

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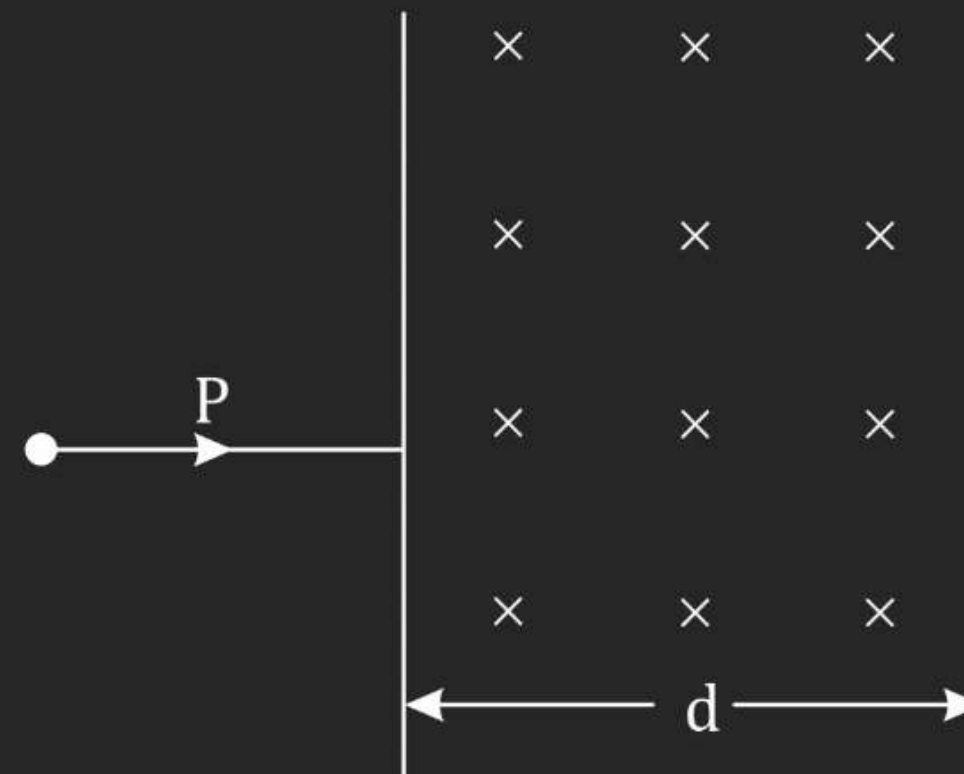
Q.6 *Q.W.* A particle with charge αe Q , moving with a momentum p , enters a uniform magnetic field normally. The magnetic field has magnitude B and is confined to a region of width d , where $d < \frac{p}{BQ}$. The particle is deflected by an angle θ in crossing the field. Then :

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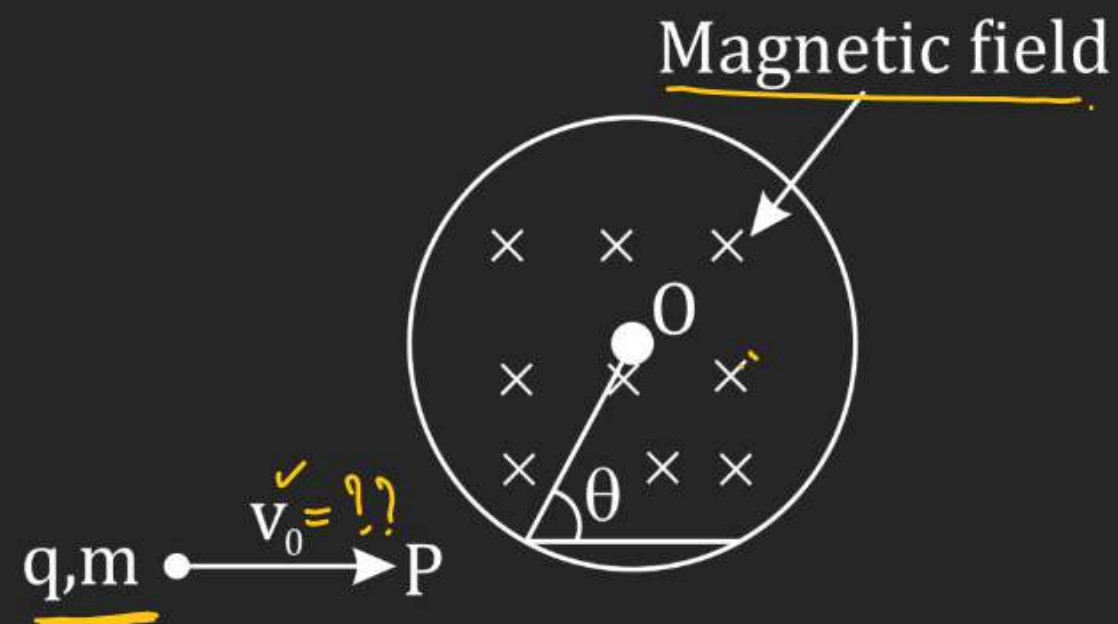
Q.7 A particle of charge q and mass m is projected with a velocity v_0 towards a circular region having uniform magnetic field B perpendicular and into the plane of paper from point P as shown in figure. R is the radius and O is the centre of the circular region. If the line OP makes an angle θ with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

(A) $\frac{qBR}{m \sin \theta}$

☒ (B) $\frac{qBR}{2m \sin \theta}$

(C) $\frac{2qBR}{m \sin \theta}$

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



Charge particle pass through c.

$$\frac{r}{H} = \left(\frac{m v_0}{q B} \right)$$

radius of the arc $\underline{AB=R}$

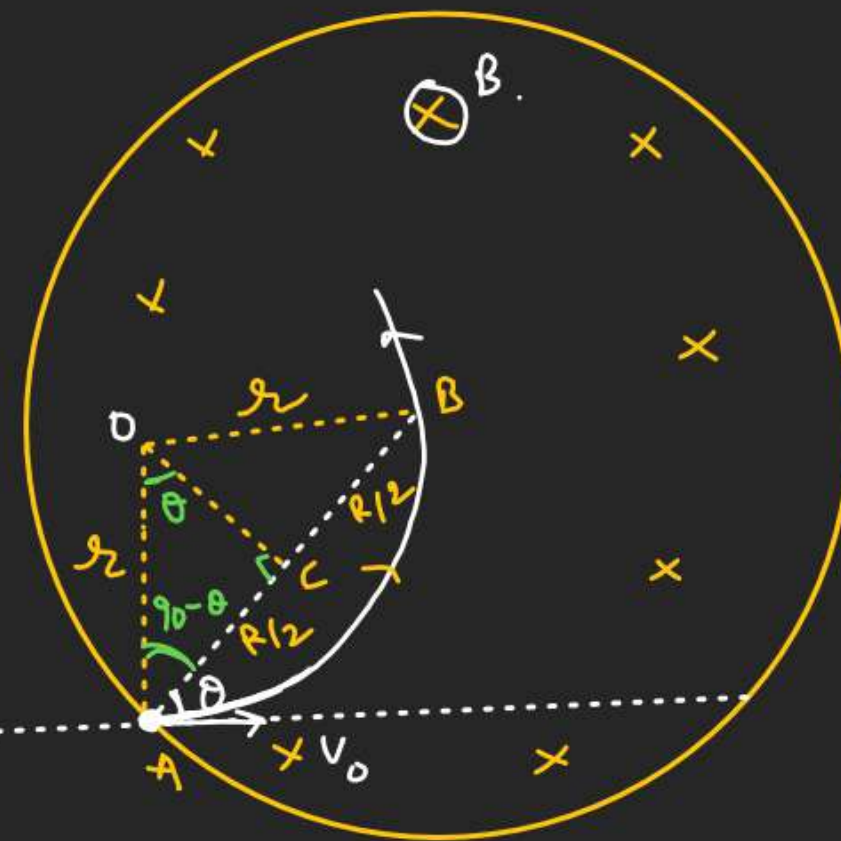
$$AC = \underline{R}$$

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

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

$$\frac{m g \sin \theta}{\mu_B} = \frac{R}{2 \sin \theta}$$

$$V_0 = \left(\frac{Rg \cos \theta}{2m \sin \theta} \right) \checkmark$$



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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) $\frac{qBd}{mV}$

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

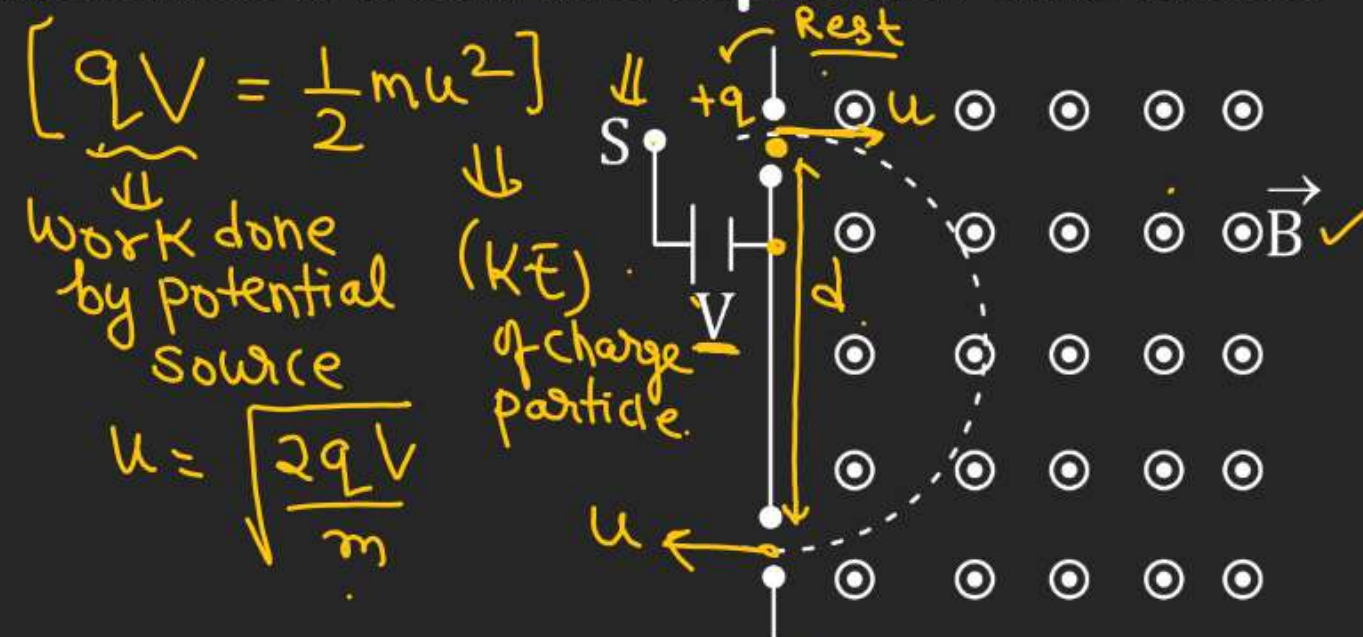
(B) $\frac{qB^2d^2}{4V}$

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

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

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

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



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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 $mv/qB = 2.00$ m, $d_1 = 0.5$ m and $d_2 = 1$ m)

$v \perp B \rightarrow$ Circular

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

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

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

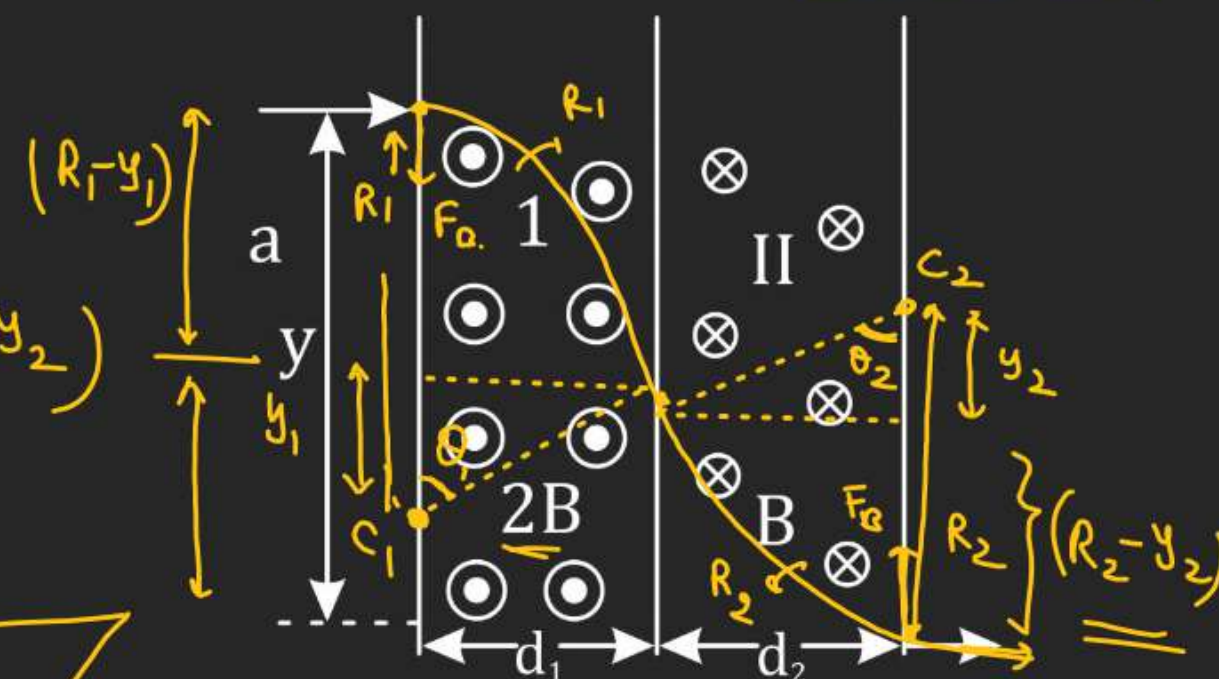
(D) $\frac{1}{2}(2 + \sqrt{3})\text{m}$

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

$y = (R_1 - y_1) + (R_2 - y_2)$
 $\sin \theta_1 = \left(\frac{d_1}{R_1}\right) \checkmark$
 $\sin \theta_2 = \left(\frac{d_2}{R_2}\right) \checkmark$

$y_1 = R_1 \cos \theta_1$

$y_2 = R_2 \cos \theta_2$



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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

H.W.

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

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 *H.W.* A particle of positive 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 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) $(x - r)^2 + (y + r/2)^2 = r^2/4$

44. Concept of angle of deviation →

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

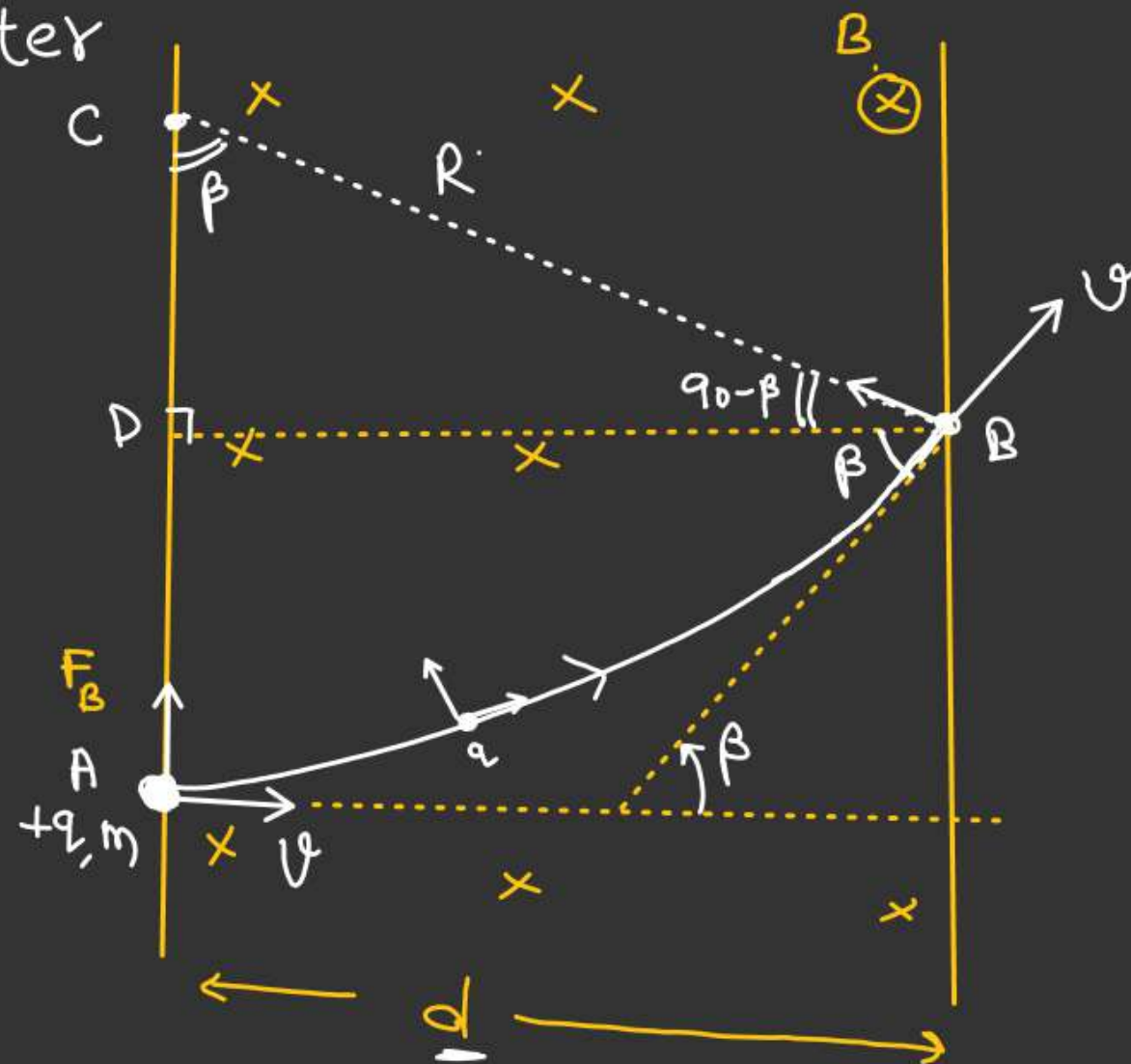
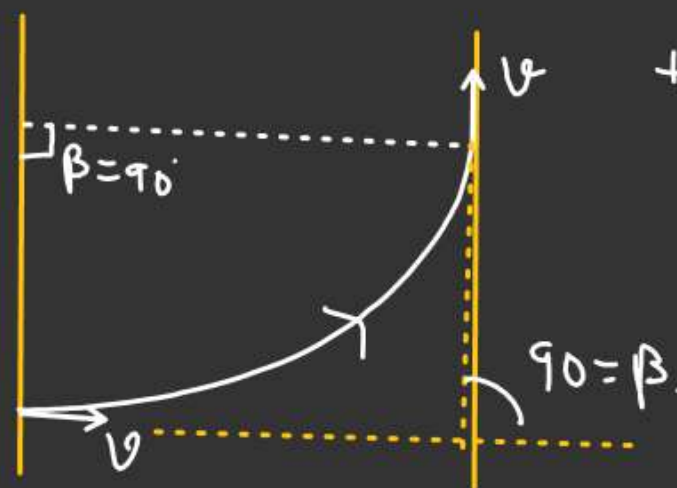
In $\triangle CBD$

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

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

Possible only when
 $d \leq R$

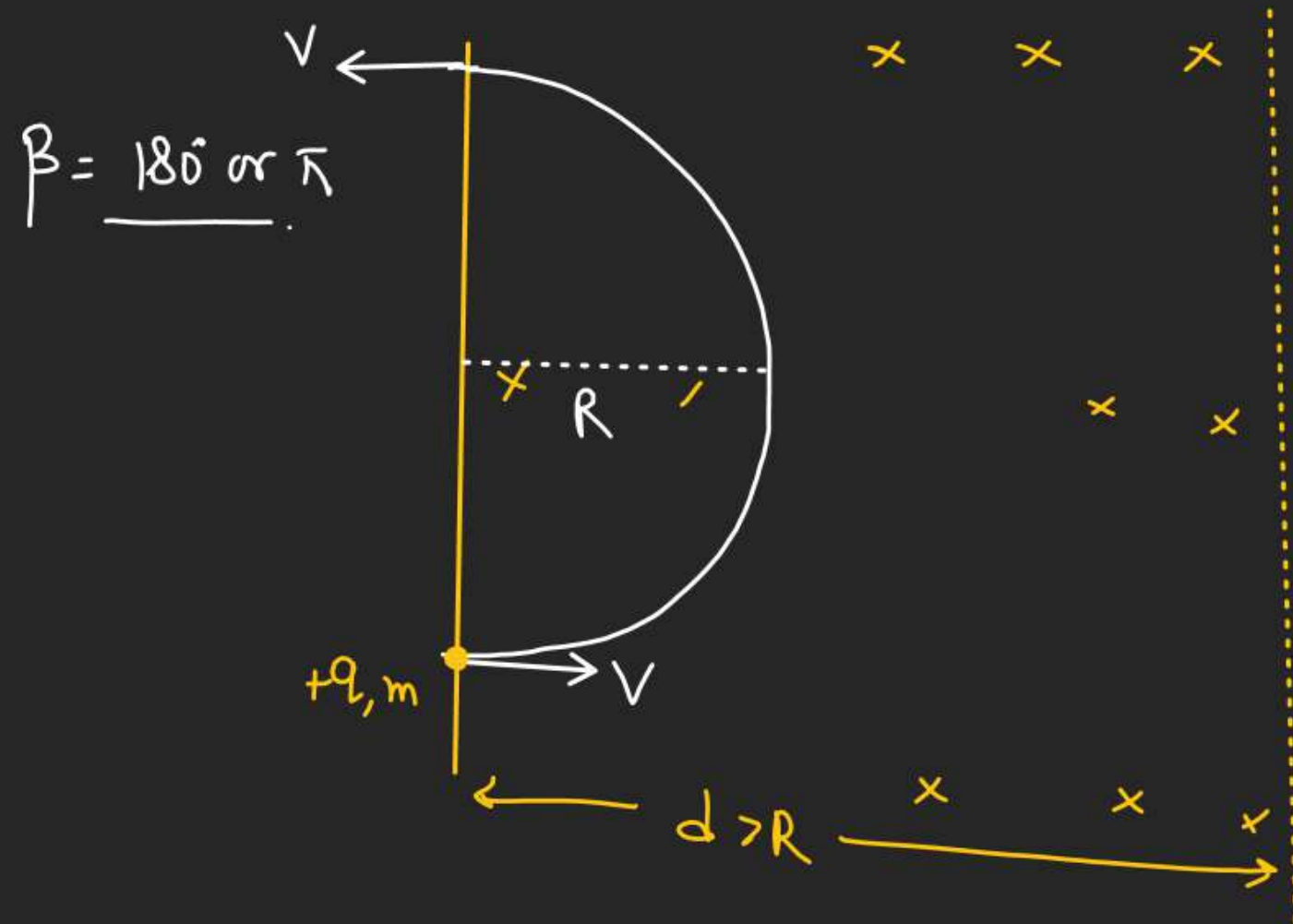
For $(d = R)$
 $\sin \beta = +1 \Rightarrow \beta = 90^\circ$



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Motion of charge particle in a magnetic field

(III) $d > R$ $\Rightarrow \beta = ??$



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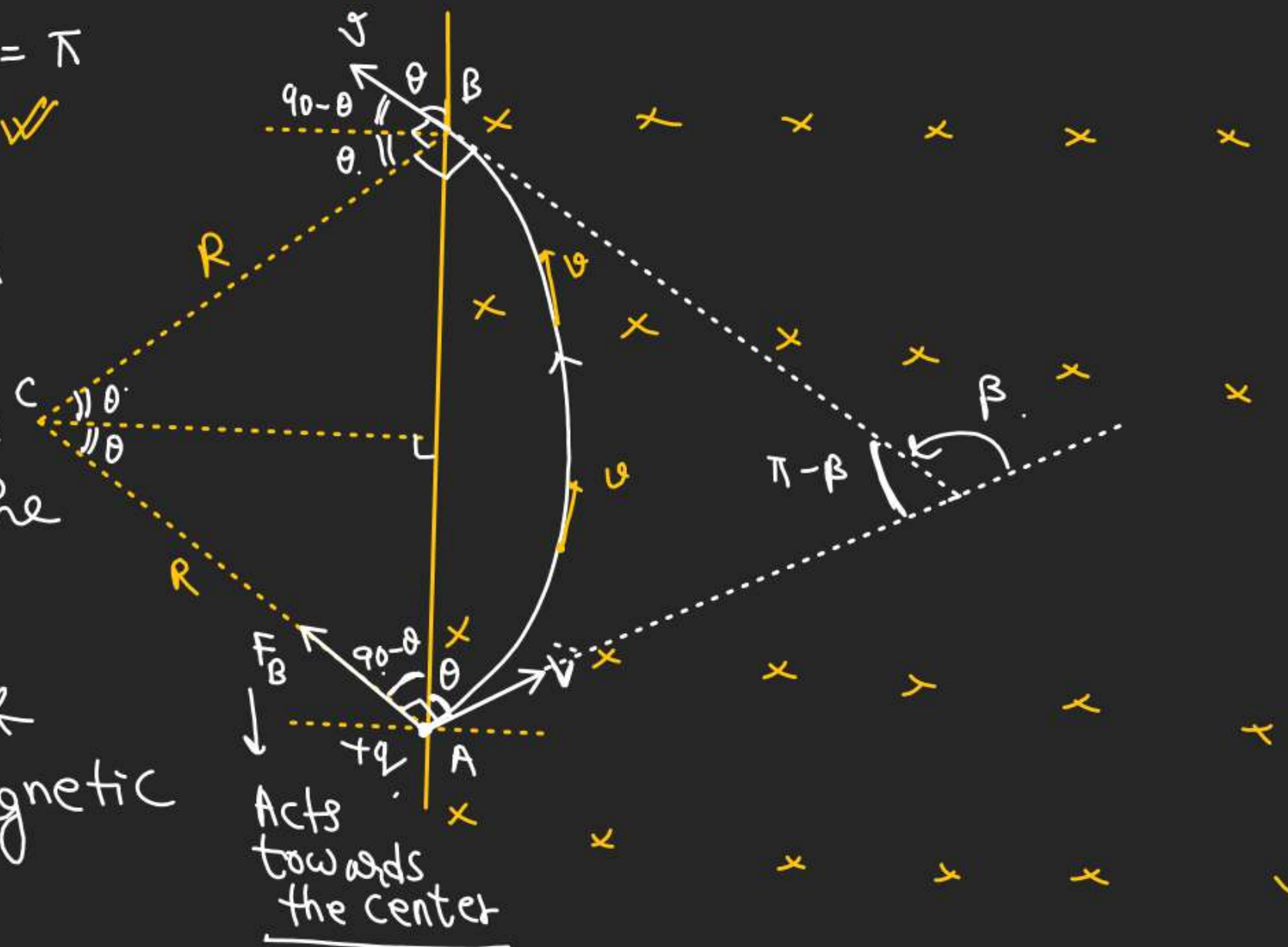
Motion of charge particle in a magnetic field

(*) Charge particle enter at an angle θ for.

Vertical. ($d > R$)

Note:- In this Case
Angle of deviation is
equal to twice the angle with
which Charge particle enter
from vertical & 2θ is also
the angle subtend 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.

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

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

$$t = \frac{mv}{qB} \times 2\theta$$

$$t = \left(\frac{2m}{qB}\right) \theta \quad \leftarrow \text{(Radian)}$$

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

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

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

$$F = \frac{dp}{dt}$$

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

$$\Rightarrow \int_0^{\Delta t} F \cdot dt = \int_{p_i}^{p_f} dp$$

$$\text{Impulse} = (\Delta p)$$

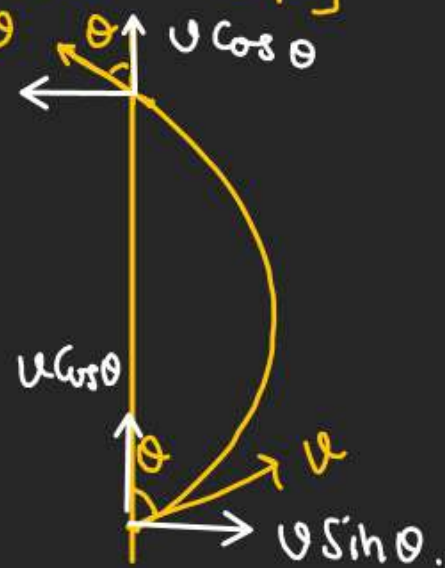
$$\vec{v}_i = v \sin \theta \hat{i} + v \cos \theta \hat{j}$$

$$\vec{v}_f = -v \sin \theta \hat{i} + v \cos \theta \hat{j}$$

$$\vec{J} = (\Delta \vec{p}) = m(\vec{v}_f - \vec{v}_i)$$

$$= -(2mv \sin \theta) \hat{i}$$

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



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Q. Q.

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

Angle of deviation
 $\beta =$ Total angle subtend
by the arc at the
center of the
Circle.

$$\beta = (2\pi - 2\theta)$$

