JEE MAIN

MOVING CHARGES FORMULAE

Now that's how you REVISE

- Mohit Goenka, IIT Kharagpur

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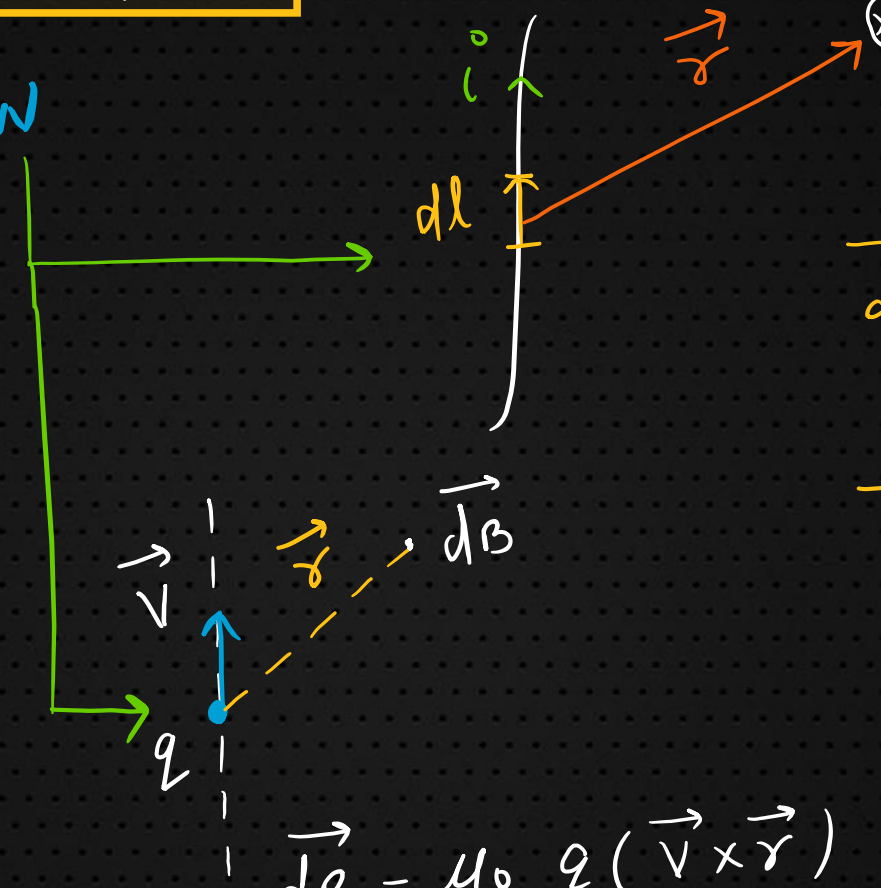
EDUNITI

Eduniti for Physics

MAGNETIC EFFECT OF CURRENT

1. BIOT SAVART'S LAW



$$\otimes \quad \vec{dB} = \frac{\mu_0}{4\pi} \frac{i(\vec{dl} \times \vec{r})}{r^3}$$

→ direction of $\vec{dB}$ is decided by dirn of $\vec{dl} \times \vec{r}$.

→ μ_0 : Permeability of free space

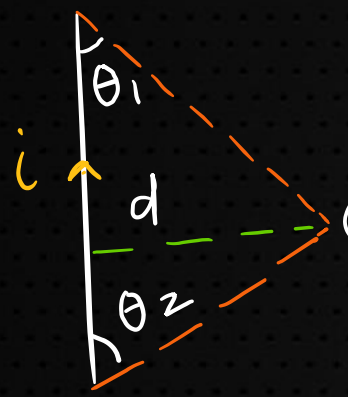
$4\pi \times 10^{-7}$ Tm/A

→ $\vec{dl}$ is along current

$$\vec{dB} = \frac{\mu_0}{4\pi} \frac{q(\vec{v} \times \vec{r})}{r^3}$$

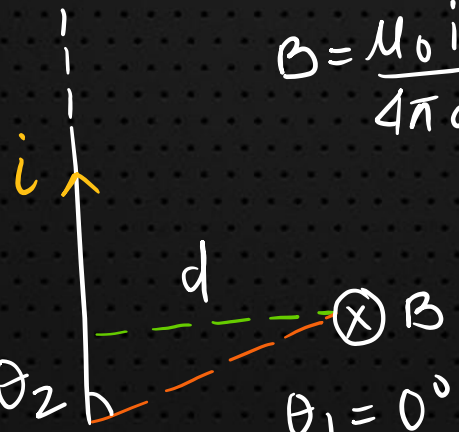
2. B DUE TO CURRENT CARYING STRAIGHT WIRE

FINITE WIRE



$$B = \frac{\mu i}{4\pi d}(\cos\theta_1 + \cos\theta_2)$$

SEMI-INFINITE WIRE



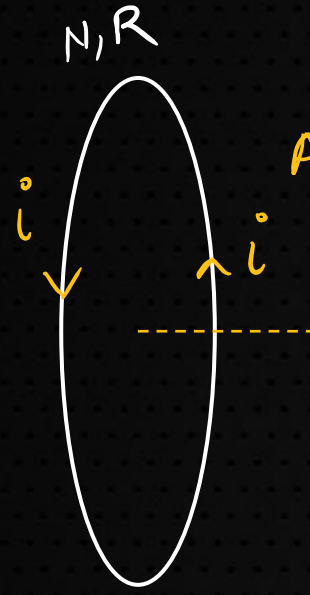
$$B = \frac{\mu_0 i}{4\pi d}(1 + \cos\theta_2)$$

INFINITE WIRE

$$\theta_1 = \theta_2 = 0°$$

$$B = \frac{\mu_0 i}{2\pi d}$$

3. B DUE TO CURRENT CARRYING CIRCULAR WIRE

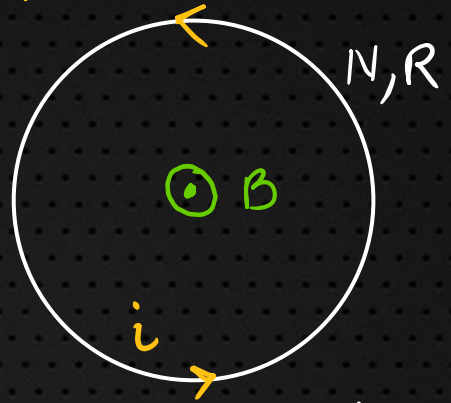


ALONG AXIS

$$B = \frac{\mu_0 i R^2 N}{2(R^2+x^2)^{3/2}}$$

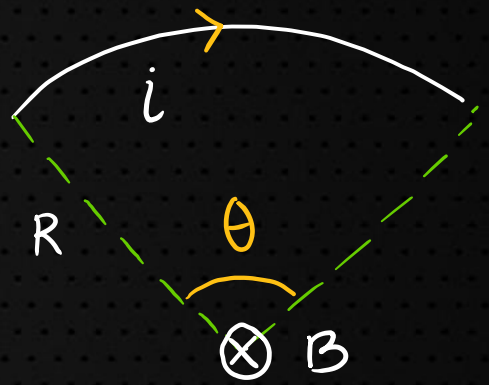
N: No of turns

AT CENTER



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

AT CENTER DUE TO ARC



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

4. B DUE TO SOLENOID AND TOROID

SOLENOID

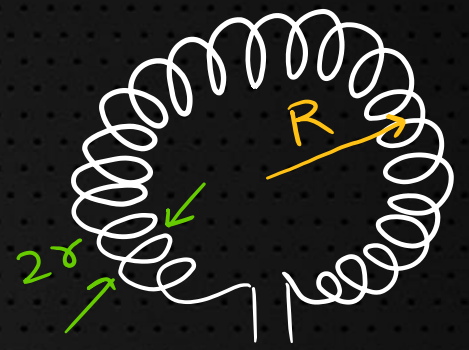
$B = \mu_0 n i$

n: no of turns / Length (N/ℓ)

Valid for ideal solenoid

$(\ell >> r)$

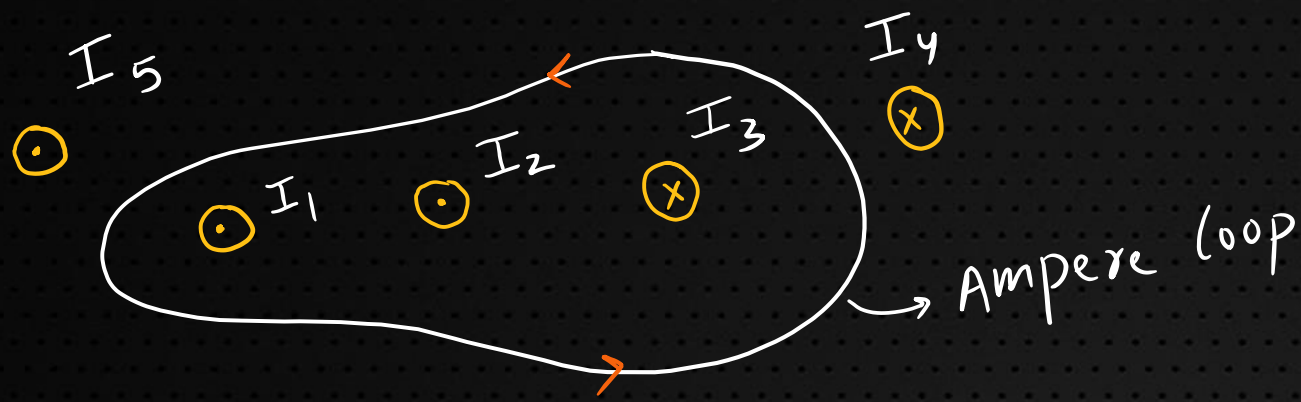
TOROID



$B = \mu_0 \frac{N}{2\pi R} i \quad (R >> r)$

N: No of turns

5. AMPERE CIRCUITAL LAW



NOTE: Outward I is +VE.

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (I_1 + I_2 - I_3)$$

NOTE: (i) only I enclosed by Ampere Loop considered

(ii) B is due to all current

FORCE ON q MOVING IN B, $\vec{F}_m = q(\vec{v} \times \vec{B})$

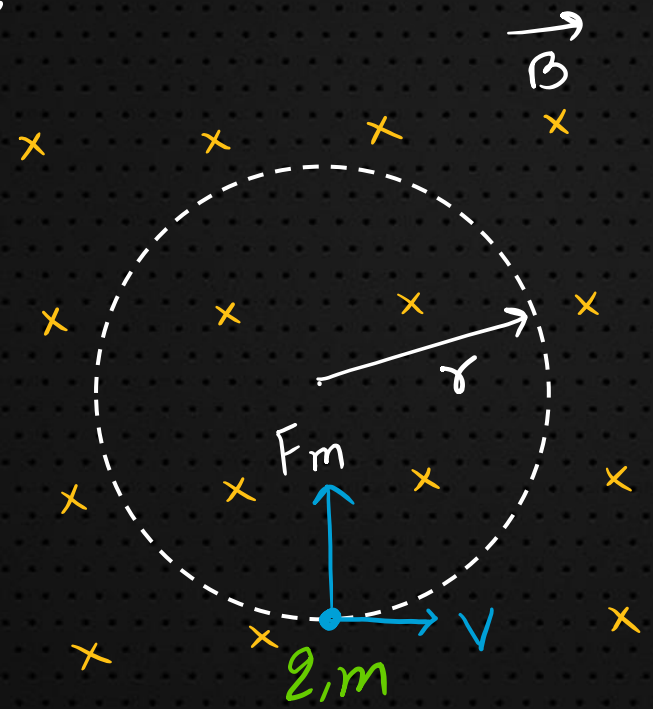
$\vec{F}_m$ is always perpendicular to $\vec{v}$

⇒ Thus no work done.

⇒ no change in speed or K.E.

NOTE $K = q\Delta V$

6. If V is ⊥ to B



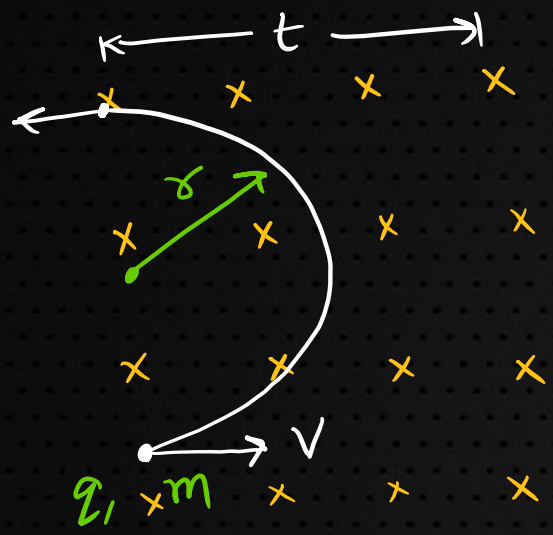
(i) $r = \frac{mv}{qB}$ or $\sqrt{\frac{2mK}{qB}}$

(ii) $T = \frac{2\pi m}{qB}$, time period

(iii) $\omega = \frac{qB}{m}$

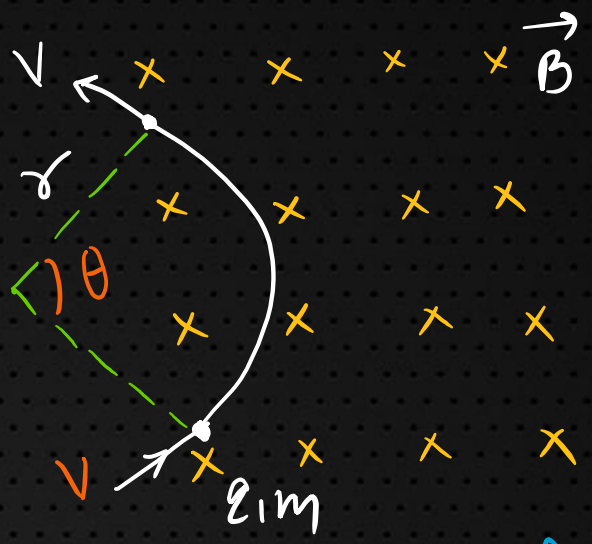
7. IF NOT COMPLETE CIRCLE

(i)



$r < t$, $T = \frac{\pi m}{qB}$

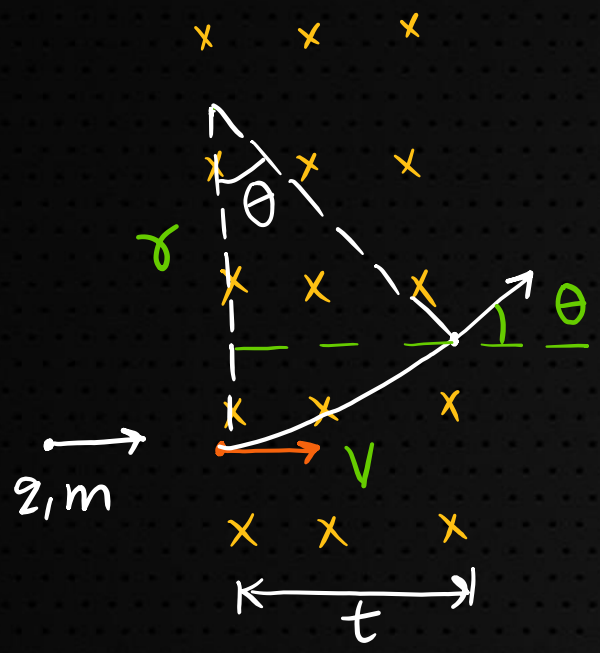
(ii)



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

↳ Duration of time inside B

8. ANGLE OF DEVIATION



$r > t$

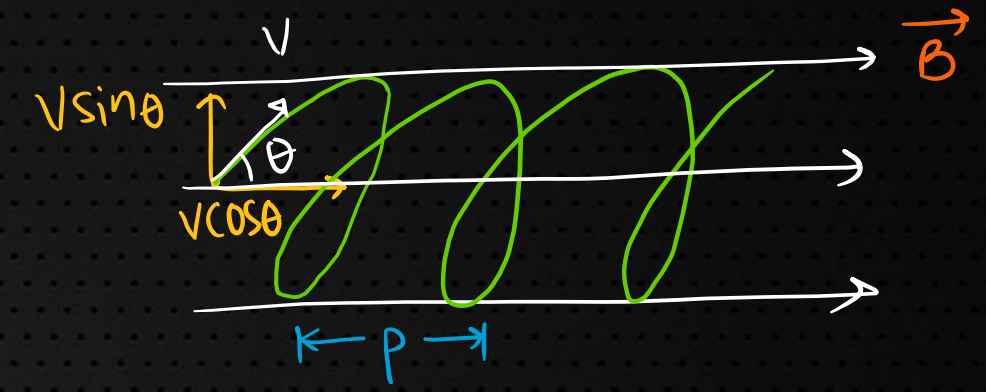
$\sin\theta = t/r$

$= \frac{tqB}{mv}$

$\therefore \boxed{\theta = \sin^{-1}\left(\frac{qBt}{mv}\right)}$

9. V AT ANGLE θ to B

(Helical path)



(i) $r = \frac{mv\sin\theta}{qB}$

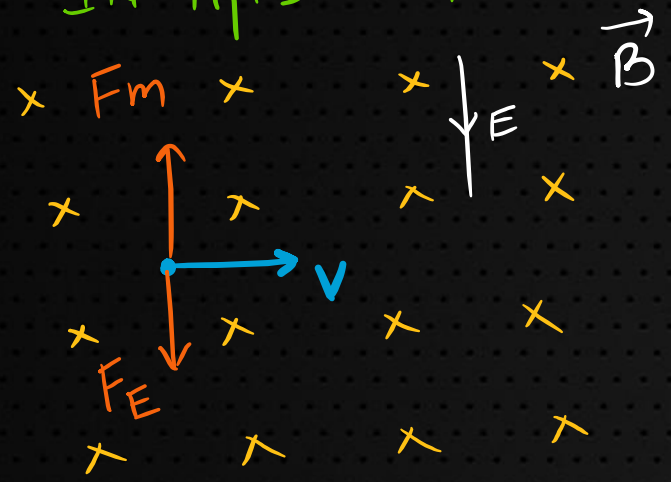
(ii) $T = 2\pi m/qB$

(iii) Pitch, $P = V\cos\theta \times T$

10. SPECIAL CASE

$E \perp B \perp V$

IN this situation possibility of a moving undeviated.



COND^{n}:

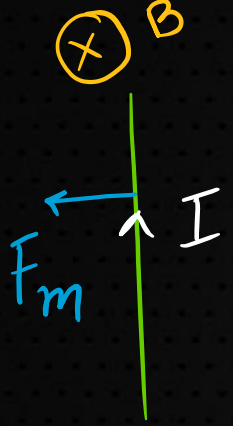
$F_E = F_M$

$\Rightarrow qE = qVB$

$\Rightarrow \boxed{V = \frac{E}{B}}$

11. FORCE ON I CARYING CONDUCTOR IN B (UNIFORM FIELD)

$\vec{F} = I(\vec{\ell} \times \vec{B})$



STRAIGTH WIRE

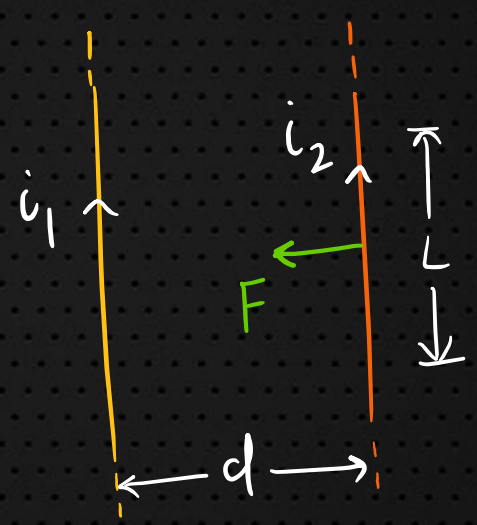
$F_m = IlB$

closed LOOP

$F_{Net} = 0$

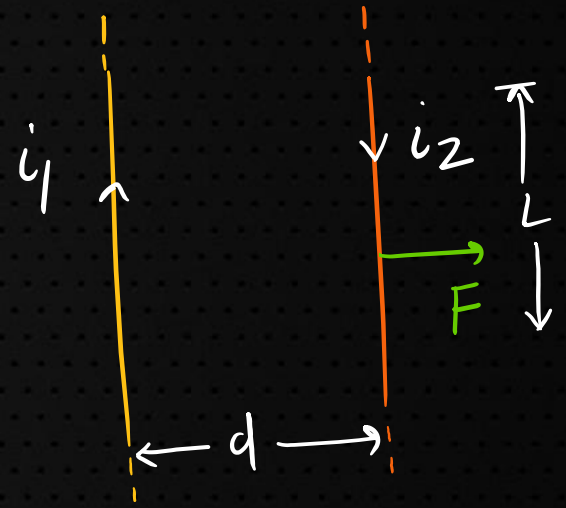
Parallel wire

Parallel i



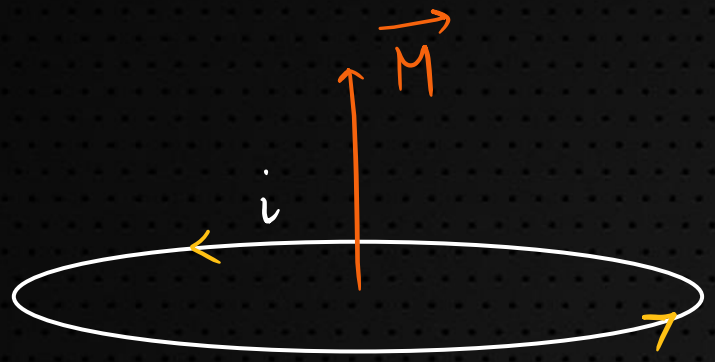
$F = \frac{\mu_0 i_1 i_2 L}{2\pi d}$

ANTI-PARALLEL i



$F = \frac{\mu_0 i_1 i_2 L}{2\pi d}$

12. MAGNETIC MOMENT



$\vec{M} = N i \vec{A}$

NOTE:

(i) N : No of turns

(ii) A = Loop area

(iii) Dirn of M using right hand thumb rule.

13. TORQUE ON LOOP in B

$\vec{\tau} = \vec{M} \times \vec{B}$

14. POTENTIAL ENERGY OF LOOP in B

$U = -\vec{M} \cdot \vec{B}$

STABLE → $\theta = 0^\circ \Rightarrow U_{min} = -MB$

UNSTABLE → $\theta = 180^\circ \Rightarrow U_{max} = MB$

15. FORCE ON LOOP IN B (NON-UNIFORM B)

$F = M \frac{dB}{dx}$ [USE IF VARIATION OF B IS SMALL]

M : Magnetic moment of loop