

MAGNETIC FIELD

Motion of charge particle in a magnetic field

Q.1 A particle having charge $q = 1\mu\text{C}$ moves in uniform magnetic field with velocity $v_1 = 10^6 \text{ ms}^{-1}$ at angle 45° with x-axis in the xy-plane and experiences a force $F_1 = 5\sqrt{2}\text{mN}$ along the negative z-axis. When the same particle moves with velocity $v_2 = 10^6 \text{ ms}^{-1}$ along the z-axis it experiences a force F_2 in y. direction. Find the magnitude and direction of the magnetic field. Also find the magnitude of the force F_2 .



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Q.6 A particle with charge Q , moving with a momentum p , enters a uniform magnetic field normally. The magnetic field has magnitude B and is confined to a region of width d , where $d < \frac{p}{BQ}$. The particle is deflected by an angle θ in crossing the field. Then :

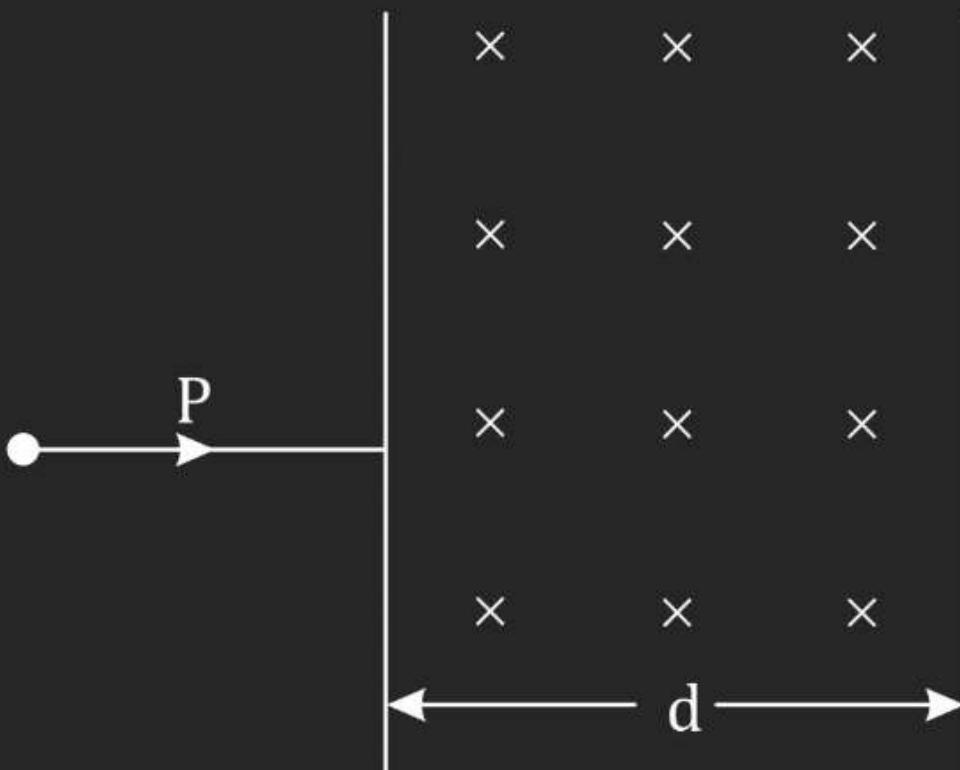
F.W.

(A) $\sin \theta = \frac{BQd}{p}$

(B) $\sin \theta = \frac{p}{BQd}$

(C) $\sin \theta = \frac{Bp}{Qd}$

(D) $\sin \theta = \frac{pd}{BQ}$



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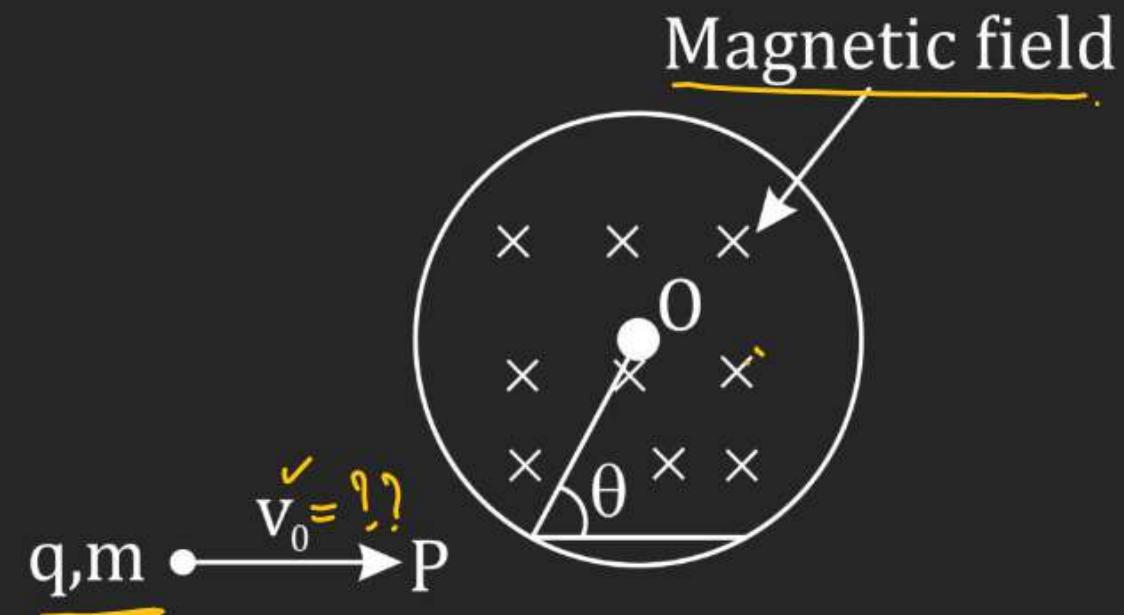
Q.7 A particle of charge q and mass m is projected with a velocity v_0 towards a circular region having uniform magnetic field B perpendicular and into the plane of paper from point P as shown in figure. R is the radius and O is the centre of the circular region. If the line OP makes an angle θ with the direction of v_0 then the value of $v_0 = ?$ so that particle passes through O is :

(A) $\frac{qBR}{msin\theta}$

(B) $\frac{qBR}{2msin\theta}$

(C) $\frac{2qBR}{msin\theta}$

(D) $\frac{3qBR}{2msin\theta}$



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Charge particle pass through C.

$$\frac{r}{l} = \left(\frac{mv_0}{qB} \right)$$

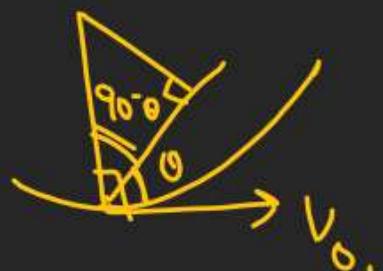
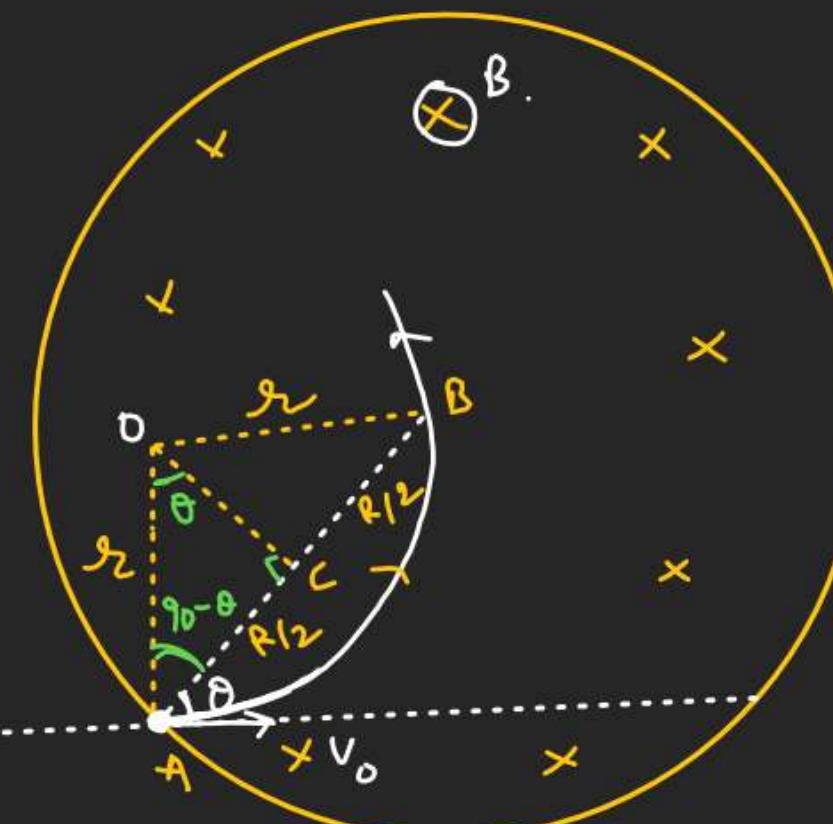
Radius of the arc $\frac{AB = R}{AC = \frac{R}{2}}$

$$\sin \theta = \frac{AC}{OA} = \frac{\frac{R}{2}}{r} = \frac{R}{2r}$$

$$r = \left(\frac{R}{2 \sin \theta} \right)$$

$$\frac{mv_0}{qB} = \frac{R}{2 \sin \theta}$$

$$v_0 = \left(\frac{RqB}{2m \sin \theta} \right) \checkmark$$



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Q.9 A mass spectrometer is a device which select particle of equal mass. An iron with electric charge $q > 0$ and mass m starts at rest from a source S and is accelerated through a potential difference V . It passes through a hole into a region of constant magnetic field \vec{B} perpendicular to the plane of the paper as shown in the figure. The particle is deflected by the magnetic field and emerges through the bottom hole at a distance d from the top hole. The mass of the particle is:

$$R = \frac{d}{2}$$

(A) $\frac{qBd}{mV}$

$$\frac{mu}{qB} = \frac{d}{2}$$

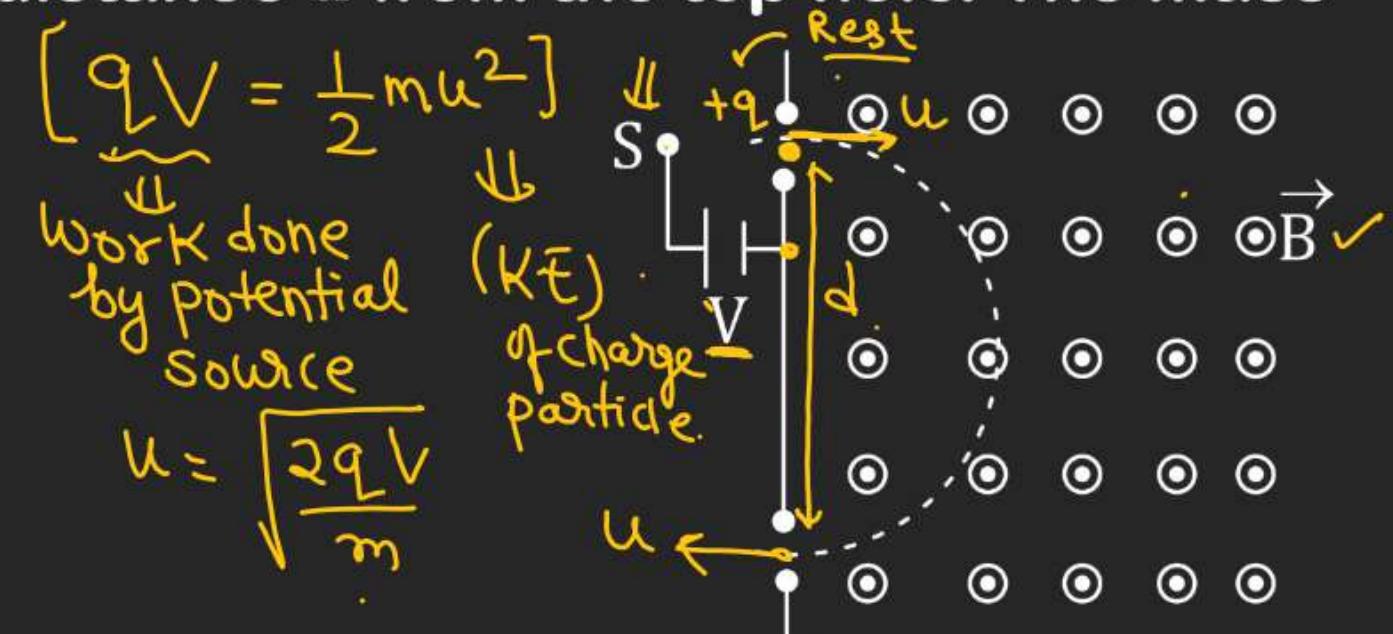
(B) $\frac{qB^2d^2}{4V}$

~~(C) $\frac{qB^2d^2}{8V}$~~

$$\frac{m\sqrt{2qV}}{m} = \frac{dqB}{2}$$

(D) $\frac{qBd}{2mV}$

$$m = \frac{d^2 q^2 B^2}{4 \times 2qV} = \left(\frac{qB^2 d^2}{8V} \right)$$



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Q.14 In the situation in the diagram, the given separation (y) between the lines along which the positive charged particle enters into and leaves the region of magnetic field is (Given $mv/qB = 2.00 \text{ m}$, $d_1 = 0.5 \text{ m}$ and $d_2 = 1 \text{ m}$)

$v \perp B \rightarrow \text{Circular}$

~~(A)~~ $\frac{3}{2}(2 - \sqrt{3})\text{m}$

(B) $\frac{3}{2}(2 + \sqrt{3})\text{m}$

(C) $\frac{3}{2} \text{ m}$

(D) $\frac{1}{2}(2 + \sqrt{3})\text{m}$

$$R_1 = \frac{mv}{qB}, R_2 = \frac{mv}{qB}$$

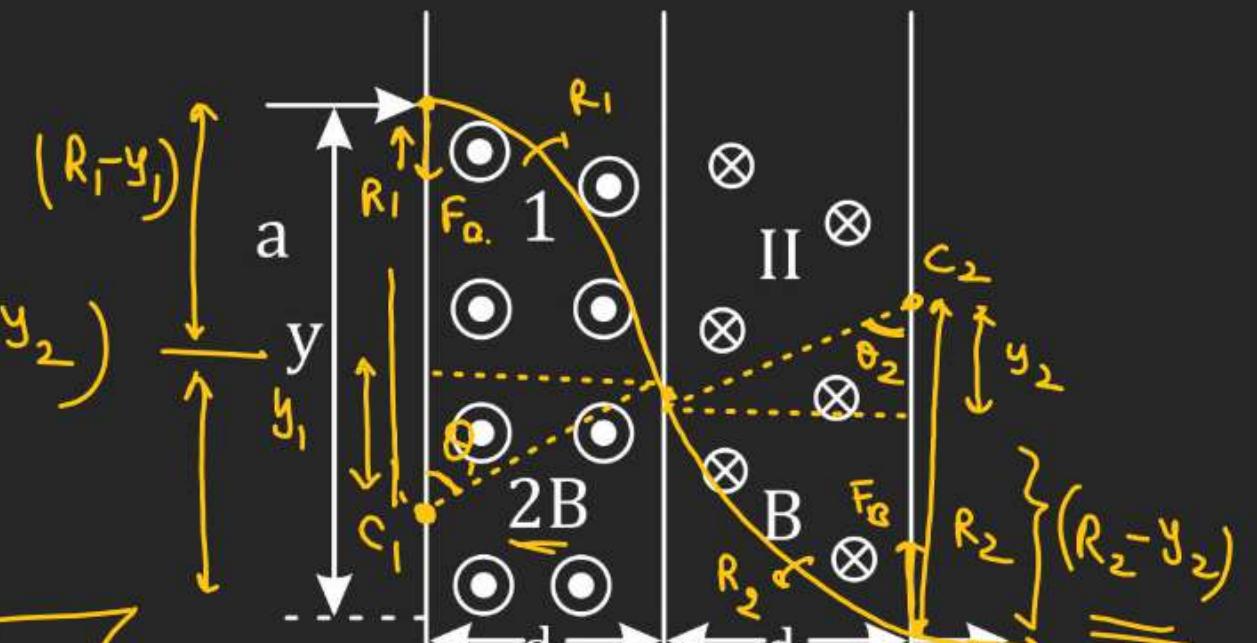
$$y =$$

$$y = (R_1 - y_1) + (R_2 - y_2)$$

$$\sin \theta_1 = \left(\frac{d_1}{R_1} \right)$$

$$\sin \theta_2 = \left(\frac{d_2}{R_2} \right)$$

$$y_1 = R_1 \cos \theta_1$$



$$y_2 = R_2 \cos \theta_2$$

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Q.15 A particle of charge per unit mass α is released from origin with velocity $\vec{v} = v_0 \hat{i}$ in a magnetic field



$$\vec{B} = -B_0 \hat{k} \text{ for } x \leq \frac{\sqrt{3}}{2} \frac{v_0}{B_0 \alpha} \text{ and } \vec{B} = 0 \text{ for } x > \frac{\sqrt{3}}{2} \frac{v_0}{B_0 \alpha}$$

The x-coordinate 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) $\frac{\sqrt{3}}{2} \frac{v_0}{B_0 \alpha} + \frac{v_0 t}{2}$

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Q.16 A particle of positive charge q and mass m enters with velocity \hat{Vj} at the origin in a magnetic field $B(-\hat{k})$ which is present in the whole space. The charge makes a perfectly inelastic collision with an identical particle (having same charge) at rest but free to move at its maximum positive y -coordinate.

After collision, the combined charge will move on trajectory (where $r = \frac{mv}{qB}$)

(A) $y = \frac{mv}{qB}x$

(B) $(x + r)^2 + (y - r/2)^2 = r^2/4$

(C) $(x + r)^2 + (y - r/2)^2 = r^2/8$

(D) $(x - r)^2 + (y + r/2)^2 = r^2/4$

AA

Concept of angle of deviation: →

Note:- Angle Substended by the arc at its Center
is equal to angle of deviation β .

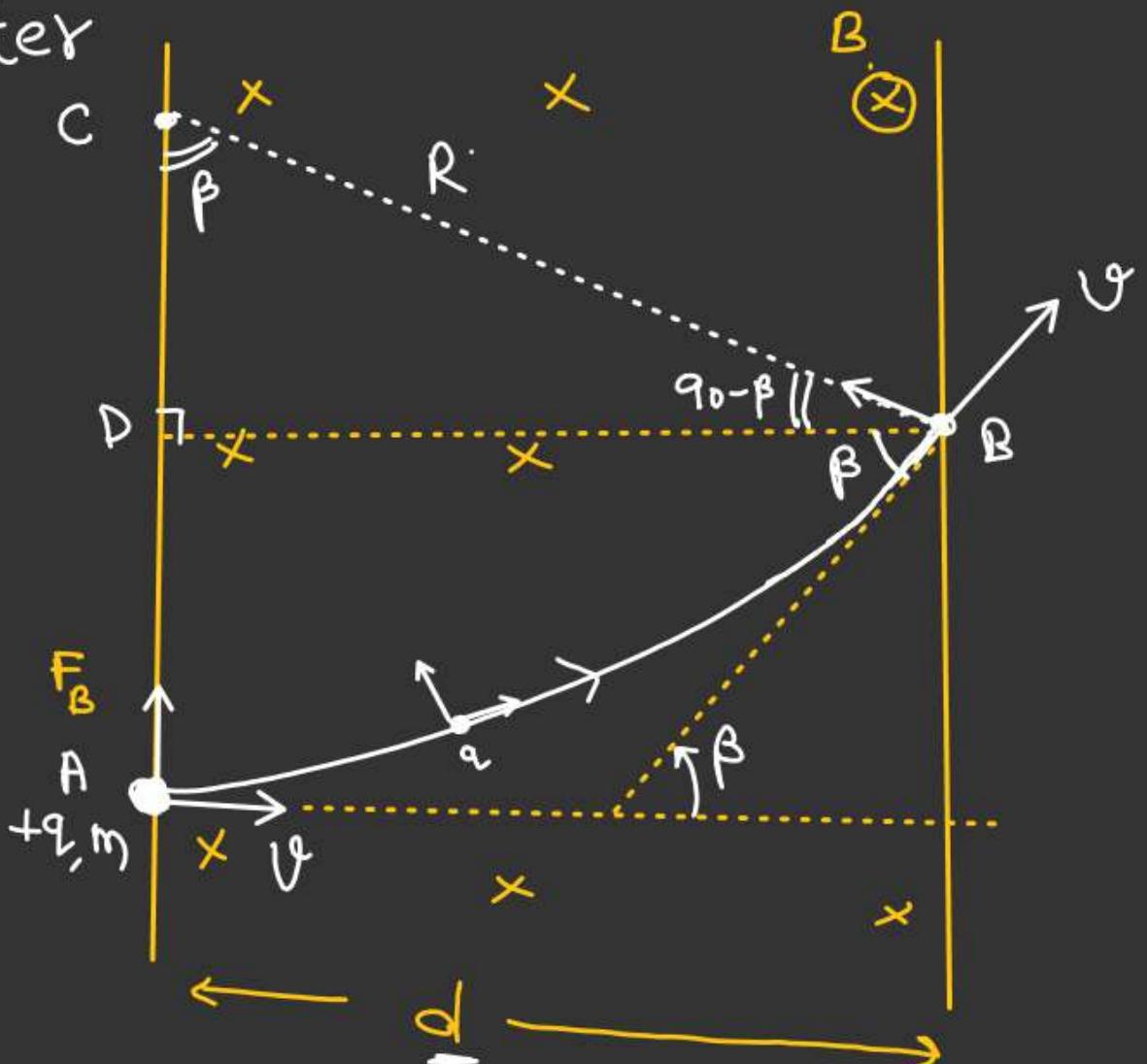
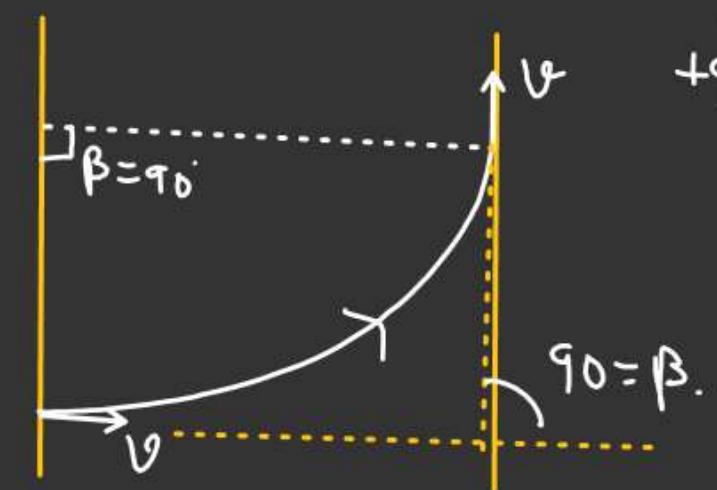
In $\triangle CBD$

$$\text{** } \sin \beta = \frac{DB}{CB} = \frac{d}{R}$$

$$\boxed{\sin \beta = \frac{d}{R}}$$

Possible only when
 $d \leq R$

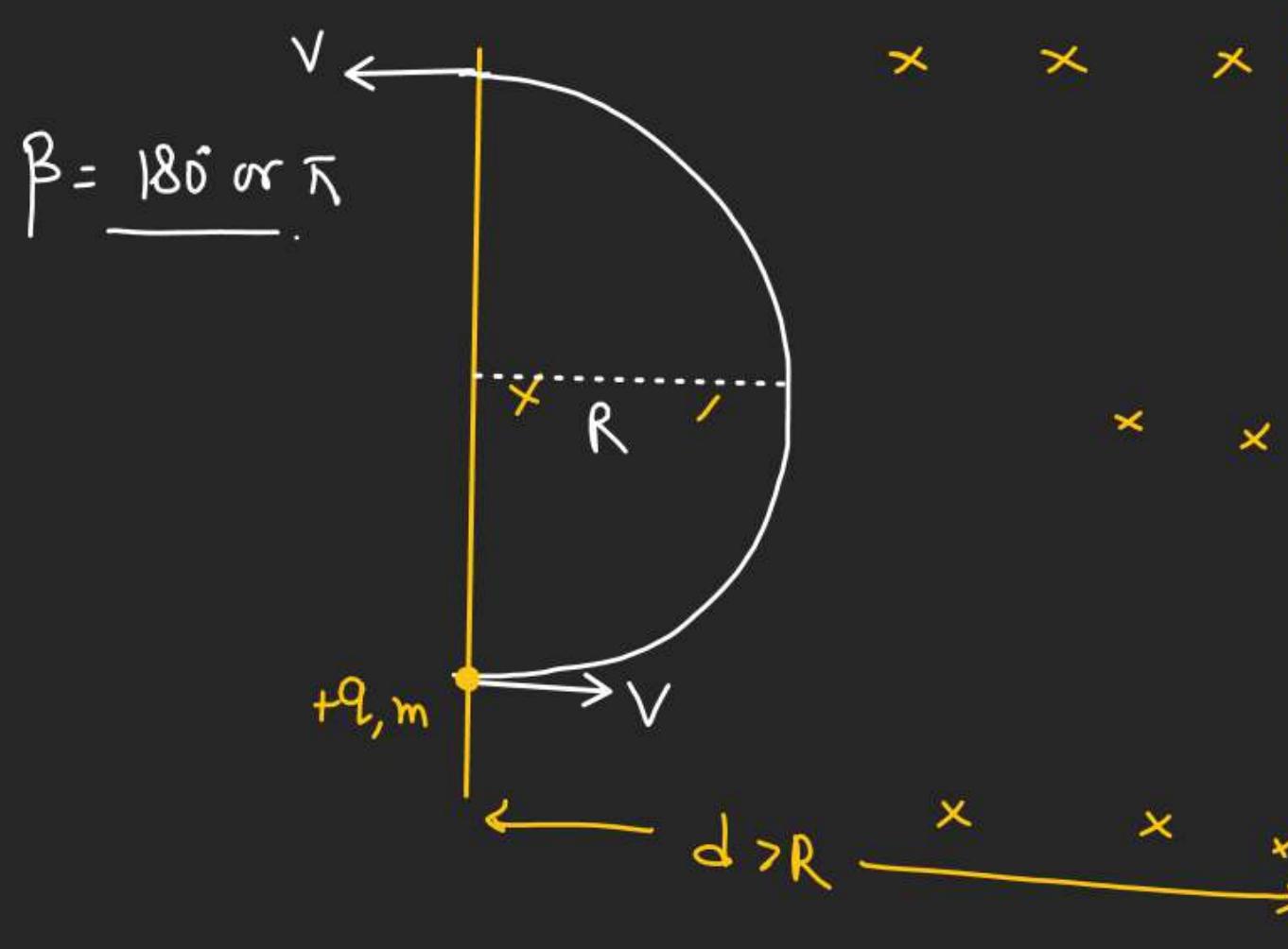
For ($d = R$)
 $\sin \beta = +1 \Rightarrow \beta = 90^\circ$



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$$(III) \quad \underline{d > R} \Rightarrow \beta = ??$$



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(*) Charge particle enter at an angle θ for

Vertical ($d > R$)

$$\text{Note: } \frac{2\theta + \pi - \beta}{\beta} = \pi$$

$$\boxed{\beta = 2\theta}$$

In this Case

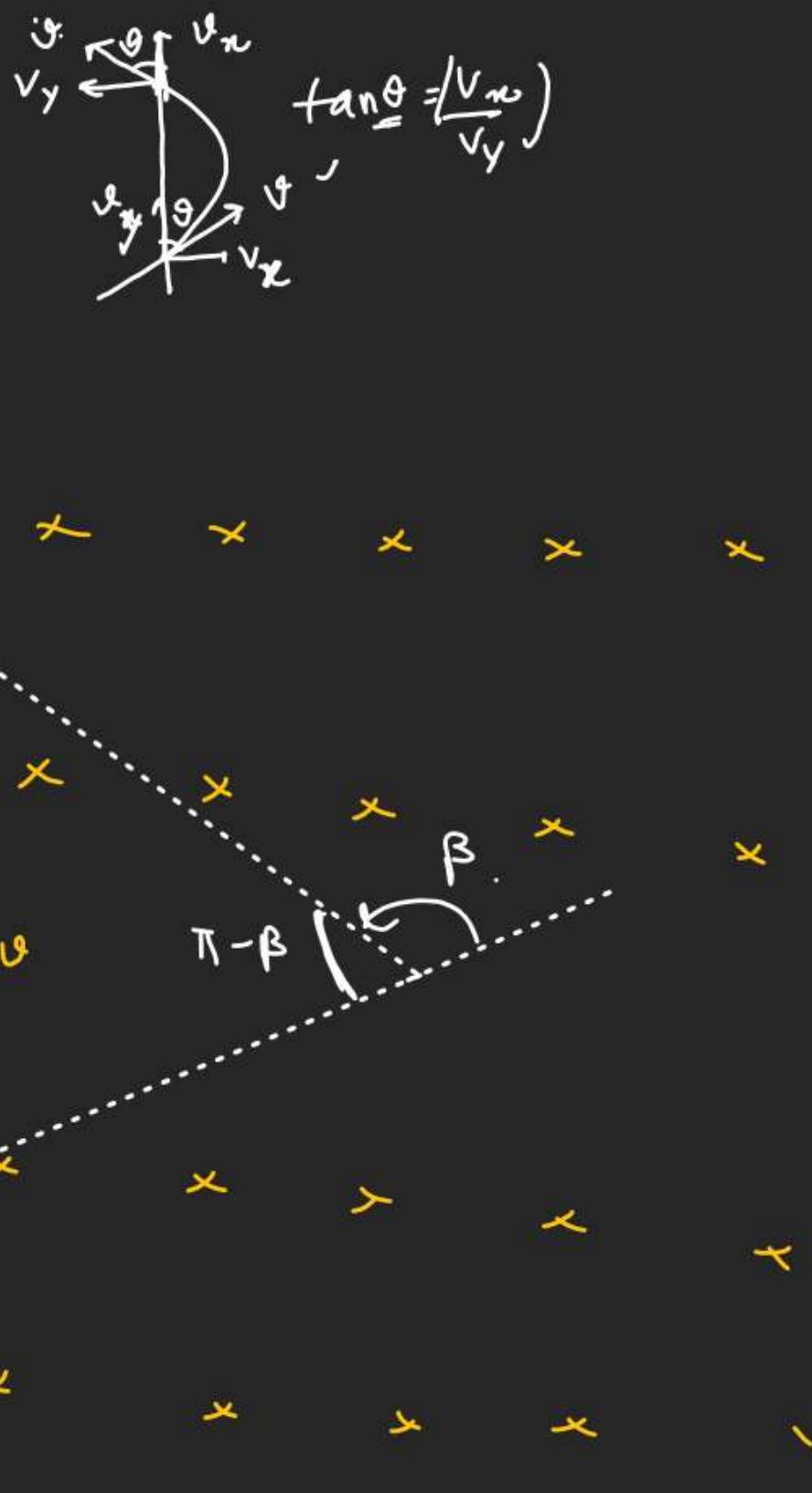
Angle of deviation is equal to twice the angle with

which charge particle enter

from vertical & 2θ is also

the angle subtended by the arc at its center.

(*) For charge minor arc & center outside the magnetic field zone.



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(*) Time Spent by the Charge particle in magnetic field.

(*) Find impulse delivered by the magnetic force on the charge particle.

$$t = \frac{\text{Arc length}(AB)}{v}$$

$$R = \left(\frac{mv}{qB} \right) \quad (T = \frac{2\pi m}{qB})$$

$$t = \frac{R(2\theta)}{v}$$

$$t = \frac{m v \cancel{x} 2\theta}{qB} \quad \cancel{v}$$

$$t = \left(\frac{2m}{qB} \right) \frac{\theta}{\cancel{v}} \quad \cancel{v}$$

$\boxed{t = \left(\frac{T}{2\pi} \right)(2\theta)}$

$$\begin{matrix} 2\pi \rightarrow T \\ 2\theta \rightarrow ?? \end{matrix}$$

$$F = \frac{dp}{dt} \Rightarrow \int (F \cdot dt) = \int \frac{dp}{dt} dt = p_f - p_i$$

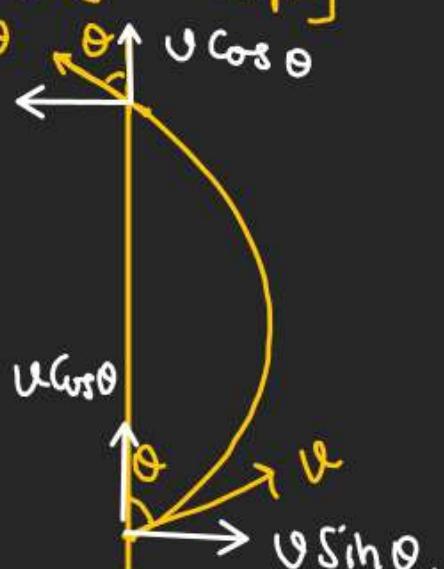
$$J = (F \Delta t)$$

$$\vec{v}_i = v \sin \theta \hat{i} + v \cos \theta \hat{j} \quad \text{Impulse} = (\Delta p)$$

$$\vec{v}_f = -v \sin \theta \hat{i} + v \cos \theta \hat{j} \quad [\vec{J} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t}]$$

$$\begin{aligned} \vec{J} = (\Delta \vec{p}) &= m(\vec{v}_f - \vec{v}_i) \\ &= -(2mv \sin \theta) \hat{j} \end{aligned}$$

$$|J| = \underline{2mv \sin \theta} \quad \checkmark$$



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\nwarrow

For -ve charge,
major arc formed and
Center of the circle lies in magnetic
field zone.

$\nwarrow \beta =$ Total angle Subtend
by the arc at the
center of the
circle.

$$\boxed{\beta = (2\pi - 2\theta)}$$

