2. ELECTROMAGNETISM

SYNOPSIS

1. FORCE ACTING ON A CHARGED PARTICLE MOVING IN A UNIFORM MAGNETIC FIELD:

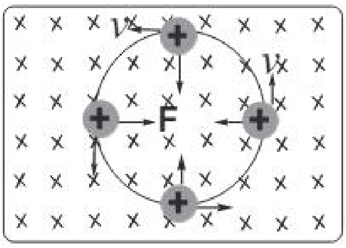
i) If charge +q is moving with velocity $\vec{v}$, making an angle θ with the direction of field, force acting on the charge is, $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$

Magnitude of force is F = Bqv $\sin\theta$, direction of $\vec{F}$ is perpendicular to plane containing both $\vec{v}$ and $\vec{B}$.

ii) If $\theta = 0^0$ or 180^0, then the force acting on the particle is zero. And the particle keeps moving in the same path. i.e. undeviated.

iii) If the charged particle enters normal to the magnetic field, the force acting on it is maximum. ie $F_{max} = Bqv$

iv) This force acts right angles to $\vec{B}$ and $\vec{v}$. It acts as centripetal force and the path of particle will be circular.



Then the radius of the circular path is given by

$r = \frac{mv}{Bq} \Rightarrow r = \frac{P}{Bq}$ (from Bqv $= \frac{mv^2}{r}$)

Where p = momentum

v) $r = \frac{\sqrt{2mK}}{qB}$ where K is kinetic energy of the particle

vi) If charged particle is accelerated through a potential difference of V volts before it enters into the magnetic field normally then $r = \frac{\sqrt{2mqV}}{qB}$.

vii) Speed, kinetic energy remains constant, but velocity, acceleration, momentum and force are variable since their directions are continuously changing.

viii) The time period of rotation is

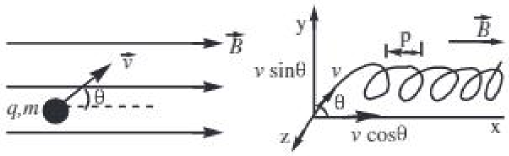
$T = \frac{2\pi r}{v} \qquad \therefore T = \frac{2\pi m}{qB}$

Angular frequency of rotation is $\omega = \frac{Bq}{m}$

$\therefore$ T and ω are independent of v and r of charged particle.

ix) When the particle enters the magnetic field at angle 'θ' with $\vec{B}$, (such that $\theta \neq 0^0$, $\theta \neq 90^0$, $\theta \neq 180^0$), then the path followed by the particle will be **helical**.

x) Radius of circular path of the helix is given by $r = \dfrac{mv\sin\theta}{qB}$



xi) Time period of rotation is $T = \dfrac{2\pi m}{qB}$

xii) Distance travelled by the particle along magnetic field in one complete rotation or *Pitch of helix* is given by P =(vcos θ) T

$$P = \frac{2\pi mv\cos\theta}{qB}$$

xiii) Work done by the magnetic field on the charged particle is zero.

2. LORENTZ FORCE :

i) When a charge enters a region where both electric and magnetic fields exists simulta-neously, force acting on it is called Lorentz force and is given by

$$\vec{F} = \vec{F_e} + \vec{F_m} = q\left[\vec{E} + \left(\vec{V} \times \vec{B}\right)\right]$$

ii) **Cyclotron:**

a) The cyclotron is a machine to accelerate charged particles or ions to high energies using both electric and magnetic fields in combination.

b) Cyclotron uses the fact that the frequency of revolution of the charged particle in a magnetic field is independent of its energy.

c) Centripetal force is provided by the magnetic force $\dfrac{mv^2}{r} = Bqv$

d) Radius of circular path is $r = \dfrac{mv}{Bq}$

e) Time period of charged particle is $T = \dfrac{2\pi r}{v}$

$T = \dfrac{2\pi m}{Bq}$ $f = \dfrac{1}{T} = \dfrac{Bq}{2\pi m}$ = cyclotron frequency.

f) K.E. of charged particles is

K.E =1/2 mv^2 $= \dfrac{1}{2}m\left(\dfrac{Bqr}{m}\right)^2 = \dfrac{B^2q^2r^2}{2m}$

3. FORCE ON A CURRENT CARRYING CONDUCTOR KEPT IN MAGNETIC FIELD:

i) A conductor carrying current i is placed in a uniform magnetic field of induction B at an angle θ with the field direction. The force acting on it is given by

$$\overline{F} = i\left(\bar{l} \times \overline{B}\right), \qquad \left|\overline{F}\right| = Bil\,\mathrm{Sin}\,\theta$$

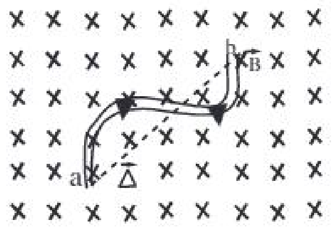
ii) If B and l are parallel or anti-parallel F = 0

iii) If B and l are perpendicular, then F_{Max} = Bil.

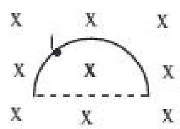
iv) Direction of force can be found using Fleming's left hand rule.

4. FLEMING'S LEFT HAND RULE :

i) a) The force acting on a curved wire joining points a and b as shown in the figure is the same as that on a straight wire joining these points. It is given by the expression $\vec{F} = i\,\vec{L} \times \vec{B}$



b) The force experienced by a semi circular wire of radius 'r' when it is carrying a current 'i' and is placed in a uniform external magnetic field of induction B as shown in the figure is given by F = BI(2r).



Force directed vertically upwards

ii) If an oarbitrarily shaped closed loop carrying a current I is placed in a uniform magnetic field, the force acting on it is zero.

5. BIOT-SAVART'S LAW :

i) According to Biot-savart's law the magnitude of the intensity of magnetic field due to a small element of length '$d\ell$', carrying current 'i' is given by dB = $\frac{\mu_0}{4\pi}\frac{i\,d\ell\sin\theta}{r^2}$

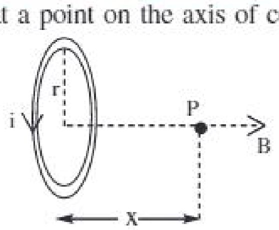
ii) In vector form , $d\vec{B} = \frac{\mu_0}{4\pi} i \frac{d\vec{\ell} \times \vec{r}}{r^3}$

iii) The magnetic induction due to entire conductor 'QR' is given by B = $\frac{\mu_0 i}{4\pi}\int_Q^R \frac{d\ell\sin\theta}{r^2}$

6. MAGNETIC INDUCTION DUE TO CIRCULAR COIL CARRYING CURRENT

i) The magnetic field at a point on the axis of coil is

$$B_a = \frac{\mu_0 n i r^2}{2\left(r^2 + x^2\right)^{3/2}}$$



ii) If x >>> r, then the magnetic field on the axis of the coil is

$$B = \frac{\mu_0 n i r^2}{2x^3} = \frac{\mu_0}{4\pi}\left(\frac{2ni\pi r^2}{x^3}\right)$$

If we compare this expression for the intensity of electric field on the axis of an electric dipole, B $= \frac{\mu_0}{4\pi}\frac{2M}{x^3}$

iii) The magnetic moment of the circular coil is given by M = niA. Hence the current carrying coil behaves like a magnetic dipole with poles on either side of its face.

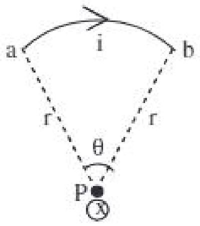
iv) The magnetic field at the centre of the coil is $B_c = \frac{\mu_0 ni}{2r}$

Here 'n' is number of turns and 'r' is radius of coil. The direction of $\vec{B}$ is perpendicular to the plane of the coil

v) The relation between magnetic field induction at the centre of the current carrying circular coil to the magnetic field induction on its axis at a distance 'x' is

$$B_c = B_a\left(1+\frac{x^2}{r^2}\right)^{3/2}$$

vi) If the wire is bent in the form of an arc subtending an angle 'θ' at the centre, magnetic induction at centre is



$$B = \frac{\mu_0 i}{4\pi r}(\theta)$$

Here θ is in radians

vii) If the wire is bent in the form of semicircle, then the magnetic induction at the centre is given by $B = \frac{\mu_0 i}{4r}$

viii) The same wire of length 'l' carrying current 'i' is first bent into a circular coil with n_1 turns and then into another circular coil with n_2 turns. If B_1, B_2 are magnetic inductions at their centres, then

a) $\frac{B_1}{B_2} = \left(\frac{n_1}{n_2}\right)^2$

b) If r_1 and r_2 are radii of turns of the coil in the above case, then ratio of magnetic induction is

$$\frac{B_1}{B_2} = \left(\frac{r_2}{r_1}\right)^2$$

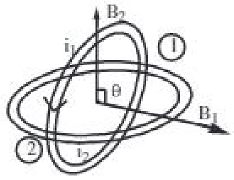
ix) If two circular coils are connected in series, then the ratio of magnetic induction at their centres is $\frac{B_1}{B_2} = \left(\frac{n_1}{n_2}\right)\left(\frac{r_2}{r_1}\right)$

x) If the two coils are made up of same wire and connected in parallel,Then the ratio of the magnetic induction at their centres is $\frac{B_1}{B_2} = \left(\frac{r_2}{r_1}\right)^2$ The field is independent of number of turns

xi) If two concentric circular loops carrying current i_1, i_2 and their planes are inclined at an angle θ, the resultant magnetic induction at the common centre is

$B=\sqrt{B_1^2+B_2^2+2B_1B_2\cos\theta}$

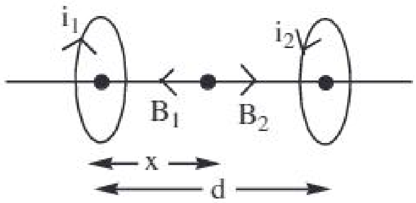
where $B_1=\frac{\mu_0 i_1}{2r_1}$, $B_2=\frac{\mu_0 i_2}{2r_2}$



a) If $\theta=90^0$ then $B=\sqrt{B_1^2+B_2^2}$

b) If $\theta=0^0$, and the coils carrying current in same direction, then $B = B_1 + B_2$

xii) If two circular loops having same radii (r) and same number of turns are arranged coaxially with a large separation d (d>>r) between their centres have currents i_1 and i_2 in the opposite direciton, then null point occurs on the axis at a closer point to the coil carrying small current.



At null point $B_1 = B_2$

$$\frac{i_1}{x^3}=\frac{i_2}{(d-x)^3}\Rightarrow x=\frac{d}{\left(\frac{i_2}{i_1}\right)^{1/3}\pm 1}$$

'+' sign is used when null point is formed in between the coils.

'–' sign is used when null point is formed outside the coils.

xiii) If a charge 'q' is moving in a circular orbit of radius 'r' with uniform speed 'v' making 'f' rotations per second, with time period 'T' and angular velocity ω

a) current $i=fq=\frac{q}{T}=\frac{vq}{2\pi r}=\frac{\omega q}{2\pi}$

b) Equivalent magnetic moment

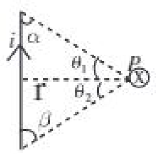
$$M = i\left(\pi r^2\right)=fq\left(\pi r^2\right)=\frac{\omega q r^2}{2}=\frac{\pi r^2 q}{T}=\frac{vqr}{2}$$

c) Magnetic induction at the centre is

$$B=\frac{\mu_0 i}{2r}=\frac{\mu_0}{2r}(fq)=\frac{\mu_0}{2r}\frac{q}{T}=\frac{\mu_0 Vq}{4\pi r^2}=\frac{\mu_0\omega q}{4\pi r}$$

7. MAGNETIC FIELD DUE TO STRAIGHT CONDUCTOR

i) Magnetic induction due to a straight conductor of finite length at a perpendicular distance 'r' is

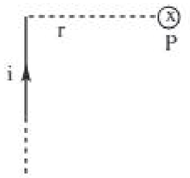


$$B=\frac{\mu_0 i}{4\pi r}(\sin\theta_1+\sin\theta_2)\quad ; \quad B=\frac{\mu_0 i}{4\pi r}(\cos\alpha+\cos\beta)$$

ii) Magnetic induction at a point due to a straight conductor of infinite length carrying current 'i', at a perpendicular distance 'r' is given by $B=\frac{\mu_0 i}{2\pi r}$

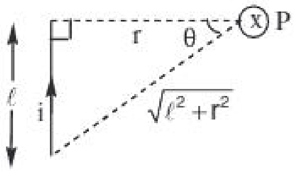
iii) If the point P is along the length of the conductor , at that point B = 0

iv) If the point 'P' is at one end of infinitely long straight conductor and lies at a perpendicular distance 'r', the magnetic induction at P is given by



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

v) If the point 'P' is at perpendicular distance 'r' at one end of conductor of finite length l, the magnetic induction at P is given by



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

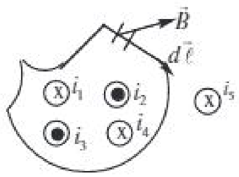
$$B = \frac{\mu_0 i}{4\pi r}\frac{l}{\sqrt{l^2+r^2}}$$

8. AMPERE'S LAW : (CIRCUITAL LAW) :

i) Ampere's law is used for calculating the magnetic field under highly symmetrical conditions.

ii) The line integral of the intensity of magnetic induction field around any closed path is equal to μ_0 times the net current across the area bounded by the path

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



Where i is the net current enclosed by the closed path with reference to figure $\mathbf{i = i_1 - i_2 - i_3 + i_4}$

iii) An inifinte long conductor carries current 'i'. If a magnetic pole of strength 'm' is kept at a perpendicular distance r, force acting on it is $F = mB = \frac{\mu_0 i}{2\pi r}m$

iv) If the pole is moved round the conductor once, work done is

$$W = \oint \vec{F}.\vec{ds} = \frac{\mu_0 im}{2\pi r}\times 2\pi r = \mu_0 im$$

v) If the pole is moved round conductor 'n' times, work done is W= μ_0 mni

vi) The workdone in the above case is independent of radius of the circle around which the pole is moving.

vii) If current is flowing through a solid cylinder, magnetic field is produced both inside and outside the conductor.

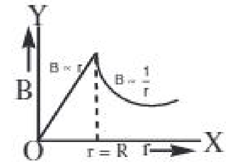
a) The magnetic field induction inside the current carrying very long soild cylinder at a distance 'r' from the axis is given by,

$B = \frac{\mu_0 i(r)}{2\pi R^2}$ where R is the radius of the conductor i.e., $B \propto r$ (r <R)

b) Magnetic field induction out side the current carrying very long soild cylinder at a distance 'r' from the axis is geven by

$B = \frac{\mu_0 i}{2\pi r}$ i.e., $B \propto 1/r$ (r >R)

c) **B versus r graph :**

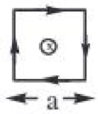


viii) a) If current is flowing through a hollow cylinder, magnetic induction at any point inside it is zero

b) The magnetic field at distance 'r' from the axis out side the current carrying very long hollow cylinder is $B = \frac{\mu_0 i}{2\pi r}$

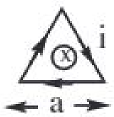
ix) Magnetic induction at the centre of current carrying wire bent in the form of a square of side 'a' is

$B = 8\sqrt{2}\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{a}\right)$



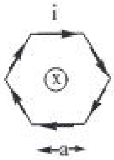
x) Magnetic induction at the centroid of current carrying wire bent in the form of equilateral triangle of side 'a' is

$B = 18\ \frac{\mu_0}{4\pi}\frac{i}{a}$

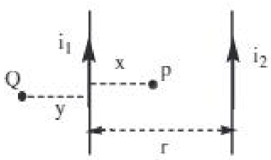


xi) Magnetic induction at the centre of current carrying wire bent in the form of hexagon of side 'a' is given by

$B = 4\sqrt{3}\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{a}\right)$



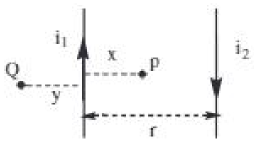
xii) Two straight and infinite long parallel wires separated by a distance 'r' carry currents i_1 and i_2 in the **same** direction as shown. The resultant magnetic field at P and Q is



$$B_P = \frac{\mu_0}{2\pi}\left[\frac{i_1}{x} \sim \frac{i_2}{(r-x)}\right]$$

$$B_Q = \frac{\mu_0}{2\pi}\left[\frac{i_1}{y} + \frac{i_2}{(r+y)}\right]$$

xiii) Two straight and infinite long parallel wires separated by a distance 'r' carry currents i_1 and i_2 in **opposite** direction as shown. The resultant magnetic field at P and Q is



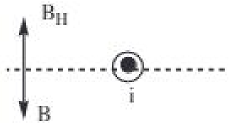
$$B_P = \frac{\mu_0}{2\pi}\left[\frac{i_1}{x} + \frac{i_2}{(r-x)}\right]$$

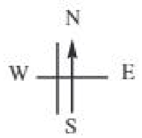
$$B_Q = \frac{\mu_0}{2\pi}\left[\frac{i_1}{y} \sim \frac{i_2}{(r+y)}\right]$$

9. NULL POINTS :

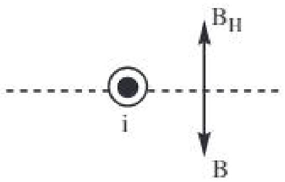
i) Null points due to a very long straight current carrying conductor placed in earth's magnetic field:

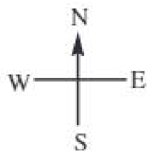
a) When a straight vertical conductor has current in **upward direction**, null point occurs on **west** of the conductor.



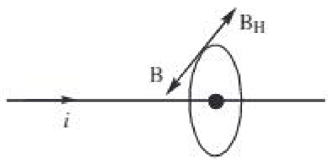


b) When a straight vertical conductor has current in **downward direction**, null point occurs on **east** of the conductor.





c) If a straight horizontal conductor has current towards east then a null point occurs above the conductor.

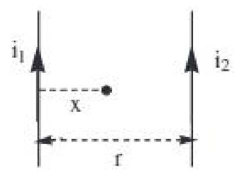


Note: In the above cases at null point $B = B_H$ $\Rightarrow \frac{\mu_0}{2\pi}\frac{i}{r} = B_H$

10. NULL POINTS DUE TO TWO CURRENT CARRYING PARALLEL WIRES.

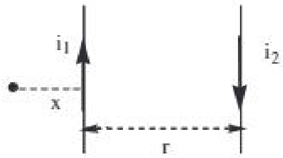
i) Two straight parallel conductors are carrying currents i_1, i_2 ($i_1 < i_2$) in the **same direction**, and are seperated by a distance r , the null point is formed **in between** them. The distance of the null point from the conductor carrying smaller current is

$$x = \frac{r}{\frac{i_2}{i_1}+1}$$



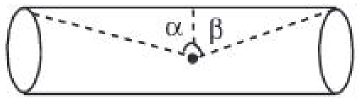
ii) Two straight parallel conductors are carrying currents i_1, i_2 ($i_1 < i_2$) in **opposite directions**, and are seperated by a distance r , then the null point is formed **out side** the conductors, the distance of the null point from the conductor carrying smaller current is given by

$$x = \frac{r}{\frac{i_2}{i_1} - 1}$$



11. SOLENOID AND TOROID :

i) The magnetic Induction at a point on the axis of solenoid $B = \frac{\mu_0 ni}{2}(\sin\alpha + \sin\beta)$ (pont is well inside the solenoid)

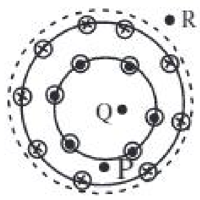


ii) Magnetic induction of infinite length solenoid $B = \mu_0 ni$ (point is well inside the solenoid)

iii) If the point is near one end $B = \frac{\mu_0 ni}{2}$

iv) Magnetic induction at the centre of finite length solenoid $B = \frac{\mu_0}{4\pi}(4\pi ni)\sin\alpha$ and $\sin\alpha = \frac{L}{\sqrt{L^2 + 4R^2}}$

v) Magnetic induction with in the winding of toroid is $B_P = \frac{\mu_0}{2\pi}\frac{Ni_0}{r}$ then $L = 2\pi r$ and $B = \frac{\mu_0 Ni_0}{L}$



vi) The field inside the core and the field outside the toroid is zero i.e, $B_Q = 0$ and $B_R = 0$

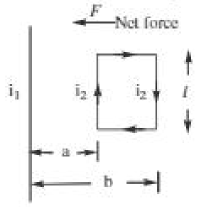
12. FORCE BETWEEN TWO PARALLEL CURRENT CARRYING LONG STRAIGHT CONDUCTORS :

i) Force per unit length on each wire is given by $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{i_1 i_2}{r}$

If $i_1 = i_2 = 1$ amp, r=1 m, then force per unit length of the conducter is $2\text{x}10^{-7}$ N/m

ii) A straight and very long wire carries current i_1 and rectangular loop of wire carrying current i_2 is placed nearby it. The force on the loop is

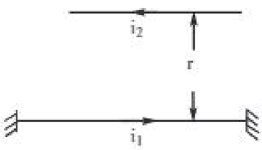
$$F = \frac{\mu_0 i_1 i_2 l}{2\pi}\left[\frac{1}{a} - \frac{1}{b}\right]$$



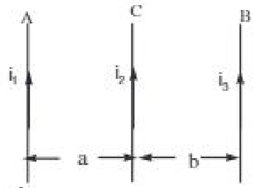
iii) A very long horizontal wire carries a current i_1 is rigidly fixed. Another wire is placed directly above and parallel to it carries a current i_2. r is the perpendicular distance of separation between the wires and currents are in opposite directions for the second wire remains stationary, the condition is

F = mg $\Rightarrow \dfrac{\mu_0 i_1 i_2 \ell}{2\pi r} = mg$

$\Rightarrow \boxed{\dfrac{m}{\ell} = \dfrac{\mu_0 i_1 i_2}{2\pi r g}}$



iv) Three long parallel conductors carry currents as shown



a) Resultant force per unit length on the wire **'C' is**

$$F = \frac{\mu_0}{2\pi}\left[\frac{i_1 i_2}{a} \sim \frac{i_2 i_3}{b}\right]$$

b) If the resultant force on the wire 'C' is zero, the condition is

$$\frac{i_1 i_2}{a} = \frac{i_2 i_3}{b} \Rightarrow \frac{i_1}{a} = \frac{i_3}{b}$$

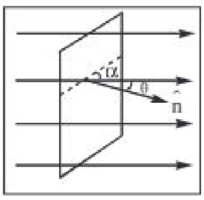
13. FORCE BETWEEN TWO STREAMS OF ELECTRIC CHARGES :

i) If two streams of electrons or protons are moving with velocity 'v' in parallel and same directions, there will be both electric repulsive force and magnetic attractive force. Since electric force predominates the magnetic force, there will be repulsion.

ii) If they move parallel and opposite directions, there will be electric repulsive force and magnetic repulsive force and hence there will be repulsion again.

14. TORQUE ACTING ON A CURRENT LOOP KEPT IN UNIFORM MAGNETIC FIELD :

i) When a coil carrying current is placed in uniform magnetic field, the net force on it is zero but it experiences a torque or couple.



Here $\alpha + \theta = 90^0$

ii) Torque acting on a current carrying coil placed in uniform magnetic field is $\vec{\tau} = \vec{M} \times \vec{B}$

iii) Torque acting on the coil is τ = Bin A sinθ

iv) If the plane of coil is parallel to the direction of magnetic field $\tau = \tau_{max}$ = Bin A

v) If the plane of coil is perpendicular to the direction of magnetic field, $\tau = 0$

15. MOVING COIL GALVANOMETER :

i) **Principle of moving coil galvanometer**: When a current carrying coil suspended in a uniform magnetic field, it experiences a torque and hence it rotates.

ii) If 'θ' is the deflection for passage of current 'i', then

$C\theta = BiAN \Rightarrow i = \left(\dfrac{C\theta}{BAN}\right)$ where $k = \left(\dfrac{C}{BNA}\right)$

= Galvanometer constant or figure of merit.It is independent of B_H. Where 'C' is couple per unit twist.

iii) a) Current sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit current flowing through it. $S_I = \frac{d\theta}{di} = \frac{BAN}{C}$.

b) Voltage sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit voltage applied to it.

$S_V = \frac{\theta}{V} = \frac{\theta}{iG} \Rightarrow \frac{\theta}{V} = \frac{BAN}{CG}$

Where G is resistance of galvanometer.

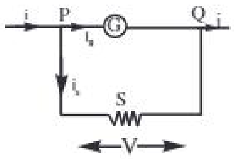
c) Sensitivity of a MCG can be increased by

i) Increasing B ii) Increasing A iii) Increasing N iv) Decreasing C

16. SHUNT :

i) A low resistance connected in parallel to galvanometer to protect it from large currrent is known as shunt.

ii) When shunt is connected range increases but sensitivity decreases.



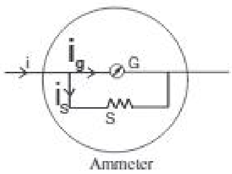
iii) $R_{equivalent} = \frac{GS}{G+S}$

iv) $V = i\,R_{eq} = i\frac{GS}{G+S}$

v) $V_{PQ} = i_g G = i_s S$

17. AMMETER :

i) Galvanometer can be converted in to Ammeter by connecting low resistance parallel to it.



ii) To increase the range by 'n' times or to decrease the Sensitivity by 'n' times, shunt to be connected across Galvanometer is

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

Here $n = \frac{i}{i_g} = \frac{\text{new range}}{\text{old range}} = \frac{\text{old divisions/amp}}{\text{new dividions/amp}}$

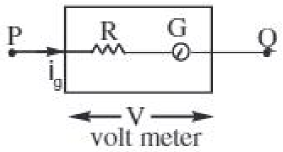
iii) Equivalent resistance of Ammeter = $\frac{GS}{G+S}$

iv) Ammeter must always be connected in series to the circuit.

v) Among low range and high range Ammeters, low range Ammeter has more resistance.

18. VOLTMETER :

i) Galvanometer is converted into voltmeter by connecting high resistance in series to it.



ii) P.D. across the ends of voltmeter is, $V = i_g(G+R)$

iii) Resistance to be connected in series to galvanometer to convert into voltmeter of range 0 - V volt is

$$R = \frac{V}{i_g} - G$$

iv) To increase the range by n times,

$$n = \frac{\text{newrange}\, V_2}{\text{old range} V_1} = \frac{i_g(G+R)}{i_g(G)} = 1 + \frac{R}{G}$$

Hence resistance to be connected in series to galvanometer is R = G(n-1)

19. TANGENT GALVANOMETER :

i) Tangent galvanometer works on the principle of Tangent law i.e., $B = B_H \,\text{Tan}\theta$

Here B = Magnetic induction at the centre of the current carrying coil = $\frac{\mu_0 ni}{2r}$

ii) current measured by Tangent galvanometer is

$$i = \left(\frac{2rB_H}{\mu_0 n}\right)\text{Tan}\theta = K\,\text{Tan}\,\theta$$

r = Radius of coil, K = reduction factor ; n = number of turns of coil

iii) Reading is more accurate when $\theta = 45^0$ since relative error $\frac{di}{i} \alpha \frac{1}{\sin 2\theta}$ and it is minimum for 45^0

iv) Sensitivity is maximum when $\theta = 0^0$ since $\frac{d\theta}{di} \alpha \cos 2\theta$, which is maximum for $\theta = 0^0$.

v) Reduction factor K depends on horizontal component of earth's magnetic field.

vi) T.G cannot be used at magnetic poles, since $B_H = 0$ at magnetic poles.

vii) T.G is used to measure the current of the order of 10^{-6}A.

LECTURE SHEET

EXERCISE-I

(Magnetic field due to current carrying conductors)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. An electric current passes through a long straight wire. At a distance 5 cm from the wire, the magnetic field is B. The field at 20 cm from the wire would be

1) 2B   2) $\frac{B}{4}$ 3) $\frac{B}{2}$ 4) B

2. A current of $1/4\pi$ amp is flowing in a long straight conductor. The line integral of magnetic induction around a closed path enclosing the current carrying conductor is

1) 10^{-7} webre/metre   2) $4\pi\times10^{-7}$ webre/metre
3) $16\pi^2\times10^{-7}$ webre/metre   4) zero

3. A wire in the form of a square of side a carries a current *i*. Then the magnetic induction at the centre of the square is (magnetic permeability of free space $=\mu_0$)

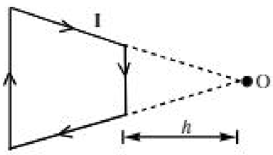
1) $\frac{\mu_0 i}{2\pi a}$ 2) $\frac{\mu_0 i\sqrt{2}}{\pi a}$ 3) $\frac{2\sqrt{2}\mu_0 i}{\pi a}$ 4) $\frac{\mu_0 i}{\sqrt{2}\pi a}$

4. Due to a straight current carrying conductor, a null point occured at p on east of the conductor. The net magnetic induction at a point Q which is half the distance of 'p' on north of the conductor is,

1) zero   2) B_H 3) $\sqrt{2}\,B_H$ 4) $\sqrt{5}\,B_H$

Numerical Value Type Questions

5. A current of $I=\sqrt{2}$ A flows in a circuit having the shape of an isosceles trapezium. The ratio of the bases of the trapezium is 2. The length of the smaller base of the trapezium is l = 100 mm, the distance h =50mm. The magnetic induction B at symmetric point O in the plane of the trapezium is $x\mu T$. Then 'x' is



6. Two long parallel wires are separated by a distance of 8 cm carry electric currents of 3A and 5 A. The distance of null point from the conductor carrying larger current when currents are flowing in the same direction is (im cm)

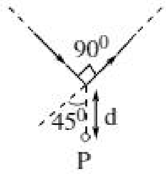
7. Two long straight parallel conductors 10 cm apart, carry currents of 5A each in the same direction. Then the magnetic induction at a point mid-way between them is ____ (in T)

8. Two long parallel wires are separated by a distance of 2 m. They carry a current of 1 A each in opposite direction. The magnetic induction at the midpoint of a straight line connecting these two wires is ____ (in μT)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Find the magnetic field at P due to the arrangement shown



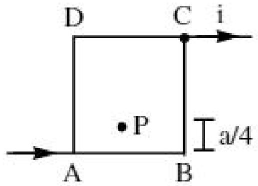
a) $\frac{\mu_0 i}{\sqrt{2}\ \pi\ d}\left(1-\frac{1}{\sqrt{2}}\right)\otimes$ b) $\frac{2\mu_0 i}{\sqrt{2}\ \pi\ d}\otimes$

c) $\frac{\mu_0 i}{\sqrt{2}\ \pi\ d}\otimes$ d) $\frac{\mu_0 i}{\sqrt{2}\ \pi\ d}\left(1+\frac{1}{\sqrt{2}}\right)\otimes$

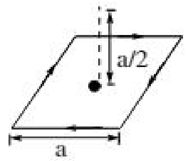
2. Figure shows a square loop of the edge a made of a uniform wire. A current i enters the loop at the point A and leaves it at the point C. Find the magnetic field at the point P which is on the perpendicular bisector of AB at a distance a/4 from it

a) $\frac{2\mu_0 i}{\pi a}\left(\frac{1}{\sqrt{5}}-\frac{1}{3\sqrt{13}}\right)\odot$ b) $\frac{2\mu_0 i}{a}\left(\frac{1}{\sqrt{5}}+\frac{1}{3\sqrt{13}}\right)\uparrow\uparrow$

c) $\frac{\mu_0 i}{2a}\left(\frac{1}{\sqrt{5}}-\frac{1}{2\sqrt{13}}\right)\odot$ d) $\frac{2\mu_0 i}{\pi a^2}\left(\frac{1}{\sqrt{3}}+\frac{1}{3\sqrt{14}}\right)\otimes$



3. The magnetic field due to a current carrying square loop of side a at a point located symmetrically at a distance of a/2 from its centre (as shown is)

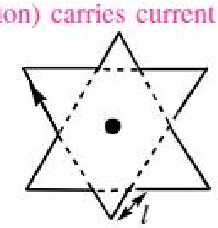


a) $\frac{\sqrt{2}\mu_0 i}{\sqrt{3}\pi a}$ b) $\frac{\mu_0 i}{\sqrt{6}\pi a}$ c) $\frac{2\mu_0 i}{\sqrt{3}\pi a}$ d) zero

4. A star shaped loop (with l = length of each section) carries current i. Magnetic field at the centroid of the loop is

a) $\frac{3\mu_0 i}{\pi l}$ b) $\frac{3\mu_0 i}{2\pi l}$

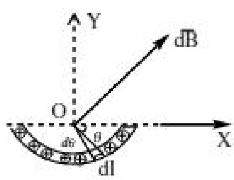
c) $(3-\sqrt{3})\frac{\mu_0 i}{\pi l}$ d) $(3+\sqrt{3})\frac{\mu_0 i}{\pi l}$



5. Three long straight conductors are arranged parallel to each other in the same plane and carry currents of 1 A, 2 A and 3 A all in the same direction. The distance between the first two conductors is "x" and the distance between the second and thrid conductors is "y". If the middle conductor is in equilibrium, the ratio x : y is

a) 1 : 3 b) 3 : 1 c) $1:\sqrt{3}$ d) $\sqrt{3}:1$

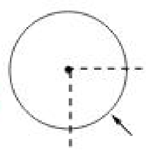
6. A current I flows in along straight wire with cross section having the form a half circular ring of radius R. The magnetic field induction at the point O is



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

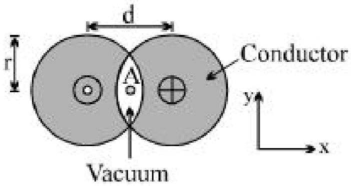
c) $B=\frac{\mu_0 I}{\pi^2 R}$ d) $B=\frac{\mu_0 I}{2\pi^2 R}$

7. A long thin walled pipe of radius R carries a current I along its length. The current density is uniform over the circumference of the pipe. The magnetic field at the center of the pipe due to quarter portion of the pipe shown, is



a) $\frac{\mu_0 I\sqrt{2}}{4\pi^2 R}$ b) $\frac{\mu_0 I}{\pi^2 R}$ c) $\frac{2\mu_0 I\sqrt{2}}{\pi^2 R}$ d) None

8. Two long conductors are arranged as shown below to form overlapping cylinders, each of radius r, whose centers are seperated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What is the magnitude and direction of the magnetic field at point A?



a) $\mu_0 Jd$ b) $\frac{\mu_0 Jd}{2}$ c) $\frac{\mu_0 Jd}{3}$ d) $\frac{\mu_0 Jd}{4}$

More than One correct answer Type Questions

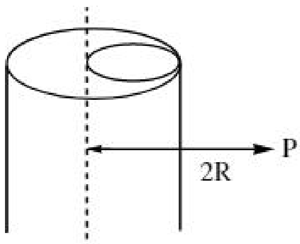
9. A long straight wire carries a current along the x-axis. Consider the points A(0, 1, 0), B(0, 1, 1), C(1, 0, 1) and D(1, 1, 1). Which of the following pairs of points will have magnetic fields of the same magnitude?

a) A and B b) A and C c) B and C d) B and D

10. A long, straight wire of radius R carries a current distribured uniformly over its cross-section. The magnitude of the magnetic field is

a) maximum at the axis of the wire
b) minimum at the axis of the wire
c) maximum at the surface of the wire
d) minimum at the surface of the wire

11. An infinitely long current carrying thick cylindrical conductor, has a cylindrical cavity of radius $\frac{R}{2}$. The axis of the cylindrical cavity is at a distance $\frac{R}{2}$ from the axis of the cylindrical conductor. A current with current density J flows along the length of the conductor. The magnetic field at a point 'P' at a distance 2R from the axis of the cylinder is (point 'P' is on the plane containing both the axes)



a) magnetic field at P is $\frac{\mu_0 JR}{12}$

b) magnetic field at P is $\frac{\mu_0 JR}{6}$

c) magnetic field on the axis of the cavity is non-zero

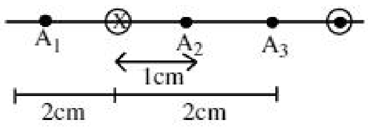
d) magnetic field on the axis of the conductor is non-zero

Linked Comprehension Type Questions

Passage - I :

Figure shows two parallel wires separated by a distance of 4.0 cm and carrying equal currents of 10 A along opposite directions.

12. Find the magnitude of the magnetic field B at A_1 is



a) 0.67×10^{-4}T b) 0.25×10^{-4}T c) 1.23×10^{-9}T d) 1.92×10^{-6}T

13. Find the magnitude of the magnetic field B at A_2 is

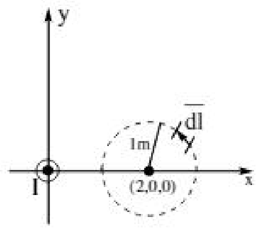
a) $1.8{\times}10^{-6}$T b) $2.7{\times}10^{-4}$T c) $3.2{\times}10^{-3}$T d) $4.2{\times}10^{-4}$T

14. Findthe magnitude of the magnetic field B at A_3 is

a) $0.67{\times}10^{-4}$ T b) $2.7{\times}10^{-4}$ T c) $1.0{\times}10^{-5}$ T d) 2.0×10^{-4} T

Passage - II :

An infinitely long wire lying along z-axis carries a current I, flowing towards positive z-direction. There is no other current. Consider a circle in x-y plane with centre at (2m, 0, 0) and radius 1 meter. Divide the circle in small segments and let $d\vec{l}$ denote the length of a small segment in anticlockwise direction, as shown.



15. The path integral $\oint \vec{B}.d\vec{l}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle is,

a) $\dfrac{\mu_0 I}{8}$ b) $\dfrac{\mu_0 I}{2}$ c) $\mu_0 I$ d) 0

16. Consider two points A(3, 0, 0) and B(2, 1, 0) on the given circle. The path integral $\int_A^B \vec{B}.d\vec{l}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle from A to B is,

a) $\dfrac{\mu_0 I}{\pi}\tan^{-1}\dfrac{1}{2}$ b) $\dfrac{\mu_0 I}{2\pi}\tan^{-1}\dfrac{1}{2}$ c) $\dfrac{\mu_0 I}{2\pi}\sin^{-1}\dfrac{1}{2}$ d) 0

17. The maximum value of path integral $\oint \vec{B}.d\vec{l}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle between any two points on the circle is

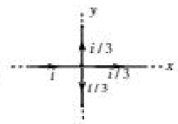
a) $\dfrac{\mu_0 I}{12}$ b) $\dfrac{\mu_0 I}{8}$ c) $\dfrac{\mu_0 I}{6}$ d) 0

Matrix Matching Type Questions

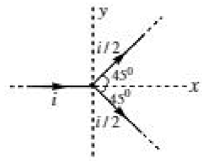
18. Column-II gives four situations in which three or four semiinfinite current carrying wires are placed in *xy* plane as shown. The magnitude of the direction of current is shown in each figure. Column-I gives statements regarding the *x*-and *y*-components of magnetic field at a point *P* whose coordinates are (0, 0, *d*). Match the statements in Column-I with the corresponding figures in Column-II.

COLUMN - I **COLUMN - II**

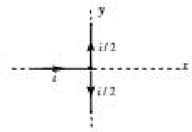
A) The *x*-component of magnetic field at point *P* is zero in

p) 

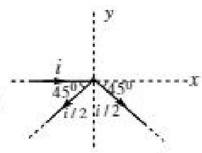
B) The z-component of magnetic field at point P is zero in

q) 

C) The magnitude of magnetic field at point P is $\frac{\mu_0 i}{4\pi d}$ in

r) 

D) The magnitude of magnetic field at pointP isgreater than $\frac{\mu_0 i}{4\pi d}$ in

s) 

Integer Type Questions

19. An infinitely long solid conducting cylindrical rod of radius *R* is carrying a current distributed uniformly throughout the cross section. What is the ratio of magnetic fields at perpendicular distances *R*/2 and 2*R* from the axis of cylinder ?

20. Two long straight parallel conductors 10 cm apart, carry current of 5A each in opposite directions. Then the magnetic induction at a point mid way between them is $x \times 10^{-5}\,T$. What is the value of '*x*' ?

EXERCISE-II

(Magnetic field due to circular current loop)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Magnetic field induction at centre of circular coil of radius 5 cm and carrying a current 0.9 A is (in S.I. units) (ϵ_0 = absolute permitivity of air S.I. units, velocity of light = 3×10^8 m/s)

1) $\frac{1}{\epsilon_0 10^{16}}$ 2) $\frac{10^{16}}{\epsilon_0}$ 3) $\frac{\epsilon_0}{10^{16}}$ 4) $10^{16}\epsilon_0$

2. A circular coil of wire of radius 'r' has 'n' turns and carries a current 'I'. The magnetic induction (B) at a point on the axis of the coil at a distance $\sqrt{3}\,r$ from its contre is

1) $\frac{\mu_0 In}{4r}$ 2) $\frac{\mu_0 In}{8r}$ 3) $\frac{\mu_0 nI}{16r}$ 4) $\frac{\mu_0 In}{32r}$

3. Two identical coils have a common centre and their planes are at right angles to each other and carry equal currents. If the magnitude of the induction field at the centre due to one of the coil is 'B', then the resultant magnetic induction field due to combination at their common centre is

1) B 2) $\sqrt{2}B$ 3) $B/\sqrt{2}$ 4) 2B

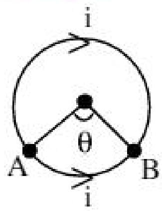
4. A circular coil is made from a wire of length 2m. Its radius is $\frac{4}{\pi}$cm. When a current of 1A passes through it, its magnetic moment is

1) πAm^2 2) $\frac{4}{100\pi}Am^2$ 3) $\frac{16}{\pi}Am^2$ 4) $\frac{1}{\pi}Am^2$

5. A straight wire of length (π^2) meter is carrying a current of 2A and the magnetic field due to it is measured at a point distant 1 cm from it. If the wire is to be bent into a circle and is to carry the same current as before, the ratio of the magnetic field at its centre to that obtained in the first case would be

1) 50 : 1 2) 1 : 50 3) 100 : 1 4) 1 : 100

6. Equal current 'i' flows in the two segments of a circular loop in the direction shown in fig. radius of the loop is 'a'. Magnetic field at the centre of the loop is,



1) zero 2) $\left(\frac{\pi-\theta}{\pi}\right)\frac{\mu_0 i}{2a}$

3) $\left(\frac{2\pi-\theta}{\pi}\right)\frac{\mu_0 i}{2a}$ 4) $\left(\frac{\theta}{2\pi}\right)\frac{\mu_0 i}{2a}$

7. A circular coil of radius 2R is carrying current 'i'. The ratio of magnetic fields at the centre of the coil and at a point at a distance 6R from the centre of the coil on the axis of the coil is,

1) 10 2) $10\sqrt{10}$ 3) $20\sqrt{5}$ 4) $20\sqrt{10}$

8. The field normal to the plane of a coil 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.

1) $\frac{3}{2}\frac{h^2}{r^2}$ 2) $\frac{2}{3}\frac{h^2}{r^2}$ 3) $\frac{3}{2}\frac{r^2}{h^2}$ 4) $\frac{2}{3}\frac{r^2}{h^3}$

Numerical Value Type Questions

9. The electic current in a circular coil of two turns produced a magnetic induction of 0.2T at its centre. The coil is unwound and rewound in to a coil of four turns. The magnetic induction at the centre of the coil now is, in tesla (if the same current flows in the coil)

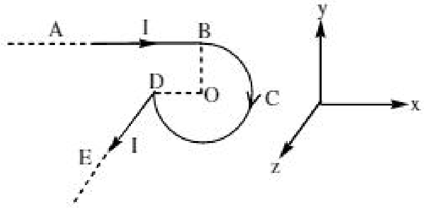
10. Two concentric circular coils A and B have radii 25 cm and 15 cm and carry currents 10 A and 15A respectively. A has 24 turns and B has 18 turns. The direction of currents are in opposite order. The magnetic induction at the common centre of the coils is $n\mu_0 T$, the value of n

11. The magnetic induction at the centre of a current carrying circular coil of radius 10 cm is $5\sqrt{5}$ times the magnetic induction at a point on its axis. The distance of the point from the centre of the coil in cm is

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. AB and DE are very long straight non-coplanar conductors at right angles. A conductor BCD in the form of 3/4th of a circle of radius r connects the two straight conductors. If the circular coil is in the plane of AB (i.e.,xy - plane) and normal to DE, then the magnetic induction at the centre O, due to current I is



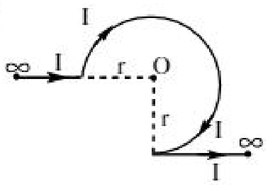
a) $\frac{\mu_0 I}{8\pi r}[3\pi+4](-\hat{k})$ b) $\frac{\mu_0 I}{8\pi r}\left[(3\pi+2)(-\hat{k})+2(\hat{j})\right]$

c) $\frac{\mu_0 I}{8\pi r}[3\pi+4](\hat{k})$ d) $\frac{\mu_0 I}{8\pi r}\left[(4+3\pi)(\hat{k})+2\hat{j}\right]$

2. A charged non-conducting thin Disc of radius R is spinning with an angular speed 'ω'. Surface charge density of disc is 'σ' then magnetic field at its centre is.

a) $\frac{\mu_0\sigma R}{2\omega}$ b) $\frac{\mu_0\sigma\omega R}{2}$ c) $\frac{\mu_0\sigma\omega R^2}{2}$ d) $\frac{\mu_0\sigma\omega R}{2\pi}$

3. The magnetic induction at point 'O' in the following fig. will be

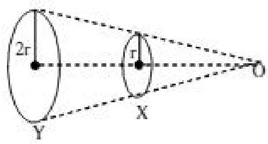


a) $\frac{\mu_0 I}{4r}\left[\frac{3}{2}-\frac{1}{\pi}\right]\odot$ b) $\frac{\mu_0 I}{4r}\left[\frac{3}{2}-\frac{1}{\pi}\right]\otimes$ s

c) $\frac{\mu_0 I}{4r}\left[\frac{3}{2}+\frac{1}{\pi}\right]\odot$ d) $\frac{\mu_0 I}{4r}\left[\frac{3}{2}+\frac{1}{\pi}\right]\otimes$

More than One correct answer Type Questions

4. Two circular coils X and Y having equal number of turns and carrying equal currents in same sense are placed co-axially, such that they subtend the same solid angle at O. Let B be the magnetic field at O due to smaller coil X, then



a) Magnetic field at O due to larger coil = 2B

b) Magnetic field at O due to larger coil = B/2

c) Total magnetic field at O is 3B/2

d) Total magnetic field at O is $\frac{\sqrt{5}B}{2}$

Linked Comprehension Type Questions

Passage :

There is plane spiral coil made on a thin insulated wire and has N turns Radii of inner and outer turns are a and b respectively

5. If a current I is passed through the spiral, the magnetic induction at the centre of the spiral will be

a) $\frac{\mu_0 NI \log_e (b/a)}{2(b-a)}$ b) $\mu_0 \log_e\left(\frac{b}{a}\right)$ c) $\frac{1}{2}\mu_0 NI \log_e(b/a)$ d) $\frac{\mu_0 NI \log_e(b/a)}{(b-a)}$

6. The magnetic moment of this spiral is

a) π NI $\log(b/a)$ b) $\pi NI(a^2+b^2+ab)$ c) $\frac{\pi NI \log(b/a)}{(b-a)}$ d) $\frac{1}{3}\pi NI(a^2+b^2+ab)$

7. If a uniform magnetic field is switched on perpendicular to plane of the coil, then

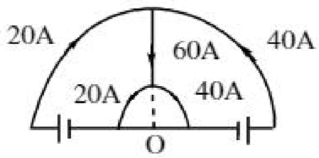
a) Net force on the coil will be zero b) Net torque will be zero

c) Net force on the coil is not zero d) None of these

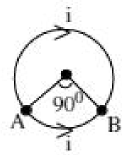
Integer Type Questions

8. The magnetic field at the centre of a semicircle of radius 5cm of passing a current i through it $2\pi\times10^{-6}\,T$. Then find the value of $2i$.

9. Two concentric coplanar semicircular conductors from part of two current loops as shown in the figure. If their radii are 11 cm and 4 cm. If the magnetic induction at the centre O is $x\times10^{-5}\,Wb/m^2$. Find the value of x.



10. Equal currents of 2A flows in the two segments of a circular loop as shown in fig. radius of circular loop is 10cm. Magnetic field at the centre of the loop 'O' is $n\pi\times10^{6}$. Where 'n' is



11. Magnetic field at two points on the axis of a circular coil at a distance of 0.05 m and 0.2 m from the centre are in the ratio 8 : 1. The radius of the coil is $x\times10^{-1}\,m$. What is the value of 'x' ?

EXERCISE-III

(Ampere's Law, Solenoid and Toroid)

LEVEL-I (MAIN)

Straight Objective Type Questions

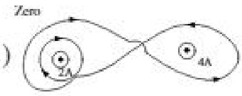
1. A current I flows along a round loop. Find $\int \overline{B}.d\overline{r}$ along the axis of the loop within the range from $-\infty$ to $+\infty$.

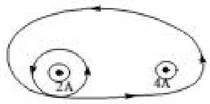
1) $\mu_0 I/2\pi$ 2) $2I/\mu_0$ 3) μ_0/I 4) $\mu_0 I$

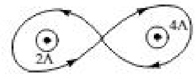
2. If current density in a conducting wire is proportional to the distance r from the axis of the conductor. Find magnetic field at the position r < R, where R is the radius of cross section of the conductor. ('i' is the current in conducting wire)

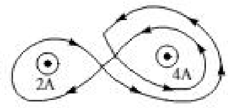
1) $\frac{\mu_0 ir^2}{2\pi R^3}$ 2) $\frac{\mu_0 ir^2}{4\pi R^3}$ 3) $\frac{\mu_0 ir^2}{2\pi R^2}$ 4) $\frac{\mu_0 ir^2}{2\pi R^4}$

3. A current carrying wire carries a current of 2A, lies along the z-axis which is out of page, another wire carrying current of 4A in same direction lies parellel to the first. Then around which loop linking both the wires $\int \vec{B}.d\vec{r}$ is zero.

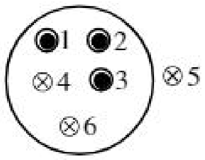
1) 

2) 

3) 

4) 

4. Six wires of current $I_1 = 1A$, $I_2 = 2A$, $I_3 = 3A$, $I_4 = 1A$, $I_5 = 5A$ and $I_6 = 4A$ cut the page perpendicular at the points 1, 2, 3, 4, 5 and 6 respectively as shown in the figure. Find value of the integral $\oint \vec{B} \cdot d\vec{l}$ around the closed path.



1) μ_0 2) $2\mu_0$ 3) $3\mu_0$ 4) $4\mu_0$

Numerical Value Type Questions

5. An infinite wire carrying a current i is passing through the centre of a circular loop of radius R. The length of wire makes an angle 60^0 with the plane of the loop. $\int \vec{B}.d\vec{l} = \frac{\sqrt{x}}{2}\mu_0 i$ when evaluated along the loop. Find x.

6. The length of a solenoid is 0.1m and its diameter is very small. A wire is wound over in two layers. The number of turns in the inner layer is 50 and that on the outer layer is 40. The strength of current flowing in two layers in the opposite direction is 3 ampere. The magnetic induction in the middle of the solenoid will be $N \times 10^{-4}$ T, where N is

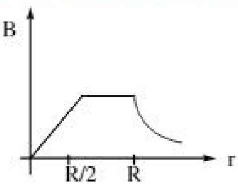
7 A toroidal solenoid has 3000 turns and a mean radius of 10cm. It has a soft iron core of relative permedability 2000. Find the magnetic field in the core when a current of 1.0A is passed through the solenoid. (in T)

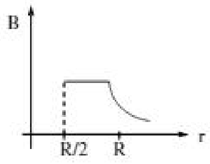
8. A long solenoid has 200 turns per cm and carries a current i, the magnetic field at its centre is 6.28×10^{-2}Wb/m^2, another long solenoid has 100 turns per cm and it carries a current i/3. The value of the magnetic field at its centre is ______ $n \times 10^{-2}$ wb/m^2, the value of n

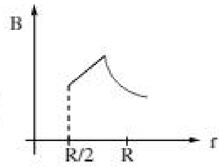
LEVEL-II (ADVANCED)

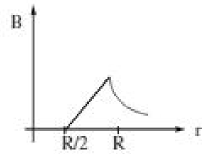
Straight Objective Type Questions

1. An infinitely long hollow conducting cylinder with inner radius R/2 and outer radius R carries a uniform current density along its length. The magnitude of the magnetic field, $|B|$ as a function of radial distance r from the axis is best represented by

a) 

b) 

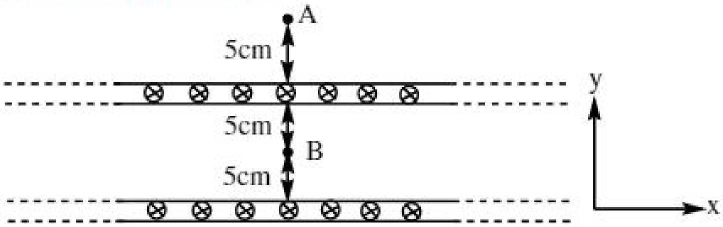
c) 

d) 

2. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b, respectively. When a current I passes through the coil, then magnetic field at the centre is

a) $\frac{\mu_0 NI}{b}$ b) $\frac{2\mu_0 NI}{a}$ c) $\frac{\mu_0 NI}{2(b-a)}\ell n\left(\frac{a}{b}\right)$ d) $\frac{\mu_0 NI}{2(b-a)}\ell n\left(\frac{b}{a}\right)$

3. Figure shows cross section of two large parallel metal sheets carrying electric currents along their surfaces. The current in each sheet is $\frac{10}{\pi}A/m$ along the sheet. Consider two points A and B, as shown in the figure with their positions.



a) Magnetic field at A is $4\mu T$ along x-direction

b) Magnetic field at A is $4\mu T$ along negative x-direction

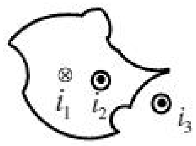
c) Magnetic field at B is $4\mu T$ along x-direction

d) Magnetic field at B is $2\mu T$ along x-direction.

Linked Comprehension Type Questions

Passage - I :

Ampere's law gives a method to calculate the magnetic field due to given current distribution. The circulation $\oint \vec{B}.\vec{dl}$ of the resultant magnetic field along a closed, plane curve is equal to μ_0 times the total current crossing the area bounded by the closed curve provided the electric field inside the loop remains constant.



Thus $\oint \vec{B}.\vec{dl} = \mu_0(i_1 - i_2)$

The contribution of current i_3 to the magnetic field cancel out because the integration is made around the full loop.

4. Consider a co-axial cable which consists of an inner wire of radius a surrounded by an outer shell of inner and outer radii b and c respectively. The inner wire carries a current i and outershell carries an equal and opposite current. The magnetic field at a distance x from axis for $x<a$ is

a) zero b) $\frac{\mu_0 i}{2\pi x}$ c) $\frac{\mu_0 ix^2}{2\pi a^3}$ d) $\frac{\mu_0 ix}{2\pi a^2}$

5. Refer to above question, the magnetic field a distance x from the axis where $a<x<b$ is

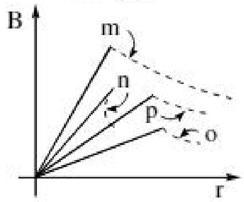
a) $\frac{\mu_0 i}{2\pi x}$ b) $\frac{\mu_0 i}{2\pi(b-a)}$ c) $\frac{\mu_0 ix}{2\pi(b^2-a^2)}$ d) zero

6. The magnetic field at a distance x from the axis where $b < x < c$ is

a) $\frac{\mu_0 i(c^2-b^2)}{2\pi \times (c^2-a^2)}$ b) $\frac{\mu_0 i(c^2-x^2)}{2\pi x(c^2-a^2)}$ c) $\frac{\mu_0 i(c^2-x^2)}{2\pi x(c^2-b^2)}$ d) zero

Passage - II :

Curves in the graph shown as function of radial distance r, the magnitude B of the magnetic field inside and outside four long wires m, n, o and p carrying currents that are uniformly distributed across the cross-section of the wires. Overlapping portions of the plots are indicated by double labels.



7. Which wire has the greatest radius ?

a) m b) n c) o d) p

8. Which wire has the greatest magnitude of the magnetic field on the surface ?

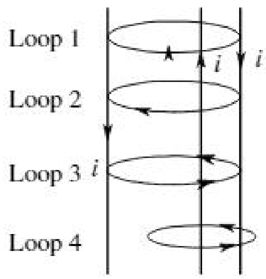
a) m b) n c) o d) p

9. The current density in the wire m is

a) greater than in wire n
b) less than in wire n
c) equal to that in wire n
d) not comparable due to lack of information

Matrix Matching Type Questions

10. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown in the figure. The direction of dI is shown in the figure.



Then, match the Column I with Column II and select the correct option from the codes given below.

COLUMN I	COLUMN II
A) Along closed loop 1	p) $\oint B.dI = \mu_0 I$
B) Along closed loop 2	q) $\oint B.dI = -\mu_0 I$
C) Along closed loop 3	r) $\oint B.dI = 0$
D) Along closed loop 4	s) net work done by the magnetic force to move a unit charge along the loop is zero
	t) $\oint B.dI = \mu_0(2I)$

	A	B	C	D
a)	q,s	p,s	r,s	r,s
b)	p,q	p,s	q,s	s,s
c)	p	q	r,s	p,s
d)	q,r	t,s	p,q	s,t

Integer Type Questions

11. A long conducting cylinder of radius R carries a current I. The current density J is a function of radius r as J = br, where b is a constant. Magnetic field at a distance r > R measured from from the axis is $B = \frac{\mu_0 b R^3}{N r_2}$, then find the value of N.

EXERCISE-IV

(Motion of the charged particle in the magnetic field)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. A proton enters a magnetic field of flux density 1.5 T with a velocity of 20×10^7 ms^{-1} at an angle of 30^0 with the field. The force on the proton is $[e_p = 1.6\times10^{-19}C]$

   1) $2.4\times10^{-10}N$ 2) $2.4\times10^{-11}N$ 3) $3\times10^{-5}N$ 4) $3\times10^{-4}N$

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

   1) 10×10^{-12} N 2) 8×10^{-11} N 3) 2.5×10^{-10} N 4) 8×10^{-12} N

3. An electron moves with speed 2×10^5 ms^{-1} along the positive x-direction in the presence of a magnetic induction $\overline{B} = \hat{i} + 4\hat{j} - 3\hat{k}$ tesla. The magnitude of the force experienced by the electron in newton is (charge on the electron = 1.6×10^{-19}C)

   1) 1.18×10^{-13} 2) 1.28×10^{-13} 3) 1.6×10^{-13} 4) 1.72×10^{-13}

4. An electron experlences a force $(4.0\,\hat{i} + 3.0\,\hat{j}) \times 10^{-13}$N in a uniform magnetic field when its velocity is $2.5\,\hat{k} \times 10^7$ m/s. When the velocity is redivected and becomes $(1.5\,\hat{i} - 2.0\hat{j}) \times 10^7$ m/s, the magnetic force of the electorn is zero. The magnetic field vector $\vec{B}$ is

   1) $-0.075\hat{i} + 0.1\hat{j}$ 2) $0.1\hat{i} + 0.075\,\hat{j}$ 3) $0.075\hat{i} - 0.1\,\hat{j} + \hat{k}$ 4) $0.075\hat{i} - 0.1\,\hat{j}$

Numerical Value Type Questions

5. A charged particle of chage 4mc enters a uniform magnetic field of induciton $\overline{B} = 4\overline{i} + y\overline{j} + z\overline{k}$ tesla with a velocity $\overline{v} = 2\overline{i} + 3\overline{j} - 6\overline{k}$. If the particle continues to move undeviated, then the strength of the magnetic field induciton (B) is ____ tesla

6. A beam 30 mev α-particle is to be obtained from a 50 cm cyclotron. The strength of magnetic field required to be applied will be (in T)

7. A clycotron is used to obtain 2 Mev protons, if the frquency is 5MHz and the potential is 20 kv. The magnetic field necessery for resonance is (in T)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. A uniform magnetic field $\vec{B} = B_0\hat{j}$ exists in a space. A particle of mass m and charge q is projected towards negative x-axis with speed v from the a point (d, 0, 0). The maximum value v for which the particle does not hit y-z plane is

   a) $\frac{2Bq}{dm}$ b) $\frac{B_0qd}{m}$ c) $\frac{Bq}{2dm}$ d) $\frac{Bqd}{2m}$

2. Two protons move parallel to each other, keeping distance *r* between them, both moving with same velocity $\vec{V}$. Then the ratio of the electric and magnetic force of interaction between them is

a) c^2/V^2 b) $2c^2/V^2$ c) $c^2/2V^2$ d) None

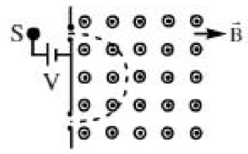
3. A charged particle of specific charge α is released from origin at time t = 0 with velocity $\vec{V} = V_o\hat{i} + V_o\hat{j}$ in magnetic field $\vec{B} = B_o\hat{i}$. The co-ordinates of the particle at time $t = \frac{\pi}{B_0\alpha}$ are (specific charge $\alpha = q/m$)

a) $\left(\frac{V_o}{2B_o\alpha}, \frac{\sqrt{2}V_o}{\alpha B_o}, \frac{-V_o}{B_o\alpha}\right)$ b) $\left(\frac{-V_o}{2B_o\alpha}, 0, 0\right)$ c) $\left(0, \frac{2V_o}{B_o\alpha}, \frac{V_o\pi}{2B_o\alpha}\right)$ d) $\left(\frac{V_o\pi}{B_o\alpha}, 0, -\frac{2V_o}{B_o\alpha},\right)$

4. A mass spectrometer is a device which select particle of equal mass. An ion with electric charge q > 0 and mass m starts at rest from a source S and is accelerated through a potential difference V. It passes through a hole into a region of constant magnetic field $\vec{B}$ perpendicular to the plane of the paper as shown in the figure. The particle is deflected by the magnetic field and emerges through the bottom hole at a distance d from the top hole. The mass of the particle is

a) $\frac{qBd}{8V}$ b) $\frac{qB^2d^2}{4V}$

c) $\frac{qB^2d^2}{8V}$ d) $\frac{qBd}{2V}$



5. A particle of specific charge α (charge per unit mass) is released at time t = 0 from origin with an initial velocity of $\vec{v} = v_0\hat{i}$ in a uniform magnetic field $\vec{B} = -B_0\hat{k}$. Find position of particle at any time t.

a) $\frac{v_0}{B_0\alpha}\left[\text{Sin}(B_0\alpha t)\hat{i} - [1+\text{Cos}(B_0\alpha t)]\hat{j}\right]$ b) $\frac{v_0}{B_0\alpha}\left[\text{Sin}(B_0\alpha t)\hat{i} + \{1-\text{Cos}(B_0\alpha t)\}\hat{j}\right]$

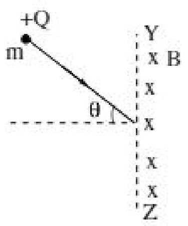
c) $\frac{v_0}{B_0\alpha}\left[\text{Cos } B_0\alpha t + \{1-\text{Sin}(B_0\alpha t)\}\hat{j}\right]$ d) $\frac{v_0}{B_0\alpha}\left[\text{Sin}\alpha t\hat{i} - \{1+\text{Cos}(\alpha t)\}\hat{i}\right]$

6. A particle with charge +Q and mass m enters a magnetic field of magnitude B, existing only to the right of the boundary YZ. The direction of the motion of the particle is perpendicular to the direction of B. Let $T = 2\pi\frac{m}{QB}$. The time spent by the particle in the field will be

a) $T\theta$ b) $2T\theta$

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

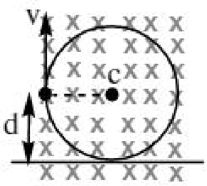
d) $T\left(\frac{\pi-2\theta}{2\pi}\right)$



7. In the previous question, if the particle has –Q charge, the time spent by the particle in the field will be

a) $T\theta$ b) $2T\theta$ c) $T\left(\frac{\pi+2\theta}{2\pi}\right)$ d) $T\left(\frac{\pi-2\theta}{2\pi}\right)$

8. A plane metallic sheet is placed with its face parallel to lines of magnetic induction B of a uniform field. A particle of mass m and charge q is projected with a velocity v from a distance 'd' from the plane normal to the lines of induction. Then the maximum velocity of projection for which the particle does not hit the plane is,



a) $\frac{2Bqd}{m}$ b) $\frac{Bqd}{m}$ c) $\frac{Bqd}{2m}$ d) $\frac{Bqm}{d}$

More than One correct answer Type Questions

9 A beam of protons with a velocity of $4\times10^5 ms^{-1}$ enters a uniform magnetic field of 0.3T. The velocity makes an angle of 60^0 with the magnetic field.

a) The radius of the helical path taken by the proton is 1.2 cm

b) The radius of the helical path taken by the proton is 12 cm

c) The pitch of the helix is 4.4 mm

d) The pitch of the helix is 4.2 cm

10. Two ions have equal masses but one is singly ionized and the other is doubly ionized. They are projected from the same place in a uniform magnetic field with the same velocity perpendicular to the field.

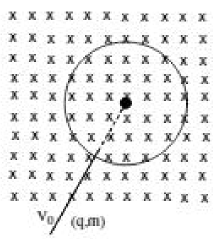
a) Both ions will move along circles of equal radii

b) The circle described by the singly-ionized charge will have a radius double that of the other circle

c) The two circles do not touch each other

d) The two circles touch each other

11. A non-conducting cylindrical shell of radius R is placed in uniform magnetic field. The axis of the cylinder is parallel to the direction of magnetic field. A hole is drilled in cylinder and a particle having charge q and mass m is projected with velocity v_0 perpendicular to magnetic field and directed towards the axis of cylinder as shown in diagram. The particle collides elastically with inner wall of the cylinder and rebounds.



a) The minimum number of collisions after which it will emerge is two.

b) The maximum speed v_0 for which it can come out is $v_0 = \left(\frac{qBR}{m}\right)\sqrt{3}$.

c) The minimum time in which it can come out will be $\left(\frac{\pi m}{qB}\right)$

d) If the particle is projected with a velocity $\frac{V_0}{3}\left\{\text{where } V_0 = \left(\frac{qBR}{m}\right)\sqrt{3}\right\}$ it will come out after five collisions.

12. Which of the following statement is/are correct :

a) A charged particle enters a region of uniform magnetic field at an angle 85^0 to magnetic lines of force. The path of the particle is a circle.

b) An electron and proton are moving with the same kinetic energy along the same direction. When they pass through uniform magnetic field perpendicular to their direction of motion, they describe circular path.

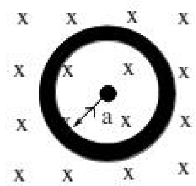
c) There is no change in the energy of a charged particle moving in a magnetic field although magnetic force acts on it.

d) Two electrons enter with the same speed but in opposite direction in a uniform transverse magnetic field. Then the two describe circle of the same radius and these move in the same direction.

Linked Comprehension Type Questions

Passage :

13. Figure shows a cricular wire loop of radius a carrying a current i, in anti clockwise direction placed in perpendicular magnetic field B consider a small part dl of the wire find the force on the part of the wire exerted by the magnetic field



a) iBdl (towards centre)

b) iB/dl (towards centre)

c) idl (towards centre)

d) $\mu_0$idlB towards centre

14. Find the tension in the wire if a current i flows in clockwise direction

a) iBdl b) iBa c) $\mu_0 iBdl$ d) $iBdla$

15. Suppose that the radius of cross-section of the wire used is r. Find the decrease in the radius of the loop if the magnetic field is switched off. The Young's modulus of the material of the wire is Y.

a) $\frac{Biadl}{Y}$ b) $\frac{iaB}{2\pi r^2 Y}$ c) $\frac{ia^2B}{\pi r^2 Y}$ d) $\frac{a^2B}{4\pi r^2 Y}$

Integer Type Questions

16. A beam of electrons is accelerated through a potential difference 'V'. It is then passed normally through a uniform magnetic field where it moves in a circle of radius 'r'. It would have moved in a circle of radius 2r if it were initially accelerated through a potential difference of kv, then k =

17. An experimenter's diary reads as follows: "a charged particle is projected in a magnetic field of $(7.0\vec{i}-3.0\vec{j})\times10^{-3}$ T. The acceleration of the particle is found to be $(\Omega\ \vec{i}+7.0\vec{j})\times10^{-6}\ m/s^2$. The number to the left of $\vec{i}$ in the last expression was not readable. What can this number ?

EXERCISE-V

(Motion of charged particle in combined electric and magnetic field)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Abeam of protons enters a uniform magnetic field of 0.3 T with a velocity of 4×10^5 m/ sec in a direction making an angle of 60° with the direction of magnetic field, the pitch of the helix will be

1) 4.7 m 2) 0.47 m 3) 0.047 m 4) 0.0047 m

2. An electron beam passes through a magnetic field of 2×10^{-3}Wb/m^2 and electric field of 3.2×10^4V/m, both acting simultanceously $(\vec{E}\perp\vec{B}\perp\vec{V})$ if the path of electrons remains undeflected calculate the speed of the electron. If the electric field is removed, what will be the radius of the electron path. [mass of electron = 9.1×10^{-31}kg]?

1) 16×10^6 m/s $\frac{20}{91}$ cm 2) 1.6×10^5 m/s $\frac{91}{20}$ cm 3) 16×10^6 m/s $\frac{91}{20}$ cm 4) 1.6×10^5 m/s $\frac{20}{91}$ cm

3. A particle moves in a circle of radius 1.0 cm under the action of a magnetic field of 0.40 T. An electric field of 200 V/m makes the path straight. Find the charge/mass ratio of the particle.

1) $\frac{5}{4}\times10^5$ C/kg 2) $\frac{4}{5}\times10^5$ C/kg 3) $\frac{5}{4}\times10^6$ C/kg 4) $\frac{4}{5}\times10^6$ C/kg

4. A proton goes undeflected in a crossed electric and magnetic field (The fields are perpendicular to each other) at a speed of 10^5 m/s. The velocity is perpendicular to both the fields. When the electric field is switched off, the proton moves along a circle of radius 2 cm. Find the magnitudes of the electric and the magnetic fields. Take the mass of the protion = 1.6×10^{-27} kg.

1) 5×10^{-3} N/C, 5×10^{-2}T
2) 5×10^{3} N/C, 5×10^{-2}T
3) 5×10^{3} N/C, 5×10^{2}T
4) 5×10^{2} N/C, 5×10^{-3}T

5. A particle having mass m and charge q is released fromt he origin in a region in which electric field and magnetic field are given by $\vec{B}=+B_0\hat{j}$ and $\vec{E}=+E_0\hat{i}$ find the speed of the particle as a function of x co ordinate.

1) $\sqrt{\frac{2qE_0 x}{m}}$ 2) $\sqrt{\frac{qE_0 x}{m}}$ 3) $\sqrt{\frac{qE_0 x}{2m}}$ 4) $\sqrt{\frac{3qE_0 x}{m}}$

Numerical Value Type Questions

6. A particle having a charge q = 1C and mass m = 0.5 kg is projected on a rough horizontal plane (x, y) from a point (15m, 0, 0) with a initial velocity $\vec{v}=20\,j$. In space an uniform electric field $\vec{E}=25(-\hat{k})$ and magnetic field $\vec{B}=10(-\hat{k})$. The acceleration due to gravity g = 10 msec^{-2} and co-efficient of friction $\mu=0.5$. The particle moves on a spiral path and reaches to the origin. The time taken by particle to reach origin is found $y\times10$ sec. Find y.

7. A non-relativistic proton beam passes without deviation in a uniform manner through a region of space where there are uniform transverse mutually perpendicular electric and magnetic fields with E = 120 kV/ m and B = 25 m T. Then the beam strikes a grounded target which helps the protons to come to rest. The force with which the beam acts on the target if the beam current is equal to I = 8 mA is $F\,\mu$ N, Find the value of F ? (Specific charge of proton = 9.6×10^7 C / kg)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. 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 $\vec{B}=B_0\hat{i}$ with velocity $\vec{v}=v_0\hat{j}$. The speed of the particle will become $2v_0$ after a time

a) $t=\frac{2mv_0}{qE}$ b) $t=\frac{2Bq}{mv_0}$ c) $t=\frac{\sqrt{3}Bq}{mv_0}$ d) $t=\frac{\sqrt{3}mv_0}{qE}$

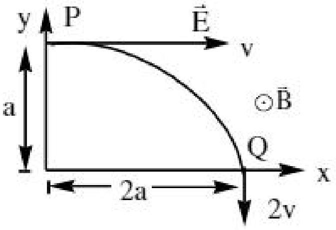
2. A particle of specific charge (q/m) is projected from the origin of coordinates with initial velocity $[u\hat{i} - v\hat{j}]$. Uniform electric magnetic fields exist in the region along the +y direction, of magnitude E and B. The particle will definitely return to the origin once if

a) $[vB/2\pi E]$ is an integer b) $(u^2 + v^2)^{1/2}$ $[B/\pi E]$ is an integer

c) $[vB/\pi E]$ is an integer d) $[uB/\pi E]$ is an integer

More than One correct answer Type Questions

3. A particle of charge +q and mass m moving under the influence of a uniform electric field $E\hat{i}$ and uniform magnetic field $B\hat{k}$ follows a trajectory from P to Q as shown in figure. The velocities at P and Q are $v\hat{i}$ and $-2v\hat{j}$. 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 electric field at $P = \frac{3}{4}\left(\frac{mv^3}{a}\right)$

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

d) Rate of work done by both the fields at Q is zero

4. Two identical charged particles enter a uniform magnetic field with same speed but at angles 30° and 60° with field. Let a, b and c be the ratio of their time periods, radii and pitches of the helical paths than

a) abc = 1 b) abc > 1 c) abc < 1 d) a = bc

Linked Comprehension Type Questions

Passage - I :

A charged particle of mass m and charge q is allowed to enter in a region of space in which uniform electric and magnetic filed can be created.The subsequent path of the particle in the region will depend upon initial value of velocity and direction of the field

5. If $E = 0$, $B = B.\hat{k}$ and $V = V_0\hat{i} + V_0\hat{j}$ then the path of the particle is

a) Circle of radius $\frac{mv_0}{qB}$ in xy plane b) helical with uniform pitch $\frac{2\pi mv_0}{qB}$

c) a circle of radiaus $\frac{\sqrt{2}mv_0}{qB}$ in xy plane d) helical with non-uniform pitch

6. If $E = E_0\hat{k}$, $B = B_0\hat{k}$ and $V = V_0\hat{i}$ then the path of the paticle will be

a) the path of the particle is a helix with a non uniform pitch

b) the path of the particle is helix with uniform pitch

c) the maximum velocity of the particle in the subsequent motion is v_0

d) the velocity of the particle in the subsequent motion decreases uniformly

7. If $E = E_0\hat{k}, B = B_0\hat{k}$ and $V = V_0\hat{i} + V_0\hat{k}$ then

a) a helix with increasing pitch and axis parallel to z-axis

b) a cycloid in the x-y plane c) a cycloid the y-z plane

d) a cycloid in the x-z plane

Passage - II :

A particle with specific charge α (charge per unit mass) moves in the region of space where mutually perpendicular electric field $\vec{E} = E_0\hat{j}$ and magnetic field $\vec{B} = B_0\hat{k}$ are present. At time t = 0 particle is located at origin with zero initial velocity.

8. Find acceleration of the particle at t = 0

a) $\frac{E_0 q}{m}\hat{i}$ b) $\frac{E_0 q}{2m}\hat{i}$ c) $\frac{E_0 q}{m}\hat{k}$ d) $\frac{E_0}{mq}\hat{i}$

9. Find x-coordinate of the particle at time '*t*'.

a) $x = \frac{E_0}{B_0\omega}\sin\omega t$ b) $x = \frac{E_0}{B_0\omega}(\omega t - \sin\omega t)$ c) $x = \frac{E_0}{B_0\omega}(\omega t + \sin\omega t)$ d) $x = \frac{E_0}{B_0\omega}\cos\omega t$

10. Find y-coordinate of the particle at time '*t*'

a) $y = \frac{E_0}{B_0\omega}(1+\cos\omega t)$ b) $y = \frac{E_0}{B_0\omega}\sin\omega t$ c) $y = \frac{E_0}{B_0\omega}(1-\cos\omega t)$ d) $y = \frac{E_0}{B_0\omega}\cos\omega t$

Matrix Matching Type Questions

11. For the path of a charged particle match the following.

COLUMN - I	COLUMN - II
A) in uniform electric field	p) Straight line
B) in uniform magnetic field	q) Parabola
C) in uniform electric and magnetic field which are directed parallel to each other	r) Circle
D) in uniform electric and magnetic field which are perpendicular to each other	s) Helix

Integer Type Questions

12. A uniform charged ring of radius 10 cm rotates at a frequency of 10^4 rps about its axis the ratio of energy density of electric field to the energy density of the magnetic field at a point on the axis at distance 20 cm from the centre is x × 10^9 approximately. Find x.

13. A current *I* flows along the length of a thin walled, long metallic hollow cylinder of radius *R*, distributed uniformly on its surface. If the pressure on the wall is $P = \left(\frac{\mu_0 I^2}{\pi^2 R^2}\right) \times \left(\frac{1}{x}\right)$. Find the value of *x*.

EXERCISE-VI

(Magnetic force between two parallel conductors)

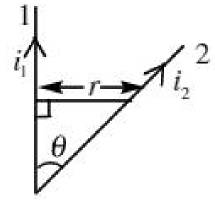
LEVEL-I (MAIN)

Straight Objective Type Questions

1. Two long parallel copper wires carrying current in the opposite direction of 5A each. If the wires are separated by a distance of 0.5m,then the force between the two wires is

1) 10^{-5} N/m attractive 2) 10^{-5} N/m repulsive
3) 2×10^{-6}N/m attractive 4) 2×10^{-5} N/m repulsive

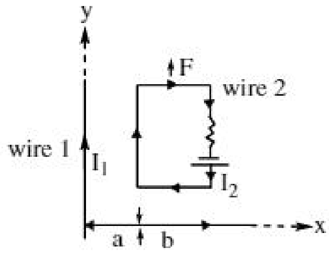
2. Wires 1 and 2 carrying currents i_1 and i_2 respectively are inclined at an angle θ to each other. What is the force on a small element dl of wire 2 at a distance r from wire 1 due to magnetic field of wire 1 ?



1) $\frac{\mu_0}{4\pi r} i_1 i_2 dl[1+\cos\theta]$ 2) $\frac{\mu_0}{2\pi r} i_1 i_2 dl \sin\theta$

3) $\frac{\mu_0}{2\pi r} i_1 i_2 dl \cos\theta$ 4) $\frac{\mu_0}{4\pi r} i_1 i_2 dl \sin\theta$

3. Wire-1 in fig is oriented along the Y-axis and carries a steady current I_1 A rectangular circuit located to the right of the wire carries a current I_2. Find the force experienced by the top of the horizontal wire (wire-2) of the rectangular circuit.



1) $\left[\frac{\mu_0 I_1 I_2}{2\pi} ln\left(1+\frac{b}{a}\right)\hat{j}\right]$ 2) $\left[\frac{\mu_0 I_1 I_2}{2\pi} ln\left(1+\frac{b}{a}\right)(-\hat{j})\right]$

3) $\left[\frac{\mu_0 I_1 I_2}{2\pi} ln\left(1+\frac{b}{a}\right)(-\hat{i})\right]$ 4) $\left[\frac{\mu_0 I_1 I_2}{2\pi} ln\left(1+\frac{b}{a}\right)(\hat{i})\right]$

4. Two parallel horizontal conductors are suspended by light vertical threads each of length 75cm. Each conductor has a mass of 40gm per m. When no current flows through them, they are 0.5 cm apart. When same current flows through each coductor the separation is 1.5 cm. The value and direction of current is

1) 14 A in same direcrtion 2) 14 A in opposite direction

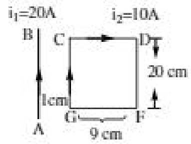
3) 196 A in same direction 4) 196 A in opposite direction

5. A current of 3A is flowing in a linear conductor having a length of 40 cm. The conductor is placed in a magnetic field of strength 500 Gauss and makes an angle of 30^0 with the direction of the field. It experiences a force of magnitude

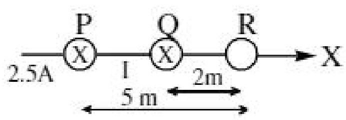
1) 3×10^4 N 2) 3×10^2 N 3) 3×10^{-2} N 4) 3×10^{-4} N

Numerical Value Type Questions

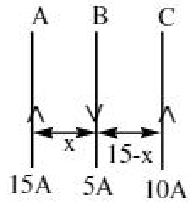
6. The force exerted by the conductor AB on the loop CDFG shown in figure is ($N \times 10^{-4}$ N attraction) the value of n is



7. Two long parallel wires carrying currents 2.5A and I amp in the same direction (directed into plane) are held at P and Q respectively as shown. The points P and Q are located at 5 m and 2m respectively from a collinear point R. An electron moving with a velocity of 4×10^5 m/s along positive x axis experiences a force of 3.2×10^{-20} N at the point 'R'. The value of I is (in A)



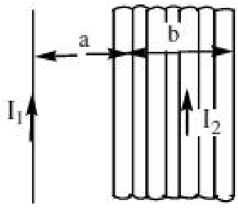
8. Three long straight and parallel wires carrying currents are arranged as shown in figure. The wire 'B' which carries a current of 5A is so palced that it experiences no force. The distance of wire 'B' from A is then (in cm)



LEVEL-II (ADVANCED)

Straight Objective Type Questions

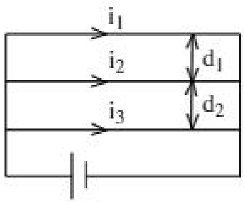
1. Two long thin parallel conductors of the shape shown in fig carry direct currents I_1 and I_2. The seperation between the conductors is *a*, the width of the right-hand conductor is equal to b. With both conductors lying in one plane, find the magnetic interaction force between them reduced to a unit of their length.



a) $\frac{\mu_0}{4\pi}\frac{I_1I_2}{a}\text{In}\left(1+a/b\right)$ b) $\frac{\mu_0}{4\pi}\frac{2I_1I_2}{b}\text{In}\left(1+b/a\right)$

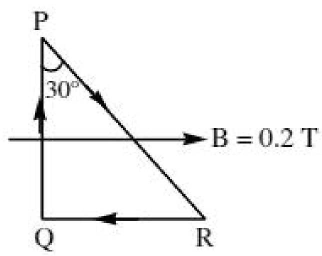
c) $\frac{\mu_0}{4\pi}\frac{I_1I_2}{b}\text{In}\left(1-a/b\right)$ d) $\frac{\mu_0}{4\pi}\frac{2I_1I_2}{b}\text{In}\left(1-b/a\right)$

2. Three long wires of resistances in the ratio 3:4:5 are connected in parallel to each other as shown in figure. If net force on middle wire is zero then $\frac{d_1}{d_2}$ will be



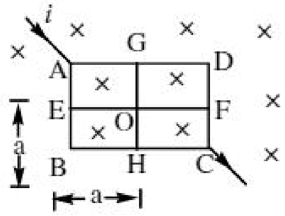
a) 9.25 b) 5:3 c) $\sqrt{5}:\sqrt{3}$ d) 1:1

3. A wire bent in the form a right angled triangle PQR, carries a current 1 A. It is placed in a region of a uniform magnetic field B = 0.2T. If PR = 1 m, the net force on the wire is



a) 1.73 N b) 3.46N c) 2.732N d) Zero

4. The figure shows a uniform conducting structure which carries current i with each small square has side a. The structure is kept in a uniform magnetic field B. Then the magnetic force on the structure willbe



a) $2\sqrt{2}\,iBa$ b) $\sqrt{2}\,iBa$ c) 2 iBa d) iBa

5. A straight current carrying conductor is placed in such a way that the current in the conductor flows in the direction out of the plane of the paper. The conductor is placed between two poles of two magnets, as shown. The conductor will experience a force in the direction towards

a) P b) Q c) R d) S

EXERCISE-VII

(Torque on current loop, MCG)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. A rectangular coil of wire of 100 turns and $10 \times 15 cm^2$ size carrying a current of 2Amp. is in a magnetic field of induction 2×10^{-3} wb/m^2. If the normal drawn to the plane of the coil makes an angle 30^0 with the field, then the torque on the coil is

1) $3\times10^{-5}N-m$ 2) $3\times10^{-3}N-m$ 3) $3\sqrt{3}\times10^{-5}N-m$ 4) $3\sqrt{3}\times10^{-3}N-m$

2. A moving coil galvanometer 'A' has 200 turns and a resistance of 100Ω. Another meter 'B' has 100 turns resistance 40Ω. All the other quantities are same in both the cases. The current sensitivity of A is

1) double that of B 2) 2.5 times of B 3) 5 times of B 4) $\frac{1}{5}$ th of B

Numerical Value Type Questions

3. A circular coil of 20 turns and radius 10cm is placed in a uniform magnetic field of 0.1T normal to the plane of the coil. If a current of 5A passes through the coil, then the torque on the coil is

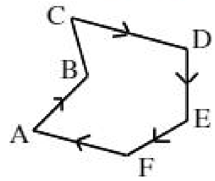
4. A coil in the shape of an equilateral triangle of side 0.02 m is suspended from a vertex such that it is hanging in a vertical plane between the pole pieces of a permanent magnet producing a horizontal field of 5×10^{-2} T. Find the couple acting on the coil when a current of 0.1A is passed through it and the magnetic field parallel its plane ($\times 10^{-6}$ N–m)

5. To increase the current sensitivity of a moving coil galvanometer by 50% its resistance is increased so that the new resistance becomes twice its initial resistance. By what percentage does the voltage sensitivity change ?

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Find the magnitude of magnitic moment of the current carrying loop. Each side of loop is 10 cm long & current in the loop is i = 2A.



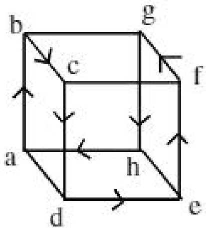
a) 0.28 A–m^2

b) 0.028A–m^2

c) 0.038A–m^2

d) 0.02A–m^2

2. A conductor carries a constant current I along the closed path abcdefgha involving 8 of the 12 edges of length l. Find the magnetic dipole moment of the closed path



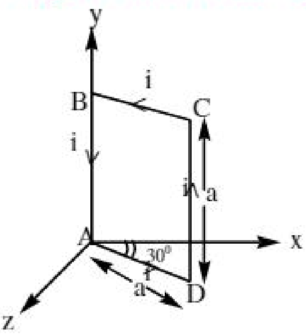
a) $l^2 I\hat{j}$

b) $lI\hat{j}$

c) $\frac{l}{I}\hat{j}$

d) $-lI\hat{j}$

3. A square coil of side 'a' carrying current 'i' and is having one of its side AB parallel to y-axis and its plane is at angle $\theta = 30^0$ with x-axis (as shown). If a uniform magnetic field B exist in the region along $\hat{k}$ direction, then torque due to magnetic force on the coil is:



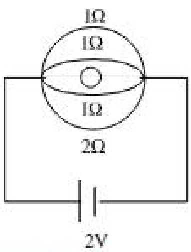
a) $\frac{i\,a^2\,B}{2}\hat{j}$

b) $\frac{i\,a^2\,B}{\sqrt{2}}\left(-\hat{k}+\hat{j}\right)$

c) $-\frac{i\,a^2\,B}{2}\hat{j}$

d) $\frac{ia^2\,B}{2}\hat{i}$

4. Two circular conductors of radius 1 m each are arranged in mutual perpendicular planes with their diametric opposite points in contact as shown. The resistances of different semi circular parts are shown in figure. A small current carrying loop carrying current I_0 through it is arranged at the common center in stable equilibrium position and can be freely rotated about its diametric axis. The mass and radius of circular loop is m and r respectively. The time period of small oscillation of small loop is



a) $\sqrt{\frac{2\pi m}{\mu_0 I_0}}$

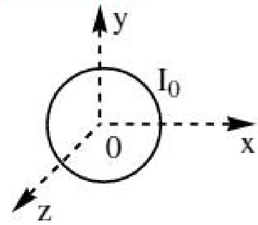
b) $\sqrt{\frac{4\pi m}{\mu_0 I_0}}$

c) $\sqrt{\frac{8\pi m}{\mu_0 I_0}}$

d) $\sqrt{\frac{\pi m}{\mu_0 I_0}}$

More than One correct answer Type Questions

5. A uniform ring of mass m and radius R carrying current I_0 is lying in the x-y plane in vaccum with centre at origin. A uniform external magnetic field of strength $\vec{B} = B_0\left(2\hat{i} - 2\hat{j} + 5\hat{k}\right)$Tesla is switched on at t = 0 (here B_0= constant). Gravity is neglected. If the ring can freely rotate, then



a) Initial angular acceleration of ring is $\frac{4\sqrt{2}I_0B_0\pi}{m}$

b) Initial angular acceleration of ring is $\frac{2\sqrt{2}I_0B_0\pi}{m}$

c) The magnetic force acting on loop $2\sqrt{3}I_0\pi RB_0$

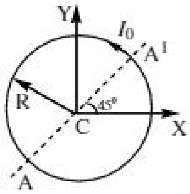
d) The magnetic force acting on loop is zero

Linked Comprehension Type Questions

Passage :

A ring of mass m and radius r carrying current I_0 is lying in the x-y plane with centre at the origin. A uniform magnetic field of strength $B_0(2\hat{i} - 3\hat{j} + 5\hat{k})$ T is applied in the region. If the ring can rotate about the axis AA' in x-y plane only.

6. Find initial angular acceleration



a) $\frac{5\sqrt{2}I_0B_0\pi}{2m}\text{rad/s}^2$ b) $\frac{2\sqrt{2}I_0B_0}{2\pi m}\text{rad/s}^2$

c) $\frac{\sqrt{2}I_0B_0}{3m}\text{rad/s}^2$ d) $\frac{5\sqrt{2}I_0B_0\pi}{m}\text{rad/s}^2$

7. Find the initial magnetic energy stored in the ring

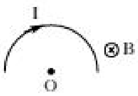
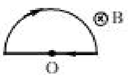
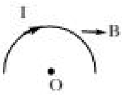
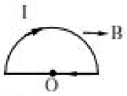
a) $-5\pi R^2I_0B_0J$ b) $3\pi RI_0B_0J$ c) $-\pi R^2I_0B_0J$ d) $2\pi R^2I_0B_0J$

8. Find the force on the loop

a) $-8\pi R^2I_0B_0J$ b) $\frac{5\sqrt{2}I_0B_0\pi}{2m}$ c) zero d) $\sqrt{2}I_0B_0$

Matrix Matching Type Questions

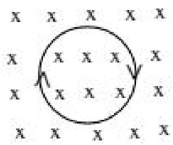
9. In Column-I some current carrying elements are given along with the direction of magnetic field in the region. In Column-II information about the force and torque acting on elements are given. Match the entries of Column-I with the entries of Column-II

COLUMN - I	COLUMN - II
A) 	p) Force = 0
B) 	q) Force $\neq 0$
C) 	r) Torque about O is zero
D) 	s) Torque about O is non zero

Integer Type Questions

10. A solid non-conducting sphere of radius R and charge q (uniformly distributed) rotates about its diametric axis with constant angular velocity ω. The magnetic moment of the sphere is $\frac{qR^2\omega}{n}$. Find n

11. A circular current loop is placed in an unform magnetic field of 1 tesla as shown. If the radius of loop is 1 m, the magnetic force on the loop is



KEY SHEET (LECTURE SHEET)

EXERCISE-I

LEVEL-I	1) 2	2) 1	3) 3	4) 4	5) 2	6) 5cm	7) 0	8) 0.4
LEVEL-II	1) a	2) a	3) c	4) c	5) a	6) c	7) a	8) b
	9) b,d	10) bc	11) b,c,d	12) a	13) b	14) d	15) d	16) b
	17) c	18) A-p,q,r; B-p,q,r,s; C-r; D-p,q,s				19) 1	20) 4	

EXERCISE-II

LEVEL-I	1) 1	2) 3	3) 2	4) 2	5) 2	6) 2	7) 2	8) 1
	9) 0.8	10) 420	11) 3					
LEVEL-II	1) b	2) b	3) b	4) b,c	5) a	6) d	7) b,c	8) 2
	9) 5	10) 2	11) 1					

EXERCISE-III

LEVEL-I	1) 4	2) 1	3) 1	4) 1	5) 4	6) 3.76	7) 12	8) 1.05
LEVEL-II	1) d	2) d	3) a	4) d	5) a	6) c	7) c	8) a
	9) a	10) a	11) 3					

EXERCISE-IV

LEVEL-I	1) 2	2) 4	3) 3	4) 1	5) 14	6) 1.582	7) 0.327	
LEVEL-II	1) b	2) a	3) d	4) c	5) b	6) c	7) d	8) b
	9) a,d	10) b,d	11) a,b,c,d		12) b,c,d	13) a	14) b	
	15) c	16) 4	17) 3					

EXERCISE-V

LEVEL-I	1) 3	2) 3	3) 1	4) 2	5) 1	6) 2	7) 4	
LEVEL-II	1) d	2) c	3) abd	4) a,d	5) c	6) a	7) a	8) a
	9) b	10) c	11) A-p,q; B-p,r,s; C-p,s; D-p				12) 9	13) 8

EXERCISE-VI

LEVEL-I	1) 2	2) 1	3) 3	4) 2	5) 3	6) 7.2	7) 4	8) 9
LEVEL-II	1) b	2) b	3) d	4) a	5) b			

EXERCISE-VII

LEVEL-I	1) 2	2) 1	3) 0	4) 0.866	5) 25			
LEVEL-II	1) b	2) b	3) a	4) c	5) ad	6) d	7) a	8) c
	9) A-q,r; B-p,r; C-p,s; D-p,s				10) 5	11) 0		

PRACTICE SHEET

EXERCISE-I

(Magnetic field due to a current carrying conducter)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. A current of 5A flows downwards in a long straight vertical conductor and the earth's horizontal flux density is 2×10^{-7} then the neutral point occurs

   1) due north 10 cm from the wire
   2) due east 10m from the wire
   3) due east 5m from the wire
   4) due west 5m from the wire

2. The magnetic induction field at the centroid of an equilateral triangle of side 'l' and carrying a current 'i' is

   1) $\frac{2\sqrt{2}\mu_0 i}{\pi\ell}$
   2) $\frac{9\mu_0 i}{2\pi\ell}$
   3) $\frac{4\mu_0 i}{\pi\ell}$
   4) $\frac{3\sqrt{3}\mu_0 i}{\pi\ell}$

3. A long straight vertical conductor carries a current of 8A in the upward direction. If the horizontal component of earth's magnetic induction is 4×10^{-5} T. Then at a distance of 4cm to the south of it the resultant magnetic induction in the horizontal plane is,

   1) 2×10^{-5} T
   2) 4×10^{-5} T
   3) $4\sqrt{2} \times 10^{-5}$T
   4) 8×10^{-5}T

4. Corrent 'i' is flowing in hexagenal coil of side a. The magnetic induction at the centre of the coil will be,

   1) $\frac{3\sqrt{3}\mu_0 i}{\pi a}$
   2) $\frac{\mu_0 i}{3\sqrt{3}\pi a}$
   3) $\frac{\mu_0 i}{\sqrt{3}\pi a}$
   4) $\frac{\sqrt{3}\mu_0 i}{\pi a}$

5. The magnetic field at the origin due to a current element $i\,d\vec{l}$ placed at a position $\vec{r}$ is

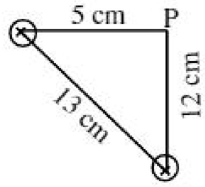
   1) $\frac{\mu_0 i}{4\pi}\frac{d\vec{l} \times \vec{r}}{r^3}$
   2) $-\frac{\mu_0 i}{4\pi}\frac{\vec{r} \times d\vec{l}}{r^3}$
   3) $\frac{\mu_0 i}{4\pi}\frac{\vec{r} \times d\vec{l}}{r^3}$
   4) $-\frac{\mu_0 i}{4\pi}\frac{d\vec{l} \times \vec{r}}{r^3}$

6. A long, straight wire carrying a current of 30 A is placed in an external, uniform magnetic field of 4.0×10^{-4}T parallel to the current. Find the magnitude of the resultant magnetic field at a point 2.0 cm away from the wire.

   1) 2×10^{-6}T
   2) 3×10^{-4}T
   3) 5×10^{-4}T
   4) 10×10^{-2}T

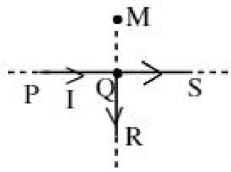
Numerical Value Type Questions

7. Two long parallel conductors carry currents $i_1 = 3A$ and $i_2 = 3A$ both are directed into the plane of paper. The magnitude of resultant magnetic field at point 'P' is, (in μT)



8. 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 fields at a/2 and 2a is,

9. An infinitely long conductor PQR is bent to form a right angle as shown. A current I flows throug PQR. The magnetic field due to this current at the point M is B_1. Now another infinitely long straight conductor QS is connected to Q so that the current is, 1/2 in QR as well as in QS, the current in PQ remaining unchanged. The magnetic field at M is now B_2. The ratio B_1/B_2 is given by



10. A straight conductor of length 32 cm carries a current of 30 A. Magnetic induction at a point which is in air at a perpendicular distance of 12cm from the mid point of the conductor is, (in gauss)

11. Two parallel long wires carry currents i_1 and i_2 with $i_1>i_2$. When the currents are in the same direction, the magnetic field at a point midway between the wires is $10\mu T$. If the direction of i_2 is reversed, the field becomes $30\mu T$. The ratio i_1 / i_2 is,

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. A current I flows through a wire of finite length L. The magnetic field at a distance d from the wire on its perpendicular bisector is..

a) $\frac{\mu_0 I}{2\pi d}.\frac{L}{\sqrt{L^2+4d^2}}$ b) $\frac{\mu_0 I}{4\pi d}.\frac{L}{\sqrt{L^2+4d^2}}$ c) $\frac{\mu_0 I}{\pi d}.\frac{2L}{\sqrt{L^2+4d^2}}$ d) Zero

2. Two mutually perpendicular conductors carrying currents I_1 and I_2 lie in one plane. Locus of the point at which the magnetic induction is zero, is a

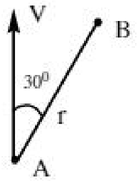
a) circle with centre as the point of intersection of the conductor.

b) parabola with vertex as the point of intersection of the conductors

c) straight line passing through the point of intersection of the conductors.

d) rectangular hyperbola

3. A charged particle A of charge q=2C has velocity v = 100 m/s. When it passes through point A and has velocity in the direction shown. The strength of the magnetic field at a point B due to this moving charge is (r = 2 m).

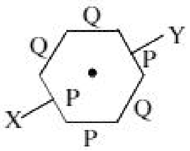


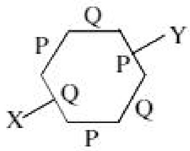
a) 2.5 μT b) 5.0 μT c) 2.0μT d) None

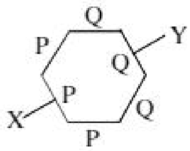
4. Current I is flowing through a regular polygon with n-sides then magnetic field at its center is (polygon is inscribed in a circle of radius *r*)

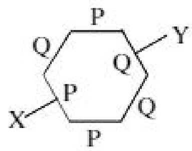
a) $B_{net} = \frac{\mu_0}{2\pi}\frac{nI}{r}Tan\left(\frac{\pi}{n}\right)$ b) $B_{net} = \frac{\mu_0 nI}{2\pi r}Tan(\pi)$ c) $B_{net} = \frac{\mu_0 nI}{\pi r}Tan\left(\frac{\pi}{n}\right)$ d) $B_{net} = \frac{\mu_0 nI}{2\pi r}Tan\ (n\pi)$

5. In the following hexagons, made up of two different material P and Q, current enters and leaves from points X and Y respectively. In which case the magnetic field at its centre is not zero.

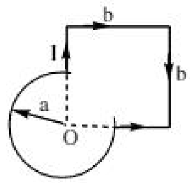
a) 

b) 

c) 

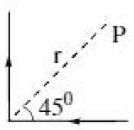
d) 

6. Find the magnetic induction of the field at the point O of a loop with current I, whose shape is illustrated in fig. the radius a and the side b are known



a) $\frac{\mu_0 I}{3\pi}\left(\frac{3\pi}{2a}+\frac{\sqrt{2}}{b}\right)$ b) $\frac{\mu_0 I}{4\pi}\left(\frac{3\pi}{4a}+\frac{\sqrt{2}}{2b}\right)$ c) $\frac{\mu_0 I}{2\pi}\left(\frac{2\pi}{3a}+\frac{\sqrt{2}}{b}\right)$ d) $\frac{\mu_0 I}{2\pi}\left(\frac{3\pi}{4a}+\frac{\sqrt{2}}{2b}\right)$

7. A long wire carrying current *i* is bent to form a right angle as shown in figure. Then magnetic induction at point P on the bisector of this angle at a distance r from the vertex is C



a) $\frac{\mu_0 i}{2\pi r}$ b) $\frac{\mu_0 i}{4\pi r}(1+\sqrt{2})$ c) $\frac{\mu_0 i(1+\sqrt{2})}{2\pi r}$ d) $\frac{\mu_0 i}{4\pi r}$

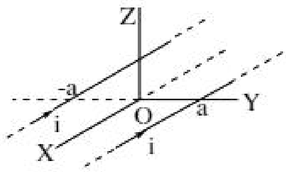
8. Find the magnetic induction at the centre of a rectangular wire frame whose diagonal is equal to d = 16 cm and the angle between the diagonals is equal to $\varphi = 30^0$; the current flowing in the frame equals I = 5.0 A

a) 0.40 mT b) 0.30 mT c) 0.10 mT d) 0.20 mT

More than One correct answer Type Questions

9. Consider three quantities $x = E/B$, $y = \sqrt{1/\mu_0\varepsilon_0}$ and $z = \frac{l}{CR}$. Here, l is the length of a wire, C is a capacitance and R is a resistance. All other symbols have standard meanings.
   a) x, y have the same dimensions
   b) y, z have the same dimensions
   c) z, x have the same dimensions
   d) none of the three pairs have the same dimensions

10. Two long thin, parallel conductors carrying equal currents in the same direction are fixed parallel to the x-axis, one passing through y = a and the other through y = –a. The resultant magnetic field due to the two conductors at any point is B. Which of the following are correct ?



   a) B = 0 for all points on the x-axis
   b) At all points on the y-axis, excluding the origin, B has only a z-component.
   c) At all points on the z-axis, excluding the origin, B has only a y-component.
   d) B cannot have an x-component.

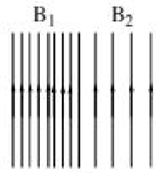
11. A steady electric current is flowing through a cylindrical conductor
   a) The electric field at the axis of the conductor is zero
   b) The magnetic field at the axis of the conductor is zero
   c) The electric field in the vicinity of the conductor is zero
   d) The magnetic field in the vicinity of the conductor is zero

Linked Comprehension Type Questions

Passage :

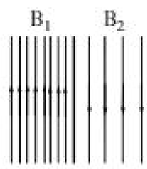
A conducting current - carrying plane is placed in an external uniform magnetic field. As a result, the magnetic induction becomes equal to B_1 on one side of the plane and to B_2, on the other side of the plane.

12. Find the magnetic force acting per unit area of the plane in the cases illustrated in fig. (A).
   a) $F=(B_1^2-B_2^2)/2\mu_0$, the force is directed to the right
   b) $F=(B_2^2-B_1^2)/\mu_0$ the force is directed to the right
   c) $F=(B_1^2-2B_2^2)/\mu_0$ the force is directed to the left
   d) $F=(B_1^2+B_2^2)/2\mu_0$ the force is directed to the left



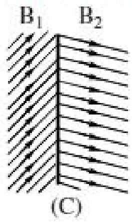
(A)

13. Find the magnetic force acting per unit area of the plane in the cases illustrated in fig.(B).
   a) $F=(B_1^2+B_2^2)/2\mu_0$ the force is directed to the right
   b) $F=(B_1^2-B_2^2)/2\mu_0$ the force is directed to the right
   c) $F=(B_2^2-B_1^2)/\mu_0$ the force is directed to the left
   d) $F=(B_2^2+B_1^2)/\mu_0$ the force is directed to the left



(B)

14. Find the magnetic force acting per unit area of the plane in the cases illustrated in fig. (C).



(C)

a) $F=(B_2^2+B_1^2)/\mu_0$ the force is directed to the left

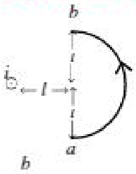
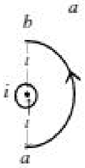
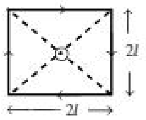
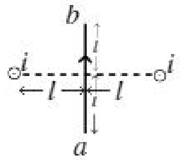
b) $F=(B_1^2+B_2^2)/2\mu_0$ the force is directed to the right

c) $F=(B_1^2-B_2^2)/2\mu_0$ the force is directed to the right

d) $F=(2B_1^2-B_2^2)/3\mu_0$ the force is directed to the left

Matrix Matching Type Questions

15. Elements in Column-I contains infinitely long straight conductor (s) carrying current i normally outwards from the paper and the paths shown with arrows. Column-II contains the values of $\int \vec{B}.d\vec{l}$ along the shown paths. Match the two columns.

COLUMN - I	COLUMN - II
A) 	p) zero
B) 	q) $\mu_0 i$
C) 	r) $\frac{\mu_0 i}{2}$
D) 	s) $\frac{\mu_0 i}{4}$

Integer Type Questions

16. The magnetic induction field at the centroid of the triangle carrying current of 1A having each side of length 4.5×10^{-2}m is $x\times10^{-5}$T. What is the value of 'x' ?

17. A long straight wire carrying a current of 30 A is placed in an external uniform magnetic field of induction 4×10^{-4} T. The magnetic field is acting parallel to the direction of current. The magnitude of the resultant magnetic induction in $x\times10^{-4}$ tesla at a point 2.0 cm away from the wire, what is value of 'x' ? $(\mu_0=4\pi\times10^{-7}\,H/m)$

EXERCISE-II

(Magnetic field due to a circular current loop)

LEVEL-I (MAIN)

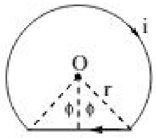
Straight Objective Type Questions

1. In an orbit of radius 0.5 A^0 an electron revolves with a frequency of 6.25×10^{15} Hz. The magnetic induction field at its centre is (in Tesla)

1) 4π 2) 2π 3) 4 4) 2

2. A conducting wire bent in the form of a semi circle of radius 10 cm carries current of 2A. At the centre of the semicircle the magnetic induction (in Tesla)
   1) $4\pi\times10^{-6}$ 2) $8\pi\times10^{-7}$ 3) $6\pi\times10^{-6}$ 4) $2\pi\times10^{-6}$
3. A circular arc of wire subtends an angle $\pi/2$ at the centre. If it carries a current i and its radius of curvature is R then the magnetic field at the centre of the arc is
   1) $\frac{\mu_0 i}{R}$ 2) $\frac{\mu_0 i}{2R}$ 3) $\frac{\mu_0 i}{4R}$ 4) $\frac{\mu_0 i}{8R}$
4. A circular coil 'A' has a radius R and the current flowing through it is I. Another circular coil 'B' has a radius 2R and if 2I is the current flowing through it, then the magnetic fields at the centre of the circular coil are in the ratio of
   1) 4 : 1 2) 2 : 1 3) 3 : 1 4) 1 : 1
5. Two circular coils of radii 20 cm and 30cm having number of turns 50 and 100 made of same material are connected in series. The ratio of the magnetic field of induction at their centres is
   1) 3:2 2) 9:4 3) 3:4 4) 1:3
6. A wire of length 'L' meters carrying a current 'i' amperes is bent in the form of a circle.The magnitude of its magnetic moment is
   1) $\frac{iL}{4\pi}$ 2) $\frac{iL^2}{4\pi}$ 3) $\frac{i^2L}{4\pi}$ 4) $\frac{i^2L^2}{4\pi}$
7. A wire of length 'l' is bent into a circular loop of radius R and carries a current I. The magnetic field at the centre of the loop is 'B'. The same wire is now bent into a double loop of eqaul radii. If both loops carry the same current I and it is in the same direction, the magnetic field at the centre of the double loop will be
   1) zero 2) 2B 3) 4 B 4) 8 B
8. The ratio of magnitude of magnetic field at the centre of a circular current carrying coil to its magnetic moment is 'N'. If the current and radius both were doubled the ratio will become
   1) $\frac{N}{8}$ 2) $\frac{N}{4}$ 3) 2 N 4) 4 N
9. A particle of charge 'q' and mass 'm' moves in a circular orbit of radius 'r' with angular speed 'ω'. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on
   1) ω and q 2) ω, q and m 3) q and m 4) ω and m
10. An electron of charge 'e' moves in a circular orbit of radius 'r' around the nucleus at a frequency 'n'. The magnetic moment associated with the orbital motion of the electron is,
   1) πner^2 2) $\frac{\pi nr^2}{e}$ 3) $\frac{\pi ne}{r^2}$ 4) $\frac{\pi er^2}{n}$
11. Two wires A and B are of lengths 40 cm and 30 cm. A is bent into a circle of radius r and B into an arc of radius r. A current i_1 is passed through A and i_2 through B. To have the same magnetic inductions at the centre, the ratio of i_1:i_2 is
   1) 3 : 4 2) 3 : 5 3) 2 : 3 4) 4 : 3
12. The magnetic induction at the centre of a circular loop of area πm^2 is 0.1 T. The magnetic moment of the loop is
   1) $\frac{0.1\pi}{\mu_0}$ 2) $\frac{0.2\pi}{\mu_0}$ 3) $\frac{0.3\pi}{\mu_0}$ 4) $\frac{0.4\pi}{\mu_0}$

13. The total magnetic induction at point 0 due to curved portion and straight portion in the following figure, will be

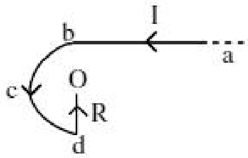


1) $\frac{\mu_0 i}{2\pi r}[\pi-\phi+\tan\phi]$

2) $\frac{\mu_0 i}{2\pi r}$

3) $\frac{\mu_0 i}{\pi r}[\pi-\phi+\tan\phi]$ 4) 0

14. An infinitely long wire is bent in the form of a semicircle at the end as shown in the figure. It carries current I along abcdo. If radius of the semicircle be R, then the magnetic field at 'O' which is the center of the circular part is,



1) $\frac{\mu_0}{4\pi}\frac{2I}{R}(\pi+1)$ 2) $\frac{\mu_0}{4\pi}\frac{2I}{R}(\pi-1)$ 3) $\frac{\mu_0}{4\pi}\frac{I}{R}(\pi+1)$ 4) $\frac{\mu_0}{4\pi}\frac{I}{R}(\pi-1)$

15. A straight wire is first bent into a circle of radius 'r' and then into a square of side 'x' each of one turn. If currents flowing through them are in the ratio 4 : 5, the ratio of their effective magnetic moments is

1) $\frac{\pi}{8}$ 2) $\frac{12}{5\pi}$ 3) $\frac{16}{5\pi}$ 4) $\frac{8}{5\pi}$

Numerical Value Type Questions

16 . An electron revolves in a circle of radius 0.4A^0 with a speed of 10^6 ms^{-1} in a hydrogen atom. The magnetic field produced at the centre of the orbit due to motion of the electron, in tesla, is $[\mu_0=4\pi\times10^{-7}H/m]$

17. The magnetic induction at a point on the aixs of the circular coil is $\frac{1}{2\sqrt{2}}$ times the magnetic induction at the centre of the coil, when current is passed through the coil. If radius of the coil is 10cm then the distance of that point is (in cm)

18. A current carrying circular coil of radius 6.28 cm is placed with its plane in magnetic meridian. The resultant magnetic induction at the centre of the coil is [Given current in the coil is 3A and B_H = 0.4 Gauss] (in × 10^{-5} T)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on its axis at a distance of 4 cm from the centre is $54\mu T$. The magnetic field (in μT) at the centre of the loop will be

a) 250 b) 150 c) 125 d) 72

2. Two similar coaxial coils, separated by some distance, carry the same current I but in opposite directions. The magnitude of the magnetic field B at a point on the axis at the mid point of the line joining the centre is :

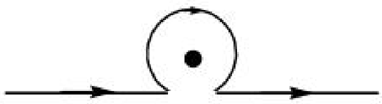
a) Zero
b) the same as that produced by one coil
c) twice that produced by one coil
d) half of that produced by one coil.

3. A single -layer coil (solenoid) has length l and cross-section radius R. Number of turns per unit length is equal to n. Find the magnetic induction at the centre of the coil when a current I flows through it.

a) $B=\mu_0 nI\sqrt{1+\left(\frac{2R}{\ell}\right)^2}$
b) $B=\mu_0 nI\Big/\sqrt{1+\left(\frac{2R}{\ell}\right)^2}$
c) $B=\mu_0 nI\Big/\sqrt{1-\left(\frac{2R}{\ell}\right)^2}$
d) $B=\mu_0 nI\Big/\sqrt{1+(2R)^2}$

More than One correct answer Type Questions

4. A long straight conductor, carrying a current i, is bent to form an almost complete circular loop of radius R on it. the magnetic field at the centre of the loop



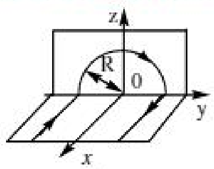
a) is directed into the paper
b) is directed out of the paper
c) has magnitude $\frac{\mu_0 i}{2R}\left(1-\frac{1}{\pi}\right)$
d) has magnitude $\frac{\mu_0 i}{2R}\left(1+\frac{1}{\pi}\right)$

Linked Comprehension Type Questions

Passage :

5. Find the magnetic induction at the point O if wire carrying a current $I = 8.0$ A has the shape shown in fig. The radius of the curved part of the wire is $R = 100$ mm, the linear parts of the wire are very long

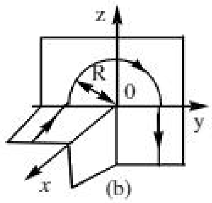
a) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{\pi^2+4}$
b) $\frac{\mu_0}{4\pi}\frac{i}{R}(2+\pi)$
c) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{1+(\pi+1)^2}$
d) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{\pi^2+2}$



(a)

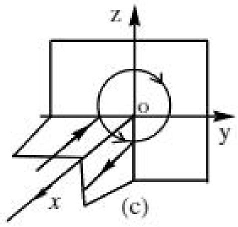
6. Find the magnetic induction at the point O if wire carrying a current $I = 8.0$ A has the shape shown in fig. b.

a) $\frac{\mu_0}{4\pi}\frac{i}{R}(\pi+2)$
b) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{1+(\pi+1)^2}$
c) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{\pi^2+4}$
d) $\frac{\mu_0}{4\pi}\frac{\sqrt{2}i}{R}$



(b)

7. Find the magnetic induction at the point O if wire carrying a current I = 8.0 A has the shape shown in fig. c. (R is the radius of the curved part).



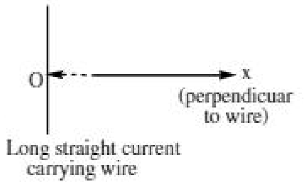
a) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{\pi^2+4}$ b) $\frac{\mu_0}{4\pi}\frac{i}{R}\sqrt{1+(\pi+1)^2}$

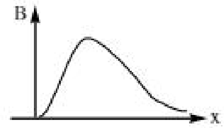
c) $\frac{\mu_0}{4\pi}\frac{\sqrt{2}i}{R}$ d) $\frac{\mu_0}{2\pi}\frac{i}{R}$

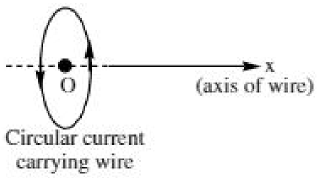
Matrix Matching Type Questions

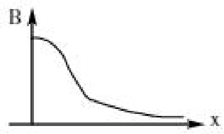
8. The entries in Column-I depict certain current distributions, while the entries in Column-II depict the variation of the magnetic field (B) as one moves along the x–axis for each of these distributions, but in a different order. Match the entries in Column-I with the proper entries in Column-II.

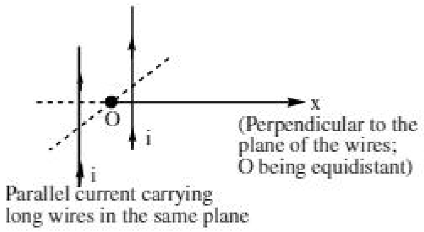
COLUMN-I **COLUMN-II**

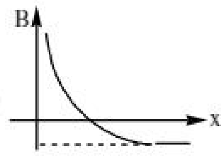
A) 

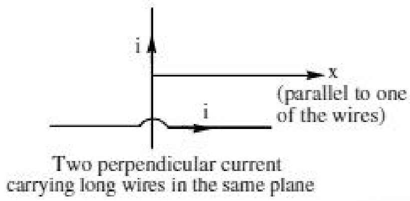
p) 

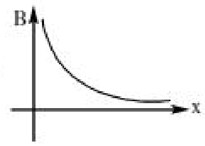
B) 

q) 

C) 

r) 

D) 

s) 

Integer Type Questions

9. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3 ampere and 4 ampere are the currents flowing in each coil respectively. The magnetic induction in $x \times 10^{-5}$ weber/m^2 at their common centre, what is the value of 'x' . ($\mu_0 = 4\pi \times 10^{-7}$ wb/A – m)

10. A $2\mu C$ charge moves in a circular orbit of radius 2cm around the nucleus at a frequency 10 rev/sec. The magnetic moment associated with the orbital motion of the electron is $x\pi \times 10^{-9}$ A – m^2. What is the value of 'x' ?

EXERCISE-III

(Ampere's Law, Solenoid and Toroid)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The magnetic induction at the centre of a solenoid is B. If the length of the solenoid is reduced to half and the same wire is wound in two layers the new magnetic induction is

1) B 2) 2B 3) B/2 4) 4B

2. A solenoid of 0.4m length with 500 turns carries a current of 3A. A coil of 10 turns and of radius 0.01m carries a current of 0.4A. The torque required to hold the coil with its axis at right angles to that of solenoid in the middle point of it is

1) $6\pi^2 \times 10^{-7}$ Nm 2) $3\pi^2 \times 10^{-7}$ Nm 3) $9\pi^2 \times 10^{-7}$ Nm 4) $12\pi^2 \times 10^{-7}$ Nm

3. A toroid has a core of inner radius 21 cm and outer radius 23 cm, around which 2000 turns of a wire are wound. If the current in the wire is 11 A, what is the magnetic field outside the toroid, inside the core of the toroid and in the empty space surrounded by the toroid

1) $0, 0.4\times10^{-2}$T$, 0$ 2) 4×10^{-2}T$, 0, 0$ 3) $0, 2\times10^{-4}$T$, 0$ 4) 2×10^{-4}T$, 0, 4\times10^{-4}$

Numerical Value Type Questions

4. The length of a solenoid is 0.1 m and its diameter is very small. A wire is wound over in two layers. The number of turns in the inner layer is 50 and that on the outer layer is 40. The strength of current flowing in two layers in the same direction is 3 ampere. The magnetic induction in the middle of the solenoid will be (in mT)

5. A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is 6.28×10^{-2}Wb/m^2. Another long solenoid has 100 turns per cm and it carries a current $i/3$. The value of the magnetic field at its centre is n $\times$ 10^{-2} wb/m^2, where n =

6. A long solenoid has 100 turns per cm and carries a current i. The magnetic field at its centre is 6×10^{-2}Wb/m^2. Another long solenoid has 400 turns per cm and it carries a current i/2. The value of the magnetic field at its centre is (in wb/m^2)

7. A solenoid of length 1m and having 200 turns of wire carries a current of 2A. A thin coil having 10 turns of wire and of radius 0.1m carries a current of 2A. The torque required to hold the coil in the middle of the solenoid with its axis perpendicular to the axis of the solenoid is n $\times10^{-5}$ Nm where n = ____ .

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The length of a solenoid is 0.5 m and its diameter is very small. A wire is wound over in two layers. The number of turns in the inner layer is 100 and that on the outer layer is 50. The strength of current flowing in two layers in the same direction is 2amp. The magnetic induction in the middle of the solenoid will be

a) $24\pi \times 10^{-5} T$ b) $36\pi \times 10^{-5} T$ c) $12\pi \times 10^{-5} T$ d) $6\pi \times 10^{-5} T$

2. A long solenoid has a length and mean diameter D. It has n layers of windings each N turns. The magnetic field at the centre is directly proportional to

a) D b) L c) D^0 d) $\frac{1}{D}$

3. A closely wound solenoid 80cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8cm. If the current arried is 8.0A, then estimate the magnitude of B inside the solenoid near is centre

a) 1.5×10^{-2}T, along to the axis of solenoid b) 2.5×10^{-2}T, along the axis of solenoid

c) 3.5×10^{-2}T, along the axis of solenoid d) 1.5×10^{-2}T, opposite to the axis of solenoid

More than One correct answer Type Questions

4. A long thick conducting cylinder of radius R carries a uniformly distributed current over its cross-section. Which of the following statement(s) is/are correct?

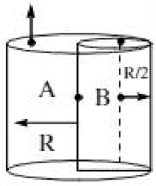
a) The magnetic field strength is maximum on the surface

b) The magnetic field strength is zero on the surface

c) The strength of magnetic field inside the cylinder will vary as inversely proportional to r

d) The energy density of magnetic field outside the cylinder varies as inversely proportional to $\frac{1}{r^2}$

5. From a cylinder of radius R, a cylinder of radius R/2 is removed as shown in the figure. Current flowing in the remaining cylinder is i. Magnetic field strength is



a) Zero at point A b) Zero at point B

c) $\frac{\mu_0 i}{3\pi R}$ at point A d) $\frac{\mu_0 i}{3\pi R}$ at point B

6. Two identical current carrying co-axial loops, carry current i in an opposite sense. A simple amperian loop passes through both of once. Calling the loop as C,

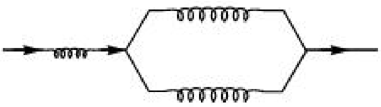
a) $\int_C B.dl = m2\mu_0 l$ b) the value of $\int_C B.dl$ is independent of sense of C

c) there may be a point on C, where B and dl are perpendicular

d) B vanishes every where on C

Integer Type Questions

7. Three identical long solenoids P, Q and R are connected to each other as shown in the figure. If the magnetic field at the centre of P is 2.0T, then what would be the field (in T) at the centre of Q? Assume that the field due to any solenoid is confined with the volume of that solenoid only.



8. A packed bundle of 100 long straight, insulated wires forms a cylinder of radius R = 0.5cm. If each wire carries a current of 2A, then magnetic force per unit length on a wire located at 2mm from the centre of the bundle is $704 \times N \times 10^{-6}$N. Find the value of N.

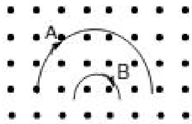
EXERCISE-IV

(Motion of charged particle in the magnetic field)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Two particles A and B of mass m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are υ_A and υ_B respectively, and the trajectories are as shown in the figure. Then



1) $m_A\upsilon_A < m_B\upsilon_B$ 2) $m_A\upsilon_A > m_B\upsilon_B$
3) $m_A < m_B$ and $\upsilon_A < \upsilon_B$
4) $m_A = m_B$ and $\upsilon_A = \upsilon_B$

2. Two ions having masses in the ratio 1 : 2 and charges 1 : 2 are projected into uniform magnetic field perpendicular to the field with speeds in the ratio 2 : 3. The ratio of the radii of circular paths along which the two paticles move is

1) 4 : 3 2) 2 : 3 3) 3 :1 4) 1 : 2

3. A proton, a deutron and an α-particle whose kinetic energies are same enter at right angles to a uniform magnetic field. Then the ratio of the radii of their circular paths is

1) $1:\sqrt{2}:1$ 2) $\sqrt{2}:1:1$ 3) 1:2:1 4) 2:2:1

4. A particle having a charge of $100\mu c$ and mass of 10mg is projected in a uniform magnetic field of 25 Tesla, with a speed of $10ms^{-1}$. The velocity is perpendicular to the field. The radius of path and period of revolution are

1) 4cm, 25sec 2) 4m, 25 millisec 3) 4cm, $25\times10^{\;3}$ sec 4) 4m, 25sec

5. A magnetic field of $4\times10^{\;3}\hat{K}T$ exerts a force of $\left(4\hat{i}+3\hat{j}\right)\times10^{\;10}N$ on a particle of charge $10^{-9}C$ and going in X-Y plane. The velocity of the charged particle is

1) $75\hat{i}-100\hat{J}$ 2) $-75\hat{i}+100\hat{J}$ 3) $100\hat{i}-75\hat{J}$ 4) $100\hat{i}+75\hat{J}$

6. A proton, a deuteron and an α particle enter a uniform magnetic field at right angles to the field. If they are accelerated through same potential difference before entering the magnetic field, then the ratio of their angular momenta during their motion in the magnetic field is

1) 1 : 2 : 4 2) 2 : 1 : 4 3) 4 : 1 : 2 4) 1 : 1 : 8

7. An electron accelerated through a potential difference 'V' passes through a uniform transverse magnetic field and experiences a force F. If the accelerating potential is increased to 2V, the electron in the same magnetic field will experience a force

1) F 2) $\frac{F}{2}$ 3) $\sqrt{2}F$ 4) 2F

Numerical Value Type Questions

8. A cyclotron in which protons are accelerated has a flux density of 1.57T, the variation of frequency of electric field is – (Hz) (in $\times10^7$ Hz)

9. A cyclotron existed to give proton beam, amgnetic induction is $0.15Wb/m^2$, and the extream raidus is 1.5m. The energy of emergent proton (in mev) will be

LEVEL-II (ADVANCED)

Straight Objective Type Questions

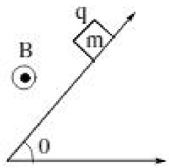
1. A tightly wound, long solenoid has n turns per unit length, a radius r and carries a current i. A particle having charge q and mass m is projected from a point on the axis in a direction per-pendicular to the axis. What can be the maximum speed for which the prarticle does not strike the solenoid

a) $\frac{m}{\mu_0 2rni}$ b) $\frac{\mu_0 qrni}{m}$ c) $\frac{\mu_0 qrn}{mi}$ d) $\frac{\mu_0 qrni}{2m}$

2. Three ions H^+, He^+ and O^{+2} having same kinetic energy pass through a region in which there is a uniform magnetic field perpendicular to their velocity, then :

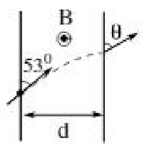
a) H^+ will be least deflected. b) He^+ and O^{+2} will be deflected equally.
c) O^{+2} will be deflected most. d) all will be deflected equally.

3. A block of mass m & charge q is released on a long smooth inclined plane magnetic field B is constant, uniform, horizontal and parallel to surface as shown. Find the time from start when block loses contact with the surface.



a) $\frac{m\cos\theta}{qB}$ b) $\frac{m\,\text{cosec}\theta}{qB}$
c) $\frac{m\cot\theta}{qB}$ d) none

4. A particle moving with velocity v having specific charge (q/m) enters a region of magnetic field B having width d = $\frac{3mv}{5qB}$ at angle 53° to the boundary of magnetic field. Find the angle θ in the diagram.

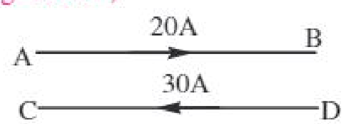


a) 37° b) 60° c) 90° d) none

5. The magnetic field existing in a region is given by $\vec{B} = B_0\left[1+\frac{X}{l}\right]\hat{k}$. A square loop of edge l and carrying current i, is placed with its edges parallel to the x and y-axis. Find the magnitude of the net magnetic force experienced by the loop

a) $2B_0il$ b) B_0il c) $\frac{B_0il}{2}$ d) $(3/2)Bil$

6. A long horizontal wire AB which is free to move in vertical plane and carries a steady current 20 A, is in equilibrium at a height of 0.1 meter above another parallel long wire CD, which is fixed in horizontal plane and carries current 30A,as shown in the figure. Find the time period of oscillations when AB is slightly depressed ($g=10m/s^2$)



a) 0.1 s b) 0.2 s c) 0.3 s d) 0.628 s

7. A current I flows, in a long thin-walled cylinder of radius R. What pressure do the walls of the cylinder experience?

a) $\mu_0 I^2/8\pi^2R^2$ b) $\mu_0 I/8\pi R$ c) $\mu_0 I^2/16\pi R^2$ d) $\mu_0 I/4\pi^2 R$

More than One correct answer Type Questions

8. A charged particle 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 just touches a straight line y = 5(m) at $x = 5\sqrt{3}(m)$. The mass of particle = 5×10^{-5} kg charge = $1\mu C$.

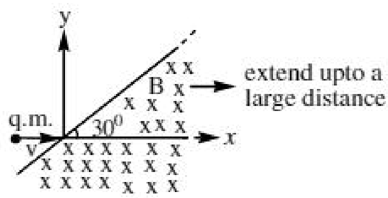
a) the particle is projected at an angle 60^0 with x-axis

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

9. A charge particle of charge q, mass m is moving with initial velocity 'v' as shown in figure in a uniform magnetic field $-B\hat{k}$ .Select the correct alternative/alternatives:-



a) Velocity of particle when it comes out from magnetic field is $\vec{v} = v\cos 30^0 \hat{i} - v\sin 30^o \hat{j}$

b) Time for which the particle was in magnetic field is $\dfrac{\pi m}{3qB}$

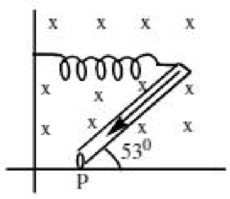
c) Distance travelled in magnetic field is $\dfrac{\pi mV}{3qB}$

d) The particle will never come out of magnetic field

Linked Comprehension Type Questions

Passage :

A thin uniform rod with negligible mass & length 0.2 m is attached to the floor by a friction less hinge at point P. A horizontal spring with force constant K = 4.80N/m connects the other end of the rod to a vertical wall. The rod is in a uniform magnetic field B = 0.34T directed into the plane of figure. There is current I = 6.50 A in the rod.



10. Calculate the torque due to the magnetic force on the rod, for an axis at P.

a) 0.0442 N/m b) 0.0442 N/m anticlockwise

c) 0.442 N/m clockwise d) 0.442 N/m anticlockwise

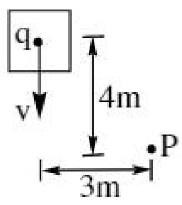
11. When the rod is in quilibrium & makes an angle of 53^0 with the floor. Is the spring stretched or compressed

a) 0.05765 m, stretched
b) 0.056765 m compressed
c) 0.0242 m stretched
d) 0.0242 m compressed

Integer Type Questions

12. A non-relativistic proton beam passes without deviation through the region of space where there are uniform transverse mutually perpendicular electric and magnetic field with E=120KV/m and B=50mT. The beam strikes a grounded target. Find the force with which beam acts on the target if the beam current is equal to I= 0.80mA (neglect gravity, and assume the collision to be perfectly inelastic) is ____$\times 10 \mu N$

13. An elevator carrying a charge of 0.5 C is moving down with a velocity of 5×10^3 m/s. The elevator is 4 m from the bottom and 3 m horizontally from P as shown. What magnetic field (in μT) does it produce at point P.



EXERCISE-V

(Motion of changed particle in combined electornic and magnetic field)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Velocity and acceleration vectors of a charged particle moving in a magnetic field at some instant are $\vec{v} = 3\hat{i} + 4\hat{i}$ and $\vec{a} = 2\hat{i} + x\hat{j}$. Select the wrong alternative

1) $x = -1.5$
2) $x = 3$
3) magnetic field is along z-direction
4) Kinetic energy of the particle is constant

2. A particle of specific charge (charge/mass) α 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 $(x_0, y_0, 0)$ is $(4\hat{i} + 3\hat{j})$. The value of x_0 is :

1) $\frac{13}{2}\frac{\alpha E_0}{B_0}$
2) $\frac{16 \quad \alpha B_0}{E_0}$
3) $\frac{25}{2\alpha E_0}$
4) $\frac{5\alpha}{2B_0}$

3. A particle of charge Q and mass *m* moves in a circular path of radius R in a uniform magnetic field of magnitude B. The same particle now moves with the same speed in a circular path of same radius R in the space between the cylindrical electrodes of the cylindrical capacitor. The radius of the inner electrode is R/2 while that of the outer electrode is 3R/2. Then the potential difference between the capacitor electrodes must be

1) $QBR(\ln 3)/m$
2) $QB^2R^2(\ln 3)/2m$
3) $QB^2R^2(\ln 3)/m$
4) Zero

Numerical Value Type Questions

4. A charged particle of charge 5mc and mass 5gm is moving with a constant speed 5 m/s. in a uniform magnetic field on a curve $x^2 + y^2 = 25$. Where x and y are in meter. The value of magnetic field required will be (in T along z axis)

5. A particle moves in a circular path of diameter 1.0m under the action of magnetic field of 0.4T. An electric field of 200 V/m makes the path of particle straight. Find the charge/mass ratio of the particle. (in C/kg)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

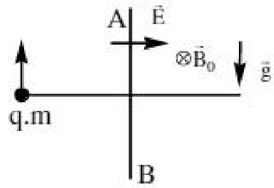
1. An electron is projected with velocity v_0 in a uniform electric field E perpendicular to the field. Again it is projetced with velocity v_0 perpen-dicular to a uniform magnetic field B. If r_1 is initial radius of curvature just after entering in the electric field and r_2 is initial radius of curvature just after entering in magnetic field then the ratio r_1/r_2 is equal to

a) $\frac{Bv_0^2}{E}$ b) $\frac{B}{E}$ c) $\frac{Ev_0}{B}$ d) $\frac{Bv_0}{E}$

2. A particle having mass m and charge q is released from the origin in a region in which electric field and magnetic field are given by $\vec{B} = -B_0\hat{j}$ and $\vec{E} = E_0\hat{k}$. Find the speed of the particle as a function of its z coordinate.

a) $\sqrt{\frac{qE_0z}{m}}$ b) $\sqrt{\frac{2qE_0z}{m}}$ c) $\sqrt{\frac{qE_0z}{2m}}$ d) $\sqrt{\frac{m}{2qE_0z}}$

3. A uniform electric field E is present horizontally along the paper throughout the region but uniform magnetic field B_0 is present horizontally (perpendicular to plane of paper in inward direction) right to the line AB. A charge particle having charge q mass m is projected vertically upward and it crosses the line AB after time t_0 . Find the speed of projection if particle moves with constant velocity after. (Given qE = mg)



a) gt_0 b) $2gt_0$ c) $gt_0/2$
d) Particle cant move with constant velocity after crossing AB

Linked Comprehension Type Questions

Passage - I :

Electric field and magnetic field in a region of space are given by $\vec{E} = E_0\hat{j}$ and $\vec{B} = B_0\hat{j}$. A particle of specific charge α (charge per unit mass) is released from origin with velocity $\vec{V} = V_0\hat{i}$

4. Determine velocity of particle at any time t.

a) $v_0\text{Cos}(B_0\alpha t)\hat{i} + (E_0\alpha t)\hat{j} + v_0\text{Sin}(B_0\alpha t)\hat{k}$

b) $v_0\text{Sin}(B_0\alpha t) - (E_0\alpha t)\hat{j} + v_0\text{Cos}(B_0\alpha t)\hat{k}$

c) $v_0\text{Sin}(B_0\alpha t)\hat{i} + (E_0\alpha t)\hat{j} - v_0\text{Cos}(B_0\alpha t)\hat{k}$

d) $v_0\text{Cos}(B_0\alpha t)\hat{i} - (E_0\alpha t)\hat{j} - v_0\text{Cos}(B_0\alpha t)\hat{k}$

5. Find position of particle at time t.

a) $\frac{v_0}{B_0\alpha}\text{Cos}(B_0\alpha t)\hat{i}+\frac{1}{2}(E_0\alpha t^2)\hat{j}-\frac{v_0}{B_0\alpha}(1+\text{Cos}B_0\alpha t)\hat{k}$

b) $\frac{v_0}{B_0\alpha}\text{Sin}(B_0\alpha t)\hat{i}+\frac{1}{2}E_0\alpha t^2\hat{j}+\frac{v_0}{B_0\alpha}(1-\text{Cos}(B_0\alpha t))\hat{k}$

c) $\frac{v_0}{B_0\alpha}\text{Sin}(B_0\alpha t)\hat{i}-E_0\alpha t^2\hat{j}+\frac{v_0}{B_0\alpha^2}(1-\text{Sin}\alpha t)\hat{k}$

d) $\text{Sin}(B_0\alpha t)\hat{i}+(E_0\alpha t^2)\hat{j}+v_0(1-\text{Cos}\alpha t)\hat{k}$

6. Find the y-coordinate of particle when it crosses the y-axis for the n^{th} time.

a) $\frac{4n\pi E_0}{B_0\alpha}$ b) $\frac{2n^2\pi}{E_0B_0\alpha}$ c) $\frac{n^2\pi E_0}{B_0\alpha}$ d) $\frac{2n^2\pi^2E_0}{B_0^2\alpha}$

Passage - II :

Magnetic force on a charged particle is given by $\vec{F}_e=q\vec{E}$. A particle having charge q= 1 C and mass 1 kg is released from rest at origin. There are electric and magnetic fields given by $\vec{E}=(10\hat{i})N/C$ for $x\le 1.8m$ and $\vec{B}=-(5\hat{k})T$ for 1.8 $m\le x\le 2.4m$. A screen is placed parallel to y – z plane at x = 3,. Neglect gravity forces.

7. The speed with which the particle will collide the screen is

a) 3 m/s b) 6 m/s c) 9 m/s d) 12 m/s

8. y-coordinate of particle where it collides with screen (in meter) is

a) $\frac{0.6(\sqrt{3}-1)}{\sqrt{3}}$ b) $\frac{0.6(\sqrt{3}+1)}{\sqrt{3}}$ c) $1.2(\sqrt{3}+1)$ d) $\frac{1.2(\sqrt{3}-1)}{\sqrt{3}}$

9. Time after which the particle will collide the screen is (in sec.)

a) $\frac{1}{5}\left(3+\frac{\pi}{6}+\frac{1}{\sqrt{3}}\right)$ b) $\frac{1}{5}\left(6+\frac{\pi}{3}+\sqrt{3}\right)$ c) $\frac{1}{3}\left(5+\frac{\pi}{6}+\frac{1}{\sqrt{3}}\right)$ d) $\frac{1}{3}\left(6+\frac{\pi}{18}+\sqrt{3}\right)$

Matrix Matching Type Questions

10. A particle enters a space where exists uniform magnetic field $\vec{B}=B_x\vec{i}+B_y\vec{j}+B_z\vec{k}$ and uniform electric field $\vec{E}=E_x\vec{i}+E_y\vec{j}+E_z\vec{k}$ with initial velocity $\vec{u}=u_x\vec{i}+u_y\vec{j}+u_z\vec{k}$. Depending on the values of various components the particle selects a path. Match the entries of column I with the entries of column II. The components other than speficied in column I in each entry are non-zero. Neglect gravity.

COLUMN – I	COLUMN – II
A) $B_y=B_z=E_x=E_z=0\ u=0$	p) Circle
B) $E=0\ u_xB_x+u_yB_y\ne -u_zB_z$	q) Helix with uniform pitch and constant radius
C) $\vec{u}\times\vec{B}=0, \vec{u}\times\vec{E}=0, u\ne 0, B\ne 0, E\ne 0$	r) Cycloid
D) $\vec{u}\perp\vec{B}, \vec{B}\parallel\vec{E}$	s) helix with variable pitch and constant radius
	t) Straight line

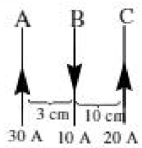
EXERCISE-VI

(Magnetic force between two parallel conductors)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Three long straight and parallel wires, carrying currents are arranged as shown figure. The force experienced by the conductor 'B' of length 25cm is



1) $4\times10^{-4}N$ from left to right
2) $4\times10^{-4}N$ from right to left
3) $2\times10^{-4}N$ from left to right
4) $2\times10^{-4}N$ from right to left

2. Two long conductors, separated by a distance 'd' carry current I_1 and I_2 in the same direction. They exert a force F on each other. Now the current in one of them is increased to two times and its direction is reversed. The distance is also increased to 3d. The value of the force between them is

1) –2F 2) $\frac{F}{3}$ 3) $-\frac{2F}{3}$ 4) $-\frac{F}{3}$

3. A horizontal rod of mass 10g and length 10cm is placed on a smooth inclined plane of an angle of 60^0 with the horizontal with the length of the rod parallel to the edge of the inclined plane. A uniform magnetic field of induction B is applied vertically downwards. If the current through the rod is $\sqrt{3}A$, the value of B for which the rod remains stationary on the inclined plane is

1) 2T 2) 3T 3) 1 T 4) 0.5 T

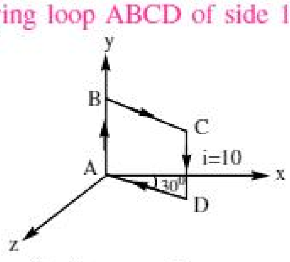
Numerical Value Type Questions

4. Currents of 10A and 2A are passed through two parallel wires A and B respectively in opposite directions. If the wire A is infinitely long and the length of wire 'B' is 2m, the force on conductor 'B' at a separation of 10cm from 'A' will be ($\times 10^{-5}N$)
5. A horizontal wire carries 200A current below which another wire of linear density 20×10^{-3} Kg/m carrying a current is kept at 2cm distance. If the wire kept below hangs in air, then the current in the wire is (in A)
6. A straight wire of length 30cm and mass 60 mg lies in a direction 30^0 east of north. The earth's magnetic field at this site is horizontal and has a magnitude of 0.8 G. The current must be passed through the wire so that it may float in air is ($g = 10m/s^2$) (in A)

LEVEL-II (ADVANCED)

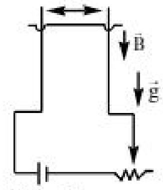
Straight Objective Type Questions

1. Figure shows a square current carrying loop ABCD of side 10 cm and current i = 10A. The magnetic moment $\vec{M}$ of the loop is



a) (0.05) $(\hat{i}-\sqrt{3}\hat{k})A-m^2$ b) (0.05) $(\hat{j}+\hat{k})\ A-m^2$ c) (0.05) $(\sqrt{3}\hat{i}+\hat{k})\ A-m^2$ d) $(\hat{i}+\hat{k})\ A-m^2$

2. A horizontal rod of mass 2kg is kept touching two vertical parallel rough rails, carrying current. There is a magnetic field B = 2T present vertically downward. The rails are connected to battery of 100V at t = 0. The resistance of the circuit is 5Ω and starts to increase at constant rate $0.5\Omega/s$. The coefficient of friction between the rails and rod is $\mu = 3/4$ (g=10m/s^2) and separation between the rails in 1m). Then



a) The friction force acting on the rod at t = 0 is 20 N

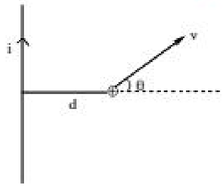
b) The friction force acting on the rod at t = 0 is 30 N

c) Acceleration of rod at t = 0 is 5m/s^2

d) At t = 5 sec. rod is about to start

More than One correct answer Type Questions

3. A charged particle of mass m and charge q is projected with a velocity v at a distanc d from along along straight current conductor. The radius of curvature of the path traced by the particle at the given position depends on ....



a) m

b) θ

c) q

d) i

EXERCISE-VII

(Torque on current loop, MCG)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. A vetical circular coil of one turn and radius 9.42 cm is placed with its plane in the magnetic meridian and short magnetic needle is pivoted at the centre of the coil so that it can freely rotate in the horizontal plane. If a current of 6A is passed through the coil, then the needle deflects by ($B_H = 4 \times 10^{-5}$T)

1) 30° 2) 45° 3) 60° 4) 90°

2. A tangent galvanometer shows no deflection when a current is passed through it, but when the current through it is reversed it gives a defleciton of 180°, then the plane of the coil is

1) in the magnetic meridian 2) normal to the magnetic meridian

3) at an angle of 45° to magnetic meridian 4) at an angle of 60° to the magnetic meridian

3. A square coil of edge l having n turns carries a current i. 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. What should be the minimum value of B for which the coil will start tipping over.

1) $\frac{mg}{nil}$ 2) $\frac{nil}{2mg}$ 3) $\frac{mg}{2nil}$ 4) $\frac{2mg}{nil}$

Numerical Value Type Questions

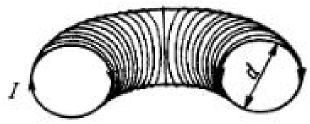
4. A coil having 20 turns is suspended in a magnetic field of 0.2 wb/m^2 of a Galvanometer by a suspension wire of couple per unit twist 10^{-6} N-m/^{0}. If the least measurable deflection is 0.1^0 then the least measurable current is (area of coil is10^{-3} m^2) (in μA)

5. A rectangular coil of area 2.5 cm × 1.5 cm has 100 turns. When a current of 2 mA is passed through it, the deflection is 30^0. The couple per unit twist of the suspended wire is 1.44×10^{-4} Nm/rad the magnetic induction is nearly (in T)

6. A current of 0.5 A produces a deflection of 60^0 in a tangent galvanometer. The current that produces a deflection of 30^0 in the same galvanometer is (in A)

7. Two wires of same length are made into a circle and square each of 1 turn respectively. Currents are passed in them such that their magnetic moments are equal, the ratio of the magnetic field at their respective centres is $\frac{\sqrt{x}\pi^3}{64}$ then the value of 'x' is.

8. Calculate the magnetic moment of a thin wire with a current I=0.8A, wound tightly on half a tore. The diameter of the cross-section of the tore is equal to d = 5.0 cm, the number of turns is N=500 (in Am^2).



LEVEL-II (ADVANCED)

Straight Objective Type Questions

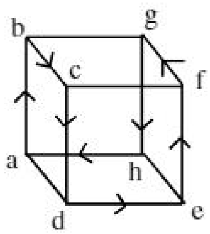
1. A conductor carries a constant current I along the closed path abcdefgha involving 8 of the 12 edges of length l. Find the magnetic dipole moment of the closed path

a) $l^2 I\hat{j}$

b) $lI\hat{j}$

c) $\frac{l}{I}\hat{j}$

d) $-lI\hat{j}$



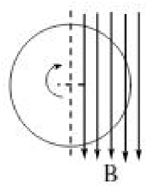
2. A thin non conducting disc of radius R is rotating clockwise (see figure) with an angular velocity ω about its central axis, which is perpendicular to its plane. Both its surfaces carry +ve charges of uniform surface density. Half the disc is in a region of a uniform, unidirectional magnetic field B parallel to the plane of the disc, as shown. Then,

a) The net torque on the disc is zero.

b) The net torque vector on the disc is directed leftwards.

c) The net torque vector on the disc is directed rightwards.

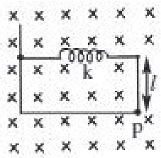
d) The net torque vector on the disc is parallel to B



3. A charge Q is uniformly distributed over the surface of a right circular cone of semi-vertical angle θ & height h. The cone is uniformly rotated about its axis at angular velocity ω calculate magnetic moment.

a) $\frac{Q\omega h}{4}\text{Tan}^2\theta$ b) $\frac{Q\omega h^2}{3}\text{Tan}^2\theta$ c) $\frac{Q\omega h^2}{4}\text{Tan}^2\theta$ d) $\frac{Q\omega h^2}{4}\text{Tan}\theta$

4. A thin uniform rod of mass and length l is in equilibrium as shown in figure. P is a pivot. When a current I flows along the rod, it rotates from its place about point P. Assume that there is no effect of current on the spring and the spring remains horizontal. Find the torque experienced by the rod about P and spring force, when the rod makes an angle θ with the horizontal.



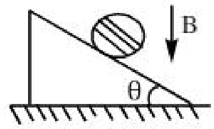
a) $\tau = \frac{1}{2}BIl^2 - Kl^2\sin\theta\cos\theta + \frac{mgl}{2}\cos\theta$

b) $\tau = \frac{1}{2}BIl^2 + Kl^2\sin\theta\cos\theta + \frac{mgl}{2}\cos\theta$

c) $\tau = \frac{1}{2}BIl^2 + Kl^2\sin\theta\cos\theta - \frac{mgl}{2}\cos\theta$

d) $\tau = -\frac{1}{2}BIl^2 - Kl^2\sin\theta\cos\theta - \frac{mgl}{2}\cos\theta$

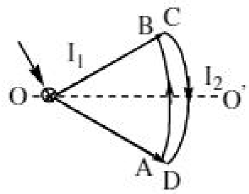
5. In the figure shown a coil of single turn is wound on a sphere of radius R and mass m. The plane of the coil is parallel to the plane and lies in the equatorial plane of the sphere. Current in the coil is i. The value of B if the sphere is in equilibrium is



a) $\frac{mg\ \cos\theta}{\pi iR}$ b) $\frac{mg}{\pi iR}$ c) $\frac{mg\ \tan\theta}{\pi iR}$ d) $\frac{mg\ \sin\theta}{\pi iR}$

More than One correct answer Type Questions

6. Which of the following statement is correct in the given figure Infinitely long wire kept perpendicular to the paper carrying current inwards



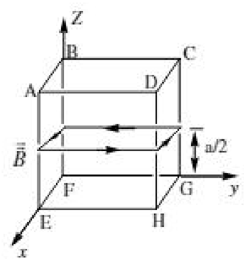
a) Net force on the loop is zero

b) Net torque on the loop is zero

c) Loop will rotate clockwise about axis OO' when seen from O

d) Loop will rotate anticlock wise about OO' when seen from O

7. A wooden cubical block ABCDEFG of mass m and side a is wrapped by a square wire loop of perimeter 4a, carrying current I. The whole system is placed on frictionless horizontal surface in a uniform magnetic field $\vec{B} = B_o\hat{j}$ as shown in figure. In this situation, normal force between horizontal surface and block passes through a point at a distance x from centre. Choose correct statement(s).



a) The block must not topple if $I < \frac{mg}{aB_o}$

b) The block must not topple if $I < \frac{mg}{2aB_o}$

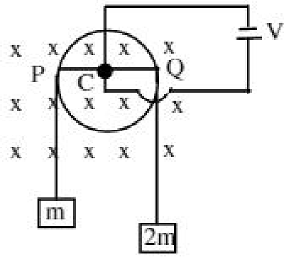
c) $x = \frac{a}{4}$ if $I = \frac{mg}{2aB_o}$ d) $x = \frac{a}{4}$ if $I = \frac{mg}{4aB_o}$

Linked Comprehension Type Questions

Passage:

A conducting ring of mass m & radius r has a weight less conducting rod PQ of length 2r & resistance 2R attached to it along its diameter. It is pivoted at its center C with its plane vertical & two blocks of mass m & 2m are suspended by means of a light in extensible string passing over it.

The ring is free to rotate about C & the system is placed in a magnetic field B is into plane of ring. A circuit is now completed by connecting the ring at C to a battery of emf V. It is found that for a certain value of V, the system remains static.



8. In static condition, current in the rod PC is

a) V/R b) V/2R c) $\frac{4V}{R}$ d) 2V/R

9. Net torque applied by the tension in the string

a) $\frac{3Bvr^2}{R}$ b) $\frac{Bvr^2}{R}$ c) $\frac{Bvr^2}{3R}$ d) $\frac{Bvr^2}{2R}$

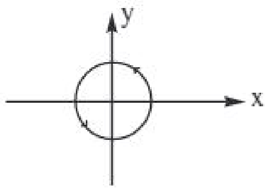
10. The value of V can be related with m,B, r as

a) $\frac{2mg\,R}{Br}$ b) $\frac{mg\,R}{Br}$ c) $\frac{mg\,R}{2Br}$ d) $\frac{3mg\,R}{Br}$

Matrix Matching Type Questions

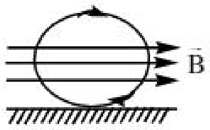
11. A circular current carrying loop is placed in x-y plane as shown in figure. A uniform magnetic field $\vec{B}=B_0\hat{k}$ is present in the region. Match the following:

COLUMN - I	COLUMN - II
A) Magnetic moment of the loop	p) zero
B) Torque on the loop	q) maximum
C) Potential energy of the loop	r) along positive z-axis
D) Net force acting on the loop	s) minimum
	t) None



Integer Type Questions

12. A conducting ring of mass 2 kg and radius 0.5 m is placed on a smooth horizontal plane. The ring carries a current i = 4A. A horizontal magnetic field B = 10T is switched on at time t = 0 as shown in figure. The initial angular acceleration of the ring will be N × 10π rad/s^2. Where N is



13. A metal ring of radius r = 0.5 m with its plane normal to a uniform magnetic field B of induction 0.2 T carries a current I = 100 A. The tension in newtons developed in the ring is_____ $\times 10^1$N.

KEY SHEET (PRACTICE SHEET)

EXERCISE-I

LEVEL-I

1) 3 2) 2 3) 3 4) 4 5) 3 6) 3 7) 13 8) 1
9) 0.67 10) 0.4 11) 2

LEVEL-II

1) a 2) c 3) a 4) a 5) a 6) d 7) c 8) c
9) a,b,c 10) a,b,c,d 11) b,c 12) a 13) b 14) c
15) A-s; B-r; C-q; D-p 16) 4 17) 5

EXERCISE-II

LEVEL-I

1) 1 2) 4 3) 4 4) 4 5) 3 6) 2 7) 3 8) 1
9) 3 10) 1 11) 1 12) 2 13) 1 14) 3 15) 3 16) 10
17) 10 18) 5

LEVEL-II

1) a 2) a 3) b 4) a,c 5) a 6) b 7) c
8) A-s; B-q; C-p; D-r 9) 5 10) 8

EXERCISE-III

LEVEL-I

1) 2 2) 1 3) 3 4) 3.4 5) 1.05 6) 0.012 7) 32

LEVEL-II

1) a 2) c 3) b 4) a,d 5) c,d 6) b,c 7) 1 8) 9

EXERCISE-IV

LEVEL-I

1) 2 2) 2 3) 1 4) 3 5) 2 6) 1 7) 3 8) 2.5
9) 2.43

LEVEL-II

1) d 2) b 3) c 4) c 5) b 6) d 7) a 8) a,c
9) a,b,c 10) a 11) a 12) 2 13) 6

EXERCISE-V

LEVEL-I

1) 2 2) 3 3) 3 4) 1 5) 2500

LEVEL-II

1) d 2) b 3) b 4) a 5) b 6) d 7) b 8) d
9) a 10) A-r; B-q,t; C-t; D-s

EXERCISE-VI

LEVEL-I

1) 1 2) 3 3) 3 4) 8 5) 98 6) 50

LEVEL-II

1) a 2) a 3) a,d

EXERCISE-VII

LEVEL-I

1) 2 2) 2 3) 3 4) 25 5) 1.006 6) 0.167
7) 2 8) 0.5

LEVEL-II

1) a 2) b 3) c 4) a 5) b 6) a,c 7) b,d 8) a
9) b 10) b 11) A-r; B-p,s; C-s; D-p 12) 4 13) 2

ADDITIONAL PRACTICE EXERCISE

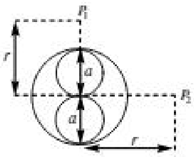
LEVEL-I (MAIN)

Straight Objective Type Questions

1. A horizontal overhead power line is at a height of 4m from the ground and carries a current of 100 A from east to west. The magnetic field directly below it on the ground is $\mu_0 = 4\pi \times 10^{-7}\,TmA^{-1}$

   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

2. A long cylindrical conductor of radius a has two cylindrical cavities of diameter a through its entire length as shown in figure. A current I is directed out of the page and is uniform throughout the cross-section of the conductor. Find the magni-tude and direction of the magnetic field in terms of μ_0, I, r and a, at point P_1

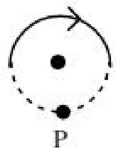
   

   1) $\frac{\mu_0 I}{\pi r}\left(\frac{2r^2 - a^2}{4r^2 - a^2}\right)$ to the left
   2) $\frac{\mu_0 I}{2\pi r}\left(\frac{2r^2 + a^2}{4r^2 - a^2}\right)$ to the right
   3) $\frac{\mu_0 I}{\pi r}\left(\frac{2r^2 + a^2}{2r^2 - a^2}\right)$ to the left
   4) $\frac{\mu_0 I}{2\pi}\left(\frac{r^2 + a^2}{r^2 - a^2}\right)$ to the right

3. In the above problem find the magnitude and direction of magnetic field at P_2

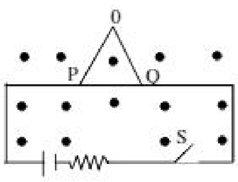
   1) $\frac{\mu_0 I}{\pi r}\frac{(2r^2 - a^2)}{r^2 + a^2}$ towards the top of the page
   2) $\frac{\mu_0 I}{\pi r}\left(\frac{2r^2 + a^2}{4r^2 + a^2}\right)$ towards the top of the page
   3) $\frac{\mu_0 I}{4\pi r}\frac{(r^2 - a^2)}{(r^2 + a^2)}$ towards the top of the page
   4) $\frac{2\mu_0 I}{\pi r^2}\frac{(r^2 + a^2)}{(4r^2 - a^2)}$ towards the top of the page

4. A thin wire is bent inthe form of a semi circular ring of radius R =0.9m carries a current I=1amp. The magnetic induction at a point P as shown in the fig. is given by n × 10^{-7} Tesla. Find the value of n.$[ln(\sqrt{2}+1) = 0.9]$.

   1) 2
   2) 1
   3) 8
   4) 9

5. Figure shows a rod PQ of length 20.0 cm and mass 200 g suspended through a fixed point O by two threads of lengths 20.0 cm each. A magnetic field of strength 0.500T exists in the vicinity of the wire PQ as shown in the figure. The wires connecting PQ with the battery are loose and exert no force on PQ. A current of 2.0 A is established when the switch S is closed. Find the tension in the threads now.

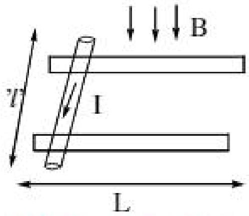
   

   1) 1.25 N
   2) 4.21 N
   3) 2.92 N
   4) 6.23 N

6. A current I flows in a long single -layer solenoid with cross-sectional radius R. The number of turns per unit length of the solenoid equals n. Find the limiting current at which the winding may rupture if the tensile strength of the wire is equal to $F_{\lim}$

1) $I_{\lim} = \sqrt{3F_{\lim}/\mu_0 nR}$
2) $I_{\lim} = \sqrt{F_{\lim}/\mu_0 nR}$
3) $I_{\lim} = \sqrt{4F_{\lim}/\mu_0 nR}$
4) $I_{\lim} = \sqrt{2F_{\lim}/\mu_0 nR}$

7. A rod of mass m and radius R rests on two parellel rails that are 'l' distance apart & have a length 'L'. The rod carries a current I & rolls along the rails without slipping. A uniform magnetic field B is directed perpendicular to the rod & the rails. If it starts from rest, what is the speed of rod as it leaves the rails



1) $\vartheta = \sqrt{\frac{BIL l}{3m}}$
2) $\vartheta = \sqrt{\frac{4BIL}{3m}}$
3) $\vartheta = \sqrt{\frac{4BIlL}{3m}}$
4) $\vartheta = \sqrt{\frac{4BIlL}{m}}$

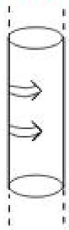
8. Two concentric coils X and Y of radii 16 cm and 10 cm lie in the same vertical plane containing N-S direction. X has 20 turns and carries 16 A. Y has 25 turns & carries 18A. X has current in anticlockwise direction and Y has current in clockwise direction for an observer, looking at the coils facing the west. The magnitude of net magnetic field at their common centre is

1) $5\pi \times 10^{-4}$ T towards west
2) $13\pi \times 10^{-4}$ T towards east
3) $13\pi \times 10^{-4}$ T towards west
4) $5\pi \times 10^{-4}$ T towards east

9. A uniform current of density j flows inside an infinite plate of thickness 2d parallel to its surface. Find the magnetic induction induced by this current as a function of the distance x from the median plane of the plate. The magnetic permea-bility is assumed to be equal to unity both inside and outside the plate.

1) $\mu_0 jx$ inside the plate, $\mu_0 jd$ outside the plate
2) $\mu_0 x$ inside the plate, $\mu_0 jd$ outside the plate
3) $\mu_0 jx$ outside the plate, $\mu_0 jd$ inside the plate
4) $\mu_0 j$ inside the plate, $\mu_0 d$ outside the plate

10. A hollow cylinder having infinite length and carrying uniform current per unit length λ along the circumference as shown. Magnetic field inside the cylinder is

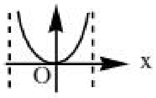


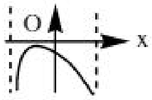
1) $\frac{\mu_0\lambda}{2}$
2) $\mu_0\lambda$
3) $2\mu_0\lambda$
4) $3\mu_0\lambda$

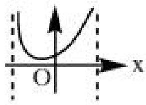
11. A direct current of density j flows along a round uniform straight wire with cross-section radius R. Find the magnetic induction vector of this current at the point whose position relative to the axis of the wire is defined by a radius vector r. The magnetic permeability is assumed to be equal to unity throughout all the space.

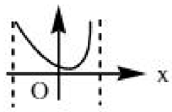
1) $\frac{1}{2}\mu_0(jr)$ for $r \ge R$; $\frac{1}{3}\mu_0(jr)\frac{R^2}{r^2}$ for $r \le R$
2) $\mu_0(jr)$ for $R \le r$; $\mu_0(jr)R^2$ for $R \ge r$
3) $\frac{1}{2}\mu_0(jr)$ for $r \le R$; $\frac{\mu_0 jR^2}{2r}$ for $r \ge R$
4) $\mu_0(jr)\frac{R^2}{r}$ for $r \ge R$; $\frac{1}{2}\mu_0\frac{R^2}{r^2}$ for $r > R$

12. Two very long straight parallel wires, parallel to y-axis, carry currents 4I and I, along +y direction and –y direction, respectively. The wires pass through the x-axis at the points (d, 0, 0) and (– d, 0, 0) respectively. The graph of magnetic field z-component as one moves along the x-axis from $x = -$ d to $x = +$d, is best given by

1) 

2) 

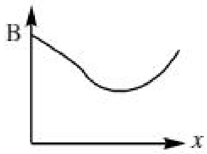
3) 

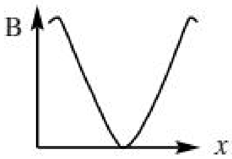
4) 

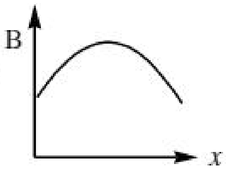
13. The magnetic field at the centre of a circular loop of area A is B. The magnetic moment of the loop will be

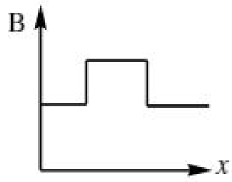
1) $\frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$ 2) $\frac{BA}{\mu_0}\sqrt{\frac{A}{\pi}}$ 3) $\frac{BA}{\mu_0}\sqrt{A}$ 4) $\frac{BA^2}{\mu_0 \pi}$

14. The magnetic field intensity variation for a finite solenoid along its length (from one end to another end) can be best represented by the graph:

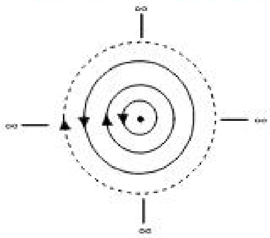
1) 

2) 

3) 

4) 

15. In figure, infinite number of concentric conducting rings each having current i in the direction shown are in the same plane as shown in figure. The radii of rings are $r, 2r$, 2^2r, 2^3r ....∞ . The magnetic filed at the centre of rings will be



1) zero

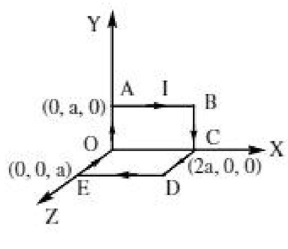
2) $\frac{\mu_0 i}{r}$

3) $\frac{\mu_0 i}{2r}$ 4) $\frac{\mu_0 i}{3r}$

16. A long cylindrical wire of radius 'a' carries a current i distributed uniformly over its cross section. If the magnetic fields at distance $r < a$ and $R > a$ from the axis have equal magnitude, then

1) $a = \frac{R+r}{2}$ 2) $a = \sqrt{Rr}$ 3) a = Rr/R+r 4) a = R^2/r

17 For loop OABCDEO carrying current I, the magnetic field at point P(a, 0, 0) will be



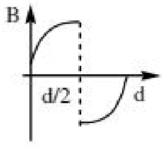
1) $\frac{\mu_o I}{\sqrt{2}\pi a}\left[-\hat{k}-\hat{j}\right]$

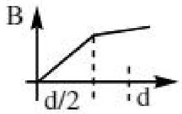
2) $\frac{\mu_o I\sqrt{2}}{\pi a}\left[-\hat{k}-\hat{j}\right]$

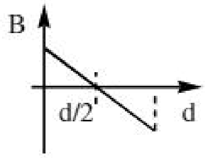
3) $\frac{\mu_o I}{\pi a}\left[-\hat{k}-\hat{j}\right]$

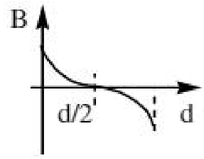
4) $\frac{\mu_o I}{2\pi a}\left[-\hat{k}-\hat{j}\right]$

18. A uniform beam of positively charged particles is moving with a constant velocity parallel to another beam of negatively charged particles moving with the same velocity in opposite direction seperated by a distance d. The variation of magnetic field B along a perpendicular line drawn between the two beams is best represented by

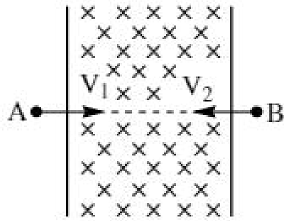
1) 

2) 

3) 

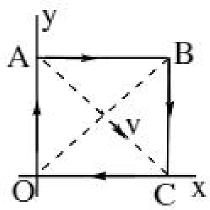
4) 

19. Two particles A and B of same mass and having charges of same magnitude but of opposite nature are thrown into a region of magnetic field (as shown) with speeds v_1 and v_2 ($v_1 > v_2$). At the time particle A escapes out of the magnetic field, angular momentum of particle B w.r.t. particle A is proportional to (assume both the particles escape the region after traversing half circle) (c)



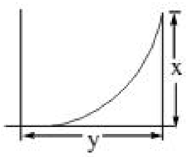
1) $v_1 + v_2$ 2) $v_1 - v_2$ 3) $v_1^2 - v_2^2$ 4) $v_1^2 + v_2^2$

20. OABC is a current carrying square loop an electron is projected from the centre of loop along its diagonal AC as shown. Unit vector in the direction of initial acceleration will be



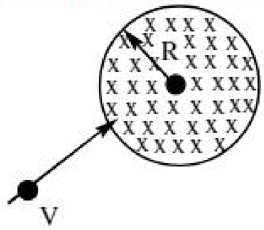
1) $\hat{k}$ 2) $-\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$ 3) $-\hat{k}$ 4) $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

21. A particle having charge q enters a region of uniform magnetic field $\vec{B}$ (directed inwards) and is deflected a distance x after traveling a distance y. The magnitude of the momentum of the particle is:



1) $\frac{qBy}{2}$ 2) $\frac{qBy}{x}$ 3) $\frac{qB}{2}\left(\frac{y^2}{x}+x\right)$ 4) $\frac{qBy^2}{2x}$

22. A particle of mass m having a charge q enters into a circular region of radius R with velocity v directed towards the centre. The strength of magnetic field is B. Find the deviation in the path of the particle



1) $\pi + 2\text{Tan}^{-1}\left(\frac{mv}{BqR}\right)$ 2) $\pi + \text{Tan}^{-1}\left(\frac{mv}{BqR^2}\right)$

3) $\pi - 2\text{Tan}^{-1}\left(\frac{mv}{qBR}\right)$ 4) $\pi - \text{Tan}^{-1}\left(\frac{mv}{Bq\,R/2}\right)$

23. A particle of specific charge $\frac{q}{m} = +\pi\frac{C}{Kg}$ is projected from the origin towards positive x-axis with a velocity of 10m/s in a uniform magnetic field $\vec{B} = -2\hat{k}T$. The velocity $\vec{V}$ of the particle after time $t = \frac{1}{6}$ s will be

1) $\left(5\hat{i} + 5\sqrt{3}\hat{j}\right)m/s$ 2) $10\hat{j}\ m/s$ 3) $\left(5\sqrt{3}\hat{i} - 5\hat{j}\right)m/s$ 4) $-10\hat{j}\ m/s$

24. A charged particle enters a uniform magnetic field with velocity vector at an angle 45^0 with the magnetic field. The pitch of the helical path followed by the particle is 'P', the radius of helix is ..

1) $\frac{P}{\sqrt{2\pi}}$ 2) $\sqrt{2P}$ 3) $\frac{P}{2\pi}$ 4) $\frac{\sqrt{2}P}{\pi}$

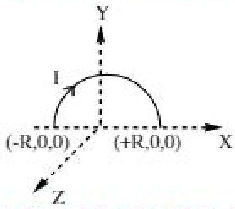
25. A semi circular current carrying wire having radius R is placed in x-y plane with its centre at origin 'O'. There is non-uniform magnetic field $\vec{B} = \frac{B_0 x}{2R}\hat{k}$ (here B_o is +ve constant) is existing in the region. The magnetic force acting on semi circular wire will be along

1) – x-axis

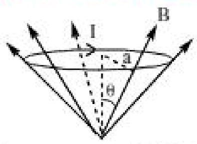
2) + y-axis

3) – y-axis

4) + x-axis

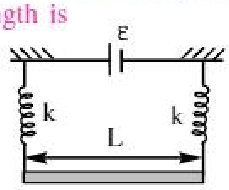


26. A circular current loop of radius a is placed in a radial field B as shown. The net force acting on the loop is



1) zero 2) $2\pi BaI\cos\theta$ 3) $2\pi BaI\sin\theta$ 4) None

27. A straight rod of mass m and length L is suspended from the identical spring as shown in the figure. The spring stretched by a distance of x_0 due to the weight of the wire. The circuit has total resistance $R\Omega$. When the magnetic field perpendicular to the plane of the paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is

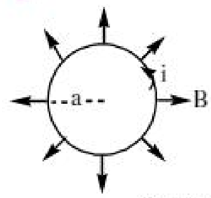


1) $\frac{mgR}{\varepsilon\ L}$; directed outward from the plane of the paper

2) $\frac{mgR}{2\ \varepsilon\ x_0}$; directed outward from the plane of the paper

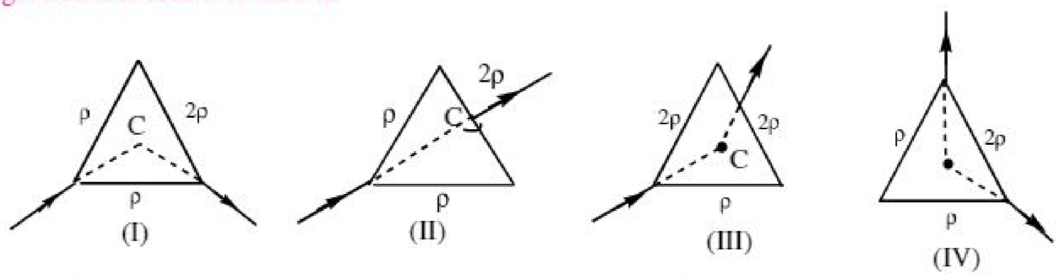
3) $\frac{mgR}{\varepsilon\ L}$; directed into the plane of the paper 4) $\frac{mgR}{\varepsilon\ x_0}$; directed into the plane of the paper

28. A circular loop of radius a, carrying a current i, is placed in a two-dimensional magnetic field. The centre of the loop coincides with the centre of the field (fig). The strength of the magnetic field at the periphery of the loop is B. Find the magnetic force on the wire.



1) $4\pi a^2 iB$ 2) $2\pi aiB$ 3) πaiB 4) $6\pi aiB$

29. Wire frames having a shape of equilateral triangles are made as shown (resistivities are shown in figure). All the wire frames have uniform and same cross section then magnetic field intensity at geometrical centre is zero in

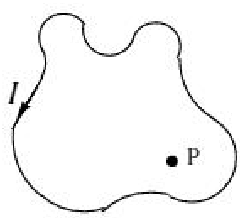


1) 'I' only 2) 'I','II' and 'IV' situations
3) 'II' and 'III' situations 4) all the situations

30. The space has electromagnetic field which is given as $\vec{B} = -B_0\hat{k}$ and $\vec{E} = E_0\hat{k}$. A charged particle having mass m and positive charge q is given velocity $v_0\hat{i}$ at origin at t = 0 sec. The z-coordinate of the particle when it passes through the z-axis is (neglect gravity through motion)

1) $\dfrac{2\pi^2 mE_0}{qB_0^2}$ 2) $\dfrac{4\pi^2 mE_0}{qB_0^2}$ 3) $\dfrac{mE_0}{qB_0^2}$ 4) $\dfrac{-4\pi^2 mE_0}{qB_0^2}$

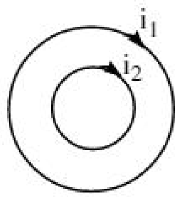
31. In the diagram shown, an irregular loop of the wire carrying a current lies in the plane of the paper here. Now, the loop is distorted into some other shape while remaining in the same plane. Point P is still within the loop. Which of the following is/are true?



1) The magnetic field at point P may be zero
2) The magnetic field at point P will not change in magnitude when the loop is distorted.
3) The magnetic field at 'P' will not change in direction when the loop is distorted (but kept in same plane).
4) None of the above is true.

32. Two concentric circular coils of radius R and r (r<<R) carry currents of i_1 and i_2 respectively. If the smaller coil of known mass is rotated slightly about one of its diameter. It starts oscillating. Then which of the following statements is/are correct. (assume that the currents in the coils are steady)

1) The oscillations are approximately simple harmonic in nature
2) The frequency of oscillations is proportional to product $i_1 i_2$
3) The frequency of oscillations is proportional to square root of R
4) The frequency of oscillations is proportional to radius r



LEVEL-II

LECTURE SHEET (ADVANCED)

Straight Objective Type Questions

1. Which of the following statements are incorrect ?

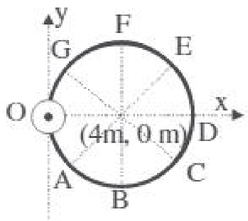
a) Field inside an infinitely long solenoid depends on the length of solenoid.

b) Field inside a long cylindrical conductor carrying uniformly distributed current, parallel to the axis is proportional to r (radial distance)

c) Field inside a long pipe carrying current parallel to its length is zero.

d) Field out side a long current carrying wire is proportional to $\left(\frac{1}{r^2}\right)$

2. An infinite uniform current carrying wire is kept along z-axis, carrying current I_0 in the direction of the positive z-axis. OABCDEFG represents a circle (where all the points are equally spaced), whose centre at point (4m, 0m) and radius 4 m as shown in the figure. If $\int_{DEF} \vec{B}.\vec{d}\ell = \frac{\mu_0 I_0}{k}$ in S.I. unit, then the value of k is



a) 4 b) 8 c) 3 d) 6

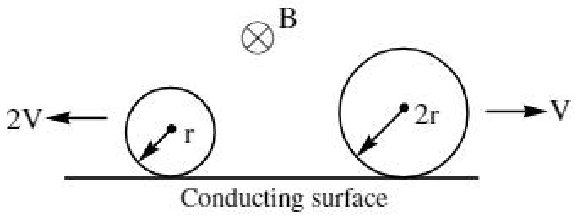
3. A circular coil of radius R and a current I, which can rotate about a fixed axis passing through its diameter is initially placed such that its plane lies along magnetic field B. Kinetic energy of loop when it rotates through an angle 90^0 is : (assume that I remains constant)(Assume axis is perpendicular to B)

a) $\pi R^2 BI$ b) $\frac{\pi R^2 BI}{2}$ c) $2\pi R^2 BI$ d) $\frac{3}{2}\pi R^2 I$

4. A charged particle is fired at an angle θ to a uniform magnetic field directed along the X-axis. During its motion, the pitch of the helical path is equal to the maximum distance of the particle from the X-axis, then

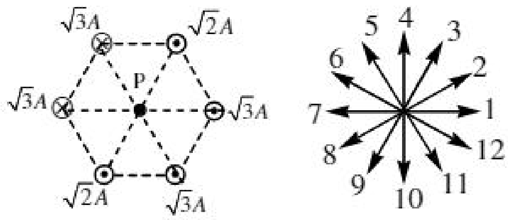
a) $\cos\theta = \frac{1}{\pi}$ b) $\sin\theta = \frac{1}{\pi}$ c) $\tan\theta = \frac{1}{\pi}$ d) $\tan\theta = \pi$

5. Two conducting rings of radii r and 2r move in opposite directions with velocities 2V and V respectively on a conducting surface. There is a uniform magnetic field of magnitude B perpendicular to the plane of the rings. The potential difference between the highest points of the two rings is



a) zero b) 2rVB c) 4rVB d) 8rVB

6. Consider a set of six infinite long straight parallel wires arranged perpendicular to the plane of paper in a hexagon as shown. The length of the each side of the hexagon is 3cm.What is the magnitude and direction of the magnetic field at point P? (Twelve direction at consecutive equal angles have been shown, give your answer in forms of their respective numbers)



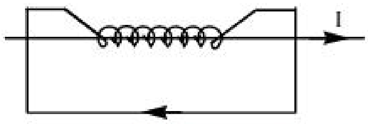
a) 70×10^{-6} T along 12

b) 40×10^{-6} T along 6

c) 40×10^{-6} T along 9

d) 60×10^{-6} T along 9

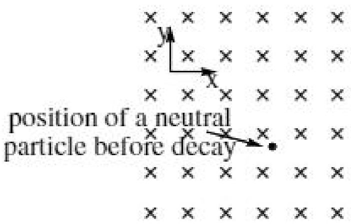
7. In the diagram shown, a wire carries current I. What is the value of the $\oint \vec{B}.\vec{dl}$ (as in Ampere's law) on the helical loop shown in the figure? The integration in done in the sense shown. The loop has N turns and part of helical loop on which arrows are drawn is outside the plane of paper.



a) $-\mu_0(NI)$ b) $\mu_0(I)$

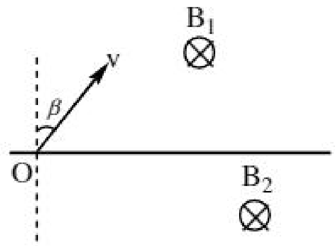
c) $\mu_0(NI)$ d) $\frac{\mu_0 I}{N}$

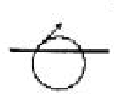
8. A neutral particle is initially at rest in a uniform magnetic field B as shown in the diagram. The particle then spontaneously decays into two fragments, one with a positive charge +q and mass 3m and the other with a negative charge –q and mass m. Neglecting the interaction between the two charged particles and assuming that the speeds are much less than speed of light, the time after the decay at which the two fragments first meet is [Data : q = 1μC, B = $2\pi\mu$T, m = 10^{-5}kg Both the charges have initial velocities in x-y plane]



a) 250 μS b) 500 μS c) 750 μS d) 1000 μS

9. In the diagram shown, a particle of charge +Q and mass M is projected making an angle β with the vertical line. Draw the possible path on which the charge will move. Above the dark line magnetic field is B_1 and below it is B_2. (Consider all possible cases for values of and)

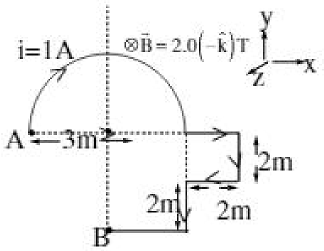


a)  b)  c)  d) 

10. A galvanometer is connected in series with a wire 'AB' through which a current 'I_0' is flowing. When this galvanometer is shunted with a 4Ω resistance, the deflection is reduced to one-fifth. If the galvanometer is further shunted with a 2Ω wire, current flowing in galvanometer is (given main current (I_0) remains same)

a) $I_0/13$ b) $I_0/5$ c) $I_0/8$ d) $5I_0/13$

11. A current carrying wire AB having current i = 1 A is placed in a perpendicular magnetic field $\vec{B} = 2.0(-\hat{k})T$ as shown in figure. The magnitude of force on wire is



a) 8 N b) 6 N c) 10 N d) 12 N

12. A long, straight wire of raidus r carries a current i and is placed horizontally in a uniform magnetic field B pointing vertically upward. The current is uniformly distributed over its cross-section. At what points will the resultant magnetic field have maximum magnitude ? What will be the maximum magnitude ?

a) looking along the current, at the left most points on the wire's surface, $B+\frac{\mu_0 i}{2\pi r}$

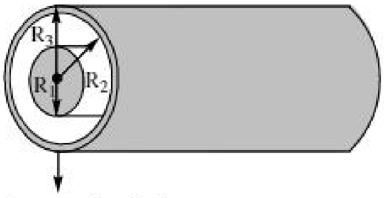
b) looking along the current at the right most points on the wires surface, $B-\frac{\mu_0 i}{2\pi r}$

c) looking along the current of the left most points inside the wire's, $B+\frac{\mu_0 i}{\pi r}$

d) looking along the current at the right most points inside the wire's, $B-\frac{\mu_0 i}{4\pi r}$

More than One correct answer Type Questions

13. A solid cylindrical conductor of radius R_1 is kept inside a hollow cylindrical conductor of inner radius R_2 and outer radius $R_3(R_1 < R_2 < R_3)$ in a co–axial manner, as shown. The solid cylinder carries a current I_1 and the hollow conductor carries current I_2 in the opposite directions. The two conductors are kept insulated from each other and current through each is distributed uniformly over the cross–section. Let r be any radial distance from the axis.



Cross-sectional view

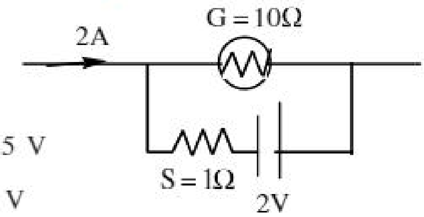
a) Magnitude of magnetic induction B at points inside the solid conductor, so that $r < R_1$, can be zero.

b) Magnitude of magnetic induction B at points inside the solid conductor, so that $r < R_1$, can be $\frac{\mu_0 I_1}{2\pi R_1^2} r$

c) Magnitude of magnetic induction B at points outside the solid conductorsuch that $R_1 < r < R_2$ will be $\frac{\mu_0 (I_1 - I_2)}{2\pi r}$

d) For $R_2 < r < R_3$ magnitude of B can be expressed as $\frac{\mu_0}{2\pi r}\left[I_1 - \frac{I_2(r^2 - R_2^2)}{(R_3^2 - R_2^2)}\right]$

14. The galvanometer shown in the figure has resistance 10Ω . It is shunted by a series combination of a resistance $S = 1\Omega$ and an ideal cell of emf 2V. A current 2A passes as shown.



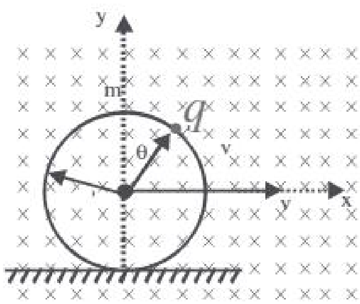
a) The reading of the galvanometer is 1A

b) The reading of the galvanometer is zero

c) The potential difference across the resistance S is 1.5 V

d) The potential difference across the resistance S is 2 V

15. A ring of mass m and radius R is set into pure rolling on horizontal rough surface, in a uniform magnetic field of strength B – as shown in the figure. A point charge q of negligible mass is attached to rolling ring. Friction is sufficient so that it does not slip at any point of this motion. (θ is measured in clockwise from positive y –axis)



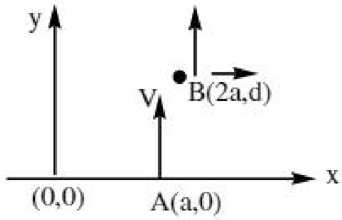
a) Ring will continue to move with constant velocity

b) The value of friction acting on ring is Bqv $\cos\theta$

c) The value of friction acting on ring is Bqv $\sin\theta$

d) Ring will lose contact with ground if v is greater than $\left(\frac{mg}{2qB}\right)$

16. A uniform electric field of strength E exists in a region x=a to x=2a. An electron (charge –e, mass m) enters a points A perpendicularly with velocity v. It moves through the electric field & exits at point B. Then (assume y component of velocity doesn't change):



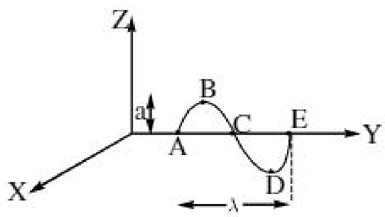
a) $E=-\frac{2amv^2}{ed^2}\hat{i}$

b) Rate of work done by the electric field at B is $\frac{4ma^2v^3}{d^3}$

c) Rate of work by the electric field at A is zero

d) Velocity at B is $\frac{2av}{d}\hat{i}+v\hat{j}$

17. The conductor ABCDE has the shape shown. It lies in the YZ plane, with A and E on the Y-axis. When it moves with a velocity V in uniform magnetic field B, an emf e is induced between A and E.



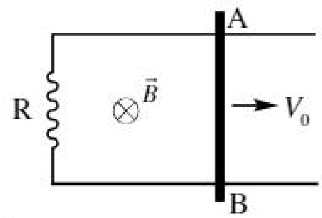
a) e=0, if V is in the Y-direction and B is in x- direction.

b) e=2 Bav, if V is in the Y-direction and B is in the x-direction

c) e= BλV, if V is in the z-direction and B is in the x-direction

d) e=BλV, if V is in the x-direction and B is in the Z-direction

18. A conducting rod AB of mass m slides without friction over two long conducting horizontal rails separated by a distance l. At the left the rails are inter connected by a resistor R. The system is located in uniform magnetic field perpendicular to the plane of the loop. At the moment t=0, the rod AB starts moving to the right with an initial velocity V_0. Neglect resistance of rails and self induction of the circuit.



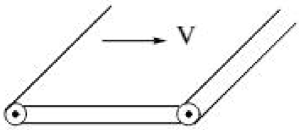
a) The rod covers a distance $\frac{mRV_0}{2B^2l^2}$ before stopping.

b) The rod covers a distance $\frac{mRV_0}{B^2l^2}$ before stopping.

c) The heat liberated in the resistor during motion of the rod is $\frac{1}{2}mv_0^2$.

d) The heat liberated in the resistor during motion of the rod is $\frac{1}{4}mv_0^2$

19. Charge is sprayed onto a large non conducting belt above the left hand roller. The belt carries charge with a uniform surface charge density σ, as it moves with a speed v between the rollers as shown. The charge is removed by a wiper at right hand roller. For a point just above the sheet mark the correct option.



a) magnetic field is $\frac{\mu_0 \sigma v}{2}$, out of the plane of the page, parallel to axis of roller.

b) magnetic field is $\mu_0 \sigma$, out of the plane of the page, perpendicular to axis

c) electric field is $\frac{\epsilon_0 \sigma}{2}$ perpendicular to the plane of sheet

d) If an electron moves parallel to V just above the sheet it will experience an upward magnetic force.

20. A straight conductor carries a steady current. Assume in it all free electrons in the conductor move with same drift velocity V. A and B are two observers in a straight line XY parallel to the conductor. A is stationary, B moves along XY with a velocity V in the direction of free electrons

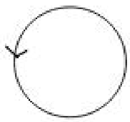
a) A and B observe the same magnetic field

b) A observe magnetic field, B does not

c) A and B observe magnetic fields of the same magnitude but opposite directions

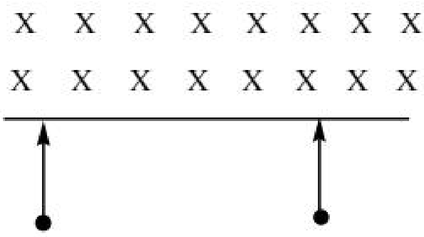
d) A and B do not observe any electric field

21. A field line is shown in the figure. This field line cannot represent



a) Magneto static field
b) Electrostatic field
c) Induced electric field
d) Gravitational field

22. An electron and a proton are moving on straight parallel paths with same velocity. They enter a semi-infinite region of uniform magnetic field perpendicular to the velocity and diverge. Which of the following statement(s) is/are true (neglecting force of interaction between electron and proton and the semi infinite region is bound only on the entry side)



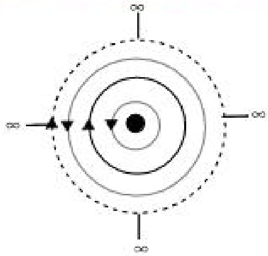
a) They will never come out of the magnetic field region

b) They will come out travelling along parallel paths

c) They will come out at the same time

d) They will come out at different times

23. In figure, infinite conducting rings each having current i in the direction shown are placed concentrically in the same plane as shown in the figure. The radius of rings are r, 2r, 2^2r, 2^3r ...∞. The magnetic field at the centre of rings will be



a) zero b) $\frac{\mu_0 i}{r}$

c) $\frac{\mu_0 i}{2r}$ d) $\frac{\mu_0 i}{3r}$

24. Identify the correct Statements :

a) The magnetic field at the ends of a very long current carrying solenoid is half of that at the center.

b) Ampere's Law is applicable for steady currents only.

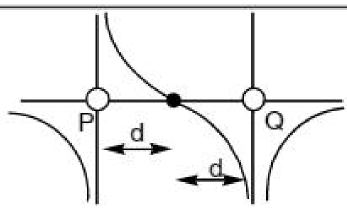
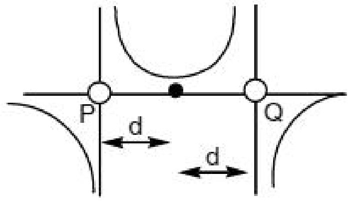
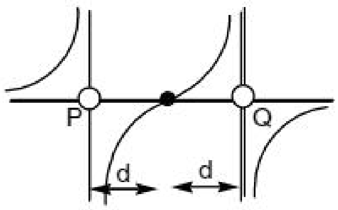
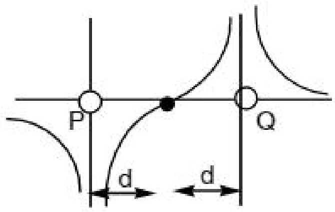
c) Magnetic field due to a current carrying wire is directly proportional to the current.

d) If the solenoid is sufficiently long, the field within it is uniform.

Linked Comprehension Type Questions

Passage - I :

P and Q are two infinite long current carrying conductors separated at some distance as described in column –I, the corresponding variation of magnetic fiedl with distance from the conductors is as shown Column – II. Match the correct situation of Column – I with Column – II and III.

Column – I	Column – II	Column – III
(P) P and Q are carrying current in same directions into the plane of paper		(A) $B \neq 0$ midway between them for $d_P = d_Q$ from the point.
(Q) Current in conductor P is inwards and Q is outwards		(B) B= 0 at in midway between two conductors For $i_P = i_Q$.
(R) P and Q are carrying currents in same direction out ward from plane of paper		(C) B is min at least of two point o the line joining conductors. (excluding at infinity)
(S) P and Q are carrying currents in opp directions out ward from plane of paper		(D) B is minimum between them as $i_P = i_Q$

25. Which of the following is correct match

a) R, 2, D b) S, 4, C c) R, 1, B d) Q, 3, A

26. Which of the following is correct match

a) R, 4, A b) S, 2, A c) P, 3, C d) Q, 1, C

27. Which of the following is correct match

a) R, 1, D b) Q, 4, A c) Q, 2, D d) P, 3, B

Passage - II :

A charged particle of mass m and charge q is projected on a rough horizontal XY plane. Both electric and magnetic fields are given by $\vec{E} = -10\vec{k}N/C$ and magnetic field $\vec{B} = -5\vec{k}$ tesla are present in the region. The particle enters into the magnetic field at (4,0,0)m with a velocity $50\vec{j}\ m/\sec$. The particle starts into a curved path on the plane. If coefficient of fricition $\mu = \frac{1}{3}$ between particle and plane, then ($qE = 2mg$, $g = 10m/s^2$).

Radius of curvature of the path followed by particle, intially is

28. Radius of curvature of the path followed by particle, initially is

a) 5m b) 2.5m c) 1.25m d) 10m

29. The time after which particle comes to rest, is

a) 5s b) 4s c) 3s d) 1s

30. Total work done by electric force on the particle is

a) 250 J b) zero c) 125 J d) none

Passage III:

A particle of charge q and mass m moving on x – y plane under the influence of uniform electric field $E\hat{i}$ and a magnetic field $B\hat{k}$ enters in the 1[st] quadrant of a coordinate system at a point (0,a) with initial velocity $V\hat{i}$ and leaves the quadrant at a point (2a,0) with velocity $-2v\hat{j}$.

31. Magnitude of Electric field is

a) $\frac{mv^2}{qa}$ b) $\frac{3mv^2}{4qa}$ c) $\frac{4mv^2}{3qa}$ d) $\frac{2mv^2}{3qa}$

32. Rate of work done by electric field at point (0,a) is

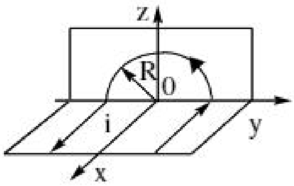
a) $\frac{3mv^3}{4a}$ b) $\frac{mv^3}{a}$ c) $\frac{4mv^3}{3a}$ d) $\frac{2mv^3}{3a}$

33. Rate of work done by both fields at $(2a,0)$

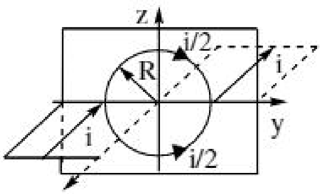
a) $\frac{3mv^2}{4a}$ b) $\frac{mv^3}{a}$ c) $\frac{4mv^3}{3a}$ d) Zero

Matrix Matching Type Questions

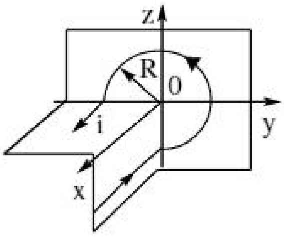
34. **COLUMN - I** **COLUMN - II**

1) 

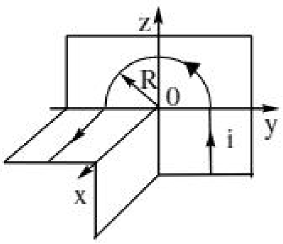
p) x

2) 

q) y

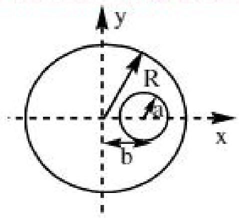
3) 

r) z

4) 

s) none

35. Match the following :A very long straight conductor has a circular cross-section of radius R . Inside the conductor there is a cylindrical hole of radius a whose axis is parallel to the axis of the conductor and at a distance b from it, as shown in the diagram .The conductor with hole carries current i. Let the z-axis be the axis of conductor and the axis of the hole at x = b , Match the following column.

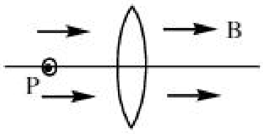


COLUMN - I	COLUMN - II
A) Magnitude of magnetic field at point P(2R, 0)	p) Zero
B) X-component of magnetic field at point P(0, 0)	q) $\frac{\mu_0 i}{2\pi b}\left(\frac{a^2}{R^2-a^2}\right)$
C) Magnitude of magnetic field at point P(0, 0)	r) $\frac{\mu_0 i}{2\pi(R^2-a^2)}\left(\frac{a^2}{2R-b}-\frac{R}{2}\right)$
D) Magnitude of magnetic field at point P(b, 0)	s) $\frac{\mu_0 ib}{2\pi(R^2-a^2)}$

Integer Type Questions

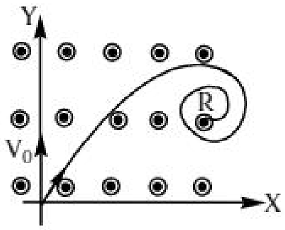
36. A current I flows along the length of a thin walled, long metallic hollow cylinder of radius R, distributed uniformly on its surface. If the pressure on the wall is $P=\left(\frac{\mu_0 I^2}{\pi^2 R^2}\right)\times\left(\frac{1}{x}\right)$. Find the value of x.

37. Figure shows a convex of focal length 12 cm lying a uniform magnetic field B of magnitude 1.2 T parallel to its principal axis. A particle having a charge 2.0×10^{-3}C and mass 2.0×10^{-5} kg is projected perpendicular to the plane of the diagram with a speed of 4.8 m/s. The particle moves along a circle with its centre on the principal axis at a distance of 18 cm from the lens find the radius of circle traced by its image is ___cm.

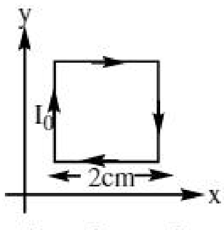


38. Two parallel infinitely long wires carrying equal currents in opposite directions so that repulsive force per unit length on wires is 0.1 N. The separation between the wires is 2m. If magnetic field exactly midway between the wires and in the plane of the wires is $k\times10^{-4}T$. Then, the value of k is

39. A particle having mass m, charge q is projected with velocity v_0 along y-axis in a region of uniform magnetic field B_0 which is outward and perpendicular to the plane of the paper as shown in the figure. The particle is continuously subjected to a frictional force which varies with velocity as $\vec{F}_r=-\alpha\vec{V}$, where α is a constant. Consequently the particle moves on a spiral path till it comes to rest at point P. If total distance travelled by the particle is $(10x)$ m, find x.
(Take $\alpha=10^{-3}\,kg/s; q=10^{-3}C; B_0=1T, v_0=1m/s, m=20gm$)



40. A square loop of side 2 cm carrying current I_0 is placed in x-y plane in a magnetic field $B=(4\hat{i}+3\hat{j})T$. If the unit vector along the axis about which it will start rotating is $\frac{a\hat{i}+b\hat{j}}{5}$, find (a – b)



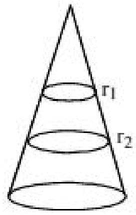
41. A proton beam passes without deviation through a region of space where there are uniform transverse mutually perpendicular electric and magnetic fields with $E=120\frac{kV}{m}$ and $B=50\,mT$. Then, the beam strikes a grounded target. The force imparted by the beam on the target if the beam current is equal to I = 0.80 mA is $x\times10^{-5}$ N. Find x (nearest integer)

42. The current density $\vec{J}$ inside a long, solid, cylindrical wire of radius a = 12 mm is in the direction of the central axis, and its magnitude varies linearly with radial distance r from the axis according to $J = \frac{J_0 r}{a}$ where $J_0 = \frac{10^5}{4\pi} A/m^2$. The magnitude of the magnetic field at $r = \frac{a}{2}$ in μT is $2x$. find x.

PRACTICE SHEET (ADVANCED)

Straight Objective Type Questions

1. Two current carrying circular wires wrapped over a non conducting conical frame form the loops 1 and 2 of radius r_1 and r_2 respectively. If they produce no net magnetic field at the apex P, the value $\frac{i_1}{i_2} =$



a) $\sqrt{\frac{r_2}{r_1}}$ b) $\frac{r_1}{r_2}$

c) $\left(\frac{r_1}{r_2}\right)^2$ d) 1

2. A direct current is passing through a wire of a given length. It is bent to form a coil of one turn. Now it is further bent to form a coil of two turns but of smaller radius. The ratio of the magnetic induction at the centre of the coil of two turns and at the centre of the coil of one turn is:

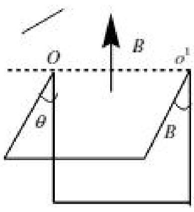
a) 1 : 8 b) 8 : 1 c) 4 : 1 d) 1 : 1

3. A particle is moving with velocity $\vec{v} = \hat{i} + 3\hat{j}$ and it produces an electric field at a point given by $\vec{E} = 2\hat{k}$. It produces a magnetic field at that point equal to (all quantities are in S.I. units)

a) $\frac{6\hat{i} - 2\hat{j}}{c^2}$ b) $\frac{6\hat{i} + 2\hat{j}}{c^2}$ c) zero

d) Cannot be determined from the given data

4. A wire of cross section area A forms three sides of a square and is free to rotate about OO'. If the structure is deflected by and angle 'θ' from the vertical when current i is passed through it in a magnetic field B acting vertically upwards and density of the wire is e then the value of θ is



a) $\frac{2Aeg}{iB} = \cot\theta$ b) $\frac{2Aeg}{iB} = \tan\theta$ c) $\frac{2Aeg}{iB} = \sin\theta$ d) $\frac{Aeg}{iB} = \cos\theta$

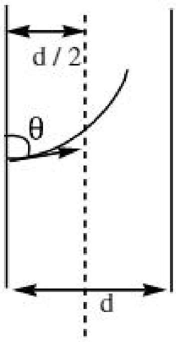
5. An infinite current carrying wire is placed along x-axis such that it lies between x = 0 to $x \to +\infty$ (infinity). The current is in direction of positive x-axis. Let B_1, B_2 and B_3 be the magnitude of magnetic field at points A(a, a), B(0, a) and C(–a, a) respectively. Then pick the incorrect option.

a) $B_1 > B_2 > B_3$
b) $B_1 : B_2 : B_3 = \sqrt{2}+1 : 1 : \sqrt{2}-1$
c) $B_2 = \dfrac{B_1 + B_3}{2}$
d) $\dfrac{B_1 B_3}{B_2^2} = \dfrac{1}{2}$

6. A very long straight conducting wire, lying along the Z axis carries a current of 2A. The integral $\int \vec{B}.d\vec{l}$ is computed along the straight line PQ where P has the co-ordinates (2cm, 0, 0) and Q has the co-ordinates (2cm, 2cm, 0). The integral has the magnitude (in SI units)

a) Zero b) $8\pi \times 10^{-7}$ c) $2\pi \times 10^{-7}$ d) $\pi \times 10^{-7}$

7. A charged particle of mass m and charge q enters a uniform magnetic field B with a velocity v making an angle $\theta (\neq 0^0, \neq 90^0)$ with the boundary of the field as shown in figure. The width of the magnetic field is 'd' when the particle penetrates half way into the field, the change in the kinetic energy of the particle is

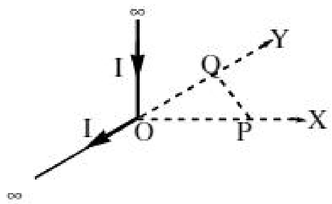


a) $\dfrac{mv^2}{2B}\sin\theta$ b) $\dfrac{Bqd}{mv^2}\sin\theta$ c) zero d) $vdqB\sin\theta$

8. A long cylindrical wire of radius 'a' carries a current 'i' distributed uniformly over its cross section. If the magnetic field at distances r and R from the axis have equal magnitude, then

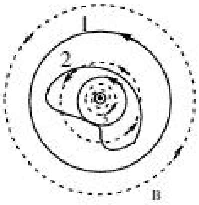
a) $a = \dfrac{R+r}{2}$ b) $a = \sqrt{Rr}$ c) $a = \dfrac{Rr}{R+r}$ d) $a = \dfrac{2Rr}{R+r}$

9. Figures Shows combination of two semi infinite long wires kept on Z and Y-axis. It carries constant current I as shown in figure. Calculate $\int_Q^P \vec{B}.\vec{dl}$ on line QP. Co-ordinate of point P and Q are (a, 0, 0) and (0, a, 0) respectively.



a) $\mu_0 I$ b) $\dfrac{\mu_0 I}{2}$ c) $\dfrac{\mu_0 I}{4}$ d) $\dfrac{\mu_0 I}{8}$

10. Consider three closed loops drawn using solid line in the magnetic field (magnetic field lines are drawn using dotted line) of an infinite current-carrying wire normal to the plane of paper as shown.



If a,b and c represent the values of line integrals of the magnetic field along the paths 1,2 and 3 respectively, then :

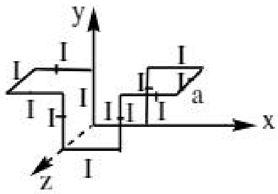
a) $a > b > c$ b) $a = c > b$ c) $a = b = c$ d) $c > b > a$

11. When a thin conducting circular loop of radius (R) is carrying a current I, the tension developed in the loop is T. When a uniform magnetic field of magnitude B is switched on parallel to the axis of the loop, the magnitude of change in tension is ΔT and the net force acting on the loop is F. Then

a) $\Delta T = 0, F = 0$ b) $\Delta T = 2\pi BIR, F = 2BIR$

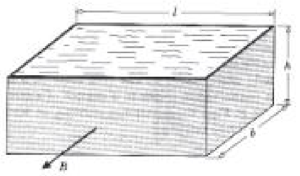
c) $\Delta T = 2BIR, F = 0$ d) $\Delta T = BIR, F = 0$

12. Find the torque acting on the current carrying loop, carrying a current I as shown in the adjacent fig. Given all the sides are of same length 'a' and a uniform magnetic field of $\vec{B} = \hat{i}$ exists in the region.



a) $3a^2I\hat{k}$ b) $a^2I\hat{k}$ c) $2a^2I\hat{j}$ d) zero

13. A conducting fluid of mass density ρ_m and electrical resistivity ρ_e is kept in an insulating vessel of dimensions $l \times b \times h$. The vessel is placed on a horizontal floor where a uniform horizontal magnetic field of induction B is established perpendicular to the face $l \times h$ as shown i the figure. How much potential difference V must be applied on the liquid between the side faces designated by dimensions $b \times h$ so that the fluid pressure at the bottom of the vessel vanishes? The acceleration of free fall is g. (Assume current density through the liquid is uniform and neglect the value of atmospheric pressure)



a) $V = \frac{\rho_m \rho_e g l}{B}$ b) $V = \frac{\rho_m \rho_e g b}{B}$ c) $V = \frac{\rho_m \rho_e g h}{B}$ d) $V = \frac{\rho_m \rho_e g h}{2B}$

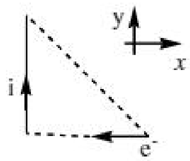
14. A current I flows through a lengthy thin walled tube of radius R having a longitudinal slit of width W. The magnetic field inside the tube at the axis under the condition W<< r is (r = distance of a point in the tube from slit)

a) zero b) $\frac{\mu_0 WI}{2\pi^2R^2r}$ c) $\frac{\mu_0 WI}{4\pi^2Rr}$ d) $\frac{\mu_0 WI}{4\pi^2R^2}$

15. A charged particle is projected in a plane perendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to

a) velocity b) momentum c) kinetic energy d) none of these

16. The direction of magnetic force on the electron as shown in the diagram is along



a) y-axis b) –y-axis c) z-axis d) –z-axis

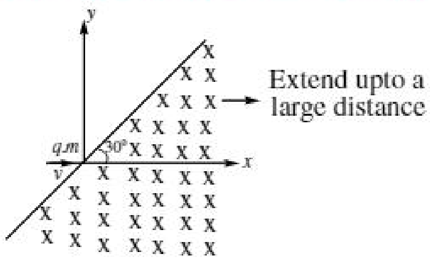
17. A charged particle enters a uniform magnetic field perpendicular to its initial direction travelling in air. The path of the particle is seen to follow the path in figure. Which of statements 1–3 is/are correct?

1) The magnetic field strength may have been increased while the particle was travelling in air
2) The particle lost energy by ionising the air
3) The particle lost charge by ionising the air

a) 1, 2, 3 are correct b) 1, 2 only are correct c) 2, 3 only are correct d) 1 only

More than One correct answer Type Questions

18. Charge particle of charge q and mass m is moving with velocity v as shown in figure in a uniform magnetic field B along –ve z-direction. Select the correct alternative (s) :



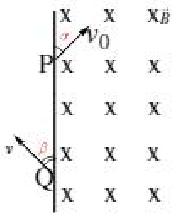
a) Velocity of the particle when it comes out from the magnetic field is $\vec{V} = v\cos60^\circ\hat{i} + v\sin60^\circ\hat{j}$

b) Time for which the particle was in magnetic field is $\frac{\pi m}{3qB}$

c) Distance travelled in magnetic field is $\frac{\pi mv}{2qB}$

d) Time for which the particle was in magnetic field is $\frac{\pi m}{qB}$

19. A particle of charge –q and mass m enters a uniform magnetic field $\vec{B}$ (perpendicular to paper inward) at P with a velocity v_0 at an angle α and leaves the field at Q with velocity v at angle β as shown in figure:



a) $\alpha = \beta$ b) $v = v_0$ c) $PQ = \frac{2mv_0 \sin\alpha}{Bq}$

d) The particle remains in the field for time $t = \frac{2m(\pi - \alpha)}{Bq}$

20. Two circular coils of radii 5cm and 10cm carry currents of 2A. The coils have 50 and 100 turns respectively and are placed in such a way that their planes as well as their centres coincide. Magnitude of magnetic field at the common centre of coils is

a) 8p" 10^{-4} T if currents in the coils are in same sense

b) 4p' 10^{-4}T if currents in the coils are in opposite sense

c) zero if currents in the coils are in opposite sense

d) 8p' 10^{-4} T if currents in the coils are in opposite sense

21. A charged particle is moving along positive y-axis in uniform electric and magnetic fields $\vec{E} = E_0\hat{k}$ and $\vec{B} = B_0\hat{i}$. Here E_0 and B_0 are positive constants. Choose the correct options

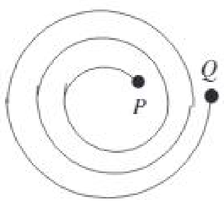
a) particle may be deflected towards positive z-axis

b) particle may be deflected towards positive z-axis

c) particle may pass undeflected

d) kinetic energy of particle may remain constant

22. A charged particle enters into a region which offers a resistance against its motion and a uniform magnetic field exists in the region. The particle traces a planar spiral path as shown in figure. Which of the following statement(s) is/are correct?



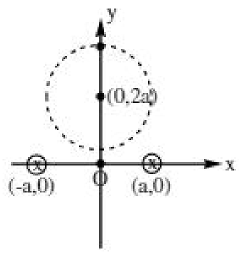
a) Component of magnetic field in the plane of spiral is zero

b) The particle enters the region at Q

c) If magnetic field is out of the page of the diagram, then the particle is positively charged

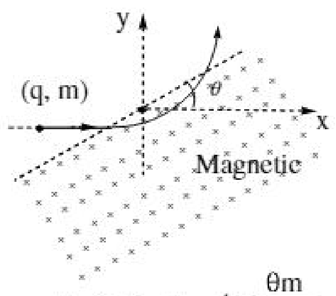
d) If magnetic field is out of the page of the diagram, then the particle is negatively charged

23. Two long conducting wires carrying equal currents are placed to the Z-axis. A charged particle is made to move in a circular path of radius 'a' with centre of the path at point (0, 2a) in clockwise direction. During the course of motion, it passes through four points P,Q,R and S having coordinates (0,a), (–a, 2a), (0, 3a) and (a, 2a) respectively. The magnitude of force exerted on the particle by the magnetic field created by the wires is maximum when it passes through points.



a) P b) Q c) R d) S

24. A uniform magnetic field $-B_0\hat{k}$ exists to the right of the plane $y = x\tan\theta$ as shown. At t = 0 a particle of mass m and positive charge q with velocity $v_0\hat{i}$ enters in magnetic field at origin. Then



a) particle will come out from magnetic field after $t = \dfrac{\theta m}{qB_0}$

b) particle will come out from magnetic field after time $t = \dfrac{2\theta m}{qB_0}$

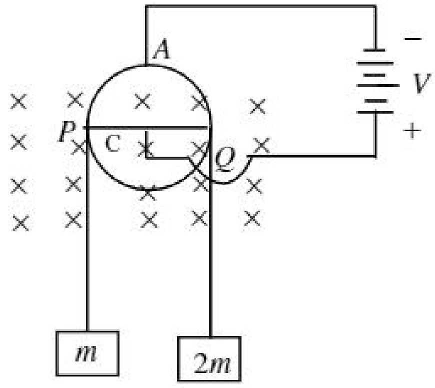
c) Co-ordinate of point from which particle will come out is $\left[\dfrac{mv_0}{qB_0}\sin 2\theta, \dfrac{mv_0}{qB_0}(1-\cos 2\theta), 0\right]$

d) Co-ordinate of point from which particle will come is $\left[\dfrac{mv_0}{qB_0}\sin\theta, \dfrac{mv_0}{qB_0}(1-\cos\theta), 0\right]$

Linked Comprehension Type Questions

Passage-1 :

A conducting ring of mass m and radius r has a weightless conducting rod PQ of length 2r and resistance 2R attached to it along its diameter. It is pivoted at its center C with its plane vertical, and two blocks of mass m and 2m are suspended by means of a light in-extensible string passing over it as shown in figure. The ring is free to rotate about C and the system is placed in a magnetic field B (into the plane of the ring). A circuit is now completed by connecting the ring at A and C to battery of e.m.f. V. It is found that for certain value of V, the system remains static. [Neglect resistance of the ring]



25. In static condition, find the current through rod PC

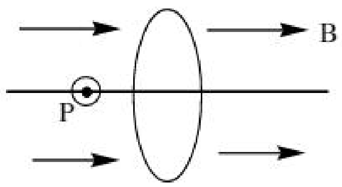
a) V/R b) V/2R c) 4V/R d) 2V/R

26. Net torque applied by the tension in string on the ring can be related as:

a) $\frac{3BVr^2}{R}$ b) $\frac{BVr^2}{R}$ c) $\frac{BVr^2}{3R}$ d) $\frac{BVr^2}{2R}$

Passage-II :

Figure shows a convex lens of focal length 12cm lying in a uniform magnetic field of B of magnitude is 1.2 T parallel to its principle axis. A particle having a charge 2×10^{-3} C and mass 2×10^{-5} kg is projected perpendicular to the plane of the diagram with a speed of 4.8 ms^{-1}. The particle moves along a circle with its centre on the principal axis at a distance of 18cm from the lens.



27. The radius of the circular path of the particle is

a) 2 cm b) 4×10^{-2}cm c) 4cm d) 8cm

28. The distance of the image point on the axis of the particle from the lens.

a) 36cm b) 18cm c) 7.2cm d) 14.4cm

Passage-III :

If a long cylindrical region contains uniform volume density of positive or negative charge, then by using Gauss Law or otherwise we can find electric field at a perpendicular distance "r" from axis of cylinder.

Consider a long neutral metallic cylinder in a uniform and homogenous magnetic field $\vec{B}$ parallel to the axis of cylinder. Now the cylinder is rotated about axis with constant angular velocity $\vec{\omega}$. Consider the state when charge redistribution within the cylinder becomes steady and all electrons describe circular motion about axis of cylinder. Consider a single free electron of mass "m" and let $\vec{B}$ & $\vec{\omega}$ are in same direction, then ($e = 1.6\times10^{-19}$ C)

29. If $\omega < \frac{eB}{m}$

a) The interior gets uniform negative charge density and outer surface, positive charge

b) The Interior gets non-uniform negative charge density and outer surface, positive charge

c) The Interior gets positive uniform charge density and outer surface, negative charge.

d) The Interior gets positive non-uniform charge density & outer surface, no charge.

30. If $\omega = \frac{eB}{m}$

a) There is only magnetic force and no electric force on free electron

b) Both magnetic & electric force act in opposite direction.

c) Both magnetic & electric force act in same direction

d) There is only electric force and no magnetic force on free electron

31. If $\omega > \frac{eB}{m}$

a) Both magnetic & electrical force act in opposite direction

b) The interior gets uniform positive charge density and outer surface negative charge

c) The interior of the cylinder remains neutral everywhere

d) The interior gets non-uniform negative charge density and outer surface, positive charge.

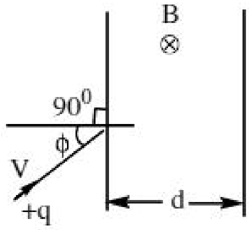
Matrix Matching Type Questions

32. A charged particle with some initial velocity is projected in which uniform and constant electric field $\overline{E}$ and /or uniform and constant magnetic field $\overline{B}$ are/is present. In Column – I information about the existence of electric and/or magnetic field and direction of initial velocity of charged particle is given and in Column – II the probable path of the charged particle is mentioned. Match the entries of Column – I with entries of Column – II.

COLUMN-I	COLUMN-II
A) $E = 0, B \neq 0,$ initial velocity $(\neq 0)$ is at an unknown angle with $\overline{B}$	p) Straight line
B) $E \neq 0, B = 0$ and initial velocity $(\neq 0)$ is at an unknown angle with $\overline{E}$	q) Parabola
C) $E \neq 0, B \neq 0, \overline{E} \parallel \overline{B}$ and initial velocity $(\neq 0)$ is perpendicular to $\overline{E}$	r) Circular
D) $E \neq 0, B \neq 0, \overline{E} \perp \overline{B}$ and initial velocity $(\neq 0)$ is perpendicular both $\overline{E}$ and $\overline{B}$	s) Helical path with non-uniform pitch

Integer Type Questions

33. In the figure shown a positively charged particle of charge 'q' and mass 'm' enters into a uniform magnetic field of strength 'B' as shown in the figure. The magnetic field points inwards and is present only within a region of width 'd'. The initial velocity of the particle is perpendicular to the magnetic field and $\phi = 30^0$. The time spent by the particle inside the magnetic field if d = 0.2m, B = 1T, q = 1C, m = 1kg and v = 1 m/s is $n \times \frac{\pi}{36}$ then find n. (Use sin $45^0 = 0.7$ if required.)

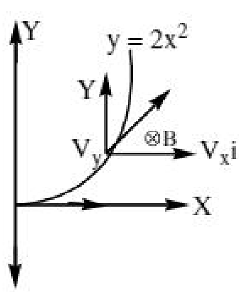


34. Two wires of same length are made into a circle and square each of 1 turn respectively. Currents are passed in them such that their magnetic moments are equal, the ratio of the magnetic field at their respective centres is $\frac{\sqrt{x}\pi^3}{64}$ then the value of 'x' is

35. A magnetic field $\vec{B} = -B_0\hat{i}$ exists within a sphere of radius $R = \upsilon_0 T\sqrt{3}$ where T is the time period of one revolution of a charged particle starting its motion from origin and moving with a velocity $\vec{\upsilon_0} = \frac{\upsilon_0\sqrt{3}}{2}\hat{i} - \frac{\upsilon_0}{2}\hat{j}$. Number of turns the particle will take to come out of the magnetic field is ____

36. At t = 0 a square loop of side (L/2) enters in a uniform magnetic filed B = 4T which acts in a region of length L = 2m. The loop is made to move with constant acceleration of $1 m/s^2$. The resistance per unit length of the square frame is $1\Omega/m$. Find the magnetic force (in N) on the frame at time t = 1 sec.

37. A non-uniform magnetic field B varies with x. It exist for $x \geq 0$, into the xy plane. A charge q of mass m, enters the magnetic field at the origin with speed $v\hat{i}$. It is seen that it travels along $y = 2x^2$ curve. Find the value of B at x = 0. $\left(\text{Given} : \frac{mv}{q} = 2\right)$



38. A magnet of magnetic moment $3Am^2$ when placed along the x-axis experiences a torque $\vec{\tau}=3\hat{j}+4\hat{k}$ and when placed along the y-axis, the torque $\vec{\tau}=-3\hat{i}+\hat{j}-6\hat{k}$. If the magnetic field is $(\alpha+0.6)$ tesla find α

KEY SHEET (ADDITIONAL PRACTICE EXERCISE)

LEVEL-I (MAIN)

1) **3**	2) **1**	3) **2**	4) **2**	5) **1**	6) **4**	7) **3**	8) **1**	9) **1**	10) **2**
11) **3**	12) **3**	13) **1**	14) **3**	15) **4**	16) **2**	17) **1**	18) **4**	19) **3**	20) **2**
21) **3**	22) **3**	23) **1**	24) **3**	25) **1**	26) **3**	27) **1**	28) **2**	29) **3**	30) **1**
31) **2**	32) **1**								

LEVEL-II

LECTURE SHEET (ADVANCED)

1) **d**	2) **b**	3) **a**	4) **d**	5) **d**	6) **c**	7) **c**	8) **c**	9) **a**	10) **a**
11) **c**	12) **a**	13) **b**	14) **b**	15) **a,c,d**	16) **a,b,c,d**	17) **a,c,d**	18) **b,c**	19) **a,d**	20) **a,d**
21) **b,d**	22) **b,d**	23) **d**	24) **a,b,c,d**		25) **c**	26) **b**	27) **d**	28) **a**	29) **a**
30) **b**	31) **b**	32) **a**	33) **d**	34) **A-pr; B-s; C-pqr; D-pr**			35) **A-r; B-p; C-q; D-s**		
36) **8**	37) **8**	38) **4**	39) **2**	40) **7**	41) **2**	42) **5**			

PRACTICE SHEET (ADVANCED)

1) **b**	2) **c**	3) **a**	4) **a**	5) **b**	6) **d**	7) **c**	8) **b**	9) **d**	10) **c**
11) **d**	12) **a**	13) **a**	14) **c**	15) **c**	16) **a**	17) **b**	18) **a,b**	19) **a,b,c,d**	
20) **a,c**	21) **a,b,c,d**		22) **a,b,c**	23) **b,d**	24) **b,c**	25) **a**	26) **b**	27) **c**	
28) **a**	29) **a**	30) **a**	31) **b**	32) **A-p,r; B-p,q; C-s; D-p**			33) **3**	34) **2**	35) **2**
36) **4**	37) **8**	38) **2**							