# LECTURE NOTES

# PHYSICS

## MEGNETISM,

## E.M.I.

## ALTERNATE CURRENT,

## E.M.W.

BY

# D.J. SIR

Book – 2

# "MAGNETISM"

⊛ ⇒ Various source of Mgnetic Field :-

① Bar Magnet.
② Earth Mgnet.

} CONSERVATIVE.

③ Moving current.
④ current carrying system.
⑤ Variable Electric Field. (E).

} NON-CONSERVATIVE.

✡ ⇒ Magnetic Field / Mag. Flux Density / Mg. Induction: *(B)

(i) "vector" Quantity.

(ii) Unit → M.K.S :- Tesla (T), $\frac{Wb}{m^2}$, $\frac{N}{A \times m}$

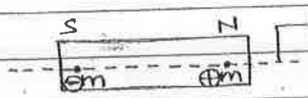
→ C.G.S :- Gauss (G), $\frac{Maxwell}{cm^2}$, $\frac{Dyne}{AbA \times cm}$

$\boxed{1T = 10^4 G}$

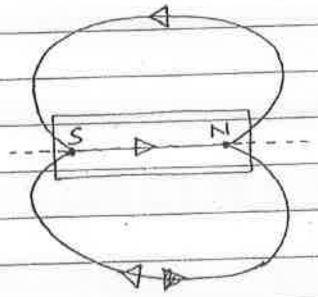
(iii) It Represents strength of Magnetic Field at Given Point.

(A) BAR - MAGNET :-

⊛ **$Fe_2O_3$ Material




⊛




$B_{outside}$ = "N" to "S"

$B_{inside}$ = "S" to "N"

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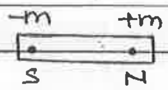
② Magnetic Moment of Magnetic Dipole (M) :-




⊛ $M = m\, l_{eff}$

$\vec{M} = m\, \vec{l}_{eff}$

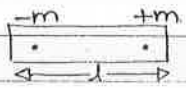
→ *** $l_{effective}$ = Minim Distance b/wn Magnetic Poles.
(−m to +m) "or"
(S to N)

→ Vector Quantity.

→ Unit → $A \times m^2$

Special unit = 1 Bohr Magneton ($\mu_B$) = ** $0.923 \times 10^{-23}$ $A \times m^2$

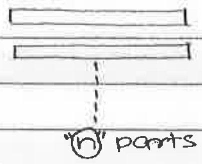
*** Ques> Magnetic moment of a magnet is "M" :-




$M = m\, l.$

ⓘ If it is cut into "n" equal parts along magnetic axis.

Soln :-




∴ For each small magnet :-

$m' = \frac{m}{n}$

$l' = l.$

$M' = m'l' = \left(\frac{m}{n}\right) l.$

$\boxed{M' = \frac{M}{n}}$

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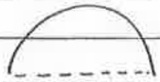
(iv)



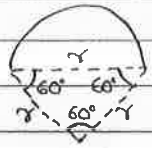
$l = \pi r \Rightarrow r = \frac{l}{\pi}$

$M' = (m)(2r)$

$= m\left(2 \times \frac{l}{\pi}\right)$

$\boxed{M' = \frac{2M}{\pi}}$

NEET 2013 # (v) #




$\text{Angle} = \frac{\text{Arc}}{\text{Radius}}$

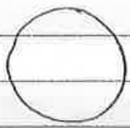
$\frac{\pi}{3} = \frac{l}{r} \Rightarrow r = \frac{3l}{\pi}$

$M' = (m)(r)$

$= m\left(\frac{3l}{\pi}\right)$

$\boxed{M' = \frac{3M}{\pi}}$

*(vi)



$m' = m$

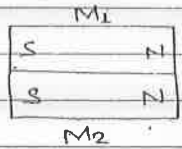
*$l_{effective} = 0$

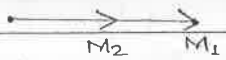
$\boxed{M' = 0}$

(vii) $M_{toroid} = 0$

(1) COMBINATION OF MAGNET :-

(i)




$M_{net} = M_1 + M_2$

∴ *sum Positn

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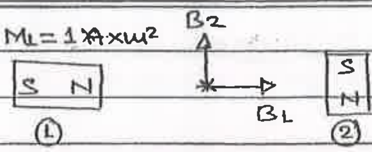
Ques> $M_1 = 1\,A\times m^2$ $\quad$ $M_2 = 1\,A\times m^2$



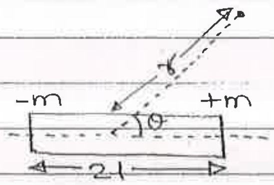

$B_{net} = ?$

Sol$^n$ :- $B_1 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{2M}{r^3} = \dfrac{4\pi \times 10^{-7}}{4\pi} \times \dfrac{2\times 1}{1^3} = 2\times 10^{-7}\,T$

$B_2 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{M}{r^3} = \dfrac{4\pi \times 10^{-7}}{4\pi} \times \dfrac{1}{1^3} = 1\times 10^{-7}\,T$

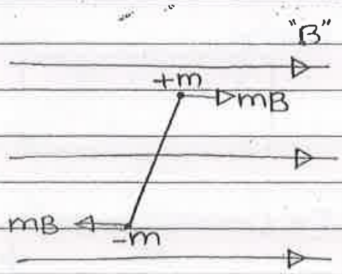
$\therefore B = \sqrt{B_1^2 + B_2^2} = \sqrt{5} \times 10^{-7}\,T$

③ MAGNETIC POTENTIAL DUE TO DIPOLE :-




$$\boxed{V_m = \frac{\mu_0}{4\pi} \frac{M\cos\theta}{r^2}}$$

④ Behaviour in External Uniform Magnetic Field :-




(i) $F_{net} = 0$

(ii) $\tau = MB\sin\theta$

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

(iii) $U = -MB\cos\theta$

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

(iv) $W = MB(\cos\theta_1 - \cos\theta_2)$

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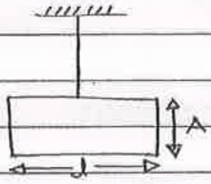
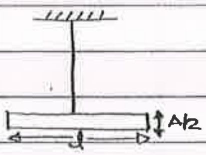
**Ques>** A magnet is vibrated in a Magnetic Field, Time Period is T, If its Half Part is vibrated in same Field than Time Period = ?

Soln :-



$$T = 2\pi\sqrt{\frac{I}{MB}}$$

(i) cut along Magn. Axis :

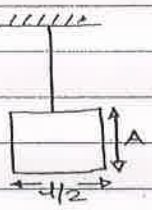


$$T' = 2\pi\sqrt{\frac{I'}{M'B'}}$$

$$= 2\pi\sqrt{\frac{I/2}{(M/2)(B)}}$$

$$T' = T$$

AIEEE (ii) cut ⊥ to Magnet Axis :-



$$T' = 2\pi\sqrt{\frac{I'}{M'B'}}$$

$$= 2\pi\sqrt{\frac{I/8}{(M/2)(B)}}$$

$$T' = \frac{T}{2}$$

**Force b/wn Dipoles :-**

(i) S N ←— r —→ S N

$$F = \frac{\mu_0}{4\pi} \cdot \frac{6M_1M_2}{r^4} \qquad \therefore F \propto \frac{1}{r^4}$$

(Attractn)

# "MAGNETIC EFFECT OF CURRENT"

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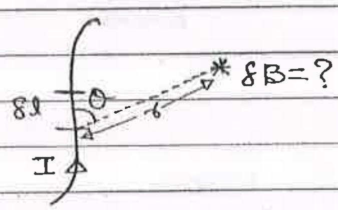
→ Oested Experiment proved that Magnetic Field is Produced Around current carrying wire.

## ⇒ BIOT SIVORT LAW (B.S.L) :-

It is used to calculate Magnetic Field due to current carrieng small element.




$\delta B \propto I$

$\propto \delta l$

$\propto \sin\theta$

$\propto \dfrac{1}{r^2}$

$$\therefore \delta B \propto \frac{I\,\delta l \sin\theta}{r^2}$$

$$\boxed{\delta B = \frac{\mu_0}{4\pi} \cdot \frac{I\,\delta l \sin\theta}{r^2}}$$

⇒ vector Form :-

$$\vec{\delta B} = \frac{\mu_0}{4\pi}\, \frac{I\,\vec{\delta l} \times \hat{r}}{r^2}$$

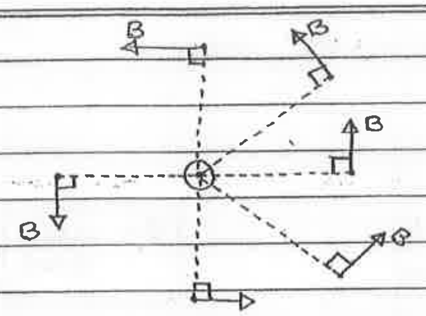
$$\vec{\delta B} = \frac{\mu_0}{4\pi}\, \frac{I\,\vec{\delta l} \times \vec{r}}{r^3}$$

$I\vec{dl}$ ⇒ current element vector. (Directn along the current)

$\vec{r}$ ⇒ Position vector of observation Point.

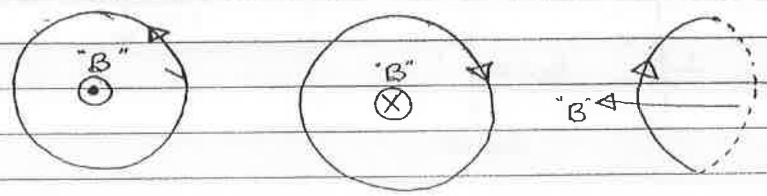
$\theta$ ⇒ Angle B/wn these two vectors.

EX :-



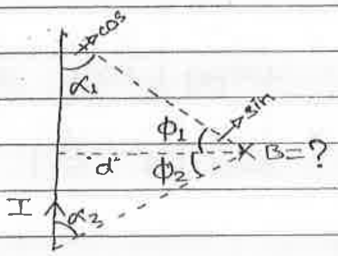

② FOR CLOSED CURRENT :-

If Right Hand Fingers are along close current than Thumbs indicates, Direction of "B" at centre.




✡ ⇒ MAGNETIC FIELD DUE TO FOLLOWING :-

Ⓐ STRAIGHT CURRENT CARRIENG WIRE :-




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

$$\boxed{B = \frac{\mu_0 I}{4\pi d}(\cos\alpha_1 + \cos\alpha_2)}$$

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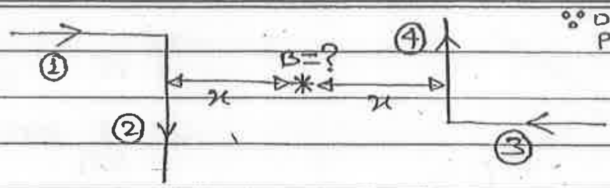
Ques>




∵ Diagram is wrong.
Push ③ upto ① level.

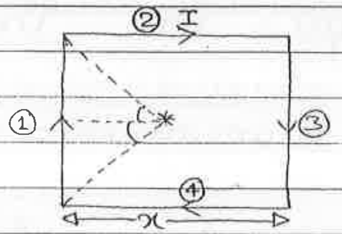
soln :- $B_1 = B_3 = 0$ ∵ Along the wire $(\theta = 0°)$

$$\vec{B_4} = \frac{\mu_0 I}{4\pi(x)} \odot$$

$$\vec{B_2} = \frac{\mu_0 I}{4\pi(x)} \odot$$

$$\vec{B} = \frac{\mu_0 I}{2\pi x} \odot$$

Ques>




∵ $B_{centre} = ?$

soln :- $B_1 = \frac{\mu_0 I}{4\pi(x/2)} (\sin 45 + \sin 45)$

$$\vec{B_1} = \frac{\mu_0 I}{\sqrt{2}\pi x} \otimes = \vec{B_2} = \vec{B_3} = \vec{B_4}$$

$$\vec{B}_{total} = 2\sqrt{2}\left(\frac{\mu_0 I}{\pi x}\right) \otimes.$$

** Ques> A "Regular Polygon" Made up of Fixed Length of wire "l", "n"-sides, "I"- current than; $B_{centre} = ?$

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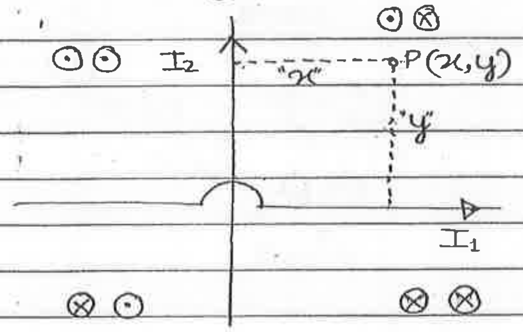
AIEEE

**Ques>** Two long wire are along co-ordinate axis as shown. If point (P) is Neutral Point, than Find its Locus?




(i) $\vec{B_1} = \frac{\mu_0 I_1}{2\pi y}$ ⊙ (ii) $\vec{B_2} = \frac{\mu_0 I_2}{2\pi x}$ ⊗

$\because$ Neutral Point :-

$\because B_{Net} = 0$

$\because B_1 = B_2 \Rightarrow \frac{\mu_0 I_1}{2\pi y} = \frac{\mu_0 I_2}{2\pi x}$

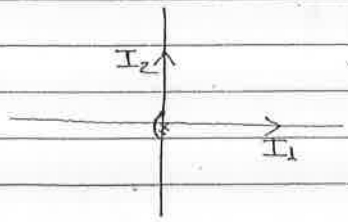
$$\boxed{y = \left(\frac{I_1}{I_2}\right)x} \Rightarrow y = m(x) + \underset{©}{0}$$

$\because$ "straight Line" Passing through origin (c=0).

$\because$ Passing through 1st "&" 3rd co-ordinates.

**Ques>** Two long wire is along "x"- axis "&" y-axis as shown; than Find magnetic Fied at Height "d" From origin?

soln




$\because B_1 \perp B_2$ ~~(given)~~

$\because B = \sqrt{B_1^2 + B_2^2}$

$$B = \frac{\mu_0}{2\pi d}\sqrt{I_1^2 + I_2^2}$$

$\because B_1 = \frac{\mu_0 I_1}{2\pi d}$ ⊗ ↓ $\because B_2 = \frac{\mu_0 I_2}{2\pi d}$ ⊗ →

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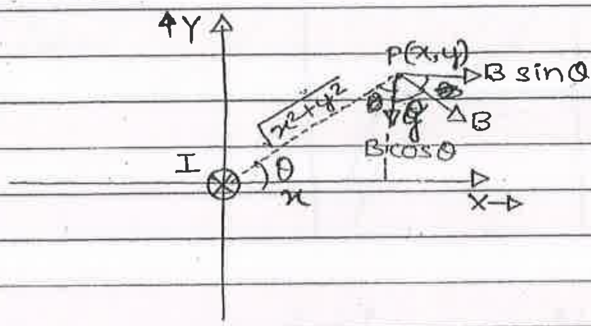
IIT Ques> A long wire placed at origin and the current "I" in "$-\hat{z}$" direction. Than magnetic field at point "P"$(x, y)$ ?

Soln :-




(i) $B_P = \dfrac{\mu_0 I}{2\pi\sqrt{x^2+y^2}}$

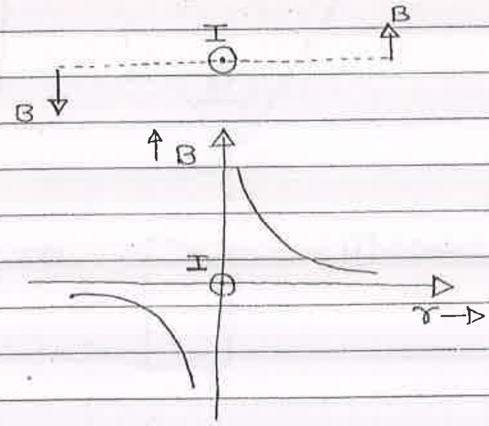
(ii) $\vec{B_P} = B\sin\theta\,(\hat{i}) + B\cos\theta\,(-\hat{j})$

$= \dfrac{\mu_0 I}{2\pi\sqrt{x^2+y^2}}\left\{\dfrac{y}{\sqrt{x^2+y^2}}\hat{i} - \dfrac{x}{\sqrt{x^2+y^2}}\hat{j}\right\}$

$\vec{B_P} = \dfrac{\mu_0 I}{2\pi(x^2+y^2)}(y(\hat{i}) - x(\hat{j}))$

*** ⊛ ⇒ GRAPH :-

$B_\infty = \dfrac{\mu_0 I}{2\pi r} \propto \dfrac{1}{r}$



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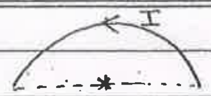
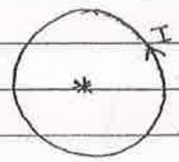
case:- (II) :-




$\because \phi = \pi$

$$\boxed{B = \frac{\mu_0 I}{4r}}$$

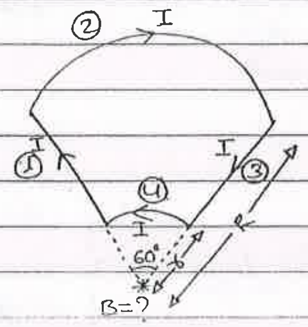
case:- (III) :-




$\because \phi = 2\pi$

$$\boxed{B = \frac{\mu_0 I}{2r}}$$

Ques>




$B_1 = B_3 = 0$

$$B_2 = \frac{\mu_0 I (\pi/3)}{4\pi R}$$

$$\vec{B_2} = \frac{\mu_0 I}{12R} \otimes$$

$$\vec{B_4} = \frac{\mu_0 I}{12r} \odot$$

$$\vec{B}_{center} = \frac{\mu_0 I}{12}\left(\frac{1}{r} - \frac{1}{R}\right) \odot$$

$$= \frac{\mu_0 I}{12}\left(\frac{1}{R} - \frac{1}{r}\right) \otimes$$

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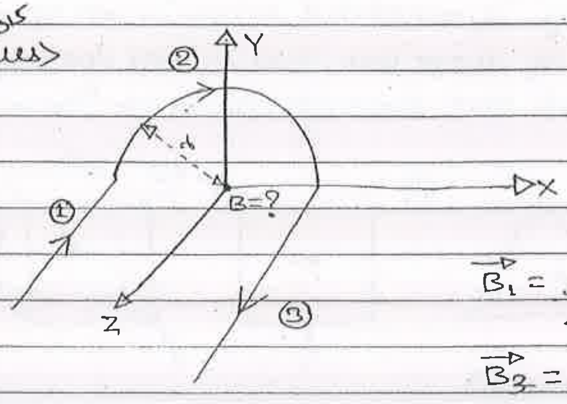
Ques>




$$\vec{B_1} = \frac{\mu_0 I}{4\pi r}(-\hat{j})$$

$$\vec{B_3} = \frac{\mu_0 I}{4\pi r}(-\hat{j})$$

$$\vec{B_2} = \frac{\mu_0 I}{4r}(-\hat{k})$$

$$\therefore \vec{B} = -\frac{\mu_0 I}{4r}\left(\hat{k} + \frac{2}{\pi}\hat{j}\right)$$

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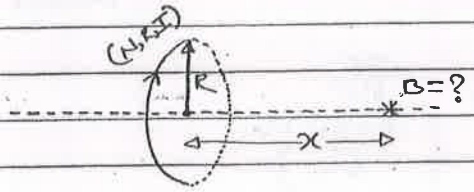
## (C) CIRCULAR CURRENT CARRIENG "RING" :-




$B_0$

$$\boxed{B_{axis} = \frac{\mu_0 N I R^2}{2(R^2+x^2)^{3/2}}}$$

$\because x\uparrow \Rightarrow B_{axis}\downarrow$

$$\Rightarrow \boxed{B_{axis} = \frac{B_0}{(1+x^2/R^2)^{3/2}}}$$

case :- (I) :- At centre $(x=0)$ :-

$$B_0 = \frac{\mu_0 N I}{2R} = {}^{*}B_{max}$$

$\because$ By Binomial Theoram.

case :- (II) :- At Nearby points $(x \ll R)$

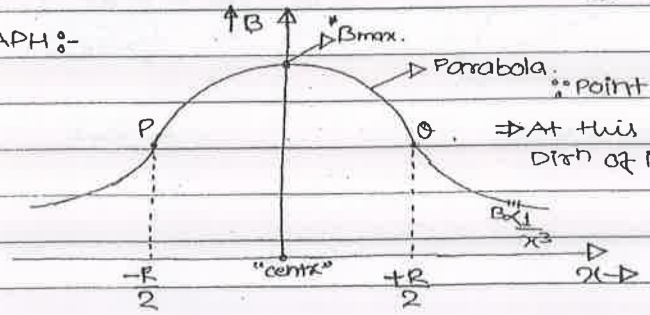
$$B_{axis} = B_0\left(1+\frac{x^2}{R^2}\right)^{-3/2}$$

$$B_{nearby} = B_0\left[1-\frac{3x^2}{2R^2}\right]$$

case :- (III) :- For Far Away points $(x \gg R)$

$$B_{Far\,Away} = \frac{\mu_0 N I R^2}{2x^3} \propto \frac{1}{x^3}$$

$\Rightarrow$ GRAPH :-




$\because$ Point of Inflextion (P & Q)

$\Rightarrow$ At this point curves changes Dirn of its curvature. so: Becomes "LINER.

$\because \frac{dB}{dx} = \text{const.}$

$\because \frac{d^2B}{dx^2} = 0$

$\therefore \boxed{x = \pm R/2}$

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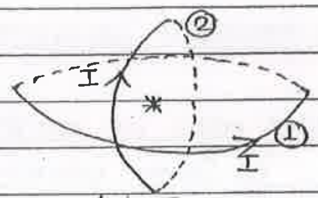
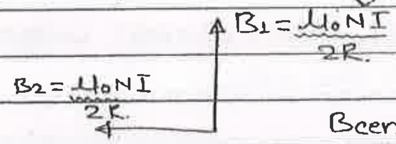
Ques> TWO Ring $(N, R, I)$ are $\perp$ to each other, than $B_{centre} = ?$




soln :-




$$B_{centre} = \sqrt{2}\left(\frac{\mu_0 N I}{2R}\right)$$

*IMP* ⊛ ⇒ If coil $(N, R)$ is made of Fix length of wire,

$$l = N(2\pi R)$$

$$\boxed{N \propto \frac{1}{R}}$$

Ques> TWO circular coils same Radius and same current and turns are $N_1$ & $N_2$; than at the center; $\frac{B_1}{B_2} = ?$

soln :- $B = \frac{\mu_0 N I}{2R} \propto N \Rightarrow \frac{B_1}{B_2} = \frac{N_1}{N_2}$

Ques> If circular coil of $N_1$ turns is converted into $N_2$ turns and current's Remains the same; than $\frac{B_1}{B_2} = ?$ at centre

soln :- $B = \frac{\mu_0 N I}{2R}$

∵ Fix length of wire ⇒ $N \propto \frac{1}{R}$

$$B \propto N \cdot N$$

$$\boxed{B \propto N^2} \Rightarrow \boxed{\frac{B_1}{B_2} = \frac{N_1^2}{N_2^2}}$$

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(iii)** $\boxed{H = \frac{B}{\mu} = \frac{B_{vaccum}}{\mu_0}}$

## ✡ ⇒ AMPERE'S CIRCUITAL LAW (ACL):-

"LINE Integration" of magnetic Field along a closed path is Equal to $\mu_0$-times of Total current inclosed in that Path.

$$\because \boxed{\oint \vec{B}\cdot\vec{dl} = \mu_0 \Sigma I} \rightarrow \text{I}^{st} \text{ FORM} \qquad \because \oint \vec{E}\cdot\vec{ds} = \frac{\Sigma q}{\epsilon}$$

$$\oint \cancel{\mu_0}\vec{H}\cdot\vec{dl} = \cancel{\mu_0}\Sigma I$$

$$\therefore \boxed{\oint \vec{H}\cdot\vec{dl} = \Sigma I} \rightarrow 2^{nd} \text{ FORM}$$

E.M.F = work for Rotating *unit charge in a *close loop.

$$= \frac{W_{closed\ loop}}{q}$$

$$= \frac{\oint \vec{F}\cdot\vec{dl}}{q} \Rightarrow \frac{\oint q\vec{E}\cdot\vec{dl}}{q}$$

$$\text{E.M.F} = \oint \vec{E}\cdot\vec{dl}$$

SO; FROM HERE:-

⇒ "M.M.F" (Magneto motive Force)

(i) $\text{M.M.F} = \oint \vec{H}\cdot\vec{dl}$

(ii) UNIT → Ampear.

(iii) $\frac{\text{E.M.F}}{\text{M.M.F}} = \text{ohm}.$

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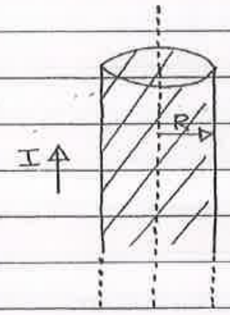
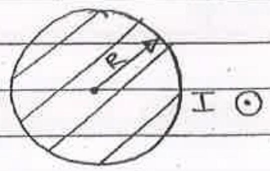
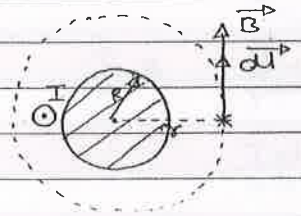
## ② SOLID CYLINDRICAL WIRE :-




$r$ :- Distance of observation point from axis of WIRE.

① case :- I   $r > R$ :-



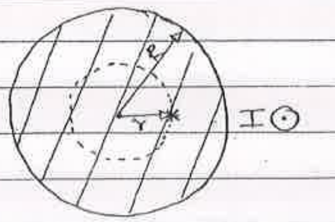

$$\oint B\,dl\cos 0^\circ = \mu_0 \Sigma I$$

$$B(2\pi r) = \mu_0 I$$

$$\boxed{B_{outside} = \frac{\mu_0 I}{2\pi r}} \propto \frac{1}{r}$$

$$\boxed{B_{surface} = \frac{\mu_0 I}{2\pi R}}$$

Ⅱ case :- II :- $r < R$ :-



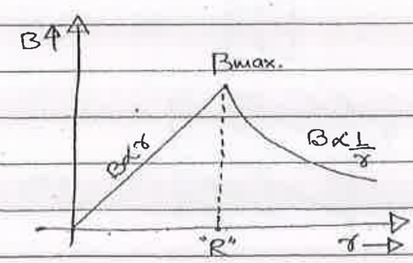

$$\oint B\,dl\cos 0 = \mu_0 \Sigma I$$

$$B(2\pi r) = \mu_0 \left\{\frac{I}{\pi R^2} \times \pi r^2\right\}$$

$$\boxed{B_{inside} = \frac{\mu_0 I r}{2\pi R^2}} \propto r$$

$$\boxed{B_{axis} = 0}$$

⇒



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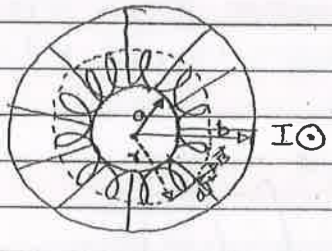
I-IMP

**Ques>** cross section of cylindrical wall wire is shown. Find Magnetic field at "r" distance from Axis ?




sol^n :- (i) $r > b$ :-

$$B = \frac{\mu_0 I}{2\pi r}$$

(ii) $r = b$ :-

$$B = \frac{\mu_0 I}{2\pi b}$$

AIEEE

(iii) $a < r < b$ :-

$$\oint B \cdot dl \cos 0^\circ = \mu_0 \Sigma I$$

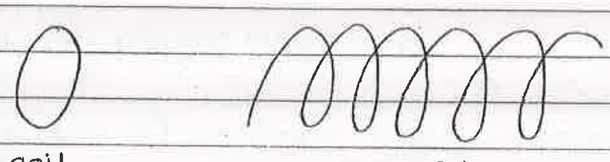
$$B(2\pi r) = \mu_0 \left[\frac{I}{\pi b^2 - \pi a^2}\right] \left[\pi r^2 - \pi a^2\right]$$

$$B = \frac{\mu_0 I}{2\pi r} \left\{\frac{r^2 - a^2}{b^2 - a^2}\right\}$$

(iv) $r < a$ :-

$$\Sigma I = 0 \Rightarrow \because B = 0$$

④ SOLENOID / ELECTROMAGNET :-



⇒ If Nothing given than considered at *Infinite solenoid.

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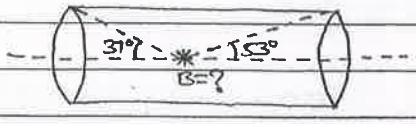
*Ques>




∵ Total Turns = 5000

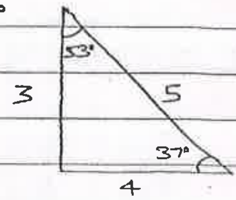
∵ Length of Frame = 50 cm.

∵ current = 1 A.

soln:- $B = \frac{4\pi \times 10^{-7} \left\{\frac{5000}{0.5}\right\} (1)}{2} \left[\cos 37° - \cos(\pi - 53°)\right]$

$B = 2\pi \times 10^{-3} \left[\frac{4}{5} + \frac{3}{5}\right]$

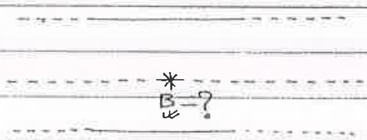
∵




$B = \frac{14\pi \times 10^{-3}}{5}$ T

(B) LONG SOLENOID (INFINITE):-

(i) At Axis:-

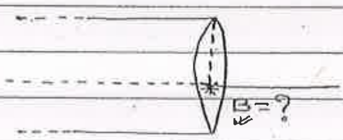



∵ $\alpha = 0$

∵ $\beta = 180°$

IMP $\boxed{B_{axis} = \mu_0 n I}$

(ii) At END:-

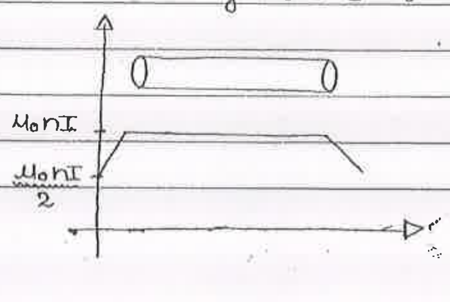



∵ $\alpha = 0°$

∵ $\beta = 90°$

$\boxed{B_{end} = \frac{\mu_0 n I}{2}}$

*** EX:- For long solenoid:-



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*(ii) $F_m \perp V$

⇒ circular Motion.

radius ($r$) :-

$$\frac{mv^2}{r} = qvB.$$

$$\boxed{r = \frac{mv}{qB}} \qquad \boxed{r = \frac{\overset{\text{Momentum.}}{P}}{qB} = \frac{\sqrt{2m(K.E)}}{qB}}$$

$$\boxed{r = \frac{\sqrt{2m(q\Delta V)}}{qB}} \rightarrow \text{voltage.}$$

Qus> A Proton & $\alpha$-particle & Duetrum making circular motion in U.T.F. Find Ratio of their Radius :- if;

(i) All have same velocity.

(ii) same Momentum.

(iii) same Kinetic Energy.

soln.

| Proton | Deuterum | $\alpha$-particle |
| --- | --- | --- |
| $\begin{pmatrix} +e \\ m_p \end{pmatrix}$ | $\begin{pmatrix} +e \\ 2m_p \end{pmatrix}$ | $\begin{pmatrix} +2e \\ 4m_p \end{pmatrix}$ |
| $r_p$ : | $r_d$ : | $r_\alpha$ |

(i) $r = \frac{m\cancel{v}}{q\cancel{B}} \propto \left(\frac{m}{q}\right) \Rightarrow \frac{m_p}{e} : \frac{2m_p}{e} : \frac{4m_p}{2e}$

$$= \underset{(P)}{1} : \underset{(d)}{2} : \underset{(\alpha)}{2}$$

(ii) $r = \frac{\cancel{P}}{q\cancel{B}} \propto \frac{1}{q} \Rightarrow \frac{1}{e} : \frac{1}{e} : \frac{1}{2e}$

$$\Rightarrow \underset{(P)}{2} : \underset{(d)}{2} : \underset{(\alpha)}{1}$$

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$\Rightarrow \quad \frac{1}{2} mv^2 = \text{const.}$

$\therefore v = \text{const.}$

$\boxed{\begin{array}{l} \text{speed} = \text{const} \\ \text{velocity} \neq \text{const.} \end{array}}$

⊛ ⇒ Momentum $(\vec{P})$ :-

$\vec{P} = m\vec{v}$

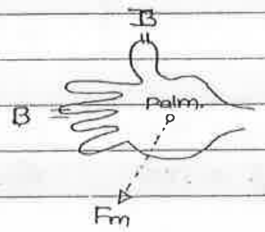
$\boxed{\begin{array}{l} \vec{P} \neq \text{const.} \\ |P| = \text{const.} \end{array}}$

⊛ ⇒ POWER (P) :-

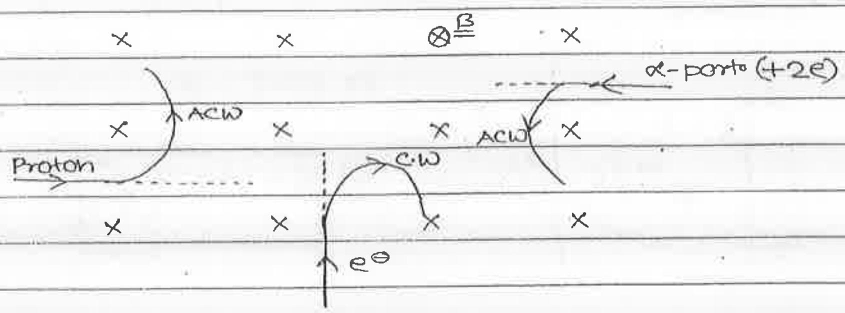
$P = \vec{F_m} \cdot \vec{V}$

$\boxed{P = 0}$

⊛ ⇒ Tool's to Find $F_m$ :-




Eg :-



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soln :- (i) $d \geq r$ :-

$$(b-a) \geq \frac{mv}{qB}$$

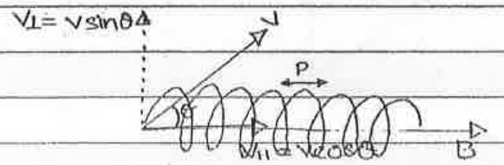
$$\therefore V \leq \frac{qB(b-a)}{m}$$

(ii) $d < r$ :-

$$\because (b-a) < \frac{mv}{qB}$$

$$\therefore V > \frac{qB(b-a)}{m}$$

③ $0° < \theta < 90°$




(i) $V_{\parallel} = V\cos\theta \Rightarrow F_m = 0 \Rightarrow$ straight line.
(ii) $V_{\perp} = V\sin\theta \Rightarrow F_m \neq 0 \Rightarrow$ circular

} ** HELIX

$$\text{radius } (r) = \frac{mV_{\perp}}{qB} = \frac{mV\sin\theta}{qB}$$

$$\text{Time Period } (T) = \frac{2\pi m}{qB}.$$

** Pitch :- (P) :- Horrizontal distance covered by Particle during one Time Period.

$$P = T \times V_{\parallel} \Rightarrow \left(\frac{2\pi m}{qB}\right) v\cos\theta$$

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Ques> A charge particle enters in uniform Magnetic Field at 45°, than find Ratio of Radius "&" Pitch of its Helical path?

soln :- $\frac{r}{P} = \frac{mv\sin\theta/qB}{\frac{2\pi m}{qB} \times v\cos\theta} = \frac{\sin\theta}{2\pi\cos\theta} \Rightarrow \frac{1}{2\pi}$

✡ ⇒ LORENTZ FORCE ($F_L$) :-

It is Net Force on charge particle Due to E & B both

$$\vec{F_L} = \vec{F_e} + \vec{F_m}$$
$$= q\vec{E} + q(\vec{v} \times \vec{B})$$
$$= q[\vec{E} + (\vec{v} \times \vec{B})]$$

Ques> A charge particles enter in a Region having $\vec{E}$ "&" $\vec{B}$ and its velocity Remains unchanged. Than Find condition?
(Given:- $\vec{E}, \vec{v}, \vec{B}$ are Mutaly ⊥)

soln :- ∵ velocity = constant.
∴ accn = 0 ⇒ Fnet = 0.

(i) $F_e = F_m$

$qE = qvB \sin 90°$

$$\boxed{v = \frac{E}{B}}$$

(ii) $\vec{F}_{net} = 0$

∴ $\vec{F_e} + \vec{F_m} = 0$

∴ $q\vec{E} + q(\vec{v} \times \vec{B}) = 0$

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

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

∵ (only this Relatn only.)

✡ Ques> A charge particles enter in Region having $\vec{E}$ and $\vec{B}$ and its path remains straight line, than check various Possiblity?

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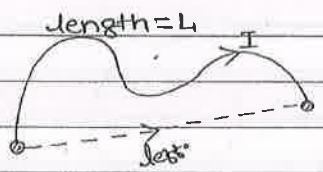
## ✡ ⇒ MAGNETIC FORCE ON CURRENT CARRIENG WIRE:-

⊛ $F_m = I\, l_{eff}\, B \sin\theta$.

$\vec{F_m} = I(\vec{l_{eff}} \times \vec{B})$.

⊛ $l_{eff}$ :- Minm distance b/wn the ends of wire.

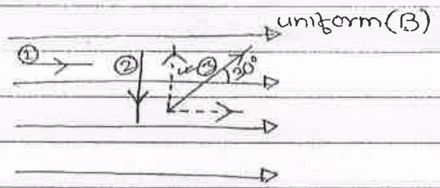
*(dirn: From initial to Final Point)




⊛ $F_m \perp l_{eff}$.

$F_m \perp B$

Ques>

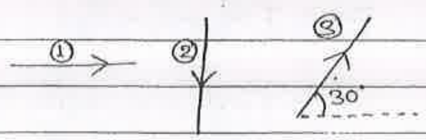



soln :-
$F_1 = IlB \sin 0° = 0$

$F_2 = IlB \sin 90° = IlB \odot$

$F_3 = IlB \sin 30° = \frac{IlB}{2} \otimes$

Ques> Uniform "B" ⊗




$F_1 = IlB \sin 90° = IlB \uparrow$

$F_2 = IlB \sin 90° = IlB \rightarrow$

$F_3 = IlB \sin 90° = IlB$ (Direcn)

Angle b/wn "l" & "B"

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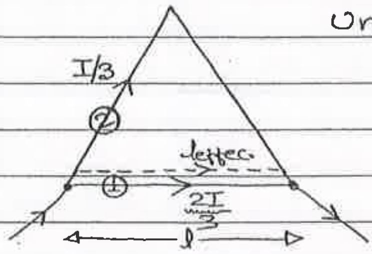
***Ques> calculate Magnetic Force on Equilateral triangle of side $l$ placed in Uniform Magnetic Field "B" as shown ⊗

soln :-




Uniform "B" ⊗

$$\vec{F_1} = \left(\frac{2I}{3}\right)(l)\,B\sin 90^\circ$$

$$\vec{F_1} = \frac{2IlB}{3}\uparrow$$

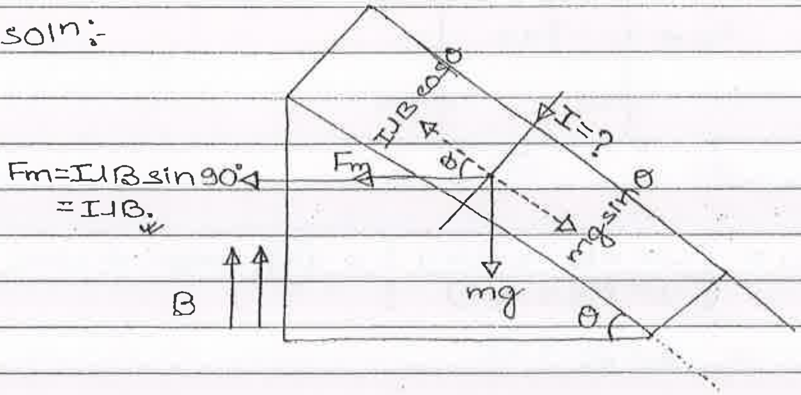
$$\vec{F_2} = \left(\frac{I}{3}\right)(l)\,B\sin 90^\circ.$$

$$\vec{F_2} = \frac{IlB}{3}\uparrow$$

$\therefore\ F_{net} = IlB\uparrow$

**Ques> A wire (m, l) is placed on a inclined plane as shown, If Magnetic Field is vertically upward, than calculat current in wire, so that is is just Balance on Inclin plane?

soln :-




At Balance :-

$$mg\sin\theta = IlB\cos\theta$$

$$\therefore\ \boxed{I = \frac{mg\tan\theta}{lB}}$$

J.M.S J.M.D

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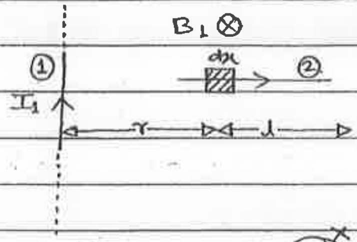
Ques>




∴ calculate Force of wire (2) due to wire (1)

soln :- $F_{2,1} = I_2 l_2 (B_1) \sin 90^\circ$

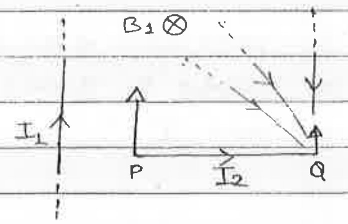
Force on element of wire (2)

$$dF_{2,1} = (I_2)(dx)\left(\frac{\mu_0 I_1}{2\pi x}\right)\sin 90^\circ$$

$$F_{2,1} = \int_r^{r+l} \frac{\mu_0 I_1 I_2}{2\pi}\cdot\frac{dx}{x}$$

$$\boxed{F_{2,1} = \frac{\mu_0 I_1 I_2}{2\pi}\log_e\left(\frac{r+l}{r}\right)}$$

Ques>

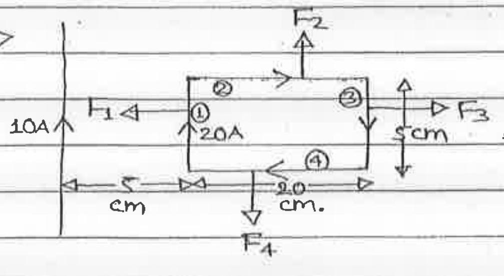



∵ $B_P > B_Q$

∴ $F_P > F_Q$

soln :- Initialy wire (2) Perform Translatory and Rotation Motion both and become Anti Parllel; After that moves away making Translatory motion only.

AIEEE Ques>




∵ $\vec{F_2} = -\vec{F_4}$

$$F_1 = \left\{\frac{4\pi\times10^{-7}\times10\times20}{2\pi\times(5\times10^{-2})}\right\}(5\times10^{-2})$$

$$= 4\times10^{-5}\ N$$

$$F_3 = \left\{\frac{4\pi\times10^{-7}\times10\times20}{2\pi\times(25\times10^{-2})}\right\}(5\times10^{-2})$$

$$= 0.8\times10^{-5}\ N$$

$(F_{net})_{loop} = 3.2\times10^{-5}$ N.

[Toward wire (1)]

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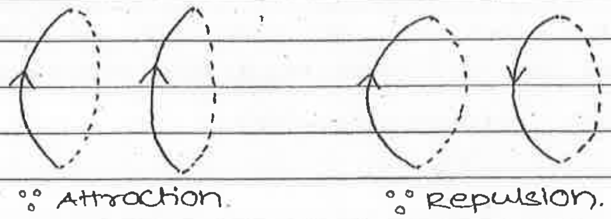
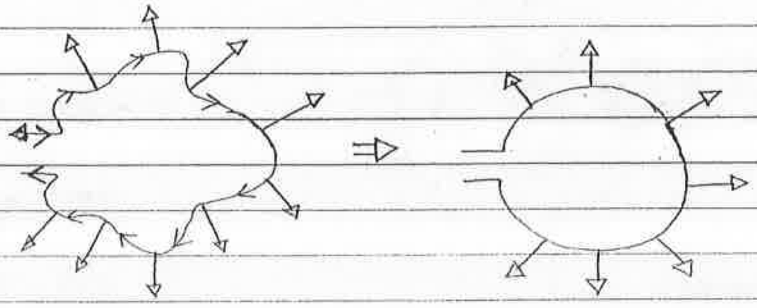
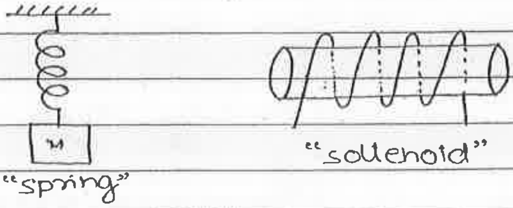
✡ ⇒ IMPORTANT POINT'S :-

① Their is Magnetic Attraction or Repulsion between TWO PARLLEL current carrying loop as shown.




② 

If current is passed in Irregular shape loop made up of Flexible wire, than due to Repulsion b/wn every small section ; it converts into circle.

③ 


⇒ when "DC" current is Passed in spring or solenoid ; than

(i) Due to Magnetic Attracth b/wn consecutive turns. it contracts ; so length decreases.

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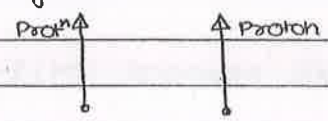
$\Rightarrow$ $F_m = \frac{\mu_0}{4\pi} \frac{q_1 q_2 v_1 v_2}{d^2}$ (Attractn / Repulsn)

$\Rightarrow$ $\left[\frac{F_e}{F_m} = \frac{1}{\mu_0 \epsilon_r} \frac{1}{v_1 v_2} = \frac{c^2}{v_1 v_2}\right]$ $\therefore F_e > F_m$ ** (always)
effective.

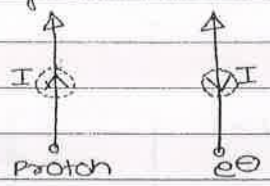
Ques> Two proton moving in same directn in parllel path; as shown.




soln:- $F_e \neq 0$ (Repulsion.)
$F_m \neq 0$ (Attraction.)

$F_{net} \neq 0$ (Repulsion)
$\therefore F_e > F_m$

Ques> ~~Two~~ one electron "&" one proton moving in same directn in parllel path; as shown




soln:- $F_e \neq 0$ (attractn)
$F_m \neq 0$ (repulsn)
$F_{net} \neq 0$ (Attractn) $\therefore F_e > F_m$

## ✡ $\Rightarrow$ MAGNETIC BEHAVIOUR OF CURRENT CARRIENG COIL:-

① It Behaves like "Magnetic Dipole"; so ** Magnetic Pole (N & S) are devlop at its Faces.

$\Rightarrow$ If I is clockwise $\Rightarrow$ "S" pole
If I is Anti clockwise $\Rightarrow$ "N" pole.

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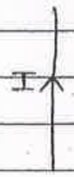
Ques>

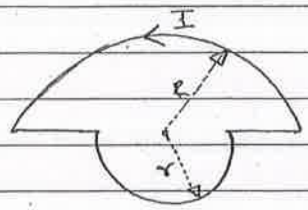



$M = NIA$

$\because$ Area trapped by loop $= 0$

$\vec{M} = 0$

AIPMT Ques>

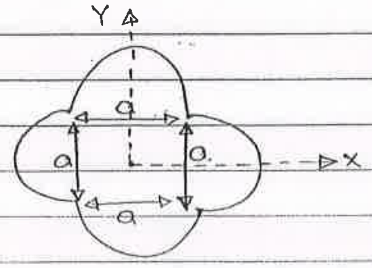



$M = NIA$

$= (1)(I)\left\{\frac{\pi R^2}{2} + \frac{\pi r^2}{2}\right\}$

$\vec{M} = \frac{I\pi}{2}(R^2 + r^2)\ \odot$

IIT ** Ques> 2013




$M = NIA$

$(1)(I)\left\{a^2 + 2\left[\pi\left(\frac{a}{2}\right)^2\right]\right\}$

$\vec{M} = Ia^2\left[1 + \frac{\pi}{2}\right](-\hat{k})$

Ques> For two circular coils $\frac{M_1}{M_2} = ?$ ; if

(i) same current ; same Radius in term $N_1$, $N_2$

soln :- $M = NIA$

$M = NI(\pi R^2)$

$M \propto N$

$\therefore \frac{M_1}{M_2} = \frac{N_1}{N_2}$

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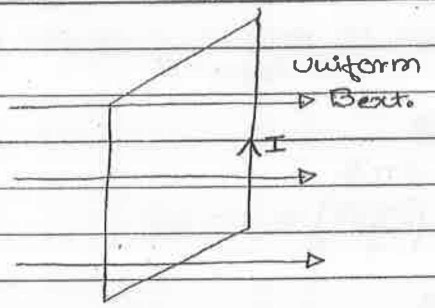
(3) Behaviour in Uniform Ext. Mag. Field:-



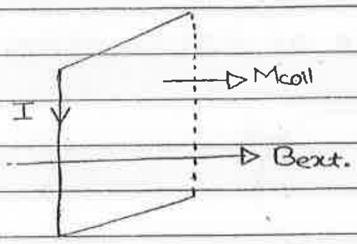

(i) $F_{net} = 0$

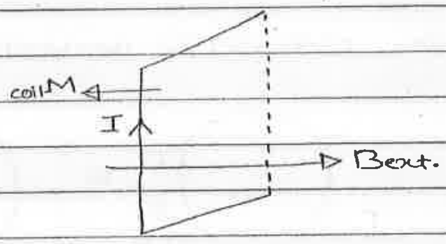
(ii) $\tau = MB \sin\theta$.

(iii) $U = -MB\cos\theta$.

(iv) $W_{\theta_1 \to \theta_2} = MB(\cos\theta_1 - \cos\theta_2)$

case:- I ⇒ If $\theta = 0°$ | case:- II ⇒ If $\theta = 180°$




$F = 0$
$\tau = MB\sin\theta = 0$
$U = -MB\cos\theta = -MB(\text{min}^m)$
}* stable equib$^m$

$F = 0$
$\tau = MB\sin\theta = 0$
$U = -MB\cos\theta = +MB$ (Max$^m$)
}* unstable equib$^m$

** (i) when coil is in equilibrium than its Plane is ⊥ to the Field.

(ii) coil is in equilibrium ~~for~~ For Two configuration only. where; one is stable ($\theta = 0°$) and another is unstable ($\theta = 180°$)

** Qus> An Equilateral triangle coil of side "l" and current "I" is placed in Uniform Field "B", where Field is Making 30° with Plane of coil; than ?

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⊛ In some atom at High energy level :-

$$I = \frac{qV}{2\pi r} \propto \frac{1}{n} \cdot \frac{1}{n^2}$$

∵ $r = 0.529 \times \frac{n^2}{Z}$

∵ $V = 2.18 \times 10^6 \frac{Z}{n}$

$$\boxed{I \propto \frac{1}{n^3}}$$

Here; n = orbit no.

② Bcenter :-

→ $B_{center} = \frac{\mu_0 I}{2r} = \frac{\mu_0 q f}{2r} = \frac{\mu_0 q \omega}{4\pi r} = \frac{\mu_0 q V}{4\pi r^2}$

→ In first orbit of H-atom

$$B_{center} = \frac{4\pi \times 10^{-7} \times (1.6 \times 10^{-19})(2.2 \times 10^6)}{4\pi \,(0.529 \times 10^{-10})^2} = \boxed{12.5} \text{ Tesla}$$

→ In some atom ; upper level :-

$$B = \frac{\mu_0 q V}{4\pi r^2} \propto \frac{1}{n} \cdot \frac{1}{(n^2)^2}$$

$$\boxed{B \propto \frac{1}{n^5}}$$

③ Magnetic Moment (M) :-

→ $M = NIA = I(\pi r^2)$

$$= qf\pi r^2 = \frac{q\omega r^2}{2} = \frac{qVr}{2}$$

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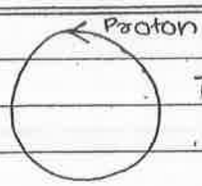
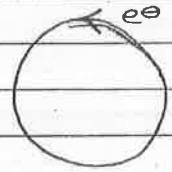
(1)



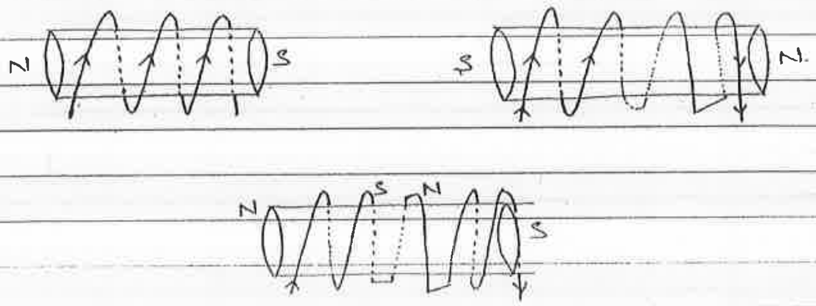

$$\vec{M} = \frac{(+e)\,\vec{L}}{2M}$$




$$\vec{M} = \frac{(-e)\,\vec{L}}{2M}$$

☆ ⇒ IMPORTANT POINTS :-

More than (2) poles can be developed in solenoid by changing the Binding pattern.



J.M.S J.M.D

# MAGNETISM

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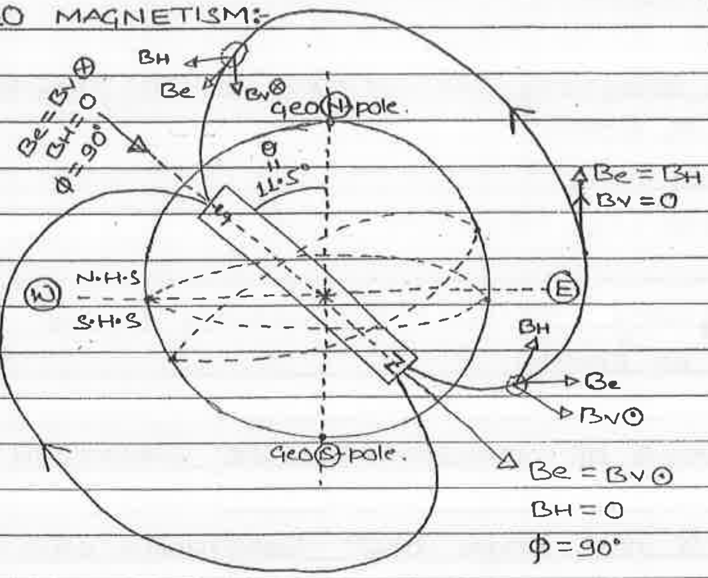
## ✡ ⇒ GEO MAGNETISM:-




IMP.

## ⇒ Earth magnetic Field ($B_e$):-

(i) At Poles :- $B_H = 0$

$B_V = B_e$

- N.H.S $B_V \otimes$
- S.H.S $B_V \odot$

(ii) At center:- $B_V = 0$

$B_H = B_e$

∵ (∥ to earth surface "&" south to North dirⁿ)

(iii) At other place :- $B_H \neq 0$

$B_V \neq 0$

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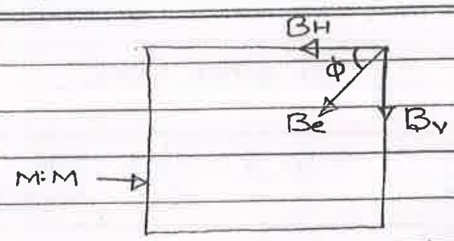
⊛ ⇒




$$B_H = B_e \cos\phi$$
$$B_V = B_e \sin\phi$$
$$\tan\phi = \frac{B_V}{B_H}$$
$$B_e = \sqrt{B_H^2 + B_V^2}$$

Ques> If $B_H = 3\times10^{-5}\ T$ and $\phi = 30°$ than :-
(i) $B_V = ?$  (ii) $B_e = ?$  (iii)

soln :- (i) $\tan\phi = \frac{B_V}{B_H} \Rightarrow \tan 30° = \frac{B_V}{3\times10^{-5}}$

$$B_V = \sqrt{3}\times10^{-5}$$

(ii) $B_H = B_e \cos\phi$

$3\times10^{-5} = B_e \cos 30°$

$B_e = 2\sqrt{3}\times10^{-5}$

⊛ ⇒ DIP ANGLE :- ($\phi$)

(i) Real Dip Angle ($\phi$) ⇒ Measured in M.M only.

(ii) Apparent Dip Angle ($\phi'$) ⇒ Measured in vertical Plane other than M.M.

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Qus> If Real Dip = 35° ; than Apparent Dip = ?

(i) 32°  (ii) 38° ✓

(ii) 25°  (iv) 28°  $\because \phi' > \phi$

(ii) If $\alpha = 90°$

$$\tan\phi' = \frac{\tan\phi}{\cos 90°}$$

$$= \frac{\tan\phi}{0} \Rightarrow \tan\phi' = \infty$$

$$\boxed{\phi' = 90°}$$

** ⇒ In vertical plane "⊥ to M.M"; Apparent Dip is *Always 90°, irrespective of Real Dip.

⊛ ⇒ $\boxed{T = 2\pi\sqrt{\frac{I}{MB}}}$ ✓

(I) If Magnetic vibrates in Horrizontal Plane than;
$B = B_H$ ✓

(II) If Magnet vibrates in Magnetic Meridian than;
$B = B_e$ ✓

(III) If Magnet vibrates in vertical Plane "⊥" to M.M
than; $B = B_V$ ✓

Qus> A Magnet vibrates in M.M ; Time Period = 3 sec.
If same Magnet is vibrated in Horrizontal Plane
than Time Period = $3\sqrt{2}$ sec. Than Dip Angle = ?

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## ✡ ⇒ TERMINOLOGIES :-

① Isoclinic Line ⟶ same $\phi$.

② Aclinic Line ⟶ $\phi = 0°$

③ Isogonic Line ⟶ same $\theta$.

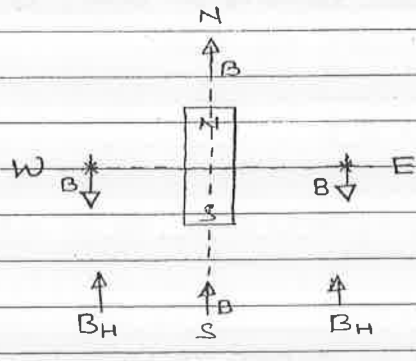
④ Agonic Line ⟶ $\theta = 0°$

⑤ Isodynamic Line ⟶ same $B_H$

⑥ Adynamic Line ⟶ $B_H = 0$.

## ✡ ⇒ NEUTRAL POINT ($B_{net} = 0$) :-

① If Magnet is Placed in Horrizontal Plane and its North pole is toward North Directn. than;




⇒ There are two Neautral Points at Equator. Each at Diffrent side at some distance from the Magnet.

→ जिससे angle बनेगा $\tan\theta$ उसके साथ चिपकेगा।

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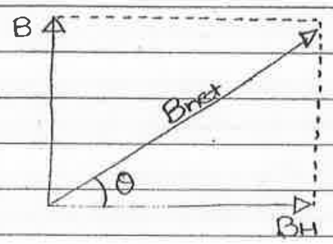
## ✡ ⇒ TANGENT LAW :-

when TWO Magnetic Fields $B$ "&" $B_H$ are ⊥ to each other and Net Magnetic Field makes angle $\theta$ with $B_H$ than :-




$$\tan\theta = \frac{B}{B_H}$$

$$\boxed{B = B_H \tan\theta}$$

## ✡ ⇒ MEASURING DEVICE :-

### (1) TANGENT GALVANOMETER :-

(a) Based on the Tangent Law.

(b) It is used to measure *small current.

(c) It's scale is non-linear.

(d) In this; coil remains stationary and Magnet Moves so; it is called "Moving Magnet Galvanometer."

(e)** It is "Most sensative" at the Deflection of 45°.

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Ques> In a Galvanometer;

If current $= I \Rightarrow \phi = 30°$

If current $= I' = ? \Rightarrow \phi = 60°$

Soln :- (i) Moving coil (G) :-

$$\boxed{I \propto \phi}$$

$$\frac{I'}{I} = \frac{60}{30} \Rightarrow I' = 2I$$

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soln :- $M_1 + M_2 \Rightarrow T = 3\,sec.$
$|M_1 - M_2| \Rightarrow T' = 5\,sec$ $\Bigg\}$ $\frac{M_1}{M_2} = ?$

$$T = 2\pi\sqrt{\frac{I}{MB_H}} \propto \frac{1}{\sqrt{M}}$$

$$\frac{3}{5} = \sqrt{\frac{M_1 - M_2}{M_1 + M_2}}$$

$$\frac{9}{25} = \frac{M_1 - M_2}{M_1 + M_2}$$

$$\therefore \frac{M_1}{M_2} = \frac{17}{8}$$

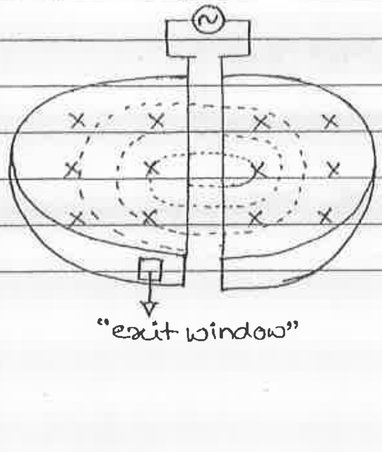
⊛ "<u>or</u>" $M_1 + M_2 \Rightarrow T = 3\,sec.$
$|M_2 - M_1| \Rightarrow T' = 5\,sec.$

$$\frac{3}{5} = \sqrt{\frac{M_2 - M_1}{M_1 + M_2}}$$

$$\therefore \frac{M_1}{M_2} = \frac{8}{17}$$

③ CYCLOTRON :-

⇒ It is used to produce Highly Energied ⊕ve ions. for scientific Purpose.



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## ✡ ⇒ COSMIC RAYS :-

cosmic Rays are High Energy Protons. so, when it Approaches Toward Earth :-

① At POLES :-

$\therefore V \parallel B_V \Rightarrow F_m = 0.$

⇒ so Reaches at Pole Easily.

(ii) At EQUATOR :-

$B_V = 0 \Rightarrow F_m \neq 0$

$\therefore V \perp B_H$

⇒ so cosmic Rays are Deviated ; so can not Reach at the Equator.

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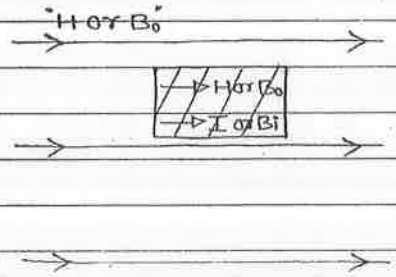
④ MAGNETIC PERMIBIALITY ($\mu$) :-

It is Ability of Material to allow the line of Force to Pass through it.




Magnetic Field inside Rod

$$B = B_0 + B_i$$

$$\mu H = \mu_0 H + \mu_0 I$$

$$\mu H = \mu_0 H\left(1 + \frac{I}{H}\right)$$

$$\frac{\mu}{\mu_0} = 1 + \frac{I}{H}$$

*$\mu$ = Permibiality.

$$\boxed{\mu_r = 1 + \chi}$$

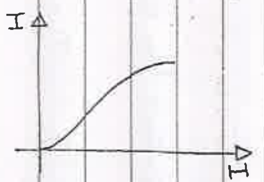
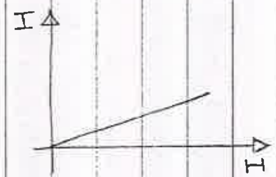
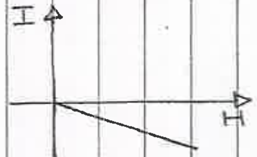
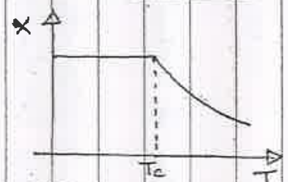
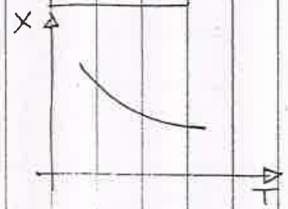
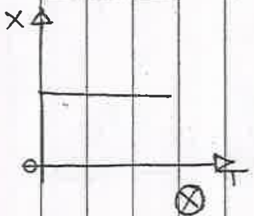
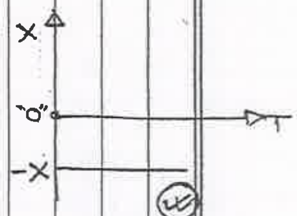
$\therefore$ $\boxed{\mu = \mu_0 \mu_r}$

*$\mu_r$ = Relative Permiblality.

**Ques> A substance of $\chi = 3 \times 10^{-4}$ is placed in $H = 4 \times 10^{4}$ A/m than calculate :-

① Intensity of Magnetisation.
② Relative Permibiality of Material.
③ Permibiality of material.
*④ Magnetic Field inside

** VERY IMPORTANT FOR EXAM

| "PROPERTY" | "FERRO" | "PARAMAGNETIC" | "DIAMAGNETIC" |
|---|---|---|---|
| ① $I$ "ꭙ" $H$ | $I >> H$ (Along H) | $I < H$ (Along H) | $I < H$ (opposite to H) |
| ② $\chi = \frac{I}{H}$ | $\chi >> 1$ ($\oplus$ve) ($\chi >> 1$) | $\chi < 1$ ($\oplus$ve) ($0 < \chi < 1$) | $\chi < 1$ ($\ominus$ve) ($-1 < \chi < 0$) |
| ③ $\mu_r = 1 + \chi$ | $\mu_r >> 2$ | $1 < \mu_r < 2$ | $0 < \mu_r < 1$ |
| ④ $I$ v/s $H$ |  |  |  |
| ⑤ $\chi$ v/s Temp. (K)** | Curie Wiess Low $\boxed{\chi = \frac{C}{T - T_c}}$  | Curie Low $\boxed{\chi \propto \frac{1}{T}}$  | $\boxed{\chi \propto T^{\circ}}$   |
| ⑥ State: | only solid | solid, Liquid, Gas | solid, Liquid, Gas. |
| ⑦ Behaviour in Non-Uniform Magnetic Field | Moves from weak to strong Field *(Rapidly) | Moves from weak to strong Field *(slowely) | Moves from strong to weak |

* $T_c$ :- Curie's Temp. After which Ferro. behave like Para.

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## ✡ ⇒ DIAMAGNETICSM :-

(i) Material of all paired electrons.

(ii) Atomic Dipole Moment is zero.

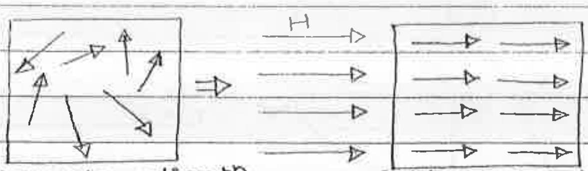
*(iii) It is Inherant Property of *each Material.

(iv) It is Explained by orbital Motion of electron.

## ✡ ⇒ PARAMAGNETISM :-

(i) Material Having un-paired electrons.

(ii) Atomic Dipole Moment is Non-Zero.




*Before Magentisatn
$\therefore M_{net} = 0$

*After magnetisatn.
$\therefore M_{net} \neq 0$

(iii) It is Explained by "SPIN MOTION" of electron.

## ✡ ⇒ FEROMAGNETISM :-

(i) Material of Unpaired electrons.

(ii) Atomic Dipole Moment is Non-Zero.

(iii) It is Explained by **Domain Theory.

→ correct Measure of Magnetic Hardness of Material ⇒ coercivity.

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⊛ ⇒ coercivity :-

(i) It is opposite "H" for complete De-Magnetisatn.

(ii) Forward coorsivity (O–R) = Reverse ~~Retentivity~~ coarsivity (O–U).

⊛ ⇒ At saturation :-

(i) slope of I–H curve $= \frac{dI}{dH} = 0$.

$\because B = \mu_0(H+I)$

(ii) slope of B–H curve $= \frac{dB}{dH} = \mu_0(1+0) = \mu_0$

(iii) "Area" of B–H curve $= \mu_0$ ("Area" of I–H curve)

⊛ ⇒ Heat Produced in Magnetisation "&" Demagnetisatn :-

Heat Produced in "t" sec. = VAnt.

V = volume of Rod.
A = Area of "I–H" curve.
n = Frequency of Magnetisatn or Demagnetisatn.
t = second.

⊛ ⇒ on the Basis of "coercivity"; Ferro-Material are of (2) ty:

| SOFT FERRO. | HARD FERRO. |
|---|---|
| (i) Low coercivity "&" Retentivity. | (i) High coercivity "&" Retentivit. |
| (ii) small B–H area | (ii) Large B–H Area. |
| (iii) Use for Making "Temprory" Magnet "&" Transformer. | (iii) Use for Making Permanent Magnet "&" Transformer. |
| (iv) eg:- soft Iron, Perm Alloy. | (iv) eg:- cobalt-steel. |

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J.M.S J.M.D

"E.M.I"

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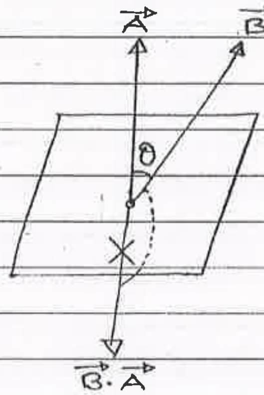
✡ ⇒ MAGNETIC FLUX ($\phi$) :-

(i) It is Number of Line of Force, passing through surface Placed Normaly in Magnetic Field.




$\phi = \vec{B}\cdot\vec{A}$

$\phi = BA\cos\theta$

$\boxed{\phi = NBA\cos\theta}$

∴ $\theta$ = Angle b/w $\vec{A}$ & $\vec{B}$ (Acute Angel alway)

(ii) scaler Quantity.

(iii) Unit :- (i) M.K.S = weber (Wb)
(ii) C.G.S = Maxwell.

∴ 1 Wb = $10^8$ Maxwell.

Qus> square coil of side 5cm ; turns = 1000, placed in uniform Field 100 Tesla. If Field is making 30° with loop than Magnetic Flux ?

Soln :- $\phi = NBA\cos\theta$

$= (10^3)(10^2)(5\times10^{-2})^2\cos 60°$

$= 125$ Wb.

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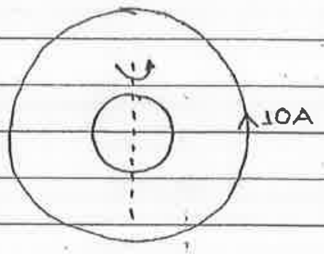
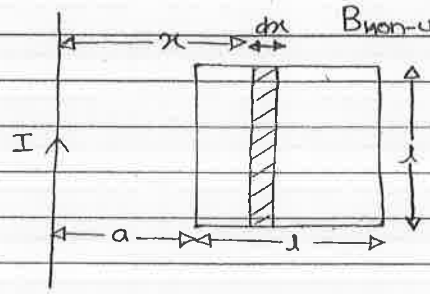



$$\phi_{छोटी} = N_{छोटी}\, B_{बड़ी}\, A_{छोटी} \cos\theta$$

$$= (1)\left(\frac{4\pi \times 10^{-7} \times 10}{2 \times 0.628}\right)(10^{-4}) \cos\omega t$$

$$= 10^{-9} \cos\omega t.$$

Ques>




$B_{non\text{-}uniform}$ ⊗

⇒ Flux with squar coil?

Solⁿ:- $\phi_{loop} = N\, B\, A \cos\theta$ ✗ (B → variable.)

∴ Flux of element area:-

$$= (1)\left(\frac{\mu_0 I}{2\pi x}\right)(l\,dx) \cos 0°$$

$$\phi_{loop} = \int_a^{a+l} \frac{\mu_0 I}{2\pi} \cdot \frac{dx}{x} \Rightarrow \boxed{\frac{\mu_0 I l}{2\pi} \log_e\left(\frac{a+l}{a}\right)}$$

✱ ⇒ $\phi = NBA\cos\theta$

$\phi = f(B, A, \theta)$

(i) If $\phi = \text{const.}$ ⇒ NO E.M.I

(ii) If $\phi \neq \text{const.}$ ⇒ E.M.I

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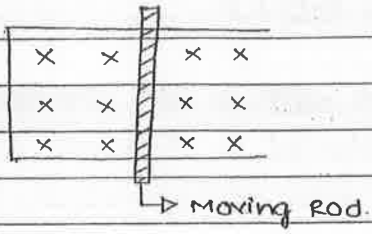
(6)

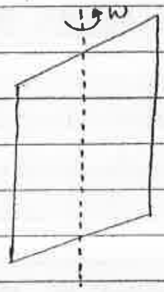



$\because A \neq$ const.

$\therefore \phi \neq$ const.

$\Rightarrow$ E.M.I.

(7)

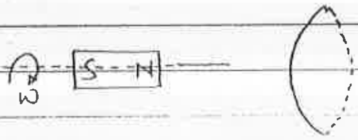



$\because \theta \neq$ const.

$\therefore \phi \neq$ const.

$\Rightarrow$ E.M.I.

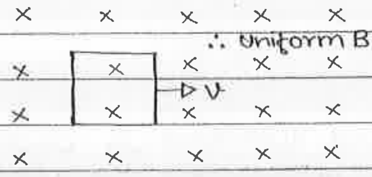
(8)




$\therefore \phi =$ const.

$\therefore$ NO E.M.I.

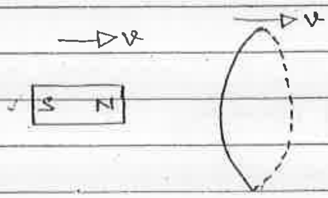
(9)




$\therefore \phi =$ const.

$\Rightarrow$ NO E.M.I

(10)




$\therefore \phi =$ const.

$\Rightarrow$ NO. E.M.I.

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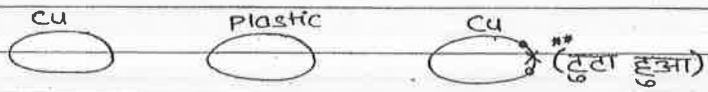
## ⇒ FORMULA'S FOR E.M.F :-

① $e = -\frac{d\phi}{dt} \propto R^{0}$ ∴ [R = Resistance]

② $I_{induced} = \frac{e}{R} = \frac{-1}{R}\frac{d\phi}{dt}$

③ $q_{induced} = I_{indu.}\,dt = \frac{-d\phi}{R}$

Ques> If $B \neq$ const. $\Rightarrow \phi \neq$ const




| | | Cu | Plastic | Cu (टूटा हुआ) |
|---|---|---|---|---|
| (i) | E.M.I :- | ✓ | ✓ | ✓ |
| (ii) | e :- | ✓ | ✓ | ✓ |
| (iii) | $I_{induced}$ :- | ✓ | × | × |

Ques> Two Identical loop's ; same $\frac{d\phi}{dt} \neq 0$


$R_{Ag} < R_{Cu}$

Soln :- (i) $e_{ind} \propto R^{0}$

∴ $e_{Cu} = e_{Ag}$

(ii) $I_{induced} \propto \frac{1}{R}$

∴ $I_{Ag} > I_{Cu}$

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Ques> Flux with a coil;

$$\phi = 6t^2 - 5t + 1$$

than the Induced E.M.F (e) = ?

(i) at; $t = 1$ sec.

(ii) at; $t = 0.25$ sec.

soln :- (i) $t = 1$ sec

$$e = -\frac{d\phi}{dt}$$

$$e = -(12t - 5)$$

$$= -(12 \times 1 - 5)$$

$$= -7 \text{ volt.}$$

(ii) $t = 0.25$ sec.

$$e = -\frac{d\phi}{dt}$$

$$e = -(12t - 5)$$

$$-\left(12 \times \frac{1}{4} - 5\right)$$

$$= +2 \text{ volt.}$$

| | | | |
|---|---|---|---|
| (i) | $-7$ V | 3 volt | |
| (ii) | $+7$ V | 7 volt | |
| (iii) | $+3$ V | 2 volt | |
| (iv) | $-3$ V | Non of these | |

| | | |
|---|---|---|
| (i) | $-2$ V | 3 volt |
| (ii) | $+2$ V | 2 volt |
| (iii) | $+3$ V | 7 volt |
| (iv) | $-3$ V | Non of these |

Ques> Flux with a coil; $\phi = t^2 e^{-t}$

than find instant when induced E.M.F (e) become zero (0)?

soln :- $\phi = t^2 e^{-t}$

$$e = -\frac{d\phi}{dt}$$

$$e = -\left[t^2(-e^{-t}) + e^{-t}(2t)\right]$$

$$0 = -(t)(e^{-t})[-t + 2] \qquad \therefore (x y z = 0)$$

If $\Rightarrow t = 0 \Rightarrow$ than; $t = 0$

If $\Rightarrow e^{-t} = 0 \Rightarrow$ than; $t = \infty$

If $\Rightarrow (-t + 2) = 0 \Rightarrow$ than; $t = 2$

$t = 2$ sec.

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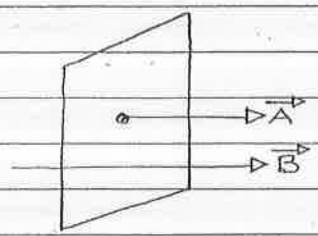
$$e = -\frac{d\phi}{dt} \Rightarrow -\left(\frac{\phi_2 - \phi_1}{t}\right) = \frac{NBA}{t}$$

$$q_{induc.} = -\frac{d\phi}{R} = \frac{NBA}{R}$$

(iii) If coil Removed from Field in time "t" than :-



$\Rightarrow \because B = 0$

$\because \phi_2 = 0$

$$\phi_1 = NBA \cos 0° = NBA$$

$$e = -\frac{d\phi}{dt} = \frac{NBA}{t}$$

$$q_{ind.} = -\frac{d\phi}{R} = \frac{NBA}{R}$$

\#\# Ques> A square loop is Moving with constant velocity in a uniform Magnetic Field as shown (P.T.O) ?

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$$= -B \cdot \pi \cdot 2r \frac{dr}{dt}$$

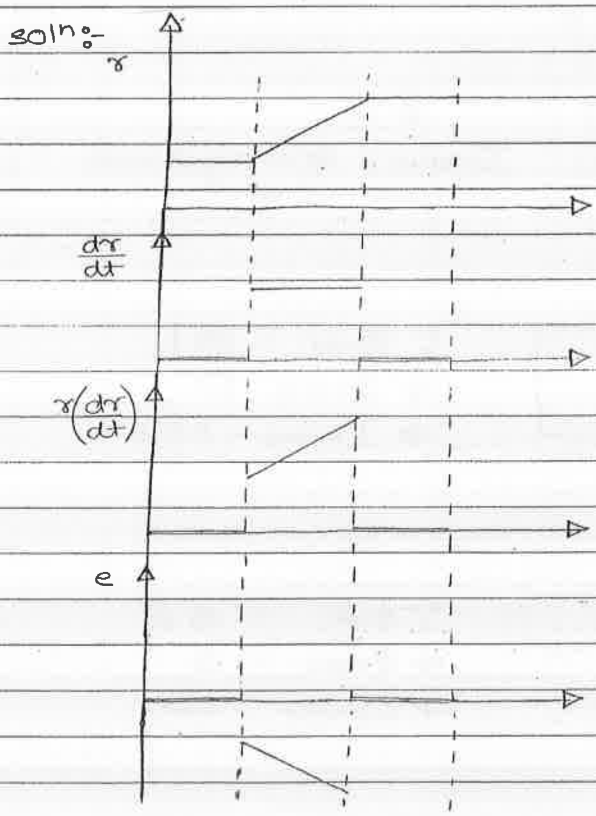
$$= -40\times10^{-3} \times \pi \times 2 \times 1 \times 10^{-2} (-2\times10^{-3})$$

$$= +16\pi \times 10^{-7}\ V$$

$$= 1.6\pi \times 10^{-6}\ V = 1.6\pi\ \mu V.$$

** Ques> A circular coil placed in "⊥" Magnetic Field and its Radius changes as shown, Graph of Induced E.M.F?

soln:-




$$\therefore e \propto -r\left(\frac{dr}{dt}\right)$$

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(i) case :- I ⇒ If $I_{wire}$ ↑

P

$\phi_P = \odot \uparrow$

$\phi_{induc.} = \otimes$

$I_{induc.}$ = CW

Q

$\phi_Q = \otimes \uparrow$

$\phi_{induc.} = \odot$

$I_{induc.}$ = ACW

(ii) case :- II ⇒ If $I_{wire}$ ↓

P

$\phi_P = \odot \downarrow$

$\phi_{induc.} = \odot$

$I_{induc.}$ = ACW

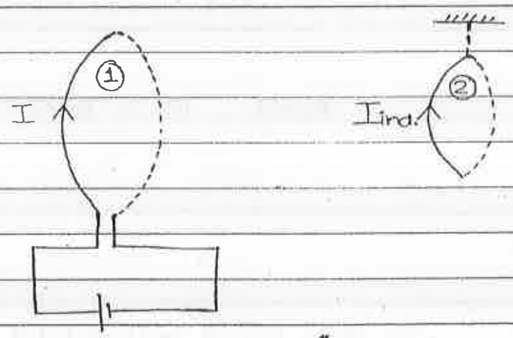
Q

$\phi_Q = \otimes \downarrow$

$\phi_{induc.} = \otimes$

$I_{induc.}$ = C.W.

*(4)




∴ If coil is heated *(Given)

(5) ∴ $R_{①} \uparrow \Rightarrow I_{①} \downarrow$

$\phi_{②}$ (left) ↓

⇒ so Induced current in coil (2) is in same Direction as $I_{①}$

so; their will be Magnetic Attractn b/wn them ; so

Both coils come closer.

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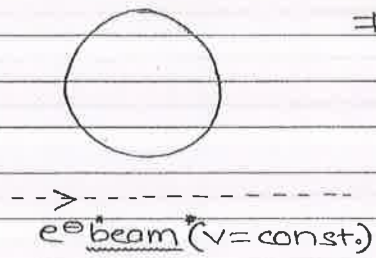
(ii) when Moving Away From "P" than;-

$\therefore \phi_{coil} = \otimes \downarrow$

$\Rightarrow \phi_{indu.} = \otimes$

$\Rightarrow I_{induc.} = CW.$

(8)

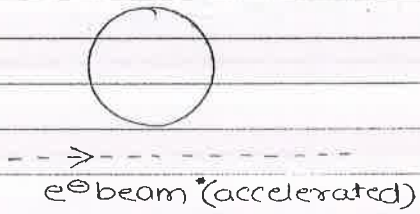


$\Rightarrow$ It is Equivalent to current carrying wire; which has constant current.

so; $\phi_{coil}\ \otimes$ = const.

$\Rightarrow$ NO E.M.I

(9)



$\Rightarrow$ current carrying wire with increasing current continiously.

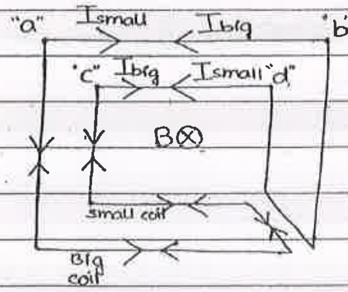
so;

$\therefore \phi_{coil} = \otimes \uparrow$

$\Rightarrow \phi_{induc.} = \odot$

$\Rightarrow I_{induc.} = ACW.$

IIT (10)




If $B\uparrow \Rightarrow (\phi_{indu.})_{small} = A.C.W.$

$(\phi_{indu.})_{Big} = A.C.W.$

$$I = \frac{-1}{R}\frac{d\phi}{dt} = \frac{-1}{R}\cdot A \frac{dB}{dt}$$

$\therefore A_{Big} > A_{small}$

$\therefore$ "$I$" $\propto$ "$A$" $\Rightarrow$ so; $I_{Big} > I_{small}$

$\therefore I_{ab} = I_{big} - I_{small}$ ("b" to "a")

$\therefore I_{cd} = I_{big} - I_{small}$ ("c" to "d")

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⊛ ⇒ $\phi = f(B, A, \theta)$.

If; $\phi \neq$ const. ⇒ E.M.I

(i) If $B \neq$ const. ⇒ Static Induction. → SELF / → MUTUAL

(ii) If $A \neq$ const. ⇒ Dynamic Induction.

(iii) If $\theta \neq$ const. ⇒ Periodic Induction.

✡ ⇒ SELF INDUCTION :-

(i) When current in a coil changes with time and Induction Takes place in same coil than it is called self Induction.

(ii) According to Lenz Law coil opposes the change of current, so it is called inertia of electricity.

⇒ Self Inductance (L) :-

In coils :-

$\therefore \phi \propto I$

$\therefore \phi = LI$

$$\therefore \boxed{L = \frac{\phi}{I}}$$

Scalar Quantity.

Unit :- $\frac{Wb}{A}$, Henary (H).

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∴ Total flux of solenoid :-

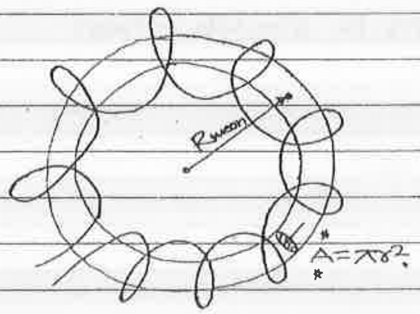
$$\phi = NBA\cos\theta$$
$$= N\left(\mu_0\left(\frac{N}{l}\right)I\right)(A)\cos 0^\circ$$

$$\frac{\phi}{I} = \frac{\mu_0 N^2 A}{l}$$

$$L_{solenoid} = \frac{\mu_0 \mu_r N^2 A}{l} \frac{\times l}{\times l}$$
$$= \mu_0 \mu_r \left(\frac{N}{l}\right)^2 (A \times l)$$
$$= \mu_0 \mu_r n^2 (\text{volume})$$

$$L_{solenoid} = \frac{\mu_0 \mu_r N^2 A}{l} = \mu_0 \mu_r n^2 (\text{volm.})$$

(C) $L_{Toroid}$ :-




∴ Let current is I

$$B = \mu_0 n I = \mu_0\left(\frac{N}{2\pi R_m}\right) I$$

∴ Total Flux of Toroid :-

$$\phi = NBA\cos\phi$$

$$= N\left(\frac{\mu_0 N I}{2\pi R_m}\right)(\pi r^2)\cos 0^\circ$$

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Ques> If length and Radius of Frame of solenoid are doubled; than Find % change in its self Inductan If:-

(i) Total turn's Remain constant.

(ii) Turn Density Remains constant.

Solⁿ:- (i) $L_{solenoid} = \frac{\mu_0 \mu_r N^2 A}{l}$

$= \frac{\mu_0 \mu_r N^2 (\pi r^2)}{l}$

$L_{solenoid} \propto \frac{r^2}{l}$

$L' = 2L$

$\% \text{ change} = \frac{L' - L}{L} \times 100$

$= 100\%$

(ii) $L_{solenoid} = \mu_0 \mu_r (n)^2 \times \text{volum}$

$= \mu_0 \mu_r (n)^2 \; (\pi r^2 l)$

$L_{solenoid} \propto r^2 l.$

$L' = 8L$

$\% \text{ change} = \frac{L' - L}{L} \times 100$

$= 700\%$

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Qus> $L_{coil} = 5H$. ;- Find $e = ?$ ; If :-

soln :- (i) current is Increasing at the Rate of 2 A/sec.

$$e = -L\frac{dI}{dt}$$

$$= -5(+2) \Rightarrow -10V.$$

(ii) current is Decreasing at the Rate of 2 A/sec.

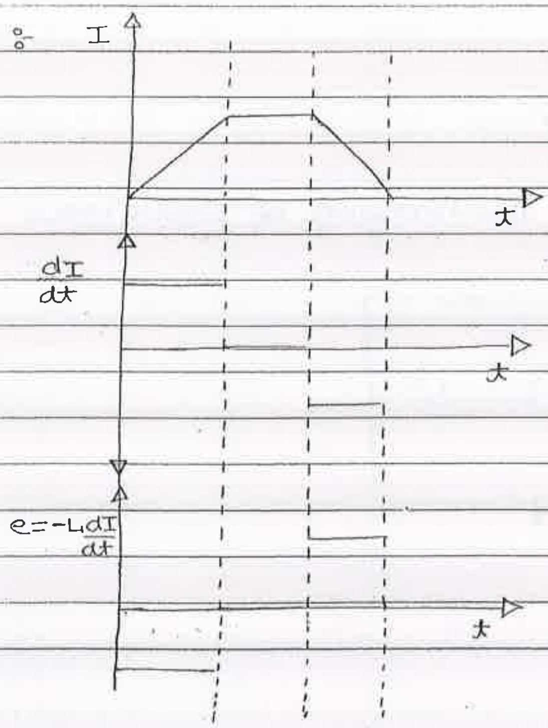
$$e = -L\frac{dI}{dt}$$

$$= -5(-2) \Rightarrow +10V.$$

AIPMT

Qus> In a coil current is changing as shown in figure; than Graph of Induced E.M.F with Time ?

soln :-



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CASE :- I :- GROWTH OF CURRENT (1-2) :-

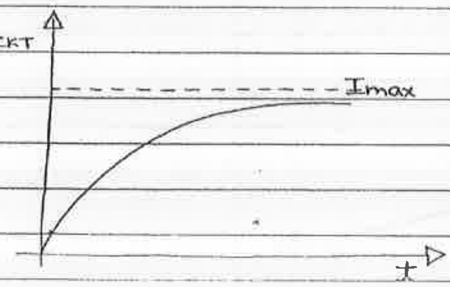
⇒ $t = 0$ $t = \uparrow$ $t = \infty$

$I_{CKT} = 0$ $I_{CKT} = \uparrow$ $I_{CKT} = V_0/R = \text{Max.}$

$U_L = 0$ $U_L = \uparrow$ $U_L = \frac{1}{2} L I_{max}^2 = \text{Max}$

⇒ $I_{CKT} = I_{max}\left(1 - e^{-\frac{R}{L}t}\right)$

⇒




⊛ ⇒ TIME CONST. ($\tau$)

$\tau = \frac{L}{R}$ (63% Growth of current.)

⇒ $t = \tau$ ⇒ 63%

$t = 3\tau$ ⇒ 95%

$t = 5\tau$ ⇒ 99.3%

⇒ $t = 0$ ; $L \equiv$ OPEN CKT. $(I = 0)$

$t = \infty$ ; $L \equiv$ SHORT CKT. $(I = \text{Max}^{m})$

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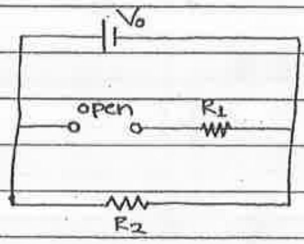
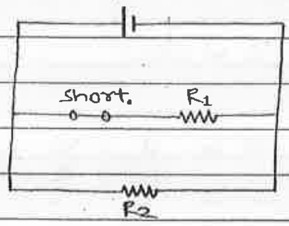
Soln :- (i) $t = 0$




$$I_{CKT} = \frac{V_0}{R_2}$$

(ii) $t = \infty$




$$I'_{CKT} = \frac{V_0}{\left(\frac{R_1 R_2}{R_1 + R_2}\right)}$$

Qus> In; L,R CKT :- $R = 50\,\Omega$

$L = 2.5$ H

Battery = 3V.

Soln :- (i) $\tau = \frac{L}{R} = \frac{2.5}{50}$ sec.

$= 50$ m sec.

(ii) Final current :-

$$I_{max} = \frac{V_0}{R} = \frac{3}{50} = 60 \text{ mA}$$

*(iii) $\frac{I_{max}}{2} = I_{max}\left(1 - e^{-\frac{R}{L}\cdot t}\right)$

$$\frac{1}{2} = 1 - e^{-R/L \cdot t}$$

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Ques> Battery = 100 V , R = 100 Ω, L = 100 mH ;
After steady state current discharging is started.
Find circuit current after one milli sec ?

Soln :- $I_{CKT} = \frac{V_0}{R} e^{-R/L \cdot t}$

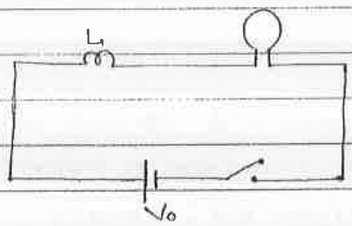
$= \frac{100}{100} e^{-\frac{100}{100 \times 10^{-3}} \times 1 \times 10^{-3}}$

$= 1 \times e^{-1}$

$= \frac{1}{e}$ Amp.

$= 0.37$ Amp.

*Ques>




Soln :- (i) when switch is made ON :-

$\therefore \phi_{coil} \uparrow \Rightarrow \frac{d\phi}{dt} = \oplus ve.$

$\therefore e = -\frac{d\phi}{dt} = \ominus ve.$

$\therefore V_{bulb} = V_0 - e \Rightarrow$ Less Bright.

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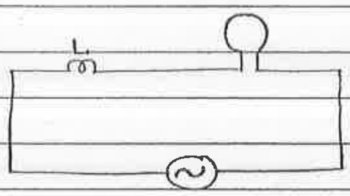
(ii) After Full Insertion :-

$\phi =$ Maxm "A" const.

$\Rightarrow e = -\frac{d\phi}{dt} = 0$

$\therefore V_{bulb} = V_0$ *(Bulb Regain its INITIAL and FULL Brightness.)

Ques>




⊛ If (Ferromag.) IRON ROD is Inserted in INDUCTOR :-

Soln :- $\mu_r \uparrow$ $\therefore$ (compare it while Reading A-C)

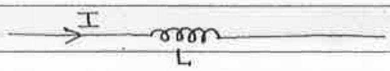
$L \uparrow$

$X_L \uparrow$

$Z \uparrow$

$I \downarrow$

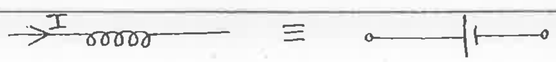
(4) Battery Equivalent Model :-




$$\boxed{e = L\frac{dI}{dt}}$$

(i) If "I" Decreasing :-


(ii) If "I" Increasing :-



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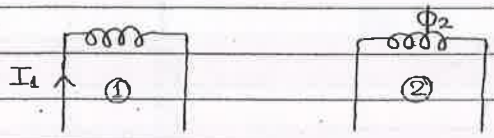
## ⇒ MUTUAL INDUCTION (M) :-

when current in a coil changes with TIME than INDUCTN takes Place in other coil. It is called Mutual Induction.




$$\therefore \quad \phi_2 \propto I_1$$

$$\Rightarrow \phi_2 = M I_1$$

$$\therefore \quad \boxed{M = \frac{\phi_2}{I_1} = \frac{\phi_1}{I_2}}$$

⇒ Unit :- HENERY (H), $\frac{Wb}{A}$

⇒ Mutual Induction is Defined for Particular oriantation of TWO COILS.

$$M = K\sqrt{L_1 L_2}$$

⇒ (K) ⇒ COUPLING COEFFICIENT.

$$(0 \leq K \leq 1)$$

Ideal coupling ; $K = 1$

⇒ coupling coeff. (K) Represents the Flux Linkage b/wn TWO COILS.

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Ques> $L_1 = 2mH$  $L_2 = 8mH$  coupling = 30%
than; $M = ?$

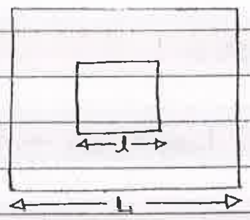
soln :- $M = K\sqrt{L_1 L_2}$
$= 0.3\sqrt{2 \times 8} \Rightarrow 1.2\ mH.$

Ques> current in Primary coil is change from '5A' to "0 A" in 0.1 sec and Induced E.M.F in secondry is 10 mV than; M = ?

soln :- $e_2 = -M \dfrac{dI_1}{dt}$

$$10 \times 10^{-3} = -M\left(\frac{0-5}{0.1}\right)$$

$$M = \frac{10 \times 10^{-3}}{50} = 0.2\ mH.$$

Ques> 

∴ Given; $L >> R$ ;- than; $M = ?$

soln :- IMP current is Always taken in the BIG COIL.
Flux is Always taken in the SMALL COIL.

Let ; $I_{BIG}$

$$B_{BIG} = 2\sqrt{2}\left(\frac{\mu_0 I_{BIG}}{\pi L}\right)$$

$$\phi_{small} = N_{small}\, B_{BIG}\, A_{small} \cos\theta$$

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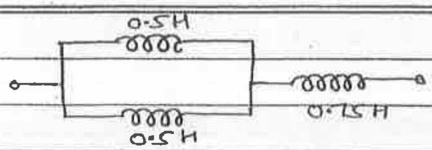
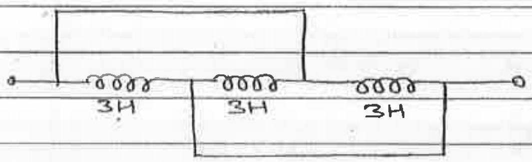
Ques>




$L_{eq} = ?$

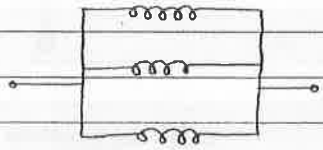
soln :- $L_{eq} = 0.25 + 0.75 = 1H.$

Ques>




$L_{eq} = ?$

soln :-



$L_{eq} = 1\,H.$

Ques> If $L_1 = L_2 = 5H$ ; coupling $= 10\%$
series Equivalent = ?

(a) coil is in same sense.

(b) coil is in oppo. sense.

soln :- $K = \frac{10}{100} = 0.1$

$M = 0.1\sqrt{5 \times 5} = 0.5\,H$

(a) $L_1 + L_2 + 2M = 11\,H.$

(b) $L_1 + L_2 - 2M = 9\,H.$

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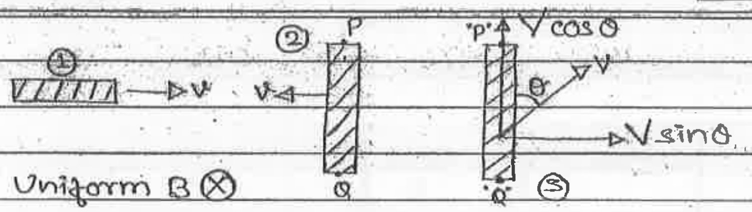
EX:-




Uniform B ⊗

Sol$^n$:- ① "$l$" ‖ "V" so; "NO FLUX CUTTING"

so; no $e_{motional}$ = zero.

(ii) "FLUX CUTTING" is there. so; $e_{motional} = BVl$.

∴ P (−ve) = LOW Potential

∴ Q (+ve) = HIGH Potential.

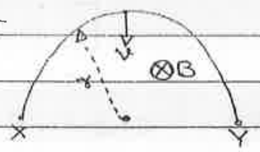
(iii) FLUX CUTTING is there. so; $e_{motional} = B(V\sin\theta)l$

∴ P (+ve) = H.P. ∴ Q (−ve) = L.P $= BVl\sin\theta$

⇒* so; ① $V_P - V_Q = 0$ (ii) $V_P - V_Q = BVl$ (iii) $V_P - V_Q = -BVl$

AIPMT

Ques> A conducting Half circular Arc:-




Sol$^n$:- $e_{motional} = BVl$

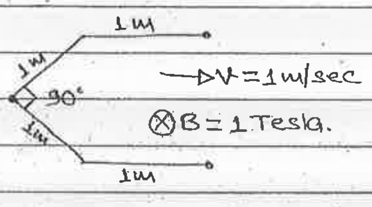
$= BV(2r) \Rightarrow 2BVr$

x = −ve.

Y = +ve

$V_X - V_Y = -2BVr$

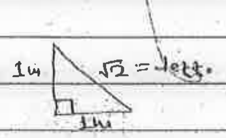
Ques>




∴ Find P.D b/w$^n$ Free Ends ?

Sol$^n$:- $e = B \cdot V \cdot l$

$= 1 \times 1 \times \sqrt{2} = 1.414$ volt.



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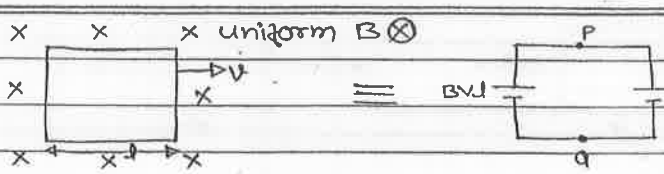
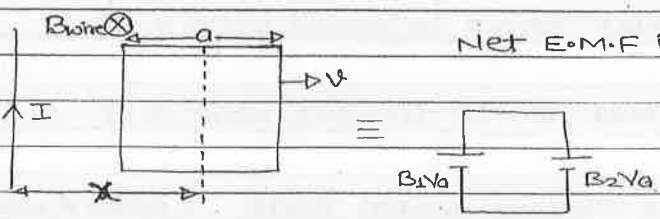
IIT Ques> uniform B ⊗



Soln :- (i) Net E.M.F in loop = 0 ∴ (cell in series; opposite Polarity)

(ii) $V_P - V_Q = BVl$ ∴ (cell in parallel; same Polarity)

AIPMT Ques>



Net E.M.F in LOOP :-

Soln :- Net E.M.F in Loop :-

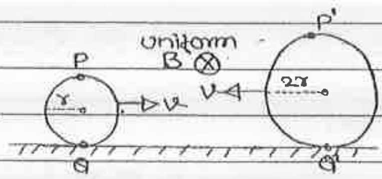
$$\therefore \; B_1 Va - B_2 Va \Rightarrow Va\left[\frac{\mu_0 I}{2\pi(x-\frac{a}{2})} - \frac{\mu_0 I}{2\pi(x+\frac{a}{2})}\right]$$

$$= \frac{\mu_0 I Va}{\pi}\left[\frac{1}{2x-a} - \frac{1}{2x+a}\right]$$

$$= \frac{\mu_0 I Va}{\pi}\left[\frac{2x+a-2x+a}{(2x-a)(2x+a)}\right]$$

$$\therefore \; e_{net} \propto \frac{1}{(2x-a)(2x+a)}$$

IIT Ques> "TWO" conducting Loop Moving on conducting Path ; as SHOWN :-



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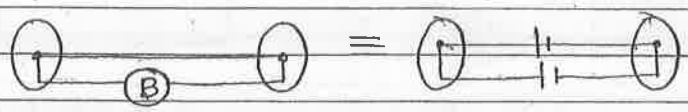
(iii) If Bulb is connected Across the Axle; than :-



$\therefore$ Net E.M.F in Loop = 0

$\therefore$ So; Bulb will "NOT GLOW".

Ques> Aeroplane Moving in Horizontal Plane at the same Height; than :-

Soln :- (i) $V \parallel l_{aeroplane}$ ; so, P.D across length = 0.

(ii) Wing's cut By lines ;
So. P.D across wing =
$\boxed{E_{motional} = B v l_{wings}}$

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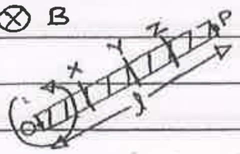
Ques> $\otimes B$ P.D = ?




soln :- (i) O "Δ" P ⇒ $e = \frac{1}{2} B\omega (l)^2$

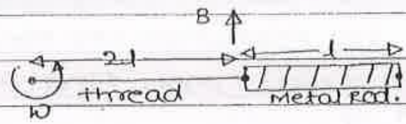
(ii) x "Δ" Z ⇒ $e = \frac{1}{2} B\omega \left[ \left(\frac{3l}{4}\right)^2 - \left(\frac{l}{4}\right)^2 \right]$

$= \frac{1}{4} B\omega l^2.$

(iii) y "Δ" P ⇒ $e = \frac{1}{2} B\omega \left[ l^2 - \left(\frac{l}{2}\right)^2 \right]$

$= \frac{3}{8} B\omega l^2.$

**Ques>



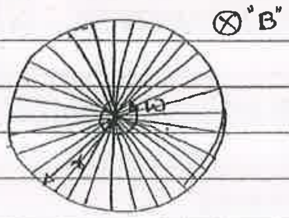

⇒ Find P.D b/wn ends of Metal Rod ?

soln :- $e = \frac{1}{2} B\omega \left[ (3l)^2 - (2l)^2 \right]$

$= \frac{5}{2} \omega l^2$

⇒ If "n" Identical Rod Rotates as shown; cutting FLUX LINES "Δ" there Free ends are connected using conducting wire than it is Equivalent to Parllel Grouping of "n" Identical cell Each $\frac{1}{2} B\omega l^2$; than

✡ ⇒ DISC :-



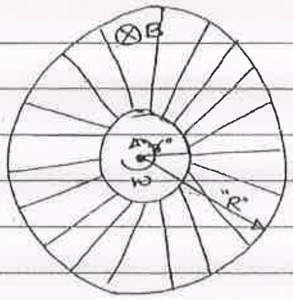

$$\boxed{P.D = \frac{1}{2} B\omega r^2}$$

∴ $r$ ⇒ Radius.

→ If NO of Rod's become Infinite than it is like a Rotating Metal Disc in a Perpendicular magnetic Field. so there is P.D b/w$^n$ periphery and centre.

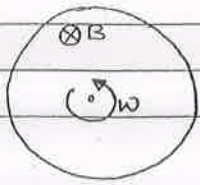
✡ ⇒ ANULAR DISC :-

P.D b/w$^n$ "Inner outer Edge"

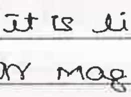



$$\boxed{P.D = \frac{1}{2} B\omega \left[R^2 - r^2\right]}$$

✡ ⇒ RING :-




P.D(e) = 0. ∵ (R = r)



If Rotates like ~~this than it~~ will have em

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## ⊛ Flux with coil :-

$$\boxed{\phi = NBA \cos \omega t.}$$

## ⊛ Induced E.M.F :-

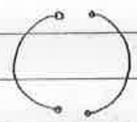
$$e = -\frac{d\phi}{dt} \Rightarrow -(NBA(-\sin \omega t)(\omega))$$

$$\boxed{e = NBA\omega \sin \omega t}$$

***⊛ $\dfrac{e_{max}}{\phi_{max}} = \dfrac{NAB\omega}{NAB} = \omega$

⇒ "FLUX" is leading from "E.M.F" by 90°. so when Flux is "0" than Induced E.M.F is Maximum and vice versa.

⇒ In D.C generator "commutator" is used in the place of "slip Ring" which always has Maxm load current Unidirectional.



commutator Diagram.

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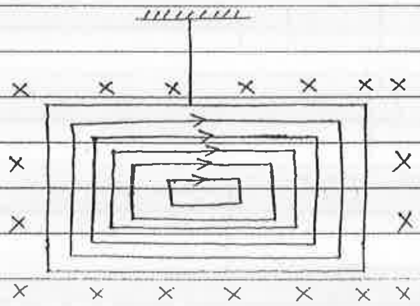
$$\oint \vec{E} \cdot dl = -A \frac{dB}{dt}$$

$$\oint q\vec{E} \cdot dl = -qA \frac{dB}{dt}$$

$$\therefore W_{close\ loop} = -qA \frac{dB}{dt} \neq 0.$$

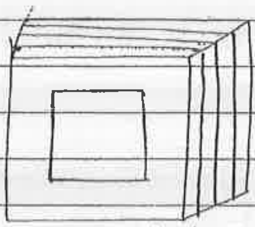
⇒ SO; Induced Electric Field is always Non-conserv

✡⇒ EDDY CURRENT (FOCAULT CURRENT):-

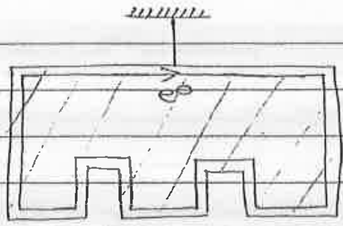


→ When Magnetic Field changes than Induced current in Metalic structure is in the form of Many concentric loop like Edyy's in water so it is called as EDDY CURRENT.

→** Eddy current Produces large Amount of Heat called Eddy losses.



Lamenated core



Sloted structure.

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⇒ When MOTOR is "SWITCHED ONN" :-

(i) At $t=0$ ; $\omega=0$ ⇒ $e_b=0$ ⇒ $^{*}I$ = High & unsafe.

(ii) If $t\uparrow$ ; $\omega\uparrow$ ⇒ $e_b\uparrow$ ⇒ $I\downarrow$.

(iii) After SOME TIME ; $\omega$ = Max$^m$ & const.
⇒ $e_b$ = Max$^m$ & const.
⇒ $^{*}I$ = Normal & safe.

✡ ⇒ STARTER :-

It is a variable Resistant used to protect the Motor from Initial High current. (at the time of swit. ONN)

✡ ⇒ POWER :-

(i) $\boxed{P_{input} = E I_a}$

(ii) $\boxed{P_{loss} = I_a^2 R_a}$

(iii) $P_{output} = P_{input} - P_{loss}$

$= E I_a - I_a^2 R_a$

$= I_a [E - R_a I_a]$

$\boxed{P_{output} = e_b I_a}$

(iv) $\% \eta = \frac{P_{output}}{P_{input}} \times 100$

$\boxed{\% \eta = \frac{e_b}{E} \times 100}$

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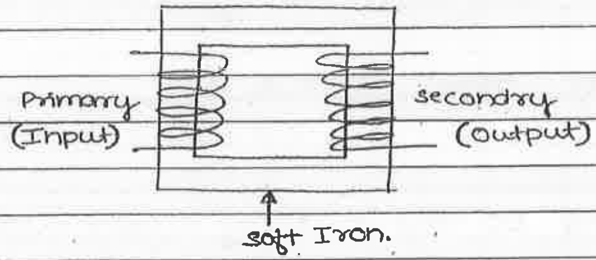


## ⊛ Ideal Transformer :-

$P = \text{const.}$

$\therefore VI = \text{const.}$

$\therefore V \propto \frac{1}{I}$

$P = \text{const.}$

$\therefore \frac{V^2}{R} = \text{const.}$

$\therefore V \propto \sqrt{R}$

## ⊛ Turn Ratio (K) :-

$$\boxed{K = \frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{\sqrt{Z_s}}{\sqrt{Z_p}}}$$

⇒ step UP

$\therefore V_s > V_p$

$\therefore N_s > N_p$

$\therefore I_s < I_p$

$\therefore Z_s > Z_p$

$\therefore \boxed{K > 1}$

step DOWN

$\therefore V_s < V_p$

$\therefore N_s < N_p$

$\therefore I_s > I_p$

$\therefore Z_s < Z_p$

$\therefore \boxed{K < 1}$

$$\Rightarrow R = \frac{\rho l}{A} \propto \frac{1}{A}$$

$\therefore R_s$ High ⇒ $A_s$ small.

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(5) HUMMING LOSS :-

Energy Loss in the Form of SOUND.

(H) ⇒ $$\boxed{\% \eta = \frac{P_{output}}{P_{input}} \times 100}$$

V.Imp ** Ques> A Bulb of 100 watt is operated by supply 220 volt and 0.5A current using a Transformer. Then :-

soln :- (i) $K = \frac{1}{2}$

(ii) $\% \eta = \frac{100 \times 100}{220 \times 0.5}$

$= 91\%$

** Ques> Transformer of 90% Effeciency ; works on 200V "A" 3 Kw.

If ; $I_s = 6A$ ; $I_P = ?$

$V_s = ?$

soln :- $I_P = \frac{P_{prim}}{V_{prim.}} = \frac{3 \times 10^3}{200} = 15A$

$$\boxed{\frac{V_s}{V_P} = \frac{I_P}{I_s}}$$ X :: Not use this bcz Not an case of "Ideal Transformer"

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J.M.S J.M.D

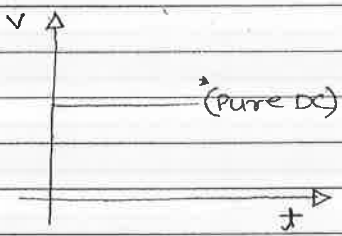
# "ALTERNATE CORRENT"

★ ⇒ Electric SIGNAL ⇒

(i) DIRECT :- Unidirectional and constant.

(ii) ALTERNATING :- (i) Bidirectional "&" PERIODIC.
(ii) Posative peak value = Negative peak valu

★ ⇒ SOME BASIC GRAPHS FOR A.C "&" D.C :-

①
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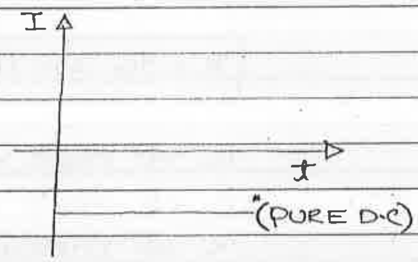


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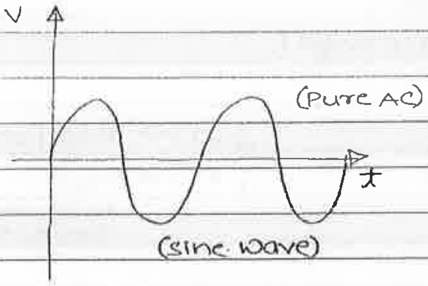


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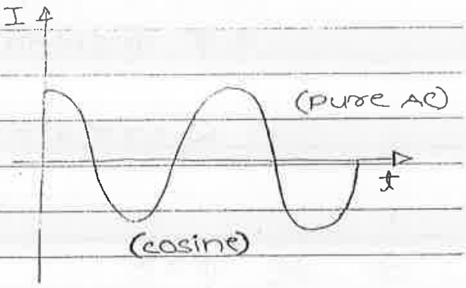


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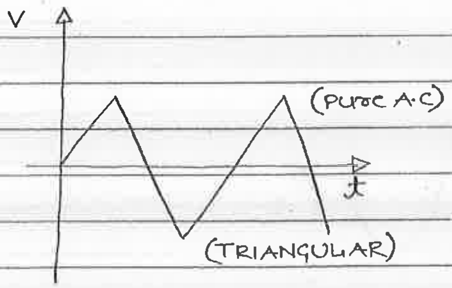


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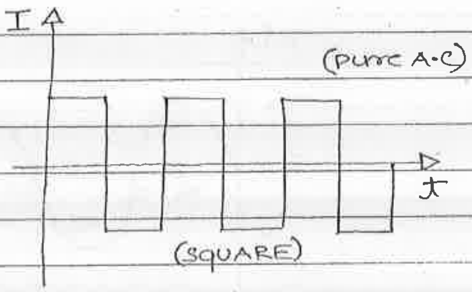

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⇒ $\boxed{2\pi = T}$  eg:- (i) $60^\circ = \frac{\pi}{3} = \frac{T}{6}$

(ii) $45^\circ = \frac{\pi}{4} = \frac{T}{8}$

(iii) $30^\circ = \frac{\pi}{6} = \frac{T}{12}$

⇒ In one cycle zero occurs "TWICE". so Direction changes "TWICE".

IMP.
⇒ If Time Indipendent signal then PURE D.C. And If Time Dependent sin or cosine signal than PURE A.C.

Qus> An Electric voltage is V = 10 volt *(Time Indipend. so pure D.C) ⇒ PURE D.C

Qus> An Electric current ; I = 50 sin 30° Applied than;-

soln:- (TIME ≠ Not depends) ∴ Time Indipendent ⇒ so; PURE D.C.

Qus> ~~[V = 0]~~ An electric voltage is $V = 0.311 \sin\left(100\pi t + \frac{\pi}{4}\right)$

soln:- (i) pure A.C

(ii) Peak Voltage = 0.311 volt

(iii) Peak to Peak voltage = 2 × 0.311 ⇒ 0.622 volt

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Ques> An Electric current is ;-

$I = 100 \sin(100\pi t) \cos(100\pi t)$

soln :- $I = 100 \sin(100\pi t) \cos(100\pi t)$

$= 50 [2 \sin(100\pi t) \cos(100\pi t)]$

$I = 50 \sin(200\pi t)$

(i) pure A.C

(ii) Peak to Peak = $50 \times 2 \Rightarrow 100$ Amp.

(iii) $I_{peak} = 50$.

(iv) Initial Phase = 0.

(v) $\omega = 200\pi$ Rad./sec.

(vi) $f = \frac{\omega}{2\pi} = 100$ Hz.

(vii) $T = \frac{1}{f} = \frac{1}{100}$ sec. $\Rightarrow$ 10 m sec.

Ques> An Electric current is ;- $I = I_0 \sin^2 \omega t$ ?

soln :- $I = I_0 \sin^2 \omega t$

$= I_0 \left[\frac{1 - \cos 2\omega t}{2}\right]$

$I = \underbrace{\frac{I_0}{2}}_{\text{Pure D.C}} - \underbrace{\frac{I_0}{2}}_{\text{Pure A.C}} \cos 2\omega t$

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*Ques> For sinosudal voltage; avg. for Half cycle is :-

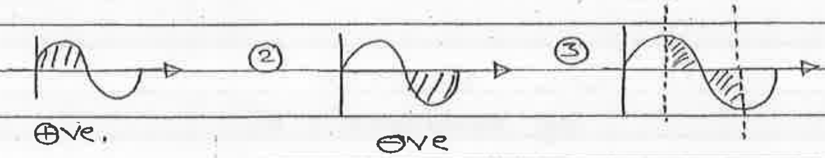
(1) Always ⊕ve.

(2) Always ⊖ve.

(3) Always zero.

(4) May be ⊕ve, ⊖ve, "or" zero.

Soln :- (1) (2) (3)



⊕ve. ⊖ve

(2) ROOT MEAN SQUARE VAUE (R.M.S) / Apparent / Virtul Effective :-

$$x_{rms} = \left[\frac{1}{T}\int_0^T x^2 \cdot dt\right]^{1/2}$$

$$\boxed{x_{rms} = \frac{x_0}{\sqrt{2}}}$$

IMP *(i) If Nothing is given ; than given A.C value is considered R.M.S value.

*(ii) For Heat "&" POWER calculation R.M.S value is Used.

eg:- (1) Domestic supply ⇒ 220V ; 50Hz

⇒ $V_{rms} = 220V.$

$V_{peak} = 220\sqrt{2} = 311\ V.$

$V_{supply} = V_0 \sin(2\pi f t)$

$= 311 (\sin(2\pi \times 50 \times t))$

$V_{supply} = 311 \sin(100\pi t)$

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**Ques> $I = I_1 + I_2 \sin\omega t$ ; is one Electric current?

soln :- (i) A.C + D.C

(ii) $\langle I \rangle_T = \langle I_1 + I_2 \sin\omega t \rangle_T$

$= I_1 + I_2(0)$

$= I_1$

(iii) $I_{rms} = \left\{ \langle I^2 \rangle_T \right\}^{1/2}$

$= \left\{ \langle I_1^2 + I_2^2 \sin^2\omega t + 2 I_1 I_2 \sin\omega t \rangle_T \right\}^{1/2}$

$= \left\{ I_1^2 + I_2^2 (1/2) + 2 I_1 I_2 (0) \right\}^{1/2}$

$\therefore I_{rms} = \sqrt{\dfrac{I_1^2 + I_2^2}{2}}$

**Ques> An electric current is $I = \sqrt{t}$. Than Find its RMS b/wn 2 to 4 sec?

soln :- $I_{rms} = \left\{ \dfrac{1}{(4-2)} \int_2^4 I^2\, dt \right\}^{1/2}$

$= \left\{ \dfrac{1}{2} \int_2^4 t \cdot dt \right\}^{1/2}$

$= \left\{ \dfrac{1}{2} \left[ \dfrac{t^2}{2} \right]_2^4 \right\}^{1/2}$

$= \left\{ \dfrac{1}{4} (16-4) \right\}^{1/2}$

$= \sqrt{3}$

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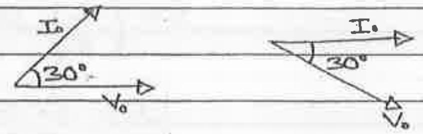
## ✡ ⇒ PHASOR DIAGRAM :-

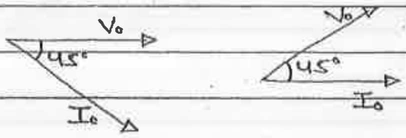
(i) $V = V_0 \sin \omega t$

$I = I_0 \sin(\omega t + 30°)$




(ii) $V = V_0 \sin \omega t$

$I = I_0 \sin(\omega t - 45°)$

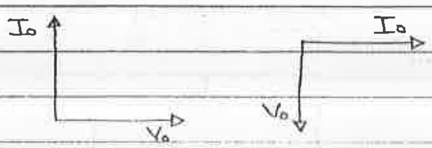



(iii) $V = V_0 \sin \omega t$

$I = I_0 \sin \omega t$


(iv) $V = V_0 \sin \omega t$

$I = I_0 \cos \omega t$



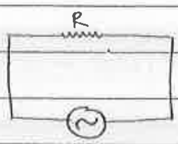

## ✡ ⇒ PHASE DIFFRENCE ($\phi$) :-

It is diffrence of phase of voltage "A" current.

## ✡ ⇒ POWER FACTOR (PF) ⇒ $\cos \phi$.

## ✡ ⇒ A.C CORCUITS :-

(1) Pure Resistive (R) circuit :-




∴ Let ; $V = V_0 \sin \omega t$.

By K.V.L :- $V - IR = 0$.

⇒ ** $I = \underline{V}$
Problem

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$$I = \frac{V_0}{X_L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$\boxed{I = I_0 \sin(\omega t - \pi/2)}$$

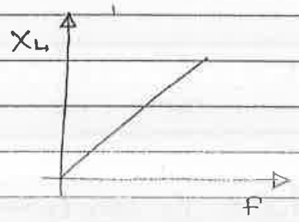
(*) ⇒ Inductive resistance ($X_L$)

*(i) $X_L = \omega L = 2\pi f L$

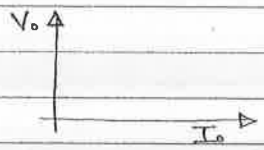
(ii) Unit ⇒ ohm.

(iii) $X_L \propto f$.

$f = 0 \Rightarrow X_L = 0$
$f \uparrow \Rightarrow X_L \uparrow$
$f = \infty \Rightarrow X_L = \infty$




⇒ "V" leading by 90°.

⇒ 


⇒ $\phi = 90°$
⇒ $P.F = \cos\phi = 0$ ∴ ** (so; 'L' does not consumes POWER)

(3) PURE "C" CIRCUIT :-

⇒ Practically pure (C) circuit is also not Possible.

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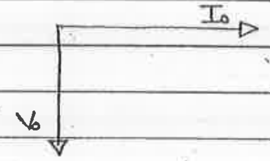
$\Rightarrow$ voltage is Laging by $90^\circ$.

$\Rightarrow$



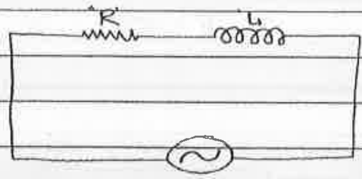

$\Rightarrow$ $\phi = 90^\circ$.

$\Rightarrow$ $P.F = \cos\phi = 0$ . $\therefore$ [so; 'c does not consume Power.]

④ SEREIS "R–L" CIRCUIT :-

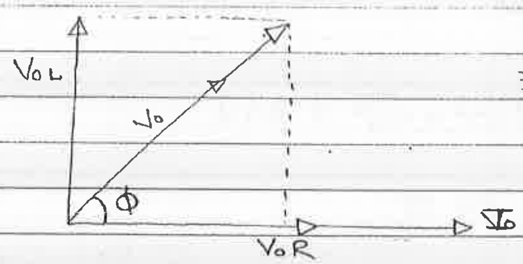
Let CKT current :-

$I = I_0 \sin\omega t$.



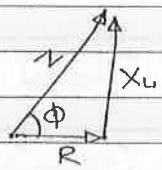

$\Rightarrow$ $V_R = V_{0R} \sin\omega t$

$V_L = V_{0L} \sin(\omega t + \pi/2)$




$\therefore$ Voltage Triangle.

$\equiv$




$\therefore$ Impedance Triangle

$\Rightarrow$ $V_0 = \sqrt{V_{0R}^2 + V_{0L}^2}$

$\Rightarrow$ Ⓥ Leading.

$\Rightarrow$ $\phi = \tan^{-1}\left(\frac{V_{0L}}{V_{0R}}\right) = \tan^{-1}\left(\frac{X_L}{R}\right)$

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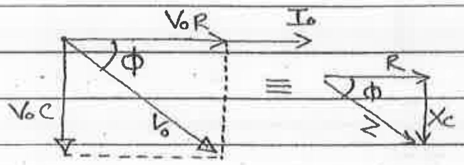
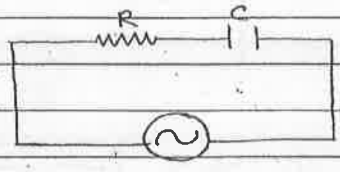
## (5) SERIES R–C CURCUIT :-




(i) $V_0 = \sqrt{V_0R^2 + V_0C^2}$

(iv) (V) lagging..

(iii) $\phi = \tan^{-1}\left(\frac{V_0C}{V_0R}\right) \Rightarrow \tan^{-1}\left(\frac{X_C}{R}\right)$

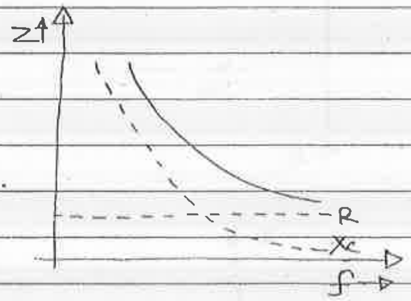
(iv) $P.F = \cos\phi = \frac{V_0R}{V_0} = \frac{R}{Z}$

(V) Impedance (Z) :-

(a) $Z = \sqrt{R^2 + X_C^2}$

(b) unit ⇒ $\Omega$

(c) "Z" v/s "f"




$f = 0 \Rightarrow X_C = \infty \Rightarrow Z = \infty.$

$f = \uparrow \Rightarrow X_C = \downarrow \Rightarrow Z = \downarrow$

$f = \infty \Rightarrow X_C = 0 \Rightarrow Z = R$

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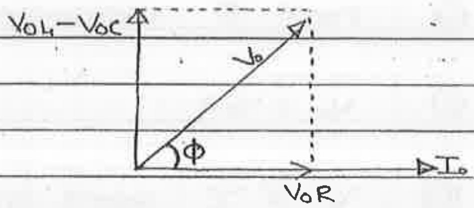
Ⓐ case :- I ⇒ If $V_{oL} > V_{oC}$ :-

⇒ Behave as series R-L CKT.




(i) $V_o = \sqrt{V_{oR}^2 + (V_{oL} - V_{oC})^2}$

(ii) "V" leading

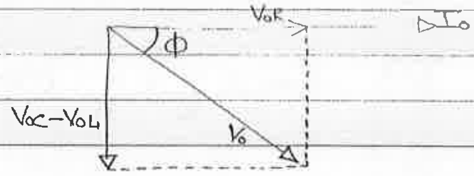
(iii) $\phi = \tan^{-1}\left(\dfrac{V_{oL} - V_{oC}}{V_{oR}}\right) = \tan^{-1}\left(\dfrac{X_L - X_C}{R}\right)$

(iv) $P.F = \cos\phi = \dfrac{V_{oR}}{V_o} = \dfrac{R}{Z}$

(v) $Z = \sqrt{R^2 + (X_L - X_C)^2}$

Ⓑ case :- II ⇒ If $V_{oL} < V_{oC}$ :-

(i) Behave as SERIES R-C CKT.




(ii) $V_o = \sqrt{V_{oR}^2 + (V_{oC} - V_{oL})^2}$

(iii) "V" lagging.

(iv) $\phi = \tan^{-1}\left(\dfrac{X_C - X_L}{R}\right) = \tan^{-1}\left(\dfrac{V_{oC} - V_{oL}}{V_{oR}}\right)$

(v) $P.F = \cos\phi = \dfrac{R}{Z}$

(vi) $Z = \sqrt{R^2 + (X_C - X_L)^2}$

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"IMP" ⇒ Z v/s f :-    $\therefore f \propto \frac{1}{X_C} \propto X_L$

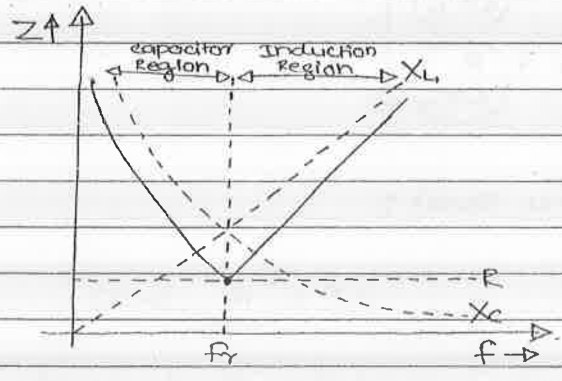
(i) $f = 0$ :- $R = R$, $X_L = 0$, $X_C = \infty$ } $Z = \infty = X_C$ *(Pure "C" CKT)

(ii) $0 < f < f_r$ :- $R = R$, $X_L \uparrow$, $X_C \downarrow$ } *(series R-C CKT) $X_C > X_L$

(iii) $f = f_r$ :- $R = R$, $X_L = X_C$ } *(PURE "R" CKT) [Resonance condit^n]

(iv) $f_r < f < \infty$ :-
$R = R$, $X_L > X_C$ } *(SERIES "R-L" CKT)

(v) $f = \infty$ :-
$R = R$, $X_L = \infty$, $X_C = 0$ } $Z = \infty = X_L$ *(PURE "L" CKT)



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## ⊛ Fractional BW :-

$$\frac{\Delta f}{f_r} = \frac{\Delta \omega}{\omega_r}$$

$$\Rightarrow \frac{R/L}{1/\sqrt{LC}} \Rightarrow R\sqrt{\frac{C}{L}}$$

∴ Rajsthan ckt League

## ⊛ Quality Factor (Q) :-

⇒ It is measure of sharpness of I v/s f curve.

⇒ ∴ SHARPNESS ↑ ⇒ Q ↑ ⇒ SOUND QUALITY BETTER.

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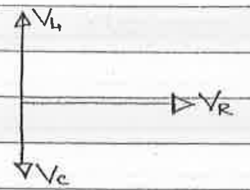
$$\Rightarrow Q = \frac{1}{\text{Fractnl BW}} = \frac{f_r}{\Delta f} = \frac{\omega_r}{\Delta \omega} \Rightarrow \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{X_L}{R} = \frac{X_C}{R}$$

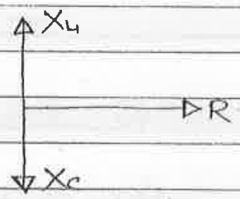
∴ The Above is used in communication system.

## ⇒ V. IMPORTANT POINTS :-

① $V_{NET}$ =




② Z =




③ $I_{CKT} = \frac{V}{Z}$

④ $\phi = \tan^{-1}\left(\frac{X}{R}\right)$

⑤ $P.F = \cos\phi = \frac{R}{Z}$

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⑨ $P.F = \cos\phi \Rightarrow \frac{30}{50} = 0.6$

⑩ $V_{supply} = 50\sqrt{2}\sin(\omega t - 53°)$.

Ques> IN "SERIES RLC" CIRCUIT :-

$\because V_L = V_C = 500\,V$

$\because R = 200\Omega$

$V_{supply} = 200\,V,\ 50\,Hz$

Solⁿ :- ① $V_L = V_C$ $\therefore$ (Resonance condition).

② PURE R-CKT.

③ $V_{supply} = V_R = 200\,V$.

④ $Z = R = 200\Omega$.

⑤ $I_{CKT} = \frac{V}{Z} = \frac{200}{200} = 1$ Amp.

⑥ $L = ? \Rightarrow V_L = I X_L$

$$V_L = I(2\pi f L)$$

$$500 = (1)[2\pi \times 50 \times L]$$

$$L = \frac{5}{\pi} \text{ Henery.}$$

⑦ $C = ? \Rightarrow V_C = I X_C$

$$V_C = I\left(\frac{1}{2\pi f C}\right)$$

$$500 = 1\left(\frac{1}{2\pi \times 50 \times C}\right)$$

$$C = \frac{10^{-4}}{5\pi}$$

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##③ $P_{average} = V_{rms} I_{rms} \cos\phi$

$= V_{rms} I_{rms} \cos 90^\circ$

$= 0.$

###Ques> In "SEREIS R-L". CURCUIT :-

$E_{supply} = \dot{E}_0 \cos \omega t.$

Given; $X_L = R.$

$\Rightarrow$ Power = ?

Soln :- $V_{rms} = \frac{E_0}{\sqrt{2}}$ ------- (i)

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{2}R.$$

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{E_0/\sqrt{2}}{\sqrt{2}R} = \frac{E_0}{2R} \text{ ---------- (2)}$$

$$\cos\phi = \frac{R}{Z} \Rightarrow \frac{R}{\sqrt{2}R} = \frac{1}{\sqrt{2}} \text{ ----------- (3)}$$

Ist Me.

$\therefore$ $P = V_{rms} I_{rms} \cos\phi \Rightarrow \frac{E_0^2}{4R.}$

IInd Me.

$\therefore$ $P = I_R^2 R \Rightarrow \left(\frac{E_0}{2R}\right)^2 R. = \frac{E_0^2}{4R}$

IIIrd Meth.

$\therefore$ $V_R = \bar{I}R \Rightarrow \left(\frac{E_0}{2R}\right) R = \frac{E_0}{2}$

$\Rightarrow P = \frac{V_R^2}{R} \Rightarrow \frac{(E_0/2)^2}{R} = \frac{E_0^2}{4R}$

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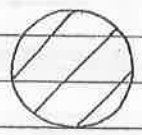
## ✡ ⇒ SKIN EFFECT :-

"A.C current" flows through outer surface of the conducting wire. so, It is called skin effect.



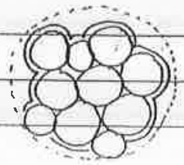
single strand wire

$\because R = \frac{\rho l}{A}$

$\because A_{effec.} \downarrow\downarrow$

$\Rightarrow R_{effec.} \uparrow\uparrow$

$\Rightarrow LOSS = I^2R \uparrow\uparrow$



$\therefore A_{effec.} \uparrow$

$\Rightarrow R_{effec} \downarrow$

$\Rightarrow I^2R = LOSS \downarrow\downarrow$

## ✡ ⇒ CHOKE COIL :-

It is EXTRA INDUCTOR inserted in A.C circuit to control the current without extra Power Loss.

$I\downarrow = \frac{V}{Z\uparrow}$

⇒ R ✗ (POWER LOSS ↑↑).

⇒ C ✗ (पैसा खाता है = costly).

⇒ L ✓ *(economic).

⇒ Ideal choke coil ⇒ Pure L ckt. (R=0).

choke coil ⇒ series R-L ckt.

choke coil Based on wattless current.

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Potential :- $\frac{Q}{C} + L\frac{dI}{dt} = 0$

$$\frac{Q}{C} + L\frac{d^2Q}{dt^2} = 0 \qquad \therefore I = \frac{dQ}{dt}$$

$$\boxed{\frac{d^2Q}{dt^2} + \frac{Q}{LC} = 0} \qquad \therefore \frac{d^2x}{dt^2} + \omega^2 x = 0$$

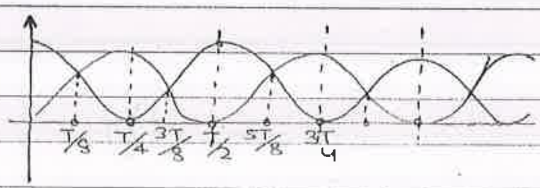
$$\therefore \omega^2 = 1/LC$$

V.IMP

(i) $Q = Q_0 \cos \omega t$

(ii) $I = \frac{dQ}{dt}$ $\therefore I = I_0 \cos(\omega t + \pi/2)$

(iii) $U_{maxm} = \frac{1}{2}\frac{Q_0^2}{C}$ (iv) $U_{maxm} = \frac{1}{2} L I_0^2$



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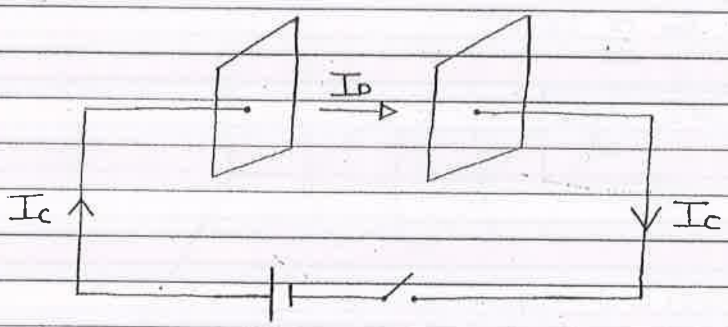
# "E·M·W"

⊛ ⇒ FARADAY'S LAW FOR E·M·I :-

$$\oint \vec{E}\cdot\vec{dl} = -\frac{d\phi}{dt}$$

⊛ ⇒ MAXWELL'S CONCEPT OF DISPLACEMENT CURRENT :-




⇒ During charging magnetic field is produced b/wⁿ the plates due to variable electric field.

⇒ Imaganiary current corrosponding to this field is called Displacement current.

⇒ $I_C = I_D$.

⇒ Both current's ($I_C$ & $I_D$) are Incomplete and making complete current Jointly. SO; these are supplementry of Each other.

$$I_D = \frac{dq}{dt} = \frac{d(CV)}{dt}$$

$$\boxed{I_D = C\frac{dV}{dt}}$$

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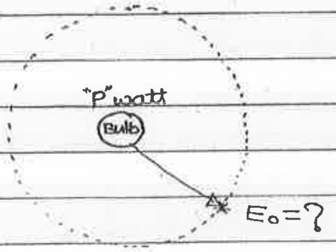
Ques> A Bulb of "P" watt is emmitting light. Find Peak Electric Field at "r" Distance ?

soln:- $I = \frac{P}{4\pi r^2} \Rightarrow \frac{1}{2}\epsilon_0 c E_0^2$

$$E_0 = \sqrt{\frac{P}{2\pi c \epsilon_0 r^2}}$$




☆ ⇒ EMW SPECTRUM :-

"VIBGYOR"

| | | | | | | |
|---|---|---|---|---|---|---|
| $\gamma$ | $x$ | UV | visible | IR | $\mu$w | Radio wave |

0.1Å 100Å 3800Å 7800Å

⟶ $\lambda \uparrow$

⟶ $\left(E_{ph} = \frac{hc}{\lambda}\right) \downarrow$