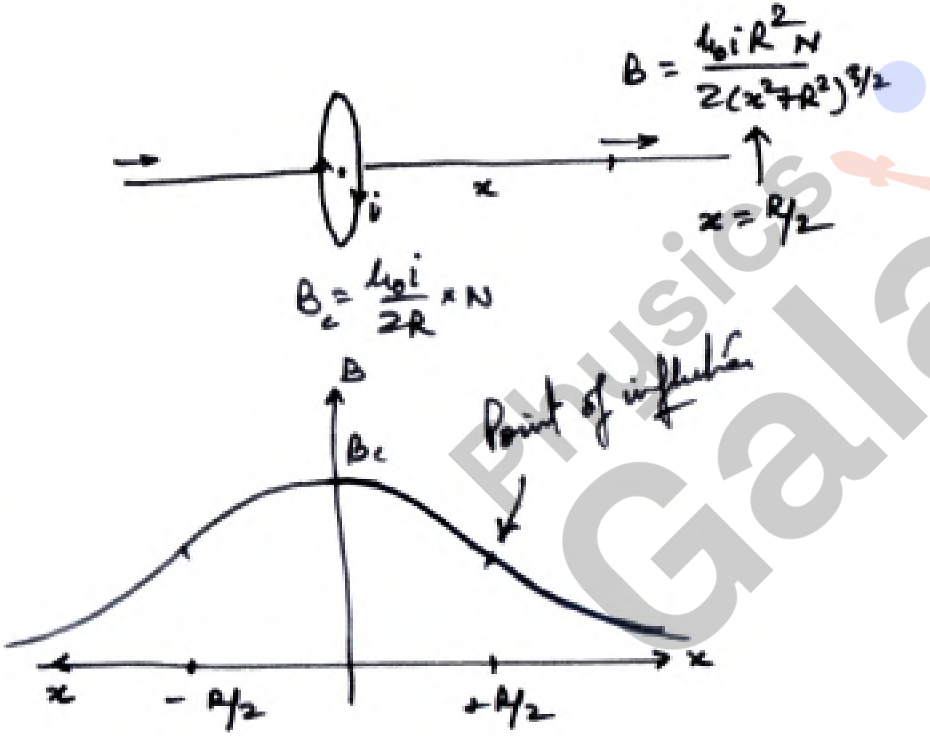
Revision Booster WORKSHOP for NEET & JEE Main

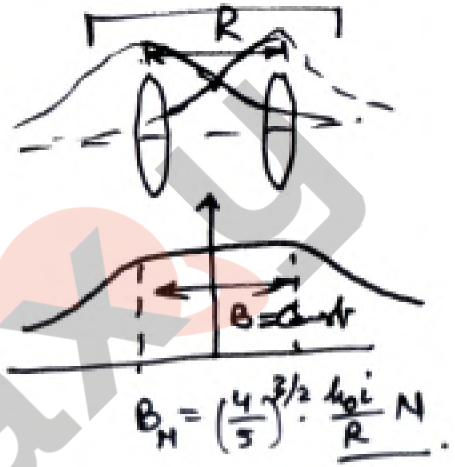
Magnetism, EMI & AC

Notes of Revision Booster Workshop for JEE Main & NEET

Questions Based on

Helmholtz Coils

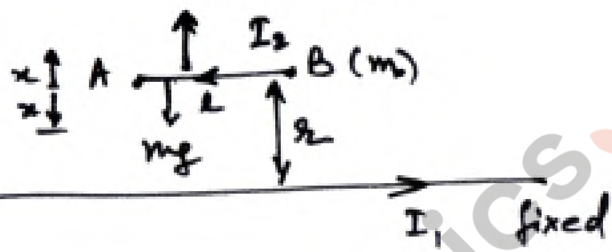




Questions Based on

Equilibrium of a Wire Above Another Wire

$$F_m = \frac{\mu_0 I_1 I_2 l}{2\pi r}$$



for eq^m of AB $\quad \dfrac{\mu_0 I_1 I_2 l}{2\pi r} = mg$

after disp by x, we use

$$ma = F_R = -\left(\frac{\mu_0 I_1 I_2 l}{2\pi (r-x)} - mg\right)$$

(x)

$$a = -\omega^2 x$$

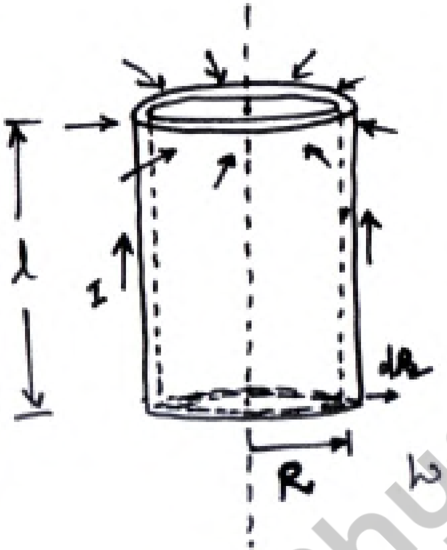
$\rightarrow$ for eq^m $x \to r$

$$\omega = \sqrt{\frac{f'(x)}{m}} = $$

$$f'(x) = -\frac{\mu_0 I_1 I_2 l}{2\pi x^2} \Rightarrow \left(\frac{\mu_0 I_1 I_2 l}{2\pi r^2}\right)$$

Questions Based on

Magnetic Pressure in a Metal Pipe



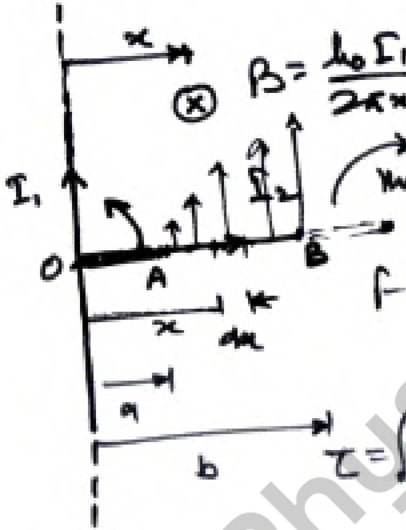
magnetic pressure $P_m = \frac{B^2}{2\mu_0} = u_m$

W/D in expanding the rod from R to R'

$W = \int P_m dV = \int_R^{R'} P_m \cdot (2\pi r l . dr) = - - - -$

Questions Based on

Magnetic Torque Between Two Wires



$B = \frac{\mu_0 I_1}{2\pi x}$

mag force on dx

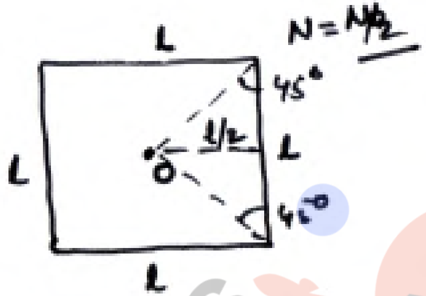
$F = \int dF = \int B I_2 dx = \int_a^b \frac{\mu_0 I_1}{2\pi x} \cdot I_2 dx = \frac{\mu_0 I_1 I_2}{2\pi} \ln(b/a)$

$\tau = \int d\tau = \int dF \cdot dx = - - - -$

QUESTIONS BASED ON

MAGNETIC FIELD BY CHANGING SHAPE OF A COIL

$$B_0 = \frac{\mu_0 I}{2R}$$



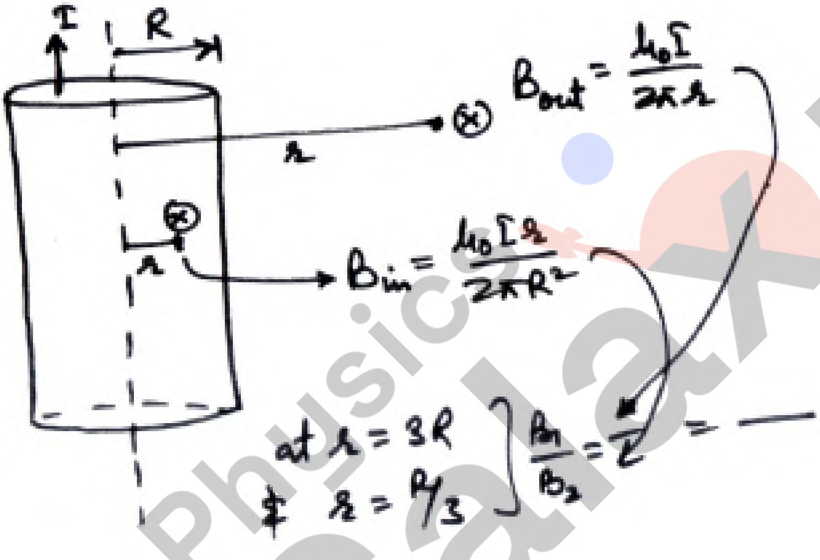
$$N_0 \cdot 2\pi R = \frac{N_0}{2}(4L)$$

$$L = \pi R$$

$$B_0' = \frac{\mu_0 I}{4\pi(L/2)}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) \times 4 \times N_0/2 = ---$$

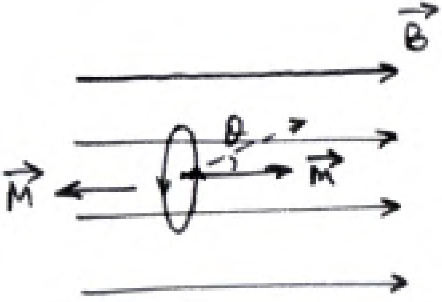
QUESTIONS BASED ON

RATIO OF MAGNETIC FIELD INSIDE AND OUTSIDE A WIRE



QUESTIONS BASED ON

TORQUE ON LOOP IN UNFORM MAGNETIC FIELD



Restoring torque $\tau_R = -MB\theta$

$\alpha = -\frac{MB}{I}\theta = -\omega^2\theta$

angular SHM →

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

$\boxed{\vec{F}_{net} = 0}$

$\vec{\tau} = \vec{M} \times \vec{B} = 0$
→ $MB\sin\theta$

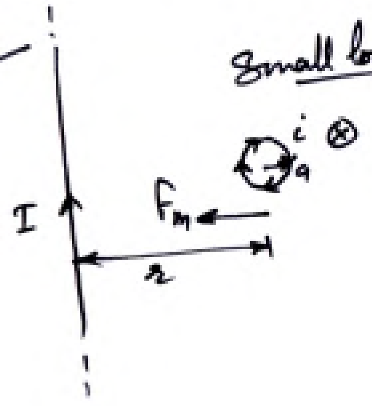
if $\vec{M}$ is $\parallel^l$ to $\vec{B} \Rightarrow U = -MB$ (min) ⇒ stable eq^m

if $\vec{M}$ is $\downarrow\uparrow^l$ to $\vec{B} \Rightarrow U = MB$ (max) ⇒ unstable eq^m

Questions Based on

Torque on a Loop Due to a Wire

Force



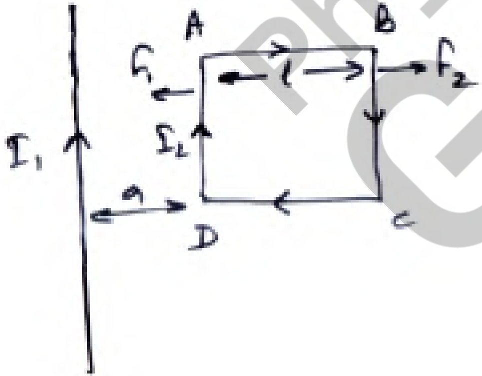
Small loop → magnetic dipole

$\mu = i\pi a^2$

$\vec{\mu}$ is $\parallel^l$ to $\vec{B}$

$\vec{\tau}_{net} = 0$

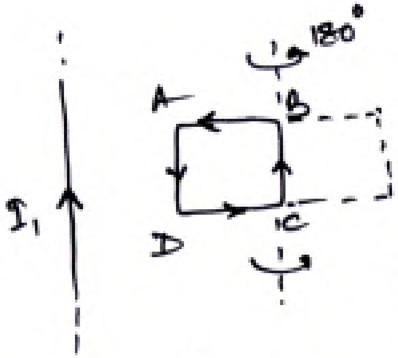
force on dipole $\vec{F} = \vec{\mu}\cdot\frac{d\vec{B}}{dx}\hat{i} =$ ___



$$F_{ABCD} = \frac{\mu_0 I_1 I_2}{2\pi a}\cdot l - \frac{\mu_0 I_1 I_2}{2\pi(a+l)}\cdot l = \checkmark$$

QUESTIONS BASED ON

WORK DONE IN MOVING/CHANGING ORIENTATION OF A COIL



Work done on a coil in MF

$$W = -I\Delta\phi = I(\phi_i - \phi_f)$$

$-NIAB\cos\theta$

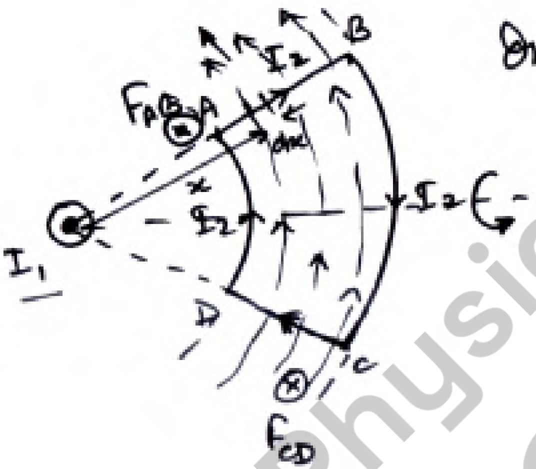
$U = -MB\cos\theta$

magnetic PE of a coil in MF $U = -I\phi$

$$W = U_f - U_i = I(\phi_i - \phi_f)$$

Questions Based on

Magnetic Torque on a Coil in Cross-sectional Plane of a Wire



On wires AD and BC $F_{net} = 0$

anticlockwise rotational torque on loop ABCD.

QUESTIONS BASED ON

DIFFERENT CHARGES ENTERING IN MAGNETIC FIELD AT SAME MOMENTUM

$$R = \frac{mv}{qB}$$

$$\Rightarrow R \propto \frac{1}{q}$$

Same KE particles enter in MF

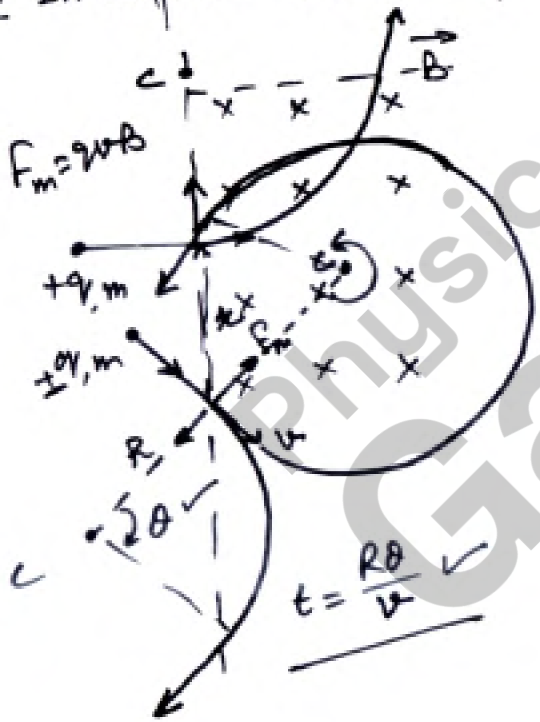
$$R = \frac{\sqrt{2mK}}{qB}$$

$$\left(R \propto \sqrt{m}\right) \text{ \& } \left(R \propto \frac{1}{q}\right)$$

QUESTIONS BASED ON

CIRCULAR PATH IN UNIFORM MAGNETIC FIELD

✓ **NOTE:** In uniform MF, particle from outside can never complete the circle.

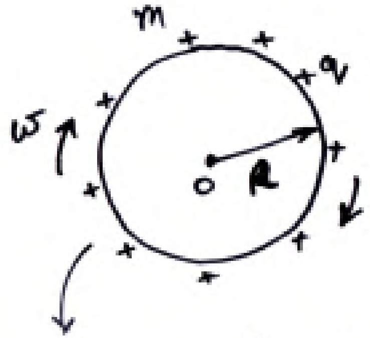


$R = \frac{mv}{qB}$

$t = \frac{R\theta}{v}$

QUESTIONS BASED ON

MAGNETIC FIELD DUE TO ROTATION OF CHARGE



Convection current $I = \frac{q\omega}{2\pi}$

$B_0 = \frac{\mu_0 I}{2R}$

magnetic moment $\mu = I.\pi R^2$

$\mu = \frac{q}{2m} \cdot L$

for a rotating charged body we use $\boxed{\frac{\mu}{L} = \frac{q}{2m}}$

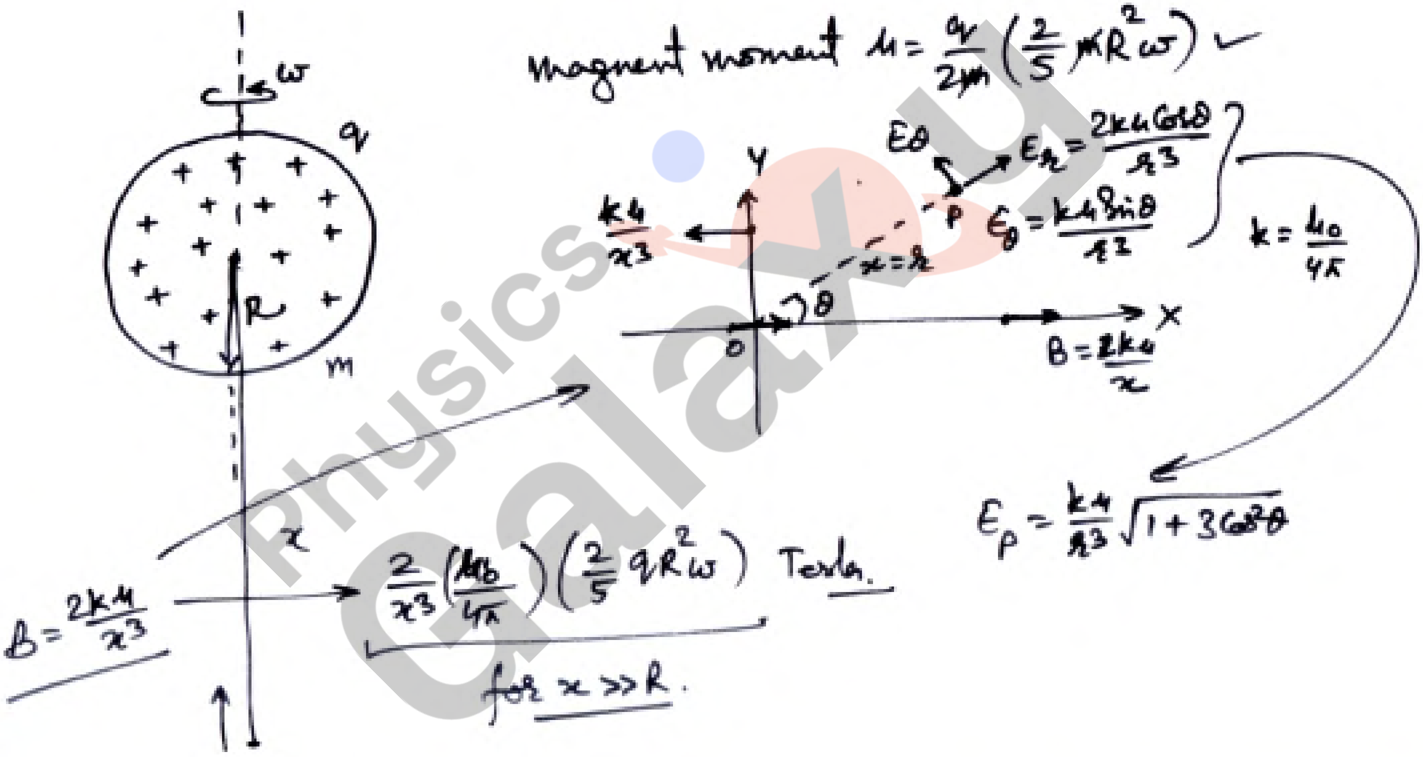
magnetic moment of disc

$q = \sigma . \pi R^2$

$\mu = \frac{q}{2m} \cdot \left(\frac{1}{2} mR^2 \cdot \omega\right)$

Questions Based on

Magnetic Dipole Momentum of a Rotating Sphere



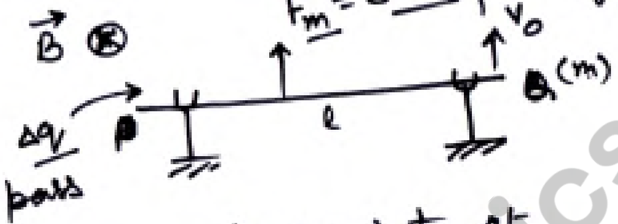
QUESTIONS BASED ON

MAGNETIC IMPULSE ON A WIRE

$v_f = 0$

$h = \frac{v_0^2}{2g} = -$ By impulse eq^n

$f_m = BIl$



$J_m = F\Delta t = mv_0$

$J_m = B\Delta q l = mv_0$

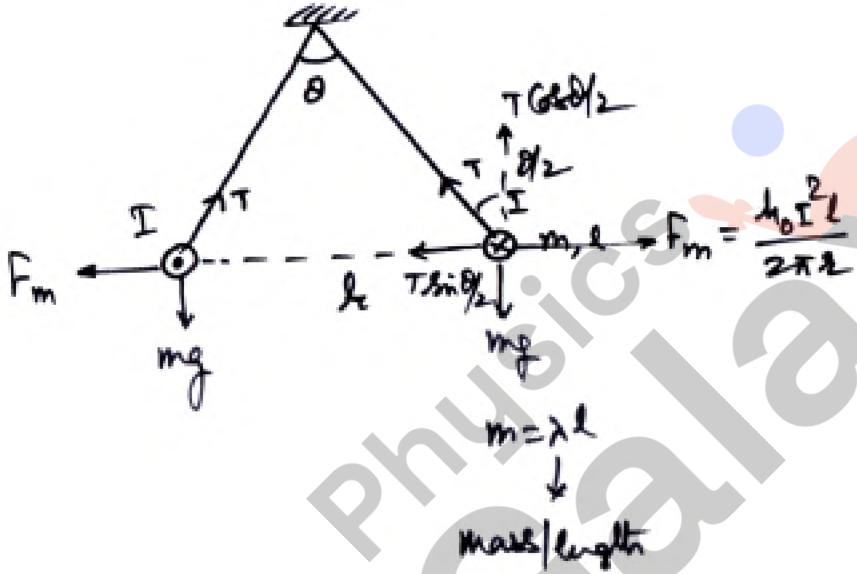
$v_0 = \frac{B\Delta q l}{m}$

Say charge Δq passes in time Δt

$\Rightarrow I_{avg} = \frac{\Delta q}{\Delta t}$

QUESTIONS BASED ON

EQUILIBRIUM OF TWO SUSPENDED WIRES



for wires to be in eq^m

$$T \sin\theta/2 = \frac{\mu_0 I^2 l}{2\pi r} \quad \text{— (1)}$$

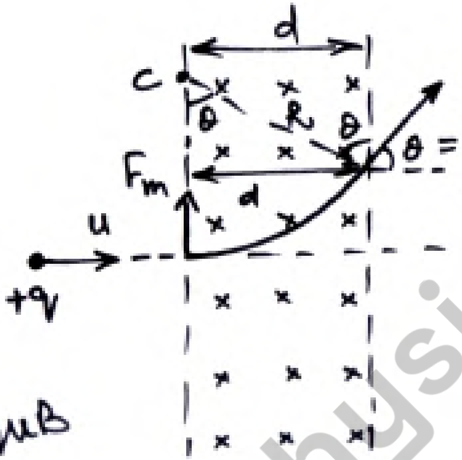
$$T \cos\theta/2 = mg \quad \text{— (2)}$$

$\tan\theta/2 = \ldots$

$T = \sqrt{(\ )^2 + (\ )^2}$

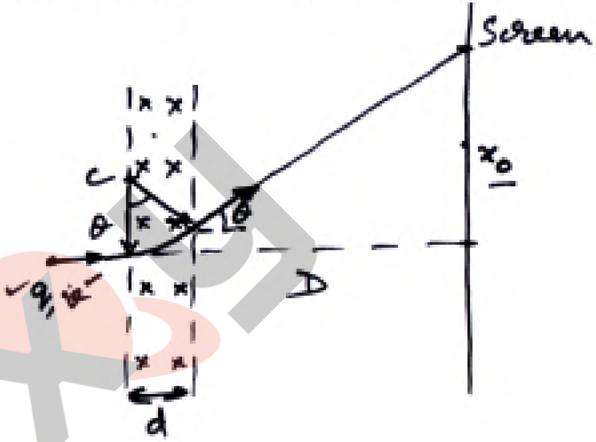
QUESTIONS BASED ON

DEFLECTION OF A CHARGE BY SECTOR OF MAGNETIC FIELD



$\theta = \sin^{-1}\frac{qdB}{mu}$

if $d < R$.



if $d \ll D$

$\Rightarrow x_0 = D\tan\theta$

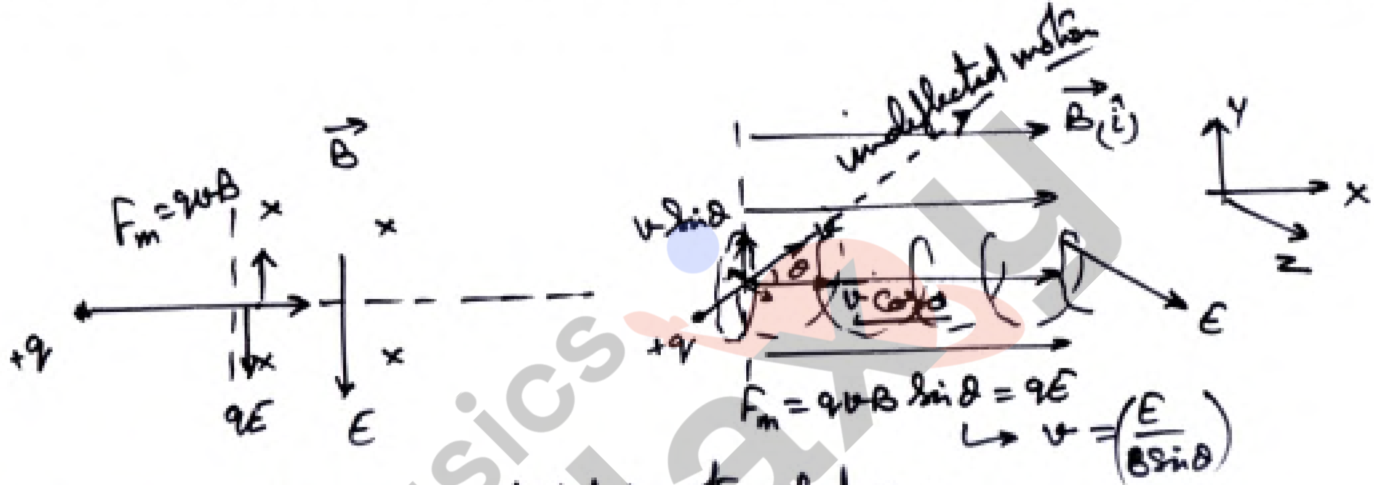
$F_m = quB$

$R = \frac{mu}{qB}$

if $d > R \Rightarrow \theta = 180°$

Questions Based on

Motion of a Charge in Both Electric and Magnetic Field

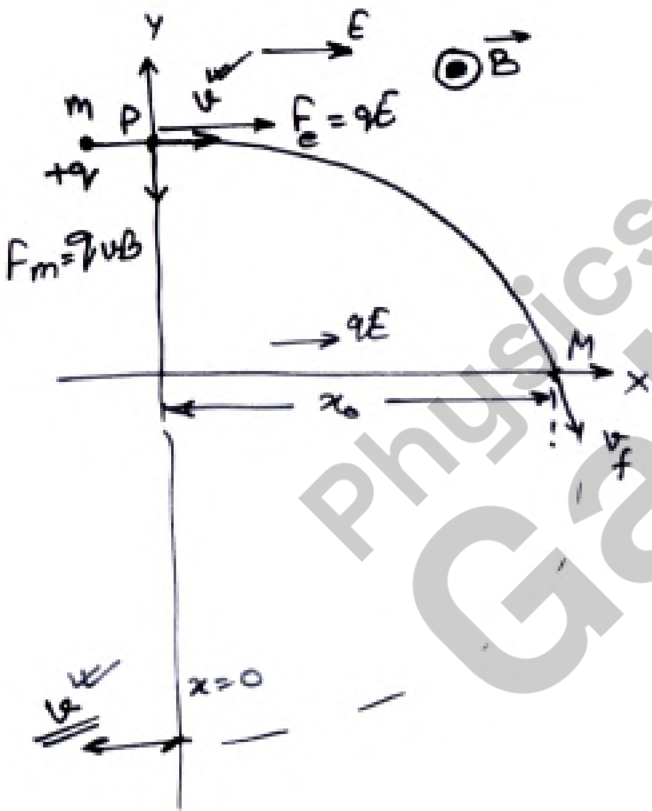


if $qE = qvB \Rightarrow$ it causes undeflected motion of charge

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

Questions Based on

Deflective Motion of a Charge in Both Electric & Magnetic Field



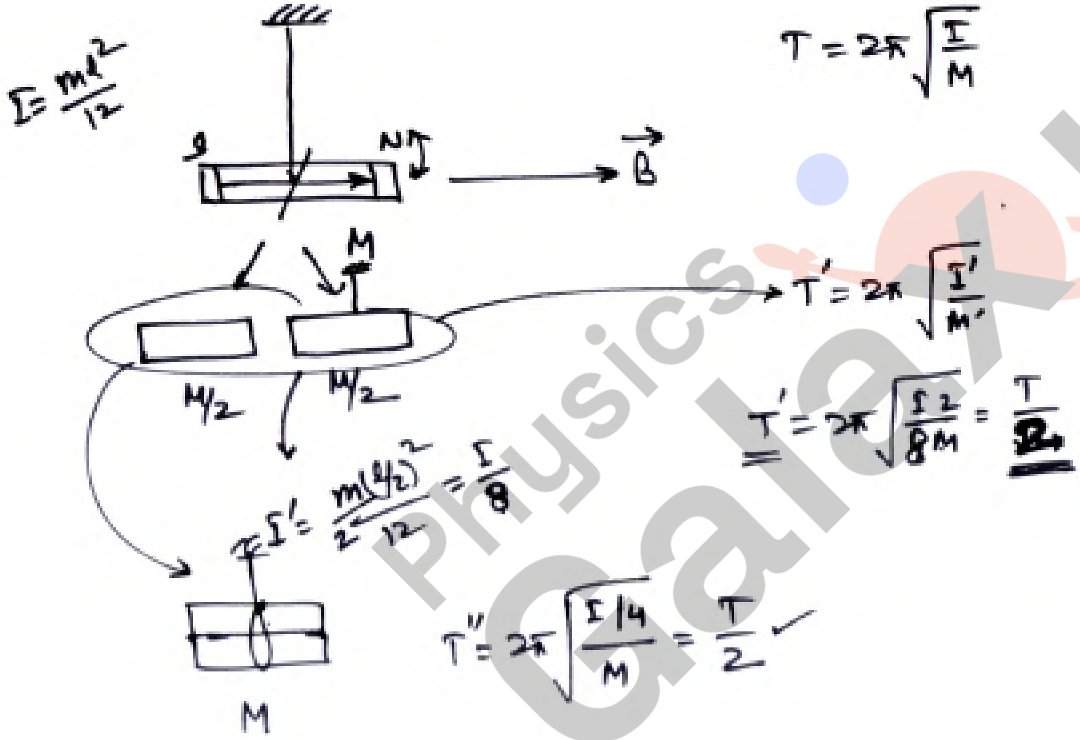
NOTE: WD by F_m is always zero.

from P to M, WD by Electric force

$$W = qEx_0 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv^2$$

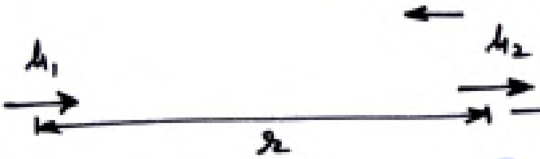
Questions Based on

Breaking an Oscillating Magnet



Questions Based on

Force Between Magnetic Dipoles



$\longrightarrow B_1 = \frac{2k\mu_1}{r^3} = \frac{\mu_0 \mu_1}{2\pi r^3}$ (magnetic moment)

force on μ_2 due to μ_1 is given as

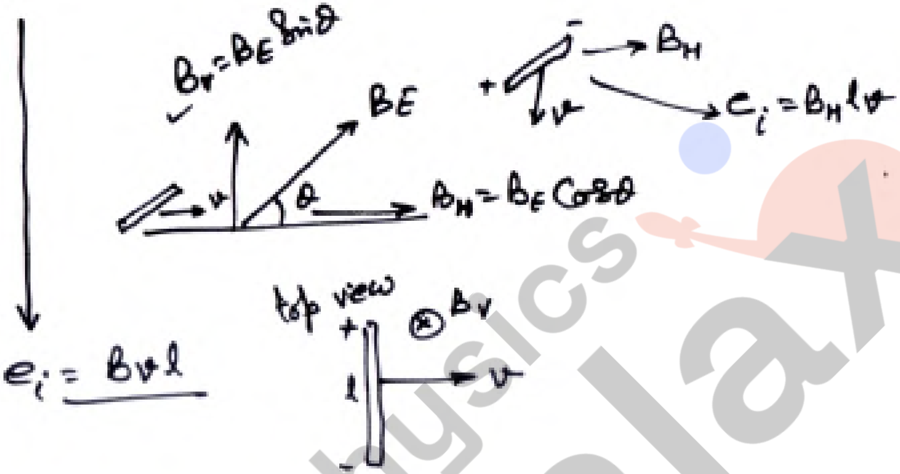
$$F = \mu_2 \frac{dB_1}{dr} = \mu_2\left(-\frac{3\mu_0 \mu_1}{2\pi r^4}\right) = -\frac{3\mu_0 \mu_1 \mu_2}{2\pi r^4}$$ ✓

$$F \propto \frac{1}{r^4}$$

$$F \propto r^n \rightarrow n = -4.$$

Questions Based on

EMF Induced in Earth's Magnetic Field

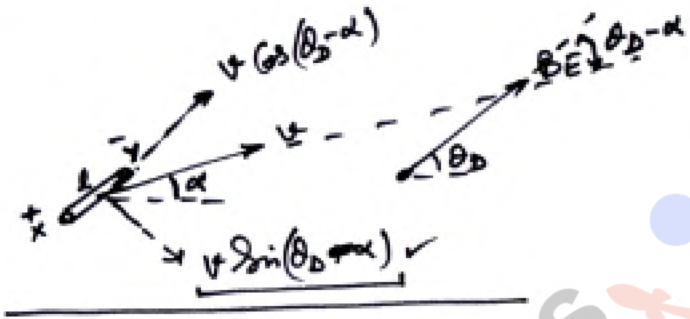


$e_i = B_V v l$

$e = B_V l v$

Questions Based on

EMF Induced in a Conductor in Incleined Motion



Motional emf in cond XY is

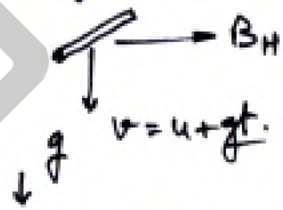
$$e_{xy} = B_E l v \sin(\theta_D - \alpha)$$

Questions Based on

EMF Induced Across Wings of a Plane

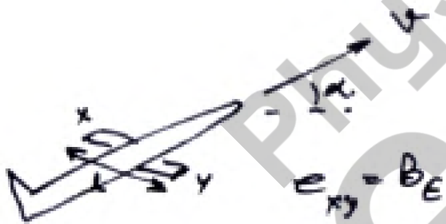
$e = B_V \cdot l \cdot v$

vertically falling Conductor



$v = u + gt$

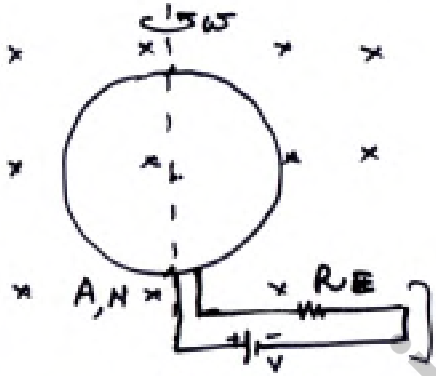
$e = B_H \cdot v \cdot l$



$e_{xy} = B_E \cdot l\, v \sin(\theta_D - \alpha)$

QUESTIONS BASED ON

EMF INDUCED IN A ROTATING COIL



$$i = \frac{V - NBA\omega \sin(\omega t + \theta)}{R}$$

in absence of R_E

$$e = NBA\omega \sin(\omega t + \theta)$$

$$i = \frac{e}{R}$$

$$P_{TH} = i^2 R = \frac{N^2 B^2 A^2 \omega^2}{R} \cdot \sin^2(\omega t + \theta)$$

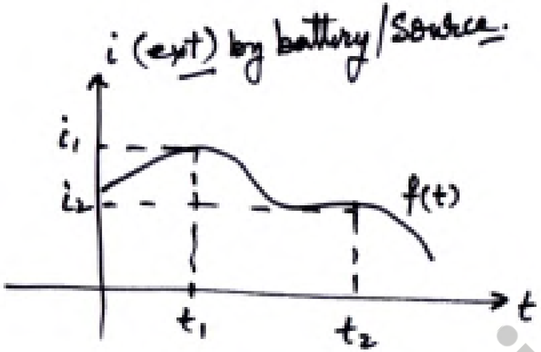
$$P_{avg} = \frac{N^2 B^2 A^2 \omega^2}{2R}$$

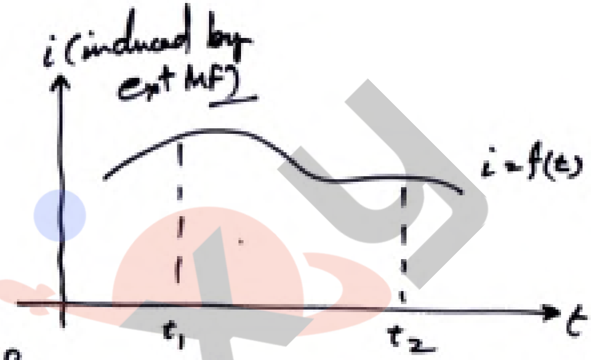
charge flows in a coil due to change in flux

$$\Delta q = \frac{\Delta \phi}{R} = \frac{L \Delta i}{R}$$

Questions Based on

Flux Calculation by Varying Current





$\Delta\phi = ?$

R

$\Delta q_f = \int_{t_1}^{t_2} i\,dt$ = area under i-t curve

$\phi = Li$

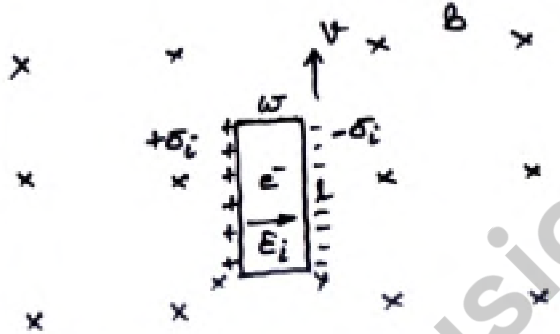
$\Delta\phi = L\Delta i = L(i_2 - i_1)$ ✓

$\Delta q_f = \dfrac{\Delta\phi}{R}$

$\Rightarrow \Delta\phi \propto \Delta q_f \times R$ ✓

QUESTIONS BASED ON

INDUCED SURFACE CHARGES CAUSING MOTIONAL EMF



Induced Surface charge are such that

$$E_i = \frac{\sigma_i}{\epsilon_0}$$

$$\Rightarrow \sigma_i = \epsilon_0 v B.$$

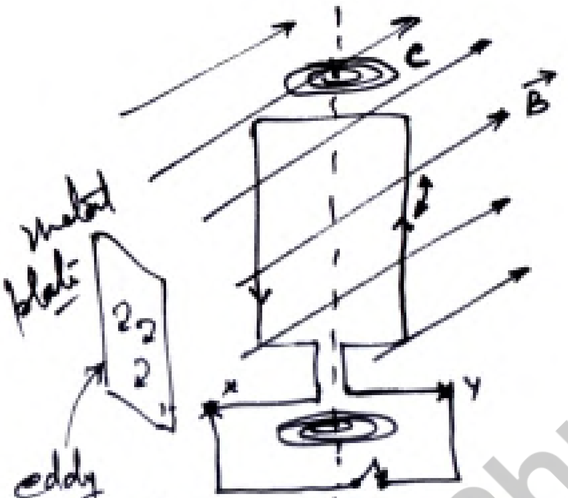
$e_{xy} = Bvw$

$eE_i \longleftrightarrow evB$

inside conductor on e^- $\quad E_i = vB$

QUESTIONS BASED ON

DAMPING OF AN OSCILLATING COIL



eddy current

Restoring torque $\tau_R = c\theta$

$\alpha = -\left(\frac{C}{I}\right)\theta$

In moving coil Galvanometer

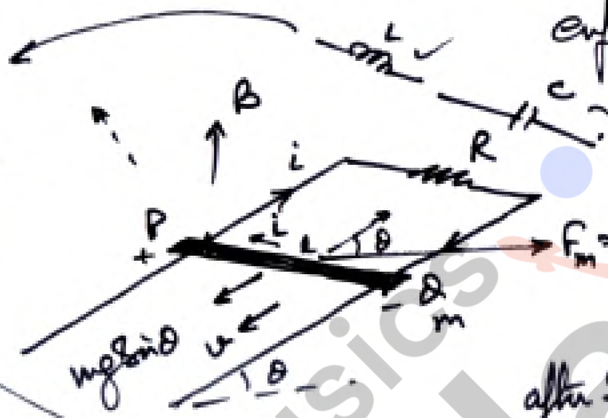
$BINA = C\theta$

$\theta = \left(\frac{BNA}{C}\right)I$

On short ckting x and y, an induced current flows in coil which quickly damps the oscillations.

Questions Based on

Terminal Speed on Inclined Rails



emf in PQ: $e_{PQ} = Blv\cos\theta$

$i = \frac{Blv\cos\theta}{R} = i_T$

$e_{PQ} = L\frac{di}{dt}$

$i = $ ——

$q = Ce_{PQ}$

$i = \frac{dq}{dt} = - -$

eqn of motion

$mg\sin\theta - \frac{B^2l^2v}{R}\cos\theta = ma$

$a = \frac{dv}{dt} = $ ——

$= \frac{v\,dv}{dx} = $ ——

(exp fn in t)

after some time $a = 0$

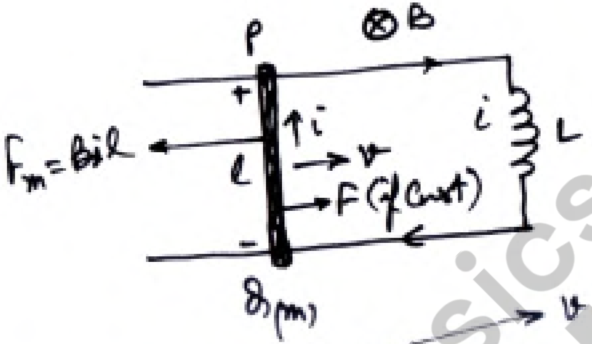
$v_T = \frac{mgR\sin\theta}{B^2l^2\cos^2\theta}$ → Terminal speed.

$[mgv_T = i_T^2R]$

Power supply by grav. forces.

Questions Based on

An Inductor Across Motional EMF



⇒ Rod PQ executes SHM.

If ext force F is present

$F - Bil = ma$

$a = \ldots$

$e_{PQ} = Bvl = L\frac{di}{dt}$ — (1)

$v = \frac{L}{Bl}\frac{di}{dt}$

$\frac{dv}{dt} = a = -\frac{Bil}{m}$

$\frac{L}{Bl}\cdot\frac{d^2i}{dt^2} = -\frac{Bil}{m}$

$\Rightarrow \frac{d^2i}{dt^2} + \left(\frac{B^2l^2}{mL}\right)i = 0$

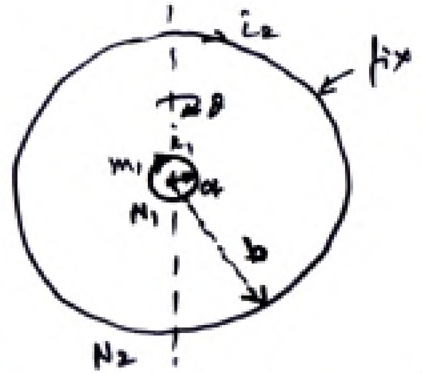
diff eq^n of SHM in i

$i = i_0 \sin(\omega t + \alpha)$

$\omega = \frac{Bl}{\sqrt{mL}}$

Questions Based on

Interaction Between Two Concentric Coils



$a << b$

Stable eq^m → when coils in same plane

On slight disp by θ, Restoring torque on smaller coil

$$\tau_R = -i_1 \pi a^2 N_1 \left(\frac{\mu_0 i_2}{2b} \cdot N_2\right)\theta$$

$$\alpha = -\left[\frac{[\quad]}{\left(\frac{1}{2} m_1 a^2\right)}\right]\theta \leftarrow \omega^2$$

$$T = \frac{2\pi}{\omega} = \_\_$$

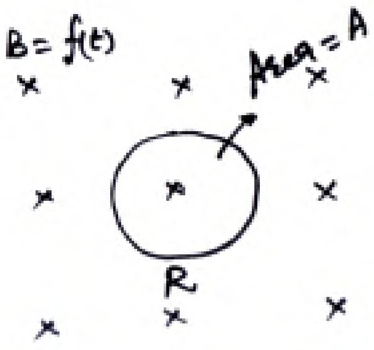
Interaction energy betw^n coils

$$U = -M \cdot B = -(i_1 \pi a^2 N_1)\left(\frac{\mu_0 i_2}{2b} N_2\right)\cos\theta$$

$W_{ext} = U_f - U_i$; $W_{sys} = U_i - U_f$

Questions Based on

Thermal Power Due to TVMF



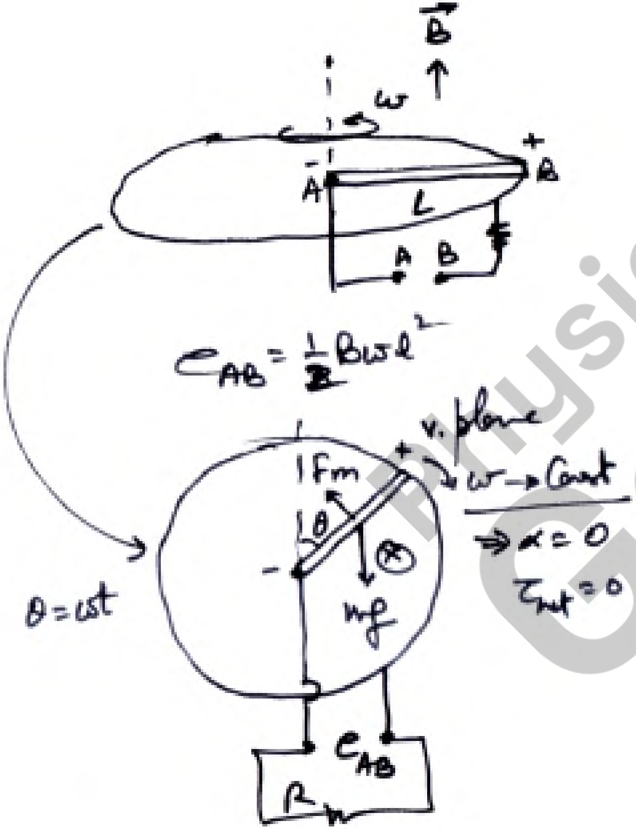
$$e_{coil} = A\frac{dB}{dt}\cdot N$$

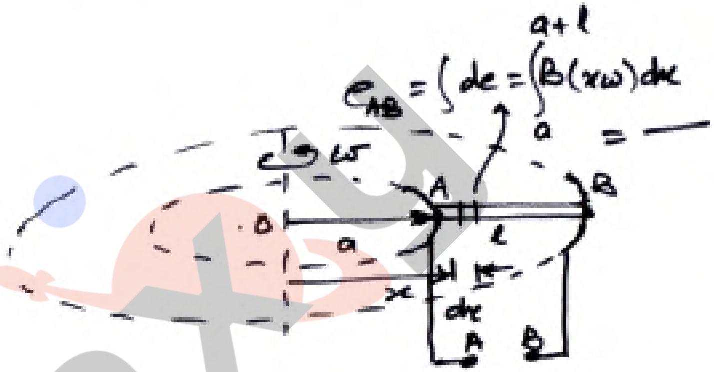
$$i_{coil} = \frac{e_{coil}}{R}$$

$$P_{th} = i_c^2 R = \frac{e_{coil}^2}{R^2}\cdot R = \frac{e_{coil}^2}{R} = \frac{1}{R}\left(\frac{dB_1}{dt}\right)^2$$

Questions Based on

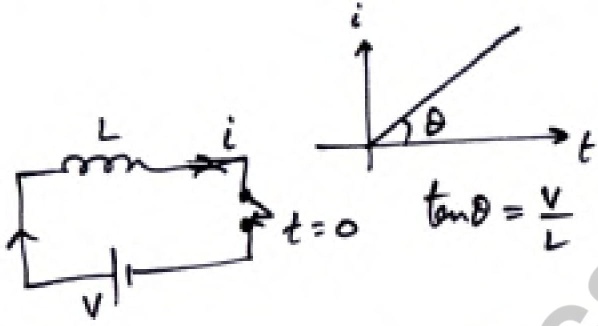
Motional EMF in a Rotating Rod





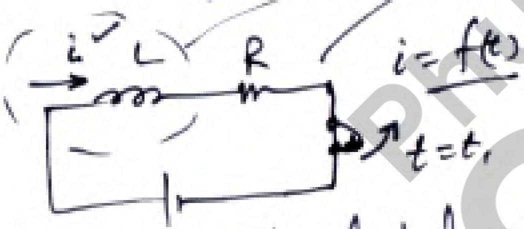
QUESTIONS BASED ON

INDUCTORS IN CIRCUITS



$\tan\theta = \frac{V}{L}$

$i = \frac{V}{L} t$



$i = f(t)$

When inductor is reconnected in any ckt

flux const

$\Rightarrow i_i = i$

$i_t = f(t_1) e^{-R_1 t/L}$

At any instant flux linked with inductor $\phi = Li$

Questions Based on

Transformer Applications & Losses

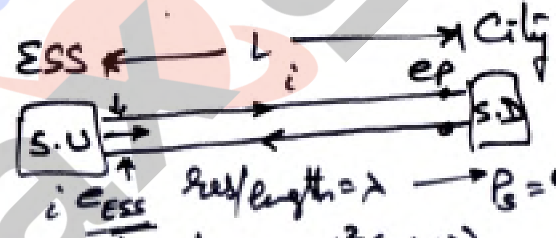
losses < iron → cannot be calculated directly $P_{Li} = P_{TL} - P_{CL}$

losses < copper → $i_p^2 R_p + i_s^2 R_s$

for transfer eqⁿ ⇒ $\frac{e_s}{e_p} = \frac{N_s}{N_p}$

$e_s i_s = e_p i_p - P_{Li} - P_{Lc}$

for ideal T_x $e_s i_s = e_p i_p$

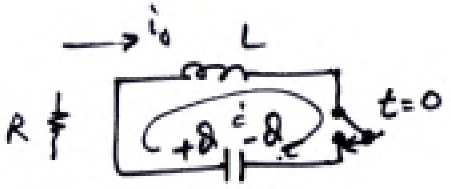


res/length $= \lambda$ → $P_s = e_p i$

Comm line loss $= i^2(\lambda(2L))$

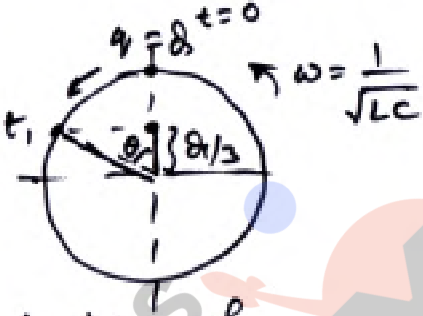
Questions Based on

Phase Charges in LC Oscillations



$Q = 0$

$\alpha_i = 90^\circ$



find time when charge on cap reduces to $Q/3$.

$$\theta = \cos^{-1}\frac{Q/3}{Q}$$

$$t_1 = \frac{\theta}{\omega} = \sqrt{LC}\cos^{-1}(1/3)$$

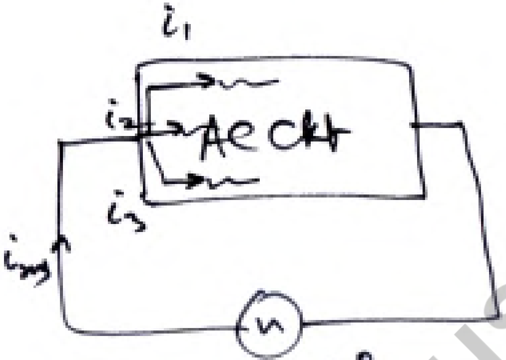
$$q = Q\sin(\omega t + \alpha_i)$$

$$i = Q\omega\cos(\omega t + \alpha_i)$$

$$Q = Q_0 e^{-\beta t}$$

QUESTIONS BASED ON

PHASE ANALYSIS IN AC CIRCUITS

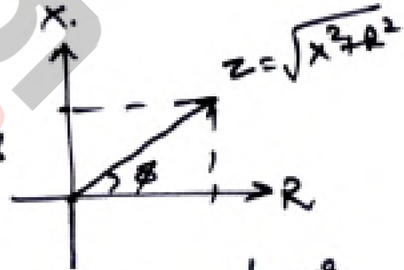


$e = e_0 \angle 0°$

$\bar{i} = \bar{i}_1 + \bar{i}_2 + \bar{i}_3$

$\bar{i} = \frac{\bar{e}}{\bar{Z}} = \frac{e_0 \angle 0°}{Z_0 \angle \phi} = \frac{e_0}{Z_0} \angle -\phi$

$i = \left(\frac{e_0}{Z_0}\right) \sin(\omega t - \phi)$



H.W to analyze instantaneous power

Power → avg = 0

Current → wattless current.

Power factor of ckt = $\cos\phi$

$P_{avg} = i_{rms} e_{rms} \cos\phi$

at $\cos\phi = 1$ → ckt is in resonance.

Resonant ckts – Q-factor, Selectivity, Bandwidth] P/Q.