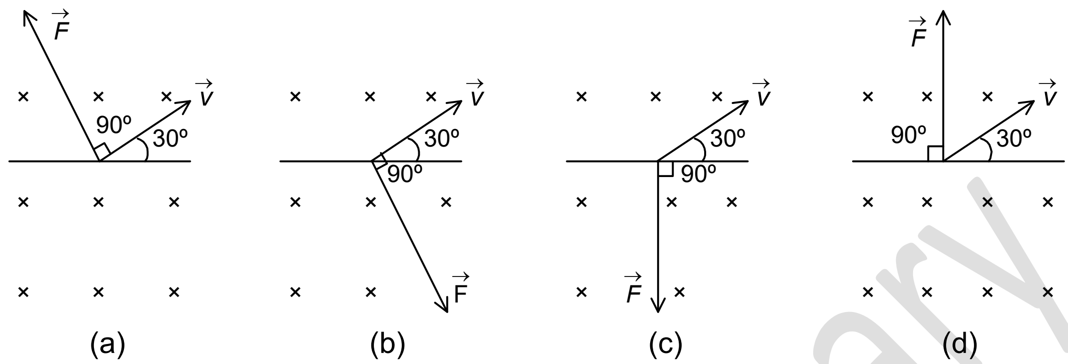
1. A uniform magnetic field $\vec{B} = -B_0\hat{k}$ exists in the region $x > 0$. An electron with speed u travels along the +ve x-axis. When the electron emerges out of the field, its y co-ordinate and speed v will be as



(a) $y > 0$, $v > u$ (b) $y < 0$, $v > u$
(c) $y < 0$, $v = u$ (d) $y > 0$, $v = u$

2. The particle shown is negatively charged. What is the direction of force on it due to the magnetic field?





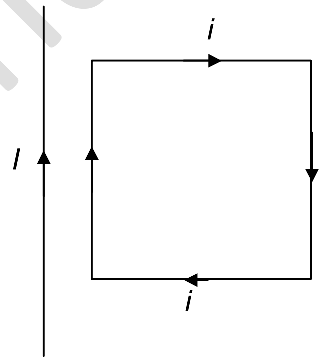
3. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current I is established in the wire as shown in figure, the loop will

(a) rotate about an axis parallel to the wire

(b) move away from the wire

(c) move towards the wire

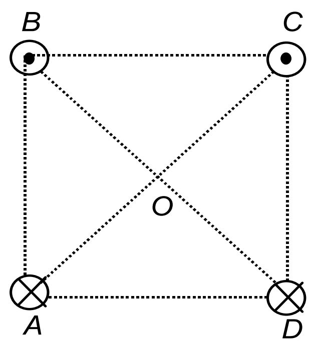
(d) remain stationary



4. Four long straight wires are located at the corners of a square *ABCD*. All the wires carry equal currents. Current in the wires *A* and *D* are inwards and in *C* and *B* are outwards. The magnetic field at the centre *O* is along

(a) *AD* (b) *CB*

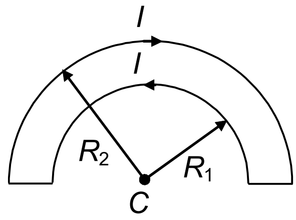
(c) *AB* (d) *CD*



5. If the direction of the initial velocity of the charged particle is perpendicular to that of the magnetic field, then the orbit will be

(a) a straight line (b) an ellipse (c) a circle (d) a helix

6. The wire loop formed by joining two semicircular sections of radii R_1 and R_2, carries a current I, as shown. The magnitude of magnetic of field at the center C is



(a) $\frac{\mu_0 I}{2}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$ (b) $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

(c) $\frac{\mu_0 I}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ (d) $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

7. The field normal to the plane of a wire of n turns and radius r which carries a current I is measured on the axis of the coil at a small distance h from the centre of the coil. This is smaller than the field at the centre by the fraction.

(a) $\frac{3}{2}\frac{h^2}{r^2}$ (b) $\frac{2}{3}\frac{h^2}{r^2}$ (c) $\frac{3}{2}\frac{r^2}{h^2}$ (d) $\frac{2}{3}\frac{r^2}{h^2}$

8. A long horizontally fixed wire carries a current of 100 ampere. Directly above and parallel to it is a fine wire that carries a current of 20 ampere and weighs 0.04 newton per meter. The distance between the two wires for which the upper wire is just supported by magnetic repulsion is

(a) 10^{-2} decimetre (b) 10^{-2} mm (c) 10^{-2}m (d) 10^{-2} cm

9. A proton and an electron with equal momentum are entered in a magnetic field then

(a) both remain unaffected.

(b) path of e^- will be more curved than proton.

(c) path of proton will be more curved than electron.

(d) path of both particles will be equally curved.

10. A magnetic needle is lying in equilibrium in a uniform magnetic field B. To rotate it through 60^0, we need to spend energy W. How much torque is need to be applied to keep it in that position?

(a) $\frac{\sqrt{3}}{2}W$ (b) $\frac{1}{2}W$ (c) $\sqrt{3}W$ (d) W

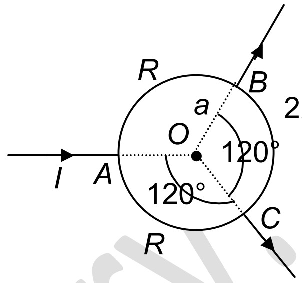
11. A magnetic needle of negligible width and thickness as compared to its length oscillates in horizontal plane with period T. If it is broken into n equal parts, then the time period of each part in the same field will be

(a) $\sqrt{n}T$ (b) nT (c) $\frac{T}{\sqrt{n}}$ (d) $\frac{T}{n}$

12. A particle of mass m and charge q moves with a constant velocity v along the positive x-direction. It enters a region containing a uniform magnetic field $\vec{B}$ directed along the negative z-direction, extending from $x = a$ to $x = b$. The minimum value of the required velocity so that the particle can just enter the region $x > b$ is

(a) qbB/m (b) $q(b - a)B/m$ (c) qaB/m (d) $q(b + a)B/2m$

13. The resistance of three parts of a circular loop are as shown in the figure. The magnetic field at the centre O is



(a) $\frac{\mu_0 I}{6a}$ (b) $\frac{\mu_0 I}{3a}$

(c) $\frac{2}{3}\frac{\mu_0 I}{a}$ (d) zero

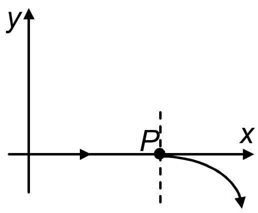
14. The magnetic field inside a current carrying long wire of circular cross-section varies as (r : distance from the center)

(a) r^0 (b) r (c) r^2 (d) r^3

15. A particle of charge q and mass m starts moving from the origin under the action of an electric field $\vec{E} = E_0\hat{i}$ and magnetic field $\vec{B} = B_0\hat{k}$. Its velocity at $(x, 3, 0)$ is $(4\hat{i} + 3\hat{j})$. The value of x is

(a) $\frac{36E_0B_0}{qm}$ (b) $\frac{25m}{2qE_0}$ (d) $\frac{10m}{qE_0}$ (d) $\frac{25E_0B_0}{m}$

16. For a positively charged particle moving in x-y plane initially along the x-axis, there is a sudden change in its path due to the presence of electric and/or magnetic fields beyond P. The curved path is shown in the x-y plane and is found to be non-circular.

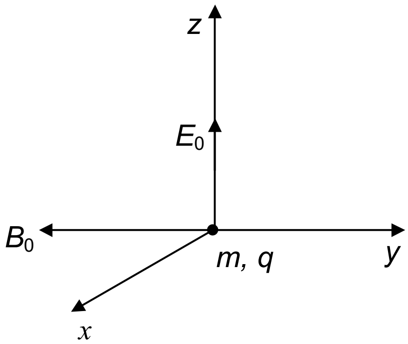


Which one of the following combinations is possible?

(a) $\vec{E} = 0$; $\vec{B} = b\hat{i} + c\hat{k}$ (b) $\vec{E} = a\hat{i}$; $\vec{B} = c\hat{k} + a\hat{j}$

(c) $\vec{E} = 0$; $\vec{B} = c\hat{j} + b\hat{k}$ (d) $\vec{E} = a\hat{i}$; $\vec{B} = 0$

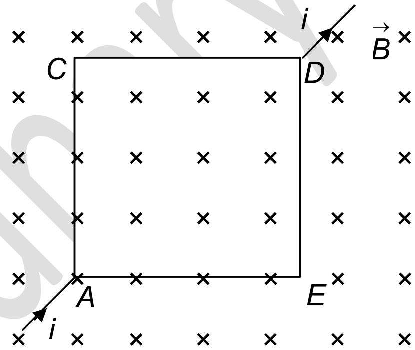
17. A particle of mass m and charge q is released from rest at the origin as shown in the figure. The speed of the particle when it has travelled a distance d along the z-axis is given by



(a) $\sqrt{\dfrac{2qE_0d}{m}}$ (b) $\sqrt{\dfrac{E_0d}{B_0}}$

(c) $\sqrt{\dfrac{m}{qE_0d}}$ (d) $\sqrt{\dfrac{2m}{qE_0d}}$

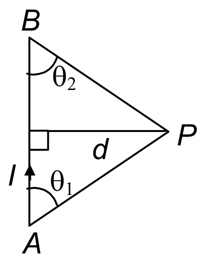
18. Figure shows a conducting square loop of side a which is placed in a plane perpendicular to a uniform magnetic field B. Points A and D are connected to a battery which sends a current i. The magnetic force on the loop is



(a) zero (b) $2\sqrt{2}\ aiB$

(c) 2 aiB (d) $\sqrt{2}\ aiB$

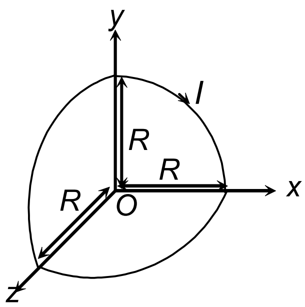
19. AB is a section of a straight wire carrying a current I. P is a point at a distance d from AB. The magnetic field at P due to AB has magnitude



(a) $\dfrac{\mu_0 I}{4\pi d}(\cos\theta_1 + \cos\theta_2)$ (b) $\dfrac{\mu_0 I}{4\pi d}(\cos\theta_1 - \cos\theta_2)$

(c) $\dfrac{\mu_0 I}{4\pi d}(\sin\theta_1 + \sin\theta_2)$ (d) $\dfrac{\mu_0 I}{4\pi d}(\sin\theta_1 - \sin\theta_2)$

20. In the given figure the magnitude of magnetic field at O is (all three wires are quarter circular arc)



(a) $\dfrac{\mu_0 I}{4R}\sqrt{3}$ (b) $\dfrac{\mu_0 I}{2R}\sqrt{3}$

(c) $\dfrac{\mu_0 I}{8R}\sqrt{3}$ (d) none of these

ONE OR MORE THAN ONE CHOICE CORRECT

1. A charged particle is projected in a magnetic field $\vec{B} = 10\hat{k}$ T from the origin in x-y plane. The particle moves in a circle and passes through a point ($5\sqrt{3}$ m, 5m, 0). Then (mass of particle = 5 × 10^{-5} kg charge = 1μC)

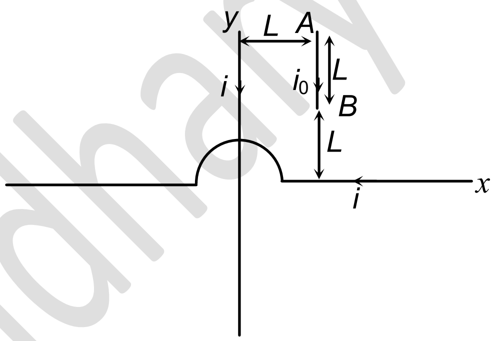
(a) the particle is projected at an angle 60^0 with x-axis

(b) the radius of curvature at $(5\sqrt{3}, 5)$ is 10 m

(c) the speed of the particle is 2 m/s

(d) the particle moves in a helical path

2. Two infinitely long wires are carrying current i each. They are kept along x-axis and y-axis as shown. Another wire AB of length L carrying current i_0 is placed as shown. Then choose the incorrect statement



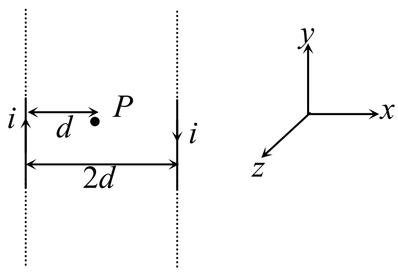
(a) the wire AB turns anticlock wise

(b) the wire does not rotate

(c) the net force on the wire is $\frac{\sqrt{2}\mu_0 i i_0}{2\pi L}$ towards the origin

(d) the net force on the wire is towards the y-axis

3. Two long parallel conductors carry current i each in opposite directions. They are placed in x-y plane are separated by a distance $2d$. There is a point P.



(a) if a small circular coil carrying current i_0 is kept in y-z plane, then it rotates.

(b) if a small circular coil is kept in x-y plane the torque on it is maximum.

(c) if a small circular coil is kept in x-z plane in the torque on it is maximum.

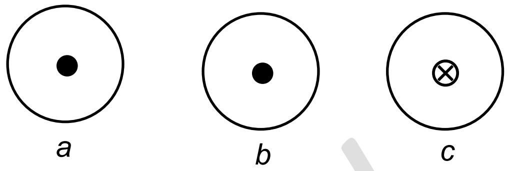
(d) an electron thrown along y-axis from P deflects towards left wire.

4. A wire of length l carrying a current i is bent first in form of an equilateral triangle, the magnetic field at the center of triangle is B_1. The same wire is now bent in the form of a circle, the magnetic field at the center is now B_2. Each of the coil is kept in a constant magnetic field with its plane perpendicular to magnetic field then τ_1 and τ_2 are torques acting on it respectively

(a) $B_1 > B_2$ (b) $B_2 > B_1$

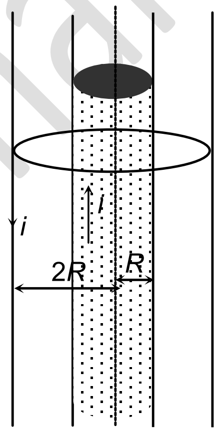
(c) $\tau_1 = \tau_2 = 0$ (d) $\tau_2 = \tau_1 \neq 0$

5. Figure shows three long wires parallel and equally spaced with identical currents. The force acting on one by others are F_A, F_B and F_C respectively



(a) $F_A > F_B$ (b) $F_B > F_C$ (c) $F_C > F_B$ (d) $F_C > F_A$

6. A long cylinder of radius R is surrounded by a thin walled long hollow cylinder of radius $2R$. For a radial distance r from the axis of inner cylinder the magnetic field induction is given by the system. The current in both the cylinder are uniform along the length and in opposite directions



(a) $0 < r < R$, magnetic field is proportional to r

(b) $R < r < 2R$, magnetic field is zero

(c) $r > 2R$, magnetic field is zero

(d) $R < r < 2R$, magnetic field is proportional to r

7. A particle is projected in a uniform electric field $\vec{E}$ and uniform magnetic field $\vec{B}$ then

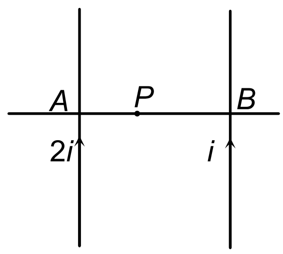
(a) its momentum may remain constant

(b) only if $|\vec{E}|=0$, its kinetic energy remains constant

(c) its kinetic energy is changing then $\vec{B}$ must be variable

(d) work done by the magnetic field is zero

8. Two long parallel wires A and B carry current $2i$ and i in the same direction respectively. The magnetic field $B_1 = 5$T is at a point P between the wires on a perpendicular line joining the wires A and B. When the direction of the current in wire B is reversed, the magnetic field at P becomes $B_2 = 10$T, then



(a) $\frac{AP}{BP} = \frac{2}{3}$

(b) Magnetic field due to only wire A, at P is 7.5T

(c) if the direction of current in two wires is same, the net magnetic field is zero at Q, then $BQ = 2AQ$

(d) if the direction of current is opposite, the net magnetic field between the wires is non zero everywhere.

9. A proton moving with a constant velocity passes through a region of space without any change in its velocity. If E and B represent the electric and magnetic fields respectively, this region of space may have

(a) $E = 0, B = 0$ (b) $E = 0, B \neq 0$ (c) $E \neq 0, B = 0$ (d) $E \neq 0, B \neq 0$

10. A long, straight wire carries a current along the Z-axis. One can find two points in the X-Y plane such that

(a) the magnetic fields are equal

(b) the directions of the magnetic fields are same

(c) the magnitudes of the magnetic fields are equal

(d) the field at one point is opposite to that at the other point.

EXERCISE – III

MATCH THE FOLLOWING

Note: Each statement in column – I has one or more than one match in column –II.

1. Four different situations are give in column-I. In these situation possible rotation of ring or disc, both of mass m, radius R and having uniformly distributed charge q with angular velocity ω is given. In column-II, corresponding to the situation in column-I, some physical quantities are given. Match the column-I with column-II

Column I	Column II
I. Ring, rotating about an axis passing through its centre and perpendicular to the plane of ring	**A.** Magnetic moment $=\dfrac{q\omega R^2}{4}$
II. Ring, rotating about one of its diameter	**B.** Magnetic moment $=\dfrac{q\omega R^2}{8}$
III. Disc, rotating about the axis passing through its centre and perpendicular to the plane of disc	**C.** Magnetic moment $=\dfrac{q\omega R^2}{2}$
IV. Disc, rotating about one of its diameter	**D.** Ratio of magnetic moment and angular momentum $=\dfrac{q}{2m}$ **E.** Angular momentum $\dfrac{mR^2\omega}{2}$

REASONING TYPE

Directions: Read the following questions and choose

(A) If both the statements are true and statement-2 is the correct explanation of **statement-1**.
(B) If both the statements are true but statement-2 is not the correct explanation of **statement-1**.
(C) If statement-1 is True and **statement-2** is False.
(D) If statement-1 is False **and statement-2** is True.

1. **Statement-1**: The radius of circular path of proton is smaller than that of α- particle projected in uniform perpendicular magnetic field with same momentum.
Statement-2: The radius of circular path in the perpendicular magnetic field is proportional to the mass of the projected charged particle.
(a) (A) (b) (B) (c) (C) (d) (D)

2. **Statement-1**: Magnetic flux through a cross section area is always zero.
Statement-2: The magnetic field lines are continuous.
(a) (A) (b) (B) (c) (C) (d) (D)

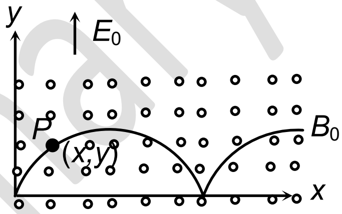
3. **Statement-1**: Magnetic moment is a vector quantity, whose direction inside the magnet is, from its South pole to North pole.
Statement-2: Magnetic lines are continuous which emerges from N-pole and enter into the S-pole in space.
(a) (A) (b) (B) (c) (C) (d) (D)

4. **Statement-1**: Coaxial cable containing equal and opposite current in wire and hollow conducting cylinder is used to produce zero magnetic fields outside the cable.
Statement-2: According to ampere's law net current enclosed in the cable is zero.
(a) (A) (b) (B) (c) (C) (d) (D)

5. **Statement-1**: A proton moving vertically upwards enters a magnetic field directed towards south. It will be deflected towards east.
Statement-2: Magnetic force acting on moving charge particle is always along the direction of velocity.
(a) (A) (b) (B) (c) (C) (d) (D)

LINKED COMPREHENSION TYPE

A particle with mass m and positive charge q released from rest at the origin as shown in figure. There is a uniform electric field E_0 in $+y$ direction and a uniform magnetic field B_0 directed out of the page. The path of the particle as shown is called cycloid. The particle always moves in x-y plane. The velocity at any time t after the start is given as



$$v_y = \frac{E_0}{B_0}\sin\left(\frac{qB_0}{m}t\right), \quad v_x = \frac{E_0}{B_0}\left(1-\cos\left(\frac{qB_0}{m}t\right)\right)$$

1. Speed of the particle at a general point $P(x, y)$ is given by
(a) $\sqrt{\frac{2qE_0\sqrt{x^2+y^2}}{m}}$ (b) $\sqrt{\frac{2qE_0 y}{m}}$
(c) $\sqrt{\frac{2qE_0 x}{m}}$ (d) $\frac{E_0}{B_0}$

2. The y-coordinate at the highest point of trajectory is
(a) $\frac{4m}{qB_0^2}$ (b) $\frac{2m}{qB_0^2}$
(c) $\frac{2mE_0}{qB_0^2}$ (d) $\frac{4mE_0}{qB_0}$

3. The time for which the y-coordinate of the particle becomes maximum for the first time is
(a) $\frac{m\pi}{qB_0}$ (b) $\frac{2\pi m}{qB_0}$
(c) $\frac{\pi m}{qE_0}$ (d) $\frac{2\pi m}{3qB_0}$

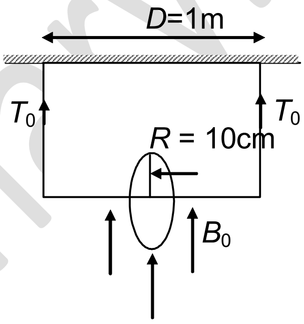
EXERCISE – IV

SUBJECTIVE PROBLEMS

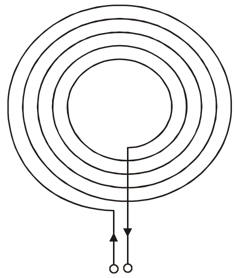
1. Two circular single turn coils are so arranged in two mutually perpendicular planes that their centres coincide. The radius of each coil is 2 cm and same current of 5 A flows through them. Find the magnetic induction at the common centre.

2. A wire of length $l = 2$m carries a current $I = 1$ amp along the X-axis. A magnetic field exists which is given as $\vec{B} = B_0(\vec{i} + \vec{j} + \vec{k})T$, $B_0 = \sqrt{2}$ T. Find the magnitude of the magnetic force acting on the wire.

3. A charge $Q = 1$C is uniformly distributed on the ring which is free to rotate about a light horizontal rod. The rod is suspended by light inextensible strings and a magnetic field $B = 10$T is applied as shown in the figure. The initial tensions in the strings are $T_0 = 100$ N. If the breaking strength of the each strings is $\frac{3T_0}{2}$, find the maximum angular velocity ω_0 with which the wheel can be rotated.

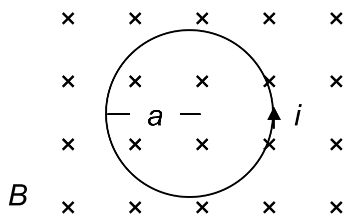


4. A thin insulated wire forms a plane spiral of N = 100 tight turns carrying a current I = 8 mA. The radii of inside and outside turns as shown in figure are equal to $a = 50$ mm and $b = 100$ mm. Find
(a) the magnetic induction at the centre of the spiral;
(b) the magnetic moment of the spiral with a given current.



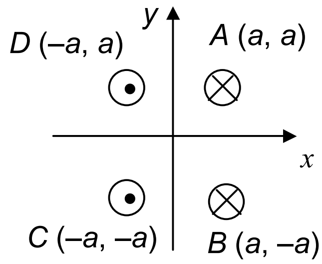
5. A non-conducting thin disc of radius $R = 1$m charged uniformly over one side with surface density $\sigma = \pi$C m^{-2} rotates about its axis with an angular velocity $\omega = 100$ rad/sec. Find
(a) the magnetic induction at the centre of the disc;
(b) the magnetic moment of the disc. ($\pi^2 = 10$)

6. Figure shows a circular wire-loop of radius $a = 10$cm carrying a current $i = 10$ amp placed in a perpendicular magnetic field $B = 1$ T. Find the force of compression in the wire.



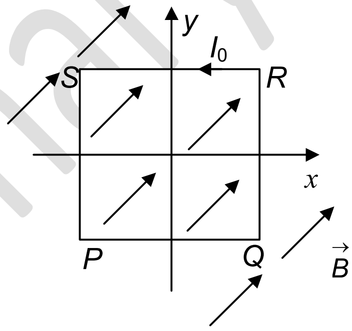
7. A square coil of edge $l = 1$m having $n = 10$ turns carries a current $i = 1$ amp It is kept on a smooth horizontal plate. A uniform magnetic field B exists in a direction parallel to an edge. The total mass of the coil is $M = 10$ kg. What should be the minimum value of B for which the coil will start tipping over?

8. Four long wires each carrying current $I = \pi$ amp as shown in the figure are placed at the points *A*, *B*, *C* and *D*. Find the magnitude and direction of
(a) magnetic field at the centre of the square in 10^{-7} T
(b) magnitude of force per metre acting on wire at point *D* in 10^{-8} N. (given $a = 10\ \pi$ cm, $\pi^2 = 10$)



9. A long, straight wire carries a current *i*, A particle having a positive charge *q* and mass *m*, kept at a distance $x_0 = 2e$ m, where *e* is the exponent. from the wire is projected towards it with a speed *v*. Find the minimum separation between the wire and the particle. (2π mv $= \mu_0\, qi$)

10. A uniform, constant magnetic field $\vec{B}$ (magnitude 40 T) is directed at an angle 45° to the *x*-axis in the *xy*-plane. *PQRS* is a rigid, square wire frame carrying a steady current $I_0 = 10$ amp with its centre at the origin *O*. At time $t = 0$, the frame is at rest in the position shown in the figure, with its sides parallel to the *x* and *y*-axis. Each side of the frame is of mass $M = 100$ μg and length $L = 2$ m.



(a) What is the torque τ about *O* acting on the frame due to the magnetic field?
(b) Find the angle by which the frame rotates under the action of this torque in a short interval of time $\Delta t = 1$ ms, and the axis about which this rotation occurs. (Δt is so short that any variation in the torque during this interval may be neglected). Given: the moment of inertia of the frame about an axis through its centre perpendicular to its plane is $\frac{4}{3} ML^2$.

ANSWERS

EXERCISE – I

NEET-SINGLE CHOICE CORRECT

1. (b)	2. (c)	3. (a)	4. (c)	5. (d)
6. (c)	7. (c)	8. (a)	9. (d)	10. (d)
11. (d)	12. (a)	13. (c)	14. (c)	15. (d)
16. (b)	17. (d)	18. (d)	19. (b)	20. (d)
21. (c)	22. (c)	23. (a)	24. (d)	25. (a)

EXERCISE – II

IIT-JEE-SINGLE CHOICE CORRECT

1. (c)	2. (b)	3. (c)	4. (a)	5. (c)
6. (d)	7. (a)	8. (c)	9. (d)	10. (c)
11. (d)	12. (b)	13. (d)	14. (b)	15. (b)
16. (b)	17. (a)	18. (d)	19. (a)	20. (c)

ONE OR MORE THAN ONE CHOICE CORRECT

1. (a,b,c)	2. (b,c)	3. (b,c)	4. (a,c)	5. (b,d)
6. (a,c)	7. (a,d)	8. (a,b,d)	9. (a,c)	10. (a,b,d)

EXERCISE – III

MATCH THE FOLLOWING

1. I – C, D, II – A, D, E; III – A, D, E; IV – B, D

REASONING TYPE

1. (d)	2. (d)	3. (b)	4. (b)	5. (c)

LINKED COMPREHENSION TYPE

1. (b)	2. (c)	3. (a)		

EXERCISE – IV

SUBJECTIVE PROBLEMS

1. $\left(\frac{\mu_0 I}{\sqrt{2}r}\right) = 222\ \mu\ \text{Wb/m}^2$

2. 4 N

3. 1000 rad/sec

4. (a) $B = \frac{\mu_0 NI}{2(b-a)}\log\left(\frac{b}{a}\right) = 7\ \mu\text{J}$ (b) $\frac{\mu\pi I\left(b^3 - a^3\right)}{3(b-a)} = 15 \times 10^{-3}\ \text{A-m}^2$

5. (a) $\left(\frac{\mu_0 \sigma\omega R}{2}\right)$ 200 μT (b) $\left(\frac{\sigma\pi\omega R^4}{4}\right) = 250\ \text{A-m}^2$

6. $(Bla) = 1\ \text{N}$

7. $\left(\frac{Mg}{2l\ln}\right) = 5\ \text{T}$

8. (a) 40 (b) 500

9. 2 m

10. (a) $Bll^2 = 1600\ \text{N-m}$ (b) $\left(\frac{3}{4}\frac{lBt^2}{M}\right) = 3^0$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1

Q.1 Along the direction of current carrying wire, the value of magnetic field is ?
(1) zero
(2) infinity
(3) depends on the length of the wire
(4) uncertain

Q.2 Value of 1 tesla in gauss is -
(1) 10^3 (2) 10^6 (3) 10^4 (4) 10^2

Q.3 The vector form of Biot-Savart law is -
(1) $d\vec{B} = \frac{kid\vec{\ell}\times\vec{r}}{r^2}$ (2) $d\vec{B} = \frac{kid\vec{\ell}\times\vec{r}}{r^3}$
(3) $d\vec{B} = \frac{kid\vec{\ell}\times\vec{r}}{r}$ (4) $d\vec{B} = \frac{kid\vec{\ell}\times\hat{r}}{r}$

Q.4 To obtain maximum intensity of magnetic field at a point the angle between position vector of point and small elements of length of the conductor is -
(1) 0 (2) $\pi/4$
(3) $\pi/2$ (4) π

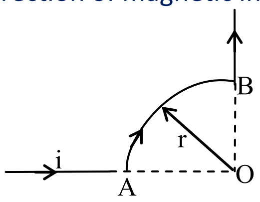
Q.5 The value of intensity of magnetic field at a point due to a current carrying conductor is obtained from-
(1) Gauss's law (2) Faraday's law
(3) Coulomb's law (4) Biot Savart's law

Q.6 The value of intensity of magnetic field at a point due to a current carrying conductor depends -
(1)Only on the value of current
(2)Only on a small part of length of conductor
(3) On angle between the line joining the given point to the mid point of small length and the distance between the small length of the point
(4) On all and the above

Q.7 Which of the following statements is false for Helmholtz coils -
(1) In Helmholtz coils, both coils are coaxial
(2)The planes of Helmholtz coils are perpendicular to each other
(3) The distance between the coils is equal to the radius of the coil
(4) The magnetic field produced in the middle region between the coils is uniform

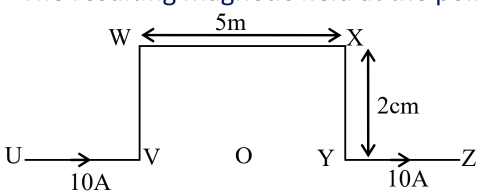
Q.8 The diameter of a circular coil is 0.16m and it has 100 turns. If a current of 5 ampere is passed through the coil, then the intensity of magnetic field at a point on the axis at a distance 0.06 m from its centre will be -
(1) 2×10^{-3} Wb/m^2 (2) 2×10^{-2} Wb/m^2
(3) 2×10^{3} Wb/m^2 (4) 2×10^{2} Wb/m^2

Q.9 The section AB in the following figure is a quarter of a circle of radius r. The magnitude and direction of magnetic induction at the centre O will be -



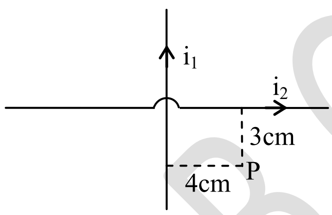
(1) $\frac{\mu_0 i}{2r}$ ⊙ (2) $\frac{\mu_0 i}{4r}$ ⊗ (3) $\frac{\mu_0 i}{8r}$ ⊙ (4) $\frac{\mu_0 i}{8r}$ ⊗

Q.10 The resulting magnetic field at the point O due to the current carrying wire shown in the figure-



(1) points vertically upwards
(2) points vertically downwards
(3) is zero
(4) is the same as due to the segment WX alone

Q.11 Two insulated wires of infinite length are lying mutually at right angles to each other as shown in the figure. Current of 2A and 1.5A respectively are flowing in them. The value of magnetic induction at point P will be -



(1) 2×10^{-3} N/A-m
(2) 2×10^{-5} N/A-m
(3) 0
(4) 2×10^{-4} N/A-m

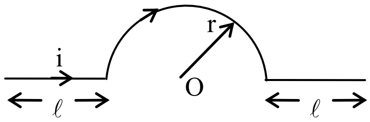
Q.12 A current of 10 A is flowing through a circular coil of diameter 1 cm. What is the magnetic induction at its centre ?
(1) $4\pi \times 10^{-4}$ Tesla (2) $2\pi \times 10^{-4}$ Tesla
(3) $4\pi \times 10^{-8}$ Tesla (4) $4\pi \times 10^{-6}$ Tesla

Q.13 The ratio of magnetic inductions at the centre of a circular coil of radius a and on its axis at a distance equal to its radius, will be -

(1) $\frac{1}{\sqrt{2}}$ (2) $\frac{\sqrt{2}}{1}$

(3) $\frac{1}{2\sqrt{2}}$ (4) $\frac{2\sqrt{2}}{1}$

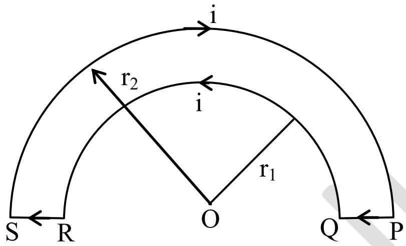
Q.14 A current i is flowing in a conductor as shown in the figure. The magnetic induction at point O will be –



(1) 0 (2) $\frac{\mu_0 i}{r}$

(3) $\frac{2\mu_0 i}{r}$ (4) $\frac{\mu_0 i}{4r}$

Q.15 A wire loop PQRSP is constructed by joining two semicircular coils of radii r_1 and r_2 respectively as shown in the figure. Current is flowing in the loop. The magnetic induction at point O will be -



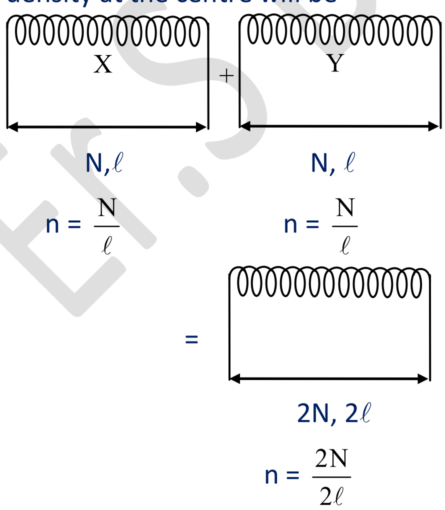
(1) $\frac{\mu_0 i}{4}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ (2) $\frac{\mu_0 i}{4}\left[\frac{1}{r_1}+\frac{1}{r_2}\right]$

(3) $\frac{\mu_0 i}{2}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ (4) $\frac{\mu_0 i}{2}\left[\frac{1}{r_1}+\frac{1}{r_2}\right]$

Q.16 The magnetic flux density at a point distant d from a long straight current carrying conductor is B. Then its value of at distance $\frac{d}{2}$ will be -

(1) 4B (2) 2B (3) B/2 (4) B/4

Q.17 In the given figure X and Y are two coils whose length and number of turns are same and each carry current I. The flux density at the centre, inside the coil is B and that at the end is B/2, when two coils are joined to make a coil of double the length and current I is passed through it then flux density at the centre will be-

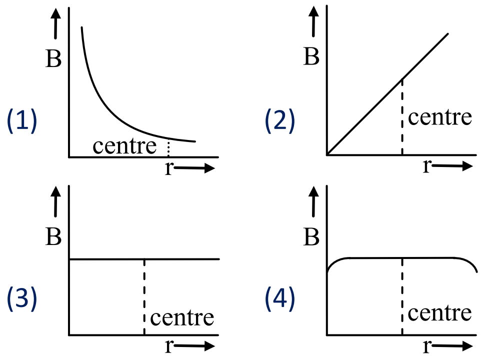


(1) zero (2) B/2 (3) B (4) 2B

Q.18 At the centre of a straight solenoid the magnetic induction is B. If the length is reduced to half but to keep the number of turns same, these are wound in two layers, then the magnetic induction at the centre will be -

(1) B/2 (2) B (3) 2B (4) 4B

Q.19 In a solenoid the magnetic induction produced due to current (B) is a function of distance r from one end -



Q.20 The number of turns per unit length of a solenoid is 10. If its average radius is 5 cm and it carries a current of 10A, then the ratio of flux densities obtained at the centre and at the end on the axis will be -

(1) 1 : 2 (2) 2 : 1
(3) 1 : 1 (4) 1 : 4

Q.21 A solenoid of length 0.5 m and diameter 0.6m consists of 1000 turns of fine wire carrying a current of 5.0×10^{-3} ampere. The magnetic field in Weber/m^2 at the ends of the solenoid will be

(1) 8.71×10^{-6} (2) 6.28×10^{-6}
(3) 3.14×10^{-6} (4) 6.28×10^{-5}

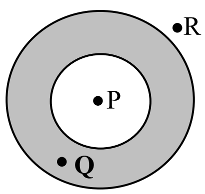
Q.22 The average radius of a toroid made out of a nonmagnetic material is 0.1m and it has 500 turns. If it carries 0.5 ampere current, then the intensity of magnetic field along its circular axis in Tesla will be

(1) 5×10^{-4} (2) 5×10^{-3}
(3) 5×10^{-2} (4) 2×10^{-3}

Q.23 A hollow tube is carrying an electric current along the length distributed uniformly over its surface. The magnetic field -

(1) increases linearly from the axis to the surface
(2) is non-zero inside the tube
(3) inside the tube is zero
(4) is zero just outside the tube

Q.24 Current is flowing through a conducting hollow pipe whose area of cross-section is shown as. The value of magnetic induction will be zero at-



(1) points P, Q and R
(2) Point R but not at P and Q
(3) Q but not at P and R
(4) P but not at Q and R

Q.25 At any internal point of a solenoid the value of magnetic field produced depends -

(1) only on current flowing in the solenoid
(2) only on length of the solenoid
(3) on number of the turns.
(4) on all of the above

Q.26 The magnetic field generated along the axis of a solenoid is proportional to -
(1) its length
(2) square of current flowing in its
(3) number of turns per unit length in it
(4) reciprocal of its radius

Q.27 When the number of turns in a toroidal coil is doubled, the value of magnetic flux density will become-
(1) four times (2) eight times
(3) half (4) double

Q.28 Total number of turns in a toroid is N and radius is R. If current i is passed through it, then the magnetic field inside the toroid will be-
(1) $\frac{\mu_0 Ni}{2R}$ (2) $\mu_0 Ni$
(3) $\frac{\mu_0 Ni}{2\pi R}$ (4) $\frac{\mu_0 Ni}{R}$

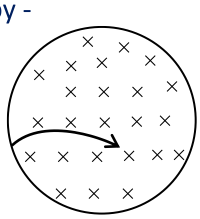
Q.29 An air core toroid with 10 turns/cm carries a current of 1 milliampere. The intensity of magnetic field inside it, in Weber/m^2 will be-
(1) $4\pi \times 10^{-6}$ (2) $4\pi \times 10^{-7}$
(3) $4\pi \times 10^{-8}$ (4) $4\pi \times 10^{-9}$

Q.30 Choose the wrong statement -
(1) The radius of path of a charged particle moving in a uniform magnetic field is proportional to the momentum of the particle
(2) An electron beam is moving towards east, on which a perpendicular magnetic field is acting upwards. The beam will be deflected towards the north direction
(3) A positive charge is going straight away from the observer. The magnetic line of force produced due to it are in clockwise direction.
(4) While passing through a given place, the path of electron remains straight line. It can be definitely said that the magnetic field is not present at that place

Q.31 An electric field of 1500 volt/m and a magnetic field of 0.4 tesla are so applied on a moving electron that the resultant force on it is zero . The speed of the electron is -
(1) 1500 m/s (2) 2800 m/s
(3) 3750 m/s (4) 600 m/s

Q.32 A proton beam enters a uniform magnetic field of 0.3 Tesla making an angle of 60º to its direction with a velocity of 4×10^5 m/s. The radius of the helical path of the proton beam will be -
(1) 4 mm (2) 6 mm
(3) 8 mm (4) 12 mm

Q.33 There is a magnetic field acting in a plane downward perpendicular to sheet of paper. Particles in vacuum move in the plane of paper from left to right. The path indicated by an arrow could be travelled by -



(1) proton (2) neutron
(3) electron (4) α-particle

Q.34 A charged particle is moved along a magnetic field line. The magnetic force on the particle is -
(1) along its velocity
(2) opposite to its velocity
(3) perpendicular to its velocity
(4) zero

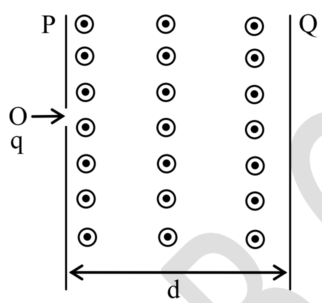
Q.35 Electron and proton of equal momentum enter a uniform field normal to the lines of force. If the radii of curvature of circular paths be r_e and r_p respectively, then -

(1) $\frac{r_e}{r_p} = \frac{1}{1}$ (2) $\frac{r_e}{r_p} = \frac{m_p}{m_e}$

(3) $\frac{r_e}{r_p} = \sqrt{\frac{m_p}{m_e}}$ (4) $\frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}}$

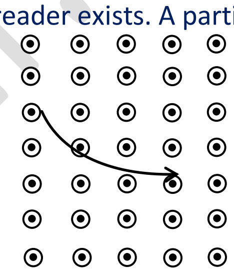
Q.36 A proton charge (+e coulomb) enters in a magnetic field of strength B (Tesla) perpendicular to the magnetic lines of force, with speed v. The force on the proton is -
(1) evB (2) 0
(3) ∞ (4) evB/2

Q.37 A charged particle having kinetic energy K enters into the region of a uniform magnetic filed between two plates P and Q as shown in fig. The charged particle just misses hitting the plate Q. The magnetic field in the region between the two plates -



(1) mK/qd
(2) 2mK/qd
(3) $\sqrt{(mK)}/qd$
(4) $\sqrt{(2mk)}$ /qd

Q.38 In a region of space a uniform magnetic filed perpendicular to the plane of the page and directed towards reader exists. A particle has a trajectory as shown in fig. The particle is-



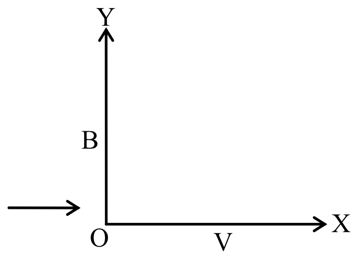
(1) proton (2) neutron
(3) electron (4) α-particle

Q.39 If a particle moves in a circular path in anti-clockwise direction after entering into a downward vertical magnetic field. The charge on the particle is -
(1) positive (2) negative
(3) neutral (4) nothing can be said

Q.40 In a room a uniform magnetic field is acting vertically downward. When an electron moves in the horizontal plane its speed in a circular path is constant. Its path is -
(1) clockwise in horizontal plane
(2) clockwise in vertical plane
(3) anti-clockwise in horizontal plane
(4) anti-clockwise in vertical plane

Q.41 When an electron beam is moving in a magnetic field, then the work done is equal to the -
(1) charge of electron
(2) magnetic field
(3)product of electronic charge and the magnetic field
(4) 0

Q.42 If a positively changed particle is moving as shown in the figure, then it will get deflected out to magnetic field towards -



(1) +x-direction (2) +y-direction
(3) –x-direction (4) +z-direction

Q.43 An electron enters a magnetic field along perpendicular direction. Following quantity will remain constant -
(1) momentum (2) kinetic energy
(3) velocity (4) acceleration

Q.44 Which of the following rays are not deflected by a magnetic field -
(1) α-rays (2) β-rays
(3) γ-rays (4) positive rays

Q.45 An electron, a proton and a deuteron move in a magnetic field with same momentum perpendicularly. The ratio of the radii of their circular paths will be -
(1) 1 : 1 : 1 (2) 1 : 1 : 2
(3) 1 : 2 : 4 (4) 2 : 1 : 1

Q.46 If an electron moves in a circular path with velocity v in a magnetic field B, then during a semicircular journey, its gain in energy will be-
(1) $\frac{1}{2}$ MB^2 (2) 0
(3) $\frac{1}{4}$ MB^2 (4) BevR

Q.47 Two parallel beams of electrons moving in the same direction will-
(1) repel each other
(2) attract each other
(3) not interact with each other
(4) annihilate each other

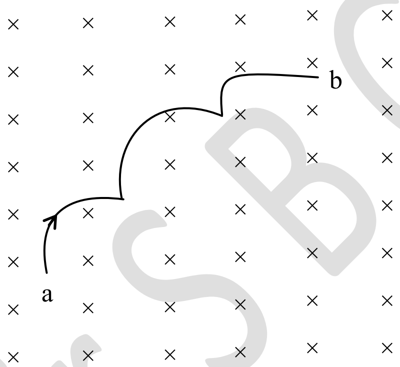
Q.48 When an electron beam is moving in a magnetic field, then the work done is equal to the –
(1) charge of electron
(2) magnetic field
(3) product of electronic charge and the magnetic field
(4) zero

Q.49 Two long parallel conductors A and B are at a distance 0.01m from each other. The current in conductor A is double of that in B and force between then is 0.004 Newton/m. The current flowing through B in ampere will be -
(1) 0.1 (2) 1.0 (3) 10 (4) 100

Q.50 A current of 1 ampere is passed through a wire of a length 0.5 meter. If it is placed normally in a field of 4 Weber/m^2, then the force acting on the wire in Newton will be -
(1) 2 (2) 5 (3) 4 (4) zero

Q.51 A linear conductor of length 40 cm is carrying a current of 3 ampere and is placed in a magnetic field of intensity 500 gauss. If a conductor is making an angle 30º with the field, then the force acting on it will be -
(1) 3×10^4 N
(2) 3×10^2 N
(3) 3×10^{-2} N
(4) 3×10^{-4} N

Q.52 Fig shows a wire of arbitrary shape carrying a current i between points a and b. The length of the wire is L and the straight distance between points a and b is d. The wire lies in a plane at right angles to z uniform magnetic field B. The force on the curve wire is -



(1) iLB (2) idB
(3) i(L – d) B (4) None of these

Q.53 A direct current is sent through a helical spring. The spring -
(1) tends to get shorter
(2) tends to get longer
(3) tends to rotate about the axis
(4) tends to move northward

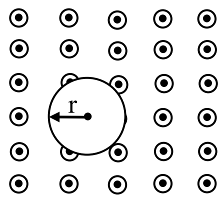
Q.54 Two long, thin wires distant a apart exert a force F on one another when current through each wire is i. The distance between the wires is doubled and the current is decreased to i/3. The force they exert on one another now-
(1) F/6 (2) F/9 (3) 2F/3 (4) F/18

Q.55 The distance between two thin long straight parallel conducting wires is b. On passing the same current in them, the force per unit length between them will be-

(1) $\frac{\mu_0 i}{2\pi b}$ (2) $\frac{\mu_0 i^2}{2\pi}$ (3) $\frac{\mu_0 i^2}{2\pi b}$ (4) 0

Q.56 A stream of electrons is projected horizontally from right. A straight conductor carrying a current is supported parallel to electron stream and above it. If the current in the conductor is from left to right them what will be the effect on electron stream ?
(1) The electron stream will be speeded up towards the right
(2) The electron stream will be retarded
(3) The electron stream will be pulled upward
(4) The electron stream will be pulled downward.

Q.57 A circular loop carrying current i is placed in a uniform magnetic induction field B as shown in fig. The force on circular loop is -



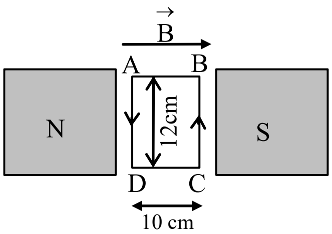
(1) $2\pi rBi$ (2) πrBi (3) 0 (4) Bir

Q.58 A current of 2 ampere is flowing through a coil of radius 0.1 m and having 10 turns. The magnetic moment of the coil will be :
(1) 20 A-m^2 (2) 2A-m^2
(3) 0.314 A-m^2 (4) 0.628 A-m^2

Q.59 The effective radius of a circular coil is R and number of turns is N. The current through it is i ampere. The work done is rotating the coil from angle θ = 0º to θ = 180º in an external magnetic field B will be -
(1) πNiR^2B (2) $2\pi NiR^2B$
(3) $(2NiB)/(\pi R^2)$ (4) $4\pi NiR^2B$

Q.60 A current carrying wire of length ℓ is bent to from a circular coil. If this coil is placed in any other magnetic field, then for the maximum torque on the coil, the number of turns will be
(1) 1 (2) 2 (3) 4 (4) 8

Q.61 A coil of 50 turns is situated in a magnetic field B = 0.25 Weber/m^2 as shown in figure. A current of 2 ampere is flowing in the coil. Torque acting on the coil will be :



(1) 0.15 N (2) 0.3 N
(3) 0.45 N (4) 0.6 N

Q.62 A magnetic needle is kept in a non-uniform magnetic field. It experiences-
(1) a force and a torque
(2) a force but not a torque
(3) a torque but not a force
(4) neither a force nor a torque

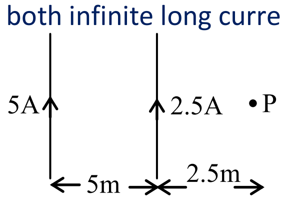
Q.63 A current carrying loop lying in a magnetic field behaves like a-
(1) magnetic dipole
(2) magnetic pole
(3) magnetic material
(4) non-magnetic material

Q.64 A proton moves along horizontal line and towards observer, the pattern of concentric circular field lines of magnetic field which produced due to its motion-
(1) Anti clockwise, in horizontal plane
(2) Anti clockwise, in vertical plane
(3) Clockwise, in horizontal plane
(4) Clockwise, in vertical plane

Q.65 A current is flowing in electricity line towards north, the direction of magnetic field at a point which is just below the line-
(1) towards north (2) towards south
(3) towards east (4) towards west

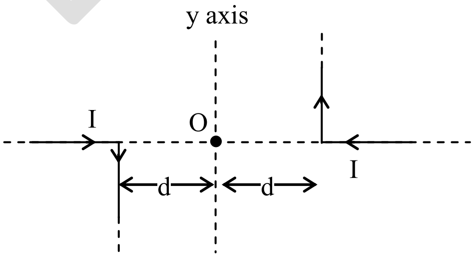
Q.66 A current is flowing in a vertical wire in downward direction, the direction of magnetic field of a point which is just right side to the wire-
(1) towards north
(2) towards south
(3) towards east
(4) towards west

Q.67 Magnetic field at point 'P' due to both infinite long current carrying wires is-



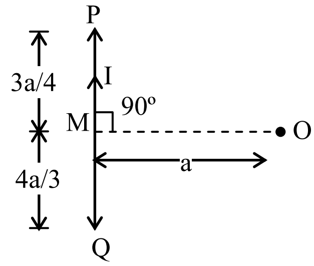
(1) $\frac{\mu_0}{2\pi}\otimes$ (2) $\frac{5\mu_0}{6\pi}\otimes$ (3) $\frac{5\mu_0}{6\pi}\odot$ (4) $\frac{\mu_0}{2\pi}\odot$

Q.68 Magnetic field at origin 'O' due to given current distribution is-



(1) $\frac{\mu_0 I}{2\pi d}\odot$ (2) $\frac{\mu_0 I}{2\pi d}\otimes$
(3) $\frac{\mu_0 I}{4\pi d}\odot$ (4) $\frac{\mu_0 I}{4\pi d}\otimes$

Q.69 Magnetic field at point 'O' due to finite length wire PQ, (where I in ampere and a in meter) is-



(1) $\frac{7\mu_0 I}{10\pi a}$ (2) $\frac{14\mu_0 I}{5\pi a}$

(3) $\frac{7\mu_0 I}{20\pi a}$ (4) $\frac{70\mu_0 I}{2\pi a}$

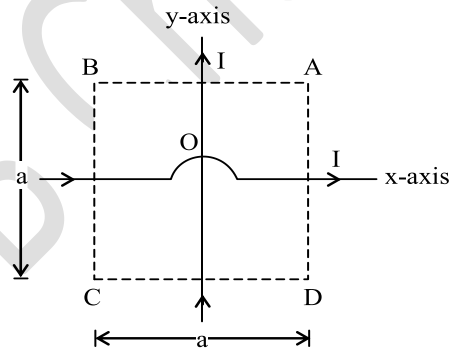
Q.70 A long wire carries a current of 90A from east to west direction. Magnetic field due to current at a point which is 1.5 m just below the wire –

(1) 12×10^{-6} T, towards north
(2) 6×10^{-6} T, towards south
(3) 12×10^{-6} T, towards south
(4) 6×10^{-6} T, towards north

Q.71 Two long parallel wires carries i and 2i current in same direction respectively. Magnetic field just between the wires is 'B'. If 2i current is switched off then magnetic field at the same point is –

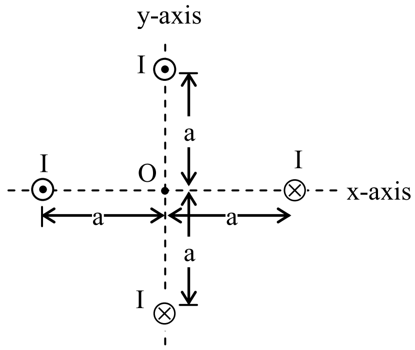
(1) 2B (2) B (3) B/2 (4) $\sqrt{2}$ B

Q.72 Two infinite length wires carries equal current and placed along x and y axis respectively. At which points the resultant magnetic field is zero?



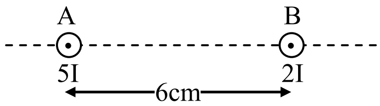
(1) A, B (2) B, D (3) A, C (4) C, D

Q.73 For gives current distribution each infinite length wire produces magnetic field 'B' at origin then resultant magnetic field at origin 'O' is –



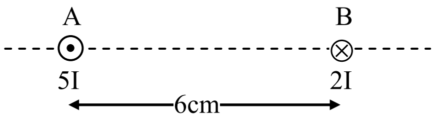
(1) 4B (2) $\sqrt{2}$ B (3) $2\sqrt{2}$ B (4) zero

Q.74 The position of point from wire 'B', where net magnetic field is zero due to following current distribution –



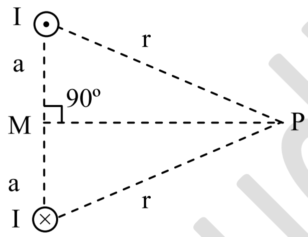
(1) 6/7 cm (2) 12/7 cm
(3) 18/17 cm (4) 16/7 cm

Q.75 The position of point from wire 'B', where net magnetic field is zero due to following current distribution –



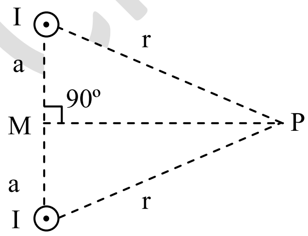
(1) 4 cm (2) 2 cm (3) 8 cm (4) 12 cm

Q.76 Magnetic field at point 'P' due to following current distribution is –



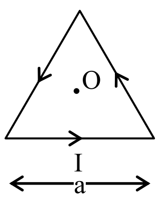
(1) $\frac{\mu_0 I}{\pi r^2}\sqrt{r^2-a^2}$ (2) $\frac{\mu_0 Ia}{\pi r^2}$
(3) $\frac{\mu_0 I}{2\pi r^2}\sqrt{r^2-a^2}$ (4) $\frac{\mu_0 Ia}{2\pi r^2}$

Q.77 Magnetic field at point 'P' due to following current distribution is –



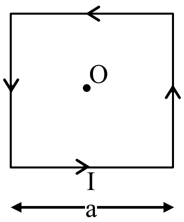
(1) $\frac{\mu_0 I}{\pi r^2}\sqrt{r^2-a^2}$ (2) $\frac{\mu_0 Ia}{\pi r^2}$
(3) $\frac{\mu_0 I}{2\pi r^2}\sqrt{r^2-a^2}$ (4) $\frac{\mu_0 Ia}{2\pi r^2}$

Q.78 Magnetic field at the centre of various **regular polygons,** which are formed by a constant length (ℓ) current carrying wire as Equilateral triangle is –



(1) $\frac{\mu_0 I}{2\sqrt{3}\pi a}$ (2) $\frac{27\mu_0 I}{2\pi a}$
(3) $\frac{9\mu_0 I}{2\pi a}$ (4) $\sqrt{3}\,\frac{\mu_0 I}{\pi a}$

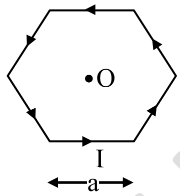
Q.79 Magnetic field at the centre of various **regular polygons,** which are formed by a constant length (ℓ) current carrying wire as square is –



(1) $\frac{2\sqrt{2}\mu_0 I}{\pi a}$ (2) $\frac{\mu_0 I}{2\sqrt{2}\pi a}$

(3) $8\sqrt{2}\frac{\mu_0 I}{\pi a}$ (4) $\sqrt{2}\frac{\mu_0 I}{\pi a}$

Q.80 Magnetic field at the centre of various **regular polygons,** which are formed by a constant length (ℓ) current carrying wire as Regular hexagon is –



(1) $\frac{6\mu_0 I}{\pi a}$ (2) $\frac{\sqrt{3}\mu_0 I}{\pi a}$

(3) $6\sqrt{3}\frac{\mu_0 I}{\pi a}$ (4) $\frac{\mu_0 I}{\sqrt{3}\pi a}$

Q.81 Magnetic field at the centre of **regular polygon of 'n' sides** which is formed by a constant length wire, which carries current I and side of polygon is 'a' -

(1) $\frac{n\mu_0 I}{\pi a}\sin\left(\frac{\pi}{n}\right)\cot\left(\frac{\pi}{n}\right)$

(2) $\frac{n\mu_0 I}{\pi a}\cos\left(\frac{\pi}{n}\right)\tan\left(\frac{\pi}{n}\right)$

(3) $\frac{n\mu_0 I}{\pi a}\sin\left(\frac{\pi}{n}\right)\tan\left(\frac{\pi}{n}\right)$

(4) $\frac{n\mu_0 I}{\pi a}$

Q.82 The ratio of magnetic field at centre of circular loop to the magnetic field at the centre of square loop, which are made by a constant length current carrying wire -

(1) $\frac{\pi^2}{16}$ (2) $\frac{\pi^2}{8\sqrt{2}}$

(3) $\frac{\pi^2}{4\sqrt{2}}$ (4) $\frac{\pi^2}{2\sqrt{2}}$

Q.83 A circular coil of one turn in formed by a 6.28m length wire, which carries a current of 3.14A. The magnetic field at the centre of coil is -

(1) 1×10^{-6} T (2) 4×10^{-6} T

(3) 0.5×10^{-6} T (4) 2×10^{-6} T

Q.84 The magnetic field at the centre of a circular coil of radius r carrying current is B_1. The field at the centre of another coil of radius $\frac{r}{2}$ carrying same current is B_2, then ratio of B_1/B_2 is -

(1) 1 : 2 (2) 2 : 1 (3) 1 : 1 (4) 4 : 1

Q.85 Two circular coils of radius R and 2R carries 2I and I current respectively. The ratio of magnetic field at their centres -

(1) 1 : 4 (2) 1 : 2 (3) 4 : 1 (4) 2 : 1

Q.86 A length of wire carries a steady current is bent first to form a plane circular coil of one turn, same length now bent more sharply to give three turns of smaller radius. Magnetic field becomes –

(1) 3 times (2) $\frac{1}{3}$ times

(3) 9 times (4) unchanged

Q.87 Two concentric coplanner coils of equal turns have radii 10 cm and 30 cm respectively. Same current flowing in both the coils in same direction. Now direction of current is reversed in one coil then ratio of magnetic field at their common centre in two conditions respectively -

(1) 2 : 1 (2) 1 : 2 (3) 1 : 1 (4) 4 : 1

Q.88 Two concentric coplanar coils of turns n_1 and n_2 have radii ratio 2 : 1 respectively. Equal current in both the coils flows in opposite direction. If net magnetic field is zero at their common centre then $n_1 : n_2$ is -

(1) 2 : 1 (2) 1 : 2 (3) 1 : 1 (4) 4 : 1

Q.89 Two identical coils of radii R and number of turns 'N'. Both are placed concentrically and their plane are perpendicular to each other. If current in both coils is I and $\sqrt{3}$ I then net magnetic field at their common centre is -

(1) $\frac{\mu_0 NI}{2R}$ (2) $\frac{\mu_0 NI}{R}$

(3) $\sqrt{R}\ \frac{\mu_0 NI}{R}$ (4) $2\sqrt{2}\ \frac{\mu_0 NI}{R}$

Q.90 Two identical coils carry equal currents, have a common centre, and their planes are at right angles to each other. The ratio of resultant magnetic field and field due to one coil alone at the centre is -

(1) 1 : $\sqrt{2}$ (2) 1 : 2 (3) $\sqrt{2}$: 1 (4) 2 : 1

Q.91 A solid cylindrical wire of radius 'R' carries a current 'I'. The magnetic field is 5μT at a point, which is '2R' distance away from the axis of wire. Magnetic field at a point which is R/3 distance inside from the surface of the wire is-

(1) $\frac{10}{3}\mu T$ (2) $\frac{20}{3}\mu T$ (3) $\frac{5}{3}\mu T$ (4) $\frac{40}{3}\mu T$

Q.92 A hollow cylindrical wire carries a current I, having inner and outer radii 'R' and 2R respectively. Magnetic field at a point which 3R/2 distance away from its axis is-

(1) $\frac{5\mu_0 I}{18\pi R}$ (2) $\frac{\mu_0 I}{36\pi R}$

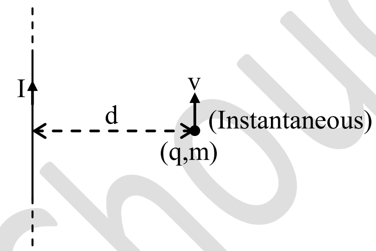
(3) $\frac{5\mu_0 I}{36\pi R}$ (4) $\frac{5\mu_0 I}{9\pi R}$

Q.93 A long, straight and solid metal wire of radius 2mm carries a current uniformly distributed over its circular cross section. The magnetic field at a distance 1mm from the axis of the wire is-
(1) B (2) 4B (3) 2B (4) B/2

Q.94 A test charge 1.6×10^{-19} Cb is moving with $\vec{v} = (2\hat{i} + 3\hat{j})$ m/sec is a magnetic field $\vec{B} = (2\hat{i} + 3\hat{j})$ Wb/m^2. The magnetic force on the test charge-
(1) $6\hat{k}T$ (2) $(4\hat{i} + 6\hat{j})T$
(3) $(4\hat{i} + 6\hat{j}) \times 10^{-19}$ T (4) zero

Q.95 A charge with 10^{-11} Cb and 10^{-7} kg mass moving with a velocity of 10^8 m/sec along x-axis. A uniform static magnetic field of 0.5T is acting along the y-axis. The magnetic force (magnitude and direction) on charge-
(1) zero
(2) 5×10^{-4} N, along z-axis
(3) 5×10^{-4} N, along x-axis
(4) 5×10^{-4} N, along y-axis

Q.96 An electron is moving at 10^6 m/sec in a direction parallel to a current of 5A flowing through an infinite long straight wire separated by a perpendicular distance of 10 cm in air. Magnetic force experienced by the electron-



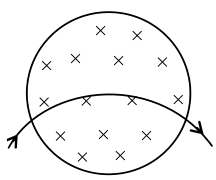
(1) 1.6×10^{-19} N (2) 1.6×10^{-20} N
(3) 1.6×10^{-18} N (4) 1.6×10^{-21} N

Q.97 A proton enters in a magnetic field 1.0 T with a velocity 2.5×10^7 m/sec at an angle of 30º with the field. The magnetic force acting on the proton-
(1) 2×10^{-11} N (2) 2×10^{-12} N
(3) 4×10^{-11} N (4) 4×10^{-12} N

Q.98 In a region a uniform magnetic field acts in horizontal plane towards north. If cosmic particles (80% protons) falling vertically downwards, then they are deflected towards-
(1) North (2) South (3) East (4) West

Q.99 An electron is moving along +x direction. To get it moving an anticlockwise circular path in x-y plane, magnetic field applied along-
(1) +y-direction (2) +z-direction
(3) –y-direction (4) –z-direction

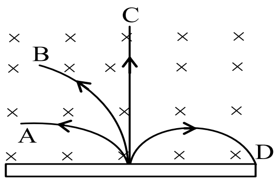
Q.100 There is a magnetic field acting in a plane perpendicular downwards. A particle in vacuum moves in the plane of paper from left to right as shown in figure. The path indicated by the arrow could be due to-



(1) Proton (2) Neutron
(3) Electron (4) Alpha particle

Q.101 A proton is moving towards north along horizontal line passes through a zero gravity region, where electric and magnetic field are mutually perpendicular to each other. The path of particle remains undeviated or undeflected. If the direction of electric field is towards east then direction of magnetic field is-
(1) Towards east
(2) Vertically downwards
(3) Towards west
(4) Vertically upwards

Q.102 A neutron, a proton, an electron and an α-particle enters in a region of uniform magnetic field with equal velocities. The tracks of the particles are shown in figure. Relates the tracks to the particles.



(1) A-proton, B-α particle, C-neutron, D-electron
(2) A-α particle, B-proton, C-neutron, D-electron
(3) A-proton, B-α particle, C-electron, D-neutron
(4) None

Q.103 Which of the following cannot be deflected by magnetic field-
(1) α-rays (2) β-rays
(3) γ-rays (4) Cosmic rays

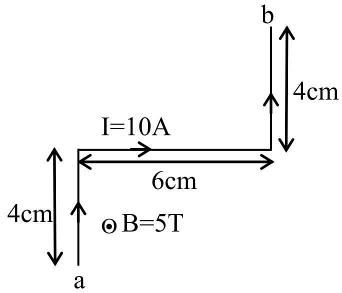
Q.104 A proton moving along z-axis with constant velocity. If a magnetic field applied along x-axis then direction of magnetic force on proton-
(1) along z-axis (2) along y-axis
(3) along x-axis (4) zero force

Q.105 A vertical wire carries a current in upward direction. If an electron beam sent horizontally towards the wire, then it will deflected-
(1) Vertically downwards and perpendicular to the plane of the paper
(2) Vertically upwards and perpendicular to the plane of the paper
(3) In the plane of the paper
(4) No deflection

Q.106 A charge is released from rest in a region of steady and uniform electric and magnetic fields which are parallel to each other. The charge will moves along which path-
(1) Circular
(2) Helical
(3) Parabola
(4) Straight line

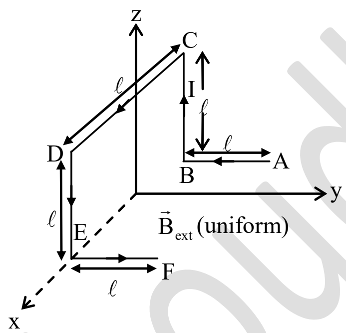
Q.107 A wire of length 5 cm is placed inside the solenoid near its centre such that it makes an angle of 30º with the axis of solenoid. The wire carries a current of 5A and the magnetic field due to solenoid is 2.5×10^{-2} T. Magnetic force on wire is-
(1) 3.12×10^{-4} N (2) 31.2×10^{-4} N
(3) 312×10^{-4} N (4) 0.312×10^{-4} N

Q.108 A wire 'ab' bent as shown in figure is placed in uniform perpendicular magnetic field of 5T. A 10A current flows through the wire. Magnetic force experienced by wire is-



(1) 5N (2) 10N (3) 2.5N (4) 1.25N

Q.109 A wire ABCDEF with each side of length 'ℓ' bent as shown in figure and carrying a current I. If it is placed in a uniform magnetic field B which is parallel to +y direction. Magnetic force experienced by the wire is-



(1) $BI\ell$, along +z direction

(2) $BI\ell$, along –z direction

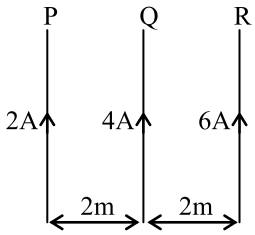
(3) $2BI\ell$, along +z direction

(4) $2BI\ell$, along –z direction

Q.110 Two parallel wires A and B carries 10A and 5A of currents in same direction respectively. Wire 'A' is infinite long and length of wire 'B' is 2m. Magnetic force on wire 'B', which is at 10 cm apart from wire 'A' is-
(1) 2×10^{-3} N, Attraction
(2) 2×10^{-4} N, Repulsion
(3) 2×10^{-3} N, Repulsion
(4) 2×10^{-4} N, Attraction

Q.111 A current of 10A flows through two long parallel wires. The magnetic force on each wire is 2×10^{-3} N/m. If their currents makes doubled and separation between them makes half then magnetic force per unit length of each wire becomes-
(1) 16×10^{-3} N/m
(2) 8×10^{-3} N/m
(3) 4×10^{-3} N/m
(4) 32×10^{-3} N/m

Q.112 Three long straight wires, carries currents are arranged according to figure. Magnetic force on 10 cm part of wire Q is-



(1) 16×10^{-9} N, towards right
(2) 16×10^{-8} N, towards right
(3) 16×10^{-8} N, towards left
(4) 16×10^{-9} N, towards left

Q.113 A long horizontal wire, which is rigidly fixed and carries 100 A current. An another wire of linear mass density 2×10^{-3} kg/m placed below and parallel to the fixed wire. If the free wire kept 2cm below and hangs in air, then current in free wire is-
(1) 19.6 A (2) 9.8 A (3) 4.9 A (4) 100 A

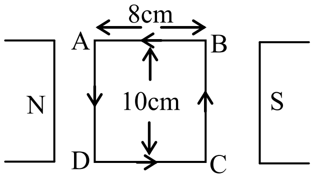
Q.114 A long horizontal wire 'A' is rigidly fixed and an another wire 'B' which is placed directly below and parallel to wire 'A'. Wire 'B' remains suspended in air due to magnetic attraction. If direction of current is reversed in any one wire then due to gravity instantaneous acceleration of free wire 'B' (where g is acceleration due to gravity)
(1) g, in downward direction
(2) g, in upward direction
(3) 2g, in downward direction
(4) 2g, in upward direction

Q.115 A magnet of magnetic moment $50\hat{i}$ A-m^2 placed along x-axis. Where magnetic field is $\vec{B} = (0.5\hat{i} + 3.0\hat{j})$ tesla. The torque acting on magnet is-
(1) 175 $\hat{k}$ N-m (2) 150 $\hat{k}$ N-m
(3) 75 $\hat{k}$ N-m (4) $25\sqrt{37}$ $\hat{k}$ N-m

Q.116 A short bar magnet placed with its axis at 30º with a uniform magnetic field of 0.16T experience a torque of magnitude 0.032 J. The magnetic moment of the bar moment will be-
(1) 0.23 J/T (2) 0.40 J/T
(3) 0.80 J/T (4) zero

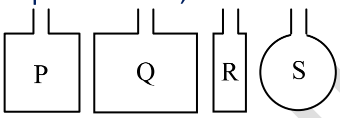
Q.117 A coil of area 10 cm^2 has 10 turns and carries a current 2A. Torque on the coil when it is placed in uniform magnetic field of 0.1 T with its plane 60º to the field.
(1) 10^{-2} N-m (2) 10^{-3} N-m
(3) $\sqrt{3} \times 10^{-2}$ N-m (4) $\sqrt{3} \times 10^{-3}$ N-m

Q.118 A coil of 100 turns kept in magnetic field B = 0.2T, carries a current of 2A as shown in figure. Torque on coil and which side of coil comes out from the plane of the paper-



(1) 0.16 N-m, BC side comes out from plane of paper
(2) 0.16 N-m, AD side comes out from plane of paper
(3) 0.32 N-m, AD side comes out from plane of paper
(4) 0.32 N-m, AD side comes out from plane of paper

Q.119 Four wires each of length 2.0 m, are bent in four loop P, Q, R and S then suspended in uniform magnetic field. All loop carries equal currents, which statement of the following is true-



(1) Couple acting on the loop P is greatest
(2) Couple acting on the loop Q is greatest
(3) Couple acting on the loop R is greatest
(4) Couple acting on the loop S is greatest

Q.120 A magnet of magnetic moment 4A-m^2 is held in a uniform magnetic field 5×10^{-4} T with the magnetic moment vector makes an angle 30º with the field. Work done in increasing the angle from 30º to 45º.
(1) 3.2×10^{-4} J (2) 1.6×10^{-4} J
(3) 1.6×10^{-3} J (4) 3.2×10^{-3} J

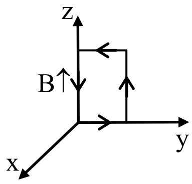
Q.121 A magnetic needle laying parallel to the magnetic field requires W units of work to turn it through 60º. Torque needed to maintain the needle in this position-
(1) W (2) $\sqrt{3}$ W (3) $\frac{W}{2}$ (4) $\frac{\sqrt{3}W}{2}$

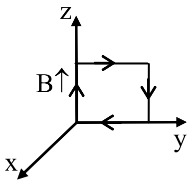
Q.122 A bar magnet has a magnetic moment 2.5 A-m^2 and it is placed in a magnetic field of 0.2 T. Calculate the work done in turning the magnet from parallel to antiparallel position relative to the field direction -
(1) 0.1 J (2) 1 J (3) 2 J (4) 5 J

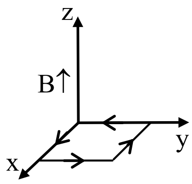
Q.123 A circular coil of 'N' turns, 'R' radius carries a 'i' current. Work done in rotating this coil in an external magnetic field from θ_1 = 0º to θ_2 = 90º-
(1) $2\pi NiR^2B$ (2) $\frac{\pi NiR^2B}{2}$
(3) πNiR^2B (4) $\frac{\sqrt{3}\pi NiR^2B}{2}$

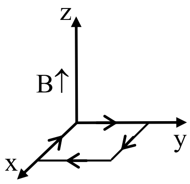
Q.124 A short bar magnet placed with its axis at 30º with uniform magnetic field of 0.16T, experiences a torque of magnitude 0.032 N-m. The potential energy of bar magnet in stable equilibrium and in unstable equilibrium respectively-
(1) –0.064 J, +0.064 J (2) –0.032 J, +0.032 J
(3) –0.016 J, +0.016 J (4) zero, zero

Q.125 Which of the following current carrying loop is in unstable equilibrium in the presence of uniform magnetic field ?

(1) 

(2) 

(3) 

(4) 

Q.126 Magnetic moment and angular momentum of an orbital electron are 'M' and L respectively. Specific charge of orbital electron-

(1) $\frac{M}{2L}$ (2) $\frac{2M}{L}$ (3) $\frac{L}{2M}$ (4) $\frac{2L}{M}$

Q.127 S.I. unit of Bohr's magnet on is equal to S.I. unit of which physical quantity-
(1) Magnetic field
(2) Magnetizing field
(3) Magnetic moment
(4) Magnetic permeability

Q.128 A particle of charge 'q' and mass 'm' is moving in a circular orbit with angular speed 'ω'. The ratio of its magnetic moment to that of its angular momentum depends on-
(1) ω, q (2) ω, q, m
(3) q, m (4) ω, m

Q.129 Magnetic moment of orbital electron in first orbit is μ_B then magnetic moment of that electron in third orbit-

(1) μ_B (2) $\frac{\mu_B}{3}$ (3) $3\mu_B$ (4) $9\mu_B$

Q.130 The north pole of earth's magnet is near the geographical -
(1) East (2) West
(3) North (4) South

Q.131 At a certain place, the horizontal component of earth's magnetic field is $\sqrt{3}$ times of the vertical component. The angle of dip at that place is-
(1) 60º (2) 45º (3) 90º (4) 30º

Q.132 A compass needle of magnetic moment is 60 A-m^2 pointing towards geographical north at a certain place, where the horizontal component of earth's magnetic field is 40μT, experiences a torque 1.2×10^{-3} N-m. The declination of that place is-
(1) 30º (2) 60º (3) 45º (4) 90º

Q.133 A freely suspended magnetic needle or bar magnet always stays in which direction-
(1) N-S (2) E-W
(3) N-E (4) in any direction

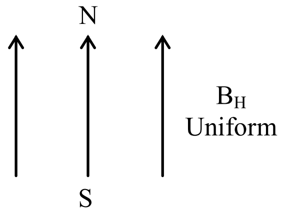
Q.134 A freely suspended current carrying coil or loop always stays in which direction -
(1) N-S (2) E-W
(3) N-E (4) in any direction

Q.135 Cosmic particles are coming from outer space towards the earth surface, then they are always deflected towards -
(1) North (2) South (3) East (4) West

Q.136 A straight horizontal wire placed on a table and currents from east to west, then the direction of magnetic force on wire-
(1) Vertical down
(2) Vertical up
(3) In horizontal plane
(4) No force

Passage(Q.No. 137 to 141) :

The magnetic field of earth is not constant and changes irregularly from place to place on the earth surface and even at a given place it varies with time too. But for above direction questions, earth's magnetic field in a small region is treated to be uniform i.e. its field lines are parallel to earth surface, equidistant and directed towards geographic south to geographic north.



Q.137 An electron moving along a horizontal line with respect to observer and towards north. Due to earth magnetic field it deflects towards east then position of observer-
(1) In NHS (2) In SHS
(3) At Equator (4) None

Q.138 If the dip circle is set at 45º to the magnetic meridian, then the apparent dip is 30º. The true dip of the place is-
(1) $\tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (2) $\tan^{-1}\left(\frac{1}{\sqrt{6}}\right)$
(3) $\tan^{-1}\left(\frac{2}{\sqrt{3}}\right)$ (4) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

Q.139 A magnetic needle is free to rotate in a vertical plane and that plane makes an angle of 60º with magnetic meridian. If the needle stays in a direction making an angle of $\tan^{-1}\left(\frac{2}{\sqrt{3}}\right)$ with respect to horizontal, what would be the actual dip at that place-
(1) 30º (2) 60º (3) 45º (4) 90º

Q.140 A dip needle arranged to move freely in the magnetic meridian, dip by an angle θ. If the vertical plane in which the needle moves, is rotated through an angle α with respect to the magnetic meridian than the needle may dip by an angle -
(1) θ (2) α
(3) More than θ (4) Less than θ

Q.141 A dip needle in a plane perpendicular to the magnetic meridian will remain-
(1) Vertical
(2) Horizontal
(3) In any direction
(4) Inclined at 45º with horizontal

Q.142 Time period of freely suspended bar magnet does not depends on-
(1) length of magnet
(2) magnetic strength of magnet
(3) horizontal component of earth's magnetic field
(4) length of suspension segment

Q.143 For oscillating magnetometer, time period of suspended bar magnet can be reduce by-
(1) moving it towards south pole
(2) moving it towards north pole
(3) moving it towards equator
(4) none of these

Q.144 A bar magnet is freely suspended in such a way that, when it oscillates in the horizontal plane. It makes 20 oscillations per minute at a place, where dip angle is 30º and 15 oscillations per minute at a place, where dip angle is 60º. Ratio of total earth's magnetic field at these two places-
(1) $9\sqrt{3} : 16$ (2) $9 : \sqrt{3}$
(3) $\sqrt{3} : 16$ (4) $16 : 9\sqrt{3}$

Q.145 Magnetic moments of two identical bar magnets are M and 2M respectively. Both are combined in such a way that their similar poles are together. The time period in this situation is T_1. If polarity of one of the magnet is reversed then its period becomes T_2 then-
(1) $T_1 > T_2$ (2) $T_1 < T_2$
(3) $T_1 = T_2$ (4) None of these

Q.146 Time period of thin bar magnet of vibration magnetometer is T. If it cuts into two equal parts in then the time period of each part fashions.
(a) Along or parallel to its length
(b) Perpendicular to its length
(1) T, T (2) T, T/2
(3) T/2, T (4) T/2, T/2

Q.147 The ratio of the magnetic field due to a small bar magnet in end on position to broad side on position is-
(1) 1/4 (2) 1/2 (3) 1 (4) 2

Q.148 The magnetic field at a point X on the axis of a small bar magnet is equal to the field at a point Y on the equator of the same magnet. The ratio of the distances of point X and Y from the centre of the magnet is-
(1) 2^{-3} (2) $2^{-1/3}$ (3) 2^3 (4) $2^{1/3}$

Q.149 If a wire in the earth's magnetic field carries a current vertically downwards, it is possible to obtain a neutral point -
(1) North of the wire (2) South of the wire
(3) East of wire (4) West of the wire

Q.150 A coil of 0.1 m radius and 100 turns placed perpendicular magnetic meridian. When current of 2 ampere is flow through the coil then the neutral point is obtained at its centre. Magnetizing field of earth in amp/m -
(1) 10 (2) 100
(3) 1000 (4) 10000

Q.151 A short bar magnet placed on the table along the north south line. Its north pole is directed towards geographic north then location of neutral points is-

(a) North (b) South (c) East (d) West

(1) a and b (2) c and d

(3) a and d (4) b and c

Q.152 A short magnet of moment 6.75 A-m^2 produces neutral on its axis. If the horizontal component of earth's magnetic field 5×10^{-5} Wb/m^2, then the distance of the neutral points from the centre of magnet -

(1) 10 cm (2) 20 cm

(3) 30 cm (4) 40 cm

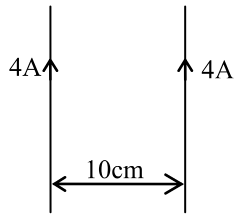
Q.153 When a magnet is placed vertical then the number of neutral point obtained in the plane of paper is-

(1) 1 (2) 2

(3) 4 (4) 3

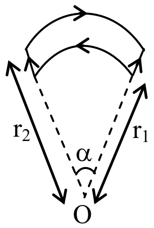
IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2

Q.1 Two current carrying parallel conductors are showing in the figure. The magnitude and nature of force acting between them per unit length will be-



(1) 8×10^{-8} N/m, attractive
(2) 3.2×10^{-5} N/m, repulsive
(3) 3.2×10^{-5} N/m, attractive
(4) 8×10^{-8} N/m, repulsive.

Q.2 The magnetic induction at centre O in the following figure, will be -



(1) $\frac{\mu_0 i\alpha}{4\pi}\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\odot$ (2) $\frac{\mu_0 i\alpha}{4\pi}\left(\frac{1}{r_1}+\frac{1}{r_2}\right)\odot$

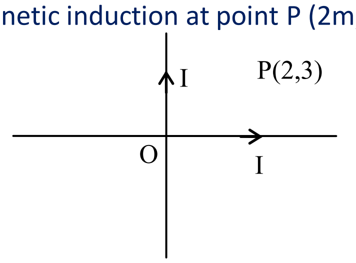
(3) $\frac{\mu_0 i\alpha}{2\pi}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]\otimes$ (4) $\frac{\mu_0 i\alpha}{2\pi}\left[\frac{1}{r_1}+\frac{1}{r_2}\right]\otimes$

Q.3 A ring of radius r is uniformly charged with charge q. If the ring is rotated with angular frequency ω, then the magnetic induction at its centre will be -

(1) $10^{-7} \times \frac{\omega}{qr}$ (2) $10^{-7} \times \frac{q}{\omega r}$

(3) $10^{-7} \times \frac{r}{q\omega}$ (4) $10^{-7} \times \frac{q\omega}{r}$

Q.4 Two mutually perpendicular insulated conducting wires carrying equal currents I, intersect at origin. Then the resultant magnetic induction at point P (2m, 3m) will be -



(1) $\frac{\mu_0 I}{5a}$ (2) $\frac{5\mu_0 I}{2\pi}$ (3) $\frac{\mu_0 I}{12\pi}$ (4) 0

Q.5 A linear conductor of length 40 cm is carrying a current of 3 ampere a is placed in a magnetic field of intensity 500 gauss. If a conductor is making an angle 30º with the field, then the force acting on it will be -

(1) 3×10^{4} N (2) 3×10^{2} N
(3) 3×10^{-2} N (4) 3×10^{-4} N

Q.6 Two parallel straight long conducting wires, which are placed at a distance r from each other, are carrying equal currents I in opposite directions. The value of magnetic induction at a point situated at a point situated x from one wire in between the wires will be -

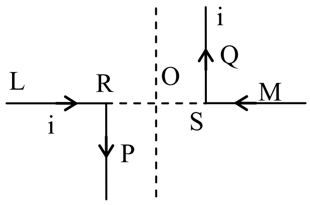
(1) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}-\frac{1}{x}\right\}$ (2) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}+\frac{1}{x}\right\}$

(3) $\frac{\mu_0 i}{2\pi(r-x)}$ (4) $\frac{\mu_0 i}{2\pi x}$

Q.7 If the ratio of magnetic fields at two point in a definite direction due to a current carrying wire is $\frac{3}{4}$, then the ratio of the distances of these points from the wire will be -

(1) $\frac{2}{\sqrt{3}}$ (2) $\frac{4}{3}$ (3) $\sqrt{\frac{3}{4}}$ (4) $\sqrt{\frac{3}{2}}$

Q.8 A pair of stationary and infinitely long bent wires are placed in the XY plane as shown in the figures. The wire carrying a current of 10 amp each as shown The segments L and M are along X-axis, the segments P and Q are parallel to Y-axis such that OS =OR = 0.02m. The direction and magnitude of magnetic induction at the origin is -



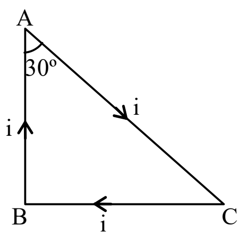
(1) $10^{-4}\ \frac{wb}{m^2}$ (2) $10^{-5}\ \frac{wb}{m^2}$

(3) $2 \times 10^{-4}\ \frac{wb}{m^2}$ (4) $2 \times 10^{-4}\ \frac{wb}{m^2}$

Q.9 The magnetic field strength at point Q distance r from a long straight wire carrying current i is (where Q lies perpendicular to one end of the conductor)

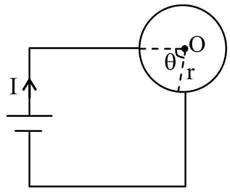
(1) $\frac{\mu_0 i}{2r}$ (2) $\frac{\mu_0 i}{4\pi r}$ (3) $\frac{\mu_0 i}{2\pi r}$ (4) $\frac{\mu_0 i}{\pi r}$

Q.10 A wire bent in the form of a right angled triangle ABC as shown in fig. carries a current 1A. it is placed in the region of a uniform magnetic induction field B = 0.2T as shown in fig. If AC = 1m. the net force on the wire is –



(1) 1.73 N (2) 3.46 N (3) 2.732 N (4) 0

Q.11 A circular coil of radius r is connected to a battery as shown in fig. The magnetic field at centre of the coil, due to coil is –



(1) $\frac{\mu_0 i}{2r}$ (2) $\frac{\mu_0 i}{2r}\left(\frac{\theta}{180}\right)$

(3) $\frac{\mu_0 i}{2\pi r}\theta$ (4) 0

Q.12 In the hydrogen atom, the electron revolves in a circular orbit of radius 0.53×10^{-10} metre and makes 6.6×10^{15} r.p.s. Then the magnetic induction at the centre of the orbit is approximately -

(1) 140 tesla (2) 12.5 tesla

(3) 1.4 tesla (4) 0.14 tesla

Q.13 A thin plastic ring of radius R having charge Q coulombs is rotated about its axis with angular frequency ω. The magnetic field intensity at the centre of the ring will be -

(1) $\frac{\mu_0 \omega Q}{4\pi R}$ (2) $\frac{\mu_0 \omega Q}{4R}$

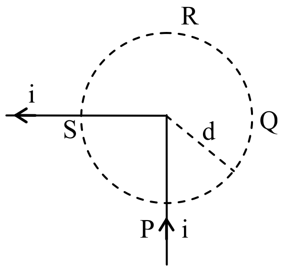
(3) $\frac{\mu_0 \omega Q}{8\pi R}$ (4) none of these

Q.14 500 turns are closely wound on a solenoid of length 50 cm. If the radius of the solenoid is 2 cm and 5 amp current is passed through it, the intensity of the magnetic field at the centre of the solenoid will be -

(1) 6.28×10^{-3} Wb/m^2 (2) 0

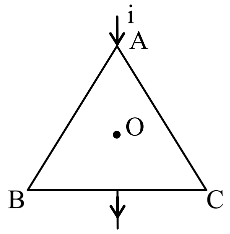
(3) 3.28×10^{-3} Wb/m^2 (4) 4.31×10^{-3} Wb/m^2.

Q.15 Figure shows a long wire bent at the middle to form a right angle. The magnitudes of the magnetic fields at the points Q and R are equal its value will be -



(1) $\frac{\mu_0 i}{4\pi d}$ (2) $\frac{\mu_0 i}{2\pi d}$ (3) $\frac{\mu_0 i}{\pi d}$ (4) $\frac{\mu_0 i}{d}$

Q.16 The wire ABC shown in figure forms an equilateral triangle. The magnetic field B at the centre O of the triangle assuming the wire to be uniforms, will be -

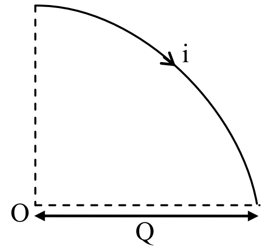


(1) ∞ (2) 0 (3) $\frac{\mu_0 i}{AB}$ (4) $\frac{\mu_0 i}{BC}$

Q.17 A tightly wound, long solenoid carries a current of 2.00 A. An electron is found to execute a uniform circular motion inside the solenoid with a frequency of 1.00×10^8 rev/s. The number of turns per metre in the solenoid will be -

(1) 142 turns/m (2) 1420 turns/m
(3) 152 turns/m (4) 1520 turns/m.

Q.18 A wire is bent in the form of a quadrant of circle of radius Q as shown in fig. The magnetic field at centre, due to a current i is-

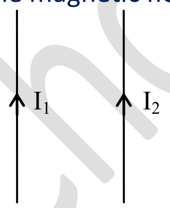


(1) $\frac{\mu_0 i}{2Q}$ (2) $\frac{\mu_0 i}{4Q}$ (3) $\frac{\mu_0 i}{8Q}$ (4) 0

Q.19 The magnetic field at a point 50 mm from a long straight line carrying a current of 3A will be -

(1) 0.12 G (2) 1.2 G
(3) 12 G (4) 0.012 G

Q.20 Two long straight parallel wires carry currents I_1 and I_2 respectively, in the same direction. The distance between the wires is R. The magnetic field at the centre of the two wires will be -



(1) $\frac{\mu_0(I_1 - I_2)}{\pi R}$ downward (If $I_1 > I_2$)

(2) $\frac{\mu_0(I_2 - I_1)}{\pi R}$ upward (if $I_2 > I_1$)

(3) $\frac{\mu_0(I_1 - I_2)}{\pi R}$ upward

(4) None of these

Q.21 A current i flows in a square loop of side 'a'. At the centre of the loop, value of B is -

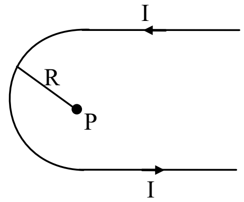
(1) 0 (2) $\frac{\mu_0 i}{2\pi a}$

(3) $\frac{2\sqrt{2}\mu_0 i}{2\pi a}$ (4) $\frac{2\sqrt{2}\mu_0 i}{\pi a}$

Q.22 A circular coil of 0.2m diameter has 100 turns and carries a current of 0.1 ampere. The intensity of magnetic field at the centre of the coil will be -

(1) 6.28×10^{-4} N/A.m
(2) 62.8×10^{-4} N/A.m
(3) 6.28×10^{-5} N/A.m
(4) 62.8×10^{-5} N/A.m

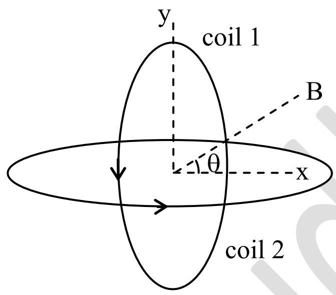
Q.23 What will be the magnetic field at point P in the figure below -



(1) $\frac{\mu_0 i}{4R}\left(\frac{2}{\pi}+1\right)$ (2) $\frac{\mu_0 i}{2R}\left(\frac{2}{\pi}+1\right)$

(3) $\frac{\mu_0}{2R}\left(\frac{2}{\pi}+1\right)$ (4) $\frac{2\mu_0}{R}\left(\frac{2}{\pi}+1\right)$

Q.24 For the arrangement of fig the magnetic field at the centre O will be -



(1) $\sqrt{2}\left(\frac{\mu_0 NI}{2a}\right)$ (2) $\frac{\mu_0 NI}{2\sqrt{2}a}$

(3) $\frac{\mu_0 NI}{2}$ (4) $\frac{\mu_0 NI}{2a}$

Q.25 A solenoid of length 0.2m has 500 turns on it. If 8.71×10^{-6} W/m^2 be the magnetic field at an end of the solenoid. then the current flowing in the solenoid will be -

(1) $\frac{0.0174}{\pi}$ amp. (2) $\frac{1.74}{\pi}$ amp.

(3) $\frac{17.4}{\pi}$ amp. (4) $\frac{174}{\pi}$ amp.

Q.26 A charge q is moving in a circular path with a frequency 'n'. The magnetic field at the centre of the path will be -

(1) $\frac{\mu_0 nq}{2R}$ (2) $\frac{\mu_0 nq}{R}$

(3) $\frac{\mu_0}{nq(2R)}$ (4) $\frac{\mu_0 n}{q(2R)}$

Q.27 An α-particle travels at an angle of 30º to a magnetic field 0.8T with a velocity of 10^5m/s. The magnitude of force will be -

(1) 12.8×10^{-14} N (2) $(1.28)\sqrt{3} \times 10^{-4}$N

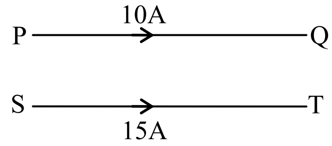
(3) 1.28×10^{-14} N (4) $(12.8)\sqrt{3} \times 10^{-4}$ N

Q.28 If a particle moves in a circular path in clockwise direction after entering in to a downward vertical magnetic field. The change on the particle is -

(1) positive (2) negative

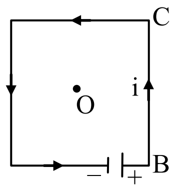
(3) nothing can be said (4) neutral

Q.29 In the adjoining fig the two parallel wires PQ and ST are at 30 cm apart. The currents flowing in the wires are according to fig. The force acting over a length of 5m of the wires is -



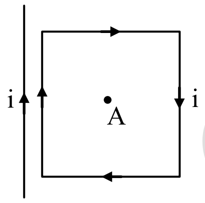
(1) 5×10^{-4} N,(attraction)
(2) 1×10^{-4},N, (attraction)
(3) 5×10^{-4} N, (repulsion)
(4) 1×10^{-4}N, (repulsion)

Q.30 Following is square loop, whose one arm BC produces magnetic field B at the centre of coil. The resultant magnetic field due to all the arms will be-



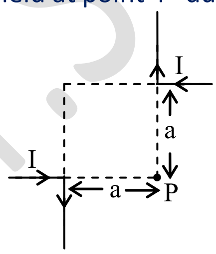
(1) 4B (2) B/2 (3) B (4) 2B

Q.31 A wire is parallel to one arm of a square current carrying loop, which also carries current. Now at any point A within the coil the magnetic field will be-



(1) less than the magnetic field produced due to loop only
(2) more than the magnetic field produced due to loop only
(3) equal to the earlier
(4) zero

Q.32 Magnetic field at point 'P' due to given current distribution-



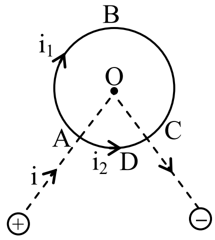
(1) $\frac{\mu_0 I}{4\pi a}\odot$ (2) $\frac{\mu_0 I}{2\pi a}\odot$ (3) $\frac{\mu_0 I}{\pi a}\otimes$ (4) Zero

Q.33 A current of 10 A is established in a long wire along positive z-direction. The magnetic field B at the point (1m, 0, 0) is-
(1) 1 μT along the –y direction
(2) 2μT along the +y direction
(3) 1μT along the –x direction
(4) 2μT along the +x direction

Q.34 Radius of current carrying coil is 'R'. Then ratio of magnetic fields at the centre of the coil to the axial point, which is $R\sqrt{3}$ distance away from the centre of the coil-
(1) 1 : 1 (2) 1 : 2 (3) 1 : 4 (4) 8 : 1

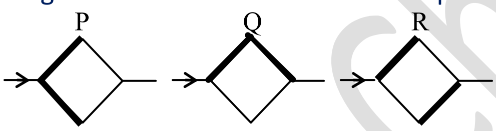
Q.35 At very close point on the axis of a current carrying circular coil (x<<<R) of radius 'R', the value of magnetic field decreases by a fraction of 5% with respect to centre value. The position of the point from the centre of the coil is-
(1) $\frac{R}{\sqrt{10}}$ (2) $\frac{R}{\sqrt{30}}$ (3) $\frac{R}{\sqrt{50}}$ (4) $\frac{R}{\sqrt{150}}$

Q.36 A circular conducting loop is connected by a battery according to figure. The length of ABC and ADC is ℓ_1 and ℓ_2 respectively then which is correct-



(1) $i_1/\ell_1 = i_2/\ell_2$ (2) $\frac{\ell_1^2}{i_1^2} = \frac{\ell_2^2}{i_2^2}$
(3) $i_1\ell_1 = i_2\ell_2$ (4) $i_1 i_2 = \ell_1\ell_2$

Q.37 Two thick wires and two thin wires, all of the same materials and same length form a square in the three different ways P, Q and R as shown in figure with current connection shown. The magnetic field at the centre of the square is zero in cases-



(1) in P only (2) in P and Q only
(3) in Q and R only (4) P and R only

Q.38 A current i flows along the length of an infinite long, straight, thin walled pipe, then-
(1) the magnetic field at all points inside the pipe is same but not zero
(2) the magnetic field at any point inside the pipe is zero
(3) the magnetic field is zero only on the axis of the pipe
(4) the magnetic field is different at different points inside the pipe

Q.39 If a long copper rod carries a direct current. The magnetic field associated with the current will be-
(1) inside the rod only
(2) outside the rod only
(3) both inside and outside of the rod
(4) neither inside nor outside the rod

Q.40 A steady electric current is flowing through a cylindrical wire-
(a) the electric field at the axis of wire is zero
(b) the magnetic field at the axis of wire is zero
(c) the electric field in the vicinity of wire is zero
(d) the magnetic field in the vicinity of wire is zero
(1) a. b. c (2) b, c
(3) only c (4) only b

Q.41 For the hollow thin cylindrical current carrying pipe which statement is correct-
(1) magnetic field inside the pipe is not zero
(2) magnetic field out side the pipe is zero
(3) electric field out side the pipe is zero
(4) electric field on the surface of pipe is zero

Q.42 In a current carrying long solenoid the field produced does not depend on-
(1) number of turns per unit length
(2) current in solenoid
(3) radius of cross section of the solenoid
(4) all of the above

Q.43 If length and number of turns becomes half for a solenoid then value of magnetic field becomes-
(1) twice (2) same
(3) half (4) one fourth

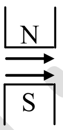
Q.44 If number of turns and current becomes double for any solenoid, then value of magnetic field becomes-
(1) twice (2) same
(3) half (4) four times

Q.45 A current of $1/4\pi$ ampere is flowing through a toroid. It has 1000 number of turn per meter then value of magnetic field (in wb/m^2) along its axis is-
(1) 10^{-2} (2) 10^{-3} (3) 10^{-4} (4) 10^{-7}

Q.46 Mean radius of a toroid is 10 cm and number of turns are 500. If current flowing through it is 0.1 ampere then value of magnetic field (in tesla) for toroid -
(1) 10^{-2} (2) 10^{-5} (3) 10^{-3} (4) 10^{-4}

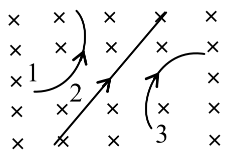
Q.47 A proton and an alpha particle are separately projected in a region where a uniform magnetic field exists. The initial velocities are perpendicular to the direction of magnetic field. If both the particles move along circles of equal radii, the ratio of momentum of proton to alpha particle $\left(\frac{P_\rho}{P_\alpha}\right)$ is-
(1) 1 (2) 1/2 (3) 2 (4) 4

Q.48 Cathode rays are moving between the poles of a magnet. Due to the effect of magnetic field of magnet-



(1) velocity of rays increases
(2) velocity of rays decreases
(3) rays deflected towards south pole
(4) rays deflected in upward direction and perpendicular to the plane of the paper

Q.49 The charges 1, 2, 3 are moves in uniform transverse magnetic field then-



(1) particle 1 positive and particle 3 negative
(2) particle 1 negative and particle 3 positive
(3) particle 1 negative and particle 2 neutral

(4) particle 1 and 3 are positive and particle 2 neutral

Q.50 Following charge has maximum frequency of rotation in uniform transverse magnetic field-
(1) a proton (2) an alpha particle
(3) an electron (4) a neutron

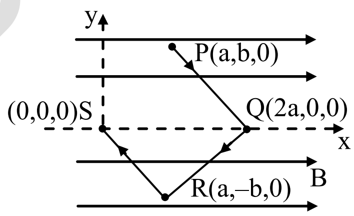
Q.51 Which of the following particle will experiences maximum magnetic force, when projected with the same velocity perpendicular to a magnetic field ?
(1) electron (2) proton
(3) He^{+} (4) Li^{++}

Q.52 When α and β rays are subjected to a magnetic field which is perpendicular to the direction of their motion, with their same speed. The curvature of path of both the particles are-
(1) equal (2) more for α particles
(3) more for β particles (4) none

Q.53 A charge particle moves along a circle under the action of possible electric and magnetic fields. Which of the following are possible-
(1) $E = 0, B = 0$ (2) $E = 0, B \neq 0$
(3) $E \neq 0, B = 0$ (4) $E \neq 0, B \neq 0$

Q.54 H^{+}, He^{+} and O^{++} all having the same kinetic energy pass through a region in which is a uniform magnetic field perpendicular to their velocity. The masses of H^{+}, He^{+} and O^{++} are 1 amu, 4 amu and 16 amu respectively then-
(a) H^{+} will be deflected most
(b) O^{++} will be deflected most
(c) He^{+} and O^{++} will be deflected equally
(d) all will be deflected equally
(1) a, b (2) a, b, c
(3) only a (4) a, c

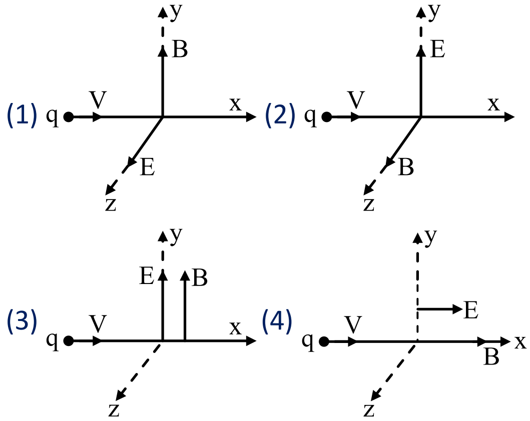
Q.55 A point charge q moves from point P to point S along the path PQRS (see fig) in a uniform magnetic field pointing along positive x-direction. The work done by the field in the above process is equal to-



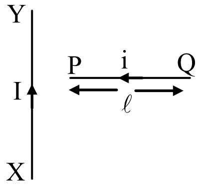
(1) zero (2) 2J (3) 4J (4) 6J

Q.56 If an electron of velocity $(2\hat{i}+3\hat{j})$ is subjected to magnetic field of $4\hat{k}$, then its-
(a) path will change
(b) speed does not change
(c) path must be circular
(d) momentum is constant
(1) a, b (2) All (3) a, b, c (4) none

Q.57 A particle of charge q and mass m is moving along the x-axis with a velocity v and enters a region of electric field E and magnetic field B as shown in figure below. For which figure the net force on the charge may be zero-

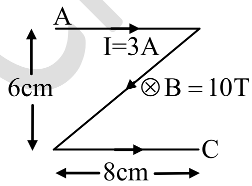


Q.58 A wire PQ carries a current 'i' is placed perpendicular to a long wire XY carrying a current I. The direction of force on PQ will be-



(1) towards right (2) towards left
(3) upwards (4) downwards

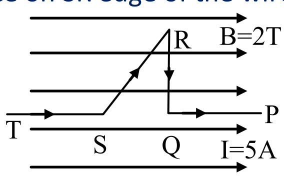
Q.59 A current carrying wire AC is placed in uniform transverse magnetic field then the force on wire AC -



(1) 3 N (2) 4.2 N (3) 6 N (4) 4 N

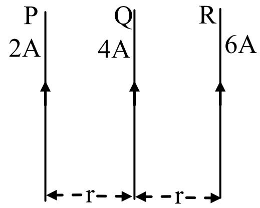
Q.60 Force exist on a current carrying wire which is placed in external magnetic field, due to-
(1) free electrons in wire
(2) free positive ions in wire
(3) (1) and (2) both
(4) none

Q.61 A wire PQRST carrying current I = 5A is placed in uniform magnetic field B = 2T as shown in figure. If the length of part QR = 4 cm and SR = 6 cm then the magnetic force on SR edge of the wire is-



(1) 0.4 N (2) 0.6 N (3) zero (4) 6 N

Q.62 P, Q and R long parallel straight wires in air, carrying currents as shown. The direction of resultant force on R is-



(1) towards left
(2) towards right
(3) the same as that of current in Q
(4) perpendicular to plane of paper

Q.63 Due to the flow of current in a circular loop of radius R, the magnetic field produced at the centre of the loop is B. The magnetic moment of the loop is-
(1) $BR^3/2\pi\mu_0$ (2) $2\pi BR^3/\mu_0$
(3) $BR^2/2\pi\mu_0$ (4) $2\pi BR^2/\mu_0$

Q.64 The magnetic moment of circular current carrying loop is-
(1) directly proportional to the length of the wire
(2) inversely proportional to the length of the wire
(3) directly proportional to the square of the length of the wire
(4) inversely proportional to the square of the length of the wire

Q.65 Which of the following will experience a force due to uniform magnetic field -
(1) an iron rod
(2) a magnetic needle
(3) static charge
(4) a conductor carrying current

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3

Q.1 A wire of length L carries a current of I ampere on bending it into a circle, the value of its magnetic moment will be-
(1) IL^2 (2) $IL^2/2\pi$ (3) IL^2/π (4) $IL^2/4\pi$

Q.2 A small bar magnet of moment M is placed in a uniform field B. If magnet makes an angle of 30º with field. The torque acting on the magnet is-
(1) MB (2) MB/2 (3) MB/3 (4) MB/4

Q.3 A magnetic needle suspended horizontally by a silk fibre, oscillates in the horizontal plane because of the restoring torque originating mainly from-
(1) The torsion of the silk fibre
(2) The force of gravity
(3) The horizontal component of earth's magnetic field
(4) All the above factors

Q.4 The period of oscillation of a magnet in vibration magnetometer is 2 sec. The period of oscillation of a magnet whose magnetic moment is four times that of the first magnet is-
(1) 1 sec (2) 4 sec
(3) 8 sec (4) 0.5 sec

Q.5 Unit of magnetic flux density is-
(1) tesla
(2) weber/metre^2
(3) newton/ampere-metre
(4) All of the above

Q.6 A charged particle is moving with velocity v under the magnetic field B. The force acting on the particle will be maximum if-
(1) v and B are in same direction
(2) v and B are in opposite direction
(3) v and B are perpendicular
(4) None

Q.7 The radius of circular loop is r and a current i is flowing in it. The equivalent magnetic moment will be-
(1) i r (2) 2π i r
(3) i πr^2 (4) i/r^2

Q.8 At certain place the angle of dip is 30º and the horizontal component of earth magnetic field is 0.50 orested. The earth's total magnetic field(in orested) is-
(1) $\sqrt{3}$ (2) 1
(3) $1/\sqrt{3}$ (4) 1/2

Q.9 The angle of dip at the magnetic equator is-
(1) 0º (2) 45º
(3) 30º (4) 90º

Q.10 At Geo-magnetic poles, the angle of dip is-
(1) 45º (2) 30º

(3) zero (4) 90º

Q.11 The time period of a freely suspended magnet is 4 sec. If it is broken perpendicular to its length into two equal parts and one part is suspended in the same way, then its time period in seconds will be-
(1) 4 (2) 2
(3) 0.5 (4) 0.25

Q.12 The order of relative magnetic permeability of soft iron is-
(1) zero (2) 10^3
(3) 10^2 (4) 10^5

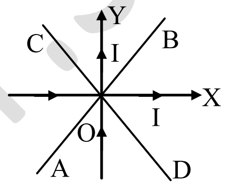
Q.13 At magnetic north pole of the earth the value of horizontal component B_H and angle of dip θ is-
(1) $B_H = 0º$, $\theta = 45º$ (2) $B_H = 90º$, $\theta = 0º$
(3) $B_H = 0º$, $\theta = 90º$ (4) $B_H = 45º$, $\theta = 45º$

Q.14 A magnet of magnetic moment M is rotating through 360º with respect to the magnetic field B, the work done will be-
(1) MB (2) 2MB
(3) 2πMB (4) Zero

Q.15 The work done in rotating a magnet of magnetic moment M by an angle of 90º from the external magnetic field direction is 'n' times the corresponding work done to turn it through an angle of 60º. Where 'n' gives by-
(1) 1/2 (2) 2
(3) 1/4 (4) 1

Q.16 A magnetic field of 5.0×10^{-4} T just perpendicular to the electric field of 15 kV/m in their effect and electron beam passes undeflected and perpendicular to both of them. The speed of the electrons is-
(1) 75 m/s (2) 3×10^4 m/s
(3) 7.5×10^4 m/s (4) 3×10^7 m/s

Q.17 There are two straight long wires, insulated from each other, along x and y axis carrying equal currents as shown in figure. AB and CD are lines in xy plane and at 45º with the axes. The magnetic field of the system is zero at points on the line-



(1) AB
(2) OB but not on OA
(3) CD
(4) OC but not on OD

Q.18 An electron, moving in a circular orbit of radius 'R' with a period T. The equivalent magnetic dipole moment of circular orbit is-
(1) $2\pi eR/T$
(2) $\pi eR/T$
(3) $2\pi eR^2T$
(4) $\pi R^2e/T$

Q.19 Two parallel wires in free space are 10 apart and each carries a current of 10 A in the same direction. The magnetic force per unit length of each wire is-
(1) 2×10^{-4} N, attractive
(2) 2×10^{-4} N, repulsive
(3) 2×10^{-7} N, attractive
(4) 2×10^{-7} N, repulsive

Q.20 A positively charged particle moving due east enters a region of uniform magnetic field directed vertically upwards. The particle will -
(1) get deflected vertically upwards
(2) move in a circular orbit with its speed increased
(3) move in a circular orbit with its speed unchanged
(4) continue to move due east

Q.21 Due to the earth's magnetic field, charged cosmic particles-
(1) require greater kinetic energy to reach the equator than the poles
(2) require less kinetic energy to reach the equator that the poles
(3) can never reach the equator
(4) can never reach the poles

Q.22 A straight wire of diameter 0.5 mm carrying a current of 1A is replaced by another wire of 1 mm diameter carrying the same current. The strength of the magnetic field far away is-
(1) twice the earlier value
(2) half of the earlier value
(3) quarter of its earlier value
(4) unchanged

Q.23 For protecting a magnetic needle it should be placed-
(1) in an iron box
(2) in wooden box
(3) in metallic box
(4) none of these

Q.24 A coil of one loop is made by a wire of length L and there after a coil of two loops is made by same wire. The ratio of magnetic field at the centre of coils respectively.
(1) 1 : 4 (2) 1 : 1
(3) 1 : 8 (4) 4 : 1

Q.25 Two long parallel wires are at a distance of 1m. If both of them carry 1A of current in same direction. The magnetic force of attraction on unit length of each wire will be-
(1) 2×10^{-7} N/m (2) 4×10^{-7} N/m
(3) 8×10^{-7} N/m (4) 10^{-7} N/m

Q.26 A current carrying coil (I = 5A, R = 10cm) having 50 number of turns then magnetic field at its centre-
(1) 1.57 mT (2) 3.14 mT
(3) 1 mT (4) 2 mT

Q.27 For a vibration magnetometer, the time period of suspended bar magnet can be reduced by-
(1) moving it towards south pole
(2) moving it towards north pole
(3) moving it towards equator

(4) anyone of them

Q.28 Two identically charged particles A and B initially at rest, are accelerated by a common potential difference V. They enters into a uniform transverse magnetic field B and describe a circular path of radii r_1 and r_2 respectively then their mass ratio is-

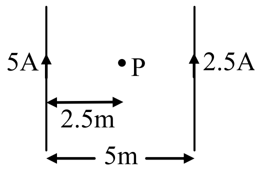
(1) $\left(\frac{r_1}{r_2}\right)^2$

(2) $\left(\frac{r_2}{r_1}\right)^2$

(3) $\left(\frac{r_1}{r_2}\right)$

(4) $\left(\frac{r_2}{r_1}\right)$

Q.29 For the given current distribution the magnetic field at point, 'P' is-



(1) $\frac{\mu_0}{4\pi}\odot$ (2) $\frac{\mu_0}{\pi}\otimes$

(3) $\frac{\mu_0}{2\pi}\otimes$ (4) $\frac{\mu_0}{2\pi}\odot$

Q.30 A charge having q/m equal to 10^8 C/kg and with velocity 3×10^5 m/s enters into a uniform magnetic field B = 0.3 tesla at an angle 30º with direction of field. Then radius of curvature will be-

(1) 0.01 m (2) 0.5 m

(3) 1 cm (4) 2 cm

Q.31 An electron having mass 'm' and kinetic energy E enter in uniform magnetic field B perpendicularly, then its frequency of uniform circular motion will be-

(1) $\frac{eE}{qVB}$ (2) $\frac{2\pi m}{eB}$

(3) $\frac{eB}{2\pi m}$ (4) $\frac{2m}{eBE}$

Q.32 In Thomson mass spectrograph $\vec{E}\perp\vec{B}$ then the velocity of undeflected electron beam will be-

(1) $\frac{|\vec{E}|}{|\vec{B}|}$ (2) $\vec{E}\times\vec{B}$

(3) $\frac{|\vec{B}|}{|\vec{E}|}$ (4) $\frac{E^2}{B^2}$

Q.33 Tangent galvanometer is used to measure-

(1) Potential difference

(2) Current

(3) Resistance

(4) Charge

Q.34 If number of turn, area and current through the coil is given by n, A and i respectively then its magnetic moment will be-

(1) niA (2) n^2iA (3) niA^2 (4) $\frac{ni}{\sqrt{A}}$

Q.35 A charge 'q' moves in a region where electric field and magnetic field both exist, then force on it-

(1) $q(\vec{v}\times\vec{B})$

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

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

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

Q.36 Two bar magnets having same geometry with magnetic moments M and 2M, are firstly placed in such a way that their similar poles are same side then its time period of oscillation is T_1. Now the polarity of one of the magnet is reversed then time period of oscillation is T_2, then-

(1) $T_1 < T_2$ (2) $T_1 = T_2$

(3) $T_1 > T_2$ (4) $T_2 = \infty$

Q.37 A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of the magnetic field is-

(1) B/2 (2) B

(3) 2B (4) 4B

Q.38 A charged particle moves through a magnetic field in a direction perpendicular to it. Then the-

(1) speed of the particle remains unchanged

(2) direction of motion of particle remains unchanged

(3) acceleration of particle remains unchanged

(4) velocity of particle remains unchanged

Q.39 A bar magnet is oscillating in the Earth's magnetic field with a period T. What happens to its period and motion if its mass is quadrupled-

(1) motion remains S.H.M with time period = $\frac{T}{2}$

(2) motion remains S.H.M with time period = 2T

(3) motion remains S.H.M with time period = 4T

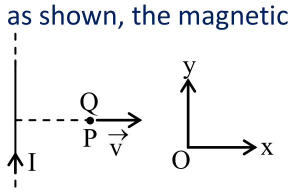
(4) motion remains S.H.M and period remains nearly constant

Q.40 An electron moves in a circular orbit with a uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is proportional to-

(1) $\sqrt{\frac{v}{B}}$ (2) $\frac{v}{B}$

(3) $\frac{B}{v}$ (4) $\sqrt{\frac{B}{v}}$

Q.41 A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity $\vec{v}$, as shown, the magnetic force on the charge is-



(1) along ox (2) opposite to oy

(3) along oy (4) opposite to ox

Q.42 A loop in the shape of an equilateral triangle of side ℓ is suspended between the pole pieces of a permanent magnet such that $\vec{B}$ is in plane of the loop. If due to a current i in the triangle a torque τ acts on it, the side ℓ of the triangle is-

(1) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)$ (2) $\frac{1}{\sqrt{3}}\frac{\tau}{Bi}$

(3) $2\left(\frac{\tau}{\sqrt{3}Bi}\right)^{1/2}$ (4) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)^{1/2}$

Q.43 When a charged particle moving with velocity $\vec{v}$ is subjected to a magnetic field of induction $\vec{B}$, the force on it is non-zero. This implies the-
(1) angle between $\vec{v}$ and $\vec{B}$ is necessary 90º
(2) angle between $\vec{v}$ and $\vec{B}$ can have at value other than 90º
(3) angle between $\vec{v}$ and $\vec{B}$ can have at value other than zero and 180º
(4) angle between $\vec{v}$ and $\vec{B}$ can have at value other than zero and 180º

Q.44 Two circular loop 1 and 2 are made by the same copper wire but the radius of the 1^{st} loop is twice that of the 2^{nd} loop, what is ratio of potential difference applied across the loops. If the magnetic field produced at their centres is equal -
(1) 3 (2) 4
(3) 6 (4) 2

Q.45 Under the influence of a uniform magnetic field a charged particle is moving in a circle of radius R with constant speed v. The time period of the motion-
(1) depends on R and not on v
(2) depends on v and not on R
(3) depends on both R and v
(4) is independent of both R and v

Q.46 A charged particle (q) is moving in a circle of radius R with uniform speed v. The associated magnetic moment μ is given by-
(1) q v R (2) q v R/2
(3) q v R^2 (4) qv R^2/2

Q.47 A beam of electrons passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons move-
(1) along a straight line
(2) in an elliptical orbit
(3) in a circular orbit
(4) along a parabolic path

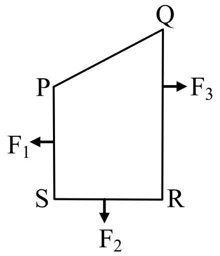
Q.48 In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then make to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{Charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to-

(1) R (2) $\frac{1}{R}$

(3) $\frac{1}{R^2}$ (4) R^2

Q.49 A particle of mass m, charge Q and kinetic energy T enters a transverse uniform magnetic field of induction $\vec{B}$. After 3 seconds the kinetic energy of the particle will be-
(1) T (2) 4 T
(3) 3 T (4) 2 T

Q.50 A closed loop PQRS carrying a current is placed in a uniform magnetic field. If the magnetic forces on segments PS, SR and RQ are F_1, F_2 and F_3 respectively and are in the plane of the paper and along the directions shown, the force on the segment QP is-



(1) $\sqrt{(F_3 - F_1)^2 - F_2^2}$ (2) $F_3 - F_1 - F_2$
(3) $F_3 - F_1 - F_2$ (4) $\sqrt{(F_3 - F_1)^2 + F_2^2}$

Q.51 A circular disc of radius 0.2 meter is placed in a uniform magnetic field of $\frac{1}{\pi}$ wb/m^2 in such way that its axis makes an angle of 60º with $\vec{B}$. The magnetic flux linked with the disc is-
(1) 0.08 wb (2) 0.01 wb
(3) 0.02 wb (4) 0.06 wb

Q.52 Under the influence of a uniform magnetic field, a charged particle moves with constant speed V in a circle of radius R. The time period of rotation of the particle-
(1) depends on V and not on R
(2) depends on R and not on V
(3) is independent of both V and R
(4) depends on both V and R

Q.53 The magnetic force acting on a charged particle of charge –2μc in a magnetic field of 2T acting in y direction, when the particle velocity is $(2\hat{i} + 3\hat{j}) \times 10^6$ m/s, is-
(1) 8N in –z direction (2) 4N in –z direction
(3) 8N in –y direction (4) 4N in –y direction

Q.54 A bar magnet having a magnetic moment of 2×10^4 J/T is free to rotate in a horizontal plane. A horizontal magnetic field $B = 6 \times 10^{-4}$ T exists in the space. The work done in taking the magnet slowly from a direction parallel to the field to a direction 60º from the field is-
(1) 0.6 J (2) 12 J (3) 6 J (4) 2 J

Q.55 A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$, the net force on the remaining three arms of the loop is-
(1) $\vec{F}$ (2) 3 $\vec{F}$ (3) – $\vec{F}$ (4) –3 $\vec{F}$

Q.56 A thin ring of radius R meter has charge q coulomb uniformly spread on it. The ring rotates about its axis with a constant frequency of f revolutions/s. The value of magnetic induction in Wb/m^2 at the centre of the ring is-

(1) $\frac{\mu_0 qf}{2R}$ (2) $\frac{\mu_0 qf}{2\pi R}$ (3) $\frac{\mu_0 q}{2\pi fR}$ (4) $\frac{\mu_0 q}{2fR}$

Q.57 A beam of cathode rays is subjected to crossed Electric (E) and Magnetic field (B). The fields are adjusted such that the beam is not deflected. The specific charge of the cathode rays is given by-

(1) $\frac{E^2}{2VB^2}$ (2) $\frac{B^2}{2VE^2}$ (3) $\frac{2VB^2}{E^2}$ (4) $\frac{2VE^2}{B^2}$

(Where V is the potential difference between cathode and anode)

Q.58 A current loop consists of two identical semicircular parts each of radius R, one lying in the x-y plane and the other in x-z plane. If the current in the loop is i, the resultant magnetic field due to the two semicircular parts at their common centre is-

(1) $\frac{\mu_0 i}{2R}$ (2) $\frac{\mu_0 i}{4R}$ (3) $\frac{\mu_0 i}{\sqrt{2}R}$ (4) $\frac{\mu_0 i}{2\sqrt{2}R}$

Q.59 A closely wound solenoid of 2000 turns and area of cross-section 1.5×10^{-4} m^2 carries a current of 2.0 A. It is suspended through its centre and perpendicular to its length, allowing it to turn in a horizontal plane in a uniform magnetic field 5×10^{-2} Telsa making an angle of 30º with the axis of the solenoid. The torque on the solenoid will be-

(1) 1.5×10^{-3} N.m (2) 1.5×10^{-2} N.m
(3) 3×10^{-2} N.m (4) 3×10^{-3} N.m

Q.60 A particle having a mass of 10^{-2} kg carries a charge of 5×10^{-8} C. The particle is given an initial horizontal velocity of 10^5 m/s in the presence of electric field $\vec{E}$ and magnetic field $\vec{B}$. To keep the particle moving in a horizontal direction, it is necessary that-

(a) $\vec{B}$ should be perpendicular to the direction of velocity and $\vec{E}$ should be along the direction of velocity
(b) Both $\vec{B}$ and $\vec{E}$ should be along the direction of velocity
(c) Both $\vec{B}$ and $\vec{E}$ are mutually perpendicular and perpendicular to the direction of velocity
(d) $\vec{B}$ should be along the direction of velocity and $\vec{E}$ should be perpendicular to the direction of velocity

Which one of the following pairs of statements is possible ?

(1) (c) and (d) (2) (b) and (c)
(3) (b) and (d) (4) (a) and (c)

Q.61 An electric charge in uniform motion produces-
(1) electric field only
(2) magnetic field only
(3) both electric and magnetic field
(4) neither electric nor magnetic field

Q.62 Force between two identical bar magnets whose centres are r meter apart is 4.8 N when their axes are in same line. If separation is increased to 2r, the force between them is reduced to-

(1) 2.4 N (2) 1.2 N
(3) 0.6 N (4) 0.3 N

Q.63 A beams of electrons moving along +y direction enters in a region of uniform electric and magnetic fields. If the beam goes undefected through this region then field (B) and (E) are directed respectively-

(1) –y axis and –z axis (2) +z axis and –x axis
(3) +x axis and –x axis (4) –x axis and –y axis

Q.64 A compass needle will show which of the following directions at the earth's magnetic pole-
(1) no particular direction
(2) bent at 45º to the vertical
(3) horizontal
(4) vertical

Q.65 The north pole of the earth's magnet is near the geographical-
(1) east pole (2) west pole
(3) north pole (4) south pole

Q.66 The period of oscillation of a vibration magnetometer depends on the following factors-
(1) M and B_H only (2) I and H only
(3) I, M and B_H only (4) I and M only

Q.67 Angle of dip is 90º is-
(1) Magnetic poles (2) Magnetic equator
(3) (1) & (2) both (4) none of these

Q.68 A charged particle enters a magnetic field B with its initial velocity making an angle of 45º with B. The path of the particle will be-
(1) a straight line (2) a circle
(3) an ellipse (4) a helix

Q.69 A magnet makes 40 oscillations per minute at a place having magnetic field of 0.1×10^{-5} T. At another place, it takes 2.5 sec to complete one vibration. The value of earth's horizontal field at that place is-
(1) 0.25×10^{-6} T (2) 0.36×10^{-6} T
(3) 0.66×10^{-8} T (4) 1.2×10^{-6} T

Q.70 The magnetic needle of a tangent galvanometer is deflected at an angle 30º. The horizontal component of earth's magnetic field 0.34×10^{-4} T is along the plane of the coil. The magnetic field of coil-
(1) 1.96×10^{-4} T (2) 1.96×10^{-5} T
(3) 1.96×10^{4} T (4) 1.96×10^{5} T

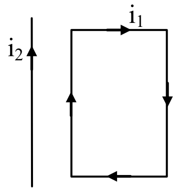
Q.71 Cyclotron is used to accelerate-
(1) electrons (2) neutrons
(3) positive ions (4) negative ions

Q.72 A closely wound flat circular coil of 25 turns of wire has diameter of 10 cm and carries a current of 4 ampere. Determine the magnetic flux density at the centre of the coil-
(1) 1.679×10^{-5} T (2) 2.028×10^{-4} T
(3) 1.257×10^{-3} T (4) 1.512×10^{-6} T

Q.73 The earth's magnetic field at a given point is 0.5×10^{-5} Wb m^{-2}. This field is to be annulled by magnetic field at the centre of a circular conducting loop of radius 5.0 cm. The current required to be flown in the loop is nearly-
(1) 0.2 A (2) 0.4 A (3) 4 A (4) 40 A

Q.74 An electron is travelling along the x-direction. It encounters a magnetic field in the y-direction. Its subsequent motion will be-
(1) straight line along the x-direction
(2) a circle in the zx-plane
(3) a circle in the yz-plane
(4) a circle in the xy-plane

Q.75 A rectangular loop carrying a current i_1, is situated near a long straight wire carrying a steady current i_2. The wire is parallel to one of the sides of the loop and is in the plane of the loop as shown in the figure. Then the current loop will-



(1) move away from the wire
(2) move towards the wire
(3) remain stationary
(4) rotate about an axis parallel to the wire

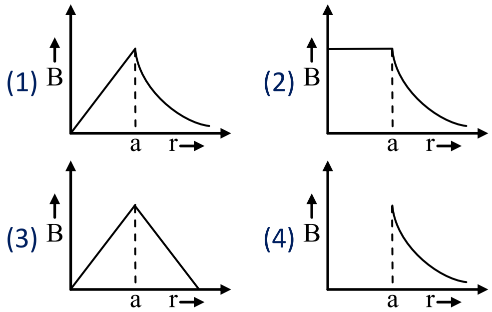
Q.76 Using mass (M), length (L), time (T) and current (A) as fundamental quantities, the dimension of permeability is-
(1) $M^{-1}LT^{-2}A^{1}$ (2) $ML^{2}T^{-2}A^{-1}$
(3) $MLT^{-2}A^{-2}$ (4) $MLT^{-1}A^{-1}$

Q.77 A proton and an α-particle moving with the same velocity and enter into a uniform magnetic field which is acting normal to the plane of their motion. The ratio of the radii of the circular paths described by the proton and α-particle respectively-
(1) 1 : 2 (2) 1 : 4 (3) 1 : 16 (4) 4 : 1

Q.78 Two parallel beams of positrons moving in the same direction will-
(1) repels to each other
(2) will not interact with each other
(3) attracts to each other
(4) Be deflected normal to the plate containing the two beams

Q.79 A circular coil of radius R carries an electric current. The magnetic field due to the coil at a point on the axis of the coil located at a distance r from the center of the coil, such that r >> R varies as-
(1) $1/r$ (2) $1/r^{3/2}$ (3) $1/r^2$ (4) $1/r^3$

Q.80 The magnetic field due to a straight wire of uniform cross section radius a and carrying a steady current is represented by-



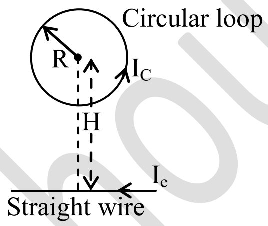
Q.81 The magnetic moment of a current (I) carrying circular coil of radius (r) and number of turns (n) varies as-
(1) $1/r^2$ (2) $1/r$ (3) r (4) r^2

Q.82 The cyclotron frequency of an electron gyrating in a magnetic field of 1 T is approximately-
(1) 28 Hz (2) 280 MHz
(3) 2.8 GHz (4) 28 GHz

Q.83 The magnetic moment (μ) of a revolving electron around the nucleus varies with principal quantum number n as-
(1) $\mu \propto n$ (2) $\mu \propto 1/n$
(3) $\mu \propto n^2$ (4) $\mu \propto 1/n^2$

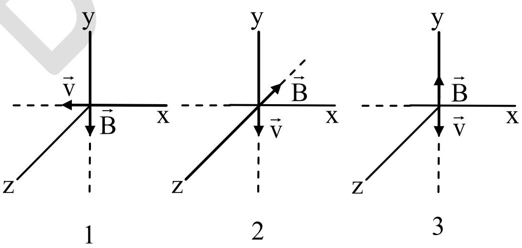
Q.84 The magnetic moment has dimensions of-
(1) [L A] (2) [L^2 A]
(3) [LT^{-1} A] (4) [L^2T^{-1} A]

Q.85 Circular loop of a wire and a long straight wire carry currents I_C and I_e, respectively as shown in figure. Assuming that these are placed in the same plane. The magnetic fields will be zero at the centre of the loop when the separation H is-



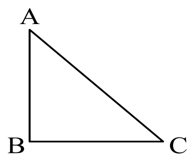
(1) $\frac{I_eR}{I_C\pi}$ (2) $\frac{I_CR}{I_e\pi}$ (3) $\frac{\pi I_C}{I_eR}$ (4) $\frac{I_C\pi}{I_CR}$

Q.86 The figure shows three situation when an electron with velocity $\vec{v}$ travels through a uniform magnetic field $\vec{B}$. In each case, what is the direction of magnetic force on the electron?



(1) +ve z-axis, –ve x-axis, +ve y-axis
(2) –ve z-axis, –ve x-axis and zero
(3) +ve z-axis, +ve x-axis and zero
(4) –ve z-axis, +ve x-axis and zero

Q.87 A current carrying closed loop in the form of a right angle isosceles triangle ABC is placed in a uniform magnetic field acting along AB. If the magnetic force on the arm BC is $\vec{F}$, the force on the arm AC is :



(1) $\sqrt{2}\,\vec{F}$ (2) $-\sqrt{2}\,\vec{F}$ (3) $-\vec{F}$ (4) $\vec{F}$

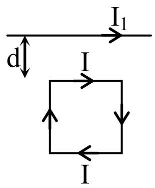
Q.88 There are four light-weight-rod samples A,B,C, D separately suspended by threads. A bar magnet is slowly brought near each sample and the following observations are noted :
(1) A is feebly repelled
(2) B is feebly attracted
(3) C is strongly attracted
(4) D remains unaffected
Which one of the following is true ?
(1) A is of a non-magnetic material
(2) B is of a paramagnetic material
(3) C is of a diamagnetic material
(4) D is of a ferromagnetic material

Q.89 A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron :
(1) will turn towards left of direction of motion
(2) will turn towards right of direction of motion
(3) speed will decrease
(4) speed will increase

Q.90 Charge q is uniformly spread on a thin ring of radius R. The ring rotates about its axis with a uniform frequency *f* Hz. The magnitude of magnetic induction at the center of the ring is
(1) $\frac{\mu_0 qf}{2\pi R}$ (2) $\frac{\mu_0 qf}{2R}$
(3) $\frac{\mu_0 q}{2fR}$ (4) $\frac{\mu_0 q}{2\pi fR}$

Q.91 A short bar magnet of magnet moment 0.4 JT^{-1} is placed in a uniform magnetic field of 0.16 T. The magnet is in stable equilibrium when the potential energy is :
(1) 0.064 J (2) – 0.064 J
(3) Zero (4) – 0.082 J

Q.92 A square loop, carrying a steady current I, is placed in a horizontal plane near a long straight conductor carrying a steady current I_1 at a distance d from the conductor as shown in figure. The loop will experience :



(1) a net attractive force tawards the conductor
(2) a net repulsive force away from the conductor
(3) a net torque acting upward perpendicular to the horizontal plane
(4) a net torque acting downward normal to the horizontal plane

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4

Q.1 The orbital angular momentum of an electron is L, then its magnetic moment will be-

(1) $\frac{eLm}{2}$ (2) $\frac{2m}{eL}$

(3) $\frac{eL}{2m}$ (4) $\frac{mL}{2e}$

Q.2 Magnetic field is produced by the flow of current in a straight wire. This phenomenon is based on-

(1) Faraday's Law (2) Maxwell's Law

(3) Coulomb's Law (4) Orested's Law

Q.3 Following is the Biot-savart's law in vector form-

(1) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\ell \sin\theta}{r}\hat{n}$

(2) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\ell \sin\theta}{r^3}\hat{n}$

(3) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\ell \sin\theta}{r^2}\hat{n}$

(4) None

Q.4 If the intensity of magnetic field at a point on the axis of current coil is half of that at the centre of the coil, then the distance of that from the centre of the coil will be-

(1) $\frac{R}{2}$ (2) R

(3) $\frac{3R}{2}$ (4) 0.766 R

Q.5 The pattern of magnetic lines of force produced by passing a direct current in a straight wire is-

(1) Perpendicular to the conductor and coming outward

(2) Perpendicular to the conductor and going inward

(3) Parallel to conductor

(4) surrounding the conductor and of circular nature

Q.6 The field produced by a moving charged particle is-

(1) Electric (2) Magnetic

(3) Both of the above (4) None of above

Q.7 If a charged particle enters into a uniform magnetic field neither perpendicular, nor parallel than its path will be-

(1) Straight line (2) Elliptical

(3) Helical (4) Parabola

Q.8 The force acts for a conducting loop when magnetic fields is-

(1) Perpendicular to the plane

(2) Parallel to plane of loop

(3) Antiparallel to plane of loop

(4) None of the above

Q.9 An electron revolving with speed V in any orbit of radius 'r' then value of current is-

(1) $\frac{eV}{2\pi r}$ (2) $\frac{2\pi r}{eV}$

(3) $eV \times 2\pi r$ (4) $\frac{4\pi r}{eV}$

Q.10 The magnetic moment of a straight wire of length L is M. If the wire is bent in form of a semicircle then its magnetic moment becomes-

(1) $\frac{2M}{\pi}$ (2) $\frac{M}{\pi}$

(3) M (4) $M\pi$

Q.11 The dimension of intensity of magnetic field is-

(1) $[M^0L^{-1}T^0A^1]$ (2) $[M^1L^1T^{-2}A^{-1}]$

(3) $[M^1L^0T^{-1}A^{-1}]$ (4) $[M^1L^1T^{-2}A^1]$

Q.12 The torque acting on a current carrying loop placed in magnetic field does not depend upon-

(1) shape of loop (2) area of loop

(3) value of current (4) magnetic field

Q.13 Two long thin parallel wires are placed at a distance (r) from each other carrying equal current I in opposite direction. The magnitude of force per unit length which is exerted by each wire on the other is-

(1) $\frac{\mu_0 I^2}{r}$ (2) $\frac{\mu_0 I^2}{2\pi r}$

(3) $\frac{\mu_0 I}{2\pi r}$ (4) $\frac{\mu_0^2 I}{2\pi r^2}$

Q.14 The unit of magnetic permeability is-

(1) $\frac{\text{weber}}{\text{amper} - \text{metre}}$ (2) $\frac{\text{weber}}{\text{metre}}$

(3) $\frac{\text{tesla}}{\text{ampere}}$ (4) $\frac{\text{tesla}}{\text{metre}}$

Q.15 In Ban bridge spectrograph the electric field is 10^4 volt/m and magnetic field is 1 T, then the velocity of undeflected postiive ions is-

(1) 10^7 m/s (2) 10^4 m/s

(3) 10^5 m/s (4) 10^2 m/s

Q.16 An electron is moving with velocity $\vec{v}$ in the direction of magnetic field $\vec{B}$, then force acting on electron is-

(1) zero (2) $e(\vec{v} \times \vec{B})$

(3) $e(\vec{B} \times \vec{v})$ (4) None

Q.17 Speed of light in vacuum is-

(1) $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ (2) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$

(3) $\sqrt{\mu_0 \varepsilon_0}$ (4) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$

Q.18 Magnetic moment of 'Neon' is (μ_B = Bohr magneton)
(1) zero
(2) μ_B
(3) $\sqrt{2}\ \mu_B$
(4) $\mu_B \sqrt{2}$

Q.19 An α-particle experiences a force of 3.84×10^{-14} N when it moves perpendicular to magnetic field of 0.2 Wb/m^2 then speed of the α-particle is-
(1) 6.0×10^5 m/sec (2) 5.0×10^5 m/sec
(3) 1.2×10^6 m/sec (4) 3.8×10^6 m/sec

Q.20 Magnetic field of earth is 0.3 gauss. A magnet oscillating with rate of 5 oscillation/min. How much the magnetic field of earth is increased, so the number of oscillations become 10 per min.-
(1) 0.3 G (2) 0.6 G
(3) 0.9 G (4) 0.12 G

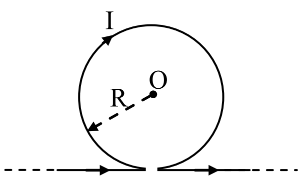
Q.21 'SI' unit of magnetic flux is-
(1) ampere/meter^2 (2) weber
(3) gauss (4) orested

Q.22 The value of work done for rotating a magnet of magnetic moment M by an angle θ with respect to magnetic field B is given by-
(1) $MB\cos\theta$ (2) $2MB\sin^2\frac{\theta}{2}$
(3) $MB\sin\theta$ (4) $MB(1 - \sin\theta)$

Q.23 An electron is moving around a proton in an orbit of radius 1Å and produces 16 Wb/m^2 of magnetic field at the centre, then find the angular velocity of electron-
(1) $20\pi \times 10^{16}$ rad/sec
(2) 10×10^{16} rad/sec
(3) $\frac{5}{2\pi} \times 10^{16}$ rad/sec
(4) $\frac{5}{4\pi} \times 10^{16}$ rad/sec

Q.24 In a mass spectrograph an ion A of mass number 24 and charge +e and an ion B of mass number 22 and charge +2e are entered in transverse magnetic field with same velocity. The ratio of radii of their paths respectively-
(1) $\frac{11}{24}$ (2) $\frac{12}{11}$ (3) $\frac{11}{22}$ (4) $\frac{24}{11}$

Q.25 Magnetic field at point O will be-



(1) $\frac{\mu_0 I}{2R}\otimes$ (2) $\frac{\mu_0 I}{2R}\odot$

(3) $\frac{\mu_0 I}{2R}\left(1-\frac{1}{\pi}\right)\otimes$ (4) $\frac{\mu_0 I}{2R}\left(1+\frac{1}{\pi}\right)\odot$

Q.26 Current I is flowing in a conducting circular loop of radius R. It is kept in a magnetic field B which is perpendicular to the plane of circular loop, the magnetic force acting on the loop is-

(1) IRB (2) 2πIRB
(3) Zero (4) πIRB

Q.27 In a mass spectrograph O^{++}, C^{+}, He^{++} and H^{+} are projected on a photographic plate with same velocity in uniform magnetic field then which will strike the plate farthest-

(1) O^{++} (2) C^{+}
(3) He^{++} (4) H^{+}

Q.28 Radius of a current carrying coil is 'R'. The ratio of magnetic field at a axial point which is R distance away from the centre of the coil to the magnetic field at the centre of the coil-

(1) $\left(\frac{1}{2}\right)^{1/2}$ (2) $\frac{1}{2}$
(3) $\left(\frac{1}{2}\right)^{3/2}$ (4) $\frac{1}{4}$

Q.29 Which of the following statement is not true; magnetic field at the centre of current carrying loop-

(1) proportional to current
(2) inversely proportional to radius
(3) proportional to number of turns
(4) none

Q.30 A current carrying wire is arranged at any angle in an uniform magnetic field, then-

(1) only force acts on wire
(2) only torque acts on wire
(3) both
(4) none

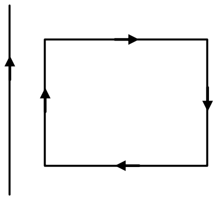
Q.31 For a magnetic needle placed in a uniform magnetic field, which of following are correct-

(a) $F \neq 0, \tau \neq 0$ (b) $F \neq 0, \tau = 0$
(c) $F = 0, \tau \neq 0$ (d) $F = 0, \tau = 0$
(1) a, b (2) a, c
(3) c, d (4) b, d

Q.32 The direction of Lorentz force can be found by-

(1) fleming's right hand rule
(2) fleming's left hand rule
(3) maxwell's screw rule
(4) none of these

Q.33 Force between straight wire and loop will be-

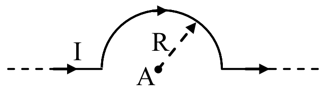


(1) repulsive (2) no force
(3) attractive (4) none

Q.34 If permeability of vacuum is μ_0 and relative permeability is μ_r then permeability of the medium will be-

(1) $\frac{\mu_0}{\mu_r}$ (2) $\mu_0 \times \mu_r$ (3) $\frac{\mu_r}{\mu_0}$ (4) $\frac{1}{\mu_0 \mu_r}$

Q.35 In the shown figure magnetic field at point A will be-



(1) $\frac{\mu_0 I}{4\pi}$ (2) $\frac{\mu_0 I}{4R}$ (3) $\frac{\mu_0 I}{4\pi R}$ (4) Zero

Q.36 If the permeability of iron piece is 3×10^{-3} Wb/A-m and intensity of magnetising field of iron piece is 120 A/m, then what is the magnetic induction of iron piece-
(1) 0.36 Wb/m^2 (2) 5×10^{-3} Wb/m^2
(3) 40 Wb/m^2 (4) 2.5×10^{-4} Wb/m^2

Q.37 In a mass spectrograph mass number and charge of ion A are 24 and +2e respectively. Mass number and charge of ion B are 22 and +e. If both ions has same speed and the radius of path traced by ion A is 24 cm then radius of path traced by ion B will be-
(1) 55 cm (2) 11 cm (3) 44 cm (4) 24 cm

Q.38 In sum and difference method of vibration magnetometer, the time period is more, if-
(1) Similar poles of both magnets are on same side
(2) Opposite poles of both magnets are on same sides
(3) Both magnets are perpendicular to each other
(4) Nothing can be said

Q.39 At a certain place a magnet makes 30 oscillations per minute. At another place where the magnetic field is double, its time period will be-
(1) 4 s (2) 2 s (3) 1/2 s (4) $\sqrt{2}$ s

Q.40 If the angle of dip at two places are 30º and 45º respectively, then the ratio of horizontal component of earth's magnetic field at two places will be-
(1) $\sqrt{3} : \sqrt{2}$ (2) $1 : \sqrt{2}$
(3) $1 : \sqrt{3}$ (4) 1 : 2

Q.41 At two places A and B using vibration magnetometer, a magnet vibrates in a horizontal plane and its respective time periods are 2 sec and 3 sec and at these places the earths horizontal components are B_A and B_B respectively. Then the ratio of B_A and B_B will be-
(1) 9 : 4 (2) 3 : 2 (3) 4 : 9 (4) 2 : 3

Q.42 Weber-ampere per meter is equivalent to-
(1) joule (2) newton

(3) henry (4) watt

Q.43 The magnetic field at a point situated at a distance r close to a long straight current carrying wire is B. The field at a distance r/2 from the wire will be-
(1) B/2 (2) B/4 (3) 2B (4) 4B

Q.44 Two magnets A and B are identical in mass, length and breadth but have different magnetic moments. In a vibration magnetometer, if the time period of B is twice the time period of A. The ratio of the magnetic moments M_A/M_B of the magnets will be-
(1) 1/2 (2) 2 (3) 4 (4) 1/4

Q.45 The time period of oscillation of a magnet in vibration magnetometer is 1.5 second. The time period of oscillation of another magnet similar in size, shape and mass but having one fourth magnetic moment that of the same place will be-
(1) 0.75 sec (2) 1.5 sec
(3) 3.0 sec (4) 6.0 sec

Q.46 A bar magnet A of magnetic moment M_A is found to oscillate at a frequency twice that of magnet B of magnetic moment M_B when placed in a vibrating magnetometer. We may say that-
(1) $M_A = 2M_B$ (2) $M_A = 8M_B$
(3) $M_A = 4M_B$ (4) $M_B = 8M_B$

Q.47 The SI unit of magnetic induction is-
(1) tesla (2) henry
(3) gauss (4) orested

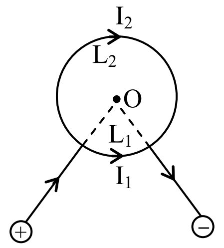
Q.48 A magnetic needle is made to vibrate in uniform field B_H, then its time period is T. If it vibrates in the field of intensity $4B_H$, it time period will be-
(1) 2T (2) T/2
(3) 2/T (4) T

Q.49 A current I flows through a circular coil of radius r, the intensity of field at its centre is-
(1) Proportional to 'r'
(2) Inversely proportional to I
(3) Proportional to I
(4) Proportional to I^2

Q.50 A charge is moving perpendicular to a magnetic field. Its path is a -
(1) Parabola (2) Circle
(3) Ellipse (4) Straight line

Q.51 Dimension of magnetic flux is-
(1) $[MLT^{-2}A^{-2}]$
(2) $[ML^2T^{-2}A^{-2}]$
(3) $[ML^2T^{-1}A^{-2}]$
(4) $[ML^2T^{-2}A^{-1}]$

Q.52 Any two point of a circular conducting wire are connected with coil in such a way that length of one part is L_1 and that of other part is L_2. Then resultant magnetic induction at the centre will be-



(1) zero (2) $\mu_0\pi I/2r$ (3) $\mu_0 I/2r$ (4) $\mu_0 I/2\pi$

Q.53 A long solenoid with 20 turns per cm is made to produce a magnetic field of 20 mT inside the solenoid. The necessary current will nearly be-
(1) 8.0 ampere (2) 4.0 ampere
(3) 2.0 ampere (4) 1.0 ampere

Q.54 A charge particle is moving in the direction of a magnetic field. The magnetic force acting on the particle-
(1) is in the direction of its velocity
(2) is in the direction opposite to its velocity
(3) is perpendicular to its velocity
(4) is zero

Q.55 One ampere current is passed through a 2m long straight wire. The magnetic field in air at a point distant 3m from one end of wire on its axis will be-
(1) $\frac{\mu_0}{2\pi}$ (2) $\frac{\mu_0}{4\pi}$
(3) $\frac{\mu_0}{8\pi}$ (4) zero

Q.56 Two tangent galvanometer, coil of same radius connected in series. The current flowing produces deflections of 60º and 45º. The ratio of number of turns in coils is-
(1) $\frac{4}{3}$ (2) $\frac{(\sqrt{3}+1)}{1}$
(3) $\frac{(\sqrt{3}+1)}{(\sqrt{3}-1)}$ (4) $\frac{\sqrt{3}}{1}$

Q.57 The vertical component of earth magnetic field is zero at or the earth's magnetic field always has a vertical component except at the-
(1) magnetic poles (2) geographical poles
(3) every place (4) magnetic equator

Q.58 If any values of current gives a 45º deflection in properly arranged tangent galvanometer. If current becomes $\frac{1}{\sqrt{3}}$ of its initial value, then deflection in it-
(1) decrease by 30º (2) decrease by 15º
(3) increase by 15º (4) increase by 30º

Q.59 A coil of 100 turn and area 5 cm^2 is placed in a magnetic field 0.2 T. The normal to the plane of the coil makes an angle of 60º with the direction of magnetic field. The magnetic flux linked with the coil is-
(1) 5×10^{-3} wb (2) 5×10^{-5} wb
(3) 10^{-2} wb (4) 10^{-4} wb

Q.60 A current is flowing in a circular coil of radius R and the magnetic field at its centre is B_0. In what distance from the centre on the axis of the coil, the magnetic field will be $B_0/8$?
(1) $\sqrt{7}\,R$ (2) $\sqrt{3}\,R$
(3) R (4) 8 R

Q.61 Wire in the form of a right angle ABC, with AB = 3cm and BC = 4 cm, carries a current of 10A. There is a uniform magnetic field of 5T perpendicular to the plane of the wire. The force on the wire will be-
(1) 1.5N (2) 2.0N
(3) 2.5N (4) 3.5N

Q.62 A rectangular coil 20 cm × 20 cm, has 100 turns and carries a current of 1A. It is placed in a uniform magnetic field 0.5 T with the direction of magnetic field parallel to the plane of the coil. The magnitude of the torque required to hold this coil in this position is-
(1) zero (2) 200N-m
(3) 2N-m (4) 10N-m

Q.63 $\sqrt{3}$ ampere current produces 30º deflection in tangent galvanometer, then 3 ampere current produces a deflection-
(1) 30º (2) 45º (3) 60º (4) 15º

Q.64 A charged particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to-
(1) the velocity
(2) the linear momentum
(3) the kinetic energy
(4) none

Q.65 An electron is moving along positive x-direction. To get it moving on anti-clockwise circular path in xy plane, a magnetic field is applied-
(1) along positive y-direction
(2) along positive z-direction
(3) along negative y-direction
(4) along negative z-direction

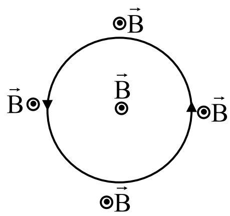
Q.66 At a certain place, the horizontal component B_0 and the vertical component V_0 of the earth's magnetic field are equal in magnitude. The total field at that place will be-
(1) B_0 (2) B_0^2 (3) $2B_0$ (4) $\sqrt{2}\,B_0$

Q.67 The vector form of Biot savart law for a current carrying element is-
(1) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\ell\sin\phi}{r^2}$ (2) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{\ell}\times\hat{r}}{r^2}$
(3) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{\ell}\times\hat{r}}{r^3}$ (4) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{\ell}\times\hat{r}}{r^2}$

Q.68 A long solenoid has length L, average diameter D and n layer of turns. Each layer contains N turns. If current flowing through the solenoid is i the value of magnetic field at the centre-
(1) Proportional to D
(2) Inversely proportional to D
(3) Does not depend on D
(4) Proportional to L

Q.69 If an electron enters a magnetic field with its velocity pointing in the same direction as the magnetic field then-
(1) the electron will turn towards right
(2) the electron will turn towards left
(3) the velocity of the electron will increase
(4) the velocity of the electron will remain unchanged

Q.70 An elastic circular wire of length ℓ carries a current I. It is placed in a uniform magnetic field $\vec{B}$ (out of paper) such that its plane is perpendicular to the direction of $\vec{B}$. The wire will experiences-



(1) No force
(2) A stretching force
(3) A compressive force
(4) A torque

Q.71 A circular loop has a radius of 5 cm and it is carrying a current of 0.1 A. Its magnetic moment is-
(1) 1.32×10^{-4} amp-m^2 (2) 2.62×10^{-4} amp-m^2
(3) 5.25×10^{-4} amp-m^2 (4) 7.85×10^{-4} amp-m^2

Q.72 An electron is moving in a circle of radius 5.1×10^{-11} m at a frequency of 6.8×10^{15} revolution/sec. The equivalent current is approximately-
(1) 5.1×10^{-3} A (2) 6.8×10^{-3} A
(3) 1.1×10^{-3} A (4) 2.2×10^{-3} A

Q.73 1 A current flows through an infinite long straight wire. The magnetic field produced at a point 1m away from it is-
(1) 2×10^{-3} T (2) $\frac{2}{10}$ T
(3) 2×10^{-7} T (4) $2\pi \times 10^{-6}$ T

Q.74 Two infinite long parallel wires carry equal currents in same direction. The magnetic field at a mid point in between the two wire is-
(1) Twice the magnetic field produced due to each of the wires
(2) Half of the magnetic field produced due to each of the wires
(3) Square of the magnetic field produced due to each of the wires
(4) Zero

Q.75 When a charged particle enters in a uniform magnetic field its kinetic energy-
(1) remains constant (2) increases
(3) decreases (4) becomes zero

Q.76 Two particles x and y have equal charges and possessing equal kinetic energy enter in a uniform magnetic field and describe circular path of radius of curvature r_1 and r_2 respectively. The ratio of their masses is-

(1) $\left(\frac{r_1}{r_2}\right)$ (2) $\left(\frac{r_1}{r_2}\right)^{1/2}$ (3) $\left(\frac{r_1}{r_2}\right)^2$ (4) $\left(\frac{r_2}{r_1}\right)$

Q.77 Magnetic field lines produced by a bar magnet, cuts each other-
(1) At neutral points
(2) Near the poles of the magnets
(3) At equatorial axis
(4) Never intersects to each other

Q.78 π ampere current is flowing through a long straight wire. Due to this a field of 5×10^{-5} T produced, then distance of the point from the axis of the wire is-
(1) $10^4\ \mu_0$ m (2) $10^4 / \mu_0$ m
(3) $10^6\ \mu_0$ m (4) $10^8\ \mu_0$ m

Q.79 An electron of kinetic energy of 7.2×10^{-18} J is revolving on circular path in magnetic field 9×10^{-5} wb/m^2 then radius of its circular path is-
(1) 1.25 cm (2) 2.5 m
(3) 2.5 cm (4) 25.0 cm

Q.80 The unit of magnetic moment will be-
(1) $\frac{A}{m}$ (2) A-m^2
(3) $\frac{T-m}{A}$ (4) $\frac{T-m}{A^2}$

Q.81 At any place horizontal and vertical component of earth magnetic field are equal then angle of dip at that place-
(1) 0º (2) 45º
(3) 90º (4) 180º

Q.82 Value of earth's magnetic field at any point is 7×10^{-5} wb/m^2. This field is neutralised by field which is produced at the centre of a current carrying loop of radius 5 cm. The current in the loop (approximately)
(1) 0.56 A (2) 5.6 A
(3) 0.28 A (4) 28 A

Q.83 An electric field E and a magnetic field B applied on a proton which moves with velocity v, it goes undeflected through the region if-
(1) E $\perp$ B
(2) E is parallel to v and perpendicular to B
(3) E, B and v all three mutually perpendicular to each other and v = $\frac{E}{B}$
(4) E and B both are parallel but perpendicular to v

Q.84 An electron moves with velocity v in uniform transverse magnetic field B on circular path of radius 'r', then e/m for it is-
(1) $\frac{v}{Br}$ (2) $\frac{B}{rv}$ (3) Bvr (4) $\frac{vr}{B}$

Q.85 A proton, deutron and α-particle are accelerated by same potential, enters in uniform magnetic field perpendicularly. Ratio of radii of circular path respectively-
(1) $1 : \sqrt{2} : \sqrt{2}$ (2) 2 : 2 : 1
(3) 1 : 2 : 1 (4) 1 : 1 : 1

Q.86 When alternating current passes through a spring then it-
(1) Contracts (2) Expands
(3) Oscillates (4) Unchange

Q.87 When direct current passed through a spring then it-
(1) Contracts (2) Expands
(3) Oscillates (4) Unchange

Q.88 A current carrying coil behave like tiny magnet. If area of coil is A and magnetic moment is 'M' then current through the coil is-
(1) $\frac{M}{A}$ (2) $\frac{A}{M}$ (3) MA (4) $\frac{A^2}{M}$

Q.89 An electron revolves with frequency 6.6×10^{15} r.p.s around nucleus in circular orbit of radius 0.53 Å of hydrogen atom, then magnetic field produced at centre of orbit is-
(1) 0.125 T (2) 1.25 T (3) 12.5 T (4) 125 T

Q.90 A 10 eV electron is circulating in a plane at right angles to a uniform field at magnetic induction 10^{-4} Wb/m^2 (=1.0 gauss). The orbital radius of the electron is-
(1) 16 cm (2) 12 cm (3) 11 cm (4) 18 cm

Q.91 Which of the following demonstrated that earth has a magnetic field-
(1) Intensity of cosmic rays (stream of charged particle coming from outer space) is more at the poles than at the equator
(2) Earth is surrounded by an ion sphere (a shell of charged particles)
(3) Earth is a planet rotating about the north south axis
(4) Large quantity of iron ore is found in the earth

Q.92 Current I_0 flow through solenoid of length L having N number of turns, when it is connected to DC emf. If charged particle is projected along the axis of solenoid with a speed v_0, then the force on the charged particle in the solenoid-
(1) Zero (2) Remains same
(3) Decreases (4) Increases

Q.93 A bar magnet has a magnetic moment equal to 5×10^{-5} A-m^2. It is suspended in a magnetic field of $8\pi \times 10^{-4}$ T. The magnet vibrates with a period of vibration equal to 15 sec. The moment of inertia of the magnet is-
(1) 5.2×10^{-7} kg-m^2 (2) 11.25×10^{-7} kg-m^2
(3) 22.5×10^{-7} kg-m^2 (4) 7.16×10^{-7} kg-m^2

Q.94 A particle moving in a magnetic field has increased its velocity then its radius of the circle-
(1) Remains the same(2) Increases
(3) Decreases (4) Becomes half

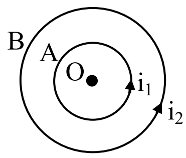
Q.95 A bar magnet is held perpendicular to a uniform field. If the couple acting on the magnet is to be halved, by rotating it, the angle by which it is to be rotated is-
(1) 30º (2) 60º (3) 45º (4) 90º

Q.96 The magnetic moment of a short magnet is 8 Am^2. The magnetic induction at a point 20cm away from its mid point on (i) axial point (ii) equatorial point respectively, will be-
(1) 2×10^{-4} and 10^{-4} T
(2) 3×10^{-4} and 2×10^{-4} T
(3) 4×10^{-4} and 3×10^{-4} T
(4) None of these

Q.97 Two isolated like magnetic poles of strength 10 and 40 S.I. units are separated by a distance 30 cm. The magnetic field is zero on the line joining them-
(1) At a point 10 cm from the stronger pole
(2) At a point 20 cm from the stronger pole
(3) At the mid-point
(4) At infinite

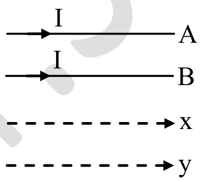
Q.98 If the magnet of length 10 cm and pole strength 40 Am is placed at an angle of 45º in an uniform magnetic field of 2×10^{-4} T. The couple acting on it will be-
(1) 0.656×10^{-5} N-m
(2) 0.656×10^{-4} N-m
(3) 0.5656×10^{-4} N-m
(4) 0.5656×10^{-3} N-m

Q.99 A and B are two concentric circular loop carrying current i_1 and i_2 as shown in figure. If ratio of their radii is 1 : 2 and ratio of the flux densities at the centre O due to A and B is 1:3 then the value of $\frac{i_1}{i_2}$ will be-



(1) $\frac{1}{2}$ (2) $\frac{1}{3}$
(3) $\frac{1}{4}$ (4) $\frac{1}{6}$

Q.100 A and B are two wire carrying a current I in the same direction x and y are two electron beams moving in the same direction. There will be-



(1) Attraction between A and B, repulsion between x and y
(2) Repulsion between A and B, attraction between x and y
(3) Attraction between A and B & x and y
(4) Repulsion between A and B & x and y

Q.101 When the current flowing in a circular coil is doubled and the number of turns of the coil in it is halved, the magnetic field at its centre will become-
(1) Same (2) Four times
(3) Half (4) Double

Q.102 Two small magnets each of magnetic moment 10 A-m^2 are placed in end on position 0.1 m apart from their centres. The force acting between them is-

(1) 0.6 N (2) 0.06 N
(3) 0.06 N × 10^7 N (4) 0.6 × 10^7 N

Q.103 Magnetic field intensity of a short magnet at a distance 1m, on axial line is 1 oersted. At a distance 2m on the same line the intensity in oersted is-
(1) 0.75 (2) 0.125
(3) 0.25 (4) 0.5

Q.104 A magnetic field-
(1) Always exerts a force on charged particle
(2) Never exerts a force on charged particle
(3) Exert a force, if the charged particle is moving across the magnetic field line
(4) Exerts a force, if the charged particle is moving along the magnetic field line

Q.105 An ionised gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the +x direction and a magnetic field along the +z direction then-
(1) Positive ions deflect towards + y direction and negative ions towards –y direction
(2) All ions deflect towards + y direction
(3) All ions deflect towards –y direction
(4) Positive ions deflect towards – y direction and negative ions towards +y direction

Q.106 A proton of mass 1.67 × 10^{-27} kg and charge 1.6 × 10^{-19} C is projected with a speed of 2 × 10^6 m/s at an angle of 60º to the X-axis. If a uniform magnetic field of 0.104 tesla is applied along Y-axis, the path of proton is-
(1) A circle of radius = 0.2 m and time period = $2\pi \times 10^{-7}$ s
(2) A circle of radius = 0.1 m and time period = $2\pi \times 10^{-7}$ s
(3) A helix of radius = 0.1 m and time period = $2\pi \times 10^{-7}$ s
(4) A helix of radius = 0.2 m and time period = $2\pi \times 10^{-7}$ s

Q.107 A straight wire carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west at the same distance. The magnetic field at P is -
(1) Greater than at Q
(2) Same as at Q
(3) Less than at Q
(4) Greater or less than at Q, depending upon the strength of current

Q.108 A circular coil of radius 20 cm and 20 turns of wire is mounted vertically with its plane in magnetic meridian. A small magnetic needle is placed at the centre of the coil and it is deflected through 45º, when a current is passed through the coil. When horizontal component of earth's field is 0.34 × 10^{-4} T, the current in coil is-
(1) 0.6 A (2) 6A
(3) 6 × 10^{-3} A (4) 0.06 A

Q.109 A bar magnet of length 3 cm has points A and B along its axis at distances of 24 cm and 48 cm from centre on the opposite sides. Ratio of magnetic fields as these points will be-

(1) 8 (2) $\frac{1}{2\sqrt{2}}$ (3) 3 (4) 4

Q.110 Match the following
(i) Magnetic flux (a) tesla
(ii) Magnetic flux density (b) weber
(iii) Relative permeability (c) no unit
(iv) Magnetic field intensity (d) ampere/meter

(1) (i)-(b), (ii)-(a), (iii)-(c), (iv)-(d)
(2) (i)-(d), (ii)-(b), (iii)-(a), (iv)-(c)
(3) (i)-(c), (ii)-(d), (iii)-(b), (iv)-(a)
(4) (i)-(b), (ii)-(d), (iii)-(c), iv)-(a)

Q.111 Two concentric circular loops of radii 0.08 m and 0.1 m carries current such that magnetic field at the centre is zero. If the current in the outer loop is 8A clockwise, current in the inner loop is-
(1) 6.4 A anticlockwise (2) 6.4 A clockwise
(3) 8A anticlockwise (4) 3.2 A clockwise

Q.112 Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. The currents 3A and 4A are flowing in each coil respectively. The magnetic induction in weber/m^2 at the centre of the coils will be-
($\mu_0 = 4\pi \times 10^{-7}$ Wb/A-m)
(1) 7×10^{-5} (2) 5×10^{-5}
(3) 10^{-5} (4) 12×10^{-5}

Q.113 A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity then-
(1) it will turn towards left of direction of motion
(2) it will turn towards right of direction of motion
(3) its velocity will increase
(4) its velocity decrease

Q.114 A magnetic needle is kept in a non-uniform magnetic field. It experiences-
(1) A force but not a torque
(2) A force and a torque
(3) Neither a force nor a torque
(4) A torque but not a force

Q.115 A current loop of area 0.01 m^2 and carrying a current of 10A is held perpendicular to a magnetic field of 0.1 T, the torque in N-m acting on the loop is-
(1) 0 (2) 0.001 (3) 0.01 (4) 1.1

Q.116 In a region constant uniform electric and magnetic field is present. Both field are parallel. In this region a charge released from rest, then path of particle is-
(1) Circle (2) Helical
(3) Straight line (4) Ellipse

Q.117 A long solenoid having 200 turns/cm and carries current i. Magnetic field at its axis is 6.28×10^{-2} wb/m^2. An another solenoid having 100 turns/cm and carries $\frac{i}{3}$ current, then magnetic field at its axis will be-
(1) 1.05×10^{-4} wb/m^2 (2) 1.05×10^{-2} wb/m^2
(3) 1.05×10^{-5} wb/m^2 (4) 1.05×10^{-3} wb/m^2

Q.118 If radius of coil becomes two times and current becomes half then magnetic field at centre of the coil will be-
(1) Two times (2) Four times
(3) Half (4) One fourth

Q.119 A current carrying coil is placed in a constant uniform magnetic field B. Torque is maximum on this coil when plane of coil is-
(1) perpendicular to B(2) parallel to B
(3) at 45º to B (4) at 60º to B

Q.120 2A current is flowing in a circular of radius 1m. Magnitude of magnetic field at the centre of circular loop will be-
(1) $\frac{\mu_0}{2}$ (2) $2\mu_0$
(3) μ_0 (4) $\frac{\mu_0}{2\pi}$

Q.121 Magnetic field is parallel to the plane of coil then torque will be-
(1) Maximum (2) Minimum
(3) Zero (4) None of these

Q.122 A circular coil placed in a uniform magnetic field. If alternating current flows through this coil then-
(1) net force will act on coil
(2) coil will be stationary
(3) coil will be rotated
(4) none of the above

Q.123 A charged particle moves through a magnetic field perpendicular to its direction, then-
(1) both momentum and kinetic energy of the particle are not constant
(2) both momentum and kinetic energy of the particle are constant
(3) kinetic energy changes but the momentum is constant
(4) the momentum changes but the kinetic energy is constant

Q.124 Two identical conducting wires AOB and COD are placed at right angles to each other. The wire AOB carries an electric current I_1 and COD carries a current I_2. The magnetic field on a point lying at a distance 'd' from O, in a direction perpendicular to the plane of the wires AOB and COD, will be given by-
(1) $\frac{\mu_0}{2\pi d}(I_1^2+I_2^2)^{1/2}$ (2) $\frac{\mu_0}{2\pi d}(I_1+I_2)$
(3) $\frac{\mu_0}{2\pi d}(I_1^2+I_2^2)$ (4) $\frac{\mu_0}{2\pi d}\left(\frac{I_1+I_2}{d}\right)^{1/2}$

Q.125 A long straight wire of radius 'a' carries a steady current i. The current is uniformly distributed across its cross section. The ratio of the magnetic field at $\frac{a}{2}$ and 2a distances is-
(1) 4 (2) 1 (3) $\frac{1}{2}$ (4) $\frac{1}{4}$

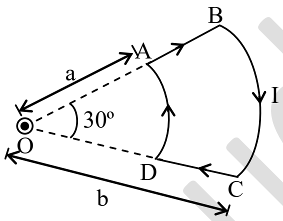
Q.126 A current I flows along the length of an infinitely long, straight, thin walled pipe, then-
(1) the magnetic field is different at different points inside the pipe
(2) the magnetic field at any point inside the pipe is the same, but not zero
(3) the magnetic field at all points inside the pipe is the same, but not zero
(4) the magnetic field is zero only on the axis of the pipe

Q.127 The dimension of magnetic field in M, L, T and C (Coulomb) is given as-
(1) $[MLT^{-1}C^{-1}]$ (2) $[MT^2C^{-2}]$
(3) $[MT^{-1}C^{-1}]$ (4) $[MT^{-2}C^{-1}]$

Q.128 A horizontal overhead power line is at a height of 4m from the ground and carries a current of 100A from east to west. The magnetic field directly below it on the ground is-
(1) 2.5×10^{-7} T, southward
(2) 5×10^{-6} T, northward
(3) 5×10^{-6} T, southward
(4) 2.5×10^{-7} T, northward

Q.129 Relative permittivity and permeability of a material are ε_r and μ_r respectively. Which of the following values of these quantities are allowed for a diamagnetic material-
(1) $\varepsilon_r = 0.5, \mu_r = 1.5$ (2) $\varepsilon_r = 1.5, \mu_r = 0.5$
(3) $\varepsilon_r = 0.5, \mu_r = 0.5$ (4) $\varepsilon_r = 1.5, \mu_r = 1.5$

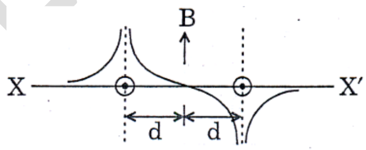
Q. No. 130 and 131 are based on the following paragraph :
A current loop ABCD is held fixed on the plane of the paper as shown in the figure. The arcs BC (radius = b) and DA (radius = a) of the loop are joined by two straight wires AB and CD. A steady current I is flowing in the loop. Angle made by AB and CD at the origin O is 30º. Another straight thin wire with steady current I_1 flowing out of the plane of the paper is kept at the origin.

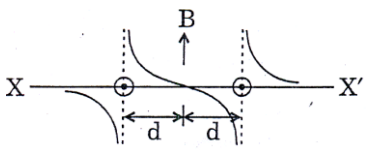


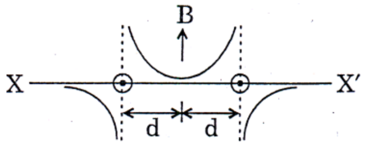
Q.130 The magnitude of the magnetic field (B) due to the loop ABCD at the origin (O) is -
(1) Zero (2) $\frac{\mu_0 I(b-a)}{24ab}$
(3) $\frac{\mu_0 I}{4\pi}\left[\frac{b-a}{ab}\right]$ (4) $[2(b-a) + \pi/3(a+b)]$

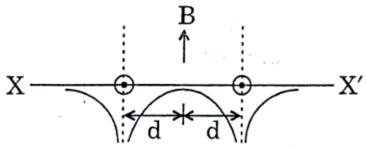
Q.131 Due to the presence of the current I_1 at the origin –
(1) The forces on AB and DC are zero
(2) The forces on AD and BC are zero
(3) The magnitude of the net force on the loop is given by $\frac{\mu_0 I I_1}{4\pi}$ $[2(b-a) + \pi/3(a+b)]$
(4) The magnitude of the net force on the loop is given by $\frac{\mu_0 I I_1}{24ab}$ $(b-a)$

Q.132 Two long parallel wires are at a distance 2d apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by -

(1)


(2)


(3) 

(4) 

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.

(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

(C) If Assertion is true but the Reason is false.

(D) If Assertion & Reason both are false.

Q.1 **Assertion:** An electron and a proton is projected with equal momentum in uniform transverse magnetic field, then curvature of their paths is equal.
Reason: Mass of proton too much then mass of electron.
(1) A (2) B (3) C (4) D

Q.2 **Assertion:** Magnetic flux enclosed with a closed surface is always zero.
Reason: Gauss law applies in the case of electric field and magnetic field both.
(1) A (2) B (3) C (4) D

Q.3 **Assertion:** Magnetic moment of toroid is zero.
Reason: Magnetic field outside the volume of current carrying toroid is zero.
(1) A (2) B (3) C (4) D

Q.4 **Assertion:** Ferromagnetic substances attracts the external magnetic field lines.
Reason: Permeability of ferromagnetic substance is very high.
(1) A (2) B (3) C (4) D

Q.5 **Assertion:** A current carrying wire is placed in magnetic field, then magnetic force acts on it.
Reason: Free electrons and positive ions are in motion inside any current carrying wire.
(1) A (2) B (3) C (4) D

Q.6 **Assertion:** A current carrying toroid is freely suspended in magnetic field then torque acts on it is always zero.
Reason: The magnetic moment of current carrying toroid is zero.
(1) A (2) B (3) C (4) D

Q.7 **Assertion:** Cyclotron is a accelerating device.

Reason: Neutrons can be accelerated by the cyclotron.
(1) A (2) B (3) C (4) D

Q.8 **Assertion:** If a charged particle is moving in perpendicular uniform magnetic field, its kinetic energy does not change.
Reason: Velocity of charge particle is not changing in magnetic field.
(1) A (2) B (3) C (4) D

Q.9 **Assertion:** Gauss theorem is not applicable in magnetism.
Reason: Mono magnetic pole does not exist
(1) A (2) B (3) C (4) D

Q.10 **Assertion:** Magnetic moment of helium atom is zero.
Reason: All the electron are paired in helium atom orbitals.
(1) A (2) B (3) C (4) D

Q.11 **Assertion:** Unlike charges are projected in opposite direction in transverse magnetic field, then they are deflected mutually opposite directions.
Reason: Maximum magnetic force acts on them mutually opposite directions.
(1) A (2) B (3) C (4) D

Q.12 **Assertion:** We cannot think of a magnetic field configuration with three poles.
Reason: A bar magnet does exerts a torque on itself due to its own field.
(1) A (2) B (3) C (4) D

Q.13 **Assertion:** In high latitudes one sees colourful curtains of light hanging down from high altitudes.
Reason: The high energy charged particles from the sun are deflected to polar regions by the magnetic field of the earth.
(1) A (2) B (3) C (4) D

Q.14 **Assertion:** The true geographic north direction is found by using a compass needle.
Reason: The magnetic meridian of the earth is along the axis of rotation of the earth.
(1) A (2) B (3) C (4) D

Q.15 **Assertion:** A moving charge is a source of magnetic field.
Reason: A current element is a source of magnetic field.
(1) A (2) B (3) C (4) D

Q.16 **Assertion:** Magnetic poles are only mathematical assumptions having no real existence.
Reason: A charged particle is moved along a magnetic field line. The magnetic force on the particle is perpendicular to its velocity.
(1) A (2) B (3) C (4) D

Q.17 **Assertion:** The density of field lines decreases in a medium of high permeability.
Reason: Because $B \propto \frac{1}{\mu}$.
(1) A (2) B (3) C (4) D

Q.18 **Assertion:** The trajectory of neutron when it is projected perpendicular to an electric field is parabola.
Reason: A moving charge entering parallel to the magnetic field lines moves in a circular path.
(1) A (2) B (3) C (4) D

Q.19 **Assertion:** A compass needle which is allowed to move in a horizontal plane is taken to a geomagnetic pole. It will stay in any direction.
Reason: At geomagnetic pole $B_H = 0$.
(1) A (2) B (3) C (4) D

Q.20 **Assertion:** A dip circle (used for dip measurement) is taken to geomagnetic equator. The needle is allowed to move in a vertical plane. The needle will stay in any direction when it is released.
Reason: At geomagnetic equator $B_V = 0$.
(1) A (2) B (3) C (4) D

Q.21 **Assertion:** If two long parallel wires, hanging freely are connected to a battery in series, they come closer to each other.
Reason: When two wires carry currents in opposite direction, they attract each other.
(1) A (2) B (3) C (4) D

Q.22 **Assertion:** In a wire, free electrons keep on moving but no magnetic force acts on a wire in a magnetic field.
Reason: In a wire, the average thermal velocity of electrons is zero. Hence no current flows through the wire.
(1) A (2) B (3) C (4) D

Q.23 **Assertion:** A linear solenoid carrying current is equivalent to a bar magnet.
Reason: The magnetic field lines due to current carrying solenoid resemble exactly with those of a bar magnet.
(1) A (2) B (3) C (4) D

Q.24 **Assertion:** When two charges, distance 'r' apart are moving with velocities v_1 and v_2, the magnetic force acting between them is given by $F_m = \frac{\mu_0}{4\pi}\frac{q_1q_2v_1v_2}{r^2}$.
Reason: Electric force acting between two charges q_1 & q_2 moving on straight parallel paths distance 'r' apart is $F_e = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$.
(1) A (2) B (3) C (4) D

Q.25 **Assertion:** Various regular polygons formed by a constant length current carrying wire, then magnetic induction at their centres are increases when their number of sides increases.
Reason: A magnetic dipole placed in non uniform magnetic field, then torque acting on it is always zero.
(1) A (2) B (3) C (4) D

Q.26 **Assertion:** Magnetic field of an atom is due to both, the orbital motion and spin motion of electron.
Reason: A moving charge particle produces magnetic field.
(1) A (2) B (3) C (4) D

Q.27 **Assertion:** If a unit north pole rotates around a current carrying wire then work has to be done.
Reason: Magnetic field produced by current is always non-conservative in nature.
(1) A (2) B (3) C (4) D

Q.28 **Assertion:** A moving charge experiences force in magnetic field, provided it is not moving parallel (or antiparallel) to the direction of the field.
Reason: Magnetic force is given by $\vec{F}_m = q(\vec{v}\times\vec{B})$, where symbols have their usual meaning.

(1) A (2) B (3) C (4) D

Q.29 **Assertion:** Work done by magnetic field on a moving charge is zero.
Reason: Force experienced by a moving charge in a magnetic field is may be zero.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 6

Q.1 Which of the following materials is repelled by an external magnetic field ?
(1) Iron (2) Cobalt
(3) Steel (4) Copper

Q.2 If a diamagnetic material is placed in a magnetic field, the flux density inside the material compared to that outside will be-
(1) Slightly less (2) Slightly more
(3) Very much more (4) Same

Q.3 To protect a sensitive instrument from external magnetic jerks, it should be placed in a container made of-
(1) Non magnetic substance
(2) Diamagnetic substance
(3) Paramagnetic substance
(4) Ferromagnetic substance

Q.4 Substances in which the magnetic moment of a single atom is not zero, are known as-
(1) Diamagnetic (2) Ferromagnetic
(3) Paramagnetic (4) Non magnetic

Q.5 Susceptibility of a magnetic substance is found to depend on temperature and the strength of the magnetising field. The material is-
(1) Diamagnetic (2) Ferromagnetic
(3) Paramagnetic (4) Superconductor

Q.6 Property possessed by only ferromagnetic substance is-
(1) Attracting magnetic substance
(2) Hysteresis
(3) Susceptibility independent of temperature
(4) Directional property

Q.7 When a diamagnetic substance is inserted in a current carrying coil, then magnetic field is-
(1) Decreased
(2) Unchanged
(3) Increased

(4) Increased or decreased depending upon the relative volume of the substance

Q.8 The hard ferromagnetic material is characterized by-
(1) Narrow hysteresis loop
(2) Broad hysteresis loop
(3) High mechanically hardness, all over
(4) Mechanically hard surface

Q.9 The magnetic moment of paramagnetic materials is-
(1) Infinity (2) Zero
(3) Constant but low (4) None of the above

Q.10 The cause of paramagnetism is-
(1) Unpaired electrons
(2) Electron excess and spin motion of electrons
(3) Paired electrons and orbital motion of electrons
(4) Electrons and orbital motion of electrons

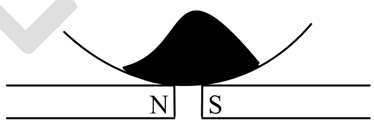
Q.11 The cause of diamagnetism is-
(1) Orbital motion of electrons
(2) Spin motion of electrons
(3) Paired electrons
(4) None of the above

Q.12 The magnetic moment of diamagnetic materials is-
(1) Infinity
(2) Zero
(3) 100 amp-m^2
(4) None of the above

Q.13 Which of the following statements is correct for diamagnetic materials ?
(1) $\mu_r < 1$
(2) χ is negative and low
(3) χ does not depend on temperature
(4) All of the above

Q.14 The area of B–H loop for soft iron, as compared to that for steel is-
(1) More
(2) Less
(3) Equal
(4) None of the above

Q.15 The liquid in the watch glass in the following figure is-



(1) Ferromagnetic (2) Paramagnetic
(3) Diamagnetic (4) Nonmagnetic

Q.16 Powerful permanent magnets are made of-
(1) Cobalt (2) Aluminum
(3) Tin-coal (4) Cobalt-steel

Q.17 Which of the following statements is correct for ferromagnetic material-
(1)These become diamagnetic at Curie temperature

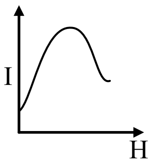
(2) These become paramagnetic at Curie temperature
(3) Their magnetic susceptibility becomes zero at Curie temperature
(4) Its magnetic properties are explained on the basis of electron principle

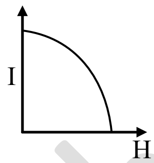
Q.18 The value of magnetic susceptibility for superconductors is-
(1) Zero (2) Infinity
(3) +1 (4) –1

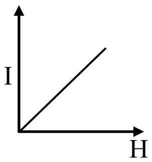
Q.19 A material rod, when placed in a strong magnetic field, aligns itself at right angles to the magnetic field. The nature of material is-
(1) Diamagnetic
(2) Paramagnetic
(3) Ferromagnetic
(4) Low ferromagnetic

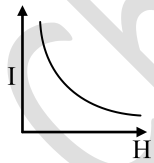
Q.20 The relative permeability of air is-
(1) Zero (2) 1.04
(3) Infinity (4) 1

Q.21 The correct I-H curve for paramagnetic materials is-

(1) 

(2) 

(3) 

(4) 

Q.22 If the magnetic susceptibility of a magnetic material is –0.004 then its nature will be-
(1) Diamagnetic (2) Paramagnetic
(3) Ferromagnetic (4) Non magnetic

Q.23 The correct measure of magnetic hardness of a material is-
(1) Ramnant magnetism
(2) Hysteresis loss
(3) Coercivity
(4) Curic temperature

Q.24 If the relative permeability of a material is 0.9999 then its nature will be-
(1) Paramagnetic (2) Diamagnetic
(3) Ferromagnetic (4) Non-magnetic

Q.25 Steel is not attracted by a magnet, because steel is-
(1) Non-magnetic (2) Unmagnetised
(3) Diamagnetic (4) Ferromagnetic

Q.26 The magnetic property inherent in all material is-
(1) Ferromagnetism (2) Diamagnetism
(3) Paramagnetism (4) Non-magnetism

Q.27 Cause of Ferromagnetism -
(1) Orbital motion of electron
(2) Spin motion of electron
(3) Permanent magnetic dipole moment
(4) None

Q.28 The coercivity of a bar magnet is 100 A/m. It is to be demagnetised by placing it inside a solenoid of length 100 cm and number of turns 50. The current flowing the solenoid will be-
(1) 4A (2) 2A
(3) 1A (4) zero

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 7

Q.1 The mass of a specimen of a ferromagnetic material is 0.6 kg and its density is 7.8×10^3 kg/m^3. If the area of hysteresis loop of alternating magnetising field of frequency 50Hz is 0.722 MKS units then the hysteresis loss per second will be-
(1) 277.7×10^{-5} J/sec (2) 277.7×10^{-6} J/sec
(3) 277.7×10^{-4} J/sec (4) 277.7×10^{-3} J/sec

Q.2 The total magnetic flux in a material of area A, which produces a pole of strength m_p when placed in a magnetic field of strength H, will be-
(1) $\mu_0(AH + m_p)$ (2) μ_0 AH
(3) μ_0 m_p (4) $\mu_0[m_pAH + A]$

Q.3 The magnetic susceptibility of a paramagnetic substance is 3×10^{-4}. It is placed in a magnetising field of 4×10^4 A/m. The intensity of magnetisation will be-
(1) 3×10^8 A/m (2) 12×10^8 A/m
(3) 12 A/m (4) 24 A/m

Q.4 The volume susceptibility of a magnetic material is 30×10^{-4}. Its relative permeability will be-
(1) 31×10^{-4} (2) 1.003
(3) 1.0003 (4) 29×10^{-4}

Q.5 The magnetic moment of a magnet of mass 75 gm is 9×10^{-7} A-m^2. If the density of the material of magnet is 7.5×10^3 kg/m^3 then intensity of magnetisation will be-
(1) 0.9 A/m (2) 0.09 A/m
(3) 9 A/m (4) 90 A/m

Q.6 The area of hysteresis loop of a material is equivalent to 250 Joule/m^3. When 10 kg material is magnetised by an alternating field of 50 Hz then energy lost in one hour will be if the density of material is 7.5 gm/cm^3.
(1) 6×10^4 Joule (2) 6×10^4 Erg
(3) 3×10^2 Joule (4) 3×10^2 Erg

Q.7 The magnetic susceptibility of a paramagnetic material at –73ºC is 0.0075 then its value at –173ºC will be-
(1) 0.0045 (2) 0.0030
(3) 0.015 (4) 0.0075

Q.8 The dipole moment of each molecule of a paramagnetic gas is 1.5×10^{-23} A-m^2. The temperature of gas is 27ºC and the number of molecules per unit volume in it is 2.0×10^{26} m^{-3}. The maximum possible intensity of magnetisation in the gas will be (in A/m) -

(1) 3×10^3 (2) 4×10^{-3}
(3) 5×10^5 (4) 6×10^{-4}

Q.9 The magnetic induction inside a solenoid is 6.5×10^{-4} T. When it is filled with iron medium then the induction becomes 1.4 T. The relative permeability of iron will be-

(1) 1578 (2) 2355 (3) 1836 (4) 2154

Q.10 The number of atoms per unit volume in a sample of iron is 9×10^{28} atoms/m^3. The magnetic moment of every iron atom is 1.5×10^{-23} A-m^2. If all the dipoles are aligned in a domain due to ferromagnetic interaction, then the intensity of magnetisation of an iron rod of length 10 cm and area of cross section 1 cm^2 will be-

(1) 1.8×10^6 A/m (2) 1.31×10^5 A/m
(3) 1.35×10^6 A/m (4) 1.4×10^4 A/m

Q.11 In the above problem, the magnetic moment of the rod will be-

(1) 0.135 A-m^2 (2) 1.35 A-m^2
(3) 13.5 A-m^2 (4) 135 A-m^2

Q.12 The hysteresis loss per cycle per unit volume for soft iron is 10^3 joule. The density of iron is 7.5 gm/cm^3 and its specific heat is 100 cal/kg-ºC. If a specimen of soft iron is subjected to an alternating magnetic field of frequency 50 Hz, then rise per minute in its temperature will be-

(1) 3.95ºC (2) 2.95ºC
(3) 1.95ºC (4) 0.95ºC

Q.13 The space inside a toroid is filled with tungsten whose susceptibility is 6.8×10^{-5}. The percentage increase in the magnetic field will be-

(1) 0.68 %
(2) 0.068 %
(3) 0.0068 %
(4) None of the above

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 8

Q.1 According to Curie's law, the magnetic susceptibility of a substance at an absolute temperature T is proportional to-
(1) 1/T (2) T
(3) $1/T^2$ (4) T^2

Q.2 A diamagnetic material in a magnetic field moves-
(1) from stronger to the weaker parts of the field
(2) from weaker to the stronger parts of the field
(3) perpendicular to the field
(4) in none of the above directions

Q.3 If the magnetic dipole moment of an atom of diamagnetic material, paramagnetic material and ferromagnetic material are denoted by μ_d, μ_p and μ_f respectively, then-
(1) $\mu_p = 0$ and $\mu_f \neq 0$ (2) $\mu_d \neq 0$ and $\mu_p = 0$
(3) $\mu_d \neq 0$ and $\mu_f \neq 0$ (4) $\mu_d = 0$ and $\mu_p \neq 0$

Q.4 Nickel shows ferromagnetic property at room temperature. If the temperature is increased beyond Curie temperature then it will show-
(1) diamagnetism
(2) paramagnetism
(3) anti ferromagnetism
(4) no magnetic property

Q.5 When a magnetic substance is heated, then it-
(1) Becomes a strong magnet
(2) Losses its magnetism
(3) Does not effect the magnetism
(4) Either (1) or (3)

Q.6 Magnetic permeability is maximum for-
(1) Diamagnetic substance
(2) Paramagnetic substance
(3) Ferromagnetic substance
(4) All of these

Q.7 A frog can be levitated in a magnetic field produced by a current in a vertical solenoid placed below the frog. This is possible because the body of the frog behaves as-
(1) paramagnetic
(2) diamagnetic
(3) ferromagnetic
(4) antiferromagnetic

Q.8 Liquid oxygen remains suspended between two pole faces of a magnet because it is-
(1) diamagnetic
(2) paramagnetic
(3) ferromagnetic
(4) antiferromagnetic

Q.9 Electromagnets are made of soft iron because soft iron has-
(1) High retentivity and low coercive force
(2) Low retentivity and high coercive force
(3) High retentivity and high coercive force
(4) Low retentivity and low coercive force

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 9

Q.1 Diamagnetic substance are-
(1) Feebly attracted by magnets
(2) Strongly attracted by magnets
(3) Feebly repelled by magnets
(4) Strongly repelled by magnets

Q.2 If a diamagnetic solution is poured into a U-tube and one arm of the U-tube placed between the poles of a strong magnet with the meniscus in a line with the field, then the level of the solution will-
(1) Rise (2) Fall
(3) Oscillate slowly (4) Remain as such

Q.3 Which of the following is true-
(1) Diamagnetism is temperature dependent
(2) Paramagnetism is temperature dependent
(3) Paramagnetism is temperature independent
(4) None of these

Q.4 Which one of the following is ferro-magnetic?
(1) Co (2) Zn
(3) Hg (4) Pt

Q.5 For paramagnetic materials magnetic susceptibility is related with temperature as-
(1) $\propto T^2$ (2) $\propto T^1$
(3) $\propto T^{-1}$ (4) $\propto T^{-2}$

Q.6 A superconductor exhibits perfect-
(1) Ferromagnetism (2) Antiferromagnetism
(3) Paramagnetism (4) Diamagnetism

Q.7 Which of the following statements is incorrect about hystersis ?
(1) This effect is common to all ferromagnetic substances

(2) The hysteresis loop area is proportional to the thermal energy developed per unit volume of the material
(3) The hysteresis loop area is independent of the thermal energy developed per unit volume of the material
(4) The shape of the hysteresis loop is characterstic of the material

Q.8 If a diamagnetic substance is brought near north or south pole of a bar magnet, it is-
(1) Attracted by the poles
(2) Repelled by the poles
(3) Repelled by the north pole and attracted by the south pole
(4) Attracted by the north pole and repelled by the south pole

Q.9 Diamagnetic substances characterise by-
(1) low and negative magnetic suceptibility
(2) low and positive magnetic suceptibility
(3) high and negative magnetic suceptibility
(4) high and positive magnetic suceptibility

Q.10 Magnetic suceptibility of a diamagnetic substance varies with absolute temperature as-
(1) directly proportional to T
(2) inversely proportional to T
(3) remains unchanged with T
(4) exponential decrease with T

Q.11 The material of permanent magnet has-
(1) High retentivity, low coercivity
(2) Low retentivity, high coercivity
(3) Low retentivity, low coercivity
(4) High retentivity, high coercivity

Q.12 Hysteresis property is shown by-
(1) paramagnetic and diamagnetic
(2) diamagnetic
(3) paramagnetic
(4) ferromagnetic

Q.13 Magnetic susceptibility of the following is-
(1) negative for diamagnetic
(2) positive for diamagnetic and paramagnetic
(3) negative for diamagnetic and zero for paramagnetic
(4) zero for paramagnetic and positive for ferromagnetic

Q.14 Which statement is true-
(1) atomic magnetic dipole moment of diamagnet is zero
(2) atomic magnetic dipole moment of para-magnet is zero
(3) atomic magnetic dipole moment of ferromagnet is zero
(4) ferromagnet is demagnetised rapidly after moving in magnetising field.

Q.15 For an isotropic medium B, μ_0, H and M are related as (where B, μ_0, H and M have their usual meaning in the context of magnetic material.
(1) $(B - M) = \mu_0 H$ (2) $M = \mu_0(H + M)$
(3) $H = \mu_0(H + M)$ (4) $B = \mu_0(H + M)$

Q.16 Curie-Weiss law is obeyed by iron at a temperature ....
(1) Below Curie temperature
(2) Above Curie temperature
(3) At Curie temperature only
(4) At all temperature

Q.17 When a piece of a ferromagnetic substance is put in a uniform magnetic field. Flux density inside it is four time the flux density away from the piece. The magnetic permeability of the material is-
(1) 1 (2) 2
(3) 3 (4) 4

Q.18 Ferromagnetic substance contain-
(1) empty subshell
(2) partially empty subshell
(3) full fill subshell
(4) none of these

Q.19 Soft iron is used to make the core of transformer, because of its-
(1) low coercivity and low retentivity
(2) low coercivity and high retentivity
(3) high coercivity and high retentivity
(4) high coercivity and low retentivity

Q.20 Above curie temperature ferromagnetic substance converted into-
(1) paramagnetic
(2) diamagnetic
(3) ferromagnetic
(4) non magnetic

Q.21 Among the following properties describing diamagnetism identify the property that is wrongly stated-
(1) Diamagnetic material do not have permanent magnetic moment
(2) Diamagnetism is explained by orbital motion of electron
(3) Diamagnetic materials have a small positive susceptibility
(4) The magnetic moment of individual electrons neutralize each other

Q.22 Relation between μ_r and χ will be-
(1) $\mu_r = 1 + \chi$ (2) $\chi = \mu_r + 1$
(3) $\frac{\mu_0}{\mu}$ (4) $\mu_0 \chi$

Q.23 Which of the following material has zero magnetic moment of single atom-
(1) Paramagnetic
(2) Ferromagnetic
(3) Diamagnetic
(4) All

Q.24 Correct relation between magnetic field B, magnetic intensity H and magnetism M is-
(1) $B = \mu_0(H + M)$ (2) $M = \mu_0(B + H)$
(3) $H = \mu_0(B + M)$ (4) $B = 2H(1 + M)$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 10

These questions consists of two statements each, printed as Assertion and Reason. While answering these questions you are required to choose any one of the following four responses.
(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** The ferromagnetic substance do not obey Curie's law.
Reason : At Curie point a ferromagnetic substance start behaving as a paramagnetic substance.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** The properties of paramagnetic and ferromagnetic substance are not effected by heating.
Reason : As temperature rises, the alignment of molecular magnets gradually decreases.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** Soft iron is used as transformer core.
Reason : Soft iron has narrow hysteresis loop.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** The susceptibility of diamagnetic materials does not depend upon temperature.
Reason : Every atom of a diamagnetic material is not a complete magnet in itself.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** For a perfectly diamagnetic substance permeability is always one.
Reason : The ability of a material of permit the passage of magnetic lines of force through it is called magnetic permeability is always one.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** For making permanent magnets, steel is referred over soft iron.

Reason : As retentivity of steel is smaller.
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** Diamagnetic materials can exhibit magnetism.
Reason : Diamagnetic materials have permanent magnetic dipole moment.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	3	2	3	4	4	2	1	4	2	2	1	4	4	1	2	3	3	4	2
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	3	4	4	3	4	3	2	4	3	4	3	4	1	1	4	3	1	1
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	4	2	3	1	2	1	4	3	1	3	2	1	4	3	3	3	4	2	1
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	1	1	2	4	2	2	1	3	3	2	3	3	2	1	2	1	3	1	2
Q.No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	2	4	1	3	3	1	1	2	3	2	3	4	4	2	3	2	3	2	3
Q.No.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	2	1	3	2	2	4	2	1	1	4	1	2	1	3	2	2	2	4	4	1
Q.No.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	2	3	1	4	2	3	3	3	4	4	1	1	2	3	1	1	2	1	3
Q.No.	141	142	143	144	145	146	147	148	149	150	151	152	153							
Ans.	1	4	3	4	2	2	4	4	3	3	2	3	1							

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	4	3	4	2	2	2	2	4	4	2	1	1	1	2	2	3	1	1,2
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	3	1	1	1	1	3	2	1	1	2	2	2	4	2	3	4	2	3	2
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	3	2	4	3	4	2	4	1	3	4	3	2	4	1	3	2	4	1	1
Q.No.	61	62	63	64	65															
Ans.	1	1	2	3	4															

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3 (ANSWERS)

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	2	3	1	4	3	3	3	1	4	2	2	3	4	2	4	1	4	1	3
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	4	1	1	1	1	3	1	3	2	3	1	2	1	2	1	2	1	2	1
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	3	3	3	2	4	2	3	3	1	4	3	3	1	3	3	1	1	4	2	2
Q.No.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	3	4	2	1	4	3	1	4	2	2	3	3	2	2	2	3	1	1	4	1
Q.No.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**								
Ans.	4	4	1	2	1	2	3	2	3	2	2	1								

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4 (ANSWERS)

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	3	4	3	4	4	3	3	4	1	1	1	1	2	1	2	1	1	1	1	3
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	2	2	2	4	3	3	2	3	4	1	3	2	3	2	2	1	3	2	4	1
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	1	2	3	3	3	3	1	2	3	2	4	1	1	4	4	4	4	2	1	2
Q.No.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	3	3	2	3	2	4	2	3	4	2	4	3	3	4	1	3	4	1	4	2
Q.No.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
Ans.	2	2	3	1	1	3	1	1	3	3	1	1	4	2	2	1	2	4	4	1
Q.No.	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
Ans.	1	1	2	3	3	3	1	1	1	1	1	2	4	2	1	3	2	4	2	3
Q.No.	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**								
Ans.	1	2	4	1	2	2	3	3	2	2	2	2								

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5 (ANSWERS)

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	2	3	2	1	3	1	3	3	1	1	4	4	1	4	1	3	4	4	1	1
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**											
Ans.	4	1	1	2	4	1	1	1	2											

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 6 (ANSWERS)

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	1	4	3	2	2	1	2	2	2	1	2	4	2	2	4	2	4	1	2
Ques.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**												
Ans.	3	1	3	2	1	2	3	2												

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 7 (ANSWERS)

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13
Ans.	1	1	3	2	2	1	3	1	4	3	3	4	3

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 8 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9
Ans.	1	1	4	2	2	3	2	2	4

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 9 (ANSWERS)

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	2	2	1	3	4	3	2	1	3	4	4	1	1	4	2	4	2	1	1
Ques.	21	22	23	24																
Ans.	3	1	3	1																

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 10 (ANSWERS)

Q.No.	1	2	3	4	5	6	7
Ans.	2	4	1	3	4	3	3