Nishant Jindal

MAGNETIC FIELD

Motion of charge particle in a magnetic field

#. A charge particle enter in a magnetic field perpendiculary with velocity v_0. [Magnetic field in whole x-y plane]

Find 1) Find the impulse due to magnetic force in the interval $t=0$ to $t=\left(\frac{\pi m}{2qB}\right)$.

$[\vec{J} = \Delta\vec{p}]$

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

Sol^n

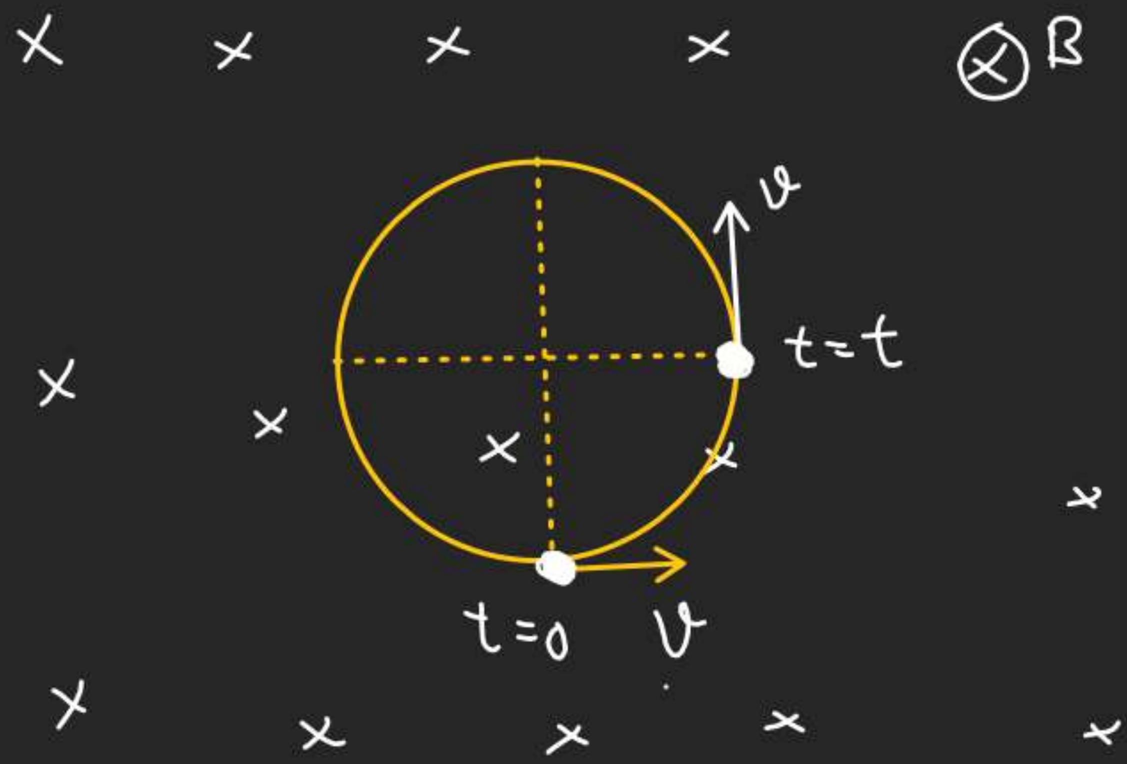
$\vec{p}_i = mv\hat{i}$

$\vec{p}_f = mv\hat{j}$

$\vec{\Delta p} = \vec{p}_f - \vec{p}_i$

$= mv\hat{j} - mv\hat{i}$

$|\vec{\Delta p}| = \sqrt{2}mv$



$T = 4\left(\frac{\pi m}{2qB}\right) \rightarrow t$

$t = \frac{T}{4}$

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(XX) A Charge particle enter in a Uniform Magnetic which is perpendicular to velocity of Charge particle and in −z direction Magnetic field is in x−y plane.
Magnetic field Changes its direction from −z axis to +z axis in every T sec. where T is time period of charge particle.
Find maximum displacement b/w any two position of charge particle during its motion.

Sol^n

PQ ⇒ Maximum displacement

$= 4R$

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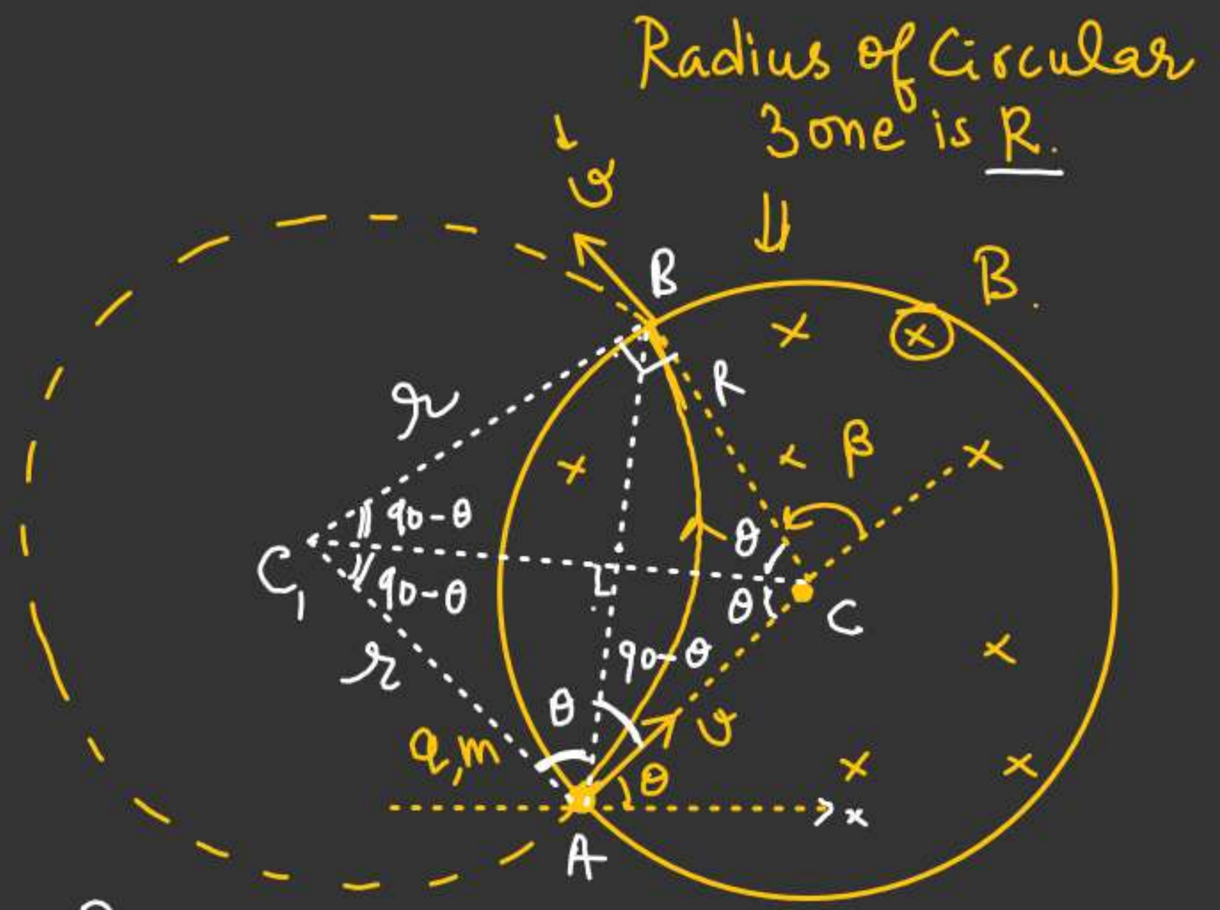
Angle of deviation of a Charge Particle in a magnetic field present in Circular zone.



In ΔBC_1C

$$\tan\theta = \frac{C_1B}{CB} = \left(\frac{r}{R}\right)$$

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

$$\tan\theta = \left(\frac{mv}{qBR}\right)$$

$$\theta = \tan^{-1}\left(\frac{mv}{qBR}\right)$$

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

$$\beta = \left[\pi - 2\tan^{-1}\left(\frac{mv}{qBR}\right)\right]$$

$$\tan^{-1}x + \cot^{-1}x = \pi/2$$

$\Downarrow$

$$\beta = \left[\pi - 2\left[\frac{\pi}{2} - \cot^{-1}\left(\frac{mv}{qBR}\right)\right]\right] = 2\cot^{-1}\left(\frac{mv}{qBR}\right)$$

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Case :- When $\vec{v}$ & $\vec{B}$ at an angle θ

$$\vec{v} = v\cos\theta\,\hat{i} + (v\sin\theta)\,\hat{j}$$

$$\vec{B} = B\,\hat{i}$$

[$v_{\parallel} \Rightarrow$ Parallel to B
$v_{\perp} \Rightarrow$ Perpendicular to B]

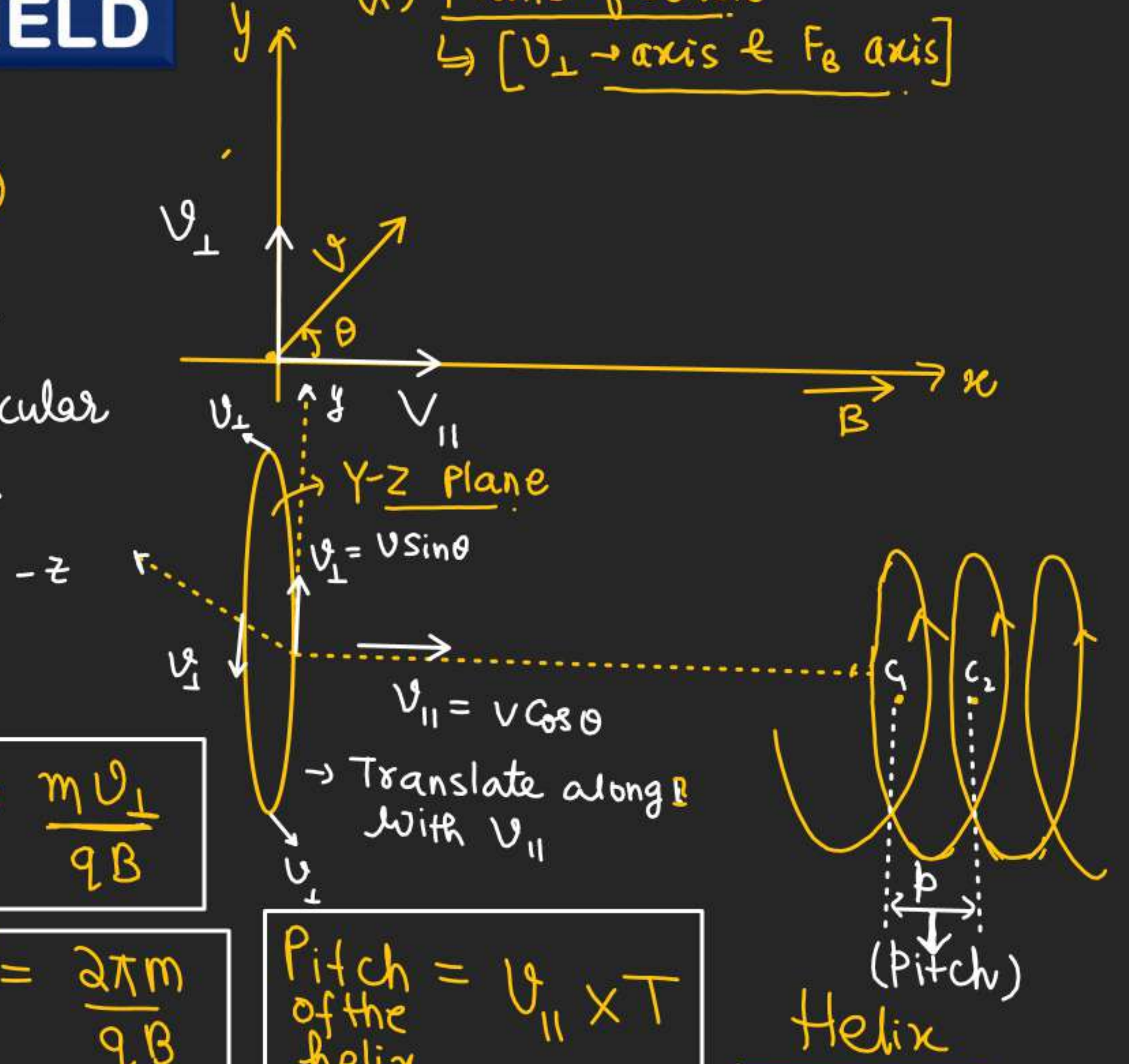
$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$= q\{[v\cos\theta\,\hat{i} + v\sin\theta\,\hat{j}] \times B\,\hat{i}\}$$

$$\vec{F} = [qBv\sin\theta](-\hat{k})$$

↳ This magnetic force acts as centripetal so center of circle along $-z-$ axis

(*) Plane of Circle
↳ [$v_{\perp}$ → axis & F_B axis]



$$\boxed{R = \frac{mv_{\perp}}{qB}}$$

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

$$\boxed{\text{Pitch of the helix} = v_{\parallel} \times T}$$

$$p = \left(v\cos\theta \times \frac{2\pi m}{qB}\right) \checkmark \qquad \boxed{R = \frac{mv\sin\theta}{qB}} \checkmark$$

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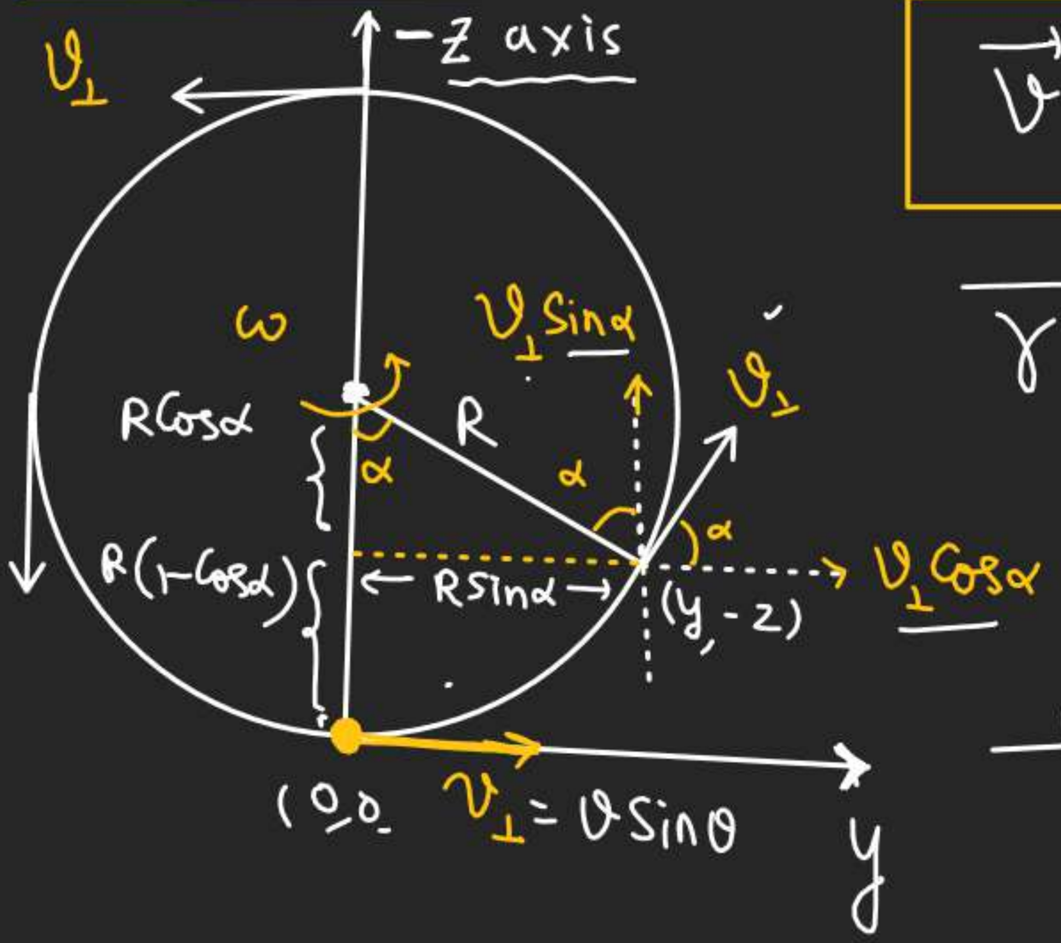
General position vector and general velocity vector in helical Motion

$\omega = \left(\frac{qB}{m}\right)$

$\alpha = \omega t$

$\alpha = \left(\frac{qB}{m}t\right)$



$\vec{V} = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}$

$$\boxed{\vec{v} = [v\cos\theta]\hat{i} + (v\sin\theta)\cos\left(\frac{qB}{m}t\right)\hat{j} - (v\sin\theta)\sin\left(\frac{qB}{m}t\right)\hat{k}}$$

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$= (v\cos\theta)t\,\hat{i} + \left(\frac{mv\sin\theta}{qB}\right)\sin\left(\frac{qB}{m}t\right)\hat{j}$

$\left(\frac{mv\sin\theta}{qB}\right)\left(1 - \cos\left(\frac{qB}{m}\right)t\right)\hat{k}$