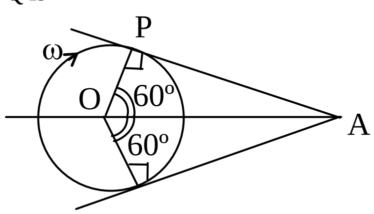
Q.1 An α particle is moving along a circle of radius R with a constant angular velocity ω. Point A lies in the same plane at a distance 2R from the centre. Point A records magnetic field produced by α particle, if the minimum time interval between two successive times at which A records zero magnetic field is 't' the angular speed ω, in terms of t is :

(A) $\frac{2\pi}{t}$ (B) $\frac{2\pi}{3t}$

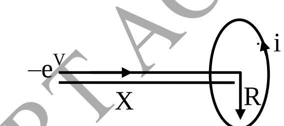
(C) $\frac{\pi}{3t}$ (D) $\frac{\pi}{t}$ **[B]**

Sol. Point A shall record zero magnetic field (due to α-particle) is at position P and Q as shown in figure. The time taken by α-particle to go from P to Q is –



$t = \frac{1}{3}\frac{2\pi}{\omega}$ or $\omega = \frac{2\pi}{3t}$

Q.2 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) $\frac{\mu_0}{Z}\frac{eviR^2X}{(X^2+R^2)^{3/2}}$ (B) μ_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 **[D]**

Sol. Direction of electron velocity is along magnetic lines of flux. Hence F = O

Q.3 Cyclotron is used to accelerate –

(A) electrons (B) neutrons

(C) positive ions (D) negative ions

[C]

Q.4 An electron of charge e moves in a circular orbit of radius r around the nucleus at a frequency ν. The magnetic moment associated the orbital motion of the electron is –

(A) $\pi\, \nu\, e\, r^2$ (B) $\frac{\pi \nu r^2}{e}$

(C) $\frac{\pi \nu e}{r}$ (D) $\frac{\pi e r^2}{\nu}$ **[A]**

Sol. M = iA

$= (e\nu)\, \pi r^2$

Q.5 A proton, a dutron and an α particle with the same KE enter in a region of uniform magnetic field, moving at right angles to B. what is the ratio of the radii of their circular paths ?

(A) $1 : \sqrt{2} : 1$ (B) $1 : \sqrt{2} : \sqrt{2}$

(C) $\sqrt{2} : 1 : 1$ (D) $\sqrt{2} : \sqrt{2} : 1$ **[A]**

Sol. $r_P = \frac{\sqrt{2m_pK}}{eB}$

$r_d = \frac{\sqrt{2(2m_p)K}}{eB}$

$r_\alpha = \frac{\sqrt{2(4m_p)K}}{(2e)B}$

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

(A) 10^{-4} (B) 3×10^{-4}

(C) 5×10^{-4} (D) 6×10^{-4} **[C]**

Sol. Magnetic field due to wire

$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}}{2\pi} \times \frac{30}{2\times10^{-2}}$

$= 3 \times 10^{-4}$ T

This magnetic field will be perpendicular to external magnetic field.

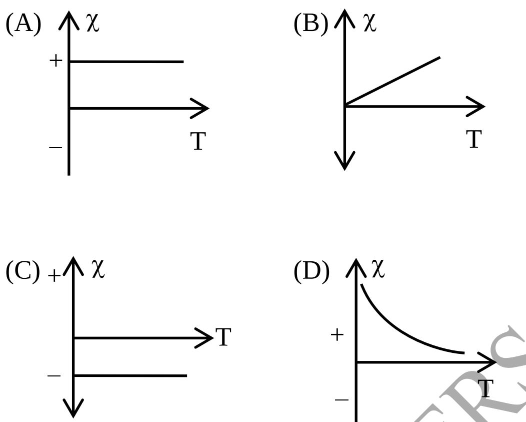
$\therefore$ Net magnetic field

$B = \sqrt{B^2 + B_0^2}$

$= \sqrt{(3\times10^{-4})^2 + (4\times10^{-4})^2}$

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

Q.7 Which one of the following graphs represents the behaviour of magnetic susuptibility (χ) of the paramagnetic substance with the temperature T ?

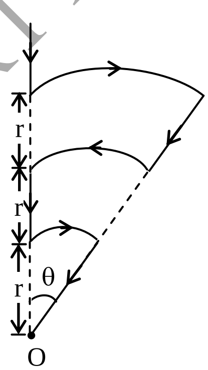


[D]

Sol. From curie law

$\chi \propto \frac{1}{T}$

Q. 8 Shown in the figure is a conductor carrying a current I. The magnetic field intensity at the point O(common centre of all the three arcs) is :



(A) $\frac{5\mu_0 I\theta}{24\pi r}$ (B) $\frac{\mu_0 I\theta}{24\pi r}$

(C) $\frac{11\mu_0 I\theta}{24\pi r}$ (D) zero

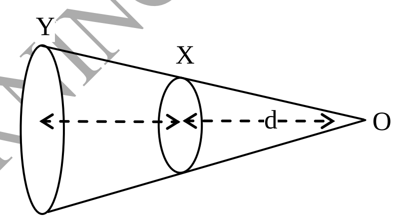
Sol. **[A]**

Hint : Find B due to each arc at O and add them using vector addition.

Since magnetic field at the centre of an arc is equal to $B = \frac{\mu_0 I}{4\pi r}\theta$

hence, net $B = \frac{\mu_0 I}{4\pi}\left[\frac{1}{r} - \frac{1}{2r} + \frac{1}{3r}\right]\theta = \frac{5\mu_0 I\theta}{24\pi r}$

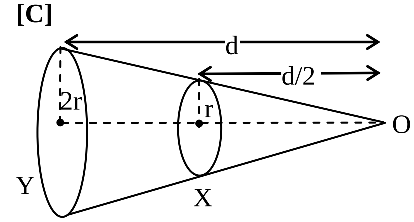
Q. 9 Two circular coils X and Y have equal number of turn and carry equal currents in the same sense and subtend same solid angle at point O. If the smaller coil X is midway between O and Y , then if we represent the magnetic induction due to bigger coil Y at O as B_Y and that due to smaller coil X at O B_X, then :



(A) $\frac{B_Y}{B_X} = 1$ (B) $\frac{B_Y}{B_X} = 2$

(C) $\frac{B_Y}{B_X} = \frac{1}{2}$ (D) $\frac{B_Y}{B_X} = \frac{1}{4}$

Sol. **[C]**



As two coils subtend the same solid angle at O, hence area of coil, Y = 4 × area of coil X

$\left[\text{Solid angle} = \frac{\text{area}}{(\perp \text{distance})^2}\right]$

i.e. radius of coil Y = 2 × radius of coil X

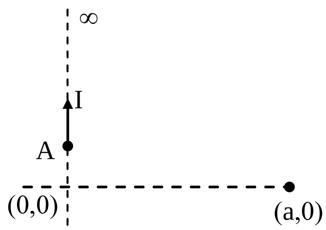
$\therefore B_Y = \frac{\mu_0}{4\pi} \times \frac{2\pi I(2r)^2}{[(2r)^2 + (d^2)]^{3/2}}$

$B_X = \frac{\mu_0}{4\pi} \times \frac{2\pi I(r)^2}{\left[r^2 + \left(\frac{d}{2}\right)^2\right]^{3/2}}$

$\therefore \frac{B_Y}{B_X} = \frac{4}{(4r^2 + d^2)^{3/2}} \times \left[\frac{4r^2 + d^2}{4}\right]^{3/2}$

$= \frac{4}{(4)^{3/2}} = \frac{4}{8} = \frac{1}{2}$

Q.10 An infintely 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).



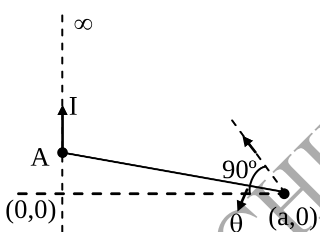
(A) $\frac{\mu_0 I}{4\pi a}\left(1+\frac{b}{\sqrt{a^2+b^2}}\right)$

(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

Sol. **[B]**



$B = \frac{\mu_0}{4\pi}\ \frac{i}{a}\ (\sin 90° + \sin(-\theta))$

$= \frac{\mu_0}{4\pi}\ \frac{i}{a}\left(1-\frac{b}{\sqrt{a^2+b^2}}\right)$

Q.11 A 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

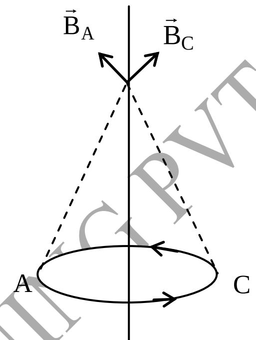
(B) it is constant in direction only

(C)it is constant in direction and magnitude both

(D) it is not constant in magnitude and direction both

Sol. **[A]**

The point charge moves in circle as shown in figure. The magnetic field vectors at a point P on axis of circle are $\vec{B}_A$ and $\vec{B}_C$ at the instants the point charge is at A and C respectively as shown in the figure.



Hence as the particles rotates in circle, only magnitude of magnetic fiels remains constant at the point on axis P but it's direction changes.

⇒ Alternate solution ⇒

The magnetic field at point on the axis due to charged particle moving along a circular path is given by

$\frac{\mu_0}{4\pi}\ \frac{q\vec{v}\times\vec{r}}{r^3}$

It can be seen that the magnitude of the magnetic field at on point on the axis remains constant. But the direction of the field keeps on changing.

Q.12 A particle of charge Q and of negligible initial speed is accelerated through a potential difference of U. The particle reaches a region of uniform magnetic field of induction B, where it undergoes circular motion . If potential difference is doubled and B is also doubled then magnetic moment of the circular current due to circular motion of charge Q will become.

(A) double (B) half

(C) four times (D) remain same

Sol. **[A]**

K.E = QU

magnetic moment = i × Area

$$= \frac{Q}{T} \times \pi R^2$$

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

$$R = \sqrt{\frac{2mKE}{qB}} = \sqrt{\frac{2mU}{qB}}$$

$$\text{Magnetic moment} = \frac{Q^2 \times B}{2\pi m} \times \frac{\pi \times 2m \times U}{QB}$$

Magnetic moment = QU

Q.13 Consider a toroid of circular cross-section of radius b, major radius R much greater than minor radius b. Find the total energy stored in toroid. (I is current)

(A) $\frac{\mu_0 N^2 I^2 b^2}{2R}$ (B) $\frac{\mu_0 N^2 I^2 b^2}{3R}$

(C) $\frac{\mu_0 N^2 I^2 b^2}{6R}$ (D) $\frac{\mu_0 N^2 I^2 b^2}{4R}$

Sol. **[D]**

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

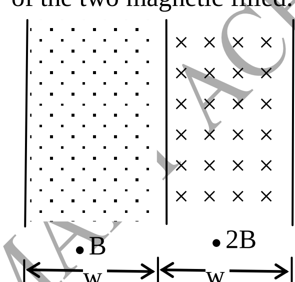
$$\phi = \pi b^2 \times B \times N$$

$$\phi = Li$$

$$L = \frac{\phi}{i} = \frac{\mu_0 N^2 b^2}{2R} \text{ with } b <<< R$$

$$\text{energy} = \frac{1}{2} Li^2 = \frac{\mu_0 N^2 I^2 b^2}{4R}$$

Q. 14 The magnetic field shown in the figure consist of the two magnetic filled.

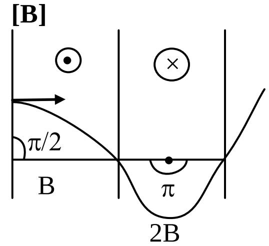


if v is the velocity just required for a charge particle of mass m and charge q to pass through the magnetic field. Particle is projected with velocity "v" then, how much time does such a charge spend in the magnetic field.

(A) $\frac{\pi m}{2qB}$ (B) $\frac{\pi m}{qB}$

(C) $\frac{\pi m}{4qB}$ (D) $\frac{3\pi m}{2qB}$

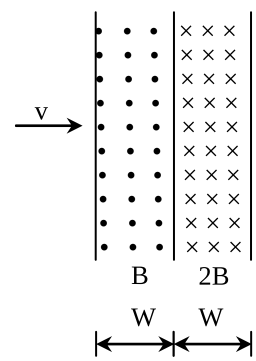
Sol. **[B]**



$$\text{Time} = \frac{\pi m}{2qB} + \frac{\pi m}{2qB}$$

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

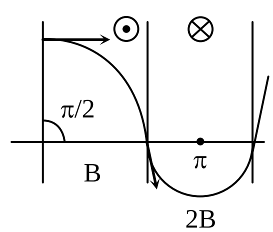
Q.15 Region of the magnetic field shown in the figure consist of two uniform magnetic fields. If v is the velocity just required for a charge q of particle of mass m and charge to pass through the region of magnetic field. Particle is projected with velocity "v' then how much time does such a charge spend in the region of magnetic field ?



(A) $\frac{\pi m}{2qB}$ (B) $\frac{\pi m}{qB}$

(C) $\frac{\pi m}{4qB}$ (D) $\frac{3\pi m}{2qB}$

Sol. **[B]**



$$\text{Time} = \frac{\pi m}{2qB} + \frac{\pi m}{2qB}$$

$= \dfrac{\pi m}{qB}$

Q.16 Two long concentric cylindrical conductors of radii a & b (b < a) are maintained at a potential difference V & carry equal & opposite currents I. An electron with a particular velocity "U" parallel to the axis will travel undeviated in the evacuated region between the conductors. Then U =

(A) $\dfrac{4\pi V}{\mu_0 I \ell n\left(\frac{b}{a}\right)}$ (B) $\dfrac{2\pi V}{\mu_0 I \ell n \frac{a}{b}}$

(C) $\dfrac{2\pi V}{\mu_0 I \ell n\left(\frac{b}{a}\right)}$ (D) $\dfrac{8\pi V}{\mu_0 I \ell n\left(\frac{a}{b}\right)}$

Sol. **[B]**

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

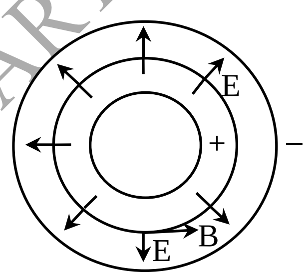
p.d. $V = \dfrac{\lambda}{2\pi\varepsilon_0} \ell n\left(\dfrac{a}{b}\right)$

$$E = \frac{V}{r \ell n\left(\frac{a}{b}\right)}$$

B varies with r

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

B & E are perpendicular to each other

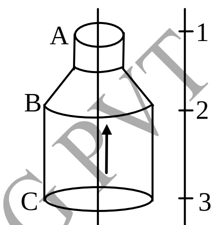


$\therefore$ qUB = qE

(if particle travel undeviated)

$$U = \frac{E}{B} = \frac{2\pi V}{\mu_0 I \ell n\left(\frac{a}{b}\right)}$$

Q.17 A long, straight, hollow conductor (tube) carrying a current has two sections A and C of unequal cross-sections joined by a conical section B. 1, 2 and 3 are points on a line parallel to the axis of the conductor. The magnetic fields at 1, 2 and 3 have magnitudes B_1, B_2 and B_3 respectively, then :



(A) $B_1 = B_2 = B_3$

(B) $B_1 = B_2 \neq B_3$

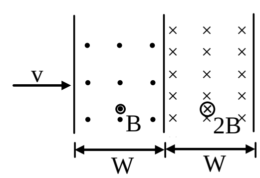
(C) $B_1 < B_2 < B_3$

(D) B_2 cannot be found unless the dimensions of the section B are known

Sol. **[A]**

To find the magnetic field outside a thick conductor, the current may be assumed to flow along the axis. As points 1 , 2 , 3 are equidistant from the axis, $B_1 = B_2 = B_3$

Q.18 The magnetic field shown in the figure consist of the two magnetic fields.

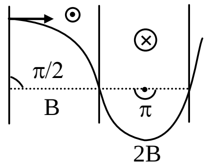


If v is the velocity just required for a charge particle of mass m and charge q to pass through the magnetic field. Particle is projected with velocity 'v' then how much time does such a charge spend in the magnetic field –

(A) $\dfrac{\pi m}{2qB}$ (B) $\dfrac{\pi m}{qB}$

(C) $\dfrac{\pi m}{4qB}$ (D) $\dfrac{3\pi m}{2qB}$ **[B]**

Sol.



Time = $\frac{\pi m}{2qB} + \frac{\pi m}{2qB} = \frac{\pi m}{qB}$

Q.19 Fig. shows a circular wire of radius r carrying a current i. The force of compression on the wire is –

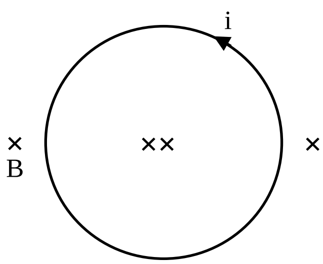


Fig.

(A) 2iaB (B) iaB

(C) 2πiaB (D) None of these

[B]

Sol. dF = idlB

$F = \int idlB = iaB$

Q.20 A coil having N turns is wound tightly in the form of a spiral with inner and outer radii **a** and **b** respectively. When current I passes through the coil, the magnetic field at the centre is –

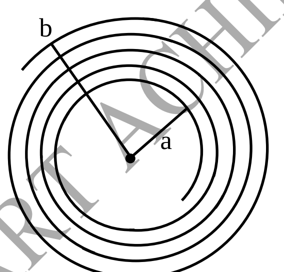


Fig.

(A) $\frac{N\mu_0 i}{2(b-a)} \log_e \frac{b}{a}$

(B) $\frac{N\mu_0 i}{2(b-a)} \log_e \frac{b+a}{b-a}$

(C) $\frac{2N\mu_0 i}{(b+a)} \log_e \frac{b}{a}$

(D) None of these **[A]**

Sol. Magnetic induction due to a circular current-carrying loop at x is $dB = \frac{\mu_0 i}{2x}$ (dN)

Total magnetic field at the centre (due to all loops)

$B = \int \frac{\mu_0 i}{2x} dN$

$= \int_a^b \frac{\mu_0 i}{2x} \frac{N}{(b-a)} dx$

$= \frac{\mu_0 i N}{2(b-a)} \log_e \frac{b}{a}$

Q.21 A particle of charge q = 4 μC and mass m = 10 mg starts moving from the origin under the action of an electric field $\vec{E} = 4\hat{i}$ and magnetic field $\vec{B} = (0.2T)\hat{k}$. Its velocity at (x, 3, 0) is $(4\vec{i} + 3\vec{j})$. The value of x is –

(A) $\frac{115}{16}$m (B) $\frac{125}{16}$m

(C) $\frac{135}{16}$m (D) $\frac{145}{16}$m **[B]**

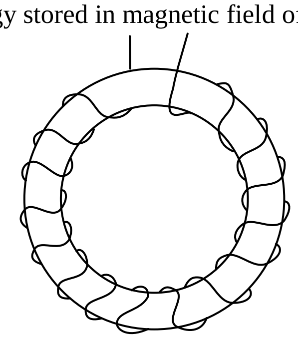
Sol. W (qE) = $\frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 - 0$

⇒ $4 \times 10^{-6} \times 4x = \frac{1}{2}m(4^2 + 3^2)$

$4 \times 10^{-6} \times 4 \times x = \frac{1}{2} \times 10 \times 10^{-6} \times 25$

$x = \frac{250}{32}m = \frac{125}{16}m$

Q.22 Consider a toroid of circular cross-section of radius b, major radius R much greater than minor radius b, (see diagram) find the total energy stored in magnetic field of toroid –



(A) $\frac{B^2\pi^2b^2R}{2\mu_0}$ (B) $\frac{B^2\pi^2b^2R}{4\mu_0}$

(C) $\frac{B^2\pi^2b^2R}{8\mu_0}$ (D) $\frac{B^2\pi^2b^2R}{\mu_0}$ **[D]**

Sol. $B = \dfrac{\mu_0 Ni}{2R}$

$\phi = \pi b^2 \times B \times N$

$\phi = Li$

$L = \dfrac{\phi}{i} = \dfrac{\mu_0 N^2 b^2}{2R}$, with $b <<< R$

Energy $= \dfrac{1}{2} Li^2 = \dfrac{\mu_0 N^2 i^2}{4R} b^2$

Q.23 Two circular coils made of similar wires but of radius 20 cm and 40 cm are connected in parallel. The ratio of magnetic fields at their centre is -

(A) 4 : 1 (B) 1 : 4

(C) 2 : 1 (D) 1 : 2 **[A]**

Sol. $\dfrac{B_1}{B_2} = \dfrac{I_1}{I_2} \times \dfrac{r_2}{r_1}$

But $\dfrac{I_1}{I_2} = \dfrac{V/R_1}{V/R_2} = \dfrac{R_2}{R_1} = \dfrac{\rho\ell_2/A}{\rho\ell_1/A} = \dfrac{\ell_2}{\ell_1}$

$= \dfrac{2\pi r_2}{2\pi r_1} = \dfrac{r_2}{r_1}$

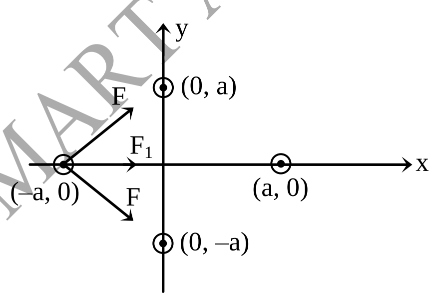
$\therefore \dfrac{B_1}{B_2} = \dfrac{r_2}{r_1} \times \dfrac{r_2}{r_1} = \left(\dfrac{40}{20}\right)^2 = 4$

Q.24 Four very long straight wires carry equal electric currents in the + z-direction. They intersect the x-y plane at (x, y) = (– a, 0), (0, a) (a, 0) and (0, – a). The magnetic force exerted on the wire at position (– a, 0) is along –

(A) + y-axis (B) – y-axis

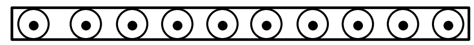
(C) + x-axis (D) – x-axis **[C]**

Sol.



Net force is along +x-axis.

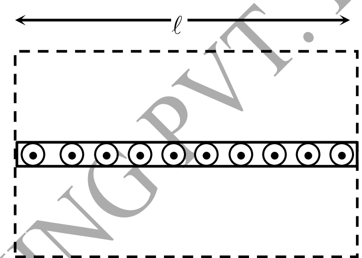
Q.25 A large metal sheet carries an electric current along its surface. Current per unit length is λ. Magnetic field near the metal sheet is –



(A) $\dfrac{1}{2}\mu_0\lambda$ (B) $\dfrac{\lambda\mu_0}{2\pi}$

(C) $\lambda\,\mu_0$ (D) $\dfrac{\mu_0}{2\lambda\pi}$ **[A]**

Sol. Applying Ampere's law



$\oint \vec{B}.d\vec{\ell} = \mu_0(\lambda\ell)$

$2B\ell = \mu_0\lambda\ell$

$B = \dfrac{1}{2}\mu_0\lambda$

Q.26 O^{++}, C^{+}, He^{++} and H^{+} ions are projected on the photographic plate with same velocity in a mass spectrograph. Which one will strike farthest ?

(A) O^{++} (B) C^{+}

(C) He^{++} (D) H^{+} **[B]**

Sol. D = diameter $= 2r = \dfrac{2mv}{qB}$

$D \propto \dfrac{m}{q}$

Here $\dfrac{m}{q}$ is maximum for C^{+}.

Q.27 The magnetic field B due to a current carrying circular loop of radius 12 cm at its centre is 0.5×10^{-4} T. The magnetic field due to this loop at a point on the axis at a distance of 5 cm from the centre -

(A) 3.9×10^{-5} T

(B) 5.2×10^{-5} T

(C) 2.1×10^{-5} T

(D) 9×10^{-5} T **[A]**

Sol. $B_0 = \dfrac{\mu_0 I}{2a}$

At axial point

$$B = \frac{\mu_0 I a^2}{2(a^2 + x^2)^{3/2}}$$

$$\frac{B}{B_0} = \frac{a^3}{(a^2 + x^2)^{3/2}}$$

$$\Rightarrow B = B_0 \ \frac{a^3}{(a^2 + x^2)^{3/2}}$$

$$= 0.5 \times 10^{-4} \times \frac{(12\text{cm})^3}{(144\text{cm}^2 + 25\text{cm}^2)^{3/2}}$$

$= 3.9 \times 10^{-5}$ T.

Q.28 A wire along x-axis carries a current 3.5 A. Find the force on a 1 cm section of the wire exerted by:

$B = 0.74\text{ T } \hat{j} - 0.3\text{ T } \hat{k}$

(A) $(2.59\hat{k} + 1.26\hat{j}) \times 10^{-2}$

(B) $(1.26\hat{k} - 2.59\hat{j}) \times 10^{-2}$

(C) $(-2.59\hat{k} - 1.26\hat{j}) \times 10^{-2}$

(D) $(-1.26\hat{k} + 2.59\hat{j}) \times 10^{-2}$ **[A]**

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

$= 3.5[10^{-2}\hat{i} \times (.74\hat{j} - 0.36\hat{k})]$

$= (2.59\hat{k} + 1.26\hat{j}) \times 10^{-2}$

Q.29 An electric current i enters and leaves a uniform circular wire of radius 'a' through diametrically opposite points. A charged particle 'q' moving along the axis of the circular wire passes through its centre at speed v. The magnetic force acting on the particle when it passes through the centre has a magnitude-

(A) $qv\dfrac{\mu_0 i}{2a}$ (B) $qv\dfrac{\mu_0 i}{2\pi a}$

(C) $qv\dfrac{\mu_0 i}{a}$ (D) zero **[D]**

Q.30 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 masses of X to that of Y is-

(A) $\left(\dfrac{R_1}{R_2}\right)^{1/2}$ (B) $\dfrac{R_2}{R_1}$

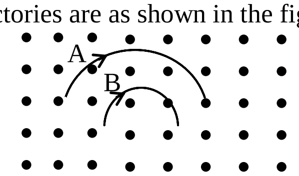
(C) $\left(\dfrac{R_1}{R_2}\right)^2$ (D) $\dfrac{R_1}{R_2}$ **[C]**

Q.31 A negative charged particle falling freely under gravity enters a region having horizontal magnetic field pointing towards north. The particle will be deflected towards-

(A) East (B) West

(C) North (D) South **[B]**

Q.32 Two particle 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-



(A) $m_A v_A < m_B v_B$

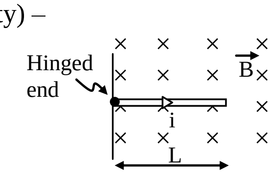
(B) $m_A v_A > m_B v_B$

(C) $m_A < m_B$ and $v_A < v_B$

(D) $m_A = m_B$ and $v_A = v_B$

Sol. **[B]** use $r = \dfrac{mv}{qB}$

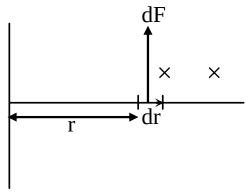
Q.33 A straight conductor of mass m and carrying a current i is hinged at one end and placed in a plane perpendicular to the magnetic field B as shown in figure. At any moment if the conductor is let free, then the angular acceleration of the conductor will be (neglect gravity) –



(A) $\frac{3iB}{2m}$ (B) $\frac{2}{3}\frac{iB}{m}$

(C) $\frac{iB}{2m}$ (D) $\frac{3i}{2mB}$ **[A]**

Sol.



Torque

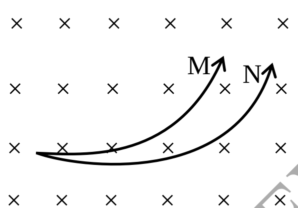
$d\tau = dF \times r$

$= iBdr \times r$

$$\tau = \int_0^L iBrdr = \frac{iBL^2}{2}$$

$$\alpha = \frac{\tau}{I} = \frac{iBL^2}{\frac{2mL^2}{3}} = \frac{3}{2}\frac{iB}{m}$$

Q.34 Two charged particle M and N are projected with same velocity in a uniform magnetic field. Then M and N respectively



(A) an electron and a proton

(B) a deuteron and a proton

(C) a deuteron and an electron

(D) a proton and α - particle **[D]**

Q.35 A charge q is moving with a velocity $\vec{v}_1 = 1\hat{i}$ m/s at a point in a magnetic field and experiences a force $\vec{F}_1 = q(-1\hat{j} + 1\hat{k})$N. If the charge is moving with a velocity $\vec{v}_2 = 1\hat{j}$ m/s at the same point, it experiences and a force $\vec{F}_2 = q[1\hat{i} - 1\hat{k}]$ N. The magnetic induction $\vec{B}$ at that point is-

(A) $(\hat{i} + \hat{j} + \hat{k})$ Wb/m^2

(B) $(\hat{i} - \hat{j} + \hat{k})$ Wb /m^2

(C) $(-\hat{i} + \hat{j} - \hat{k})$ Wb/m^2

(D) $(\hat{i} + \hat{j} - \hat{k})$ Wb/m^2 **[A]**

Q.36 A particle moves in a circular path of diameter 1.0 m under the action of magnetic field of 0.40 Tesla . An electric field of 200 V/m makes the path of particle straight. Find the charge/mass ratio of the particle.

(A) 2.5×10^5 cb/kg (B) 2×10^5 cb/kg

(C) 3.5×10^5 cb/kg (D) 3×10^5 cb/kg

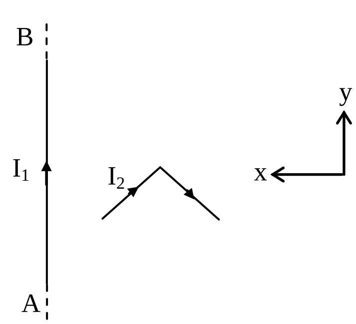
[A]

Q.37 A charged particle is released from rest in a region of steady and uniform electric and magnetic field which are parallel to each other. The particle will move in a -

(A) straight line (B) circle

(C) helix (D) cycloid **[A]**

Q.38 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 resultant force on the wire CD is-



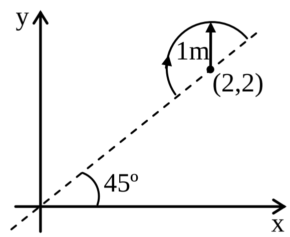
(A) zero

(B) towards negative x-axis

(C) towards positive y-axis

(D) none of these **[D]**

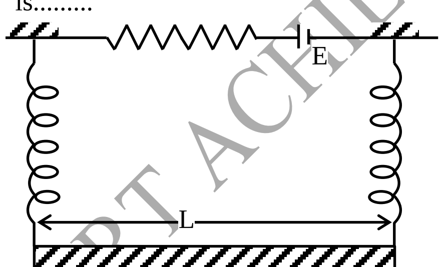
Q.39 A uniform magnetic field $\vec{B} = (3\hat{i} + 4\hat{j} + \hat{k})$ exists in region of space. A semicircular wire of radius 1 m carrying current 1 A having its centre at (2, 2, 0) is placed in x-y plane as shown in figure. The force on semicircular wire will be-



(A) $\sqrt{2}(\hat{i} + \hat{j} + \hat{k})$ (B) $\sqrt{2}(\hat{i} - \hat{j} + \hat{k})$

(C) $\sqrt{2}(\hat{i} + \hat{j} - \hat{k})$ (D) $\sqrt{2}(-\hat{i} + \hat{j} + \hat{k})$ **[B]**

Q.40 A straight rod of mass m and length L is suspended from the identical springs as shown in the figure. The spring stretched a distance x_0 due to the weight of the wire. The circuit has total resistance R. When the magnetic field perpendicular to the plane of paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is.........



(A) $\frac{2mgR}{LE}$ (B) $\frac{mgR}{EL}$

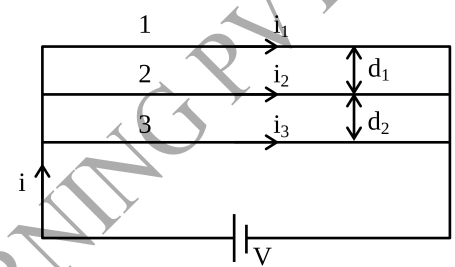
(C) $\frac{mgR}{2LE}$ (D) $\frac{mgR}{E}$ **[B]**

Q.41 A hypothetical magnetic field existing in a region is given by $\vec{B} = B_0\hat{r}$. Where $\hat{r}$ denotes the unit vector along the radial direction. A circular loop of radius a carrying a current i, is placed with its plane parallel to the x-y plane and centre at (0, 0, d) . The magnitude of magnetic force acting on the loop is-

(A) $\frac{2\pi a^2 iB_0}{d}$ (B) $\frac{2\pi a^2 iB_0}{\sqrt{a^2 + d^2}}$

(C) $\frac{\pi a^2 iB_0}{d}$ (D) $\frac{\pi a^2 iB_0}{\sqrt{a^2 + d^2}}$ **[B]**

Q.42 Three long wires of resistances in the ratio 3 : 4 : 5 are connected in parallel to each other as shown in figure . If net force on middle wire is zero then $\frac{d_1}{d_2}$ will be –



(A) 9 : 25 (B) 5 : 3

(C) $\sqrt{5} : \sqrt{3}$ (D) 1 : 1 **[B]**

Q.43 A charged particle of mass m and charge q is accelerated through a potential difference of V volts. It enters a region of uniform magnetic field which is directed perpendicular to the direction of motion of the particle. The particle will move on a circular path of radius given by -

(A) $\sqrt{\frac{Vm}{qB^2}}$ (B) $\frac{2Vm}{qB^2}$

(C) $\sqrt{\frac{2Vm}{q}}\left(\frac{1}{B}\right)$ (D) $\sqrt{\frac{Vm}{q}}\left(\frac{1}{B}\right)$

[C]

Q.44 A particle of de-Broglie wavelength 2.21×10^{-13} m and charge 1.6 x 10^{-19} cb is projected with a speed 2 x 10^6 m/s at an angle 60° to the x-axis. If a uniform magnetic field of 0.3T is applied along the y-axis , the path of the particle is -

(A) a circle of radius 0.03 m and time period $6.25\,\pi \times 10^{-8}$ sec

(B) a circle of radius 0.01 m and time period $\frac{6.25\pi}{3} \times 10^{-8}$ sec

(C) a helix of radius 0.03 m and time period $6.25\,\pi \times 10^{-8}$ sec

(D) a helix of radius 0.01 m and time period $\frac{6.25\pi}{3} \times 10^{-8}$ sec **[C]**

Q.45 A rigid circular loop of radius r and mass m lies in the x-y plane on a flat table and has a current I flowing in it. At this particular place. The earth's magnetic field is $\vec{B} = B_x\hat{i} + B_y\hat{j}$. The minimum value of I for which one end of the loop will lift from the table is

(A) $\frac{mg}{\pi r Bx}$ (B) $\frac{mg}{\pi r B_y}$

(C) $\frac{mg}{2\pi r\sqrt{B_x^2 + B_y^2}}$ (D) None of these

Q.46 Magnetic induction at the centre of a circular coil is given by -

(A) $\frac{\mu_0 NI}{2r}$ (B) $\frac{\mu_0 NIr^2}{(r^2+x^2)^{3/2}}$

(C) $\frac{\mu_0 NI}{2r^2}$ (D) $\frac{\mu_0 NI}{r}$ **[A]**

Sol. $B = \frac{\mu_0 NI}{2r}$

Q.47 A charge q moves in a region where electric field and magnetic field both exist, then force on it is -

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

(C) $q\vec{B}+q(\vec{E}\times\vec{v})$ (D) $q\vec{E}+q(\vec{v}\times\vec{B})$

[D]

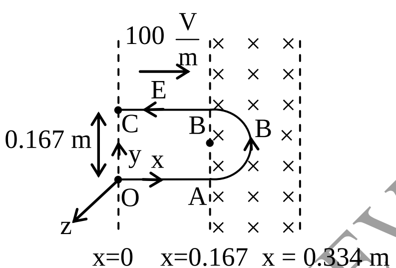
Sol. $\vec{F} = \vec{F}_E + \vec{F}_B$

$= q\,[\vec{E}+(\vec{v}\times\vec{B})]$

Q. 1 There is a constant homogeneous electric field of $100 Vm^{-1}$ within the region x = 0 and x = 0.167 m pointing in the positive x-direction. There is a constant homogeneous magnetic field B within the region x = 0.167 m and x = 0.334m pointing in the z-direction. A proton at rest at the origin (x = 0, y = 0) is released in the positive x-direction. The minimum strength of the magnetic field B, so that the proton will come back at x = 0, y = 0.167 m (mass of the proton= 1.67×10^{-27} kg) is...........mT.

Sol. **[0007]**

The situation described in the problem is shown in fig As electric field is along x-axis, so proton will be accelerated by the electric field and will enter the magnetic field at A(i.e., x = 0.167, y = 0) with velocity v along x-axis such that



$$\frac{1}{2}mv^2 = W = Fd = qEd$$

$$\text{i.e. } v = \left[\frac{2qEd}{m}\right]^{1/2}$$

$$= \left[\frac{2\times1.6\times10^{-19}\times100\times0.167}{1.67\times10^{-27}}\right]^{1/2}$$

$$= 4\sqrt{2} \times 10^4 \ \frac{m}{s}$$

Now as proton is moving perpendicular to magnetic field so it will describe a circular path in the magnetic field with radius r such that

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

And as it comes back at C[x = 0; y = 0.167m] its path in the magnetic field will be a semicircle such that

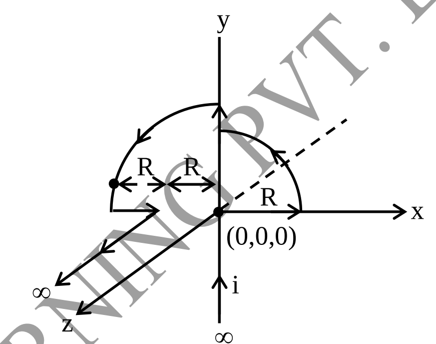
$$y = 2r = \frac{2mv}{qB} \text{ i.e. } B = \frac{2mv}{qy}$$

$$\text{i.e., } B = \frac{2\times1.67\times10^{-27}\times4\sqrt{2}\times10^4}{1.6\times10^{-19}\times0.167}$$

$$= \frac{1}{\sqrt{2}} \times 10^{-2}$$

= 7.07 mT

Q.2

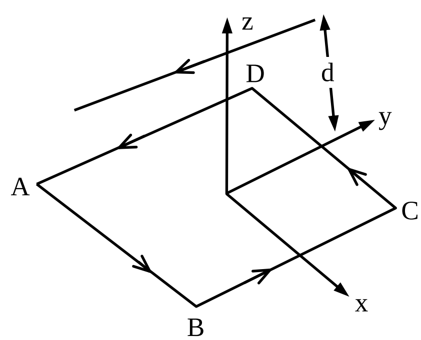


If Magnetic induction at origin is given by $\frac{\mu_0 I}{4R}\left(\frac{a}{4}\hat{k}+\frac{b}{\pi}\hat{j}\right)$

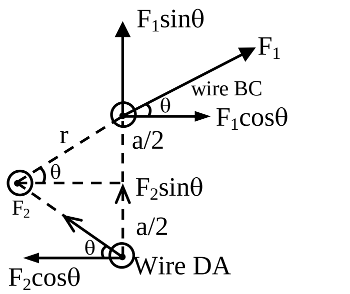
Then a × b = …..

Sol.[3] Magnetic induction at origin is due to one semi-infinite wire and two quarter circle of radii R and 2 R.

Q.3 Figure shows a square loop. 20 cm on each side in the x-y plane with its centre at the origin. The loop carries a current of 7A. Above it at y = 0, z = 12cm is an infinitely long wire parallel to the x axis carrying a current of 10 A. The net force on the loop is ------$\times10^{-4}$N.



Sol. [6]



Total force = $(F_1 + F_2)\sin\theta$

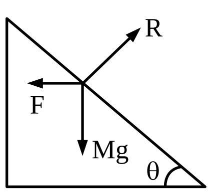
$$F_1 = F_2 = \frac{\mu_0 i_1 i_2}{2\pi r}\frac{a}{2r}$$

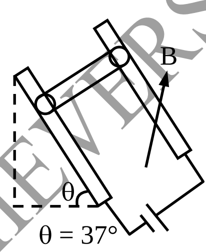
$$= \frac{\mu_0 i_1 i_2 a}{4\pi r^2}$$

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

Q.4 Two conducting rails are connected to a source of emf and form an incline as shown in figure. A bar of mass 50g slides without friction down the incline through a vertical magnetic field B. If the length of the bar is 50 cm and a current of 2.5 A is provided by battery. Value of B for which the bar slide at a constant velocity ……..×10^{-1} Tesla. [g = 10 m/s^2]

Sol. [3]





θ = 37°

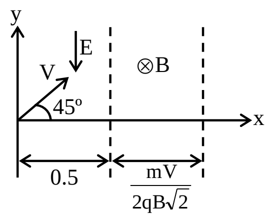
$F\cos\theta = Mg\sin\theta$

$BIL\cos\theta = Mg\sin\theta$

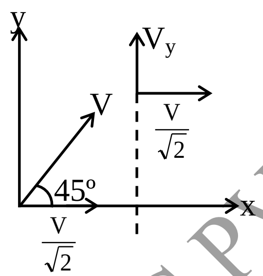
$$B = \frac{Mg}{IL}\tan\theta$$

= 0.3 Tesla

Q.5 A charge particle of charge q and mass m is projected in a region which contains electric and magnetic field as shown in figure with velocity V at an angle 45º with x-direction. If $V = \sqrt{\frac{qE}{m}}$, then net deviation in particle motion will be (neglect the effect of gravity) in clockwise direction approx in radian …….. .



Sol. **[1]**



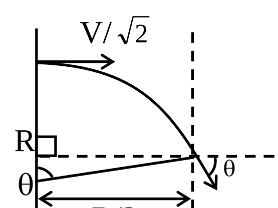
$$0.5 = \frac{Vt}{\sqrt{2}},\ t = \frac{\sqrt{2}\times 0.5}{V}$$

$$V_y = \frac{V}{\sqrt{2}} - \frac{qE}{m}\times t$$

$$V_y = \frac{V}{\sqrt{2}} - \frac{V^2}{\sqrt{2}V},\ V_y = 0$$

$$R = \frac{mV}{qB} = \frac{mV}{\sqrt{2}qB}$$

$$\sin\theta = \frac{R}{2R} = \frac{1}{2},\ \theta = 30^\circ$$



Deviation = 45º + 30º = 75º clockwise.

Q.6 A small plate of a metal (work function = 1.17 eV) is placed at a distance of 2 m from a monochromatic light source of wavelength 4800 Å and power 1.0 watt. The light falls normally on the plate. If a constant magnetic field of strength 10^4 Tesla is applied parallel to metal surface. Find the radius (in cm) of the largest circular path followed by the emitted photo electrons.

Sol. **[4]**

Energy of incident photon is eV is

$$E = \frac{12431}{4800}\text{eV} = 2.58\text{ eV} = 2.58 \times 1.6 \times 10^{-19}\text{ J}$$

$= 4.125 \times 10^{-19}$J.

The rate of emission of photon from source

$r = I/E = \dfrac{10\,\text{joule/sec}}{4.125\times10^{-19}\,\text{joule}} = 2.424\times10^{18}$/sec

No. of photon striking per square metal per sec on the plate

$= \dfrac{2.425\times10^{18}}{4\times3.14\times(2)^2} = 4.82\times10^{16}\ m^{-2}\ sec^{-1}$

The maximum kinetic energy of the photo electrons emitted from the plate having work function $\phi = 1.17$ eV is given by

$KE_{max} = E - \phi = 2.58 - 1.17 - 1.41$ eV

The maximum velocity of photo electrons ejected is given as $1/2\ m V_{max}^2 = 1.41$ eV

or $V_{max} = \sqrt{\dfrac{2\times1.41\times1.6\times10^{-19}}{9.1\times10^{-31}}}$

$= 7.036\times10^5$ m/sec

The radius of the circle traversed by photo electrons in magnetic field B is given by

$r = \dfrac{mV}{qB} = \dfrac{(9.1\times10^{-31})(7.036\times10^5)}{(1.6\times10^{-19})(10^{-4})}$

$= 40.0\times10^{-3}$meter (as $qVB = \dfrac{mV^2}{r}$) = 4.0 cm.

Q.7 A charged particle is accelerated through a potential difference of 12 kV and acquires a speed of $10^6\ ms^{-1}$. It is projected perpendicularly into the magnetic field of strength 0.2 T. The radius of circle described is…………… × 10 cm.

Sol.[0001] $R = \dfrac{mv}{qB}$

$q\times12\times10^3 = \dfrac{1}{2}m\times(10^6)^2$

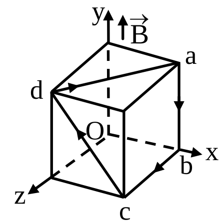
$\dfrac{24\times10^3}{10^{12}} = \dfrac{m}{q}$

$R = \dfrac{24\times10^3\times10^6}{10^{12}\times0.2}$

$R = 12\times10^{-2}$ m

R = 12 cm

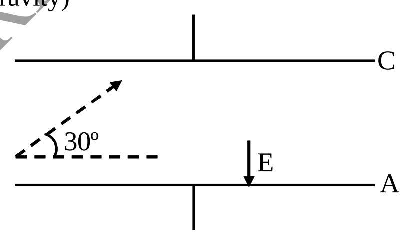
Q.8 In figure, the cube is 40.0 cm on each edge. Four straight segments of wire ab, bc, cd and da form a closed loop that carries a current I = 5.00 A, in the direction shown. A uniform magnetic field of magnitude B = 0.020 T is in the positive y-direction. Determine the magnitude and direction of the magnetic force on each segment.



Sol. $\vec{F}_{ab} = 0, \vec{F}_{bc} = (-0.04N)\hat{i}$,

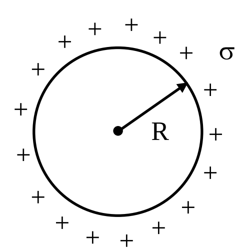
$\vec{F}_{cd} = (-0.04N)\hat{k}$, $\vec{F}_{da} = (0.04\hat{i} + 0.04\hat{k})N$

Q.9 A charged particle having charge 10^{-6} C and mass of 10^{-10} kg is fired from the middle of the plate making an angle 30º with plane of the plate. Length of the plate is 0.17 m and it is separated by 0.1m. Electric field $E = 10^{-3}$ N/C is present between the plates. Just outside the plates magnetic field is present. Find the velocity of projection of charged particle and magnitude of the magnetic field perpendicular to the plane of the figure, if it has to graze the plate at C and A parallel to the surface of the plate.(Neglect gravity)



Sol. 2.0 m/s, 3.46 mT

Q.10 Consider a uniformly charged spherical shell of radius R as shown in figure. Calculate the force experienced by the upper half of shell



Sol. $\dfrac{\sigma}{2\varepsilon_0}(\pi R^2)$

Q.11 A current I = 10A flows in a ring of radius r_0 =15 cm made of a very thin wire. The tensile strength of the wire is equal to T = 1.5 N. The ring is placed in a magnetic field, which is perpendicular to the plane of the ring so that the forces tend to break the ring. Find B at which the ring is broken.

Sol. 1 T