
PRAYAS
JEE 2025
Lecture - 6
Physics
Magnetism
By- Saleem Ahmed Sir

Topics *to be covered*

1. Lorentz force
2. Force on current carrying wire.
3.
4.

Lorentz force.

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

$$\vec{F}_{net} = \vec{F}_m + \vec{F}_e$$

*

Q

$q = +2C$

$v = 10\hat{i}$

$B = -20\hat{k}$

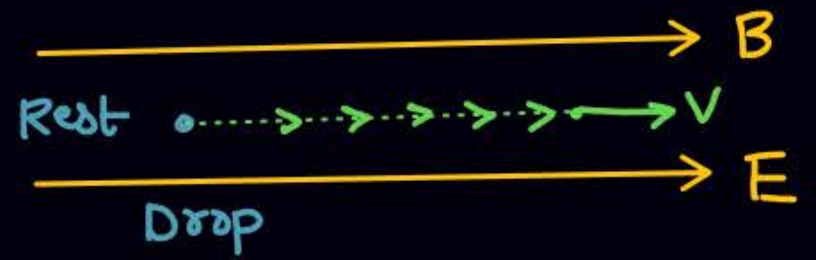
$E = 10\hat{i}$

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

$$= 2 \times 200(-\hat{j}) + 2 \times 10\hat{i}$$

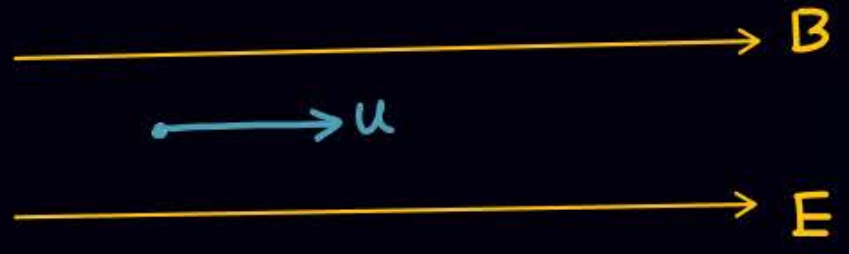
$$= 40\hat{i} - 400\hat{j}$$

①



* St. line
* speed up
* $(WD)_{EF} \neq 0$
* $(WD)_{MF} = 0$

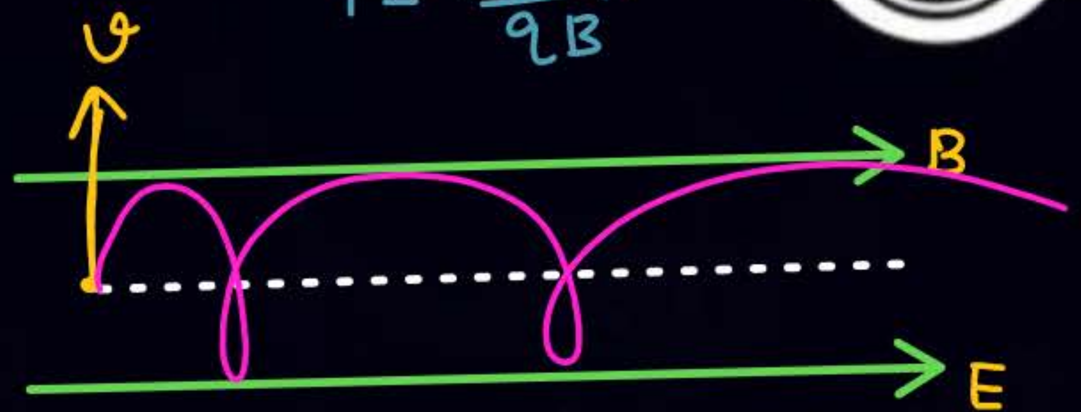
②



* St. line
* Speed up
* $(WD)_{EF} \neq 0$
* $(WD)_{MF} = 0$

③

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

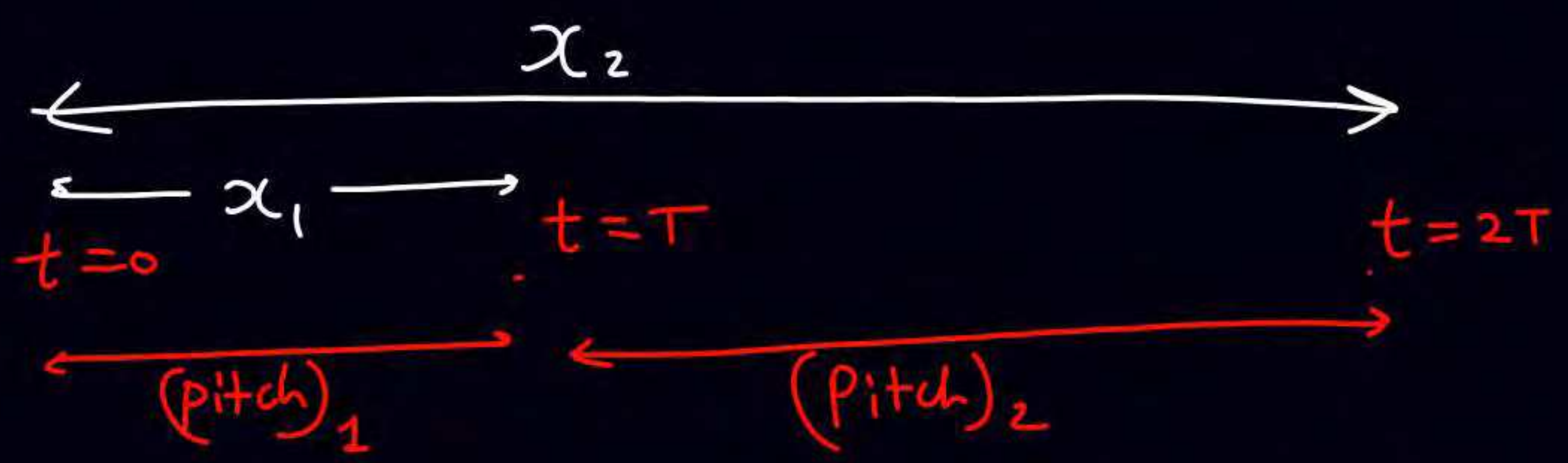


* helical but increasing pitch.
* $(pitch)_{1st} = (t=0 \longrightarrow t=T)$ x में

$(pitch)_1 = 0 + \frac{1}{2}aT^2 = \frac{1}{2}\frac{qE}{m} \cdot T^2$

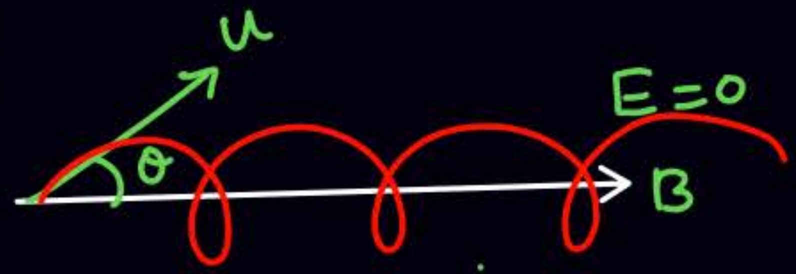
$(pitch)_2 = [t=T \longrightarrow t=2T]$ ✓

= next page.

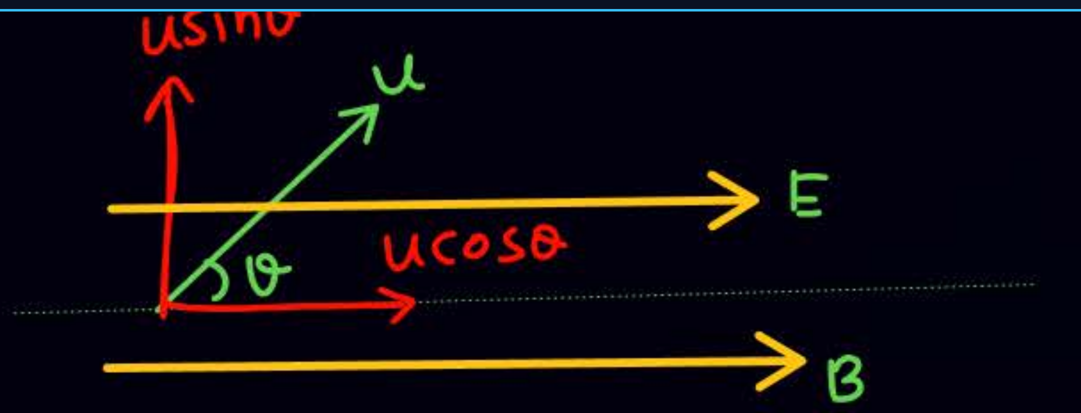


$$(\text{pitch})_2 = x_2 - x_1 = \left[0 + \frac{1}{2}\cdot a(2T)^2\right] - \left[0 + \frac{1}{2}aT^2\right]$$

$$= \frac{1}{2}a\left[(2T)^2 - T^2\right]$$



* helical, const pitch
* $r = \dfrac{mu\sin\theta}{qB}$
* pitch $= u\cos\theta \cdot T$
* $T = 2\pi m/qB$



* pitch increasing, helical.
* speed up. $(WD)_{EF} \neq 0$

  $(WD)_{mf} = 0$

* $(\text{pitch})_1 = u\cos\theta \cdot T + \frac{1}{2} \cdot \frac{qE}{m} \cdot T^2$
* $(\text{pitch})_2 = \left[u\cos\theta \cdot 2T + \frac{1}{2} a (2T)^2\right] - \left[u\cos\theta \cdot T + \frac{1}{2} a T^2\right]$

  $= u\cos\theta (2T - T) + \frac{1}{2} a \left[(2T)^2 - T^2\right]$

** If $\vec{E}, \vec{B}$ Both are present, cases in which motion of particle will be straight line.

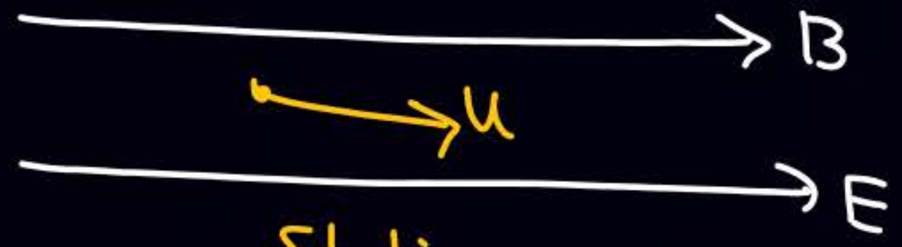
① $E = 0$

St. line.

② Release

St. line.

③



St. line.

*** ④ $\vec{F}_{net} = q(\vec{v} \times \vec{B}) + q\vec{E}$

If $\vec{F}_{net} = 0$, $q(\vec{v} \times \vec{B}) + q\vec{E} = 0$

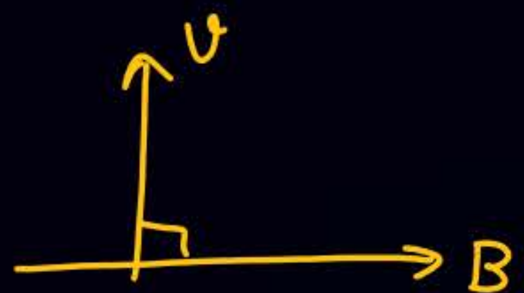
$$\boxed{\vec{E} = -(\vec{v} \times \vec{B})}$$

$\vec{E} = \vec{B} \times \vec{v}$

} St. line.

Q If a charge particle $q = +2C$ is moving with velocity $+10\hat{j}$ inside uniform $\vec{B} = 20\hat{i}$. In which dir^n we should apply electric field so that particle will move in st. line path (undeviated).

Sol^n



$$F_{net} = q\vec{v}\times\vec{B} + q\vec{E} = 0$$

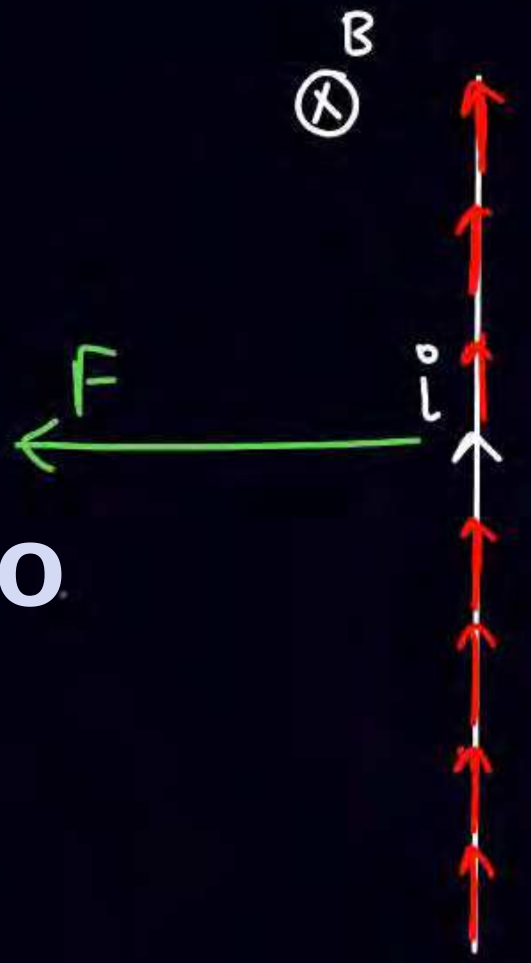
$$\vec{E} = -(\vec{v}\times\vec{B}) = -(10\hat{j}\times 20\hat{i}) = +200\hat{k}$$

$$\vec{E} = 200\ (+z\ \text{dir})$$

magnetic Force on current carrying wire Inside magnetic field

$\vec{F}_m = i(\vec{dl} \times \vec{B})$

magnetic force on small current carrying wire of length dl



* $\vec{F} = i(\vec{dl} \times \vec{B})$

If $B \rightarrow$ Uniform

$$\vec{F}_{net} = i(\vec{dl}_1 \times \vec{B}) + i(\vec{dl}_2 \times \vec{B}) + i(\vec{dl}_3 \times \vec{B}) + \cdots \infty$$

$$= i(\vec{l} \times \vec{B})$$

⊗ Uniform B

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

$\vec{l}$ → Along the current

→ Dir^n

① cross product

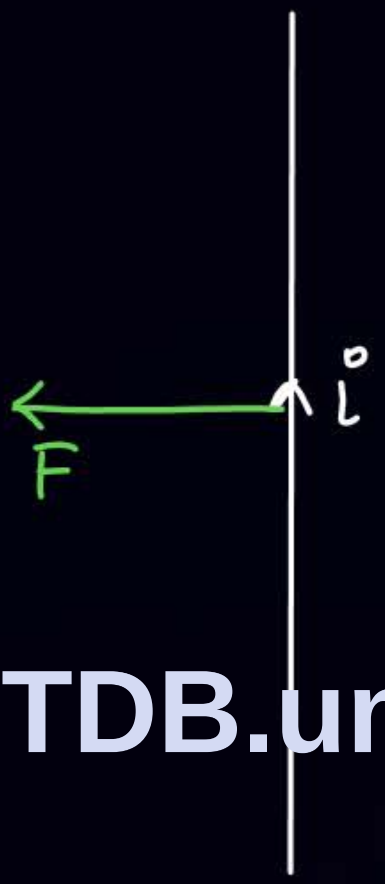
② $\hat{i}, \hat{j}, \hat{k}$

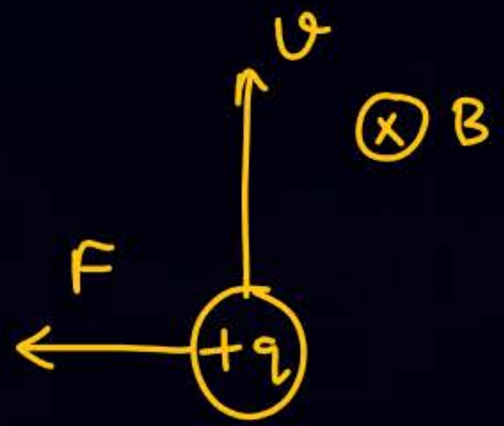
③ F.L.H. (PISTOL)

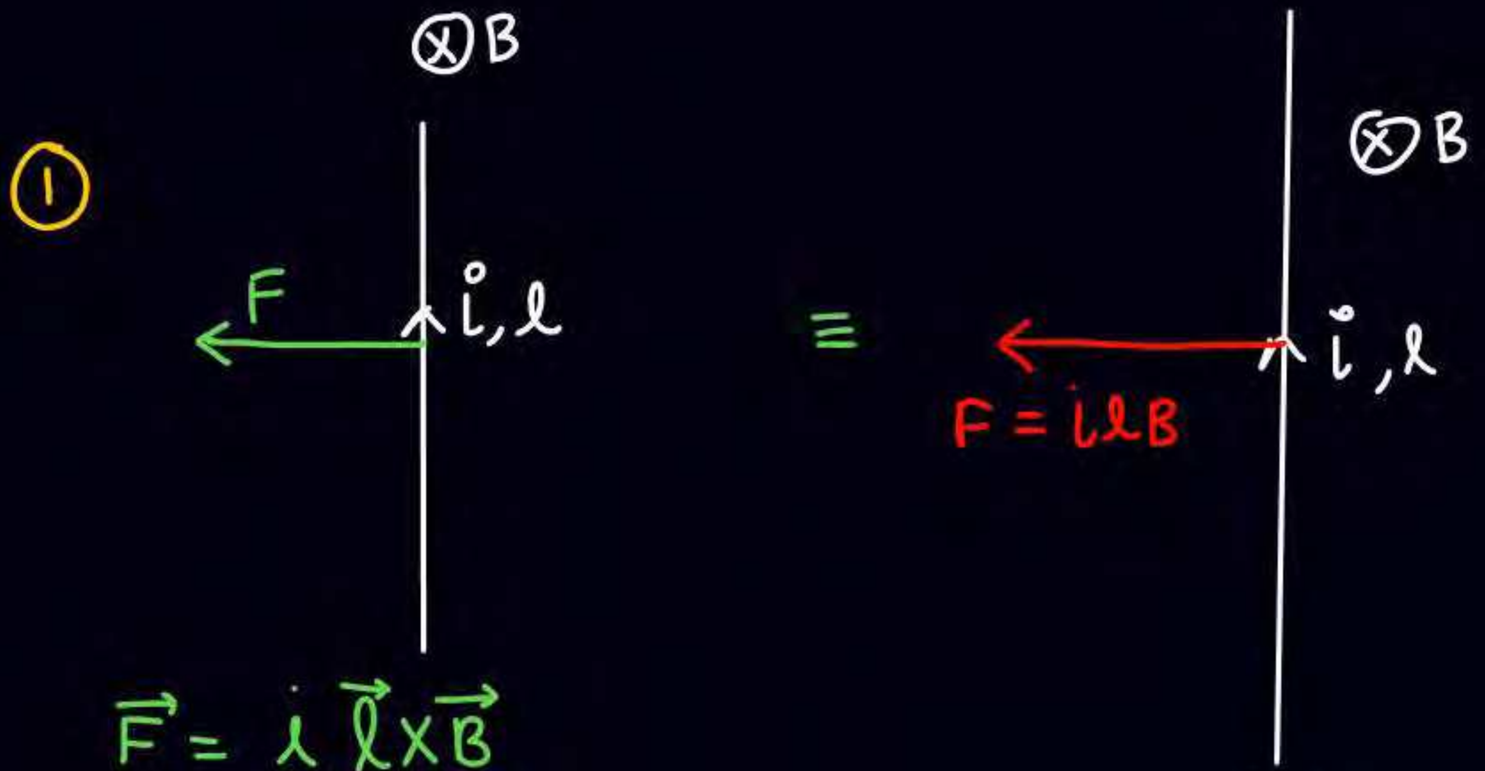
Index finger → B

Thumb → F

middle finger → i

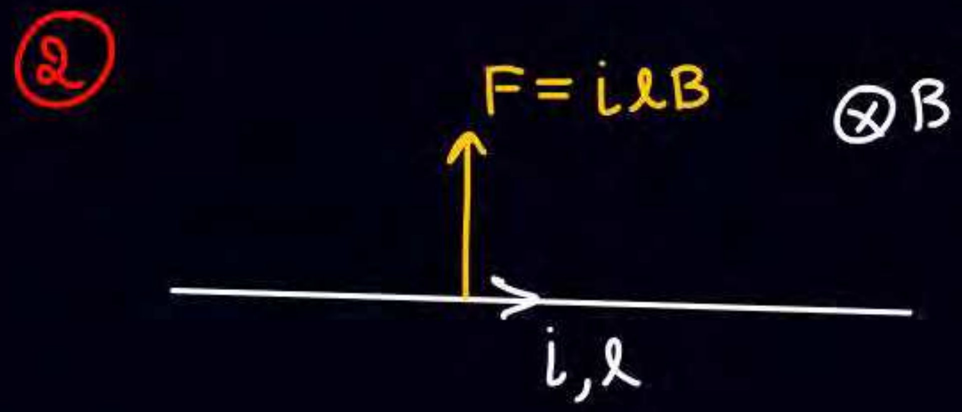


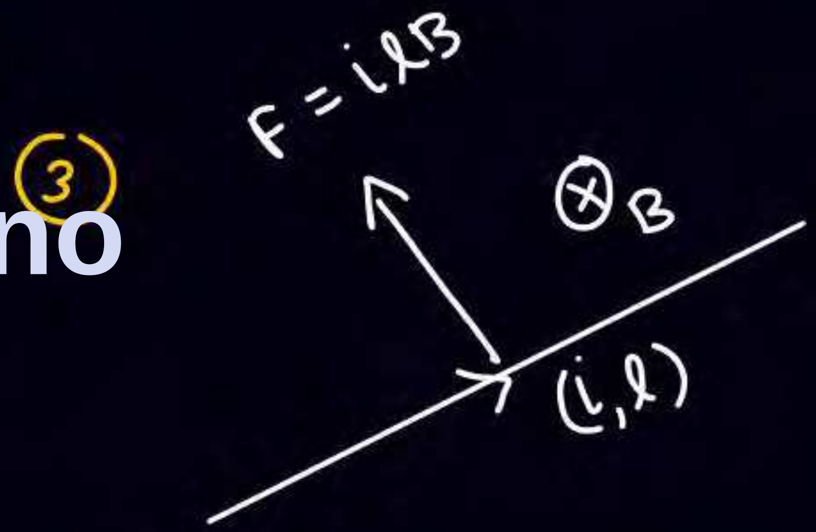


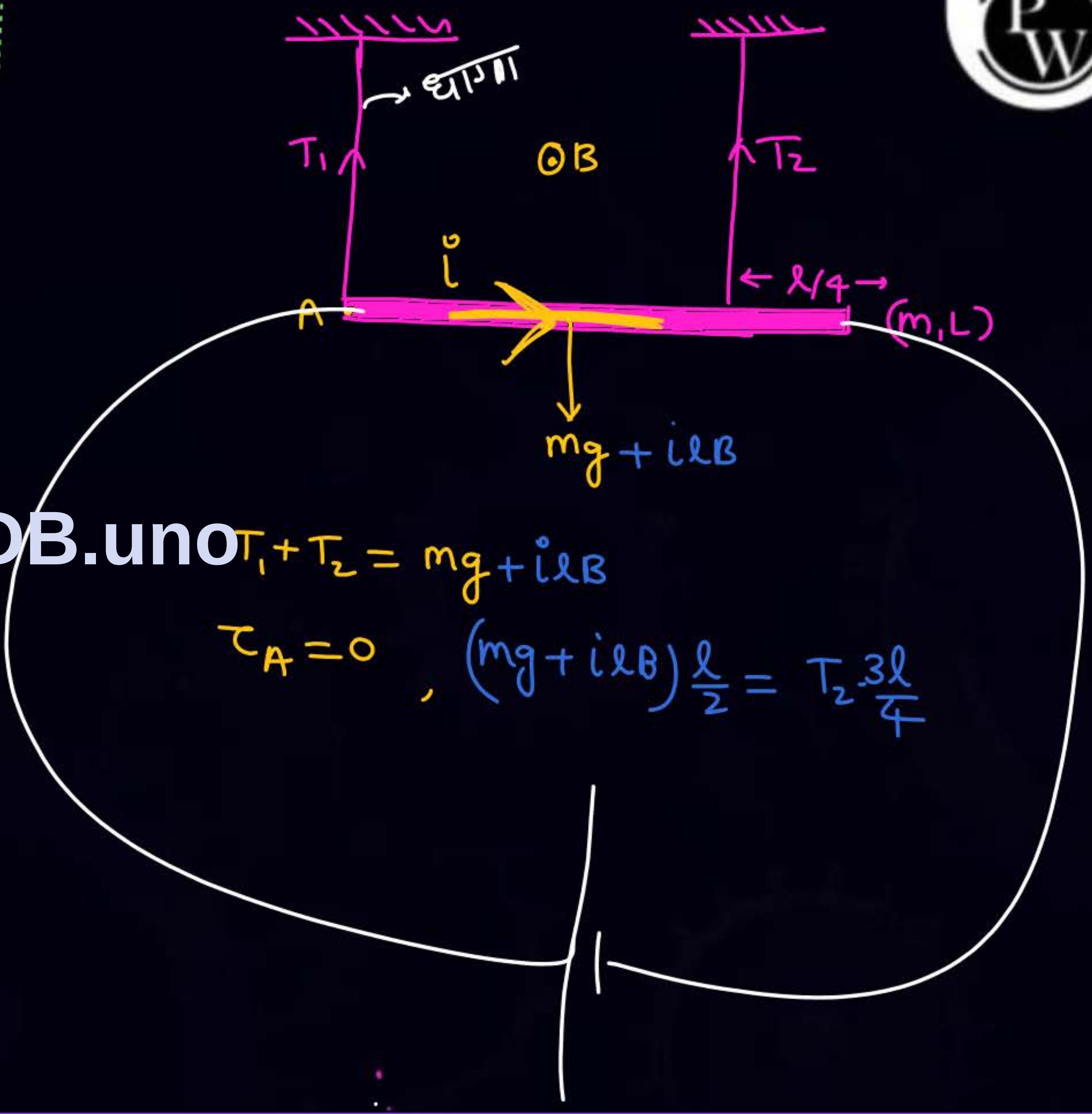


$$\vec{F} = i\,\vec{l} \times \vec{B}$$

$$F = ilB \sin 90 = ilB$$



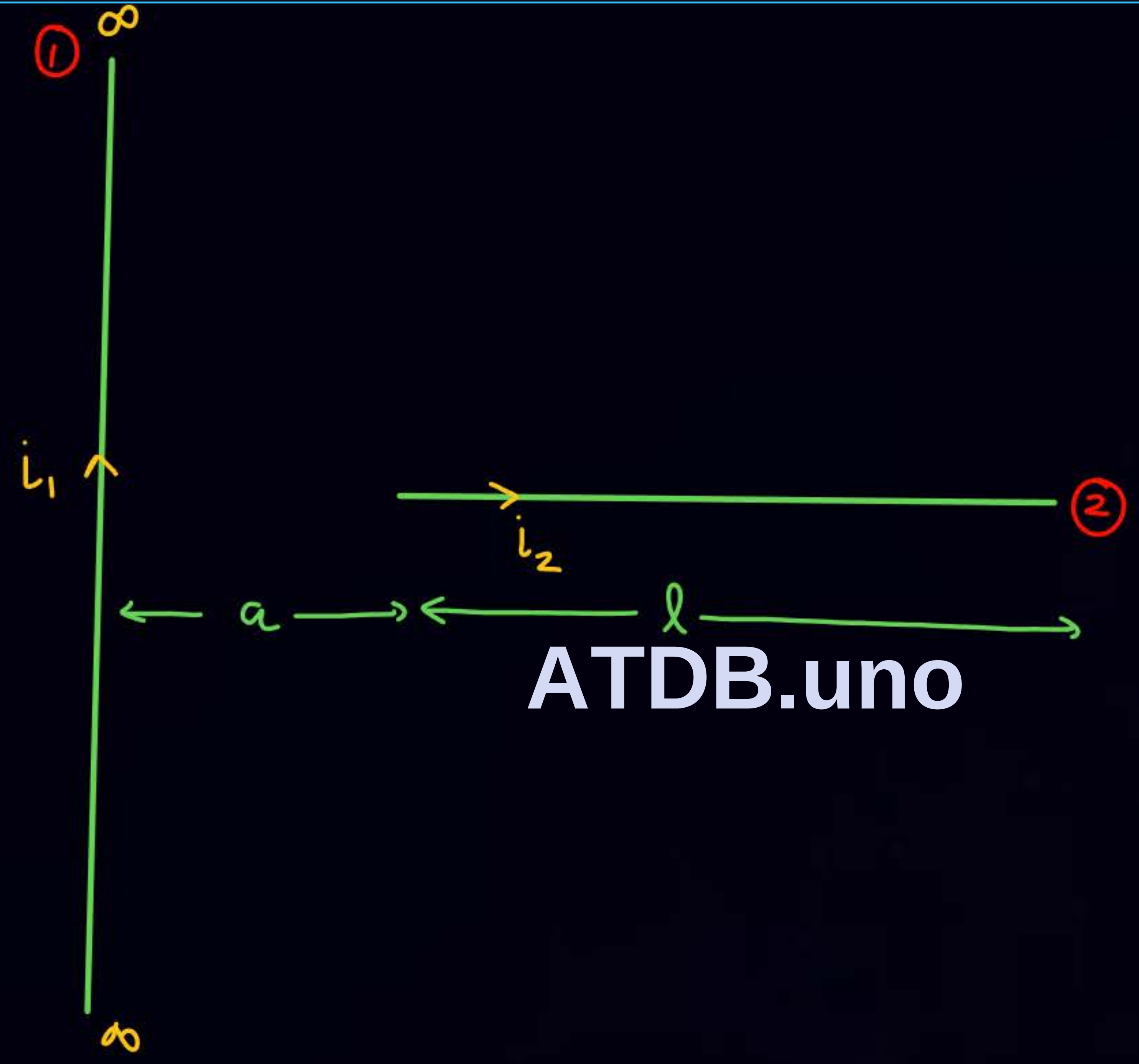




$$T_1 + T_2 = mg + ilB$$

$$\tau_A = 0, \quad (mg + ilB)\frac{l}{2} = T_2 \cdot \frac{3l}{4}$$

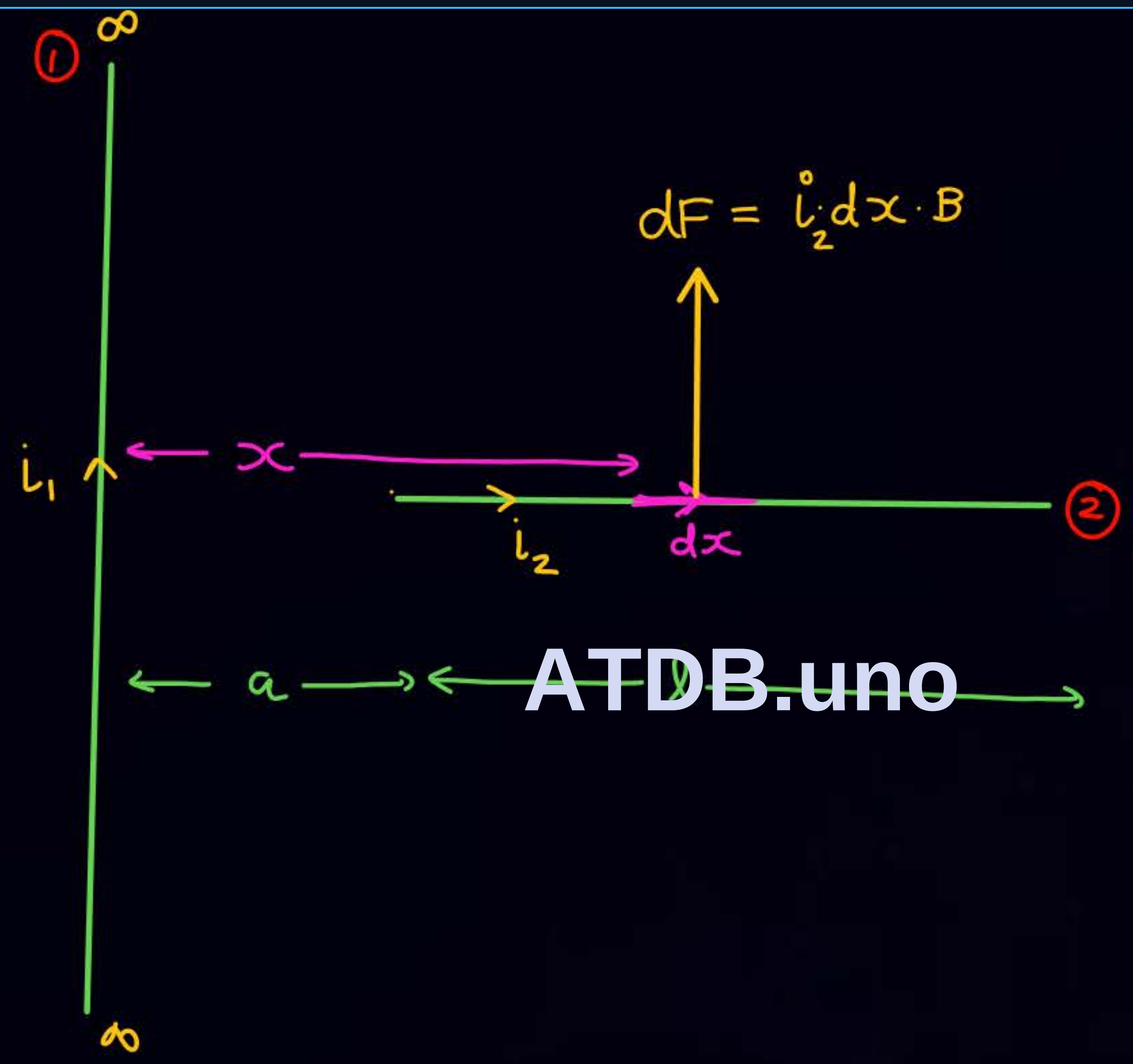
Q



find force by wire 1 on wire ②.

$i l B \sin$

Q

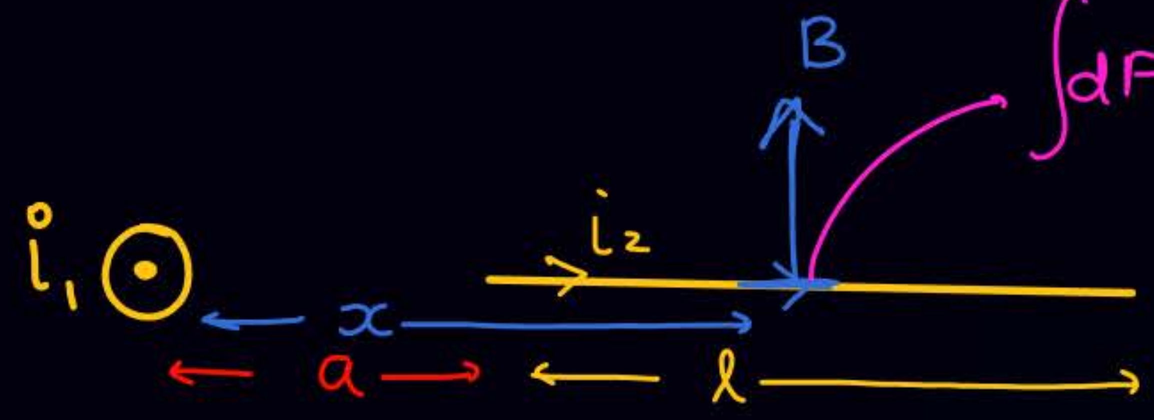


$$dF = i_2 \cdot dx \cdot B$$

$$F_{net} = \int dF = \int_{a}^{a+L} i_2 \cdot dx \cdot \frac{2 k i_1}{x}$$

$$F = 2 k i_1 i_2 \ln\left(\frac{a+L}{a}\right)$$

Q

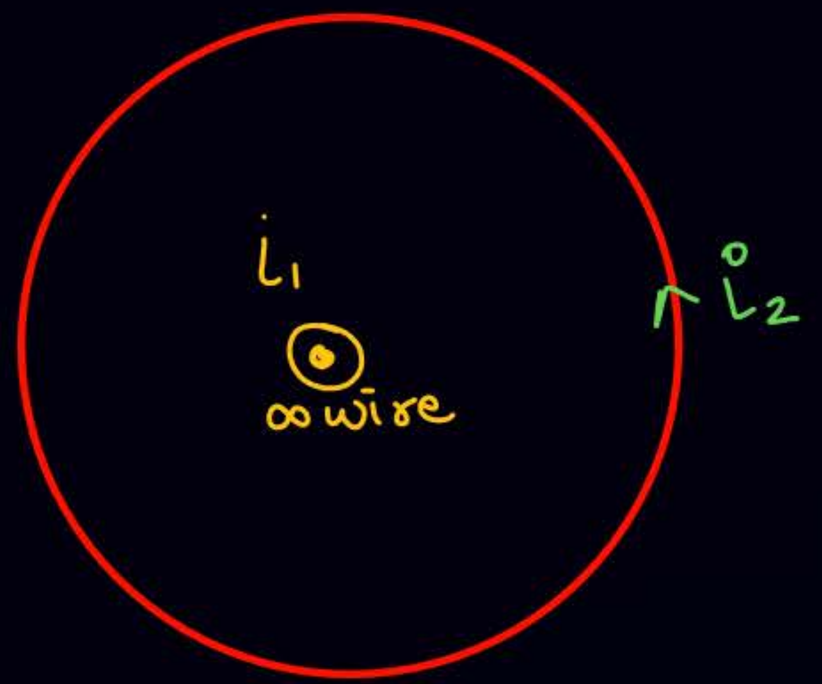


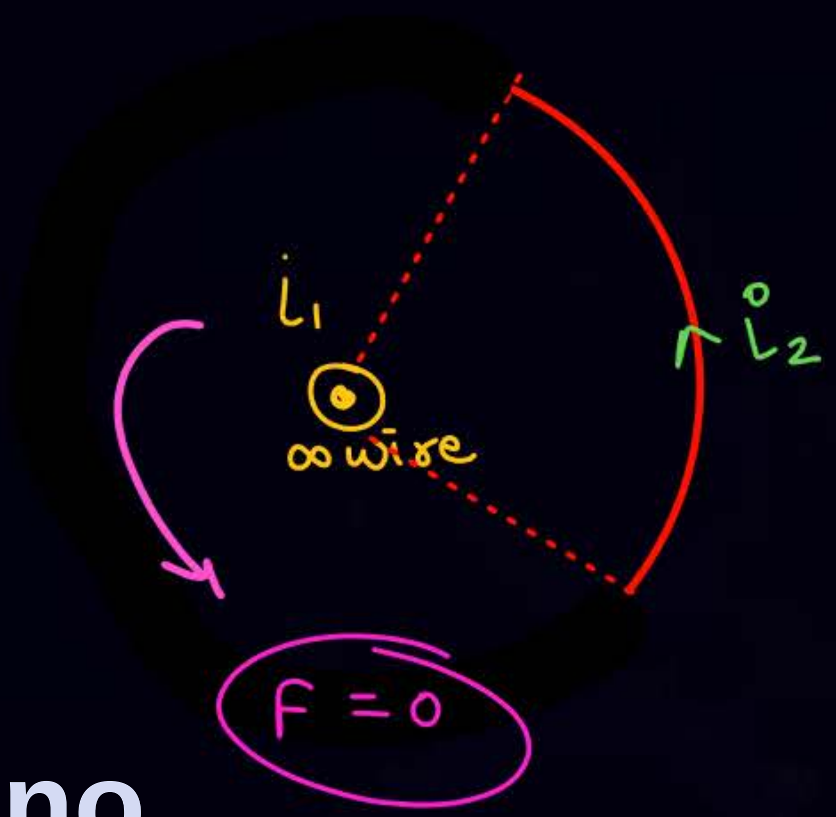
$$\int dF = \int_a^{a+l} i_2 \cdot dx \cdot \frac{2ki_1}{x}$$

$$= 2ki_1 i_2 \ln\left(\frac{a+l}{a}\right)$$

Force dir^n $\Rightarrow$ बाहर

Q

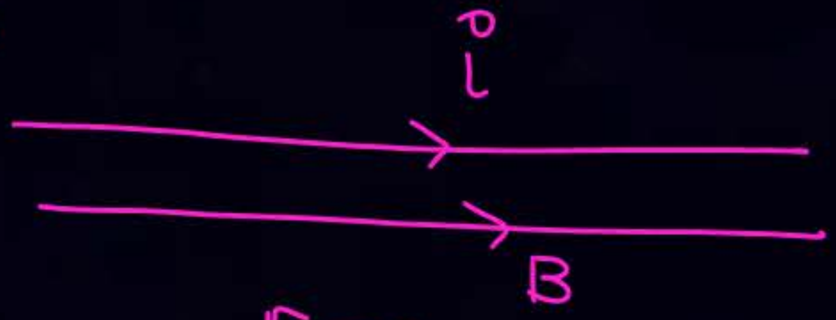




force by ∞ wire on loop

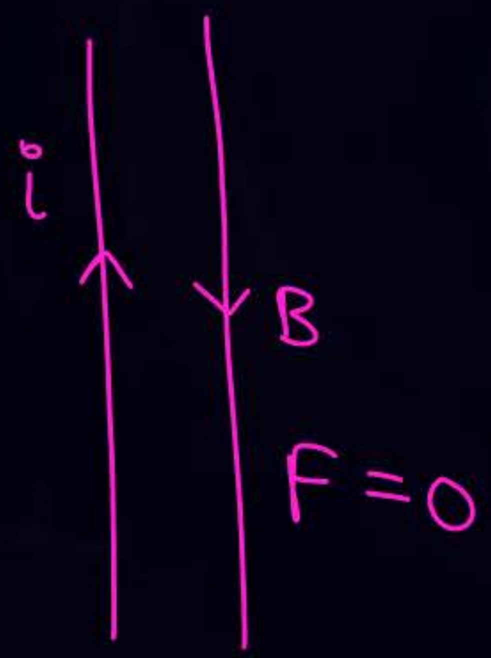
$F = 0$

Q

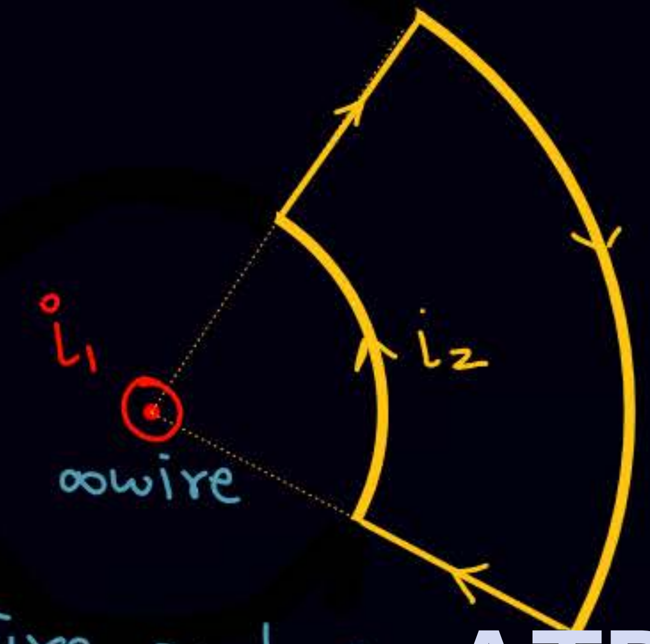


$F = 0$

Q



Q



find force by ∞ wire on loop.

Sol^n $F_{net} = 0$

Q

$F_{on\ AB} = 0$

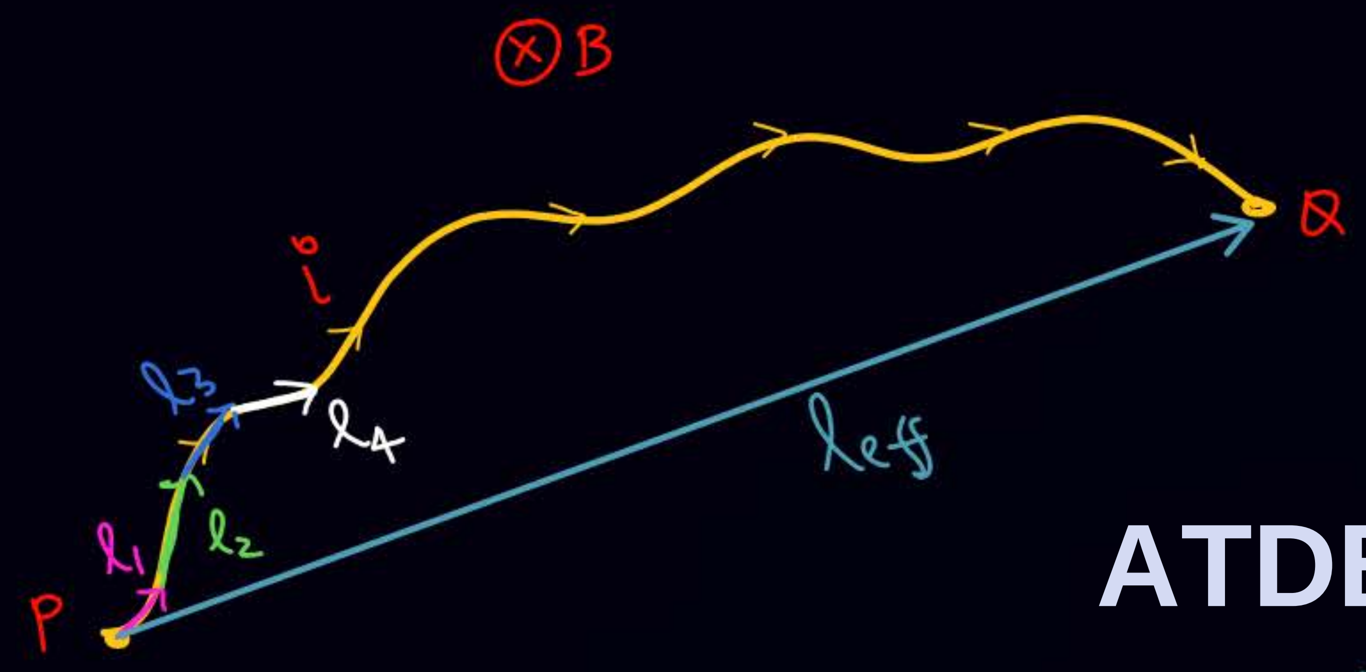
$F_{on\ CD} = 0$

$F_{on\ BC} = 2ki_1i_2 \ln\left(\frac{a+l}{a}\right)$ (बाहर)

$F_{on\ DA} = 2ki_1i_2 \ln\left(\frac{a+l}{a}\right)$ → अंदर

$F_{net} = 0$

$B \longrightarrow$ Uniform, wire (उटपटांग)



Force on wire $= i(\vec{l_1} \times \vec{B}) + i(\vec{l_2} \times \vec{B})$

$+ i(\vec{l_3} \times \vec{B}) + i(l_4 \times \vec{B})$

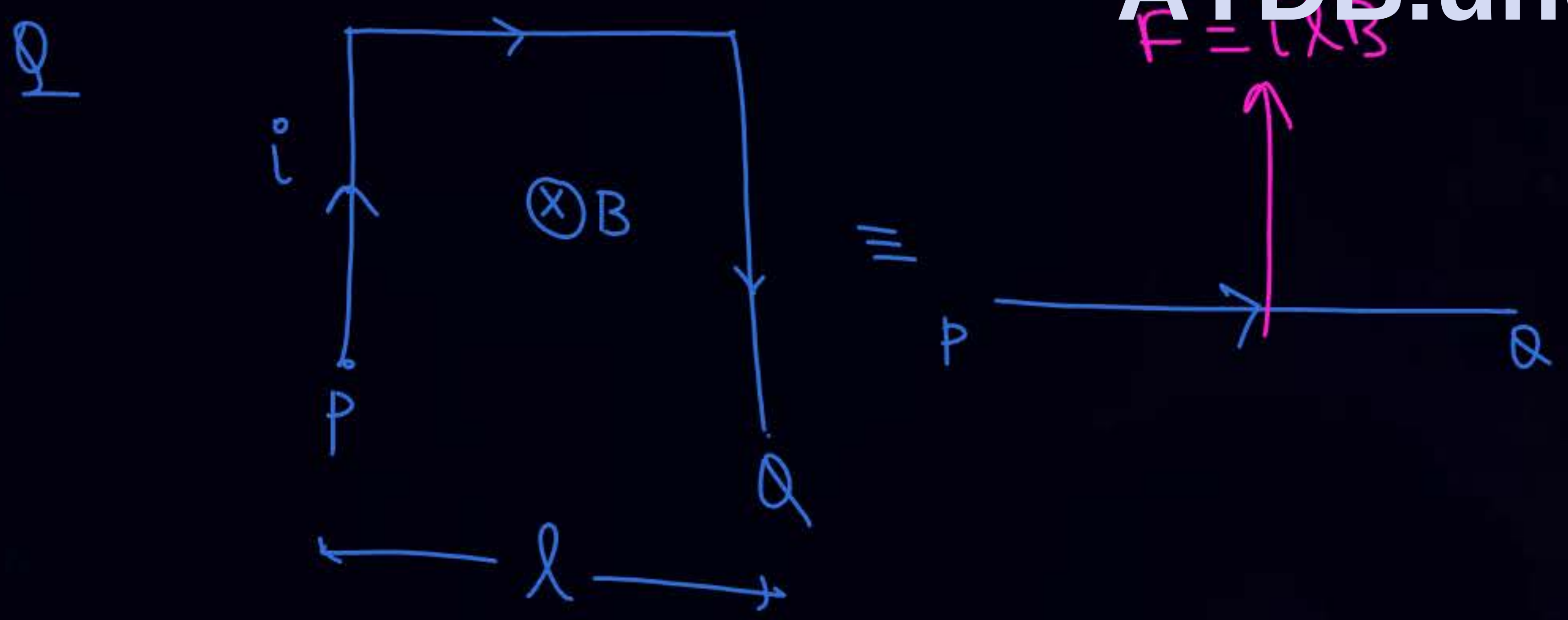
$+ - - - - \infty$

$$\vec{F}_{net} = i\,(\bar{l}_1 + \bar{l}_2 + \bar{l}_3 + - - -) \times \bar{B}$$

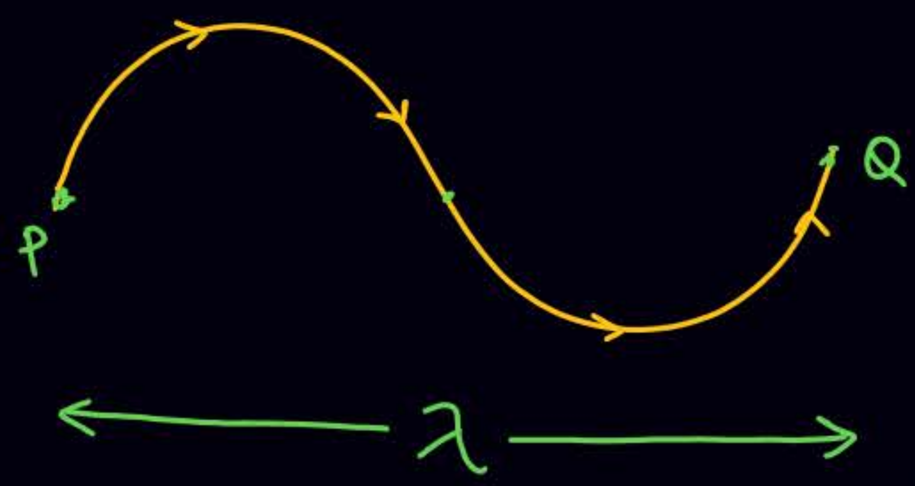
$$\vec{F}_{net} = i\, \vec{l}_{eff} \times \vec{B}$$

Str


⊗ B
1
i
P
Q
≡
$F = i \cdot 2R \cdot B$
P
i
Q
⊗


Q
i
⊗B
P
Q
l
≡
$F = i l B$
P
Q

(3) ⊗ B



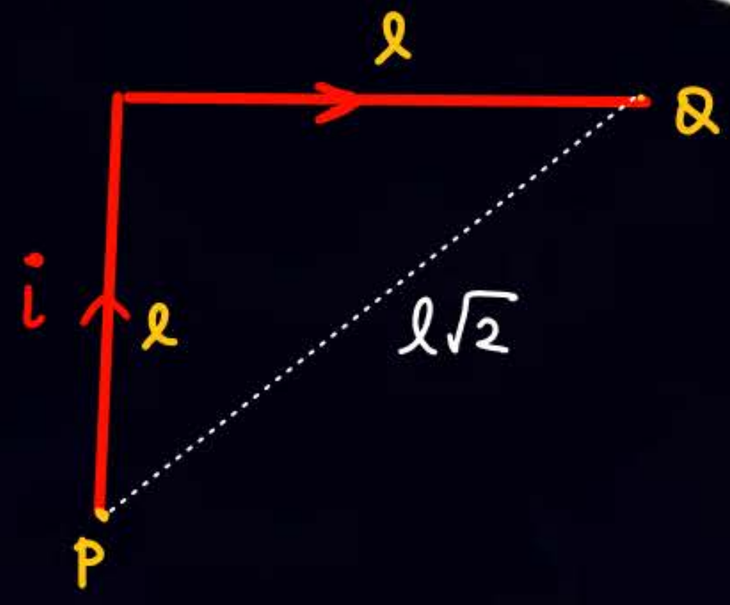
$$\vec{F} = i \lambda B (\hat{j})$$

(4)

$$F = iRB$$

$$= i(2R \sin 30)B$$

(5) ⊗ B

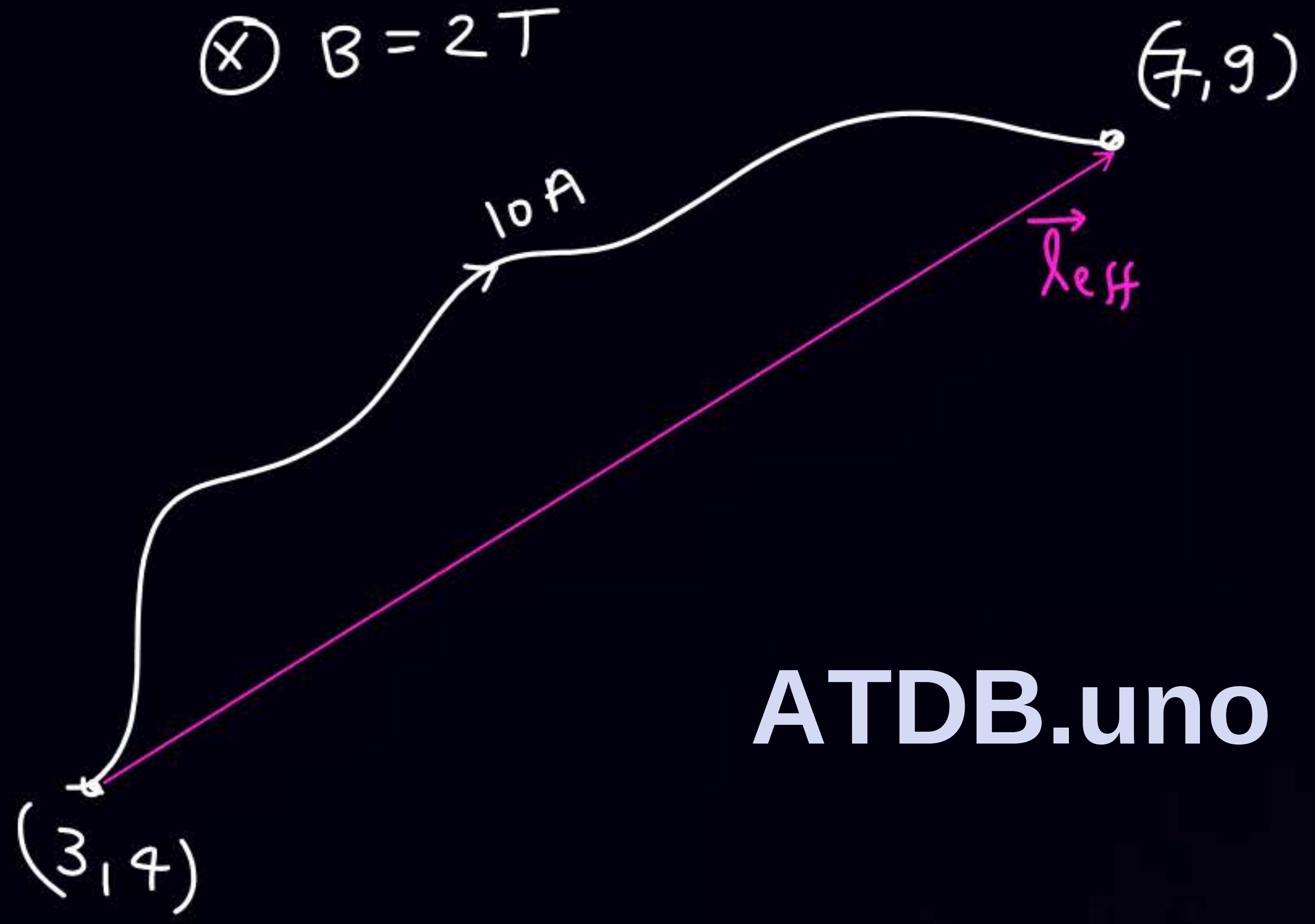


$$F = i \cdot l\sqrt{2} \cdot B$$

m

(6)

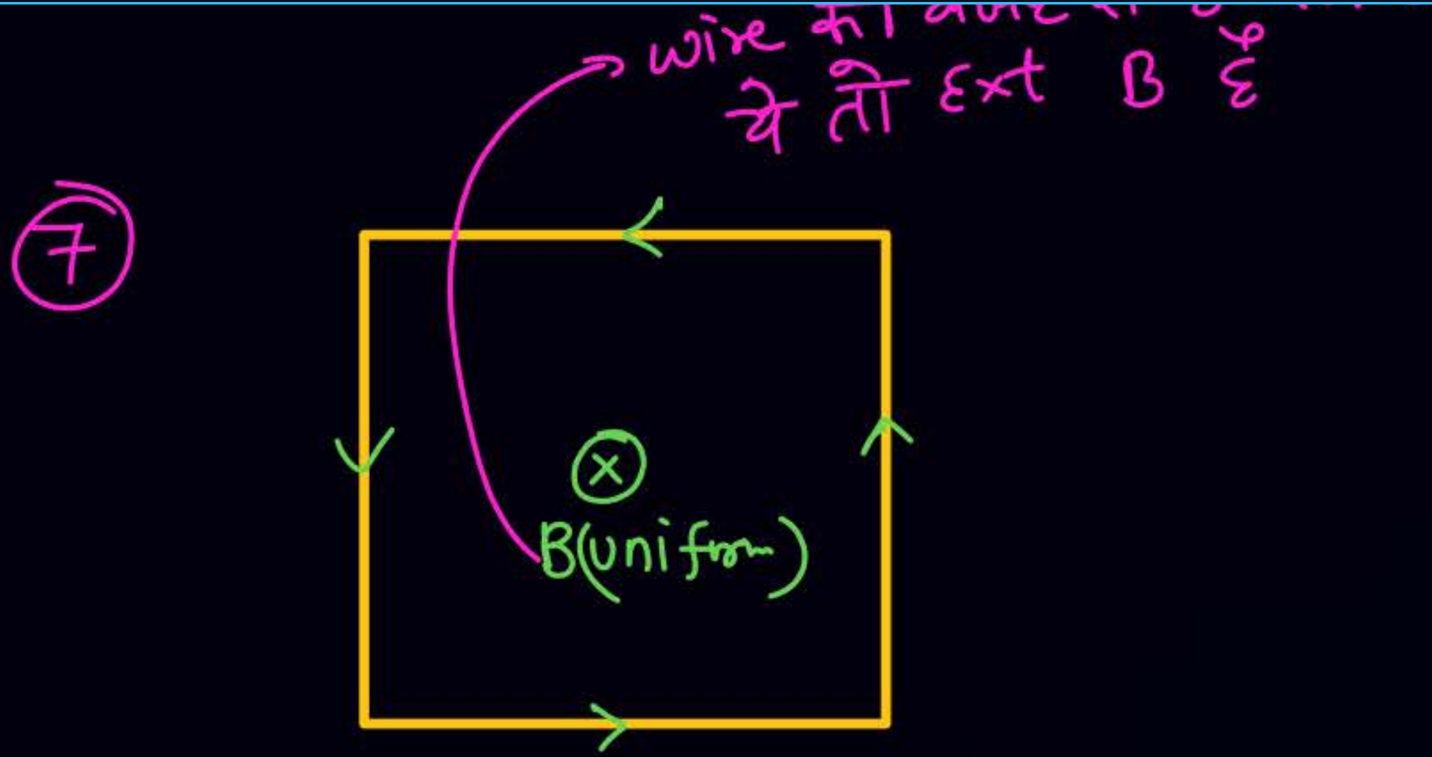
⊗ $B = 2T$



$$\vec{l} = 4\hat{i} + 5\hat{j}$$

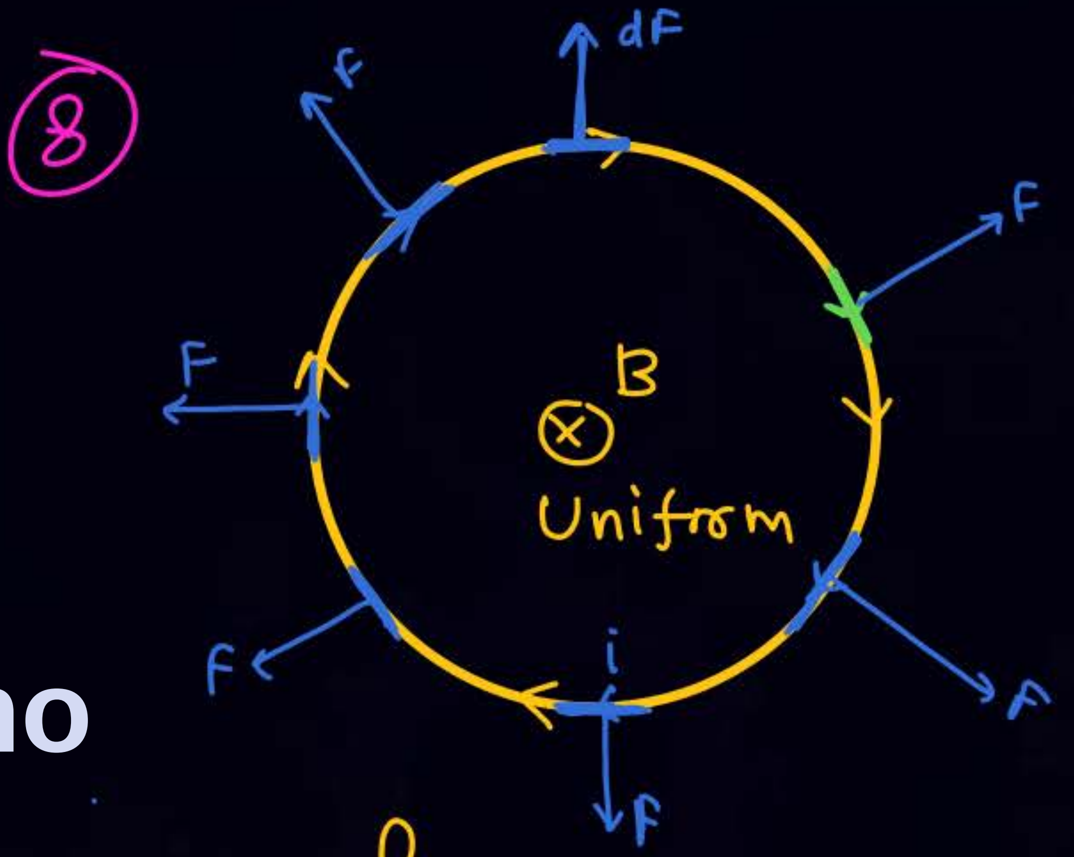
$$\vec{F} = i(\vec{l} \times \vec{B})$$

$$\vec{F} = 10\left((4\hat{i} + 5\hat{j}) \times (-2\hat{k})\right)$$



$l_{eff} = 0$

$F = 0$



$l_{eff} = 0$

$F = 0$

Home Work

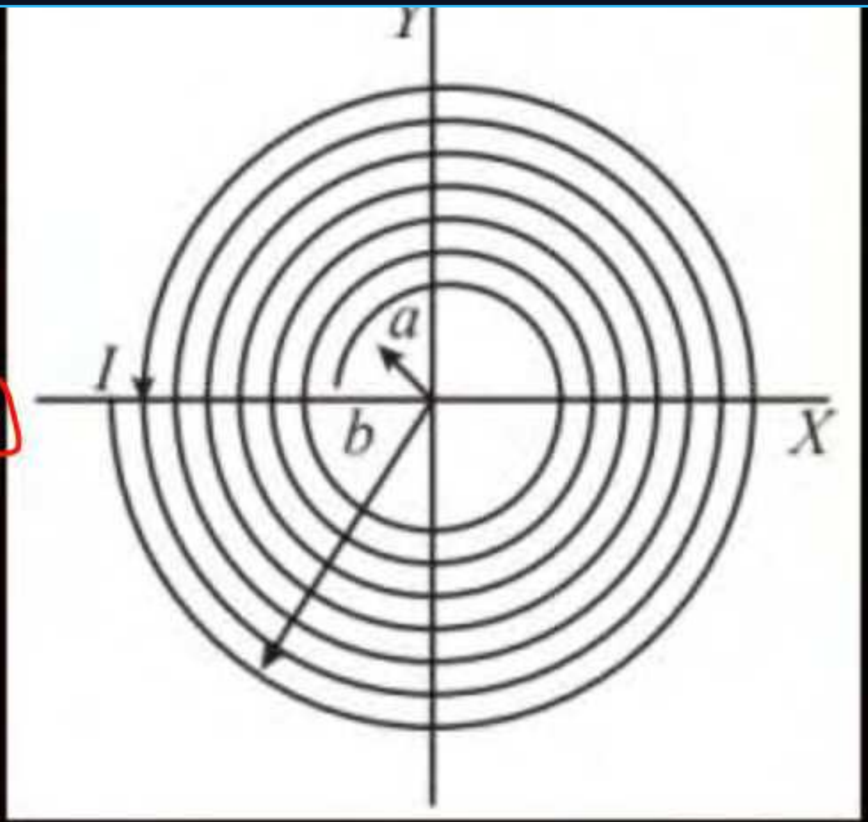
— Ques are attached

Q. 1 A long insulated copper wire is closely wound as a spiral of N turns. The spiral has inner radius a and outer radius b. The spiral lies in the $X-Y$ plane and a steady current I flows through the wire. The Z-component of the magnetic field at the centre of the spiral is

(IIT-JEE 2011)

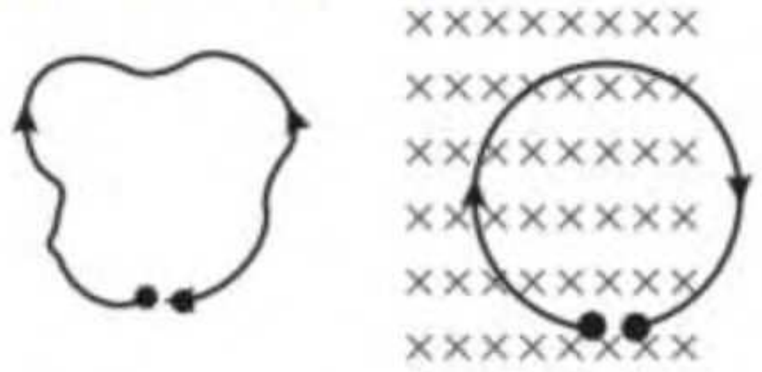
(a) $\frac{\mu_0 NI}{2(b-a)} ln\left(\frac{b}{a}\right)$ (b) $\frac{\mu_0 NI}{2(b-a)} ln\left(\frac{b+a}{b-a}\right)$

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



Ans : (a)

Q. 3 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) $\frac{IBL}{4\pi}$

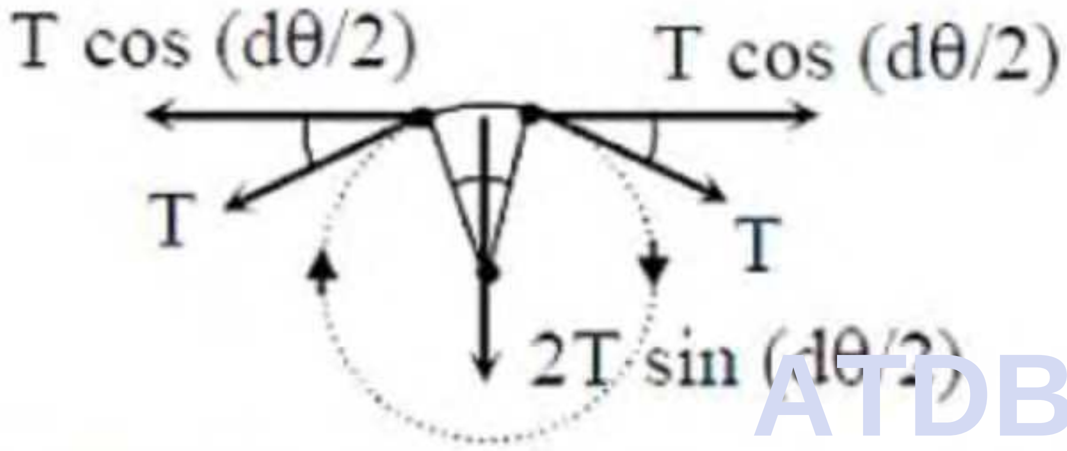
Ans : (b)

Solution 3

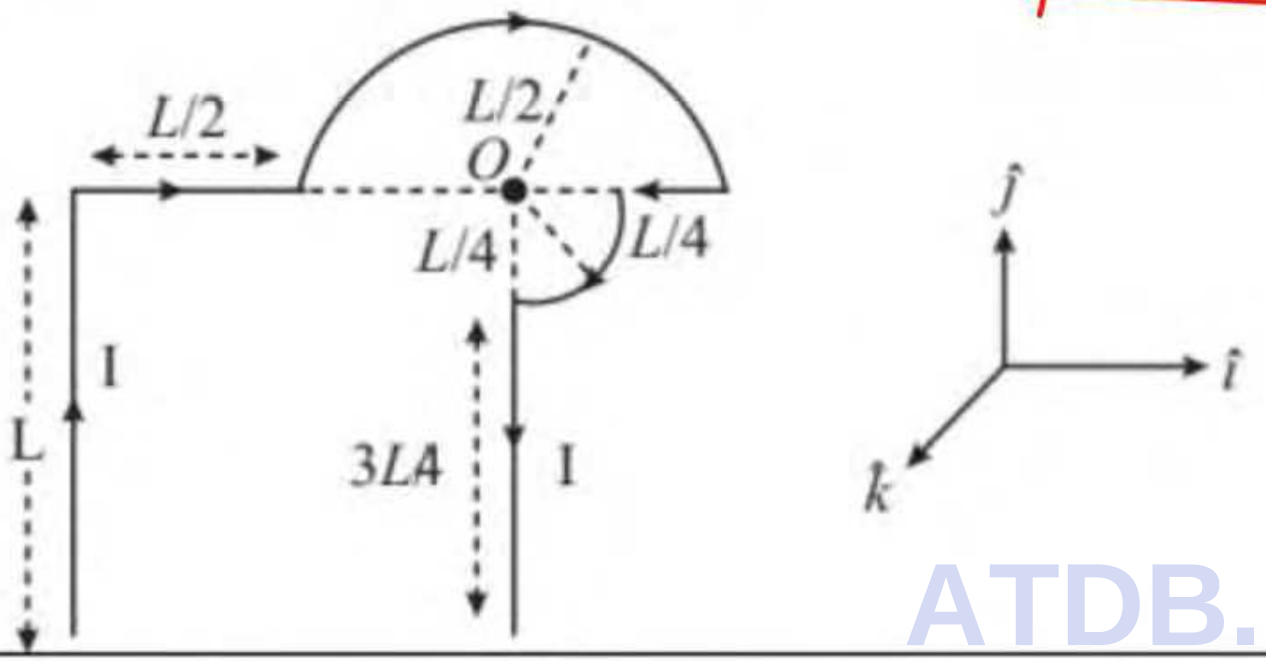
$$2T \sin \frac{d\theta}{2} = BiRd\theta$$

$$Td\theta = BiRd\theta \text{ (for } \theta \text{ small)}$$

$$T = BiR = \frac{BiL}{2\pi}$$



Q. 4 Which one of the following options represents the magnetic field $\vec{B}$ at O due to the current flowing in the given wire segments lying on the xy plane? **(JEE Adv. 2022)**



(a) $\vec{B} = \dfrac{-\mu_o I}{L}\left(\dfrac{3}{2} + \dfrac{1}{4\sqrt{2}\pi}\right)\hat{k}$ (b) $\vec{B} = -\dfrac{\mu_o I}{L}\left(\dfrac{3}{2} + \dfrac{1}{2\sqrt{2}\pi}\right)\hat{k}$

(c) $\vec{B} = \dfrac{-\mu_o I}{L}\left(1 + \dfrac{1}{4\sqrt{2}\pi}\right)\hat{k}$ (d) $\vec{B} = \dfrac{-\mu_o I}{L}\left(1 + \dfrac{1}{4\pi}\right)\hat{k}$

Ans : (c)

Solution 4

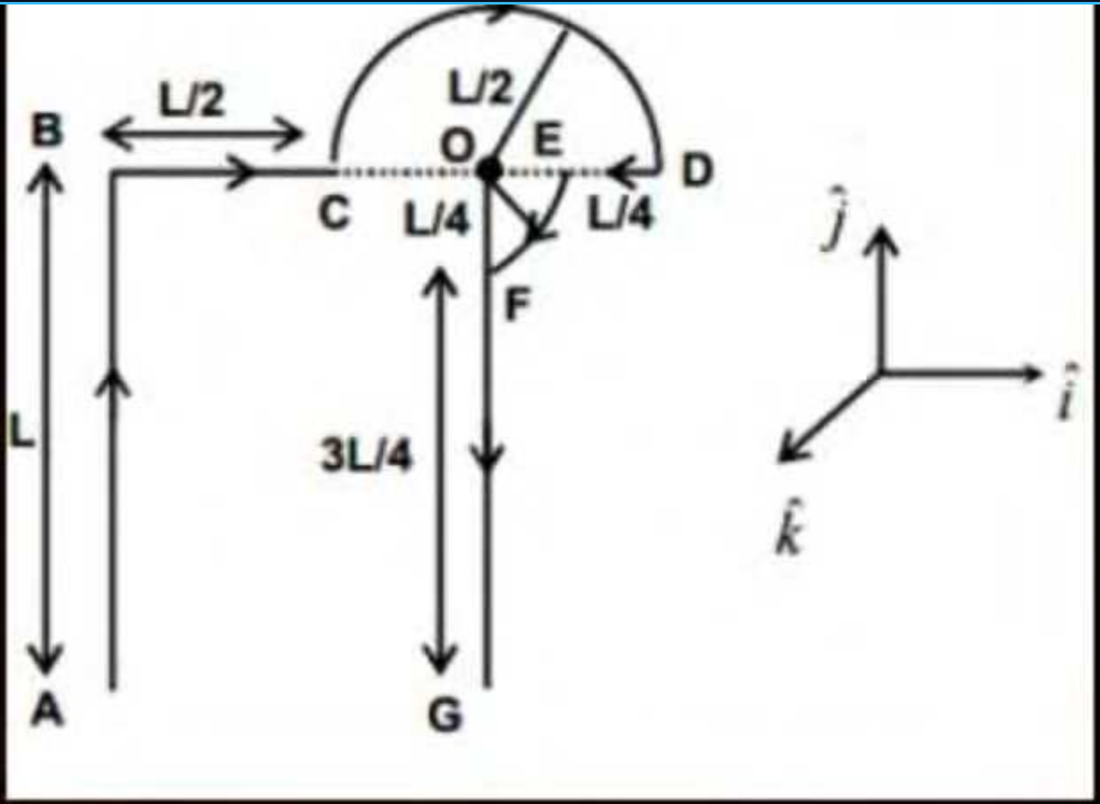
$$\vec{B}_{Net} = \vec{B}_{AB} + \vec{B}_{BC} + \vec{B}_{CD} + \vec{B}_{DE} + \vec{B}_{EF} + \vec{B}_{FG}$$

$$\vec{B}_{AB} = \vec{B}_{DE} = \vec{B}_{FG} = 0$$

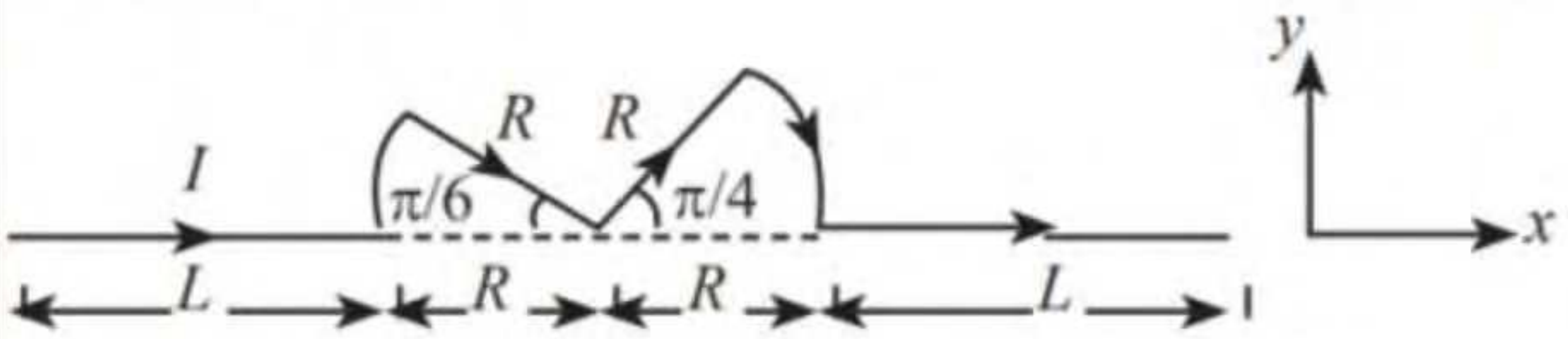
$$\vec{B}_{AB} = \frac{\mu_0 I}{4\pi L}\sin 45^\circ\left[-\hat{k}\right]$$

$$\vec{B}_{CD} = \frac{\mu_0 I}{4\left(\frac{L}{2}\right)}\left[-\hat{k}\right]$$

$$\vec{B}_{EF} = \frac{\mu_0 I}{8\left(\frac{L}{4}\right)}\left[-\hat{k}\right] \Rightarrow (C)$$



Q. 5 A conductor (shown in the figure) carrying constant current I is kept in the x–y plane in a uniform magnetic field B. If F is the magnitude of the total magnetic force acting on the conductor, then the correct statements is/are **(JEE Adv. 2015)**



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

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

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

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

Ans : (a, b, c)

Solution 5

The vector sum of all current element in wires not parallel to x axis will lead to resultant current element of length R and current along x axis. Total length of current element:

$dl = 2(L + R)\hat{x}$

$\vec{F} = i(2(L + R)\hat{x}) \times \vec{B}$

If $\vec{B}$ along $\hat{z}$ then F will be along $-\hat{y}$ and will be propotional to (L+R)

If $\vec{B}$ along $\hat{x}$ then F = 0 since vector product is zero.

If $\vec{B}$ along $\hat{y}$ then F will be along $\hat{z}$ and will be prop to (L+R)

If $\vec{B}$ along $\hat{z}$ then F will be along $-\hat{y}$ and will not be equal to 0.

Q. 6 Two parallel wires in the plane of the paper are distance x_0 apart. A point charge is moving with speed u between the wires in the same plane at a distance x_1 from one of the wires. When the wires carry current of magnitude I in the same direction, the radius of curvature of the path of the point charge is R_1. In contrast, if the currents I in the two wires have directions opposite to each other, the radius of curvature of the path is R_2. If $\frac{x_0}{x_1} = 3$, and value of $\frac{R_1}{R_2}$ is

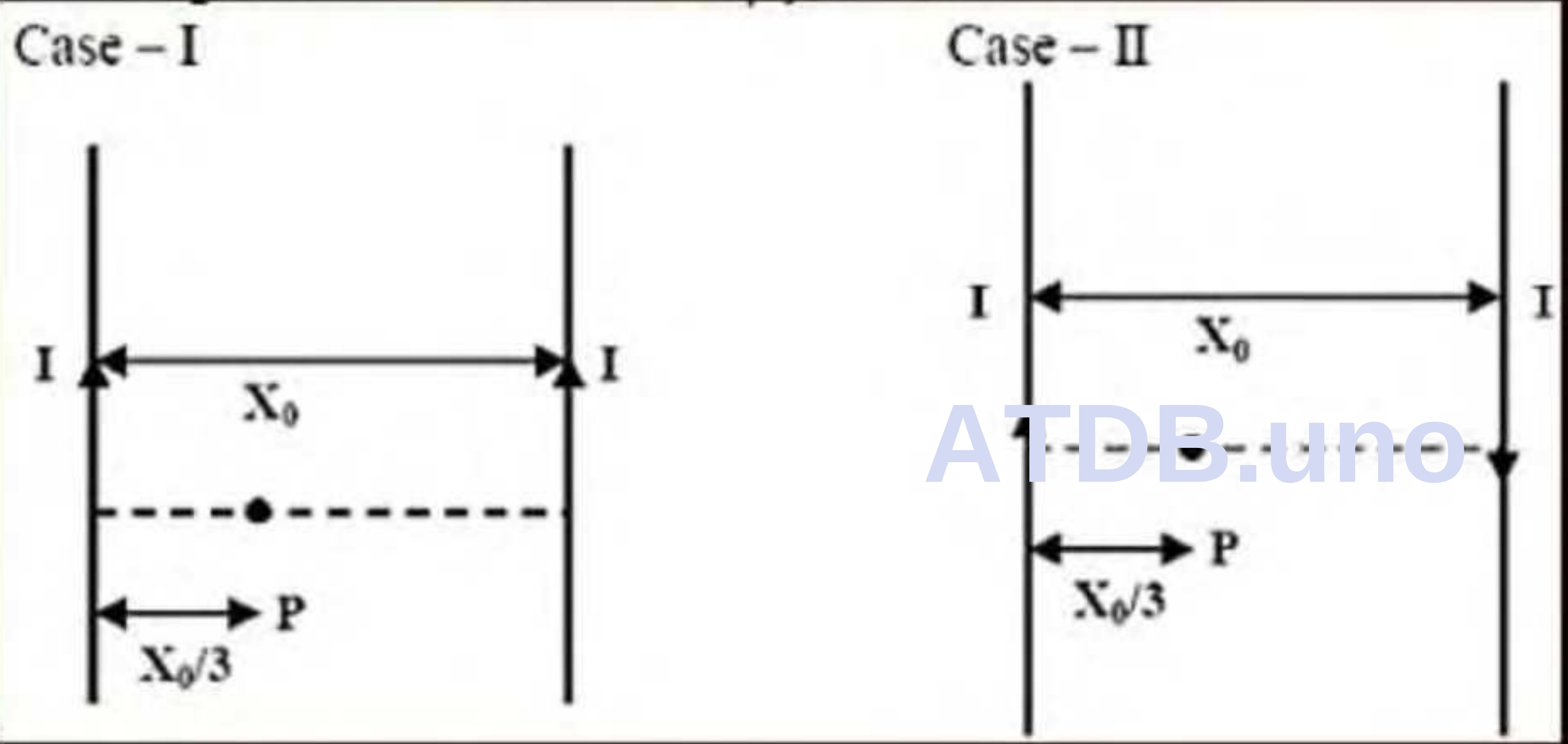
(JEE Adv. 2014)

Ans : (3)

Solution 6

$$B_1 = \frac{1}{2}\left(\frac{\mu_0}{2\pi}\right)\left(\frac{3I}{x_0}\right) \quad R_2 = \frac{mv}{qB_2}$$

$$R_1 = \frac{mv}{qB_1} \Rightarrow \frac{R_1}{R_2} = \frac{B_2}{B_1} = \frac{1/3}{1/9} = 3$$



Q. 7 An electron and a proton are moving on straight parallel paths with same velocity. They enter a semi-infinite region of uniform magnetic field perpendicular to the velocity. Which of the following statement(s) is/are true? **(IIT-JEE 2011)**

(*a*) They will never come out of the magnetic field region

(*b*) They will come out travelling along parallel paths

(*c*) They will come out at the same time

(*d*) They will come out at different times

Ans : (b, d)

Solution 7

By diagram B is true

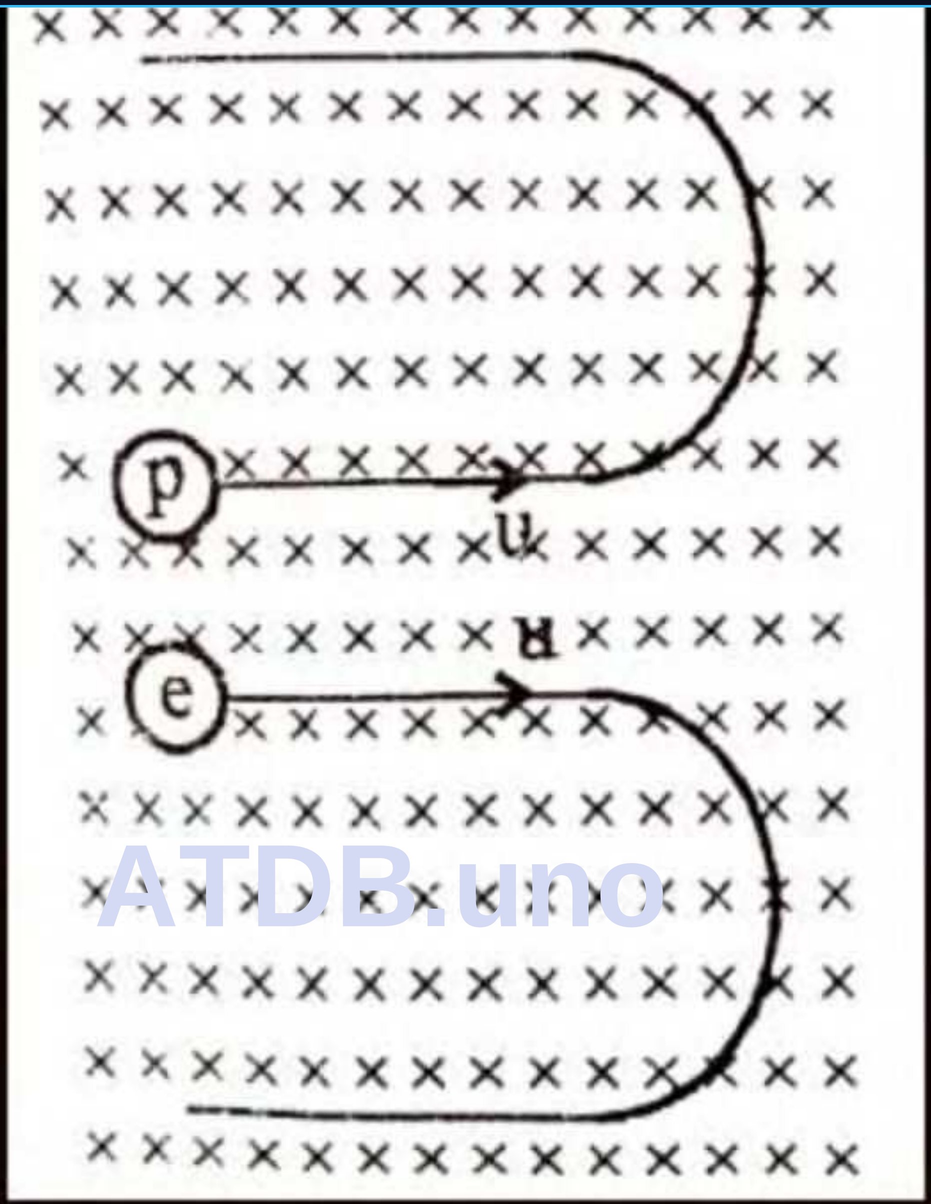
$$T = \frac{2\pi m}{qB}$$

$$t \propto m$$

$$m_p > m_e$$

$$T_p > T_e$$

So, D is also true



Q. 8 Ail α-particle (mass 4 amu) and a singly charged sulfur ion (mass 32 amu) are initially at rest. They are accelerated through a potential V and then allowed to pass into a region of uniform magnetic field which is normal to the velocities of the particles. Within this region, the α-particle and the sulfur ion move in circular orbits of radii r_α and r_s, respectively. The ratio (r_s/r_α) is________.

(JEE Adv. 2021)

Ans : (4)

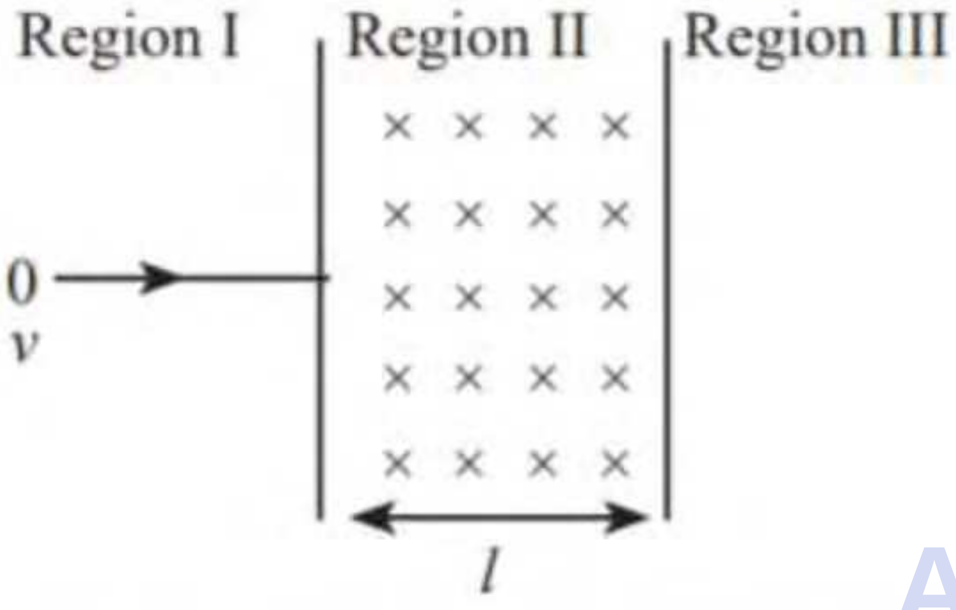
Solution 8

For a charged particle projected into uniform magnetic field, radius of path is given by

$$r = \frac{\sqrt{2mqV}}{qB} \Rightarrow r \propto \sqrt{\frac{m}{q}}$$

$$\Rightarrow \frac{r_s}{r_\alpha} = \sqrt{\frac{m_s}{m_\alpha}\left(\frac{q_\alpha}{q_s}\right)} = \sqrt{\frac{32(2)}{4(1)}} = 4$$

Q. 9 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 $v > \frac{qlB}{m}$

(*b*) The particle enters Region III only if its Velocity $v < \frac{qlB}{m}$

(*c*) Path length of the particle in Region II is maximum when velocity $v = qlB/m$

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

Ans : (a, c, d)

Solution 9

As the particle enters region II, it will have a portion of circular path in this region.

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

If the width of the region l is less than r, the particle will enter region III.

$$\therefore \frac{mv}{qB} > l$$

$$\Rightarrow v > \frac{qBl}{m}$$

$\therefore$ the path length of the particle in region II will be maximum

when $l = r$ i.e $v = \frac{qlB}{m}$

when $r = l$, time spent in the region II is $\frac{T}{2} = \frac{1}{2}\frac{2\pi m}{qB} = \frac{\pi m}{qB}$.

Time is independent of speed

Q. 10 Consider the motion of a positive point charge in a region where there are simultaneous uniform electric and magnetic fields $E = E_0\hat{j}$ and $B = B_0\hat{j}$. At time $t = 0$, this charge has velocity v in the $x-y$ plane, making an angle θ with the x-axis. Which of the following option(s) is/are correct for time $t > 0$?

(IIT-JEE 2012)

(*a*) If $\theta = 0°$, the charge moves in a circular path in the $x-z$ plane

(*b*) If $\theta = 0°$, the charge undergoes helical motion with constant pitch along the y-axis

(*c*) If $\theta = 10°$, the charge undergoes helical motion with its pitch increasing with time, along the y-axis

(*d*) If $\theta = 90°$, the charge undergoes linear but accelerated motion along the y-axis

Ans : (c, d)

Solution 10

Correct Answer - C::D

Here, $\vec{E} = E_0\hat{j}$ and $\vec{B} = B_0\hat{j}$.

Let m, q be the mass and charge of the positive point charge which is moving with velocity $\vec{v}$ in the electric and magnetic fields acting along Y-axis.

Resolving $\vec{v}$ into two rectangular components we have, $v\cos\theta$ along X-axis and $v\sin\theta$ acts along Y-axis.

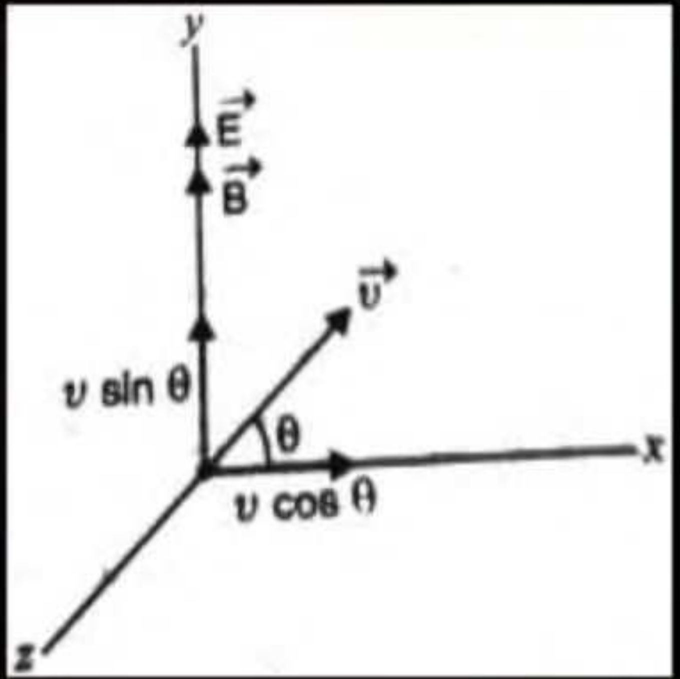
Due to component velocity $v\sin\theta$, the charged particle is accelerated due to electric field with acceleration, $a_y = E_0q/m$ along Y-axis.

The particle does not experience any force due to magnetic field.

Due to component velocity $v\cos\theta$, the particle is accelerated due to electric field with acceleration $a_y = E_0q/m$ along Y-axis.

The particle experiences maximum force due to magnetic field and describes a circular path with time period, $T = 2\pi m/Bq$ which is independent of r and v.

Due to combined electric and magnetic fields along Y-axis, when $\theta = 10^\circ$, the particle will describe a helical path whose pitch increases with time along the Y-axis (i.e., option (c) is true). When $\theta = 90^\circ$, the particle does not experience any force due to magnetic field. Hence it is accelerated along y-axis due to electric field alone. Thus option (d) is true.



Q. 11 A particle of mass M and positive charge Q, moving with a constant velocity $u_1 = 4\hat{i}\ \text{ms}^{-1}$, 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 $x = L$ for all values of y. After passing through this region, the particle emerges on the other side after 10 milliseconds with a velocity $u_2 = 2\left(\sqrt{3}\hat{i} + \hat{j}\right)\text{ms}^{-1}$. The correct statement(s) is/are **(JEE Adv. 2013)**

(a) The direction of the magnetic field is $-z$ direction.

(b) The direction of the magnetic field is $+z$ direction

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

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

Ans : (a, c)

Solution 11

Correct Answer - A::C

Refer to figure, component of final velocity of particle is in positive y-direction. The centre of circular path of particle in magnetic field is present on positive y-direction So magnetic field is present in negative z-direction.

If θ is the angle of deviation of the particle with x-axis while emerging from magnetic field, then

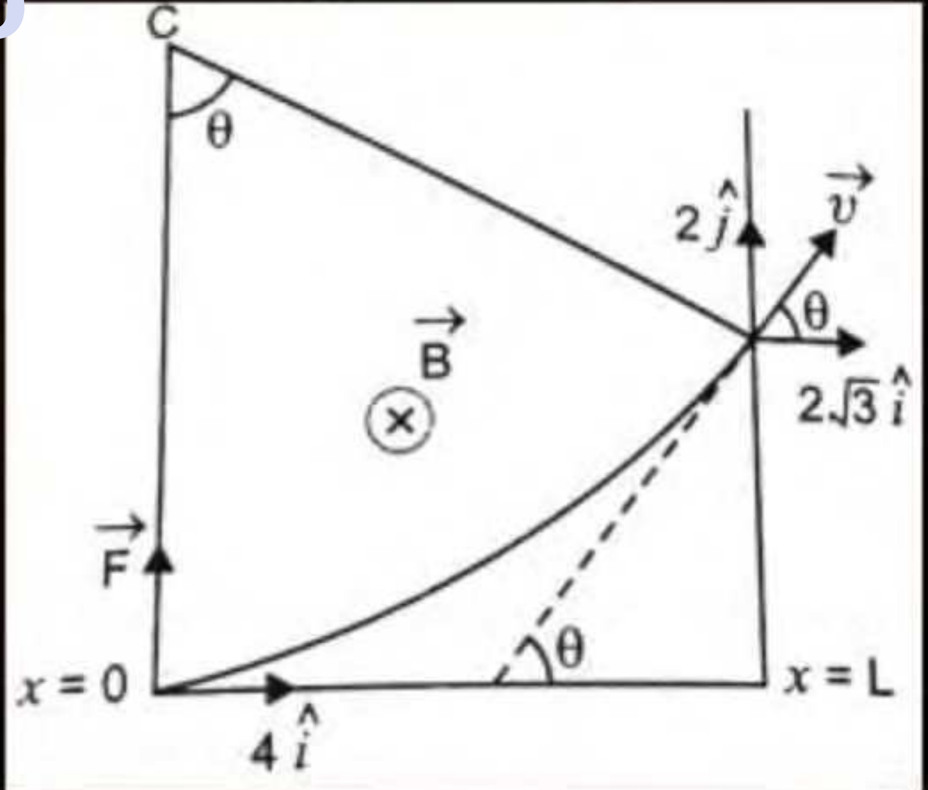
$$\tan\theta = \frac{v_y}{v_x} = \frac{2}{2\sqrt{3}} = \frac{1}{\sqrt{3}} = \frac{\tan\pi}{6} \text{ or } \theta = \frac{\pi}{6}$$

Angular velocity of rotation of particle in magnetic field, $\omega = \frac{QB}{M}$

Time taken by particle to cross the magnetic field is

$$t = \frac{\theta}{\omega} = \frac{\pi/6}{QB/M} = \frac{M\pi}{6QB}$$

$$\text{or } B = \frac{M\pi}{6Qt} = \frac{M\pi}{6Q \times (10 \times 10^{-3})} = \frac{50M\pi}{3Q}$$



Q. 13 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)**

Ans : (7)

Solution 13

Using the concept of area of triangle

$$\frac{1}{2} \times PD \times 5x = \frac{1}{2} \times 3x \times 4x$$

$$\therefore PD = \frac{12x}{5}$$

$$QD = \sqrt{(PQ)^2 - (PQ)^2} = \sqrt{9x^2 - \frac{144x^2}{25}} = \frac{9x}{5}$$

$$\text{and } DR = 5x - \frac{9x}{5} = \frac{16x}{5}$$

Magnetic field at P due to current elements PQ and PR is zero as the point P is on the conductor. Therefore, magnetic field at P due to current element QR is

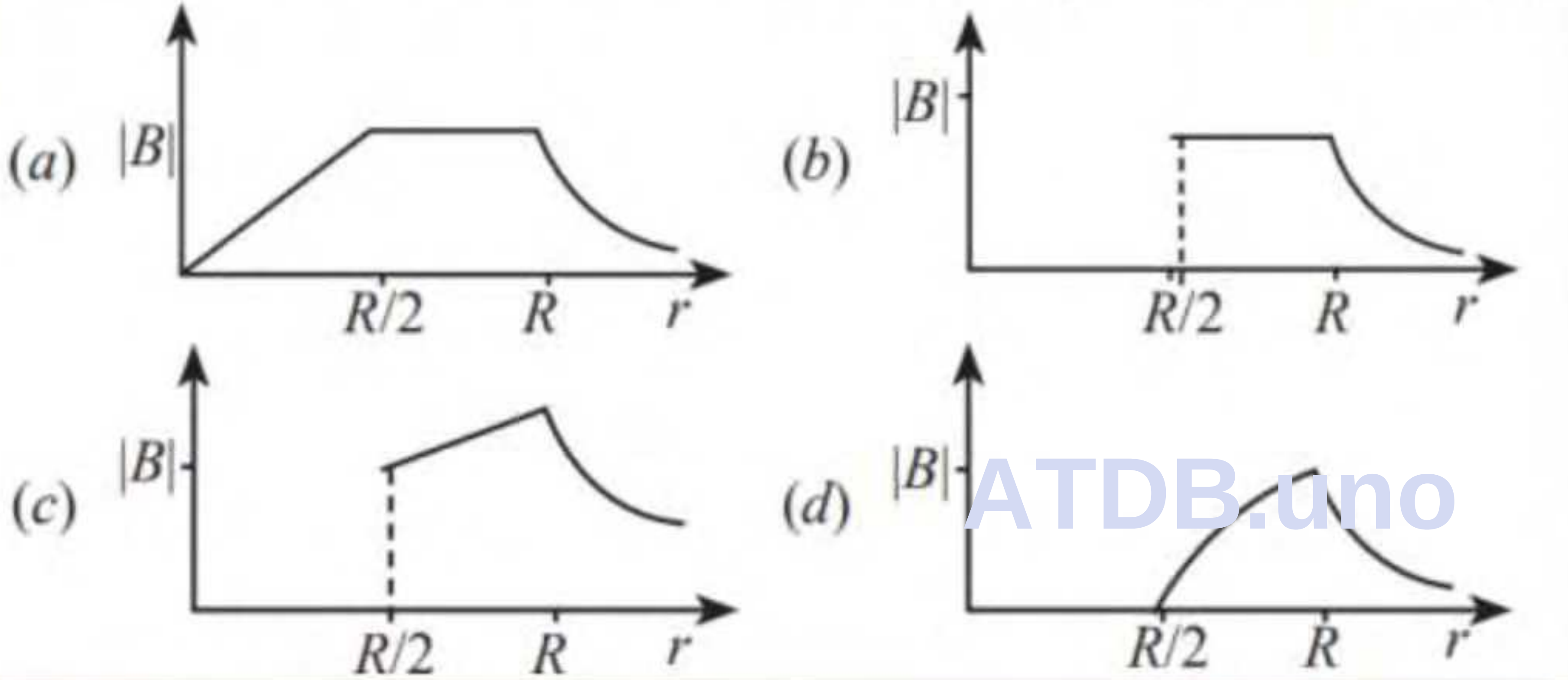
$$B = \frac{\mu_0 I}{4\pi PD}(\sin\phi_1 + \sin\phi_2)$$

$$B = \frac{\mu_0 I \times 5}{4\pi \times 12x}\left(\frac{(9x/5)}{3x} + \frac{(16x/5)}{4x}\right)$$

$$B = \frac{\mu_0 I 5}{48\pi x}\left(\frac{3}{5} + \frac{4}{5}\right)$$

$$B = \frac{7\mu_0 I}{48\pi x} \therefore k = 7$$

Q. 16 An infinitely long hollow conducting cylinder with inner radius $R/2$ and outer radius R carries a uniform current density along its length. The magnitude of the magnetic field, $|B|$ as a function of the radial distance r from the axis is best represented by **(IIT-JEE 2012)**



Ans : (d)

Solution 16

inside the cavity, for $x < (R/2)$, $B = 0$ (1)

For,

$(R/2) < x < R$

$\int B \cdot d\ell = \mu_0 I$

Putting $I = JA$

$\therefore |B| 2\pi x = \mu_0 [\pi x^2 - \pi(R/2)^2]J$

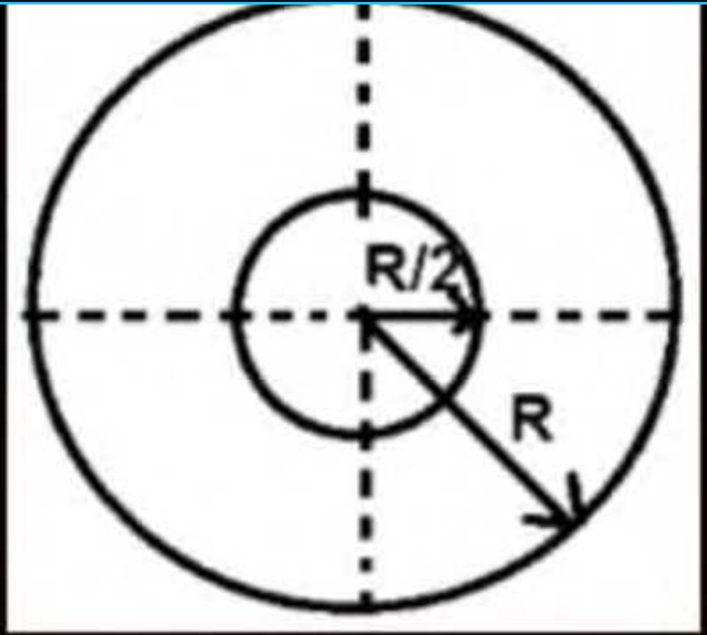
$|B| = [(\mu_0 J \times \pi)/(2\pi x)][x^2 - (R^2/4)]$

$|B| = [(\mu_0 J)/2x][x^2 - (R^2/4)]$ (2)

For $x \geq R$,

$\int \vec{B} \cdot d\vec{\ell} = \mu_0 I$

$|B| \cdot 2\pi x = \mu_0 [(\pi R^2 - \pi(R/2)^2]J$



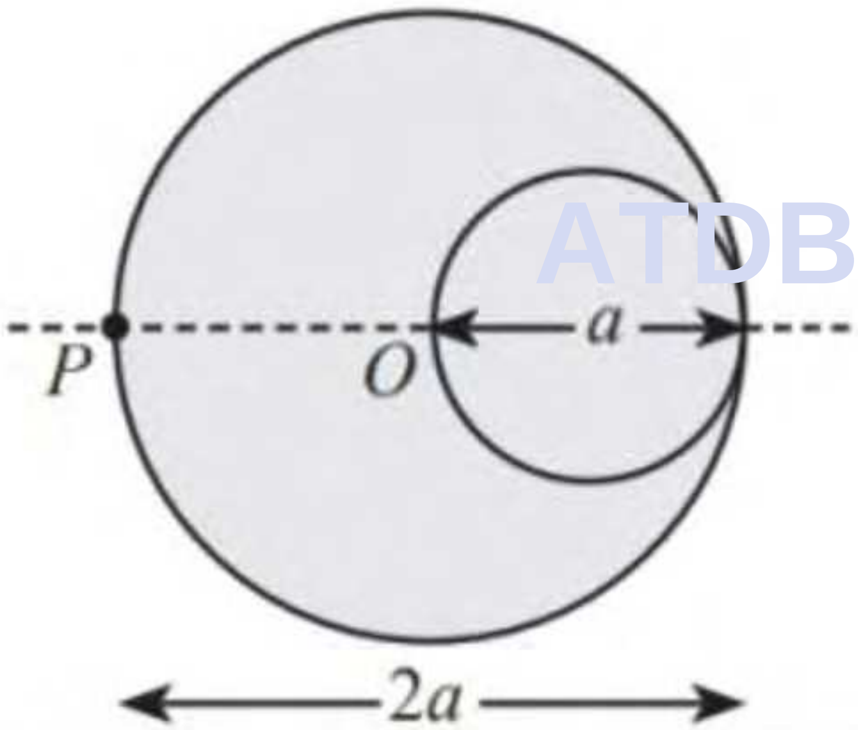
$|B| = [(\mu_0 J)/2x][(3/4)R^2]$ (3)

From (1), (2), (3) graph (d)

Q. 17 A cylindrical cavity of diameter a exists inside a cylinder of diameter $2a$ as shown in the figure. Both the cylinder and the cavity are infinitely long. A uniform current density J flows along the length.

If the magnitude of the magnetic field at the point P is given by $\frac{N}{12}\mu_0 a.J$, then the value of N is

(IIT-JEE 2012)



Ans : (5)

Solution 17

The magnetic field for an infinitely long cylinder is given by,

$$B_{in} = \frac{\mu_o J r}{2}$$

$$B_{out} = \frac{\mu_o J R^2}{2r}$$

r = distance from the axis of the cylinder.

R = Radius of the cylinder.

Assuming the bigger cylinder to carry a positive current density and the smaller cylinder carry a negative current density of magnitude J each.

∴ Magnetic field at point P = $B = B_1 + B_2$

$$B_1 = \frac{\mu_o J a}{2}$$

$$B_2 = \frac{-\mu_o J \left(\frac{a}{2}\right)^2}{2\frac{3a}{2}}$$

$$\therefore B_2 = \frac{-\mu_o J a}{12}$$

$$\therefore B = \frac{5\mu_o J a}{12}. \qquad \therefore N = 5$$

Solution 20

For particle to move in -ve y-direction, either its velocity must be in –ve y-direction (if initial velocity is not equal to zero) & force should be parallel to velocity or it must experience a net force in –ve y-direction only (if initial velocity = 0)

Q. 21 In a particular system of units, a physical quantity can be expressed in terms of the electric charge e, electron mass m_e, Planck's constant h, and Coulomb's constant $k = \frac{1}{4\pi\varepsilon_0}$, where ε_0 is the permittivity of vacuum. In terms of these physical constants, the dimension of the magnetic field is $[B] = [e]^{\alpha}[m_e]^{\beta}[h]^{\gamma}[k]^{\delta}$. The value of $\alpha + \beta + \gamma + \delta$ is ________.

[JEE-Advance-2022]

Ans : (4)

Q. 22 A dimensionless quantity is constructed in terms of electronic charge e, permittivity of free space ε_0, Planck's constant h, and speed of light c. If the dimensionless quantity is written as $e^\alpha \varepsilon_0^\beta h^\gamma c^\delta$ and n is a non-zero integer, then $(\alpha, \beta, \gamma, \delta)$ is given by

JEE Adv. 2024

(A) (2n, -n, -n, -n)

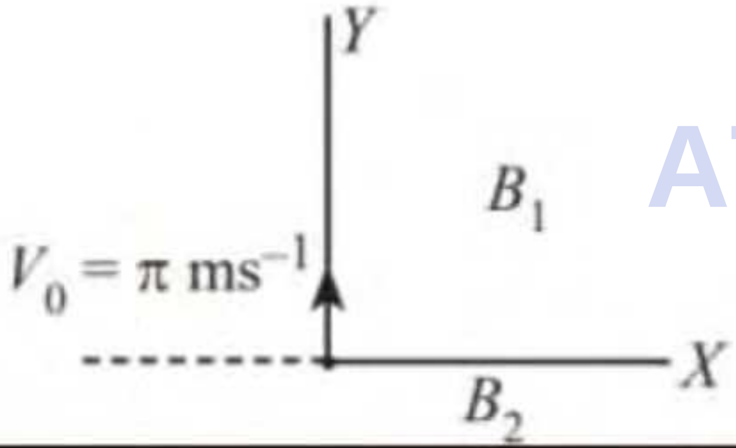
(B) (n, -n, -2n, -n)

(C) (n, -n, -n, -2n)

(D) (2n, -n, -2n, -2n)

Ans : (A)

Q. 24 In the xy-plane, the region $y > 0$ has a uniform magnetic field $B_1\hat{k}$ and the region $y < 0$ has another uniform magnetic field $B_2\hat{k}$. A positively charged particle is projected from the origin along the positive Y-axis with speed $v_0 = \pi ms^{-1}$ at $t = 0$, as shown in figure. Neglect gravity in this problem. Let $t = T$ be the time when the particle crosses the X-axis from below for the time when the particle crosses the X-axis from below for the first time. If $B_2 = 4B_1$, the average speed of the particle, in ms^{-1}, along the X-axis in the time interval T is… **(JEE Adv. 2018)**



Ans : (2)

Solution 24

Average speed along the x-axis

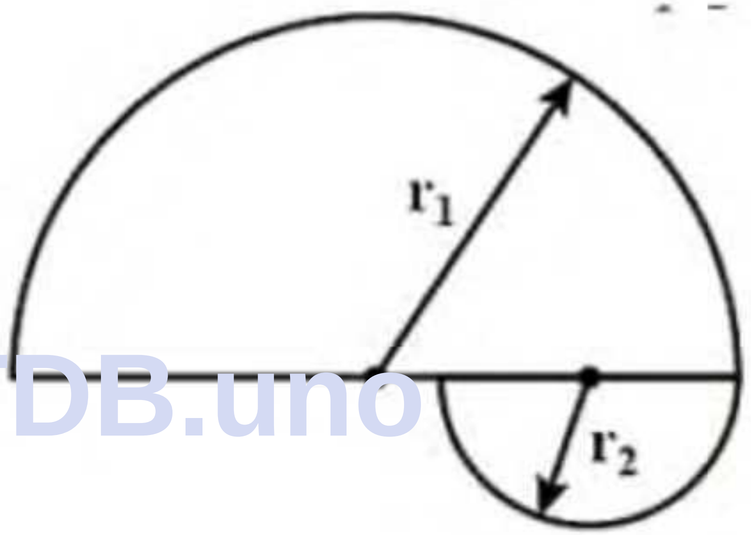
$$(V_x) = \frac{\int |\vec{V}_x| dt}{\int dt} = \frac{d_1 + d_2}{t_1 + t_2} \rightarrow (1)$$

We also have,

$$r_1 = \frac{mv}{qB_1}, r_2 = \frac{mv}{qB_2}$$

since $B_1 = \frac{B_2}{4}$

$$\therefore r_1 = 4r_2 \rightarrow (2)$$



Time in $B_1 \Rightarrow \frac{\pi B}{qB_1} = t_1$

Time in $B_2 \Rightarrow \frac{\pi B}{qB_2} = t_2$

Total distance along x-axis $d_1 + d_2 = 2r_1 + 2r_2 = 2(r_1 + r_2) = 2(5r_2)$

Total time $T = t_1 + t_2 = 5t_2$

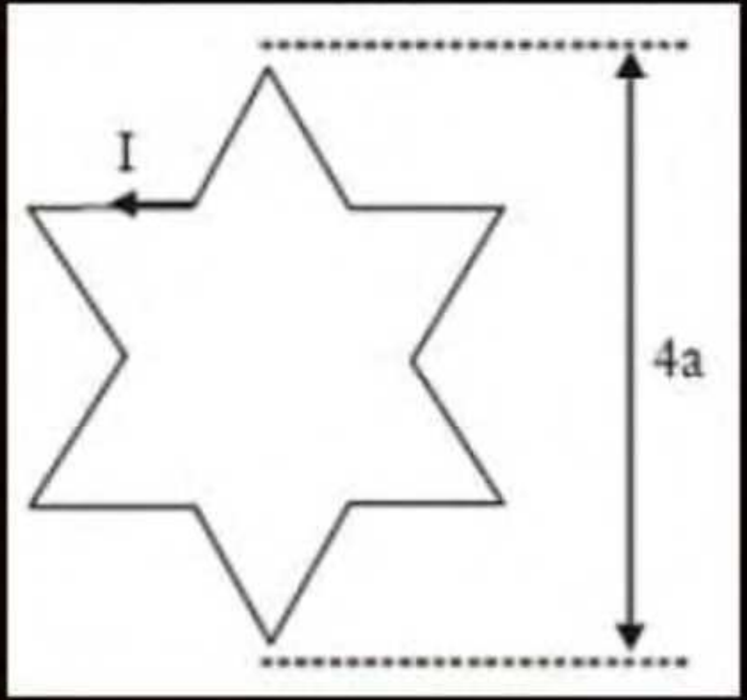
$$\therefore \text{Average speed} = \frac{10r_2}{5t_2} = 2\frac{mv}{qB_2} \times \frac{qB_2}{\pi m} = 2$$

Q. 26 A symmetric star shaped conducting wire loop is carrying a steady state current I as shown in the figure. The distance between the diametrically opposite vertices of the star is 4a. The magnitude of the magnetic field at the center of the loop is

[JEE-Advanced-2017]

(A) $\frac{\mu_0 I}{4\pi a}6[\sqrt{3}-1]$ (B) $\frac{\mu_0 I}{4\pi a}6[\sqrt{3}+1]$

(C) $\frac{\mu_0 I}{4\pi a}3[\sqrt{3}-1]$ (D) $\frac{\mu_0 I}{4\pi a}3[2-\sqrt{3}]$



Ans : (A)

Solution 26

In $\Delta OAC \quad \cos 60° = \frac{OC}{OA}$

$\therefore OC = 2a \times \frac{1}{2} = a$

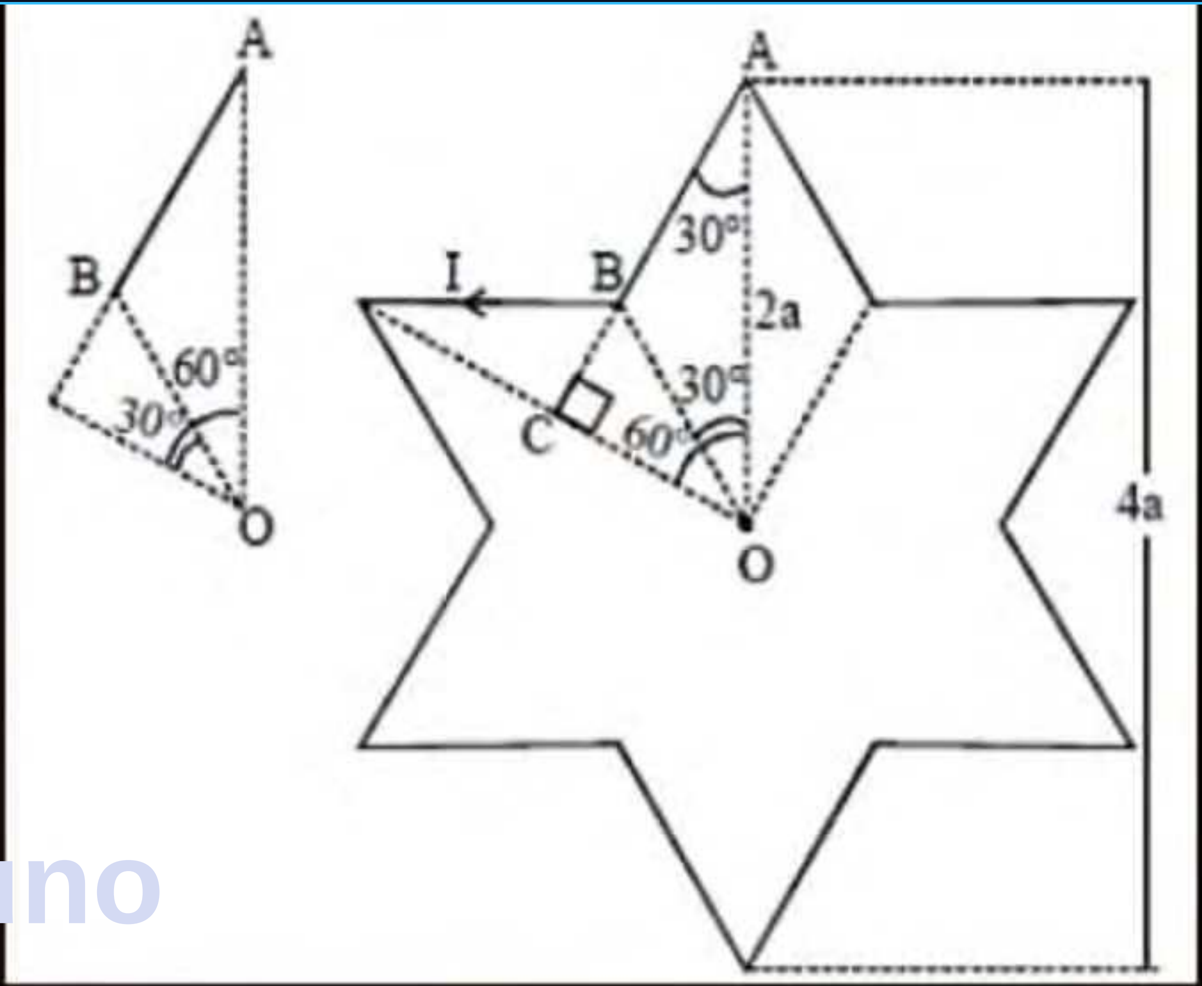
The magnetic field at 'O' due to

$AB = \frac{\mu_0}{4\pi}\frac{I}{a}[\sin 60° - \sin 30°]$

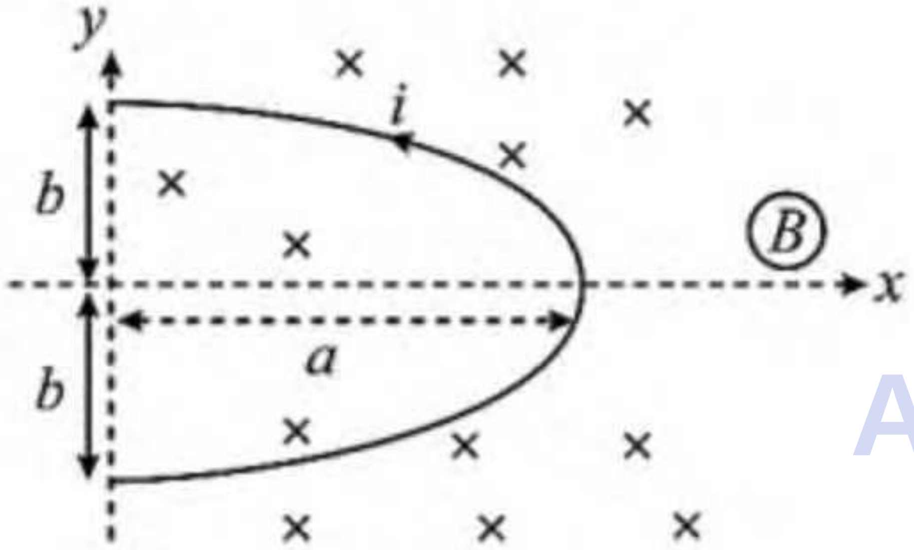
$= \frac{\mu_0}{4\pi}\frac{I}{a}\left[\frac{\sqrt{3}}{2} - \frac{1}{2}\right] = \frac{\mu_0 I}{4\pi a} \times \frac{1}{2}(\sqrt{3}-1)$

The total magnetic field due to all the straight segments of the star is

$= \left[\frac{\mu_0}{4\pi}\frac{I}{a} \times \frac{1}{2}(\sqrt{3}-1)\right] \times 12 = \frac{\mu_0}{4\pi}\frac{I}{a} \times 6(\sqrt{3}-1)$



Q. 62 In the figure, there is a conducting wire having current i and which has a shape of half ellipse $\left[\frac{x^2}{a^2}+\frac{y^2}{b^2}=1\right]$ is kept in a uniform magnetic field B as shown. If the mass of wire is m, the acceleration of wire will be



(a) $\frac{ibB}{m}$ (b) $\frac{iaB}{m}$ (c) $\frac{2iaB}{m}$ (d) $\frac{2ibB}{m}$

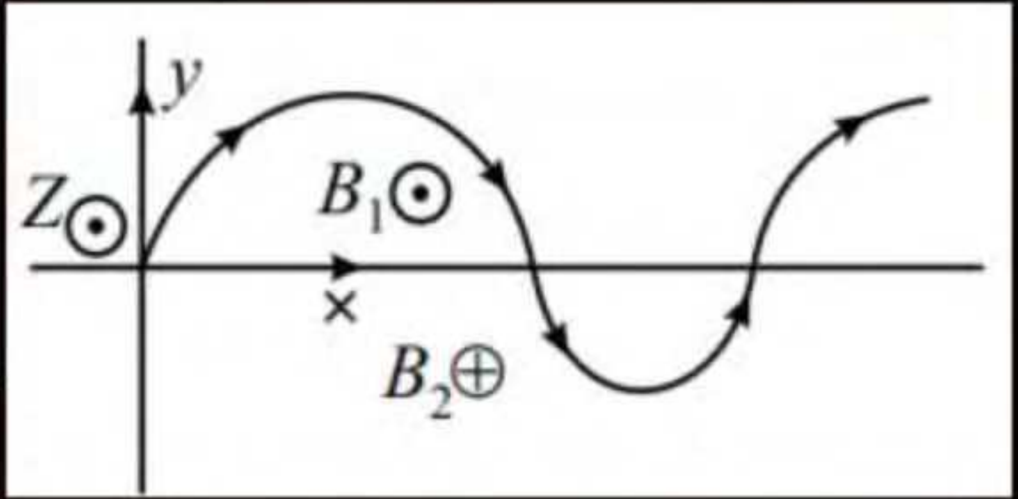
(JEE Lakshya Physics M-2 XII)

Ans : (d)

Solution 62

(d) $\dfrac{2ibB}{m}$

Q. 64 At $t = 0$ a charge q is at the origin and moving in the y-direction with velocity $\vec{v} = v\hat{j}$. The charge moves in a magnetic field that is for $y > 0$ out of page and given by $B_1\hat{z}$ and for $y < 0$ into the page and given $-B_2\hat{z}$. The charge's subsequent trajectory is shown in the sketch. From this information, we can deduce that



(a) $q > 0$ and $|B_1| < |B_2|$

(b) $q < 0$ and $|B_1| < |B_2|$

(c) $q > 0$ and $|B_1| > |B_2|$

(d) $q < 0$ and $|B_1| > |B_2|$

Ans : (a)

Q. 94 Two particles, each having a mass m are placed at a separation d in a uniform magnetic field B as shown in figure (34-E19). They have opposite charges of equal magnitude q. At time $t = 0$, the particles are projected towards each other, each with a speed v. Suppose the Coulomb force between the charges is switched off. (a) Find the maximum value v_m of the projection speed so that the two particles do not collide. (b) What would be the minimum and maximum separation between the particles if $v = v_m/2$? (c) At what instant will a collision occur between the particles if $v = 2v_m$? (d) Suppose $v = 2v_m$ and the collision between the particles is completely inelastic. Describe the motion after the collision.

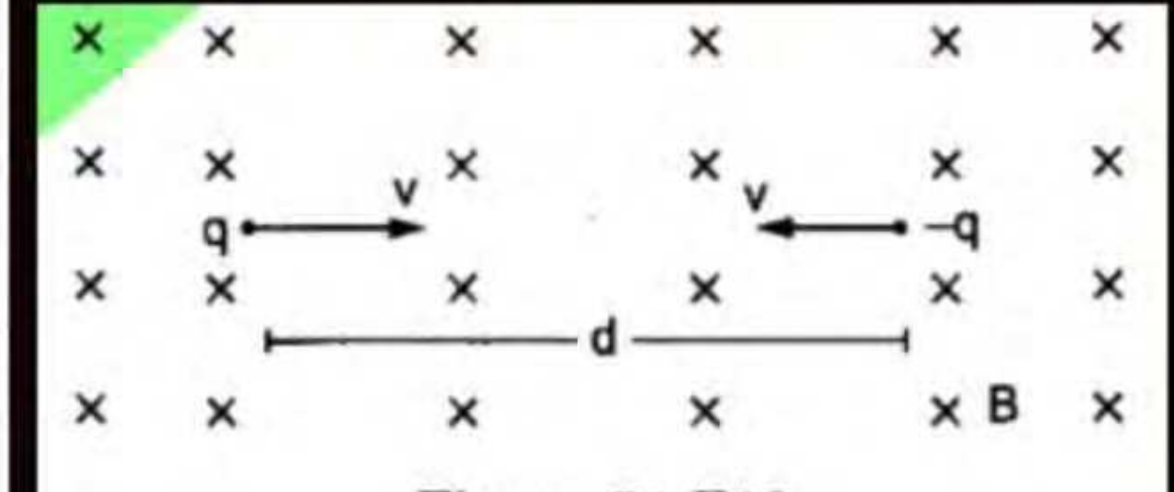


Figure 34-E19

Ans. (a) $\frac{qBd}{2\,m}$ (b) $\frac{d}{2}, \frac{3\,d}{2}$ (c) $\frac{\pi m}{6\,qB}$ (d) the particles stick together and the combined mass moves with constant speed v_m along the straight line drawn upward in the plane of figure through

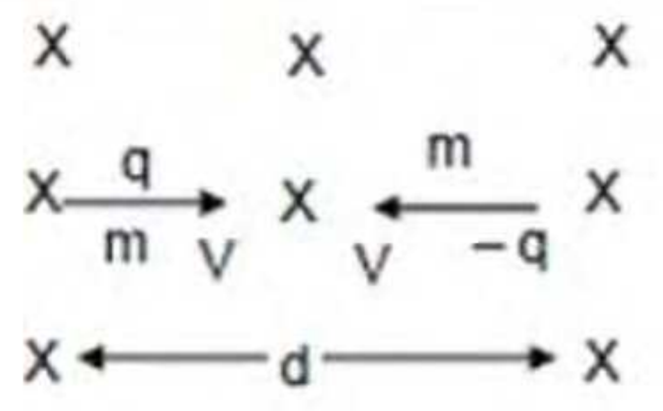
Solution 94

(a) The particulars will not collide if

$d = r_1 + r_2$

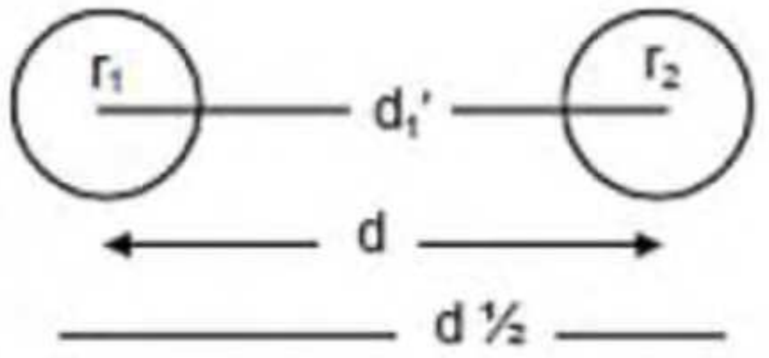
$\Rightarrow d = \frac{mV_m}{qB} + \frac{mV_m}{qB}$

$\Rightarrow d = \frac{2mV_m}{qB} \Rightarrow V_m = \frac{qBd}{2m}$



(b) $V = \frac{V_m}{2}$

$d_1' = r_1 + r_2 = 2\left(\frac{m \times qBd}{2 \times 2m \times qB}\right) = \frac{d}{2}$ (min. dist.)



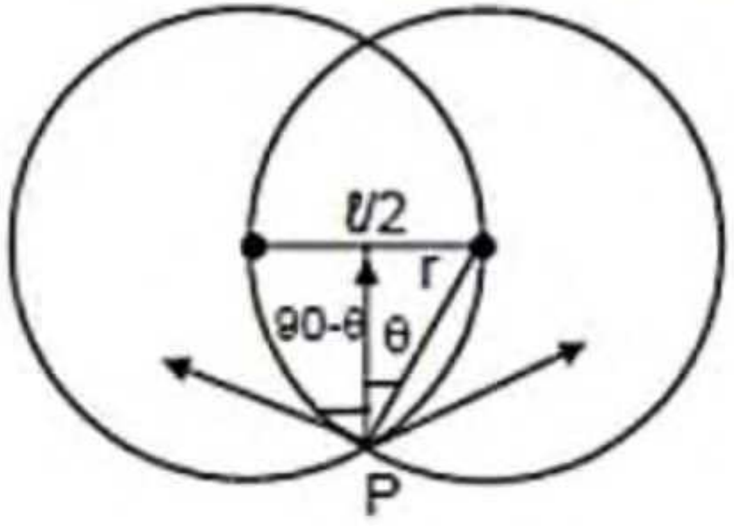
Max. distance $d_2' = d + 2r = d + \frac{d}{2} = \frac{3d}{2}$

(c) $V = 2V_m$

$r_1' = \frac{m_2V_m}{qB} = \frac{m \times 2 \times qBd}{2n \times qB}$, $r_2 = d$ $\therefore$ The arc is 1/6

(d) $V_m = \frac{qBd}{2m}$

The particles will collide at point P. At point p, both the particles will have motion m in upward direction. Since the particles collide inelastically the stick together.



Distance l between centres = d, Sin θ = $\frac{l}{2r}$

Velocity upward = v cos 90 – θ = V sin θ = $\frac{vl}{2r}$

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

$$V \sin\theta = \frac{vl}{2r} = \frac{vl}{2\frac{mv}{qb}} = \frac{qBd}{2m} = V_m$$

Hence the combined mass will move with velocity V_m

Q. 95 A particle having mass m and charge q is released from the origin in a region in which electric field and magnetic field are given by

$$\vec{B} = -B_0\vec{j} \text{ and } \vec{E} = E_0\vec{k}.$$

Find the speed of the particle as a function of its z-coordinate.

Ans. $\sqrt{\frac{2qE_0 z}{}}$

Solution 95

Velocity will be along x - $zpla \neq -\bar{B}$

$= -\bar{B}_0\bar{J}, \bar{E} = E_0\bar{K}$

$F = q(E + V \times B)$

$= qE_0K - qV_xB_0K + qV_xB_0I$

Since$V_x = 0, F_2 = qE_0$

so $a = \frac{qE_0}{m}$

$\therefore V^2 = u^2 + 2as = 2\frac{qE_0}{m}z$

$so, v = \sqrt{\frac{2qE_0z}{m}}$

[dist along z - direction be z].

QUESTION

A charge particle moving in magnetic field B, has the components of velocity along B as well as perpendicular to B. The path of the charge particle will be

[8 April, 2022 (Shift-I)]

(A) helical path with the axis perpendicular to the direction of magnetic field B

(B) straight along the direction of magnetic field B

(C) helical path with the axis along magnetic field B

(D) circular path

QUESTION

An electron is moving along the positive *x*-axis. If the uniform magnetic field is applied parallel to the negative *z*-axis. then

A. The electron will experience magnetic force along positive y-axis

B. The electron will experience magnetic force along negative y-axis

C. The electron will not experience any force in magnetic field

D. The electron will continue to move along the positive x-axis

E. The electron will move along circular path in magnetic field

Choose the correct answer from the options given below: [13 April, 2023 (Shift-II)]

(A) Band E only

(B) A and E only

(C) C and D only

(D) B and D only

QUESTION

An electron is allowed to move with constant velocity along the axis of current carrying straight solenoid.

A. The electron will experience magnetic force along the axis of the solenoid.

B. The electron will not experience magnetic force.

C. The electron will continue to move along the axis of the solenoid.

D. The electron will be accelerated along the axis of the solenoid.

E. The electron will follow parabolic path inside the solenoid.

Choose the correct answer from the options given below: [11 April, 2023 (Shift-II)]

(A) B, C and D only

(B) B and C only

(C) A and D only

(D) B and E only

QUESTION

A proton with a kinetic energy of 2.0 eV moves into a region of uniform magnetic field of magnitude $\frac{\pi}{2} \times 10^{-3}$ T. The angle between the direction of magnetic field and velocity of proton is 60° The pitch of the helical path taken by the proton is __ cm. (Take, mass of proton = 1.6×10^{-27} kg and Charge on proton = 1.6×10^{-19} C).

[6 April, 2022 (Shift-II)]

QUESTION

Given below are two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In an uniform magnetic field, speed and energy remains the same for a moving charged particle.

Reason (R): Moving charged particle experiences magnetic force perpendicular to its direction of motion.

[24 June, 2022 (Shift-I)]

A. Both (A) and (R) are true and (R) is the correct explanation of (A).

B. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).

C. (A) is true but (R) is false.

D. (A) is false but (R) is true.

QUESTION

A charge particle is moving in a uniform magnetic field $(2\hat{i} + 3\hat{j})$ T. If it has an acceleration of $(\alpha\hat{i} - 4\hat{j})\text{m/s}^2$, then the value of α is [26 July, 2022 (Shift-I)]

(A) 3

(B) 6

(C) 12

(D) 2

QUESTION

A proton, a deuteron and an α- particle with same kinetic energy enter into a uniform magnetic field at right angle to magnetic field. The ratio of the radii of their respective circular paths is: [24 June, 2022 (Shift-II)]

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

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

(C) $\sqrt{2} : 1 : 1$

(D) $1 : \sqrt{2} : 1$

QUESTION

A proton and an alpha particle of the same velocity enter in a uniform magnetic field which is acting perpendicular to their direction of motion. The ratio of the radii of the circular paths described by the alpha particle and proton is: [26 June, 2022 (Shift-I)]

(A) 1 : 4

(B) 4 : 1

(C) 2 : 1

(D) 1 : 2

QUESTION

Statement-I: The electric force changes the speed of the charged particle and hence charges its kinetic energy; whereas the magnetic force does not change the kinetic energy of the charged particle.

Statement-II: The electric force accelerates the positively charged particle perpendicular to the direction of electric field. The magnetic force accelerates the moving charged particle along the direction of magnetic field.

In the light of the above statements, choose the most appropriate answer from the options given below:

[29 June, 2022 (Shift-II)]

(A) Both Statement-I and Statement-II are correct.

(B) Both Statement-I and Statement-II are incorrect.

(C) Statement-I is correct but Statement-II is incorrect.

(D) Statement-I is incorrect but Statement-II is correct.

QUESTION

A charged particle carrying charge 1 μC is moving with velocity $(2\hat{i} + 3\hat{j} + 4\hat{k})\ ms^{-1}$. If an external magnetic field of $(5\hat{i} + 3\hat{j} - 6\hat{k}) \times 10^{-3} T$ exists in the region where the particle is moving then the force on the particle is $\vec{F} \times 10^{-9} N$. The vector $\vec{F}$ is:

[JEE Main-2020]

(1) $-0.30\hat{i} + 0.32\hat{j} - 0.09\hat{k}$

(2) $-300\hat{i} + 320\hat{j} - 90\hat{k}$

(3) $-30\hat{i} + 32\hat{j} - 9\hat{k}$

(4) $-3.0\hat{i} + 3.2\hat{j} - 0.9\hat{k}$

Ans : (3)

QUESTION

A loop of flexible wire of irregular shape carrying current is placed in an external magnetic field. Identify the effect of the field on the wire. [JEE Main-2021]

1. Loop assumes circular shape with its plane normal to the field.
2. Loop assumes circular shape with its plane parallel to the field.
3. Wire gets stretched to become straight.
4. Shape of the loop remains unchanged.

Ans : (1)

QUESTION

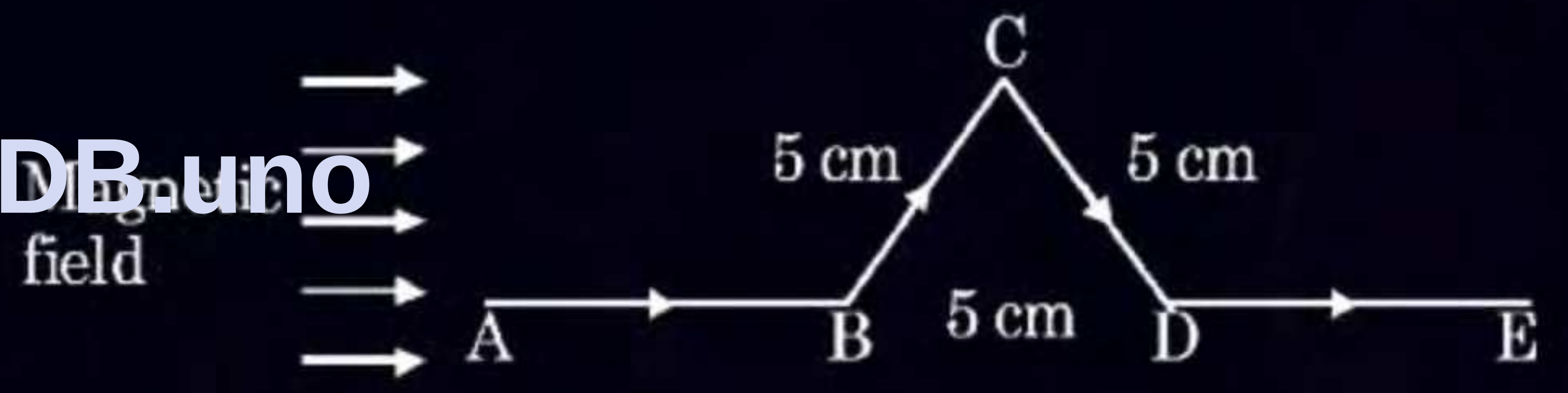
A triangular shaped wire carrying 10 A current is placed in a uniform magnetic field of 0.5 T, as shown in figure. The magnetic force on segment CD is:
(Given BC = CD = BD = 5 cm). **[JEE Main-2022]**

(1) 0.126 N

(2) 0.312 N

(3) 0.216 N

(4) 0.245 N



Ans : (3)

Homework

- Ques are attached.


THANK
YOU
ATDB.uno