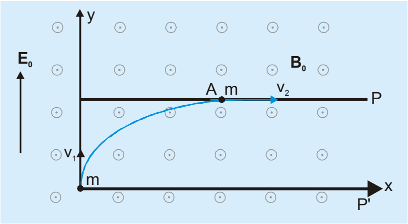
SOLVED EXAMPLES

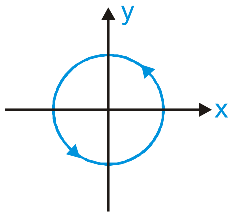
Ex.1 There are constant electric field $E_0\hat{j}$ & magnetic field $B\hat{k}$ present between plates P and P'. A particle of mass m is projected from plate P' along y axis with velocity v_1. After moving on the curved path, it passes through point A just grazing the plate P with velocity v_2. The magnitude of impulse (i.e. $\vec{F}\Delta t = \Delta\vec{p}$) provided by magnetic force during the motion of particle from origin to point A is :–



(A) $m|v_2-v_1|$ **(B)** $m\sqrt{v_1^2+v_2^2}$ **(C)** mv_1 **(D)** mv_2

Sol. Electric force is only responsible for the change in momentum along y–axis. Therefore impulse provide by magnetic force is $J_B = mv_2$.

Ex.2 Current i = 2.5 A flows along the circle $x^2 + y^2 = 9$ cm^2 (here x & y in cm) as shown. Magnetic field at point (0, 0, 4 cm) is



(A) $(36\pi\times10^{-7}\,T)\hat{k}$ **(B)** $(36\pi\times10^{-7}\,T)(-\hat{k})$ **(C)** $\left(\frac{9\pi}{5}\times10^{-7}\,T\right)\hat{k}$ **(D)** $\left(\frac{9\pi}{5}\times10^{-7}\,T\right)(-\hat{k})$

Sol. Magnetic field on the axis of a circular loop

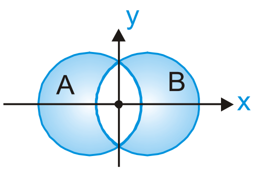
$$B = \left(\frac{\mu_0}{4\pi}\right)\times\frac{2\pi iR^2}{(R^2+z^2)^{3/2}} = 10^{-7}\times\frac{2\pi\times2.5\times3^2\times10^{-4}}{125\times10^{-6}}\hat{k} = \left(\frac{9\pi}{25}\times10^{-5}\,T\right)\hat{k} = (36\pi\times10^{-7}\,T)\hat{k}$$

Ex.3 Three identical charge particles A, B and C are projected perpendicular to the uniform magnetic field with velocities v_1, v_2 and v_3 ($v_1 < v_2 < v_3$) respectively such that T_1, T_2 and T_3 are their respective time period of revolution and r_1, r_2 and r_3 are respective radii of circular path described. Then :-

(A) $\frac{r_1}{T_1} > \frac{r_2}{T_2} > \frac{r_3}{T_3}$ **(B)** $T_1 < T_2 < T_3$ **(C)** $\frac{r_1}{T_1} < \frac{r_2}{T_2} < \frac{r_3}{T_3}$ **(D)** $r_1 = r_2 = r_3$

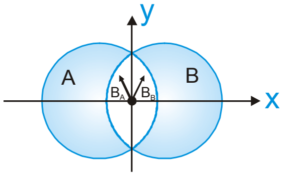
Sol. $T = \frac{2\pi m}{qB}$ & $r = \frac{mv}{qB} \Rightarrow \frac{r}{T} \propto v$

Ex.4 Two cylindrical straight and very long non magnetic conductors A and B, insulated from each other, carry a current I in the positive and the negative z–direction respectively. The direction of magnetic field at origin is

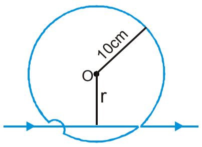


(A) $-\hat{i}$ **(B)** $+\hat{i}$ **(C)** $\hat{j}$ **(D)** $-\hat{j}$

Sol.



Ex.5 An infinitely long straight wire is bent as shown in figure. The circular portion has a radius of 10 cm with its center O at a distance r from the straight part. The value of r such that the magnetic field at the center O of the circular portion is zero will be :-



(A) $\frac{10}{\pi}$ cm **(B)** $\frac{20}{\pi}$ cm **(C)** $\frac{1}{5\pi}$ cm **(D)** $\frac{5}{\pi}$ cm

Sol. $B_{circular\ loop} = -B_{wire} \Rightarrow \frac{\mu_0 I}{2\times 10} = \frac{\mu_0 I}{2\pi r} \Rightarrow r = \frac{10}{\pi}$cm

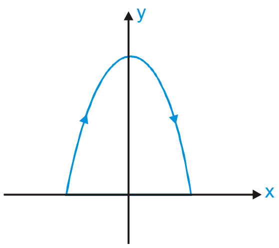
Ex.6 A conducting coil is bent in the form of equilateral triangle of side 5 cm. Current flowing through it is 0.2 A. The magnetic moment of the triangle is :-

(A) $\sqrt{3} \times 10^{-2}$ A–m^2 **(B)** 2.2×10^{-4} A–m^2 **(C)** 2.2×10^{-2} A–m^2 **(D)** $\sqrt{3} \times 10^{-4}$ A–m^2

Sol. Magnetic moment of current carrying triangular loop M = IA

$$M = 0.2\left(\frac{1}{2}\times 5\times 10^{-2}\times\frac{\sqrt{3}\times 5\times 10^{-2}}{2}\right) = 2.2 \times 10^{-4}\ \text{A-m}^2$$

Ex.7 A wire carrying a current of 4A is bent in the form of a parabola $x^2 + y = 16$ as shown in figure, where x and y are in meter. The wire is placed in a uniform magnetic field $\vec{B} = 5\tilde{k}$ tesla. The force acting on the wire is

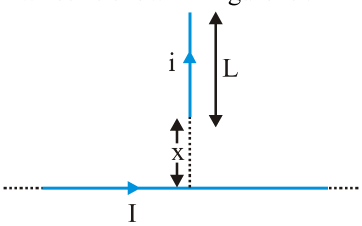


(A) $80\ \tilde{j}$ N **(B)** $-\ 80\ \tilde{j}$ N **(C)** $-160\ \tilde{j}$ N **(D)** $160\ \tilde{j}$ N

Sol. **Ans. (C)**

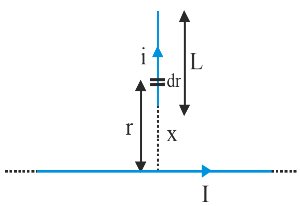
$$\vec{F} = I(\vec{\ell}\times\vec{B}) = 4(8\tilde{i}\times 5\tilde{k}) = -160\ \tilde{j}\ \text{N}$$

Ex.8 The magnetic force between wires as shown in figure is :-



(A) $\frac{\mu_0 i I^2}{2\pi}\ell n\left(\frac{x+L}{2x}\right)$ **(B)** $\frac{\mu_0 i I^2}{2\pi}\ell n\left(\frac{2x+L}{2x}\right)$ **(C)** $\frac{\mu_0 i I}{2\pi}\ell n\left(\frac{x+L}{x}\right)$ **(D)** None of these

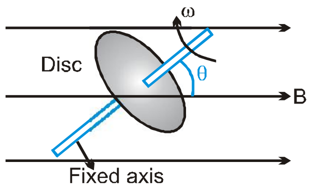
Sol. Magnetic field at dr, $B = \frac{\mu_0 I}{2\pi r}$



Force on small element at a distance r of wire of length L is $dF = i(dr)\left(\frac{\mu_0 I}{2\pi r}\right)$

$$F = \frac{\mu_0 i I}{2\pi}\int_x^{x+L}\frac{dr}{r} = \frac{\mu_0 i I}{2\pi}\ell n\left(\frac{x+L}{x}\right)$$

Ex.9 A disc of radius r and carrying positive charge q is rotating with angular speed ω in a uniform magnetic field B about a fixed axis as shown in figure, such that angle made by axis of disc with magnetic field is θ. Torque applied by axis on the disc is



(A) $\frac{q\omega r^2 B\sin\theta}{2}$, clockwise **(B)** $\frac{q\omega r^2 B\sin\theta}{4}$, anticlockwise

(C) $\frac{q\omega r^2 B\sin\theta}{2}$, anticlockwise **(D)** $\frac{q\omega r^2 B\sin\theta}{4}$, clockwise

Sol. $\frac{M}{L} = \frac{q}{2m} \Rightarrow M = \frac{q}{2m} \times \frac{mr^2}{2}\omega \Rightarrow \tau = \left|\vec{M}\times\vec{B}\right| = \frac{q\omega r^2 B\sin\theta}{4}$(clockwise)

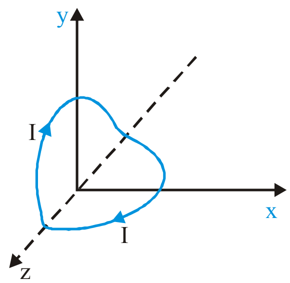
Ex.10 A circular current carrying loop of radius R is bent about its diameter by 90° and placed in a magnetic field $\vec{B} = B_0(\hat{i}+\hat{j})$ as shown in figure.

(A) The torque acting on the loop is zero

(B) The magnetic moment of the loop is $\frac{I\pi R^2}{2}\left(-\hat{i}-\hat{j}\right)$

(C) The angular acceleration of the loop is non zero.

(D) The magnetic moment of the loop is $\frac{I\pi R^2}{2}\left(-\hat{i}+\hat{j}\right)$



Sol. $\vec{M} = \frac{I\pi R^2}{2}\left(-\hat{i}-\hat{j}\right)$; $\vec{\tau} = \vec{M}\times\vec{B} = 0$

Ex.11 A particle of mass m and charge q is thrown from origin at t = 0 with velocity $2\hat{i}+3\hat{j}+4\hat{k}$ units in a region with uniform magnetic field $2\hat{i}$ units. After time $t = \frac{\pi m}{qB}$, an electric field $\vec{E}$ is switched on, such that particle moves on a straight line with constant speed. $\vec{E}$ may be

(A) $-8\hat{j}+6\hat{k}$ units **(B)** $-6\hat{i}-9\hat{k}$ units **(C)** $-12\hat{j}+9\hat{k}$ units **(D)** $8\hat{j}-6\hat{k}$ units

Sol. At $t = \frac{\pi n}{qB}$, $\vec{v} = 2\hat{i}-3\hat{j}-4\hat{k}$; For net force to be zero $q\vec{v}\times\vec{B}+q\vec{E} = 0 \Rightarrow \vec{E} = -\vec{v}\times\vec{B} = -8\hat{j}+6\hat{k}$

Ex.12 A particle of specific charge $\frac{q}{m} = \pi\times10^{10}\ \text{C kg}^{-1}$ is projected from the origin along the positive x–axis with a velocity of $10^5\ \text{ms}^{-1}$ in a uniform magnetic field $\vec{B} = -2\times10^{-3}\hat{k}$ tesla. Choose correct alternative(s)

(A) The centre of the circle lies on the y–axis

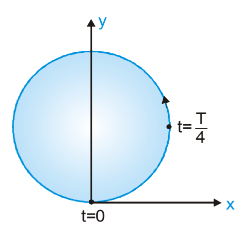
(B) The time period of revolution is 10^{-7} s.

(C) The radius of the circular path is $\frac{5}{\pi}$ mm

(D) The velocity of the particle at $t = \frac{1}{4}\times10^{-7}$ s is $10^5\hat{j}$ m / s

Sol. $\vec{F} = q\left(\vec{v}\times\vec{B}\right)$, $\vec{v} = 10^5\hat{i}$, $\vec{B} = -2\times10^{-3}\hat{k}$ $\Rightarrow$ Force will be in y–direction

$\Rightarrow$ Motion of particle will be in xy plane

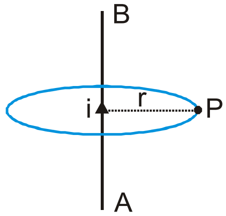


Time period $T = \frac{2\pi m}{qB} = \frac{2\pi}{\pi\times10^{10}\times2\times10^{-3}} = 10^{-7}$ s

Radius of path $= \frac{mv}{qB} = \frac{10^5}{\pi\times10^{10}\times2\times10^{-3}} = \frac{5}{\pi}\times10^{-3}$ m $= \frac{5}{\pi}$ mm

At $t = \frac{T}{4} = \frac{10^{-7}}{4}$ s. Velocity of particle will be in +y direction.

Ex.13 In the given figure, B is magnetic field at P due to shown segment AB of an infinite current carrying wire. A loop is taken as shown in figure. Which of the following statement(s) is/are correct.



(A) $\oint \vec{B} \cdot \vec{d\ell} = \mu_0 i$ **(B)** $B = \frac{\mu_0 i}{2\pi r}$

(C) Magnetic field at P will be tangential **(D)** None of these

Sol. Magnetic field at P is tangential.

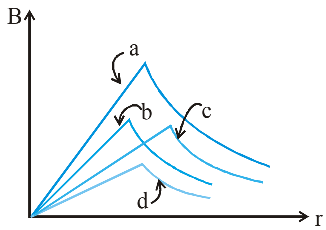
Ex.14 A current–carrying ring is placed in a magnetic field. The direction of the field is perpendicular to the plane of the ring–

(A) There is no net force on the ring.
(B) The ring will tend to expand.
(C) The ring will tend to contract.
(D) Either **(B)** or **(C)** depending on the directions of the current in the ring and the magnetic field.

Sol. Net force = 0 and ring will tend to expand/contracts depending on I & B.

Ex.15 to 17

Curves in the graph shown give, as functions of radial distance r, the magnitude B of the magnetic field inside and outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross sections of the wires. The wires are far from one another.



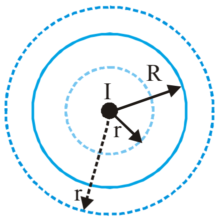
15. Which wire has the greatest radius?
(A) a **(B)** b **(C)** c **(D)** d

16. Which wire has the greatest magnitude of the magnetic field on the surface?
(A) a **(B)** b **(C)** c **(D)** d

17. The current density in wire a is
(A) greater than in wire c **(B)** less than in wire c
(C) equal to that in wire c **(D)** not comparable to that in wire c due to lack of information

Sol.

15. Inside the cylinder : $B = \frac{\mu_0 I}{2\pi R^2} r$ ...**(i)**



Outside the cylinder $\therefore B = \frac{\mu_0 I}{2\pi r}$ ...**(ii)**

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

So from surface of cylinder nature of magnetic field changes.
Hence it is clear from the graph that wire 'c' has greatest radius.

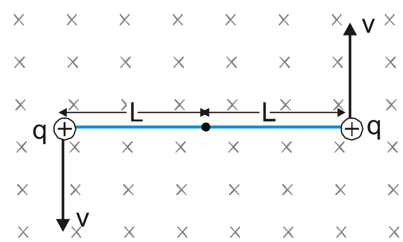
16. Magnitude of magnetic field is maximum at the surface of wire 'a'.

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

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

Ex.18 to 20

Two charge particles each of mass 'm', carrying charge +q and connected with each other by a massless inextensible string of length 2L are describing circular path in the plane of paper, each with speed $v = \frac{qB_0L}{m}$ (where B_0 is constant) about their centre of mass in the region in which an uniform magnetic field $\vec{B}$ exists into the plane of paper as shown in figure. Neglect any effect of electrical & gravitational forces.



18. The magnitude of the magnetic field such that no tension is developed in the string will be

(A) $\frac{B_0}{2}$ **(B)** B_0 **(C)** $2B_0$ **(D)** 0

19. If the actual magnitude of magnetic field is half to that of calculated in part (i) then tension in the string will be

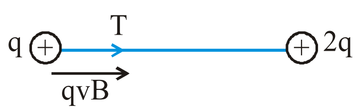
(A) $\frac{3}{4}\frac{q^2B_0^2L}{m}$ **(B)** zero **(C)** $\frac{q^2B_0^2L}{2m}$ **(D)** $\frac{2q^2B_0^2L}{m}$

20. Given that the string breaks when the tension is $T = \frac{3}{4}\frac{q^2B_0^2L}{m}$. Now if the magnetic field is reduced to such a value that the string just breaks then find the maximum separation between the two particles during their motion

(A) 16 L **(B)** 4L **(C)** 14L **(D)** 2L

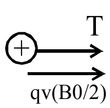
Sol.

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



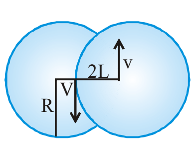
$T = 0; \Rightarrow q\left(\frac{qB_0L}{m}\right)B = \frac{mv^2}{L} \Rightarrow B = B_0$

19.



$T + \frac{qvB_0}{2} = \frac{mv^2}{R}$; $T = \frac{m(qB_0L)^2}{m^2R} - \frac{q(qB_0L)}{m} \times \frac{B_0}{2} = \frac{q^2B_0^2L}{2m}$

20.



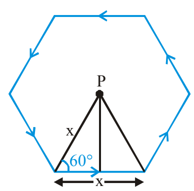
Maximum separation = 2R + (2R – 2L)

$T + qvB = \frac{mv^2}{R} \Rightarrow B = B_0/4 \Rightarrow R = 4L \Rightarrow$ maximum separation = 16L – 2L = 14L

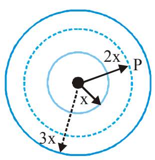
Ex.21 Column-I gives some current distributions and a point P in the space around these current distributions. Column-II gives some expressions of magnetic field strength. Match column-I to corresponding field strength at point P given in column-II

	Column – I		Column – II
(A)	A conducting loop shaped as regular hexagon of side x, carrying current i. P is the centroid of hexagon	(P)	$\frac{3\mu_0 i}{32\pi x}$
(B)	A cylinder of inner radius x and outer radius 3x, carrying current i. Point P is at a distance 2x from the axis of the cylinder	(Q)	$\frac{\sqrt{3}\mu_0 i}{\pi x}$
(C)	Two coaxial hollow cylinders of radii x and 2x, each carrying current i, but in opposite direction. P is a point at distance 1.5x from the axis of the cylinders	(R)	$\frac{\mu_0 i}{2x}$
(D)	Magnetic field at the centre of an n-sided regular polygon, of circumcircle of radius x, carrying current $i, n \to \infty$, P is centroid of the polygon.	(S)	$\frac{\mu_0 i}{3\pi x}$
		(T)	Zero

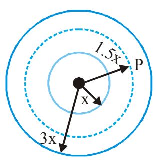
Sol. **For A :** $B_P = 6 \times \frac{\mu_0 i}{4\pi(x \sin 60°)}[\sin 30° + \sin 30°] = \frac{\sqrt{3}\mu_0 i}{\pi x}$



For B: $B_P = \frac{\mu_0\left(\frac{3}{8}i\right)}{2\pi(2x)} = \frac{3\mu_0 i}{32\pi x}$

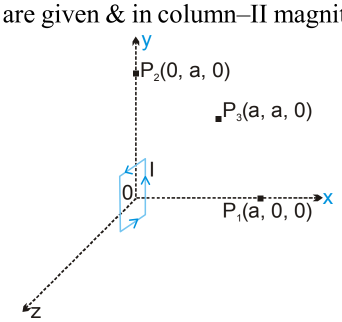


For C : $B_P = \frac{\mu_0 i}{2\pi(1.5x)} = \frac{\mu_0 i}{3\pi x}$



For D : If $n \to \infty$, n sided polygon $\to$ circle so $B = \frac{\mu_0 i}{2x}$

Ex.22 A very small current carrying square loop (current I) of side 'L' is placed in y-z plane with centre at origin of the coordinate system (shown in figure). In column–I the coordinate of the points are given & in column–II magnitude of strength of magnetic field is given. Then



	Column I		Column II
(A)	At point O (0, 0, 0)	(P)	$\frac{\mu_0 I L^2}{2\pi a^3}$
(B)	At point P_1 (a, 0, 0) (here a >> L)	(Q)	$\frac{2\sqrt{2}\mu_0 I}{\pi L}$

(C) At point P_2 (0, a, 0) (here (a >> L)) **(R)** $\frac{\mu_0 \sqrt{5}\, IL^2}{16\pi a^3}$

(D) At point P_3 (a, a, 0) (here a >> L) **(S)** $\frac{\mu_0 IL^2}{4\pi a^3}$

(T) $\frac{\mu_0 \sqrt{5} IL^2}{4\pi a^3}$

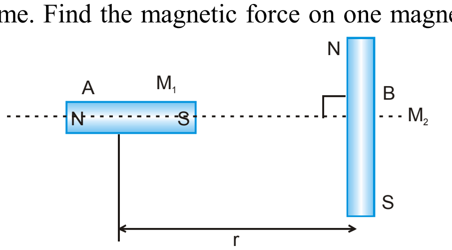
Sol. **For A:** $B_{P_1} = 4 \times \frac{\mu_0 I}{4\pi(L/2)}\left[\sin\frac{\pi}{4} + \sin\frac{\pi}{4}\right] = \frac{2\sqrt{2}\mu_0 I}{\pi L}$

For B: $B_{P_2} = \frac{2kM}{r^3} = \frac{2\left(\frac{\mu_0}{4\pi}\right)(IL^2)}{a^3} = \frac{\mu_0 IL^2}{2\pi a^3}$

For C: $B_{P_3} = \frac{kM}{r^3} = \frac{\left(\frac{\mu_0}{4\pi}\right)(IL^2)}{a^3} = \frac{\mu_0 IL^2}{4\pi a^3}$

For D: $B_{P_4} = \frac{kM}{r^3}\sqrt{1 + 3\cos^2\theta}$ where $\cos\theta = \frac{1}{\sqrt{2}} \Rightarrow B_{P_4} = \frac{\left(\frac{\mu_0}{4\pi}\right)(IL^2)}{\left(a\sqrt{2}\right)^3}\sqrt{1 + 3\left(\frac{1}{2}\right)} = \frac{\mu_0 \sqrt{5} IL^2}{16\pi a^3}$

Ex. 23 Two short magnet A and B of magnetic dipole moments M_1 and M_2 respectively are placed as shown. The axis of 'A' and the equatorial line of 'B' are the same. Find the magnetic force on one magnet due to the other.



Sol. Magnetic field due to magnet B :

$$B = \frac{\mu_0}{4\pi}.\frac{M_2}{r^3}$$

Magnetic force acting on magnet A :

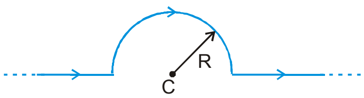
$$F = M_1\frac{dB}{dr} = -3\left(\frac{\mu_0}{4\pi}\right)\frac{M_1 M_2}{r^4}$$

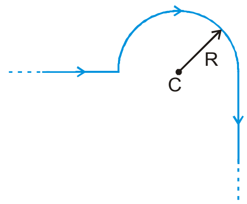
Ex. 24 A bar magnet has a pole strength of 3.6 A-m and magnetic length 8 cm. Find the magnetic field at (a) a point on the axis at a distance of 6 cm from the centre towards the north pole and (b) a point on the perpendicular bisector at the same distance.

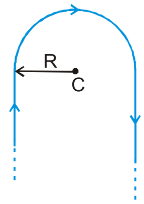
Sol. $M = 3.6 \times 8 \times 10^2$ A.m^2

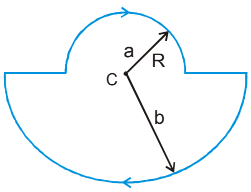
(a) $B = \frac{\mu_0}{4\pi}\cdot\frac{2Mr}{(r^2 - a^2)^2} = 8.6 \times 10^{-4}$ T. **(b)** $B = \frac{\mu_0}{4\pi}\cdot\frac{M}{(r^2 + a^2)^{3/2}} = 7.7 \times 10^{-5}$ T

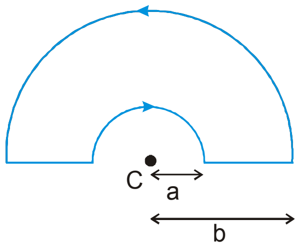
Ex. 25 Find 'B' at centre 'C' in the following cases :

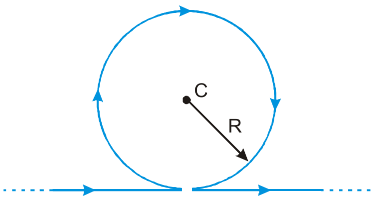
(i) 

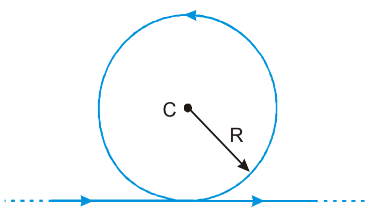
(ii) 

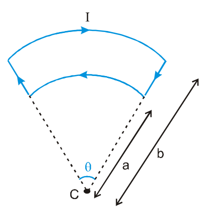
(iii) 

(iv) 

(v) 

(vi) 

(vii) 

(viii) 

Sol.

(i) $B = \frac{\mu_0 I}{2R} \times \frac{1}{2} = \frac{\mu_0 I}{4R}$

(ii) $B = B_1 + B_2 = (\frac{\mu_0 I}{2R} \times \frac{1}{2}) + (\frac{\mu_0}{4\pi} . \frac{I}{R}) = \frac{\mu_0 I}{4R}\left(1 + \frac{1}{\pi}\right)$

(iii) $B = B_1 + B_2 + B_3 = 2B_1 + B_2 = \left(2 \times \frac{\mu_0}{4\pi}\frac{I}{R}\right) + \left(\frac{\mu_0 I}{2R} \times \frac{1}{2}\right) = \frac{\mu_0 I}{2R}\left(\frac{1}{2} + \frac{1}{\pi}\right)$

(iv) $B = B_1 + B_2 = \frac{\mu_0}{2a} \times \frac{1}{2} + \frac{\mu_0}{2b} \times \frac{1}{2} = \frac{\mu_0 I}{4}\left(\frac{1}{a} + \frac{1}{b}\right)$

(v) $B = B_1 - B_2 = \left(\frac{\mu_0 I}{2a} \times \frac{1}{2} - \frac{\mu_0 I}{2b} \times \frac{1}{2}\right) = \frac{\mu_0 I}{4}\left(\frac{1}{a} - \frac{1}{b}\right)$

(vi) $B = B_1 - B_2 = \frac{\mu_0 I}{2R} - \frac{\mu_0 I}{2\pi R} = \frac{\mu_0 I}{2R}\left(1 - \frac{1}{\pi}\right)$

(vii) $B = B_1 + B_2 = \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{2\pi R} = \frac{\mu_0 I}{2R}\left(1 + \frac{1}{\pi}\right)$

(viii) $B = B_1 - B_2 = \frac{\mu_0 I}{2a} - \frac{\mu_0 I}{2b} \times \frac{\theta}{2\pi} = \frac{\mu_0 I \theta}{4\pi}\left(\frac{1}{a} - \frac{1}{b}\right)$

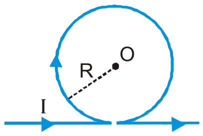
Exercise # 1

[Single Correct Choice Type Questions]

1. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3A and 4A are the currents flowing in each coil respectively. The magnetic induction in Wb/m^2 at the centre of the coils will be:– ($\mu_0 = 4\pi \times 10^{-7}$ Wb/Am)

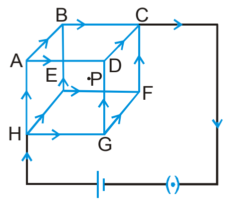
(A) 12×10^{-5} **(B)** 10^{-5} **(C)** 5×10^{-5} **(D)** 7×10^{-5}

2. An infinitely long straight conductor is bent into the shape as shown in figure. It carries a current I ampere and the radius of the circular loop is r meter. Then the magnetic induction at the centre of the circular part is :–



(A) Zero **(B)** ∞ **(C)** $\frac{\mu_0}{4\pi}\frac{2I}{r}(\pi+1)$ **(D)** $\frac{\mu_0}{4\pi}\frac{2I}{r}(\pi-1)$

3. A steady current is set up in a cubic network composed of wires of equal resistance and length d as shown in figure. What is the magnetic field at the centre P due to the cubic network ?

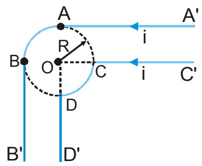


(A) $\frac{\mu_0}{4\pi}.\frac{2I}{d}$ **(B)** $\frac{\mu_0}{4\pi}.\frac{3I}{\sqrt{2}d}$ **(C)** 0 **(D)** $\frac{\mu_0}{4\pi}.\frac{8\pi I}{d}$

4. If the intensity of magnetic field at a point on the axis of current coil is half of that at the centre of the coil, then the distance of that point from the centre of the coil will be :–

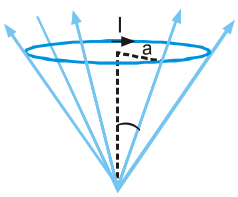
(A) $\frac{R}{2}$ **(B)** R **(C)** $\frac{3R}{2}$ **(D)** 0.766R

5. All straight wires are very long. Both AB and CD are arcs of the same circle, both subtending right angles at the centre O. Then the magnetic field at O is–



(A) $\frac{\mu_0 i}{4\pi R}$ **(B)** $\frac{\mu_0 i}{4\pi R}\sqrt{2}$ **(C)** $\frac{\mu_0 i}{2\pi R}$ **(D)** $\frac{\mu_0 i}{2\pi R}(\pi+1)$

6. A circular current loop of radius a is placed in a radial field B as shown. The net force acting on the loop is



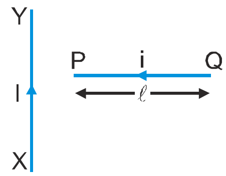
(A) zero

(B) $2\pi BaI\cos\theta$

(C) $2\pi aIB\sin\theta$

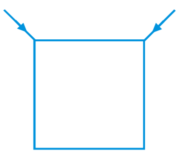
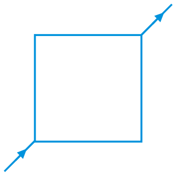
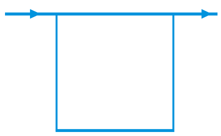
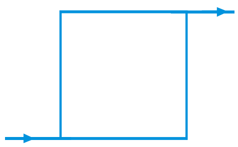
(D) None

7. A conductor PQ carries a current 'i' is placed perpendicular to a long conductor XY carrying a current I. The direction of force on PQ will be :–

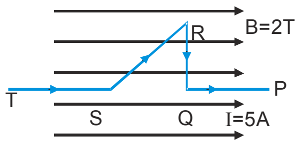


(A) towards right **(B)** towards left **(C)** upwards **(D)** downwards

8. Current flows through uniform, square frames as shown. In which case is the magnetic field at the centre of the frame not zero?

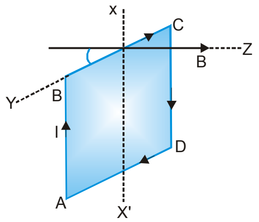
(A)  **(B)**  **(C)**  **(D)** 

9. A wire PQRST carrying current I = 5A is placed in uniform magnetic field B = 2T as shown in fig. If the length of part QR = 4 cm and SR = 6 cm then the magnetic force on SR edge of the wire is :–



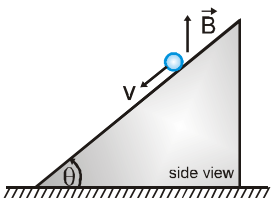
(A) 0.4 N **(B)** 0.6 N **(C)** zero **(D)** 6 N

10. The square loop ABCD, carrying a current I, is placed in a uniform magnetic field B, as shown. The loop can rotate about the axis XX'. The plane of the loop makes an angle θ ($\theta < 90°$) with the direction of B. Through what angle will the loop rotate by itself before the torque on it becomes zero–



(A) θ **(B)** $90° - \theta$ **(C)** $90° + \theta$ **(D)** $180° - \theta$

11. A conducting rod of length ℓ and mass m is moving down a smooth inclined plane of inclination θ with constant velocity v in fig. A current I is flowing in the conductor in a direction perpendicular to paper inwards. A vertically upward magnetic field $\vec{B}$ exists in space. Then magnitude of magnetic field $\vec{B}$ is

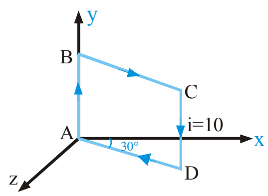


(A) $\frac{mg}{i\ell}\sin\theta$ **(B)** $\frac{mg}{i\ell}\tan\theta$ **(C)** $\frac{mg\cos\theta}{i\ell}$ **(D)** $\frac{mg}{i\ell\sin\theta}$

12. The unit of electric current ‘Ampere’ is the amount of current flowing through each of two parallel wire 1m. apart and of infinite length will give rise to a force between them equal to :–

(A) 1 N/m **(B)** 2×10^{-7} N/m **(C)** 1×10^{-2} N/m **(D)** $4\pi \times 10^{-7}$ N/m

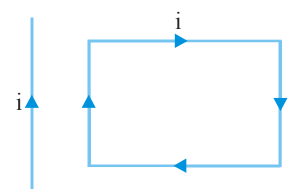
13. Figure shows a square current carrying loop ABCD of side 10 cm and current i = 10 A. The magnetic moment $\vec{M}$ of the loop is



(A) $(0.05)\left(\tilde{i} - \sqrt{3}\tilde{k}\right)$ A − m^2 **(B)** $(0.05)\left(\tilde{j} + \tilde{k}\right)$ A − m^2

(C) $(0.05)\left(\sqrt{3}\tilde{i} + \tilde{k}\right)$ A − m^2 **(D)** $\left(\tilde{i} + \tilde{k}\right)$ A − m^2

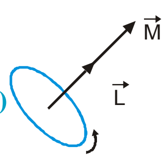
14. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If steady current I is established in the wire as shown in the figure, the loop will :

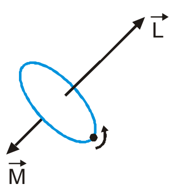


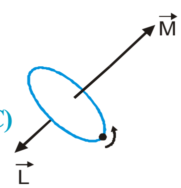
(A) rotate about an axis parallel to the wire **(B)** move away from the wire

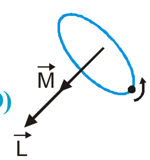
(C) move towards the wire **(D)** remain stationary

15. A negatively charged particle is revolving in a circle of radius r. Out of the following which one figure represents the correct directions of $\vec{L}$ and $\vec{M}$ ($\vec{L}$ is angular momentum of particle; $\vec{M}$ is magnetic moment of the particle).

(A)


(B)


(C)


(D)


16. A helium nucleus is moving in a circular path of radius 0.8m. If it takes 2 sec to complete one revolution. Find out magnetic field produced at the centre of the circle.

(A) $\mu_0 \times 10^{-19}$ T **(B)** $\frac{10^{-19}}{\mu_0}$T **(C)** 2×10^{-19} T **(D)** $\frac{2 \times 10^{-19}}{\mu_0}$T

17. An electron is moving along +x direction. To get it moving on an anticlockwise circular path in x–y plane, a magnetic field applied along

(A) +y–direction **(B)** +z–direction **(C)** –y–direction **(D)** –z–direction

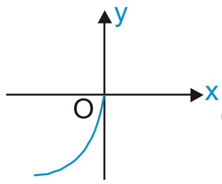
18. Two proton beams are moving with equal speed v in same direction. The ratio of electric force and magnetic force between them is – (Where c_0 is speed of light in vacuum)

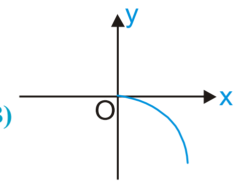
(A) $\frac{c_0^2}{v^2}$ **(B)** $\frac{v^2}{c_0^2}$ **(C)** $\frac{c_0}{v}$ **(D)** $\frac{v}{c_0}$

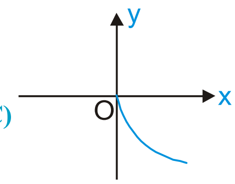
19. In a region a uniform magnetic field acts in horizontal plane towards north. If cosmic particles (80% protons) falling vertically downwards, then they are deflected towards

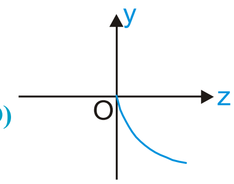
(A) North **(B)** South **(C)** East **(D)** West

20. In a region of space uniform electric field is present as $\vec{E} = E_0\hat{j}$ and uniform magnetic field is present as $\vec{B} = B_0\hat{k}$. An electron is released from rest at origin. Which of the following best represents the path followed by electron after release.

(A) 

(B) 

(C) 

(D) 

21. Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is :

(A) $(R_1/R_2)^{1/2}$ **(B)** R_2/R_1 **(C)** $(R_1/R_2)^2$ **(D)** R_1/R_2

22. A charged particle moves through a magnetic field perpendicular to its direction. Then–

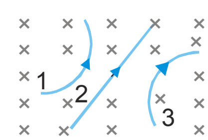
(A) the momentum changes but the kinetic energy is constant

(B) both momentum and kinetic energy of the particle are not constant

(C) both momentum and kinetic energy of the particle are constant

(D) kinetic energy changes but the momentum is constant

23. The charges 1, 2, 3 are moves in uniform transverse magnetic field then :–



(A) particle '1' positive and particle 3 negative

(B) particle 1 negative and particle 3 positive

(C) particle 1 negative and particle 2 neutral

(D) particle 1 and 3 are positive and particle 2 neutral

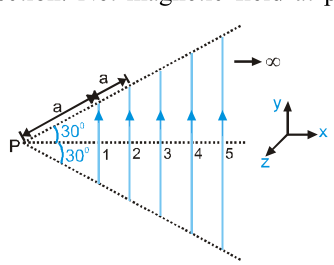
24. A charged particle moves in a magnetic field $\vec{B} = 10\hat{i}$ with initial velocity $\vec{u} = 5\hat{i} + 4\hat{j}$. The path of the particle will be

(A) straight line **(B)** circle **(C)** helical **(D)** None

25. A proton, a deuteron and an α–particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_d and r_α denote respectively the radii of the trajectories of these particles, then:

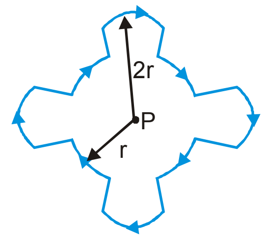
(A) $r_\alpha = r_p < r_d$ **(B)** $r_\alpha > r_d < r_p$ **(C)** $r_\alpha = r_d > r_p$ **(D)** $r_p = r_d = r_\alpha$

26. Infinite number of straight wires each carrying current I are equally placed as shown in the figure. Adjacent wires have current in opposite direction. Net magnetic field at point P is



(A) $\frac{\mu_0 I}{4\pi}\frac{\ell n 2}{\sqrt{3}a}\hat{k}$ **(B)** $\frac{\mu_0 I}{4\pi}\frac{\ell n 4}{\sqrt{3}a}\hat{k}$ **(C)** $\frac{\mu_0 I}{4\pi}\frac{\ell n 4}{\sqrt{3}a}(-\hat{k})$ **(D)** zero

27. A current I flows a closed path in the horizontal plane of the circle as shown in the figure. The path consists of eight cars with alternating radii r and 2r. Each segment of arc subtends equal angle at the common centre P. The magnetic field produced by current path at point P is



(A) $\frac{3}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed inward

(B) $\frac{1}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed outward

(C) $\frac{1}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed inward

(D) $\frac{3}{8}\frac{\mu_0 I}{r}$ perpendicular to the plane of the paper and directed outward

28. A particle of charge -16×10^{-18} C moving with velocity 10 ms^{-1} along the x–axis enters region where a magnetic field of induction B is along the y–axis and an electric field of magnitude 10^4 V/m is along the negative z–axis If the charged particle continues moving along the x–axis, the magnitude of B is–

(A) 10^3 Wb/m^2 **(B)** 10^5 Wb/m^2 **(C)** 10^{16} Wb/m^2 **(D)** 10^{-3} Wb/m^2

29. Equal current i is flowing in three infinitely long wires along positive x, y and z directions. The magnitude of magnetic field at a point (0, 0, –a) would be

(A) $\frac{\mu_0 i}{2\pi a}\left(\tilde{j}-\tilde{i}\right)$ **(B)** $\frac{\mu_0 i}{2\pi a}\left(\tilde{j}+\tilde{i}\right)$ **(C)** $\frac{\mu_0 i}{2\pi a}\left(\tilde{i}-\tilde{j}\right)$ **(D)** $\frac{\mu_0 i}{2\pi a}\left(\tilde{i}+\tilde{j}+\tilde{k}\right)$

30. 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

31. An electron (mass = 9.1×10^{-31}; charge = -1.6×10^{-19} C) experiences no deflection if subjected to an electric field of 3.2×10^5 V/m and a magnetic field of 2.0×10^{-3} Wb/m^2. Both the fields are normal to the path of electron and to each other. If the electric field is removed, then the electron will revolve in an orbit of radius

(A) 45 m **(B)** 4.5 m **(C)** 0.45 m **(D)** 0.045 m

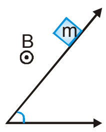
32. An electron is projected with velocity v_0 in a uniform electric field E perpendicular to the field. Again it is projected with velocity v_0 perpendicular to a uniform magnetic field B. If r_1 is initial radius of curvature just after entering in the electric field and r_2 is initial radius of curvature 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)** $\frac{Bv_0}{E}$

33. A uniform magnetic field $\vec{B} = B_0\tilde{j}$ 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

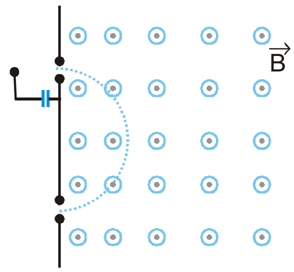
(A) $\frac{2Bq}{dm}$ **(B)** $\frac{Bqd}{m}$ **(C)** $\frac{Bq}{2dm}$ **(D)** $\frac{Bqd}{2m}$

34. 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



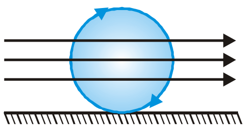
(A) $\frac{m\cos\theta}{qB}$ (B) $\frac{m\,\text{cosec}\,\theta}{qB}$ (C) $\frac{m\cot\theta}{qB}$ (D) None

35. A mass spectrometer is a device which select particle of equal mass. An iron with electric charge q > 0 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



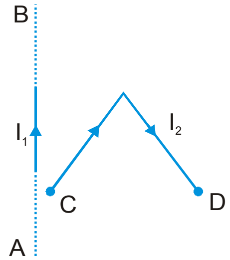
(A) $\frac{qBd}{V}$ (B) $\frac{qB^2d^2}{4V}$ (C) $\frac{qB^2d^2}{8V}$ (D) $\frac{qBd}{2V}$

36. 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 = 10 T is switched on at time t=0 as shown in figure. The initial angular acceleration of the ring will be



(A) $40\pi\ \text{rad/s}^2$ (B) $20\pi\ \text{rad/s}^2$ (C) $5\pi\ \text{rad/s}^2$ (D) $15\pi\ \text{rad/s}^2$

37. In the figure shown a current I_1 is established in the long straight wire AB. Another wire CD carrying current I_2 is placed in the plane of the paper. The line joining the ends of this wire is perpendicular to the wire AB. The force on the wire CD is



(A) zero (B) towards left (C) directed upwards (D) none of these

38. The dimensional formula for the physical quantity $\frac{E^2\mu_0\varepsilon_0}{B^2}$ is (E = electric field and B= magnetic field)

(A) $L^0M^0T^0$ (B) $L^1M^0T^{-1}$ (C) $L^{-1}M^0T^1$ (D) $L^{1/2}M^0T^{-1/2}$

39. In sum and difference method in vibration magnetometer, the time period is more if :-

(A) similar poles of both magnets are on same side

(B) opposite poles of both magnets are on same sides

(C) both magnets are perpendicular to each other

(D) nothing can be said

40. At a certain place a magnet makes 30 oscillations per minute. At another place where the magnetic field is double, its time period will be :-

(A) 4 s **(B)** 2 s **(C)** $\frac{1}{2}$ s **(D)** $\sqrt{2}$ s

41. A magnetic needle suspended horizontally be an unspun silk fibre, Oscillates in the horizontal plane because of the restoring torque originating mainly from :-

(A) the torsion of the silk fibre **(B)** the force of gravity
(C) the horizontal component of earth's magnetic field **(D)** all the above factors

42. If the angle of dip at two places are 30° and 45° respectively, then the ratio of horizontal component of earth's magnetic field at two places will be :-

(A) $\sqrt{3}:\sqrt{2}$ **(B)** $1:\sqrt{2}$ **(C)** $1:\sqrt{3}$ **(D)** 1 : 2

43. At two places A and B using vibration magnetometer, a magnet vibrates in a horizontal plane and its respective periodic time are 2 sec and 3 sec and at these places the earths horizontal components are B_A and B_B respectively. Then the ratio between B_A and B_B will be :-

(A) 9 : 4 **(B)** 3 : 2 **(C)** 4 : 9 **(D)** 2 : 3

44. At certain place the angle of dip is 30° and the horizontal component of earth magnetic field is 0.50 orested. The earth's total magnetic field (in orested) is :-

(A) $\sqrt{3}$ **(B)** 1 **(C)** $\frac{1}{\sqrt{3}}$ **(D)** $\frac{1}{2}$

45. The time period of oscillation of a magnet in vibration magnetometer is 1.5 second. The time period of oscillation of another magnet similar in size, shape and mass but having one fourth magnetic moment that of the same place will be:-

(A) 0.75 s **(B)** 1.5s **(C)** 3.0 s **(D)** 6.0 s

46. A bar magnet A of magnetic moment M_A is found to oscillate at a frequency twice that of magnet B of magnetic moment M_B when placed in a vibrating magnetometer. We may say that :-

(A) $M_A = 2M_B$ **(B)** $M_A = 8M_B$ **(C)** $M_A = 4M_B$ **(D)** $M_B = 8M_A$

47. At Geo-magnetic poles, the angle of dip is :-

(A) 45° **(B)** 30° **(C)** zero **(D)** 90°

48. At magnetic north pole of the earth the value of horizontal component B_H and angle of dip θ is :-

(A) $B_H = 0, \theta = 45°$ **(B)** $B_H = 90, \theta = 0°$ **(C)** $B_H = 0, \theta = 90°$ **(D)** $B_H = 45, \theta = 45°$

49. A magnetic needle is made to vibrate in uniform field B_H, then its time period is T. If it vibrates in the field of intensity $4B_H$, it time period will be :-

(A) 2T **(B)** $\frac{T}{2}$ **(C)** $\frac{2}{T}$ **(D)** T

50. The vertical component of earth magnetic field is zero at or the earth's magnetic field always has a vertical component except at the :-

(A) magnetic poles **(B)** geographical poles **(C)** every place **(D)** magnetic equator

51. If any values of current gives a 45° deflection in property arranged tangent galvanometer. If current becomes $\frac{1}{\sqrt{3}}$ of its initial value, then deflection in it :-

(A) decrease by 30° **(B)** decrease by 15° **(C)** increase by 15° **(D)** increase by 30°

52. Two tangent galvanometer, coil of same radius connected in series. The current flowing produces deflections of 60° and 45°. The ratio of number of turns in coils is :-

(A) $\frac{4}{3}$ **(B)** $\frac{(\sqrt{3}+1)}{1}$ **(C)** $\frac{(\sqrt{3}+1)}{(\sqrt{3}-1)}$ **(D)** $\frac{\sqrt{3}}{1}$

53. Due to earth's magnetic field charged cosmic particles :-
(A) require less K.E. to reach the equator than the pole
(B) require more K.E. to reach the equator than the pole
(C) can never reach at the pole
(D) can never reach at the equator

54. $\sqrt{3}$ ampere current produces 30° deflection in tangent galvanometer, then 3 ampere current produces a deflection :-

(A) 30° **(B)** 45° **(C)** 60° **(D)** 15°

55. At a certain place, the horizontal component B_0 and the vertical component V_0 of the earth's magnetic field are equal in magnitude. The total intensity at the place will be

(A) B_0 **(B)** B_0^2 **(C)** $2B_0$ **(D)** $\sqrt{2}\ B_0$

56. The value of earth magnetic field B_H = 0.3 gauss. In this magnetic field a magnet is oscillating with 5 oscillation/min. To increase the oscillation of magnet upto 10 oscillation/min. The value of earth magnetic field increased by :–
(A) 0.3 gausss **(B)** 0.6 gauss **(C)** 0.9 gauss **(D)** 0.12 gauss

57. Tangent galvanometer is used to measure :–
(A) potential difference **(B)** current **(C)** resistance **(D)** charge

58. At any place horizontal and vertical component of earth magnetic field are equal then angle of dip at that place
(A) 0° **(B)** 45° **(C)** 90° **(D)** 180°

59. Value of earth's magnetic field at any point is 7×10^{-5} wb/m². This field is neutralised by field which is produced at the centre of a current carrying loop of radius 5 cm. The current in the loop (approx)
(A) 0.56 A **(B)** 5.6 A **(C)** 0.28 A **(D)** 28 A

60. A bar magnet is oscillating in the earth's magnetic field with a period 'T'. What happens to its period and motion if its mass is quadrupled :-

(A) Motion remains simple harmonic with time period $= \frac{T}{2}$
(B) Motion remains simple harmonic with time period = 2T
(C) Motion remains simple harmonic with time period = 4T
(D) Motion remains simple harmonic with time period nearly constant

61. The magnetic needle of a tanget galvonometer is defleted at an angle 30° due to a magnet. The horizontal component of earth's magnetic field 0.34×10^{-4} T is along the plane of the coil. The magnetic field of coil is :-

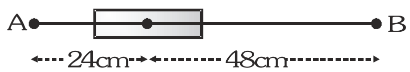
(A) 1.96×10^{-4} T **(B)** 1.96×10^{4} T **(C)** 1.96×10^{-5} T **(D)** 1.96×10^{5} T

62. A vertical straight conductor carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west at the same distance. The magnetic field at P is :-
(A) Greater than at Q
(B) Same as at Q
(C) Less than at Q
(D) Greater or less than at Q, depending upon the strength of current

63. Which of the following demonstrated that earth has a magnetic field :–
(A) Intensity of cosmic rays (stream of charged particle coming from outer space) is more at the poles than at the equator
(B) Earth is surrounded by an ionsphere (a shell of charged particles)
(C) Earth is a planet rotating about the north south axis
(D) Large quantity of iron ore is found in the earth

64. A bar magnet has a magnetic moment equal to 5×10^{-5} A-m^2. It is supended in a magnetic field which has a magnetic induction B equal to $8\pi \times 10^{-4}$ Tesla. The magnet vibrates with a period of vibration equal to 15 sec. The moment of inertia of the magnet is
(A) 5.2×10^{-7} kg-m^2 **(B)** 11.25×10^{-7} kg-m^2 **(C)** 22.5×10^{-7} kg-m^2 **(D)** 7.16×10^{-7} kg-m^2

65. A bar magnet of length 3 cm has points A and B along its axis at distances of 24 cm and 48 cm on the opposite sides. Ratio of magnetic fields as these points will be :-



(A) 8 **(B)** $\frac{1}{2\sqrt{2}}$ **(C)** 3 **(D)** 4

66. In tangent galvanometer current for 30° deflection is 1A, then current necessary for 60° deflection is
(A) 3A **(B)** 2A **(C)** 4A **(D)** 1A

67. The reduction factor of tangent galvano meter is 'K'. If its radius of coil make half and number of turns becomes double then its value of reduction factor becomes :-
(A) $\frac{K}{2}$ **(B)** $\frac{K}{4}$ **(C)** 2K **(D)** 4K

68. Magnetic moment of orbital electron in first orbit is μ_B then magnetic moment of that electron in third orbit
(A) μ_B **(B)** $\frac{\mu_B}{3}$ **(C)** $3\mu_B$ **(D)** $9\mu_B$

69. The relative permeability of iron is of the order of
(A) zero **(B)** 10^3 **(C)** 10^2 **(D)** 10^5

70. Using mass (M), length (L), time (T) and current (A) as fundamental quantities, the dimension of permeability is :-
(A) $]M^{-1}LT^{-2}A]$ **(B)** $[ML^2T^{-2}A^{-1}]$ **(C)** $[MLT^{-2}A^{-2}]$ **(D)** $[MLT^{-1}A^{-1}]$

71. Match the following –

(i) magnetic flux	**(a)** tesla
(ii) magnetic flux density	**(b)** weber
(iii) relative permeability	**(c)** no unit
(iv) magnetic field intensity	**(d)** amper/meter

(A) (i)–(b), (ii)–(a), (iii)–(c), (iv)–(d) **(B)** (i)–(d), (ii)–(b), (iii)–(a), (iv)–(c)
(C) (i)–(c), (ii)–(d), (iii)–(b), (iv)–(a) **(D)** (i)–(b), (ii)–(d), (iii)–(c), (iv)–(a)

72. Which physical quantity has dimensions $[M^1L^1T^{-2}A^{-2}]$:-
(A) magnetising field **(B)** magnetic flux **(C)** magnetic field **(D)** magnetic permeability

73. Intensily of magnetic field of the earth at a point inside a hollow iron box is :-
(A) less than out side **(B)** more than out side **(C)** same **(D)** zero

74. If a diamagnetic solution is poured into a U-tube and one arm of this U-tube placed between the poles of a strong magnet with the meniscus in a line with the field, then the level of the solution will
(A) rise **(B)** fall **(C)** oscillate slowly **(D)** remain as such

75. A superconductor exhibits perfect :-
(A) ferrimagnetism **(B)** antierromagnetism **(C)** paramagnetism **(D)** diamagnetism

76. Which of the following statements is incorrect about hystersis :-
(A) this effect is common to all ferrromagnetic substances
(B) the hysteresis loop area is proportional to the thermal energy developed per unit volume of the material
(C) the hysteresis loop area is independent of the thermal energy developed per unit volume of the material
(D) the shape of the hysteresis loop is characterstic of the material

77. The material of permanent magnet has :-
(A) High relentivity, low coercivity **(B)** Low retentivity, high coercivity
(C) Low relentivity, low coercivity **(D)** High retentivity, high coercivity

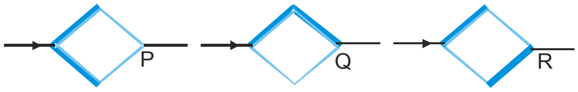
78. Magnetic susceptibility of the following is :
(A) negative for diamagnetic
(B) positive for diamagnetic and paramagnetic
(C) negative for diamagnetic and zero for paramagnetic
(D) zero for paramagnetic and positive for ferromagnetic

79. For an isotropic medium B, μ_0, H and M are related as (where B, μ_0, H and M have their usual meaning in the context of magnetic material :-
(A) $(B-M) = \mu_0 H$ **(B)** $M = \mu_0(H+M)$ **(C)** $H = \mu_0(H+M)$ **(D)** $B = \mu_0(H+M)$

80. Curie-Weiss law is obeyed by iron at a temperature.......
(A) below Curie temperature **(B)** above Curie temperature
(C) at Curie temperature only **(D)** at all temperatures

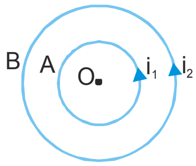
Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. Two thick wires and two thin wires, all of the same materials and same length form a square in the three different ways P, Q and R as shown in fig with current direction shown, the magnetic field at the centre of the square is zero in cases



(A) in P only **(B)** in P and Q only **(C)** in Q and R only **(D)** P and R only

2. A and B are two concentric circular conductors of centre O and carrying current i_1 and i_2 as shown in the diagram. If ratio of their radii is 1:2 and ratio of the flux densities at O due to A and B is 1:3 then the value of $\frac{i_1}{i_2}$ will be :–



(A) $\frac{1}{2}$ **(B)** $\frac{1}{3}$ **(C)** $\frac{1}{4}$ **(D)** $\frac{1}{6}$

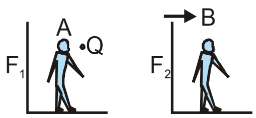
3. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milli ampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 V, the resistance in Ohm's needed to be connected in series with the coil will be–

(A) 10^3 **(B)** 10^5 **(C)** 99995 **(D)** 9995

4. 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

5. An observer A and a charge Q are fixed in a stationary frame F_1. An observer B is fixed in a frame F_2, which is moving with respect to F_1.



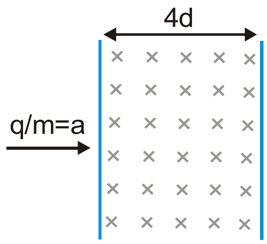
(A) Both A and B will observe electric fields.

(B) Both A and B will observe magnetic fields.

(C) Neither A nor B will observe magnetic fields.

(D) B will observe a magnetic field, but A will not.

6. If a charged particle of charge to mass ratio q/m = α is entering in a magnetic field of strength B at a speed v = (2αd)(B), then which of the following is correct?



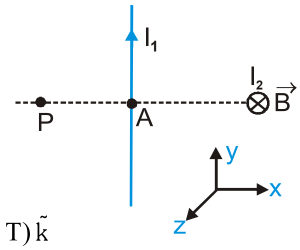
(A) Angle subtended by charged particle at the centre of circular path is 2π.

(B) The charge will move on a circular path and will come out from magnetic field at a distance 4d from the point of insertion

(C) The time for which particle will be in the magnetic field is $\frac{2\pi}{\alpha B}$

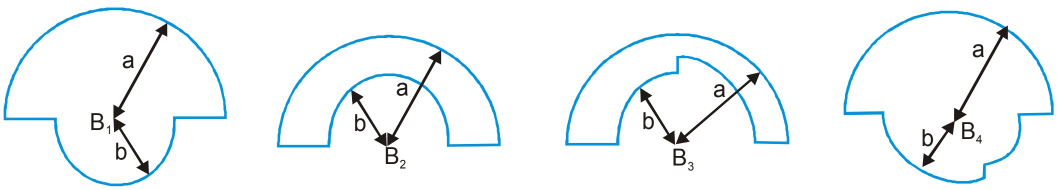
(D) The charged particle will subtend an angle of 90° at the centre of circular path

7. Two infinitely long linear conductors are arranged perpendicular to each other and are in mutually perpendicular planes as shown in figure. If I_1=2A along the y–axis and I_2 = 3A along –ve z–axis and AP = AB = 1cm. The value of magnetic field strength $\vec{B}$ at P is



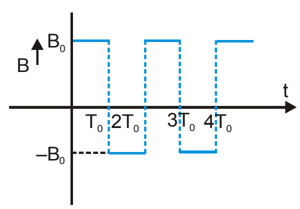
(A) $(3 \times 10^{-5}\ T)\hat{j} + (-4 \times 10^{-5}\ T)\hat{k}$
(B) $(3 \times 10^{-5}\ T)\hat{j} + (4 \times 10^{-5}\ T)\hat{k}$
(C) $(4 \times 10^{-5}\ T)\hat{j} + (3 \times 10^{-5}\ T)\hat{k}$
(D) $(-3 \times 10^{-5}\ T)\hat{j} + (4 \times 10^{-5}\ T)\hat{k}$

8. In the loops shown, all curved sections are either semicircles or quarter circles. All the loops carry the same current. The magnetic fields at the centres have magnitudes B_1, B_2, B_3 and B_4



(A) B_4 is maximum.
(B) B_3 is minimum.
(C) $B_4 > B_1 > B_2 > B_3$
(D) $B_1 > B_4 > B_3 > B_2$

9. In a region magnetic field along x axis changes with time according to the given graph. If time period, pitch and radius of helix path are T_0, P_0 and R respectively then which of the following is incorrect if the particle is projected at an angle θ_0 with the positive x–axis in x–y plane ?



(A) At $t = \frac{T_0}{2}$, co–ordinates of charge are $\left(\frac{P_0}{2}, 0, -2R_0\right)$

(B) At $t = \frac{3T_0}{2}$, co–ordinates of charges are $\left(\frac{3P_0}{2}, 0, 2R_0\right)$

(C) Two extremes from x–axis are at a distance $2R_0$ from each other

(D) Two extremes from x–axis are at a distance $4R_0$ from each other

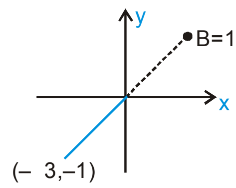
10. A uniform magnetic field of 1.5 T exists in a cylindrical region of radius 10.0 cm, it's direction being parallel to the axis along east to west. A current carrying wire in north south direction passes through this region. The wire intersects the axis and experience a force of 1.2 N downward. If the wire is turned from North South to north east–south west direction, then magnitude and direction of force is–

(A) 1.2 N, upward
(B) $1.2\sqrt{2}$ N, downward
(C) 1.2 N, downward
(D) $\frac{1.2}{\sqrt{2}}$ N, downward

11. There exists a uniform magnetic and electric field of magnitude 1 T and 1 V/m respectively along positive y–axis. A charged particle of mass 1 kg and of charge 1 C is having velocity 1 m/s along x–axis and is at origin at t = 0. Then the co–ordinates of particle at time π seconds will be–

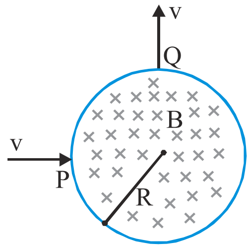
(A) (0, 1, 2)
(B) $(0, -\pi^2/2, -2)$
(C) $(2, \pi^2/2, 2)$
(D) $(0, \pi^2/2, 2)$

12. A uniform magnetic field of magnitude 1 T exists in region $y \geq 0$ is along $\hat{k}$ direction as shown. A particle of charge 1 C is projected from point $(-\sqrt{3}, -1)$ towards origin with speed 1 m/s. If mass of particle is 1 kg, then co–ordinates of centre of circle in which particle moves are



(A) $(1, \sqrt{3})$ **(B)** $(1, -\sqrt{3})$ **(C)** $\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$ **(D)** $\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$

13. A particle of charge 'q' and mass 'm' enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(S) is/are correct–



(A) $B = \frac{mv}{qR}$ **(B)** $T = \frac{\pi R}{2v}$ **(C)** $T = \frac{\pi m}{2qB}$ **(D)** None of these

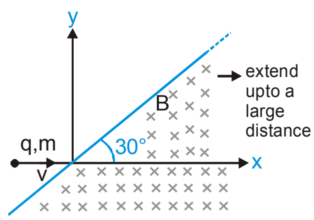
14. A charge particle of charge q, mass m is moving with initial velocity 'v' as shown in figure in a uniform magnetic field $-B\hat{k}$. Select the correct alternative/alternatives–

(A) Velocity of particle when it comes out from magnetic field is $\vec{v} = v\cos 30°\,\hat{i} - v\sin 30°\,\hat{j}$

(B) Time for which the particle was in magnetic field is $\frac{\pi m}{3qB}$

(C) Distance travelled in magnetic field is $\frac{\pi mv}{3qB}$

(D) The particle will never come out of magnetic field



15. H^+, He^+ and O^{2+} all having the same kinetic energy pass through a region in which there is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{2+} are 1 amu, 4 amu and 16 amu respectively. Then :

(A) H^+ will be deflected most **(B)** O^{2+} will be deflected most
(C) He^+ and O^{2+} will be deflected equally **(D)** All will be deflected equally

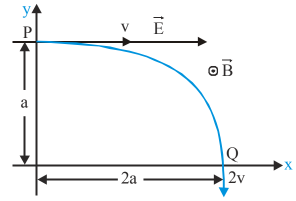
16. A particle of charge +q and mass m moving under the influence of a uniform electric field $E\hat{i}$ and uniform magnetic field $B\hat{k}$ follows a trajectory from P to Q as shown in figure. The velocities at P and Q are $v\hat{i}$ and $-2\hat{j}$, Which of the following statement(S) is/are correct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

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

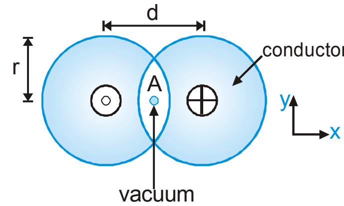
(B) Rate of work done by the electric field at P is $\frac{3}{4}\left[\frac{mv^3}{a}\right]$

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

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



17. Two long conductors are arranged as shown above to form overlapping cylinders, each of radius r, whose centers are separated 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 are the magnitude and direction of the magnetic field at point A?



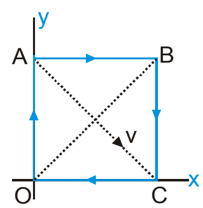
(A) $\left(\frac{\mu_0}{2\pi}\right)\pi dJ$, in the +y–direction **(B)** $\left(\frac{\mu_0}{2\pi}\right)\frac{d^2}{r}$, in the +y direction

(C) $\left(\frac{\mu_0}{2\pi}\right)\frac{4d^2J}{r}$, in the –y direction **(D)** $\left(\frac{\mu_0}{2\pi}\right)\frac{Jr^2}{d}$, in the –y direction

18. A particle of specific charge (charge/mass) α starts moving from the origin under the action of an electric field $\vec{E} = E_0\tilde{i}$ and magnetic field $\vec{B} = B_0\tilde{k}$. Its velocity at (x_0, y_0, 0) is $\left(4\tilde{i} - 3\tilde{j}\right)$. The value of x_0 is

(A) $\frac{13\alpha E_0}{2B_0}$ **(B)** $\frac{16\alpha B_0}{E_0}$ **(C)** $\frac{25}{2\alpha E_0}$ **(D)** $\frac{5\alpha}{2B_0}$

19. 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



(A) $\tilde{k}$ **(B)** $-\left(\frac{\tilde{i}+\tilde{j}}{\sqrt{2}}\right)$ **(C)** $-\tilde{k}$ **(D)** $\frac{\tilde{i}+\tilde{j}}{\sqrt{2}}$

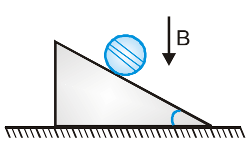
20. Two particles of charges +Q and –Q are projected from the same point with a velocity v in a region of uniform magnetic field B such that the velocity vector makes an angle θ with the magnetic field. Their masses are M and 2M, respectively. Then, they will meet again for the first time at a point whose distance from the point of projection is

(A) $\frac{2\pi Mv\cos\theta}{QB}$ **(B)** $\frac{8\pi Mv\cos\theta}{QB}$ **(C)** $\frac{\pi Mv\cos\theta}{QB}$ **(D)** $\frac{4\pi Mv\cos\theta}{QB}$

21. An electron moving with a velocity $\vec{v}_1 = 2\tilde{i}$ m/s at a point in a magnetic field experiences a force $\vec{F}_1 = -2\tilde{j}N$. If the electron is moving with a velocity $\vec{v}_2 = 2\tilde{j}$ m/s at the same point, it experiences a force $\vec{F}_2 = +2\tilde{i}N$. The force the electron would experience if it were moving with a velocity $\vec{v}_3 = 2\tilde{k}$ m/s at the same point is

(A) zero **(B)** $2\tilde{k}N$ **(C)** $-2\tilde{k}N$ **(D)** Information is insufficient

22. 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

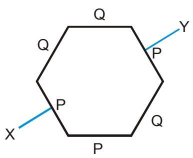


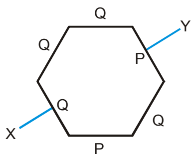
(A) $\frac{mg\cos\theta}{\pi iR}$ **(B)** $\frac{mg}{\pi iR}$ **(C)** $\frac{mg\tan\theta}{\pi iR}$ **(D)** $\frac{mg\sin\theta}{\pi iR}$

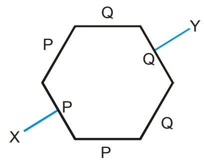
23. A conductor of length ℓ and mass m is placed along the east–west line on a table. Suddenly a certain amount of charge is passed through it and it is found to jump to a height h. The earth's magnetic induction is B. The charge passed through the conductor is

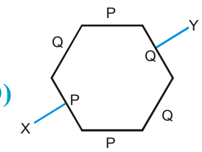
(A) $\frac{1}{Bmgh}$ **(B)** $\frac{\sqrt{2gh}}{B\ell m}$ **(C)** $\frac{gh}{B\ell m}$ **(D)** $\frac{m\sqrt{2gh}}{B\ell}$

24. 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

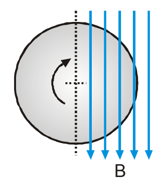
(A) 

(B) 

(C) 

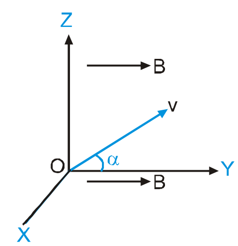
(D) 

25. 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

26. In a region of space, a uniform magnetic field B exists in the y–direction. A proton is fired from the origin, with its initial velocity v making a small angle α with the y–direction in the yz plane. In the subsequent motion of the proton



(A) its x–coordinate can never be positive
(B) its x– and z–coordinates cannot both be zero at the same time
(C) its z–coordinate can never be negative
(D) its y–coordinate will be proportional to the square of its time of flight

27. A charged particle of specific charge α is released from origin at time t = 0 with velocity $\vec{v} = v_0(\tilde{i} + \tilde{j})$ in uniform magnetic field $\vec{B} = B_0\tilde{i}$. Coordinates of the particle at time $t = \frac{\pi}{B_0\alpha}$ are

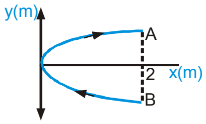
(A) $\left(\frac{v_0}{2B_0\alpha}, \frac{\sqrt{2}v_0}{\alpha B_0}, \frac{-v_0}{B_0\alpha}\right)$ **(B)** $\left(\frac{-v_0}{2B_0\alpha}, 0, 0\right)$ **(C)** $\left(0, \frac{2v_0}{B_0\alpha}, \frac{v_0\pi}{2B_0\alpha}\right)$ **(D)** $\left(\frac{v_0\pi}{B_0\alpha}, 0, \frac{-2v_0}{B_0\alpha}\right)$

28. A particle of charge per unit mass α is released from origin with velocity $\vec{v} = v_0\tilde{i}$ in a magnetic field $\vec{B} = -B_0\tilde{k}$ for $x \le \frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha}$ and $\vec{B} = 0$ for $x > \frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha}$. The x–coordinates of the particle at time $t\left(> \frac{\pi}{3B_0\alpha}\right)$ would be

(A) $\frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha} + \frac{\sqrt{3}}{2}v_0\left(t - \frac{\pi}{B_0\alpha}\right)$ **(B)** $\frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha} + v_0\left(t - \frac{\pi}{3B_0\alpha}\right)$

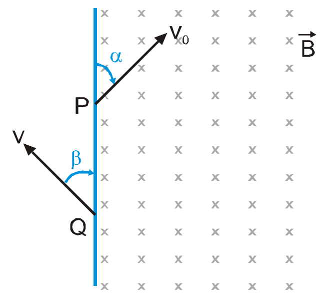
(C) $\frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha} + \frac{v_0}{2}\left(t - \frac{\pi}{3B_0\alpha}\right)$ **(D)** $\frac{\sqrt{3}}{2}\frac{v_0}{B_0\alpha} + \frac{v_0 t}{2}$

29. A conducting wire bent in the form of a parabola $y^2 = 2x$ carries a current i=2A as shown in figure. This wire is placed in a uniform magnetic field $\vec{B} = -4\hat{k}$ Tesla. The magnetic force on the wire is (in newton)



(A) $-16\hat{i}$ **(B)** $32\hat{i}$ **(C)** $-32\hat{i}$ **(D)** $16\hat{i}$

30. A particle of charge –q and mass m enters a uniform magnetic field $\vec{B}$ (perpendicular to paper inwards) 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 fig., then



(A) $\alpha = \beta$

(B) $v = v_0$

(C) $PQ = \dfrac{2mv_0 \sin\alpha}{Bq}$

(D) Particle remains in the field for time $t = \dfrac{2m(\pi - \alpha)}{Bq}$

31. A stationary, circular wall clock has a face with a radius of 15 cm. Six turns of wire are wounded around its perimeter, the wire carries a current 2.0 A in the clockwise direction. The clock is located, where there is a constant, uniform external magnetic field of 70 mT (but the clock still keeps perfect time) at exactly 1:00 pm, the hour hand of the clock points in the direction of the external magnetic field

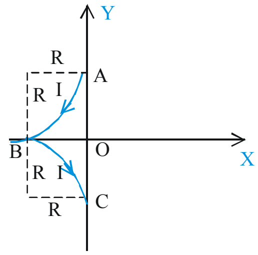
(A) Magnitude of the torque on the winding due to the magnetic field is 3.12×10^{-2} N–m.

(B) After 20 minutes the minute hand will point in the direction of the torque on the winding due to the magnetic field.

(C) Magnitude of the torque on the winding due to the magnetic field is 5.94×10^{-2} N–m.

(D) After 30 minutes the minute hand will point in the direction of the torque on the winding due to the magnetic field.

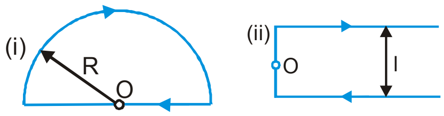
32. Conductor ABC consist of two quarter circular path of radius R lies in X–Y plane and carries current I as shown. A uniform magnetic field $\vec{B}$ is switched on in the region that exert force $\vec{F} = \sqrt{2}IRB_0\hat{k}$ on conductor ABC. $\vec{B}$ can be



(A) $\dfrac{B_0}{\sqrt{2}}(-\hat{i})$ **(B)** $\dfrac{B_0}{\sqrt{2}}\hat{i}$

(C) $\dfrac{B_0}{\sqrt{2}}(\hat{i} + \hat{j})$ **(D)** Both (B) and (C)

33. Find the magnitude and direction of a force vector acting on a unit length of a thin wire, carrying a current I = 8.0A, at a point O, if the wire is bent as shown in Figure (i) the curvature radius R = 10 cm. Figure (ii) the distance between the long parallel segments of the wire l= 20 cm. F_1 = force vector due to figure (i) F_2 = force vector due to figure (ii)



(A) $F_1 = 0.20$ mN/m **(B)** $F_2 = 0.13$ mN/m **(C)** $F_1 = 0.13$ mN/m **(D)** $F_2 = 0.20$ mN/m

34. Which of the following statement is correct ?

(A) A charge particle enters a region of uniform magnetic field at an angle 85° to magnetic lines of force. The path of the particle is a circle

(B) An electron and a 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

35. Consider the magnetic field produced by a finitely long current carrying wire

(A) The lines of field will be concentric circles with centres on the wire

(B) There can be two points in the same plane where magnetic fields are same

(C) There can be large number of points where the magnetic field is same

(D) The magnetic field at a point is inversely proportional to the distance of the point from the wire

36. Consider the following statements regarding a charged particle in a magnetic field. Which of the statements are true?

(A) Starting with zero velocity, it accelerates in a direction perpendicular to the magnetic field

(B) While deflection in magnetic field its energy gradually increases

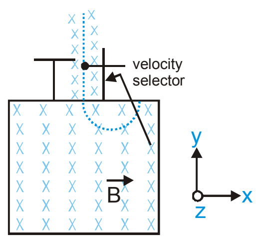
(C) Only the component of magnetic field perpendicular to the direction of motion of the charged particle is effective in deflecting it

(D) Direction of deflecting force on the moving charged particle is perpendicular to its velocity

37. 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

38. Two charged particle A and B each of charge +e and masses 12 amu and 13 amu respectively follow a circular trajectory in chamber X after the velocity selector as shown in the figure. Both particles enter the velocity selector with speed 1.5×10^6 ms^{-1}. A uniform magnetic field of strength 1.0 T is maintained within the chamber X and in the velocity selector.



(A) Electric field across the conducting plate of the velocity selector is -10^6 NC^{-1} $\tilde{i}$

(B) Electric field across the conducting plate of the velocity selector is 10^6 NC^{-1} $\tilde{i}$

(C) The ratio $\frac{r_A}{r_B}$ of the radii of the circular paths for the two particles is 12/13

(D) The ratio $\frac{r_A}{r_B}$ of the radii of the circular paths for the two particles is 13/12

39. A particle of charge q and velocity v passes undeflected through a space with non–zero electric field E and magnetic field B. The undeflecting conditions will hold if

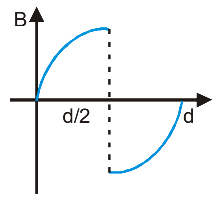
(A) signs of both q and E are reversed

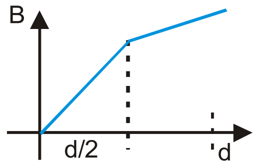
(B) signs of both q and B are reversed

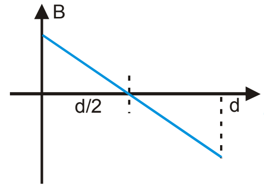
(C) both B and E are changed in magnitude, but keeping the product of $|B|$ and $|E|$ fixed.

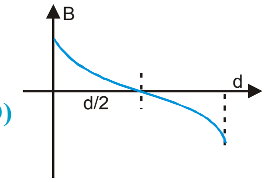
(D) both B and E are doubled in magnitude

40. 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 separated by a distance d. The variation of magnetic field B along a perpendicular line draw between the two beams is best represented by

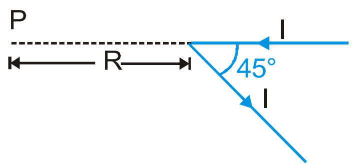
(A) 

(B) 

(C) 

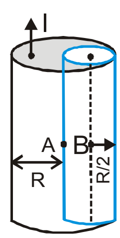
(D) 

41. A long straight wire, carrying current I, is bent at its midpoint to form an angle of 45°. Magnetic field at point P, distance R from point of bending is equal to



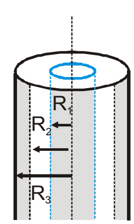
(A) $\dfrac{(\sqrt{2}-1)\mu_0 I}{4\pi R}$ (B) $\dfrac{(\sqrt{2}+1)\mu_0 I}{4\pi R}$ (C) $\dfrac{(\sqrt{2}+1)\mu_0 I}{4\sqrt{2}\pi R}$ (D) $\dfrac{(\sqrt{2}-1)\mu_0 I}{4\sqrt{2}\pi R}$

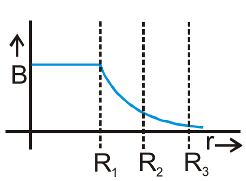
42. From a cylinder of radius R, a cylinder of radius R/2 is removed, as shown. Current flowing in the remaining cylinder is I. Magnetic field strength is–

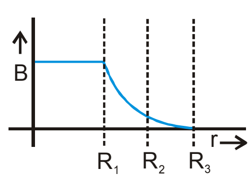


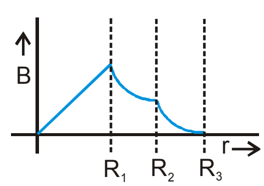
(A) zero at point A (B) zero at point B (C) $\dfrac{\mu_0 I}{3\pi R}$ at point A (D) $\dfrac{\mu_0 I}{3\pi R}$ at point B

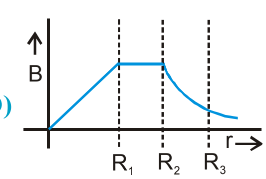
43. A coaxial cable is made up of two conductors. The inner conductor is solid and is of radius R_1 and the outer conductor is hollow of inner radius R_2 and outer radius R_3. The space between the conductors is filled with air. The inner and outer conductors are carrying currents of equal magnitudes and in opposite directions. Then the variation of magnetic field with distance from the axis is best plotted as



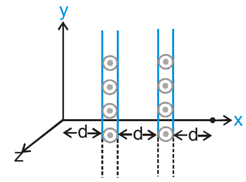
(A) 

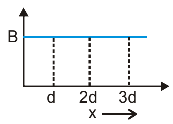
(B) 

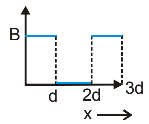
(C) 

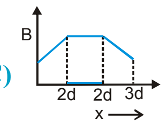
(D) 

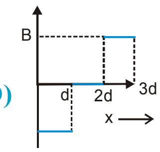
44. Two large conducting current planes perpendicular to x–axis are placed at (d, 0) and (2d, 0) as shown in figure. Current per unit width in both the planes is same and current is flowing in the outward direction. The variation of magnetic induction as function of 'x' ($0 \le x \le 3d$) is best represented by–



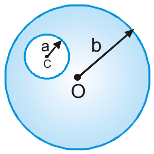
(A) 

(B) 

(C) 

(D) 

45. A long straight metal rod has a very long hole of radius 'a' drilled parallel to the rod axis as shown in the figure. If the rod carries a current 'i' find the value of magnetic induction on the axis of the hole, where OC=c



(A) $\frac{\mu_0 ic}{\pi\left(b^2-a^2\right)}$ **(B)** $\frac{\mu_0 ic}{2\pi\left(b^2-a^2\right)}$ **(C)** $\frac{\mu_0 i\left(b^2-a^2\right)}{2\pi c}$ **(D)** $\frac{\mu_0 ic}{2\pi a^2 b^2}$

46. A magnetic needle lying parallel to a magnetic field requires W unit of work to turn it through 60°. The torque needed to maintain the needle in this position will be–

(A) $\sqrt{3}$ W **(B)** W **(C)** ($\sqrt{3}$ /2)W **(D)** 2W

47. The magnetic moment of a short magnet is 8 Am^2 . The magnetic induction at a point 20cm away from its mid point on (i) axial point (ii) equatorial point respectively, will be :–

(A) 2×10^{-4} and 10^{-4} T **(B)** 3×10^{-4} and 2×10^{-4} T **(C)** 4×10^{-4} and 3×10^{-4} T **(D)** None of these

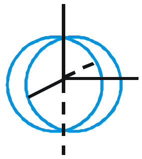
48. Two insulated rings, one of slightly smaller diameter than the other, are suspended along their common diameter as shown. Initially the planes of the rings are mutually perpendicular. When a steady current is set up in each of them.

(A) The two rings rotate into a common plane

(B) The inner ring oscillates about its initial position

(C) The outer ring stays stationary while the inner one moves into the plane of the outer ring

(D) The inner ring stays stationary while the outer one moves into the plane of the inner ring.



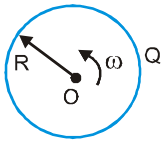
49. A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.16T experiences a torque of magnitude 0.032 J. The magnetic moment of the bar moment will be

(A) 0.23 J/T **(B)** 0.40 J/T **(C)** 0.80J/T **(D)** Zero

50. A electron experiences a force $\left(4.0\hat{i}+3.0\hat{j}\right)$ × 10^{-13} N in a uniform magnetic field when its velocity is $2.5\hat{k}\times10^{7}$ ms^{-1}. When the velocity is redirected and becomes $\left(1.5\hat{i}-2.0\hat{j}\right)\times10^{7}$ ms^{-1}, the magnetic force of the electron is zero. The magnetic field vector $\vec{B}$ is

(A) $-0.075\hat{i}+0.1\hat{j}$ **(B)** $0.1\hat{i}+0.075\hat{j}$ **(C)** $0.075\hat{i}-0.1\hat{j}+\hat{k}$ **(D)** $0.075\hat{i}-0.1\hat{j}$

51 A nonconducting disc having uniform positive charge Q, is rotating about its axis with uniform angular velocity ω. The magnetic field at the centre of the disc is–



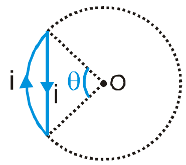
(A) directed outward **(B)** having magnitude $\frac{\mu_0 Q\omega}{4\pi R}$

(C) directed inwards **(D)** having magnitude $\frac{\mu_0 Q\omega}{2\pi R}$

52. 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)** $t = \frac{\sqrt{3}mv_0}{qE}$

53. Net magnetic field at the centre of the circle O due to a current carrying loop as shown in figure is $(\theta < 180°)$



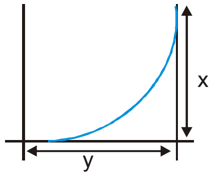
(A) zero

(B) perpendicular to paper inwards

(C) perpendicular to paper outwards

(D) is perpendicular to paper inwards if $\theta \le 90°$ and perpendicular to paper outwards if $90° \le \theta < 180°$

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



(A) $\frac{qBy}{2}$ **(B)** $\frac{qBy}{x}$ **(C)** $\frac{qB}{2}\left(\frac{y^2}{x} + x\right)$ **(D)** $\frac{qBy^2}{2x}$

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

(A) $\left[\frac{vB}{2\pi E}\right]$ is an integer **(B)** $\left(u^2 + v^2\right)^{1/2}\left[\frac{B}{\pi E}\right]$ is an integer

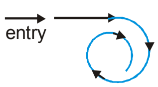
(C) $\left[\frac{vB}{\pi E}\right]$ in an integer **(D)** $\left[\frac{uB}{\pi E}\right]$ is an integer

56. 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

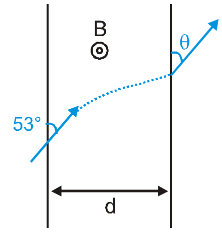
(3) The particle lost charge by ionising the air



(A) 1, 2, 3 are correct **(B)** 1, 2 only are correct

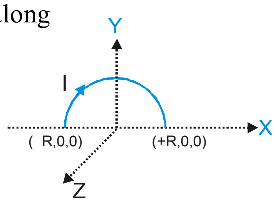
(C) 2, 3 only are correct **(D)** 1 only

57. 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) 37^0 **(B)** 60° **(C)** 90° **(D)** None

58. 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 $\vec{B} = \frac{B_0 x}{2R}\tilde{k}$ (here B_0 is +ve constant) is existing in the region. The magnetic force acting on semi circular wire will be along



(A) –x axis **(B)** +y–axis **(C)** –y axis **(D)** +x–axis

59. When a piece of a ferromagnetic substance is put in a uniform magnetic field. Flux density inside it is four times the flux density away from the piece. The magnetic permeability of the material is :-

(A) 1 **(B)** 2 **(C)** 3 **(D)** 4

60. Ferromagnetic substance contain :-

(A) empty subshell **(B)** partially empty subshell
(C) full fill subshell **(D)** none of these

61. Soft iron is used to make the core of transformer, because of its :

(A) low coercivity and low retentivity **(B)** low coercivity and high retentivity
(C) high coercivity and high retentivity **(D)** high coercivity and low retentivity

62. Susceptibility of a magnetic substance is found to depend on temperature and the strength of the magnetising field. The material is a :-

(A) Diamagnetic **(B)** Ferromagnetic **(C)** Paramagnetic **(D)** Superconductor

63. When a diamagnetic substances is inserted in a current carrying coil, then magnetic field is :-

(A) Decreased **(B)** Unchanged
(C) Increased **(D)** Increased or decreased depending upon the relative volume of the substance

64. The cause of paramagnetism is :-

(A) Unparied electrons **(B)** Electron excess and spin motion of electrons
(C) Paired electrons and orbital motion of electrons **(D)** Electrons and orbital motion of electrons

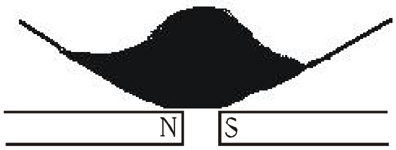
65. The cause of diamagnetism is :-

(A) Orbtital motion of electrons **(B)** Spin motion of electrons
(C) Paired electrons **(D)** None of the above

66. Which of the following statements is correct for diamagnetic materials :-
(A) $\mu_r < 1$ (B) χ is negative and low
(C) χ does not depend on temperature (D) All of the above

67. The area of B–H loop for soft iron, as compared to that for steel is :-
(A) More (B) Less (C) Equal (D) None of the above

68. The liquid in the watch glass in the following figure is :-



(A) Ferromagnetic (B) Paramagnetic (C) Diamagnetic (D) Nonmagnetic

69. Powerful permanent magnets are made of :-
(A) Cobalt (B) Aluminum (C) Tin–coal (D) Cobalt–steel

70. The value of magnetic susceptibility for super–conductors is :-
(A) Zero (B) Infinity (C) +1 (D) –1

71. A material rod, when placed in a strong magnetic field, aligns itself at right angles to the magnetic field. The nature of material is :-
(A) Diamagnetic (B) Paramagnetic (C) Ferromagnetic (D) Low ferromagnetic

72. The relative permeability of air is :-
(A) Zero (B) 1.04 (C) Infinity (D) 1

73. If the magnetic susceptibility of a magnetic material is – 0.004 then its nature will be :-
(A) Diamagnetic (B) Paramagnetic (C) Ferromagnetic (D) Non magnetic

74. The correct measure of magnetic hardness of a material is :-
(A) Ramnant magnetism (B) Hysteresis loss (C) Coercivity (D) Curic temperature

75. Steel is not attracted by a magnet, because steel is
(A) Non–magnetic (B) Unmagnetised (C) Diamagnetic (D) Ferromagnetic

76. If the magnetic dipole moment of an atom of diamagnetic material, paramagnetic material and ferromagnetic material are denoted by μ_d, μ_p and μ_f respectively, then :-
(A) $\mu_p = 0$ and $\mu_f \neq 0$ (B) $\mu_d \neq 0$ and $\mu_p = 0$ (C) $\mu_d \neq 0$ and $\mu_f \neq 0$ (D) $\mu_d = 0$ and $\mu_p \neq 0$

77. A frog can be levitated in a magnetic field produced by a current in a vertical solenoid placed below the frog. This is possible because the body of the frog behaves as :-
(A) paramagnetic. (B) diamagnetic (C) ferromagnetic (D) antiferromagnetic

78. Liquid oxygen remains suspended between two pole faces of a magnet because it is
(A) diamagnetic (B) paramagnetic (C) ferromagnetic (D) antiferromagnetic

79. The magnetic property inherent in all materials is
(A) Ferromagnetism (B) Diamagnetism (C) Paramagnetism (D) Non–magnetism

80. Cause of Ferromagnetism :-

(A) Orbital motion of electron **(B)** Spin motion of electron
(C) Permanent magnetic dipole moment **(D)** None

81. The magnetic susceptibility of a paramagnetic substance is 3×10^{-4}. It is placed in a magnetising field of 4×10^4 A/m. The intensity of magnetisation will be :-

(A) 3×10^8 A/m **(B)** 12×10^8 A/m **(C)** 12 A/m **(D)** 24 A/m

82. The volume susceptibility of a magnetic material is 30×10^{-4}. Its relative permeability will be :-

(A) 31×10^{-4} **(B)** 1.003 **(C)** 1.0003 **(D)** 29×10^{-4}

83. The magnetic moment of a magnet of mass 75 gm is 9×10^{-7} A-m^2. If the density of the material of magnet is 7.5×10^3 kg/m^3 then intensity of magnetisation will be :-

(A) 0.9 A/m **(B)** 0.09 A/m **(C)** 9 A/m **(D)** 90 A/m

84. The coercivity of a bar magnet is 100A/m. It is to be demagnetised by placing it inside a solenoid of length 100 cm and number of turns 50. The current flowing the solenoid will be

(A) 4A **(B)** 2A **(C)** 1A **(D)** zero

85. The space inside a toroid is filled with tungsten whose susceptibility is 6.8×10^{-5}. The percentage increase in the magnetic field will be :-

(A) 0.68% **(B)** 0.068% **(C)** 0.0068% **(D)** none of the above

86. A thin rectangular magnet suspended freely has a period of oscillation equal to T. Now it is broken into two equal halves (each having half of the original length) and one piece is made to oscillate freely in the same field. If its period of oscillation is T', the ratio T'/T is-

(A) $\frac{1}{2\sqrt{2}}$ **(B)** $\frac{1}{2}$ **(C)** 2 **(D)** $\frac{1}{4}$

87. The length of a magnet is large compared to its width and breadth. The time period of its oscillation in a vibration magnetometer is 2s. The magnet is cut along its length into three equal parts and three parts are then placed on each other with their like poles together. The time period of this combination will be-

(A) 2s **(B)** 2/3 s **(C)** $2\sqrt{3}$ s **(D)** $2/\sqrt{3}$ s

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement 2 (reason).

(A) Statement-1 is true, Statement-2 is true ; Statement-2 is correct explanation for Statement-1.
(B) Statement-1 is true, Statement-2 is true ; Statement-2 is NOT a correct explanation for statement-1.
(C) Statement-1 is true, Statement-2 is false.
(D) Statement-1 is false, Statement-2 is true.

1. **Statement 1 :** A direct uniformly distributed current flows through a solid long metallic cylinder along its length. It produces magnetic field only outside the cylinder .

Statement 2 : A thin long cylindrical tube carrying uniformly distributed current along its length does not produce a magnetic field inside it. Moreover, a solid cylinder can be supposed to be made up of many thin cylindrical tubes.

2. **Statement-1 :** A charged particle undergoes non-rectilinear motion in a constant magnetic field. The only force acting on the particle is the magnetic force. Then kinetic energy of this particle remains constant but momentum of the particle does not remains constant:

Statement-2 : A force that always acts on the particle in direction perpendicular to its velocity does no work on the particle. But whenever resultant force acts on the particle, linear momentum of the particle does not remains constant:

3. **Statement-1 :** A parallel beam of negatively charged particles passes undeflected through crossed electric and magnetic fields (neglect the electromagnetic interaction between the negatively charged particles). When the electric field is switched off, the beam splits up in several beams. This splitting is due to the particles in the beam having different velocities.

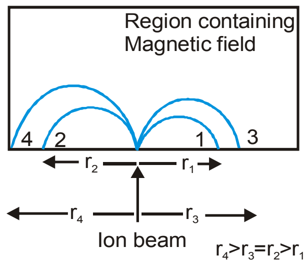
Statement-2 : For charged particles undergoing uniform circular motion in uniform magnetic field, radius of their path is directly proportional to speed. Hence charged particles with different speed may move in circular paths of different radii in a uniform magnetic field.

4. **Statement-1 :** Two charged particles are released from rest in gravity free space. After some time, one particle will exert a non-zero magnetic force on the other particle in addition to electrostatic force.

Statement-2 : A moving charge produces magnetic field. Also a magnetic force may act on a charged particle moving in an external magnetic field.

Exercise # 3 Part # I [Matrix Match Type Questions]

1. A beam consisting of four types of ions A, B, C and D enters a region that contains a uniform magnetic field as shown. The field is perpendicular to the plane of the paper, but its precise direction is not given.



ION	MASS	CHARGE
A	2m	e
B	4m	−e
C	2m	−e
D	m	+e

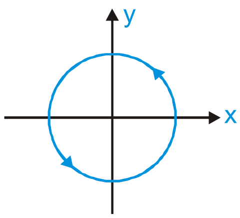
All ions in the beam travel with the same speed. The table below gives the masses and charges of the ions. The ions fall at different positions 1, 2, 3 and 4, as shown. Correctly match the ions with respective falling positions.

Table–I		Table–II	
(A)	A	**(P)**	1
(B)	B	**(Q)**	2
(C)	C	**(R)**	3
(D)	D	**(S)**	4

2. A charged particle is moving in a circular path in uniform magnetic field. Match the following :

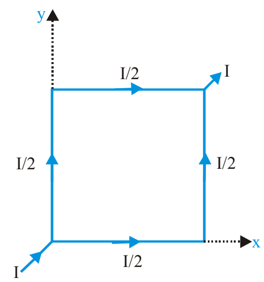
	Table–I		Table–II
(A)	Equivalent current due to motion of charge particle	**(P)**	is proportional to v
(B)	Magnetic moment	**(Q)**	is proportional to v^2
(C)	Magnetic field at centre of circle due to motion of charged particle	**(R)**	is proportional to v^0
		(S)	None

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



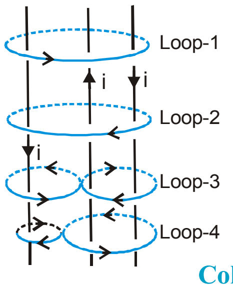
	Table–I		Table–II
(A)	Magnetic moment of the loop	**(P)**	zero
(B)	Torque on the loop	**(Q)**	maximum
(C)	Potential energy of the loop	**(R)**	along positive z–axis
(D)	Equilibrium of the loop	**(S)**	stable
		(T)	None

4. A square loop of uniform conducting wire is as shown in figure. A current I (in amperes) enters the loop from one end and exits the loop from opposite end as shown in figure. The length of one side of square loop is ℓ metre. The wire has uniform cross section area and uniform linear mass density. In four situation of column I, the loop is subjected to four different magnetic field. Under the conditions of column I, match the column I with corresponding results of column II. $\vec{B}$ in column–I is a positive non–zero constant)



	Column I		Column II
(A)	$\vec{B} = B_0\hat{i}$ in tesla	(P)	Magnitude of net force on loop is $\sqrt{2}$ $B_0 I \ell$ newton
(B)	$\vec{B} = B_0\hat{j}$ in tesla	(Q)	Magnitude of net force on loop is zero
(C)	$\vec{B} = B_0(\hat{i}+\hat{j})$ in tesla	(R)	Magnitude of net torque on loop about its centre is zero
(D)	$\vec{B} = B_0\hat{k}$ in tesla	(S)	Magnitude of net force on loop is $B_0 I \ell$ newton

5. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in figure.



	Column I		Column II
(A)	Along closed loop–1	(P)	$\oint \vec{B}.d\vec{\ell} = \mu_0 i$
(B)	Along closed loop–2	(Q)	$\oint \vec{B}.d\vec{\ell} = -\mu_0 i$
(C)	Along closed loop–3	(R)	$\oint \vec{B}.d\vec{\ell} = 0$
(D)	Along closed loop–4	(S)	Net work done by the magnetic force to move a unit charge along the loop is zero

6.

	Column I (Magnetic moment of)		Column II
(A)	a uniformly charged ring rotating uniformly about its axis	(P)	$\frac{q\omega r^2}{5}$
(B)	a charged particle rotating uniformly about a point	(Q)	$\frac{q\omega r^2}{4}$
(C)	a uniformly charged disk rotating uniformly about its axis	(R)	$\frac{q\omega r^2}{3}$
(D)	a uniformly charged spherical shell rotating uniformly about one of its diameter	(S)	$\frac{q\omega r^2}{2}$
(E)	a uniformly charged sphere rotating uniformly about one of its diameter	(T)	$q\omega r^2$

7.

	Column I		Column II
(A)	A charge at rest produces	(P)	Magnetic field
(B)	A charge moving with uniform velocity produces	(Q)	Electric field
(C)	An accelerated charge produces	(R)	Electromagnetic waves

Part # II [Comprehension Type Questions]

Comprehension # 1

In uniform magnetic field, if angle between $\vec{v}$ and $\vec{B}$ is $0° < \theta < 90°$, path of the particle is helix, with its axis parallel to $\vec{B}$ and plane perpendicular to $\vec{B}$. Here $\vec{v}$ is the velocity vector of the particle and $\vec{B}$ magnetic field vector. Let v_1 be the component of $\vec{v}$ along $\vec{B}$ and v_2 the component perpendicular to $\vec{B}$. Suppose p is the pitch, T the time period and r the radius of helix.

Then : $T = \frac{2\pi m}{Bq}$, $r = \frac{mv_2}{Bq}$ and $p = (v_1)$ (T).

A charged particle (q, m) is released from origin with velocity $\vec{v} = v_0\hat{i}$ in a uniform magnetic field $\vec{B} = \frac{B_0}{2}\hat{i} + \frac{\sqrt{3}B_0}{2}\hat{j}$.

1. Pitch of the helical path described by the particle is :

(A) $\frac{2\pi m v_0}{B_0 q}$ **(B)** $\frac{\sqrt{3}\pi m v_0}{2B_0 q}$ **(C)** $\frac{\pi m v_0}{B_0 q}$ **(D)** $\frac{2\sqrt{3}\pi m v_0}{B_0 q}$

2. z–component of velocity is $\frac{\sqrt{3}v_0}{2}$ after time t = ...

(A) $\frac{2\pi m}{B_0 q}$ **(B)** $\frac{\pi m}{B_0 q}$ **(C)** $\frac{\pi m}{2B_0 q}$ **(D)** $\frac{2\pi m}{4B_0 q}$

3. Maximum z–coordinate of the particle is :

(A) $\frac{\sqrt{3}mv_0}{B_0 q}$ **(B)** $\frac{2\sqrt{3}mv_0}{B_0 q}$ **(C)** $\frac{2mv_0}{B_0 q}$ **(D)** $\frac{mv_0}{B_0 q}$

4. When z–co–ordinate has its maximum value :

(A) $v_x = 0$ **(B)** $v_y = 0$

(C) Both (A) and (B) are correct **(D)** Both (A) and (B) are wrong

Comprehension # 2

Torque acting on a current loop in uniform magnetic field is given by $\vec{\tau} = \vec{M} \times \vec{B}$. But force on it is zero. If it is free to rotate then it will rotate about an axis passing through its centre of mass and parallel to $\vec{\tau}$. The potential energy of loop is given by $U = -\vec{M}.\vec{B}$.

A current carrying ring with its centre at origin and moment of inertia 2×10^{-2} kg–m^2 about an axis passing through its centre and perpendicular to its plane has magnetic moment $\vec{M} = (3\hat{i} - 4\hat{j})$ A–m^2. At time t = 0 a magnetic field $\vec{B} = (4\hat{i} - 3\hat{j})$ T is switched on.

1. Angular acceleration of the ring at time t = 0 in rad/s^2 is

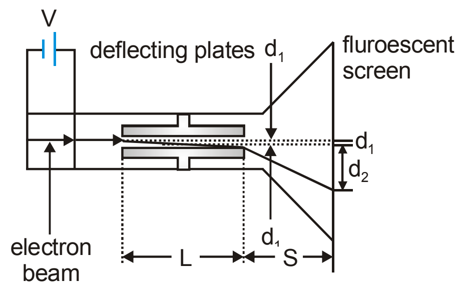
(A) 5000 **(B)** 1250 **(C)** 2500 **(D)** zero

2. Maximum angular velocity of the ring in rad/s will be :

(A) $50\sqrt{2}$ **(B)** $25\sqrt{2}$ **(C)** $100\sqrt{2}$ **(D)** $150\sqrt{2}$

Comprehension # 3

The following experiment was performed by J.J.Thomson in order to measure the ratio of the charge e to the mass m of an electron. Figure shows a modern version of Thomson's apparatus. Electrons emitted from a hot filament and accelerated by a potential difference V. As the electrons pass through the deflector plates, they encounter both electric and magnetic fields. When the electrons leave the plates they enter a field–free region that extends to the fluorescent screen. The beam of electrons can be observed as a spot of light on the screen. The entire region in which the electrons travel is evacuated with a vacuum pump.



Thomson's procedure was to first set both the electric and magnetic fields to zero, note the position of the undeflected electron beam on the screen, then turn on only the electric field and measure the resulting deflection. The deflection of an electron in an electric field of magnitude E is given by $d_1 = eEL^2/2mv^2$, where L is the length of the deflecting plates, and v is the speed of the electron. The deflection d_1 can also be calculated from the total deflection of the spot on the screen, $d_1 + d_2$, and the geometry of the apparatus.

In the second part of the experiment Thomson adjusted the magnetic field so as to exactly cancel the force applied by the electric field, leaving the electron beam undeflected. This gives eE = evB. By combining this relation with the expression for d_1 one can calculate the charge to mass ratio of the electron as a function of the known quantities.

The result is : $\frac{e}{m} = \frac{2d_1E}{B^2L^2}$

1. Why was it important for Thomson to evacuate the air from the apparatus ?

(A) Electrons travel faster in a vacuum, making the deflection d_1 smaller

(B) Electromagnetic waves propagate in a vacuum

(C) The electron collisions with the air molecules cause them to be scattered, and a focused beam will not be produced

(D) It was not important and could have been avoided

2. One might have considered a different experiment in which no magnetic field is needed. The ratio e/m can be calculated directly from the expression for d_1. Why might Thomson have introduced the magnetic field B in this experiment?

(A) To verify the correctness of the equation for the magnetic force

(B) To avoid having to measure the electron speed v

(C) To cancel unwanted effects of the electric field E

(D) To make sure that the electric does not exert a force on the electron

3. If the electron speed were doubled by increasing the potential difference V, which of the following would have to be true in order to correctly measure e/m ?

(A) The magnetic field would have to be cut in half in order to cancel the force applied by the electric field

(B) The magnetic field would have to be doubled in order to cancel the force applied by the electric field

(C) The length of the plates, L, would have to be doubled to keep the deflection, d_1, from changing

(D) Nothing needs to be changed

4. The potential difference V, which accelerates the electrons, also creates an electric field. Why did Thomson not consider the deflection caused by this electric field in his experiment ?

(A) This electric field is much weaker than the one between the deflecting plates and can be neglected

(B) Only the deflection, $d_1 + d_2$ caused by the deflecting plates is measured in the experiment

(C) There is no deflection from this electric field

(D) The magnetic field B cancels the force caused by this electric field

5. If the electron is deflected downward when only the electric field is turned on (as shown in figure), then in what directions do the electric and magnetic fields point in the second part of the experiment ?

(A) The electric field points to the bottom, while the magnetic field points into the page

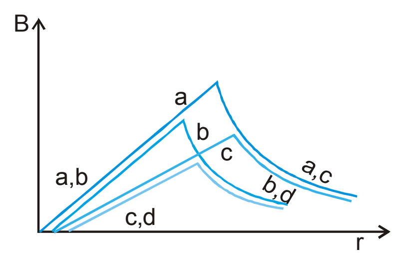
(B) The electric field points to the bottom, while the magnetic field points out of the page

(C) The electric field points to the top, while the magnetic field points into the page

(D) The electric field points to the top, while the magnetic field points out of the page

Comprehension # 4

Curves in the graph shown give, as functions of radial distance r, the magnitude B of the magnetic field inside and outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross–sections of the wires. Overlapping portions of the plots are indicated by double labels.



1. Which wire has the greatest radius ?

(A) a **(B)** b **(C)** c **(D)** d

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

(A) a **(B)** b **(C)** c **(D)** d

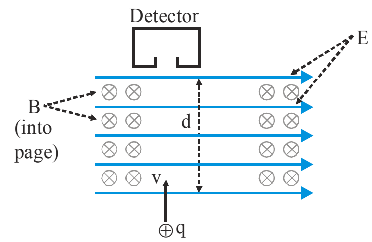
3. The current density in wire a is

(A) greater than in wire c **(B)** less than in wire c

(C) equal to that in wire c **(D)** not comparable to that of in wire c due to lack of information

Comprehension # 5

A velocity filter uses the properties of electric and magnetic fields to select charged particles that are moving with a specific velocity. Charged particles with varying speeds are directed into the filter as shown in figure. The filter consists of an electric field E and a magnetic field B, each of constant magnitude, directed perpendicular to each other as shown. The particles that move straight through the filter with their direction unaltered by the fields have the specific filter speed, v_0. Those with speeds to v_0 may experience sufficiently little deflection that they also enter the detector.



The charged particle will experience a force due to the electric field given by the relationship $\vec{F} = q\vec{E}$, where q is the charge of the particle and $\vec{E}$ is the electric field. The moving particle will also experience a force due to the magnetic field. This force acts to oppose the force due to the electric field. The strength of the force due to the magnetic field is given by the relationship $\vec{F} = q(\vec{v} \times \vec{B})$, where q is the charge of the particle, $\vec{v}$ is the speed of the particle, and $\vec{B}$ is the magnetic field strength. When the forces due to the two fields are equal and opposite, the net force on the particle will be zero, and the particle will pass through the filter with its path unaltered. The electric and magnetic field strengths can be adjusted to choose the specific velocity to be filtered. The effects of gravity can be neglected.

1. The electric and magnetic fields in the filter of figure are adjusted to detect particles with positive charge q of a certain speed, v_0. Which of the following expressions is equal to this speed ?

(A) $B/(q^2E)$ **(B)** $E/(q^2B)$ **(C)** B/E **(D)** E/B

2. Which of the following is true about the velocity filter shown in figure ?

(A) It would not work with negatively charged particles

(B) The wider the detector entrance, the more narrow the range of speed detected

(C) The greater the distance d, the more narrow the range of speeds detected

(D) The detector may not detect a charged particle with the desired filter speed if its charge is too high

3. Which of the following statements is true regarding a charged particle that is moving through the filter at a speed that is less than the filter speed ?

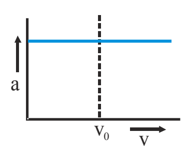
(A) It experiences a greater force due to the magnetic field than due to the electric field

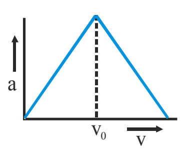
(B) It experiences a greater force due to the electric field than due to the magnetic field

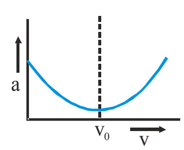
(C) It experiences equal force due to both fields but greater acceleration due to the electric field

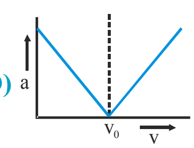
(D) It experiences equal force due to both fields but greater acceleration due to the magnetic field

4. Particles of identical mass and charge are sent through the filter at varying speeds, and the magnitude of acceleration of each particle is recorded as it first begins to be deflected. If the filter is set to detect particles of speed v_0, which one of the following is correct graph between acceleration and velocity of particle:

(A) 

(B) 

(C) 

(D) 

Comprehension # 6

There are two infinite parallel current carrying wire in vertical plane. Lower wire is fixed and upper wire is having a linear mass density λ. Two wires are carrying current I_1 and I_2. Now upper wire is placed in a magnetic field produced by lower wire. Magnetic field due to lower wire at the location of upper wire is $\frac{\mu_0 I}{2\pi d}$ where $I_1 \rightarrow$ current in lower wire, $d \rightarrow$ separation between wire. Force on any small portion of upper wire having length $d\ell$ is $dF = \frac{\mu_0 I_1 I_2 d\ell}{2\pi d}$ where $I_2 \rightarrow$ current in the upper wire. If directions of current in the wires are appropriate then upper wire can be in equilibrium if its weight is balanced by magnetic force. Now answer the following questions

1. Equilibrium separation between the two wires is

(A) $\frac{\mu_0 I_1 I_2}{4\pi\lambda_1 g}$ **(B)** $\frac{\mu_0 I_1 I_2}{2\pi\lambda g}$ **(C)** $\frac{\mu_0 I}{\pi\lambda g}$ **(D)** None of these

2. The upper wire can be in equilibrium if

(A) Direction of current in both wires is same

(B) Direction of current in both wires is opposite

(C) Equilibrium does not depend upon the direction of currents

(D) None of these

3. If upper wire is slightly displaced from its mean position and released, it will perform simple harmonic motion. As wire moves the total mechanical energy of wire

(A) Remains constant

(B) Changes

(C) We can't say anything about mechanical energy in magnetic field

(D) None of these

4. Consider wire at lower extreme position and upper extreme position. Kinetic energy of wire is zero at both the position then

(A) Gravitational potential energy is also same at both positions

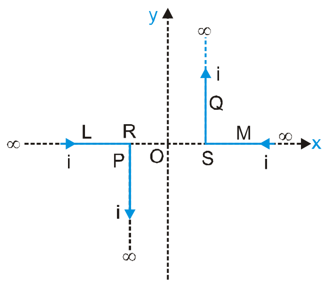
(B) Gravitation potential energy is different at both positions

(C) Gravitational potential energy change can be neglected because displacement of wire from the mean position is very small

(D) None of the above

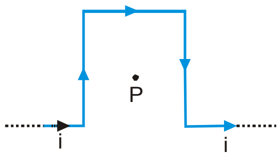
Exercise # 4 [Subjective Type Questions]

1. A pair of stationary and infinitely long bent wires are placed in the x-y plane as shown in figure. The wires carry currents of i = 10A each as shown. The segments L and M are along the x–axis. The segment P and Q are parallel to the y–axis such that OS = OR = 0.02 m. Find the magnitude and direction of the magnetic induction at the origin O.

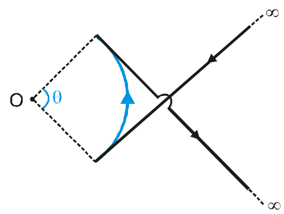


2. A current element $\Delta\vec{\ell} = \Delta x\,\hat{i} - \Delta y\,\hat{j}$ carries 10 A current. It is placed at origin. Calculate magnetic field at point 'P' which is at position vector $\vec{r} = (\hat{i} + \hat{j})$ m with respect to origin. (where $\Delta x = \Delta y$=1mm)

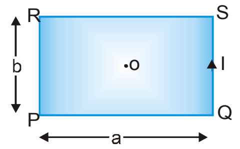
3. Find the magnetic field at the centre P of square of side a shown in figure.



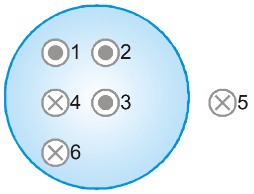
4. If magnetic field at point O is zero then find out the value of θ.



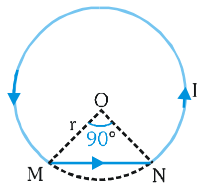
5. A rectangular loop of side a and b is carrying the current I, then find out the magnetic field at the centre of loop.



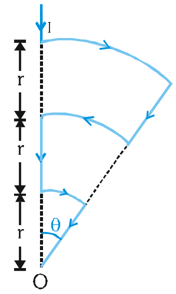
6. Six wires of current I_1 = 1A, I_2 = 2A, I_3 =3A, I_4 = 1A, I_5 = 5A and I_6 =4A cut the page perpendicularly at the points 1, 2, 3, 4 and 6 respectively as shown in the figure. Find the value of the integral $\oint \vec{B}.d\vec{\ell}$ around the closed path.



7. Calculate magnetic field at point 'O' of current distribution, where I = 3.14A and r = 6.28 cm.



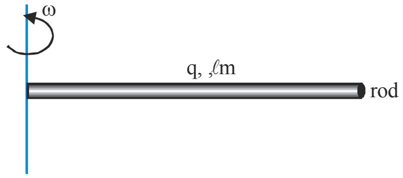
8. A conductor carrying a current I is shown in the figure. Calculate the magnetic field intensity at the point O (common centre of all the three arcs).



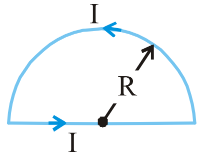
9. A circular coil of 20 turns and radius 10 cm is placed in a uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in the coil is 5.0 A, what is the average force on each electron in the coil due to the magnetic field? (The coil is made of copper wire of cross–sectional area $10^{-5} m^2$, and the free electron density in copper is given to be about 10^{29} m^{-3}.)

10. The coil is placed in a vertical plane and is free to rotate about a horizontal axis which coincides with its diameter. A uniform magnetic field of 2T in the horizontal direction exists such that initially the axis of the coil is in the direction of the field. The coil rotates through an angle of 90° under the influence of the magnetic field.
(i) What are the magnitudes of the torques on the coil in the initial and final position ?
(ii) What is the angular speed acquired by the coil when it has rotated by 90° ? The M.I. of the coil is 0.1 kg m^2.

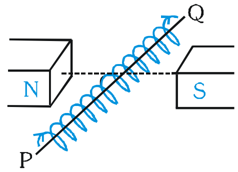
11. Calculate magnetic moment of shown system.



12. A straight wire of length 'ℓ' carries 'I' current is moulded in the form of semicircle loop then find out its magnetic moment (see figure).



13. A Closely – wound solenoid of 1000 turns and area of cross – section 2×10^{-4} m^2 carries a current of 2.0 ampere. It is placed with its horizontal axis at 30° with the direction of a uniform horizontal magnetic field of 0.16 T as shown in figure



(i) What is the torque experienced by the solenoid ?
(ii) What is the amount of work done to rotate the solenoid from stable orientation to unstable orientation

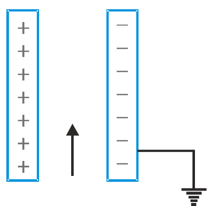
14. A closely wound solenoid of 2000 turns and area of cross–section 1.6×10^{-4} m^2, carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane.

(i) What is the magnetic moment associated with the solenoid ?

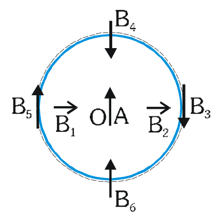
(ii) What is the force and torque on the solenoid if a uniform horizontal magnetic field of 7.5×10^{-2} T is set up at an angle of 30° with the axis of the solenoid ?

15. A potential difference of 600 V is applied across the plates of a parallel plate condenser. The separation between the plates is 3 mm. An electron projected vertically, parallel to the plates, with a velocity of 2×10^6 m/s moves undeflected between the plates. Find the magnitude and direction of the magnetic field in the region between the condenser plates.

(Neglect the edge effects). (Charge of the electron = 1.6×10^{-19}C)



16. Figure shows a small magnetised needle A placed at a point O, the arrow shows the direction of its magnetic moment. The other arrows show different positions (and orientation of the magnetic moment) of another identical magnetised needle B.



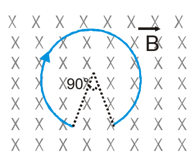
(i) In which configurations is the system not in equilibrium ?

(ii) In which configuration is the system in stable, and unstable equilibrium ?

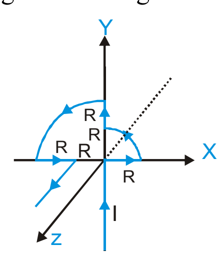
(iii) Which configuration corresponds to the lowest potential energy among all the configurations shown ?

17. A beam of protons with a velocity 4×10^5 m/s enters a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. Find the radius of the helical path taken by the proton beam. Also find the pitch of the helix (which is the distance travelled by a proton in the beam parallel to the magnetic field during one period of rotation).

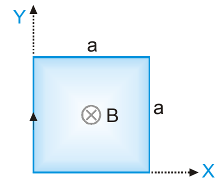
18. An arc of a circular loop of radius R is kept in the horizontal plane and a constant magnetic field B is applied in the vertical direction as shown in the figure. If the arc carries current I then find the force on the arc.



19. Find the magnetic induction at the origin in the figure shown.



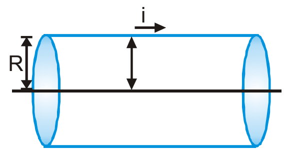
20. A rectangular loop of wire is oriented with the left corner at the origin, one edge along X–axis and the other edge along Y–axis as shown in the figure. A magnetic field is into the page and has a magnitude that is given by $\beta = \alpha y$ where α is constant. Find the total magnetic force on the loop if it carries current i.



21. Electric charge q is uniformly distributed over a rod of length ℓ. The rod is placed parallel to a long wire carrying a current i. The separation between the rod and the wire is a. Find the force needed to move the rod along its length with a uniform velocity v.

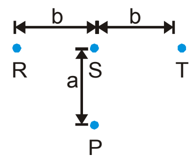
22. A proton beam passes without deviation through a region of space where there are uniform transverse mutually perpendicular electric and magnetic field with E and B. Then the beam strikes a grounded target. Find the force imparted by the beam on the target if the beam current is equal to I.

23. A cylindrical conductor of radius R carries a current along its length. The current density J, however, it is not uniform over the cross section of the conductor but is a function of the radius according to J=br, where b is a constant. Find an expression for the magnetic field B. (i) at $r_1 < R$ & (ii) at distance $r_2 > R$, measured from the axis

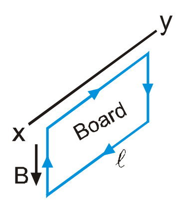


24. An infinite wire, placed along z–axis, has current I_1 in positive z–direction. A conducting rod placed in xy plane parallel to y–axis has current I_2 in positive y–direction. The ends of the rod subtend $+30^0$ and -60^0 at the origin with positive x–direction. The rod is at a distance a from the origin. Find net force on the rod.

25. Three infinitely long conductors R, S and T are lying in a horizontal plane as shown in the figure. The currents in the respective conductors are $I_R = I_0 \sin\left(\omega t + \frac{2\pi}{3}\right)$ $I_S = I_0 \sin(\omega t)$ $I_T = I_0 \sin\left(\omega t - \frac{2\pi}{3}\right)$. Find the amplitude of the vertical component of the magnetic field at a point P, distance 'a' away from the central conductor S.

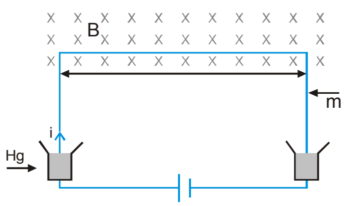


26. A square cardboard of side ℓ and mass m is suspended from a horizontal axis XY as shown in figure. A single wire is wound along the periphery of board and carrying a clockwise current I. At t=0, a vertical downward magnetic field of induction B is switched on. Find the minimum value of B so that the board will be able to rotate up to horizontal level.

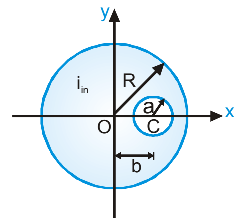


27. A neutral particle is at rest in uniform magnetic field $\vec{B}$. At t = 0, particle decays into two particles each of mass 'm' and one of them having charge 'q'. Both of these move off in separate paths lying in plane perpendicular to $\vec{B}$. At later time, the particles collide. Find this time of collision neglecting the interaction force.

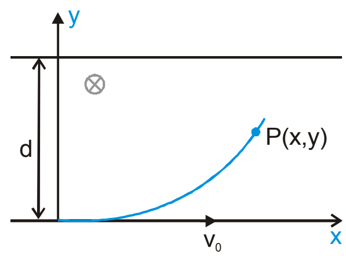
28. A U–shaped wire of mass m and length ℓ is immersed with its two ends in mercury (see figure). The wire is in a homogeneous field of magnetic induction B. If a charge, that is, a current pulse $q = \int idt$, is sent through the wire, the wire will jump up. Calculate, from the height h that the wire reaches, the size of the charge or current pulse, assuming that the time of the current pulse is very small in comparison with the time of flight. Make use of the fact that impulse of force equals $\int Fdt = mv$. Evaluate q for $B = 0.1$ Wb/m^2, m=10 gm, $\ell = 20$cm & h = 3 m. [$g = 10$ m/s^2]



29. A very long straight conductor has a circular cross–section of radius R and carries a current density J. Inside the conductor there is a cylindrical hole of radius a whose axis is parallel to the axis of the conductor and a distance b from it. Let the z–axis be the axis of the conductor, and let the axis of the hole be at x=b. Find the magnetic field **(i)** on the x=axis at x=2R **(ii)** on the y= axis at y=2R



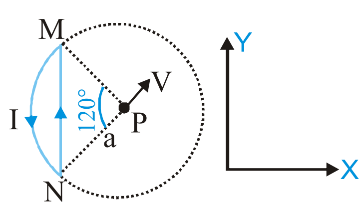
30. A non–uniform magnetic field $\vec{B} = B_0\left(1+\frac{y}{d}\right)\hat{k}$ is present in region of space in between y = 0 and y = d. The lines are shown in the diagram. A particle of mass 'm' and positive charge 'q' is moving. Given an initial velocity $\vec{v} = v_0\hat{i}$. Find the components of velocity of the particle when leaves the field.



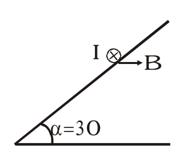
31. **(i)** A rigid circular loop of radius r & mass m lies in the xy plane on a flat table and has a current I flowing in it. At this particular place, the earth's magnetic field is $\vec{B} = \vec{B}_x\hat{i} + \vec{B}_y\hat{j}$. How large must I be before one edge of the loop will lift from table? **(ii)** Repeat if, $\vec{B} = \vec{B}_x\hat{i} + \vec{B}_z\hat{k}$.

32. A particle of mass 1×10^{-26} kg and charge $+1.6 \times 10^{-19}$ C travelling with a velocity 1.28×10^6 m/s in the +x direction enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present such that $E_x = E_y = 0$, $E_z = -102.4$ kV/m and $B_x = B_z = 0$, $B_y = 8 \times 10^{-2}$ weber/m². The particle enters this region at the origin at time t = 0. Determine the location (x, y and z coordinates) of the particle at $t = 5 \times 10^{-6}$ s. If the electric field is switched off at this instant (with the magnetic field still present), what will be the position of the particle at $t = 7.45 \times 10^{-6}$ s ?

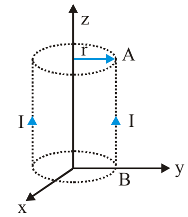
33. A wire loop carrying current I is placed in the X–Y plane as shown in the figure **(i)** If a particle with charge +Q and mass m is placed at the centre P and given a velocity along NP (figure). Find its instantaneous acceleration. **(ii)** I an external uniform magnetic induction field $\vec{B} = B\hat{i}$ is applied, find the torque acting on the loop due to the field.



34. The figure shows a conductor of weight 1.0 N and length L = 0.5m placed on a rough inclined plane making an angle 30° with the horizontal so that conductor is perpendicular to a uniform horizontal magnetic field of induction B=0.10 T. The coefficient of static friction between the conductor and the plane is 0.1. A current of I=10 A flows through the conductor inside the plane of this paper as shown. What is the force needed to be the applied parallel to the inclined plane to sustaining the conductor at rest?

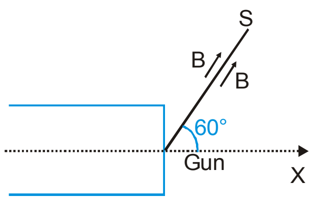


35. Find the work and power required to move the conductor of length ℓ shown in the figureone full turn in the anticlockwise direction at a rotational frequency of n revolutions per second if the magnetic field is of magnitude B_0 every where and points radially outwards from Z–axis. The figure shows the surface traced by the wire AB.



36. A square of side a is carrying the current I. Then prove that the ratio of magnetic fields due to it are at centre to the vertex is 8:1.

37. An electron gun G emits electron of energy 2kev travelling in the +ve direction. The electron are required to hit the spot S where GS =0.1 m & the line GS makes an angle of 60° with the x–axis, as shown in the figure. A uniform magnetic field $\vec{B}$ parallel to GS exists in the region outsides to electron gun. Find the minimum value of B needed to make the electron hit at S.

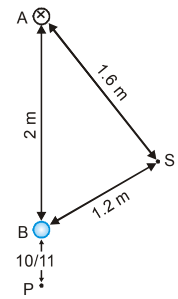


38. Two long straight parallel wires are 2 m apart, perpendicular to the plane of the paper. The wire A carries a current of 9.6 A, directed into the plane of the paper. The wire B carries a current such that the magnetic field of induction at the point P, at a distance of 10/11 m from the wire B, is zero. Find :

(i) The magnitude and direction of the current in B.

(ii) The magnitude of the magnetic field due to induction at the point S.

(iii) The force per unit length on the wire B.

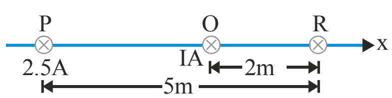


39. Two concentric circular coils X and Y of radii 16 cm and 10 cm, respectively, lie in the same vertical plane containing the north to south direction. Coil X has 20 turns and carries a current of 16 A; coil Y has 25 turns and carries a current of 18 A. The sense of the current in X is anticlockwise, and clockwise in Y, for an observer looking at the coils facing west. Give the magnitude and direction of the net magnetic field due to the coils at their centre.

40. Two coils each of 100 turns are held such that one lies in the vertical plane with their centres coinciding. The radius of the vertical coil is 20 cm and that of the horizontal coil is 30 cm. Ho would you neutralize the magnetic field of the earth at their common centre? What is the current to be passed through each coil? Horizontal component of earth's magnetic induction = 3.49×10^{-5} T and angle of dip = 30°.

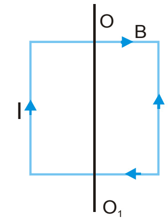
41. Two long parallel wires carrying currents 2.5 A and I (amperes) in the same direction (directed into the plane of the paper) are held at P and Q respectively such that they are perpendicular to the plane of paper. The points P and Q are located at the distance of 5 m and 2 m repetitively from a collinear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

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



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

42. A square current carrying loop made of thin wire and having a mass m=10 g can rotate without friction with respect to the vertical axis OO_1, passing through the centre of the loop at the right angles to two opposite sides of the loop. The loop is placed in a homogeneous magnetic field with an induction $B=10^{-1}$ T directed at right angles to the plane of the drawing. A current I =2A is flowing in the loop. Find the period of small oscillations that the loop performers about its position of stable equilibrium.



Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. If in a circular coil A of radius R, current i is flowing and in another coil B of radius 2R a current 2i is flowing, then the ratio of the magnetic fields, B_A and B_B produced by them will be- **[AIEEE - 2002]**

(1) 1 (2) 2 (3) 1/2 (4) 4

2. If an electron and a proton having same momentum enter perpendicularly to a magnetic field, then-

(1) curved path of electron and proton will be same (ignoring the sense of revolution) **[AIEEE - 2002]**

(2) they will move undeflected

(3) curved path of electron is more curved than that of proton

(4) path of proton is more curved

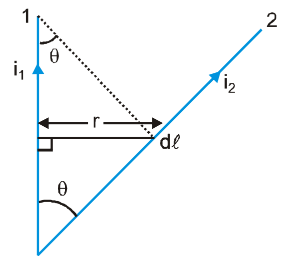
3. If a current is passed through a spring then the spring will- **[AIEEE - 2002]**

(1) expand (2) compress (3) remain same (4) none of these

4. The time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of its- **[AIEEE - 2002]**

(1) speed (2) mass (3) charge (4) magnetic induction

5. 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 $d\ell$ of wire 2 at a distance r from wire 1(as shown in figure) due to the magnetic field of wire 1 ?



(1) $\frac{\mu_0}{2\pi r} i_1 i_2\, d\ell \tan\theta$ (2) $\frac{\mu_0}{2\pi r} i_1 i_2 d\ell \sin\theta$ (3) $\frac{\mu_0}{2\pi r} i_1 i_2\, d\ell \cos\theta$ (4) $\frac{\mu_0}{4\pi r} i_1 i_2\, d\ell \sin\theta$

6. A particle of mass M and charge Q moving with velocity $\vec{v}$ describes a circular path of radius R when subjected to a uniform transverse magnetic field of induction B. The work done by the field when the particle completes one full circle is **[AIEEE - 2003]**

(1) $\left(\frac{Mv^2}{R}\right) 2\pi R$ (2) zero (3) BQ $2\pi R$ (4) BQv $2\pi R$

7. A particle of charge -16×10^{-18} C moving with velocity 10 ms^{-1} along the x-axis enters a region where a magnetic field of induction B is along the y-axis and an electric field of magnitude 10^4 V/m is along the negative z-axis If the charged particle continues moving along the x-axis, the magnitude of B is- **[AIEEE - 2003]**

(1) 10^3 Wb/m^2 (2) 10^5 Wb/m^2 (3) 10^{16} Wb/m^2 (4) 10^{-3} Wb/m^2

8. A magnetic needle laying parallel to a magnetic field requires W unit of work to turn it through 60°. The torque needed to maintain the needle in this position will be- **[AIEEE - 2003]**

(1) $\sqrt{3}$ W **(2)** W **(3)** ($\sqrt{3}$/2)W **(4)** 2W

9. The magnetic lines of force inside a bar magnet: **[AIEEE - 2003]**

(1) are from north-pole to south-pole of the magnet

(2) do not exist

(3) depend upon the area of cross-section of the bar magnet

(4) are from south-pole to north-pole of the magnet

10. A current i A flows along an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is- **[AIEEE - 2004]**

(1) infinite **(2)** zero **(3)** $\frac{\mu_0}{4\pi}.\frac{2i}{r}$ T **(4)** $\frac{2i}{r}$ T

11. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is B. It is then bent into a circular loop of n turns. The magnetic field at the centre of the coil will be- **[AIEEE - 2004]**

(1) nB **(2)** n^2B **(3)** 2nB **(4)** $2n^2B$

12. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of the loop ? **[AIEEE - 2004]**

(1) 250 μT **(2)** 150 μT **(3)** 125 μT **(4)** 75 μT

13. Two long conductors, separated by a distance d carry currents 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 new value of the force between them is- **[AIEEE - 2004]**

(1) – 2F **(2)** F/3 **(3)** – 2F/3 **(4)** –F/3

14. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milli ampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 V, the resistance in Ohm's needed to be connected in series with the coil will be- **[AIEEE - 2005]**

(1) 10^3 **(2)** 10^5 **(3)** 99995 **(4)** 9995

15. Two thin, long, parallel wires, separated by a distance d carry a current of '*i*' in the same direction. They will **[AIEEE - 2005]**

(1) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$ **(2)** repel each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$

(3) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$ **(4)** repel each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$

16. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3A and 4A are the currents flowing in each coil respectively. The magnetic induction in Wb/m^2 at the centre of the coils will be- ($\mu_0 = 4\pi \times 10^{-7}$ Wb/Am) **[AIEEE - 2005]**

(1) 12×10^{-5} **(2)** 10^{-5} **(3)** 5×10^{-5} **(4)** 7×10^{-5}

17. A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is- **[AIEEE - 2005]**

(1) $\frac{2\pi mq}{B}$ **(2)** $\frac{2\pi q^2 B}{m}$ **(3)** $\frac{2\pi qB}{m}$ **(4)** $\frac{2\pi m}{qB}$

18. A magnetic needle is kept in a non-uniform magnetic field. It experiences- **[AIEEE - 2005]**

(1) a torque but not a force **(2)** neither a force nor a torque

(3) a force and a torque **(4)** a force but not a torque

19. In a region, steady and uniform electric and magnetic fields are present. These two fields are parallel to each other. A charged particle is released from rest in this region. The path of the particle will be a-**[AIEEE - 2006]**

(1) helix **(2)** straight line **(3)** ellipse **(4)** circle

20. A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is 6.28×10^{-2} weber/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- **[AIEEE-2006]**

(1) 1.05×10^{-2} weber/m^2 **(2)** 1.05×10^{-5} weber/m^2

(3) 1.05×10^{-3} weber/m^2 **(4)** 1.05×10^{-4} weber/m^2

21. A long straight wire of radius a carries a steady current i. The current is uniformly distributed across its cross-section. The ratio of the magnetic field at a/2 and 2a is- **[AIEEE - 2007]**

(1) $\frac{1}{4}$ **(2)** 4 **(3)** 1 **(4)** $\frac{1}{2}$

22. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then- **[AIEEE - 2007]**

(1) the magnetic field is zero only on the axis of the pipe

(2) the magnetic field is different at different points inside the pipe

(3) the magnetic field at any point inside the pipe is zero

(4) the magnetic field at all points inside the pipe is the same, but not zero

23. A charged particle with charge q enters a region of constant, uniform and mutually orthogonal fields $\vec{E}$ and $\vec{B}$ with a velocity $\vec{V}$ perpendicular to both $\vec{E}$ and $\vec{B}$, and comes out without any change in magnitude or direction of $\vec{V}$. Then- **[AIEEE - 2007]**

(1) $\vec{V} = \vec{E} \times \vec{B}/B^2$ **(2)** $\vec{V} = \vec{B} \times \vec{E}/B^2$ **(3)** $\vec{V} = \vec{E} \times \vec{B}/E^2$ **(4)** $\vec{V} = \vec{B} \times \vec{E}/E^2$

24. Two identical conducting wires AOB and COD are placed at right angles to each other. The wire AOB carries an electric current I_1 and COD carries a current I_2. The magnetic field on a point lying at a distance d from O, in a direction perpendicular to the plane of the wires AOB and COD, will be given by- **[AIEEE - 2007]**

(1) $\frac{\mu_0}{2\pi}\left(\frac{I_1 + I_2}{d}\right)^{1/2}$ **(2)** $\frac{\mu_0}{2\pi d}\left(I_1^2 + I_2^2\right)^{1/2}$ **(3)** $\frac{\mu_0}{2\pi d}(I_1 + I_2)$ **(4)** $\frac{\mu_0}{2\pi d}\left(I_1^2 + I_2^2\right)$

25. A charged particle moves through a magnetic field perpendicular to its direction.Then- **[AIEEE - 2007]**

(1) the momentum changes but the kinetic energy is constant

(2) both momentum and kinetic energy of the particle are not constant

(3) both momentum and kinetic energy of the particle are constant

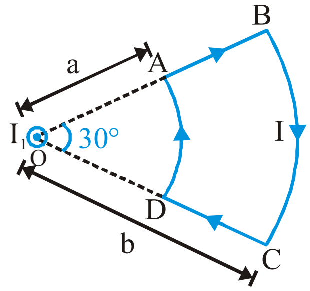
(4) kinetic energy changes but the momentum is constant

26. A horizontal overhead powerline 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 one the ground is(μ_0 = $4\pi \times 10^{-7}$TmA^{-1}) **[AIEEE - 2008]**

(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

Direction :- Question number 27 and 28 are based on the following paragraph.

A current loop ABCD is held fixed on the plane of the paper as shown in the figure. The arcs BC (radius = b) and DA (radius = a) of the loop are joined by two straight wires AB and CD. A steady current I is flowing in the loop. Angle made by AB and CD at the origin O is 30°. Another straight thin wire with steady current I_1 flowing out of the plane of the paper is kept at the origin.



27. The magnitude of the magnetic field **(B)** due to the loop ABCD at the origin (O) is :- **[AIEEE - 2009]**

(1) $\frac{\mu_0 I}{4\pi}\left[\frac{b-a}{ab}\right]$ **(2)** $\frac{\mu_0 I}{4\pi}\left[2(b-a)+\frac{\pi}{3}(a+b)\right]$ **(3)** Zero **(4)** $\frac{\mu_0 I(b-a)}{24ab}$

28. Due to the presence of the current I_1 at the origin:- **[AIEEE - 2009]**

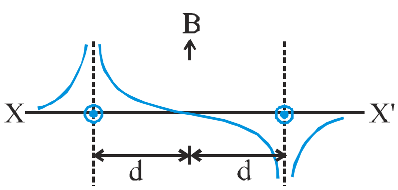
(1) The magnitude of the net force on the loop is given by $\frac{I_1 I}{4\pi}\mu_0\left[2(b-a)+\frac{\pi}{3}(a+b)\right]$

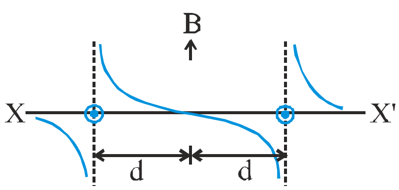
(2) The magnitude of the net force on the loop is given by $\frac{\mu_0 I\, I_1}{24ab}(b-a)$

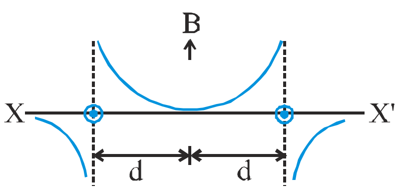
(3) The forces on AB and DC are zero

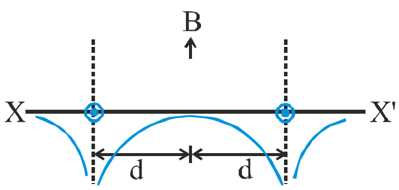
(4) The forces on AD and BC are zero

29. Two long parallel wires are at a distance 2d apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by:- **[AIEEE - 2010]**

(1)


(2)


(3)


(4)


30. A current I flows in an infinity long wire with cross section in the from of a semicircular ring of radius R. the magnitude of the magnetic induction along its axis is :- **[AIEEE - 2011]**

(1) $\frac{\mu_0 I}{2\pi R}$ **(2)** $\frac{\mu_0 I}{4\pi R}$ **(3)** $\frac{\mu_0 I}{\pi^2 R}$ **(4)** $\frac{\mu_0 I}{2\pi^2 R}$

31. An electric charge + q moves with velocity $\vec{V} = 3\hat{i} + 4\hat{j} + \hat{k}$, in an electromagnetic field given by :- $\vec{E} = 3\hat{i} + \hat{j} + 2\hat{k}$

$\vec{B} = \hat{i} + \hat{j} - 3\hat{k}$. The y-component of the force experienced by + q is :- **[AIEEE - 2011]**

(1) 2 q **(2)** 11 q **(3)** 5 q **(4)** 3q

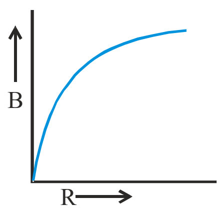
32. A thin circular disk of radius R is uniformly charged with density $\sigma > 0$ per unit area. The disk rotates about its axis with a uniform angular speed ω. The magnetic moment of the disk is :- **[AIEEE - 2011]**

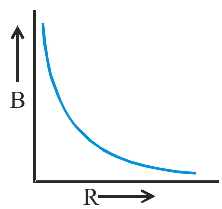
(1) $2\pi R^4\sigma\omega$ **(2)** $\pi R^4\sigma\omega$ **(3)** $\frac{\pi R^4}{2}\sigma\omega$ **(4)** $\frac{\pi R^4}{4}\sigma\omega$

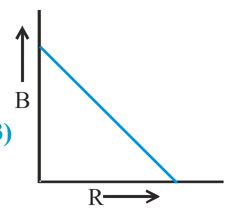
33. Proton, Deuteron and alpha particle of the same kinetic energy are moving in circular trajectories in a constant magnetic field. The radii of proton, deuteron and alpha particle are respectively r_p, r_d and r_α. Which one of the following relations is correct ? **[AIEEE - 2012]**

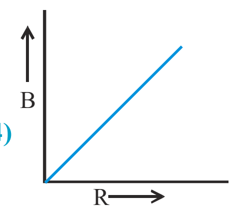
(1) $r_\alpha = r_d > r_p$ **(2)** $r_\alpha = r_d = r_p$ **(3)** $r_\alpha = r_p < r_d$ **(4)** $r_\alpha > r_d > r_p$

34. A charge Q is uniformly distributed over the surface of non-conducting disc of radius R. The disc rotates about an axis perpendicular to its plane and passing through its centre with an angular velocity ω. As a result of this rotation a magnetic field of induction B is obtained at the centre of the disc. If we keep both the amount of charge placed on the disc and its angular velocity to be constant and vary the radius of the disc then the variation of the magnetic induction at the centre of the disc will be represented by the figure :- **[AIEEE - 2012]**

(1)


(2)


(3)


(4)


0

35. Two short bar magnets of length 1 cm each have magnetic moments 1.20 Am^2 and 1.00 Am^2 respectively. They are placed on a horizontal table parallel to each other with their N poles pointing towards the South. They have a common magnetic equator and are separated by a distance of 20.0 cm. The value of the resultant horizontal magnetic induction at the mid-point O of the line joining their centres is close to :- (Horizontal component of earth's magnetic induction is 3.6×10^{-5} Wb/m^2) **[AIEEE - 2013]**

(1) 3.6×10^{-5} Wb/m^2 **(2)** 2.56×10^{-4} Wb/m^2

(3) 3.50×10^{-4} Wb/m^2 **(4)** 5.80×10^{-4} Wb/m^2

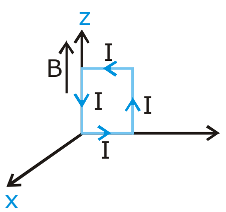
36. The coercivity of a small magnet where the ferromagnet gets demagnetized is 3×10^3 Am^{-1}. The current required to be passed in a solenoid of length 10 cm and number of turns 100, so that the magnet gets demagnetized when inside the solenoid, is: **[JEE - MAIN - 2014]**

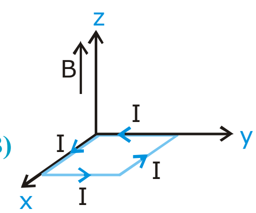
(1) 3A **(2)** 6A **(3)** 30 mA **(4)** 60 mA

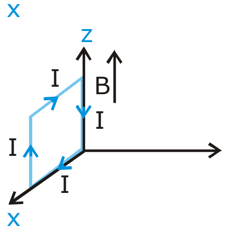
37. A conductor lies along the z-axis at $-1.5 \le z < 1.5$ m and carries a fixed current of 10.0 A in $-\hat{a}_z$ direction (see figure). For a field $\vec{B} = 3.0 \times 10^{-4} e^{-0.2x}\ \hat{a}_y$ T, find the power required to move the conductor at constant speed to x = 2.0 m, y = 0 m in 5×10^{-3} s. Assume parallel motion along the x-axis **[JEE - MAIN - 2014]**

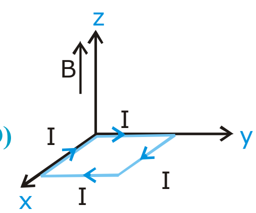
(1) 14.85 W **(2)** 29.7 W **(3)** 1.57 W **(4)** 2.97 W

38. A rectangular loop of sides 10 cm and 5 cm carrying a current I of 12 A is placed in different orientations as shown in the figures below ; **[JEE - MAIN - 2015]**

(A)


(B)


(C)


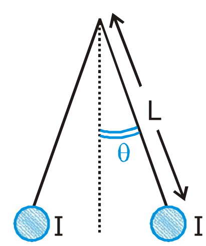
(D)


If there is a uniform magnetic field of 0.3 T in the positive z direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium ?

(1) (B) and (D), respectively **(2)** (B) and (C), respectively

(3) (A) and (B), respectively **(4)** (A) and (C), respectively

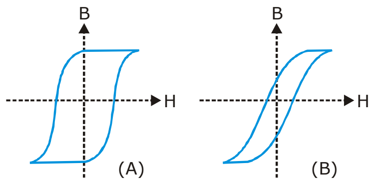
39. Two long current carrying thin wires, both with current I, are held by insulating threads of length L and are in equilibrium as shown in the figure, with threads making an angle 'θ' with the vertical. If wires have mass λ per unit length then the value of I is : (g = gravitational acceleration) **[JEE - MAIN - 2015]**



(1) $2\sqrt{\dfrac{\pi g L}{\mu_0}\tan\theta}$ **(2)** $\sqrt{\dfrac{\pi \lambda g L}{\mu_0}\tan\theta}$

(3) $\sin\theta\sqrt{\dfrac{\pi \lambda g L}{\mu_0 \cos\theta}}$ **(4)** $2\sin\theta\sqrt{\dfrac{\pi \lambda g L}{\mu_0 \cos\theta}}$

40. Hysteresis loops for two magnetic materials A and B are given below : **[JEE - MAIN - 2016]**



These materials are used to make magnets for electric generators, transformer core and electromagnet core. Then it is proper to use:

(1) A for electromagnets and B for electric generators.

(2) A for transformers and B for electric generators.

(3) B for electromagnets and transformers.

(4) A for electric generators and transformers.

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

MCQ's (One or more than one answer may be correct)

1. Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length 2R. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moments of the system and its angular momentum about the centre of the rod is : **[IIT-JEE 1998]**

(A) q/2m **(B)** q/m **(C)** 2q/m **(D)** q/πm

2. Two very long straight parallel wires carry steady currents I and –I respectively. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity $\vec{v}$ is perpendicular to this plane. The magnitudes of the force due to magnetic field acting on the charge at this instant is : **[IIT-JEE 1999]**

(A) $\frac{\mu_0 Iqv}{2\pi d}$ **(B)** $\frac{\mu_0 Iqv}{\pi d}$ **(C)** $\frac{2\mu_0 Iqv}{\pi d}$ **(D)** zero

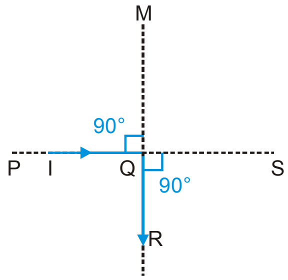
3. A charged particle is released from rest in a region of steady and uniform electric and magnetic fields which are parallel to each other. The particle will move in a : **[IIT-JEE 1999]**

(A) straight line **(B)** circle **(C)** helix **(D)** cycloid

4. A circular loop of radius R, carrying current I, lies in x–y plane with its centre at origin. The total magnetic flux through x–y plane is : **[IIT-JEE 1999]**

(A) directly proportional to I **(B)** directly proportional to R
(C) inversely proportional to R **(D)** zero

5. An infinitely long conductor PQR is bent to form a right angle as shown in figure. A current I flows through PQR. The magnetic field due to this current at the point M is H_1. Now, another infinitely long straight conductor QS is connected at Q, so that current is I/2 in QR as well as in QS, the current in PQ remaining unchanged. The magnetic field at M is now H_2. The ratio H_1/H_2 is given by : **[IIT-JEE 2000]**



(A) 1/2 **(B)** 1 **(C)** 2/3 **(D)** 2

6. An ionized gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the +x–direction and a magnetic field along the +z–direction, then : **[IIT-JEE 2000]**

(A) positive ions deflect towards +y–direction and negative ions towards –y–direction

(B) all ions deflect towards +y–direction

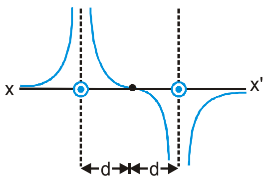
(C) all ions deflect towards –y–direction

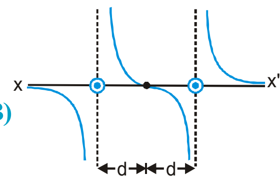
(D) positive ions deflect towards –y–direction and negative ions towards –y–direction

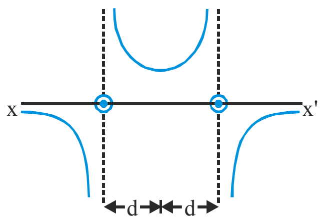
7. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum depend on : **[IIT-JEE 2000]**

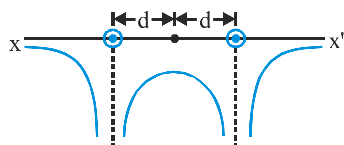
(A) ω and q **(B)** ω, q and m **(C)** q and m **(D)** ω and m

8. Two long parallel wires are at a distance 2d apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by : **[IIT-JEE 2000]**

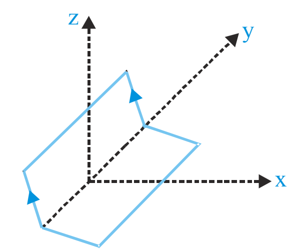
(A) 

(B) 

(C) 

(D) 

9. A non–planar loop of conducting wire carrying a current I is placed as shown in the figure. Each of the straight sections of the loop is of length 2a. The magnetic field due to this loop at the point P (a, 0, a) points in the direction: **[IIT-JEE 2001]**

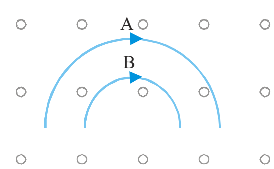


(A) $\frac{1}{\sqrt{2}}\left(-\hat{j}+\hat{k}\right)$ **(B)** $\frac{1}{\sqrt{3}}\left(-\hat{j}+\hat{k}+\hat{i}\right)$ **(C)** $\frac{1}{\sqrt{3}}\left(\hat{i}+\hat{j}+\hat{k}\right)$ **(D)** $\frac{1}{\sqrt{2}}\left(\hat{i}+\hat{k}\right)$

10. 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, the magnetic field at the centre is : **[IIT-JEE 2001]**

(A) $\frac{\mu_0 NI}{b}$ **(B)** $\frac{2\mu_0 NI}{a}$ **(C)** $\frac{\mu_0 NI}{2(b-a)}\ell n\frac{b}{a}$ **(D)** $\frac{\mu_0 I^N}{2(b-a)}\ell n\frac{b}{a}$

11. Two particles A and B of masses 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 v_A and v_B respectively and the trajectories are as shown in the figure. Then : **[IIT-JEE 2001]**

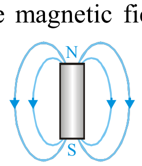


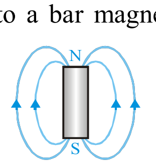
(A) $m_A v_A < m_B v_B$ **(B)** $m_A v_A > m_B v_B$ **(C)** $m_A < m_B$ and $v_A < v_B$ **(D)** $m_A = m_B$ and $v_A = v_B$

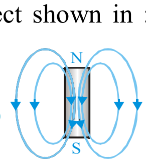
12. A long straight wire along the z–axis carries a current i in the negative z–direction. The magnetic vector field $\vec{B}$ at point having coordinate (x, y) on the z = 0 plane is :– **[IIT-JEE 2002]**

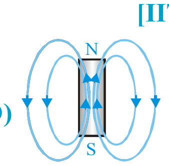
(A) $\frac{\mu_0 I(y\hat{i}-x\hat{j})}{2\pi(x^2+y^2)}$ **(B)** $\frac{\mu_0 I(x\hat{i}+y\hat{j})}{2\pi(x^2+y^2)}$ **(C)** $\frac{\mu_0 I(x\hat{j}+y\hat{i})}{2\pi(x^2+y^2)}$ **(D)** $\frac{\mu_0 I(x\hat{i}-y\hat{j})}{2\pi(x^2+y^2)}$

13. The magnetic field lines due to a bar magnet are correct shown in : **[IIT-JEE 2002]**

(A) 

(B) 

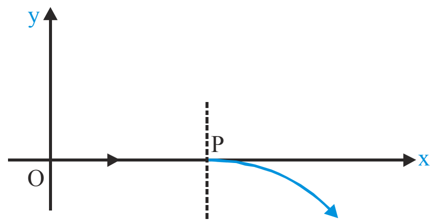
(C) 

(D) 

14. A particle of mass m and charge q moves with a constant velocity v along the positive x–direction. It enters a region containing a uniform magnetic field B directed along the negative z–direction, extending from x = a to x = b. The minimum value of v required so that the particle can just enter the region x > b is **[IIT-JEE 2002]**

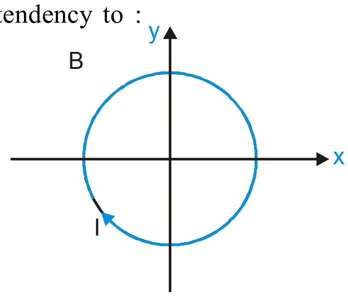
(A) $\frac{qbB}{m}$ **(B)** $\frac{q(b-a)B}{m}$ **(C)** $\frac{qaB}{m}$ **(D)** $\frac{q(b+a)B}{2m}$

15. For a positively charged particle moving in a x – y plane initially along the x–axis, there is a sudden change in it path due to the presence of electric and/or magnetic field beyond P. The curved path is shown in the x – y plane and is found to be non–circular. Which one of the following combinations is possible? **[IIT-JEE 2003]**



(A) $\vec{E}=0;\ \vec{B}=b\hat{j}+c\hat{k}$ **(B)** $\vec{E}=a\hat{i};\ \vec{B}=c\hat{k}+a\hat{i}$ **(C)** $\vec{E}=0;\ \vec{B}=c\hat{j}+b\hat{k}$ **(D)** $\vec{E}=a\hat{i};\ \vec{B}=c\hat{k}+b\hat{j}$

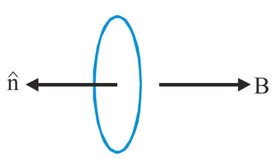
16. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to : **[IIT-JEE 2003]**

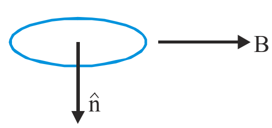


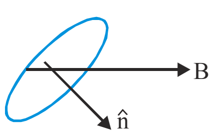
(A) contract **(B)** expand

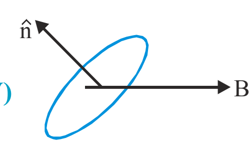
(C) move towards + ve x–axis **(D)** move towards–ve x–axis

17. A current carrying loop is placed in a uniform magnetic field in four different orientations, I, II, III, IV, arrange them in the decreasing order of potential energy : **[IIT-JEE 2003]**

(I) 

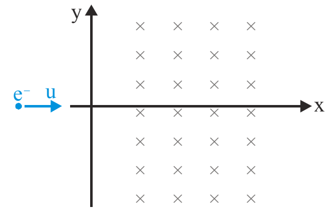
(II) 

(III) 

(IV) 

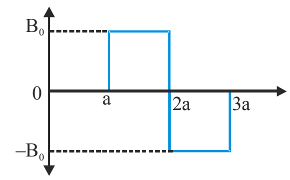
(A) I > III > II > IV **(B)** I > II > III > IV **(C)** I > IV > II > III **(D)** III > IV > I > II

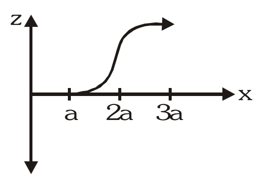
18. An electron moving with a speed u along the positive x–axis at y = 0 enters a region of uniform magnetic field $\vec{B} = -B_0\hat{k}$ which exists to the right of y–axis. The electron exist from the region after sometime with the speed v at co–ordinate y, then : **[IIT-JEE 2004]**

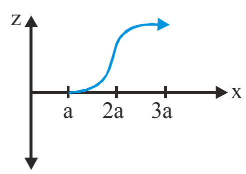


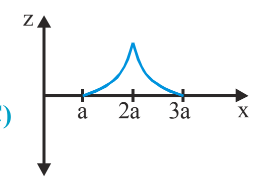
(A) v > u, y < 0 **(B)** v = u, y > 0 **(C)** v > u, y > 0 **(D)** v = u, y < 0

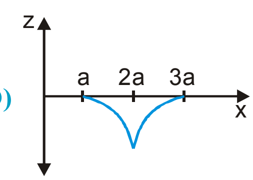
19. A magnetic field $\vec{B} = B_0\hat{j}$ exists in the region a < x < 2a and $\vec{B} = -B_0\hat{j}$, in the region 2a < x < 3a, where B_0 is a positive constant. A positive point charge moving with a velocity $\vec{v} = v_0\hat{i}$, where v_0 is a positive constant, enters the magnetic field at x = a. The trajectory of the charge in this region can be like **[IIT-JEE 2007]**



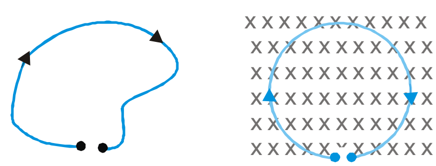
(A) 

(B) 

(C) 

(D) 

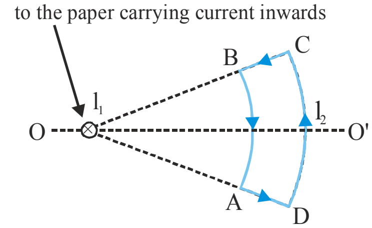
22. A thin flexible wire of length L is connected to two adjacent fixed points and carries a current I in the clockwise direction, as shown in the figure. When the system is put in a uniform magnetic field of strength B going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is : **[IIT-JEE 2010]**



(A) IBL **(B)** $\frac{IBL}{\pi}$ **(C)** $\frac{IBL}{2\pi}$ **(D)** $\frac{IBL}{4\pi}$

Multiple Correct type questions

20. Which of the following statement is correct in the given figure.



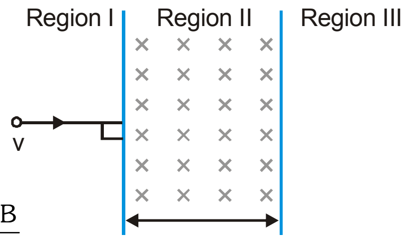
(A) Net force on the loop is zero **[IIT-JEE 2006]**

(B) Net torque on the loop is zero

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

(D) Loop will rotate anticlockwise about OO' when seen from O

21. A particle of mass m and charge q, moving with velocity v enters region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the Region II is ℓ. Choose the correct choice (S). **[IIT-JEE 2008]**



(A) The particle enters Region III only if its velocity $v > \frac{q\ell B}{m}$

(B) The particle enters Region III only if its velocity $v < \frac{q\ell B}{m}$

(C) Path length of the particle in RegionII is max. when velocity $v=\frac{q\ell B}{m}$

(D) Time spent in Region II is same for any velocity v as long as the particle returns to Region I

23. A particle of mass M and positive charge Q, moving with a constant velocity $\vec{u}_1 = 4\hat{i}\,ms^{-1}$, enters a region of uniform static magnetic field normal to the x-y plane. The region of the magnetic field extends from x = 0 to x = L from all values of y. After passing through this region, the particle emerges on the other side after 10 milliseconds with a velocity $\vec{u}_2 = 2\left(\sqrt{3}\hat{i} + \hat{j}\right)ms^{-1}$. The correct statements(s) is (are) :-

(A) The direction of the magnetic field is –z direction. **[IIT-JEE 2013]**

(B) The direction of the magnetic field is +z direction.

(C) The magnitude of the magnetic field $\frac{50\pi M}{3Q}$ units.

(D) The magnitude of the magnetic field is $\frac{100\pi M}{3Q}$ units.

24. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. This cylinder is placed coaxially inside an infinite solenoid of radius 2R. The solenoid has n turns per unit length and carries a steady current I. Consider a point P at a distance r from the common axis. The correct statement(s) is (are) :-

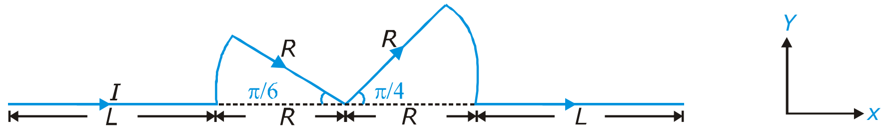
(A) In the region 0 < r < R, the magnetic field is non-zero **[IIT-JEE 2013]**

(B) In the region R < r < 2R, the magnetic field is along the common axis

(C) In the region R < r < 2R, the magnetic field is tangential to the circle of radius r, centred on the axis

(D) In the region r > 2R, the magnetic field is non-zero

25. A conductor (shown in the figure) carrying constant current *I* is kept in the x-y plane in a uniform magnetic field $\vec{B}$. If *F* is the magnitude of the total magnetic force acting on the conductor, then the correct statement(s) is (are) **[IIT-JEE 2015]**



(A) If $\vec{B}$ is along $\hat{z}$, $F \propto (L+R)$

(B) If $\vec{B}$ is along $\hat{x}$, F= 0

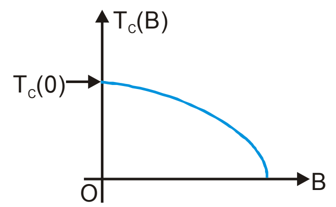
(C) If $\vec{B}$ is along $\hat{y}$, $F \propto (L+R)$

(D) If $\vec{B}$ is along $\hat{z}$, F= 0

Comprehension based questions

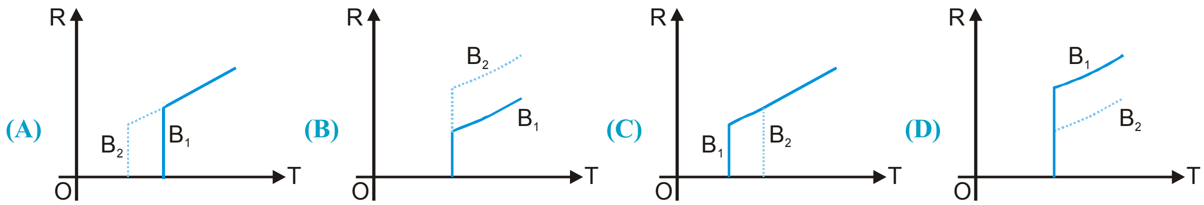
Comprehension # 1

Electrical resistance of certain materials, known as superconductors, changes abruptly from a nonzero value to zero as their temperature is lowered below a critical temperature $T_C(0)$. An interesting property of superconductors is that their critical temperature becomes smaller than $T_C(0)$ if they are placed in a magnetic field, i.e., the critical temperature $T_C(B)$ is a function of the magnetic field strength B. The dependence of T_C (B) on B is shown in the figure.



[IIT-JEE 2010]

1. In the graphs below, the resistance R of a superconductor is shown as a function of its temperature T for two different magnetic fields B_1(sold line) and B_2 (dashed line). If B_2 is larger than B_1, which of the following graphs shows the correct variation of R with T in these fields?



2. A superconductor has $T_C(0) = 100$ K. When a magnetic field of 7.5 Tesla is applied, its T_C decreases to 75 K. For this material one can definitely say that when

(A) B=5 Tesla, T_C (B) = 80 K
(B) B=5 Tesla, 75 K < T_C(B) < 100 K
(C) B= 10 Tesla, 75 K < T_C(B) < 100K
(D) B = 10 Tesla, T_C(B) = 70 K

Comprehension # 2

A point charge Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ.

[IIT-JEE 2013]

1. The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change is

(A) $-\gamma BQR^2$ **(B)** $-\gamma \frac{BQR^2}{2}$ **(C)** $\gamma \frac{BQR^2}{2}$ **(D)** γBQR^2

2. The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change is

(A) $\frac{BR}{4}$ **(B)** $\frac{BR}{2}$ **(C)** BR **(D)** 2BR

Comprehension # 3

A thermal power plant produces electric power of 600 kW and 4000 V, which is to be transported to a place 20 km away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the transformers are ideal with a power factor unity. All the currents and voltages mentioned are rms values. **[IIT-JEE 2013]**

1. In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is 1 : 10. If the power to the consumers has to be supplied at 200 V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is

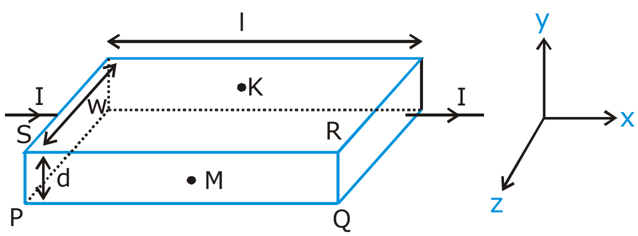
(A) 200 : 1 **(B)** 150 : 1 **(C)** 100 : 1 **(D)** 50 : 1

2. If the direct transmission method with a cable of resistance 0.4 Ω km^{-1} is used, the power dissipation (in %) during transmission is

(A) 20 **(B)** 30 **(C)** 40 **(D)** 50

Comprehension # 4

In a thin rectangular metallic strip a constant current I flows along the positive x-direction, as shown in the figure. The length, width and thickness of the strip are l, w and d, respectively. A uniform magnetic field $\vec{B}$ is applied on the strip along the positive y-direction. Due to this, the charge carries experience a net deflection along the z-direction. This results in accumulation of charge caries on the surface PQRS and appearance of equal and opposite charges on the face opposite to PQRS. A potential difference along the z-direction is thus developed. Charge accumulation continues until the magnetic force is balanced by the electric force. The current is assumed to be uniformly distributed on the cross section of the strip and carried by electrons. **[IIT-JEE 2015]**



1. Consider two different metallic strips (1 and 2) of the same material. Their lengths are the same, widths are w_1 and w_2 and thicknesses are d_1 and d_2, respectively. Two points K and M are symmetrically located on the opposite faces parallel to the x-y plane (see figure). V_1 and V_2 are the potential differences between K and M in strips 1 and 2 , respectively. Then, for a given current I flowing through them in a given magnetic field strength B, the correct statement(s) is (are).

(A) If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = 2V_1$

(B) If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = V_1$

(C) If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = 2V_1$

(D) If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = V_1$

2. Consider two different metallic strips (1 and 2) of same dimensions (length l, width w and thickness d) with carrier densities n_1 and n_2, respectively. Strip 1 is placed in magnetic field B_1 and strip 2 is placed in magnetic field B_2, both along positive y-directions. Then V_1 and V_2 are the potential differences developed between K and M in strips 1 and 2, respectively. Assuming that the current I is the same for both the strips, the correct option (S) is (are).

(A) If $B_1 = B_2$ and $n_1 = 2n_2$, then $V_2 = 2V_1$

(B) If $B_1 = B_2$ and $n_1 = 2n_2$, then $V_2 = V_1$

(C) If $B_1 = 2B_2$ and $n_1 = n_2$, then $V_2 = 0.5V_1$

(D) If $B_1 = 2B_2$ and $n_1 = n_2$, then $V_2 = V_1$

Matrix Match Type Questions

1. Some laws/processes are given in Column I. Match these with the physical phenomena given in column II. **[IIT-JEE 2007]**

	Column I		Column II
(A)	Dielectric ring uniformly charged	(P)	Time independent electrostatic field out of system
(B)	Dielectric ring uniformly charged rotating with angular velocity ω	(Q)	Magnetic field
(C)	Constant current in ring i_0	(R)	Induced electric field
(D)	$i = i_0 \cos \omega t$	(S)	Magnetic moment

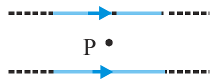
2. Column I gives certain situations in which a straight metallic wire of resistance R is used and Column II gives some resulting effects. Match the statements in Column I with the statements in Column II. **[IIT-JEE 2007]**

	Column I		Column II
(A)	A charged capacitor is connected to the ends of the wire	(P)	A constant current flows through the wire
(B)	The wire is moved perpendicular to its length with constant velocity in a uniform magnetic field perpendicular to the plane of motion.	(Q)	Thermal energy is generated in the wire
(C)	The wire is placed in a constant electric field that develops has a direction along the length of the wire	(R)	A constant potential difference between the ends of the wire
(D)	A battery of constant emf is connected to the ends of the wire	(S)	Charges of constant magnitude appear at the ends of the wire

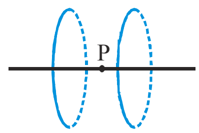
3. Two wires each carrying a steady current I are shown in four configuration in Column I. Some of the resulting effects are described in Column II. Match the statements in Column I with the statements in Column II. **[IIT-JEE 2007]**

Column I

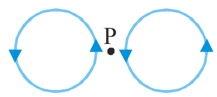
(A) Point P is situated midway due between the wires



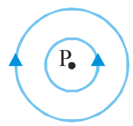
(B) Point P is situated at the mid–point of the line joining the the centers of the circular wires which have same radii



(C) Point P is situated at the mid–point joining the centres of circular wires, which have same radii



(D) Point P is situated at the centre of the wires.



Column II

(P) The magnetic fields (B) at P to the currents in the wires are in the same direction

(Q) The magnetic field (B) at P due to the currents in the wires are in opposite directions.

(R) There is no magnetic field at P.

(S) The wires repel each other.

4. Six point charges, each of the same magnitude q, are arranged in different manners as shown in Column II. In each case, a point M and a line PQ passing through M are shown. Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest. Now, the whole system is set into rotation with a constant angular velocity a about the line PQ . Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition. Assume each rotating charge to be equivalent to a steady current. **[IIT-JEE 2009]**

Column I

(A) $E=0$

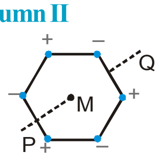
(B) $V \neq 0$

(C) $B=0$

(D) $\mu \neq 0$

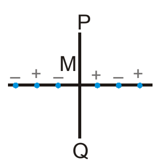
Column II

(P)



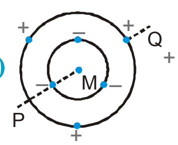
Charges are at the corners of a regular hexagon. M is at the centre of the hexagon. PQ is perpendicular to the plane of the hexagon.

(Q)



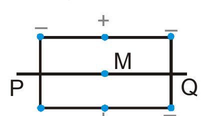
Charges are on a line perpendicular to PQ at equal intervals. M is the mid-point be tween the two innermost charges.

(R)



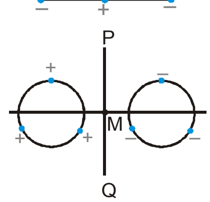
Charges are placed on two coplanar insulating rings at equal inter vals. M is the common centre of the rings. PQ is perpendicular to the plane of the rings.

(S)



Charges are placed at the corners of a react angle of sides a and 2a and at the mid points of the longer sides. M is at the centre of the rectangle. PQ is parallel to the longer sides.

(T)



Charges are placed on two coplanar, identical insulating rings at equal intervals. M is the mid point between the centres of the rings. PQ is perpendicular to the line joining the centres and coplanar to the rings

Assertion –Reason

1. **STATEMENT–1 :** The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as a core inside the coil. **[IIT-JEE 2008]**

STATEMENT–2 : Soft iron has a high magnetic permeability and cannot be easily magnetized or demagnetized.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

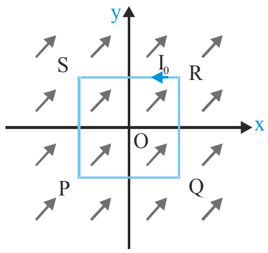
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Subjective Problems

1. A uniform constant magnetic field $\vec{B}$ is directed at an angle of 45° to the x–axis in xy plane. PQRS is rigid square wire frame carrying a steady current I_0, with its centre at the origin O. At time t = 0, the frame is at rest in the position shown in the figure with its sides parallel to x and y–axes. Each side of the frame is of mass M and length L : **[IIT-JEE 1998]**



(i) What is the magnitude of torque $\vec{\tau}$ about O acting on the frame due to the magnetic field ?

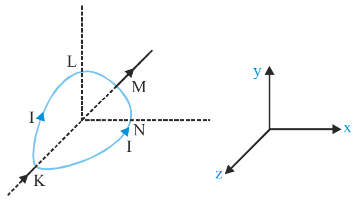
(ii) Find the angle by which the frame rotates under the action of this torque in a short interval of time Δt and the axis about which this rotation occurs (Δt is so short that any variation in the torque during this interval may be neglected). Given : The moment of inertia of the frame about an axis through its centre perpendicular to its plane is $4/3ML^2$.

2. The region between x = 0 and x = L is filled with uniform steady magnetic field $B_0\,\tilde{k}$. A particle of mass m, positive charge q and velocity $v_0\,\tilde{i}$ travels along x–axis and enters the region of the magnetic field. Neglect the gravity throughout the question. **[IIT-JEE 1999]**

(i) Find the value of L if the particle emerges from the region of magnetic field with its final velocity at an angle 30° to its initial velocity.

(ii) Find the final velocity of the particle and the time spent by it in the magnetic field, If the magnetic field now expands upto 2.1 L.

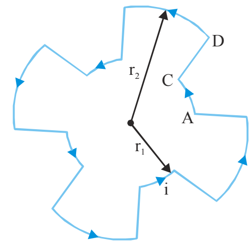
3. A circular lop of radius R is bent along a diameter and given a shape as shown in figure. One of the semicircles (KNM) lies in the x–z plane and the other one (KLM) in the y–z plane with their centres at origin. Current I is flowing through each of the semicircles as shown in figure. **[IIT-JEE 2000]**



(i) A particle of charge q is released at the origin with a velocity $\vec{v} = -v_0\,\tilde{i}$. Find the instantaneous force $\vec{F}$ on the particle. Assume that space is gravity free.

(ii) If an external uniform magnetic field $B_0\,\tilde{j}$ is applied determine the force $\vec{F}_1$ and $\vec{F}_2$ on the semicircles KLM and KNM due to the field and the net force $\vec{F}$ on the loop.

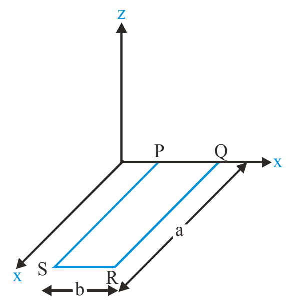
4. A current of 10 A flows around a closed path in a circuit which is in the horizontal plane as shown in the figure. The circuit consists of eight alternating arcs of radii r_1 = 0.08 m and r_2 = 0.12 m. Each subtends the same angle at the centre. **[IIT-JEE 2001]**



(i) Find the magnetic field produced by circuit at the centre.

(ii) An infinitely long straight wire carrying a current of 10 A is passing through the centre of the above circuit vertically with the direction of the current being into the plane of the circuit. What is the force acting on the wire at the centre due to the current in the circuit ? What is the force acting on the arc AC and the straight segment CD due to the current at the centre?

5. A rectangular loop PQRS made from a uniform wire has length a, width b and mass m. It is free to rotate about the arm PQ, which remains hinged along a horizontal line taken as the y–axis (see figure). Take the vertically upward direction as the z–axis. A uniform magnetic field $\vec{B} = (3\tilde{i} + 4\tilde{k})B_0$ exists in the region. The loop is held in the x–y plane and a current I is passed through it. The loop is now released and is found to stay in the horizontal position in equilibrium. **[IIT-JEE 2002]**

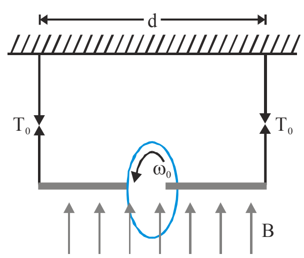


(i) What is the direction of the current I in PQ ?

(ii) Find the magnetic force on the arm RS.

(iii) Find the expression for I in terms of B_0, a, b and m.

6. A ring of radius R having uniformly distributedcharge Q is mounted on a rod suspended by two identical strings. The tension in strings in equilibrium is T_0. Now a vertical magnetic field is switched on and ring is rotated at constant angular velocity ω. Find the maximum ω with which the ring can be rotated if the string can withstand a maximum tension of $\frac{3T_0}{2}$.



[IIT-JEE 2003]

7. A proton and an alpha particle, after being accelerated through same potential difference, enter uniform magnetic field the direction of which is perpendicular to their velocities. Find the ratio of radii of the circular paths of the two particles **[IIT-JEE 2004]**

8. A moving coil galvanometer experiences torque = ki where i is current. If N coils of area A each and moment of inertia I is kept in magnetic field B. **[IIT-JEE 2005]**

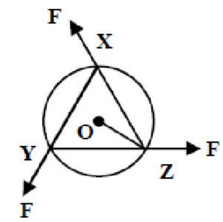
(i) Find k in terms of given parameters,

(ii) If for current i deflection is $\frac{\pi}{2}$, find out torsional constant of spring.

(iii) If a charge Q is passed suddenly through the galvanometer. Find out maximum angle of deflection.

9. A steady current I goes through a wire loop PQR having shape of a right angle triangle with PQ = 3x, PR = 4x and QR = 5x. If the magnitude of the magnetic field at P due to this loop is $k\left(\frac{\mu_0 I}{48\pi x}\right)$, find the value of k. **[IIT-JEE 2009]**

10. A uniform circular disc of mass 1.5 kg and radius 0.5 m is initially at rest on a horizontal frictionless surface. Three forces of equal magnitude F = 0.5 N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc (see figure). One second after applying the forces, the angular speed of the disc in rad s^{-1} is **[IIT-JEE 2014]**



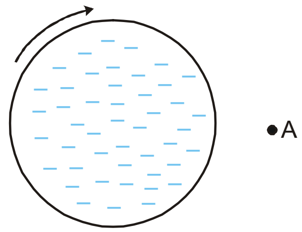
11. A rigid wire loop of square shape having side of length L and resistance R is moving along the x-axis with a constant velocity v_0 in the of the paper. At t = 0, the right edge of the loop enters a region of length 3L where there is uniform magnetic field B_0 into the plane of the paper, as shown in the figure. For sufficiently large v_0, the loop eventually crosses the region. Let x be the location of the right edge of the loop. Let v(x), l(x) and F(x) represent the velocity of the loop, current in the loop, and force on the loop, respectively, as a function of x. Counter-clockwise current is taken as positive.

Which of the following schematic plot(s) is(are) correct? (Ignore gravity) **[IIT-JEE 2016]**

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. The negatively and uniformly charged nonconducting disc as shown in the figure is rotated clockwise with great angular speed. The direction of the magnetic field at point A in the plane of the disc is



(A) into the page **(B)** out of the page

(C) up the page **(D)** down the page

2. 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 will produce 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) can not be determined from the given data

3. Two observers moving with different velocities see that a point charge produces same magnetic field at the same point A . Their relative velocity must be parallel to $\vec{r}$, where $\vec{r}$ is the position vector of point A with respect to point charge. This statement is :

(A) true

(B) false

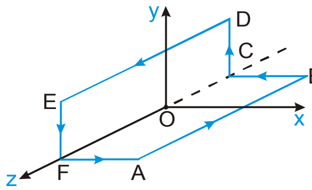
(C) nothing can be said

(D) true only if the charge is moving perpendicular to the $\vec{r}$

4. In the figure shown A B C D E F A was a square loop of side ℓ, but is folded in two equal parts so that half of it lies in x z plane and the other half lies in the y z plane. The origin 'O' is centre of the frame also. The loop carries current ' i '. The magnetic field at the centre is:

(A) $\frac{\mu_0 i}{2\sqrt{2}\,\pi\,\ell}\left(\hat{i} - \hat{j}\right)$ **(B)** $\frac{\mu_0 i}{4\,\pi\,\ell}\left(-\hat{i} + \hat{j}\right)$

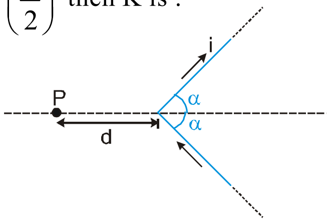
(C) $\frac{\sqrt{2}\,\mu_0 i}{\pi\,\ell}\left(\hat{i} + \hat{j}\right)$ **(D)** $\frac{\mu_0 i}{\sqrt{2}\,\pi\,\ell}\left(\hat{i} + \hat{j}\right)$



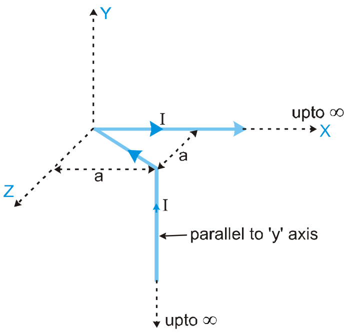
5. If the magnetic field at 'P' in the given figure can be written as K tan $\left(\frac{\alpha}{2}\right)$ then K is :

(A) $\frac{\mu_0 I}{4\pi d}$ **(B)** $\frac{\mu_0 I}{2\pi d}$

(C) $\frac{\mu_0 I}{\pi d}$ **(D)** $\frac{2\mu_0 I}{\pi d}$



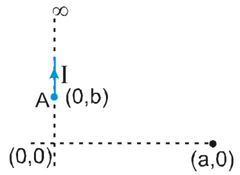
6. The magnetic field at the origin due to the current flowing in the wire as shown in figure below is



(A) $-\frac{\mu_0 I}{8\pi a}(\hat{i}+\hat{k})$ **(B)** $\frac{\mu_0 I}{2\pi a}(\hat{i}+\hat{k})$

(C) $\frac{\mu_0 I}{8\pi a}(-\hat{i}+\hat{k})$ **(D)** $\frac{\mu_0 I}{4\pi a\sqrt{2}}(\hat{i}-\hat{k})$

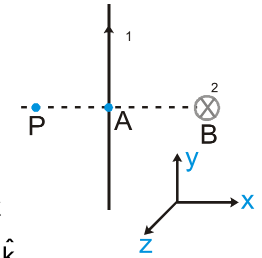
7. An infinitely long wire carrying current I is along Y axis such that its one end is at point A (0, b) while the wire extends upto + ∞. The magnitude of magnetic field strength at point (a, 0) is



(A) $\frac{\mu_0 I}{4\pi a}\left(1+\frac{b}{\sqrt{a^2+b^2}}\right)$ **(B)** $\frac{\mu_0 I}{4\pi a}\left(1-\frac{b}{\sqrt{a^2+b^2}}\right)$

(C) $\frac{\mu_0 I}{4\pi a}\left(\frac{b}{\sqrt{a^2+b^2}}\right)$ **(D)** None of these

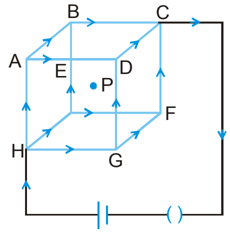
8. Two infinitely long linear conductors are arranged perpendicular to each other and are in mutually perpendicular planes as shown in figure. If I_1 = 2A along the y-axis and I_2 = 3A along negative z-axis and AP = AB = 1 cm. The value of magnetic field strength $\vec{B}$ at P is -



(A) $(3\times10^{-5}\ T)\ \hat{j} + (-4\times10^{-5}\ T)\ \hat{k}$ **(B)** $(3\times10^{-5}\ T)\ \hat{j} + (4\times10^{-5}\ T)\ \hat{k}$

(C) $(4\times10^{-5}\ T)\ \hat{j} + (3\times10^{-5}\ T)\ \hat{k}$ **(D)** $(-3\times10^{-5}\ T)\ \hat{j} + (4\times10^{-5}\ T)\ \hat{k}$

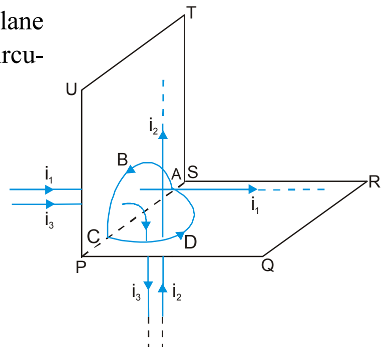
9. A steady current is set up in a cubic network composed of wires of equal resistance and length d as shown in figure. What is the magnetic field at the centre of cube P due to the cubic network ?



(A) $\frac{\mu_0}{4\pi}\frac{2I}{d}$ **(B)** $\frac{\mu_0}{4\pi}\frac{3I}{\sqrt{2}\,d}$

(C) 0 **(D)** $\frac{\mu_0}{4\pi}\frac{\theta\pi I}{d}$

10. Figure shows an amperian path ABCDA. Part ABC is in vertical plane PSTU while part CDA is in horizontal plane PQRS. Direction of circulation along the path is shown by an arrow near point B and at D. $\oint \vec{B}.d\vec{\ell}$ for this path according to Ampere's law will be :



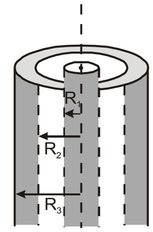
(A) $(i_1 - i_2 + i_3)\,\mu_0$

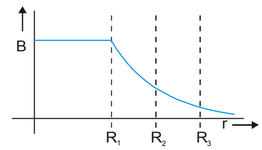
(B) $(-i_1 + i_2)\,\mu_0$

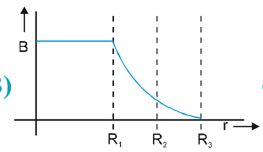
(C) $i_3\,\mu_0$

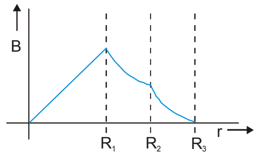
(D) $(i_1 + i_2)\,\mu_0$

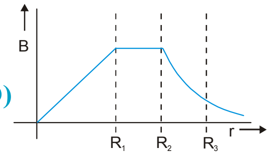
11. A coaxial cable is made up of two conductors. The inner conductor is solid and is of radius R_1 & the outer conductor is hollow of inner radius R_2 and outer radius R_3. The space between the conductors is filled with air. The inner and outer conductors are carrying currents of equal magnitudes and in opposite directions. Then the variation of magnetic field with distance from the axis is best plotted as:



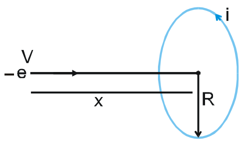
(A) 

(B) 

(C) 

(D) 

12. An electron moving with velocity V along the axis approaches a circular current carrying loop as shown in the figure. The magnitude of magnetic force on electron at this instant is



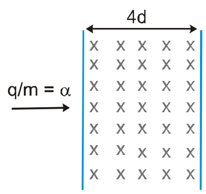
(A) $\frac{\mu_0}{2}\frac{eviR^2x}{(x^2+R^2)^{3/2}}$

(B) $\mu_0\frac{eviR^2x}{(x^2+R^2)^{3/2}}$

(C) $\frac{\mu_0}{4\pi}\frac{eviR^2x}{(x^2+R^2)^{3/2}}$

(D) 0

13. If a charged particle of charge to mass ratio $\frac{q}{m}=\alpha$ is entering in a uniform magnetic field of strength B which is extended up to 4d as shown in figure at a speed $v = (2\alpha d)(B)$, then which of the following is correct :



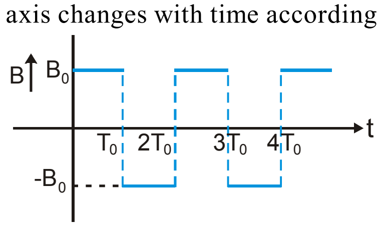
(A) angle subtended by charged particle at the centre of circular path is 2π.

(B) the charge will move on a circular path and will come out from magnetic field at a distance 4d from the point of insertion.

(C) the time for which particle will be in the magnetic field is $\frac{2\pi}{\alpha B}$.

(D) the charged particle will substend an angle of 90^0 at the centre of circular path

14. In a region magnetic field along x axis changes with time according to the given graph.



If time period, pitch and radius of helix path are T_0, P_0 and R respectively then which of the following is incorrect if the particle is projected at an angle θ_0 with the positive x-axis in x-y plane:

(A) At $t=\frac{T_0}{2}$, co-ordinates of charge are $\left(\frac{P_0}{2},0,-2R_0\right)$.

(B) At $t=\frac{3T_0}{2}$, co-ordinates of charge are $\left(\frac{3P_0}{2},0,2R_0\right)$.

(C) Two extremes from x-axis are at a distance $2R_0$ from each other.

(D) Two extremes from x-axis are at a distance $4R_0$ from each other.

15. A Positive point charge is moving in clockwise direction in a circle with constant speed. Consider the magnetic field produced by the charge at a point P (not centre of the circle) on the axis of the circle.

(A) it is constant in magnitude only

(B) it is constant in direction only

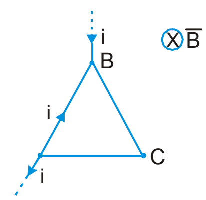
(C) it is constant in direction and magnitude both

(D) it is not constant in magnitude and direction both.

16. An α particle is moving along a circle of radius R with a constant angular velocity ω. Point A lies in the same plane at a distance 2R from the centre. Point A records magnetic field produced by α particle. If the minimum time interval between two successive times at which A records zero magnetic field is 't', the angular speed ω, in terms of t is -

(A) $\frac{2\pi}{t}$ **(B)** $\frac{2\pi}{3t}$ **(C)** $\frac{\pi}{3t}$ **(D)** $\frac{\pi}{t}$

17. Figure shows an equilateral triangle ABC of side ℓ carrying currents, placed in uniform magnetic field B. The magnitude of magnetic force on triangle is

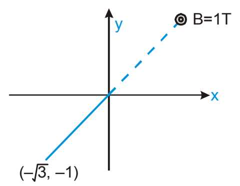


(A) $i\ell B$ **(B)** $2i\ell B$ **(C)** $3i\ell B$ **(D)** zero

18. There exists a uniform magnetic and electric field each of magnitude 1 T and 1 V/m respectively along positive y-axis. A charged particle of mass 1 kg and of charge 1 C is having velocity 1 m/sec along x-axis and is at origin at t = 0. Then the co-ordinates of particle at time π seconds will be:

(A) (0, 1, 2) **(B)** $(0, -\pi^2/2, -2)$ **(C)** $(2, \pi^2/2, 2)$ **(D)** $(0, \pi^2/2, 2)$

19. A uniform magnetic field of magnitude 1 T exists in region $y \geq 0$ is along $\hat{k}$ direction as shown. A particle of charge 1 C is projected from point $(-\sqrt{3}, -1)$ towards origin with speed 1 m/sec. If mass of particle is 1 kg, then co-ordinates of centre of circle in which particle moves are:



(A) $(1, \sqrt{3})$ **(B)** $(1, -\sqrt{3})$

(C) $\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$ **(D)** $\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$

20. A uniform magnetic field exists in region which forms an equilateral triangle of side a. The magnetic field is perpendicular to the plane of the triangle. A charge q enters into this magnetic field perpendicularly with speed v along perpendicular bisector of one side and comes out along perpendicular bisector of other side. The magnetic induction in the triangle is

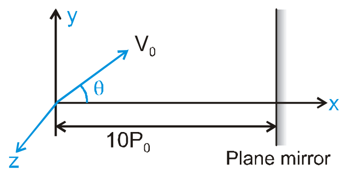
(A) $\frac{mv}{qa}$ **(B)** $\frac{2mv}{qa}$ **(C)** $\frac{mv}{2qa}$ **(D)** $\frac{mv}{4qa}$

21. A positively charged particle having charge q and mass m enters with velocity $V\hat{j}$ at the origin in a magnetic field $B(-\hat{k})$ which is present in the space every where. The charge makes a perfectly inelastic collision with identical particle at rest but free to move at its maximum y-coordinate. After collision the combined charge will move on trajectory : (where $r = \frac{mV}{qB}$)

(A) $y = \frac{mv}{qB}(-\hat{i})$ **(B)** $(x + r)^2 + (y - r/2)^2 = r^2/4$

(C) $(x - r)^2 + (y - r)^2 = r^2$ **(D)** $(x - r)^2 + (y + r/2)^2 = r^2/4$

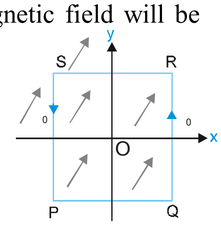
22. In the plane mirror, the co-ordinates of image of charged particle (initially at origin as shown) after two and half time periods are (initial velocity V_0 is in the xy-plane and the plane mirror is perpendicular to the x-axis. A uniform magnetic field $B\hat{i}$ exists in the whole space. P_0 is pitch of helix, R_0 is radius of helix).



(A) $17P_0, 0, -2R_0$ **(B)** $3P_0, 0, -2R_0$

(C) $17.5P_0, 0, -2R_0$ **(D)** $3P_0, 0, 2R_0$

23. A uniform, constant magnetic field $\vec{B}$ is directed at an angle of 45° to the x-axis in the xy-plane, PQRS is a rigid square wire frame carrying a steady current I_0, with its centre at the origin O. At time t = 0, the frame is at rest in the position shown in the figure, with its sides parallel to the x and y axes. Each side of the frame is of mass M and length L.. The torque $\vec{\tau}$ about O acting on the frame due to the magnetic field will be



(A) $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(-\hat{i}+\hat{j})$ **(B)** $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(\hat{i}-\hat{j})$

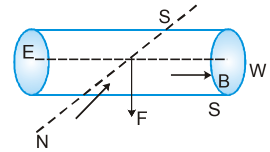
(C) $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(\hat{i}+\hat{j})$ **(D)** $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(-\hat{i}-\hat{j})$

24. A ring of mass m, radius r having charge q uniformly distributed over it and free to rotate about its own axis is placed in a region having a magnetic field B parallel to its axis. If the magnetic field is suddenly switched off, the angular velocity acquired by the ring is

(A) $\frac{qB}{m}$ **(B)** $\frac{2qB}{m}$ **(C)** $\frac{qB}{2m}$ **(D)** None of these

25. A uniform magnetic field of 1.5 T exists in a cylindrical region of radius 10.0 cm, it's direction being parallel to the axis along east to west. A current carrying wire in north south direction passes through this region. The wire intersects the axis and experience a force of 1.2 N downward. (as shown in figure).

If the wire is turned from North South to north east–south west direction, then magnitude and direction of force is:



(A) 1.2 N, upward **(B)** $1.2\sqrt{2}$ downward

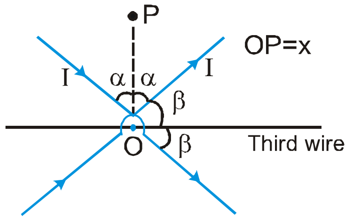
(C) 1.2 N, downward **(D)** $\frac{1.2}{\sqrt{2}}$ N, downward

26. In the above problem, if wire in north-south direction is lowered from the axis by a distance of 6 cm, then magnitude and direction of force is :

(A) 0.48 N, downward **(B)** 0.48 N, upward

(C) 0.96 N, downward **(D)** 0.96 N, upward

27. Three infinite current carrying conductors are placed as shown in figure.



Two wires carry same current while current in third wire is unknown. The three wires do not intersect with each other and all of them are in the plane of paper. Which of the following is correct about a point 'P' which is also in the same plane :

(A) Magnetic field intensity at P is zero for all values of x.

(B) If the current in the third wire is $\frac{2I}{\sin\alpha}$ (left to right) then magnetic field will be zero at P for all values of x.

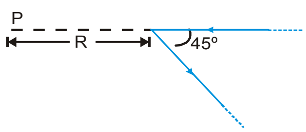
(C) If the current in the third wire is $\frac{2I}{\sin\alpha}$ (right to left) then magnetic field will be zero at P for all values of x.

(D) None of these

28. An insulating rod of length ℓ carries a charge q uniformly distributed on it. The rod is pivoted at its mid point and is rotated at a frequency f about a fixed axis perpendicular to rod and passing through the pivot. The magnetic moment of the rod system is

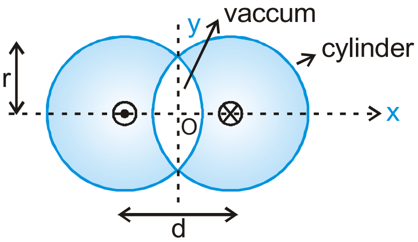
(A) Zero **(B)** $\pi q f \ell^2$ **(C)** $\frac{1}{12}\pi q f \ell^2$ **(D)** $\frac{1}{3}\pi q f \ell^2$

29. A long straight wire, carrying current I, is bent at its midpoint to form an angle of 45º. Magnetic field at point P, distance R from point of bending is equal to :



(A) $\frac{(\sqrt{2}-1)\mu_0 I}{4\pi R}$ **(B)** $\frac{(\sqrt{2}+1)\mu_0 I}{4\pi R}$ **(C)** $\frac{(\sqrt{2}+1)\mu_0 I}{4\sqrt{2}\pi R}$ **(D)** $\frac{(\sqrt{2}-1)\mu_0 I}{2\sqrt{2}\pi R}$

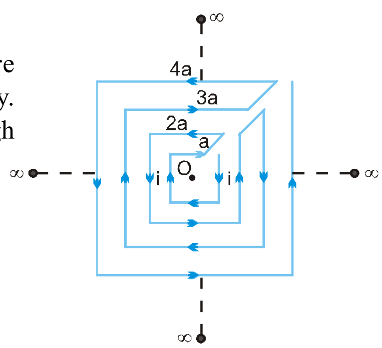
30. Two long cylinders (with axis parallel) are arranged as shown to form overlapping cylinders, each of radius r, whose centers are separated by a distance d. Current of density J (Current per unit area) flows into the plane of page along the right shaded part of one cylinder and an equal current flows out of the plane of the page along the left shaded part of the other, as shown in the figure. The magnitude and direction of magnetic field at point O (O is the origin of shown x-y axes) are



(A) $\frac{\mu_0}{2\pi}\pi J d$, in the + y-direction **(B)** $\frac{\mu_0}{2\pi}d^2\frac{J}{r}$, in the + y-direction

(C) zero **(D)** none of these

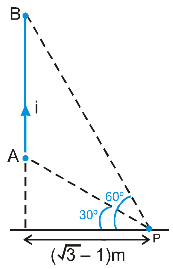
31. Determine the magnetic field at the centre of the current carrying wire arrangement shown in the figure. The arrangement extends to infinity. (The wires joining the successive squares are along the line passing through the centre)



(A) $\frac{\mu_0 i}{\sqrt{2}\pi a}$ **(B)** 0

(C) $\frac{2\sqrt{2}\mu_0 i}{\pi a}\ln 2$ **(D)** none of these

32. A straight wire current element is carrying current 100 A, as shown in the figure. The magnitude of magnetic field at point P which is at perpendicular distance $(\sqrt{3}-1)$m from the current element if end A and end B of the element subtend angle 30º and 60º at point P, as shown, is :



(A) 5×10^{-6} T
(B) 2.5×10^{-6} T
(C) 2.5×10^{-5} T
(D) 8×10^{-5} T

33. Axis of a solid cylinder of infinite length and radius R lies along y-axis it carries a uniformly distributed current ' i ' along +y direction. Magnetic field at a point $\left(\frac{R}{2}, y, \frac{R}{2}\right)$ is :

(A) $\frac{\mu_0 I}{4\pi R}(\hat{i}-\hat{k})$
(B) $\frac{\mu_0 i}{2\pi R}(\hat{j}-\hat{k})$
(C) $\frac{\mu_0 i}{4\pi R}\hat{j}$
(D) $\frac{\mu_0 I}{4\pi R}(\hat{i}+\hat{k})$

34. A magnetic dipole $\vec{M} = (A\hat{i}+B\hat{j})$ J/Wb is placed in magnetic field. $\vec{B} = (Cx^2\hat{i}+Dy^2\hat{j})$ Wb in XY plane at $\vec{r} = (E\hat{i}+F\hat{j})$ m. Then force experienced by the bar magnet is :

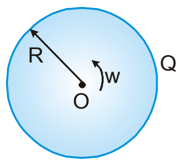
(A) $2ACE\,\hat{i} + 2BDF\,\hat{j}$ (N)
(B) $2ACE\,\hat{i}$ (N)
(C) 0
(D) $ACE\,\hat{i} + BDF\,\hat{j}$ (N)

35. A toroid of mean radius 'a' , cross section radius 'r' and total number of turns N. It carries a current 'i'. The torque experienced by the toroid if a uniform magnetic field of strength B is applied :
(A) is zero
(B) is $BiN\pi r^2$
(C) is $BiN\pi a^2$
(D) depends on the direction of magnetic field.

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

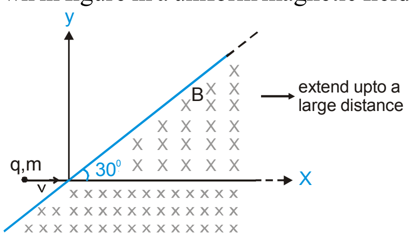
36. A long thick conducting cylinder of radius 'R' carries a current uniformly distributed over its cross section.
(A) The magnetic field strength is maximum on the surface
(B) The magnetic field strength is zero on the surface
(C) The strength of the magnetic field inside the cylinder will vary as inversely proportional to r, where r is the distance from the axis.
(D) The energy density of the magnetic field outside the conductor varies as inversely proportional to $1/r^2$, where 'r' is the distance from the axis.

37. A nonconducting disc having uniform positive charge Q, is rotating about its axis in anticlock wise direction with uniform angular velocity ω. The magnetic field at the center of the disc is.



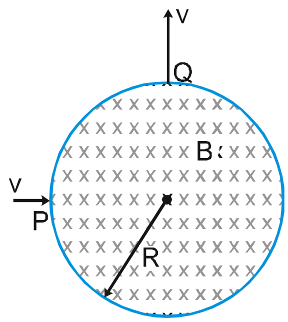
(A) directed outward
(B) having magnitude $\frac{\mu_0 Q\omega}{4\pi R}$
(C) directed inwards
(D) having magnitude $\frac{\mu_0 Q\omega}{2\pi R}$

38. 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 $\vec{v} = v\cos 60^\circ\,\hat{i} - v\sin 60^\circ\,\hat{j}$
(B) Time for which the particle was in magnetic field is $\frac{\pi m}{3qB}$
(C) Distance travelled in magnetic field is $\frac{\pi mV}{3qB}$
(D) The particle will never come out of magnetic field

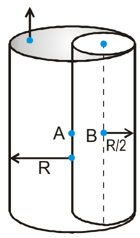
39. A particle of charge 'q' & mass 'm' enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is constant and uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(s) is/are correct :



(A) $B = \frac{mv}{qR}$ (B) $T = \frac{\pi R}{2v}$

(C) $T = \frac{\pi m}{2qB}$ (D) None of these

40. From a cylinder of radius R, a cylinder of radius R/2 is removed, as shown. 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

SECTION - III : ASSERTION AND REASON TYPE

41. **Statement-1 :** A charged particle undergoes uniform circular motion in a uniform magnetic field. The only force acting on the particle is that exerted by the uniform magnetic field. If now the speed of the same particle is somehow doubled keeping its charge and external magnetic field constant, then the centripetal force on the particle becomes four times.

Statement-2 : The magnitude of centripetal force on a particle of mass m moving in a circle of radius R with uniform speed v is $\frac{mv^2}{R}$:

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

42. **Statement 1 :** A current carrying closed loop remains in equilibrium in a uniform and constant magnetic field parallel to its axis. Consider forces only due to this magnetic field .

Statement 2 : Torque on a current carrying closed loop due to a magnetic field is maximum when the plane of the coil is parallel to the direction of the magnetic field.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

43. **Statement-1 :** A solenoid tend to contract (along its length) when a current is passed through it.

Statement-2 : If current in two coaxial circular rings of equal radii is in same sense(as seen by an observer on axis away from both the rings), the rings attract each other. Further the given current carrying rings attract each other because parallel current attract.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

44. **Statement 1 :** A direct uniformly distributed current flows through a solid long metallic cylinder along its length. It produces magnetic field only outside the cylinder .

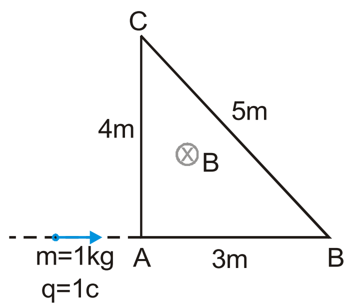
Statement 2 : A thin long cylindrical tube carrying uniformly distributed current along its circumference does not produce a magnetic field inside it. Moreover, a solid cylinder can be supposed to be made up of many thin cylindrical tubes.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

A small particle of mass m = 1kg and charge of 1C enters perpendicularly in a triangular region of uniform magnetic field of strength 2T as shown in figure :



45. Calculate maximum velocity of the particle with which it should enter so that it complete a half–circle in magnetic region :

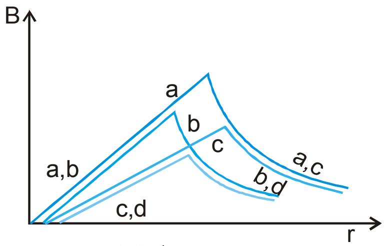
(A) 2 m/s **(B)** 2.5 m/s **(C)** 3 m/s **(D)** 4 m/s

46. In previous question, if particle enters perpendicularly with velocity 48 m/s in magnetic region. Then, how much time will it spend in magnetic region :

(A) $\frac{11\pi}{360}$ sec. **(B)** $\frac{7\pi}{360}$ sec. **(C)** $\frac{13\pi}{360}$ sec. **(D)** $\frac{17\pi}{360}$ sec.

Comprehension # 2

Curves in the graph shown give, as functions of radial distance r, the magnitude B of the magnetic field inside and outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross sections of the wires. Overlapping portions of the plots are indicated by double labels.



47. Which wire has the greatest radius ?

(A) a **(B)** b **(C)** c **(D)** d

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

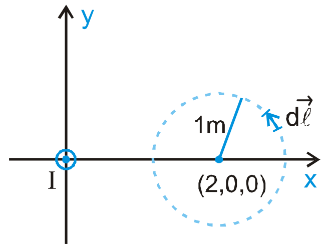
(A) a **(B)** b **(C)** c **(D)** d

49. The current density in wire a is

(A) greater than in wire c.
(B) less than in wire c.
(C) equal to that in wire c.
(D) not comparable to that of in wire c due to lack of information.

Comprehension # 3

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 (2 meter, 0, 0) and radius 1 meter. Divide the circle in small segments and let $d\vec{\ell}$ denote the length of a small segment in anticlockwise direction, as shown.



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

(A) $\frac{\mu_0 I}{8}$
(B) $\frac{\mu_0 I}{2}$
(C) $\mu_0 I$
(D) 0

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

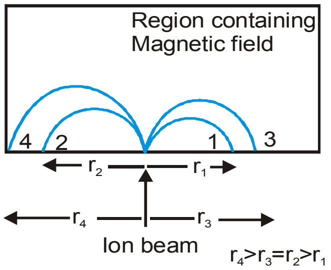
(A) $\frac{\mu_0 I}{\pi}\tan^{-1}\frac{1}{2}$
(B) $\frac{\mu_0 I}{2\pi}\tan^{-1}\frac{1}{2}$
(C) $\frac{\mu_0 I}{2\pi}\sin^{-1}\frac{1}{2}$
(D) 0

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

(A) $\frac{\mu_0 I}{12}$
(B) $\frac{\mu_0 I}{8}$
(C) $\frac{\mu_0 I}{6}$
(D) 0

SECTION - V : MATRIX - MATCH TYPE

53. A beam consisting of four types of ions A, B, C and D enters a region that contains a uniform magnetic field as shown. The field is perpendicular to the plane of the paper, but its precise direction is not given. All ions in the beam travel with the same speed. The table below gives the masses and charges of the ions.



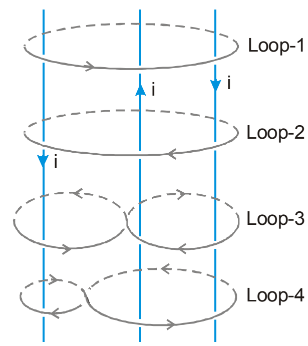
ION	MASS	CHARGE
A	2m	e
B	4m	−e
C	2m	−e
D	m	+e

The ions fall at different positions 1, 2, 3 and 4, as shown. Correctly match the ions with respective falling positions.

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

(P) 1
(Q) 2
(R) 3
(S) 4

54. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in the figure :



(A) Along closed Loop-1 — **(P)** $\oint \vec{B}.d\vec{\ell} = \mu_0 i$

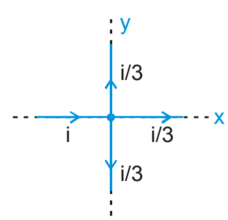
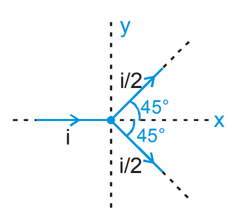
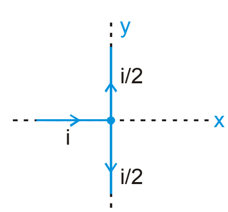
(B) Along closed Loop-2 — **(Q)** $\oint \vec{B}.d\vec{\ell} = -\mu_0 i$

(C) Along closed Loop-3 — **(R)** $\oint \vec{B}.d\vec{\ell} = 0$

(D) Along closed Loop-4 — **(S)** net work done by the magnetic force to move a unit charge along the loop is zero.

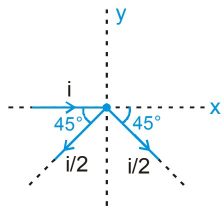
(T) $\oint \vec{B}.d\vec{\ell} = \mu_0 (2i)$

55. Column-II gives four situations in which three or four semi infinite current carrying wires are placed in xy-plane as shown. The magnitude and 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 P (0, 0, d). Match the statements in column-I with the corresponding figures in column-II

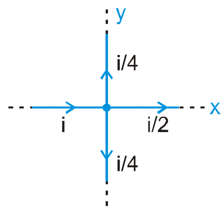
Column I	Column II
(A) The x component of magnetic field at point P is zero in	**(P)** 
(B) The z component of magnetic field at point P is zero in	**(Q)** 
(C) The magnitude of magnetic field at point P is $\frac{\mu_0 i}{4\pi d}$ in	**(R)** 

(D) The magnitude of magnetic field at point P is less than $\frac{\mu_0 i}{2\pi d}$ in

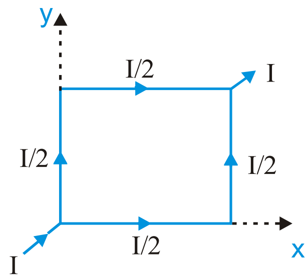
(S)



(T)



56. A square loop of uniform conducting wire is as shown in figure. A current I (in amperes) enters the loop from one end and exits the loop from opposite end as shown in figure. The length of one side of square loop is ℓ metre. The wire has uniform cross section area and uniform linear mass density. In four situations of column I, the loop is subjected to four different magnetic field. Under the conditions of column I, match the column I with corresponding results of column II (B_o in column I is a positive nonzero constant)



Column I	Column II
(A) $\vec{B} = B_o\hat{i}$ in tesla	(P) magnitude of net force on loop is $\sqrt{2}\,B_oI\ell$ newton
(B) $\vec{B} = B_o\hat{j}$ in tesla	(Q) magnitude of net force on loop is zero
(C) $\vec{B} = B_o(\hat{i}+\hat{j})$ in tesla	(R) magnitude of net torque on loop about its centre is zero
(D) $\vec{B} = B_o\hat{k}$ in tesla	(S) magnitude of net force on loop is $B_oI\ell$ newton
	(T) magnitude of force on wire along y axis is $B_0I\ell/2$ along x axis

57. A particle enters a space where exists uniform magnetic field $\vec{B} = B_x\vec{i} + B_y\vec{j} + B_z\vec{k}$ & 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 A with the entries of column B. The components other than specified in column A in each entry are non-zero. Neglect gravity.

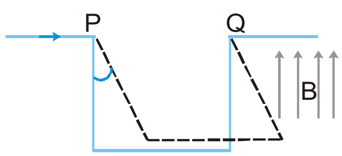
	Column -I		Column -II
(A)	$B_y = B_z = E_x = E_z = 0$; $u = 0$	(P)	circle
(B)	$E = 0$, $u_xB_x + u_yB_y \neq -u_zB_z$	(Q)	helix with uniform pitch and constant radius
(C)	$\vec{u} \times \vec{B} = 0$, $\vec{u} \times \vec{E} = 0$	(R)	cycloid
(D)	$\vec{u} \perp \vec{B}$, $\vec{B} \parallel \vec{E}$	(S)	helix with variable pitch and constant radius
		(T)	straight line

SECTION - VI : INTEGER TYPE

58. A uniformly charged ring of radius 10 cm rotates at a frequency of 10^4 rps about its axis. Find 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 $\frac{x}{10}10^9$ then x is .

59. A neutral particle is at rest in a uniform magnetic field $\vec{B}$. At t = 0, particle decays into two particles each of mass 'm' and one of them having charge 'q'. Both of these move off in separate paths lying in plane perpendicular to $\vec{B}$. At later time, the particles collide. If this time of collision is $x\pi m/qB$ then x is (neglecting the interaction force).

60. As shown in the figure, three sided frame is pivoted at P and Q and hangs vertically. Its sides are of same length and have a linear density of $\sqrt{3}$ kg/m. A current of $10\sqrt{3}$ Amp is sent through the frame, which is in a uniform magnetic field of 2T directed upwards as shown. Then angle in degree through which the frame will be deflected in equilibrium is : (Take g = 10 m/s^2)



ANSWER KEY

EXERCISE - 1

1. C	**2.** D	**3.** C	**4.** D	**5.** C	**6.** C	**7.** D	**8.** C	**9.** A	**10.** C	**11.** B	**12.** B	**13.** A
14. C	**15.** B	**16.** A	**17.** B	**18.** A	**19.** C	**20.** C	**21.** C	**22.** A	**23.** A	**24.** C	**25.** A	**26.** B
27. A	**28.** A	**29.** A	**30.** C	**31.** C	**32.** D	**33.** B	**34.** C	**35.** C	**36.** A	**37.** D	**38.** A	**39.** B
40. D	**41.** C	**42.** A	**43.** A	**44.** C	**45.** C	**46.** C	**47.** D	**48.** C	**49.** B	**50.** D	**51.** B	**52.** D
53. D	**54.** B	**55.** D	**56.** C	**57.** B	**58.** B	**59.** B	**60.** B	**61.** C	**62.** A	**63.** A	**64.** D	**65.** A
66. A	**67.** B	**68.** C	**69.** B	**70.** C	**71.** A	**72.** D	**73.** D	**74.** B	**75.** D	**76.** C	**77.** D	**78.** A
79. D	**80.** **B**											

EXERCISE - 2 : PART # I

1. D	**2.** D	**3.** D	**4.** B,D	**5.** AD	**6.** B	**7.** B	**8.** A,B,C	**9.** B,C
10. C	**11.** D	**12.** C	**13.** A,B,C	**14.** A,B,C	**15.** A,C	**16.** A,B,D	**17.** A	**18.** C
19. B	**20.** D	**21.** A	**22.** B	**23.** D	**24.** A,B	**25.** B	**26.** A	**27.** D
28. C	**29.** B	**30.** A,B,C,D	**31.** B,C	**32.** D	**33.** A,B	**34.** B,C	**35.** A,B,C	**36.** C,D
37. A,D	**38.** C	**39.** D	**40.** D	**41.** A	**42.** C,D	**43.** C	**44.** D	**45.** B
46. A	**47.** A	**48.** A	**49.** B	**50.** A	**51.** A,D	**52.** D	**53.** C	**54.** C
55. C	**56.** B	**57.** C	**58.** A	**59.** D	**60.** B	**61.** A	**62.** B	**63.** A
64. B	**65.** A	**66.** D	**67.** B	**68.** B	**69.** D	**70.** D	**71.** A	**72.** B
73. A	**74.** C	**75.** A	**76.** C	**77.** B	**78.** B	**79.** B	**80.** **C**	**81.** C
82. B	**83.** B	**84.** B	**85.** C	**86.** B	**87.** A			

PART # II

1. D **2.** A **3.** D **4.** D

EXERCISE - 3 : PART # I

1. A$\to$ R ; B $\to$S; C $\to$ Q ; D $\to$ P **2.** A$\to$ R; B $\to$ Q ;C $\to$ S **3**. A $\to$ R ; B ; P $\to$ C $\to$ T ; D $\to$ S

4. A $\to$ R,S ; B $\to$ R,S; C $\to$ Q,R ; D $\to$P,R **5.** A $\to$ Q,S; B $\to$ P,S ;C $\to$ Q,S ;D $\to$ P,S

6. A $\to$ S; B $\to$ S;C Q ; D$\to$ R; E$\to$ P **7**. A $\to$ Q; B $\to$ P,Q ; C $\to$ P,Q,R

PART # II

Comp.#1 : **1**. C **2**. C **3**. A **4**. D **Comp. #2 :** **1**. C **2**. A

Comp.#3 : **1**. C **2**. B **3**. A **4**.C **5**.D **Comp.#4 :** **1**. C. **2**. A **3**. A

Comp.#5 : **1**. D. **2**. C **3**. B **4**. D **Comp. #6 :** **1**. B **2**. B **3**. B **4**. B

EXERCISE - 4

1. 10^{-4}T, perendicular to paper outwards **2**. $7.07\times 10^{-10}\,\hat{k}$T **3**. $\frac{(2\sqrt{2}-1)\mu_0 i}{\pi a}$ **4.** 2 radian **5**. $\frac{2\mu_0 I}{\pi ab}\sqrt{a^2+b^2}$

6. $\mu_0\frac{\text{weber}}{\text{meter}}$ **7**. 3.35×10^{-5} T $\odot$ **8.** $\frac{5\mu_0 I\theta}{24\pi r}\otimes$ **9**. 5×10^{-25}N **10**. **(i)** MB **(ii)** $\left(\frac{2MB}{I}\right)^{1/2}$ **11**. $\frac{q\omega\ell^2}{6}$ **12**. $\frac{\pi I}{2}\left(\frac{\ell}{\pi+2}\right)^2$

13. (i) 3.2×10^{-2} Nm **(ii)** 0.064 J **14. (i)**$1.28\,Am^2$ **(ii)** 0, 0.048 Nm **15.** 0.1 T (perpendicular to paper inwards)

16. (i) AB_1 व AB_2 **(ii)** AB_3 व AB_6, AB_4 व AB_5 **(iii)** AB_6 **17.** 1.2×10^{-2}m, 4.37×10^{-6}m **18**. $\sqrt{2}$ IRB **19.** $\frac{\mu_0 I}{4R}\left(\frac{3}{4}\tilde{k}+\frac{1}{\pi}\tilde{j}\right)$

20. $\alpha a^2 i\,\hat{j}$ **21.** $\frac{\mu_0 iqv}{2\pi a}$ **22.** $\frac{mEI}{Be}$ **23.** **(i)** $\frac{\mu_0 br_1^2}{3}$, **(ii)** $\frac{\mu_0 bR^3}{3r_2}$ **24.** $\frac{\mu_0 I_1 I_2}{4\pi}\ell n(3)$ Along –ve Z direction

25. $\frac{\mu_0 I_0 \sqrt{3}b}{2\pi(a^2+b^2)}$ **26.** $\frac{mg}{2I\ell}$ **27.** $\frac{\pi m}{qB}$ **28.** $\sqrt{15}$ C **29.** **(i)** $\mu JR\left(\frac{1}{4}-\frac{a^2}{4R^2+b^2}\right)$ **(ii)** $-\frac{\mu_0 J}{2}\left(\frac{a^2 b}{4R^2+b^2}\right)$

30. $\sqrt{v_0^2-\left(v_0-\frac{3qB_0 d}{2m}\right)^2}$ **31.** **(i)** $I=\frac{mg}{\pi r\left(B_x^2+B_y^2\right)^{1/2}}$ **(ii)** $I=\frac{mg}{\pi rB_x}$ **32.** (6.4 m, 0,0) (6.4m, 0, 2m)

33. **(i)** $\frac{QV}{m}\frac{\mu_0 I}{6a}\left(\frac{3\sqrt{3}}{\pi}-1\right)$ **(ii)** $\vec{\tau}=BI\left(\frac{\pi}{3}-\frac{\sqrt{3}}{4}\right)a^2\tilde{j}$ **34.** $0.62\ N < F < 0.88\ N$ **35.** $-2\pi rB_0 i\ell$, $-2\pi rB_0 i\ell n$

37. $B_{min} = 4.7 \times 10^{-3}$ T **38.** **(i)** 3A, perpendicular to paper outwards **(ii)** 13×10^{-7}T **(iii)** 2.88×10^{-6} N/m

39. 1.6×10^{-3} T towards west **40.** $i_1 = 0.1110A$, $i_2 = 0.096A$ **41.** **(i)** 4A **(ii)** at distance 1m from R to the left or right of it, current is outwards if placed to the left and inwards if placed to the right of R. **42.** $T_0 = 2\pi\sqrt{\frac{m}{6IB}} = 0.57s$

EXERCISE - 5 : PART # I

1. 1	**2.** 1	**3.** 2	**4.** 1	**5.** 3	**6.** 2	**7.** 1	**8.** 1	**9.** 4	**10.** 2	**11.** 2	**12.** 1	**13.** 3
14. 4	**15.** 1	**16.** 3	**17.** 4	**18.** 3	**19.** 2	**20.** 1	**21.** 3	**22.** 3	**23.** 1	**24.** 2	**25.** 1	**26.** 3
27. 4	**28.** 4	**29.** 2	**30.** 3	**31.** 2	**32.** 4	**33.** 3	**34.** 2	**35.** 2	**36.** 1	**37.** 4	**38.** 1	**39.**4 **40.** 3

PART # II

MCQ's (One or more than one answer may be correct)

1. A	**2.** D	**3.** A	**4.** D	**5.** C	**6.** C	**7.** C	**8.** B	**9.** D	**10.** C	**11.** B	**12.** A	**13.** D
14. B	**15.** B	**16.** B	**17.** C	**18.** D	**19.** A	**20.** C	**21.** A,C	**22.** A,C,D	**23.** A,C	**24.** A,D		
25. A,B,C												

Comprehension Type

Comprehension #1 : 1. A **2.** B
Comprehension #2 : 1. B **2.** B
Comprehension #3 : 1. A **2.** B
Comprehension #4 : 1. AD **2.** AC

Match the column

1. A→ P; B → P,Q,S ; C → Q,S ; D → Q,R,S
2. A→ Q; B→ R,S ; C → S; D → P,Q,R
3. A→ Q,R ; B → P ; C → Q,R; D → Q,S
4. A→ Q,R,S; B→ R,S; C → P,Q,T ; D R,S

Assertion–Reason **1.** C

Subjective Questions

1. $\left|\vec{\tau}\right| = I_0 L^2 B(b)\theta = \frac{3}{4}\frac{I_0 B}{M}(\Delta t)^2$ **2.** **(i)** $L=\frac{mv_0}{2B_0 q}$ **(ii)** $\vec{v}_f = -v_0 i, t_{AB} = \frac{\pi m}{B_0 q}$ **3.** **(i)** $\vec{F} = -\frac{\mu_0 qV_0 I}{4R}\tilde{k}$

(ii) $\vec{F}_1 = \vec{F}_2 = 2BIR\tilde{i}$, $\vec{F} = 4BIR\tilde{i}$ **4.** **(i)** 6.54×10^{-5} T (Vertically upward or outward normal to the paper)

(ii) Zero, Zero 8.1×10^{-6} N (inwards) **5.** **(i)** P to Q **(ii)** $IbB_0\left(3\tilde{k}-4\tilde{j}\right)$ **(iii)** $\frac{mg}{6bB_0}$ **6.** $\omega_{max} = \frac{DT_0}{BQR^2}$ **7.** $\frac{1}{\sqrt{2}}$

8. $\theta_{max} = Q\sqrt{\frac{BN\pi A}{2I}}$ **9.** 7 **10.** 2

MOCK TEST

1. A	**2.** A	**3.** A	**4.** C	**5.** B	**6.** C	**7.** B	**8.** B	**9.** C
10. D	**11.** C	**12.** D	**13.** B	**14.** D	**15.** A	**16.** B	**17.** **A**	**18.** D
19. C	**20** B	**21.** B	**22.** C	**23** A	**24.** C	**25.** C	**26.** C	**27.** C
28. C	**29.** A	**30.** A	**31.** C	**32.** A	**33.** A	**34.** A	**35.** A	**36.** A,D
37. A,D	**38.** A,B,C	**39.** A,B,C	**40.** C,D	**41.** D	**42.** B	**43.** A	**44.** D	**45.** C
46. B	**47.** C	**48.** A	**49.** A	**50.** D	**51.** B	**52.** C		

53. A→ S; B→ P; C →Q; D→ R   **54.** A → Q, S ; B → P, S ; C → Q, S ; D → P, S

55. A →P,Q, R, T ; B →P, Q, R, S, T; C→ R; D →P, Q, R, S, T   **56.** A → R,S; B → R,S ; C → Q,R ; D → P,R, T

57. A → R ; B →Q,T ; C→ T ; D→ S   **59.** 9.1×10^9 **60.** 45°