Solenoid

a) finite length's solenoid.

$$B_{axis} = \frac{1}{2}\mu_0 n I(\cos\theta_1 + \cos\theta_2)$$

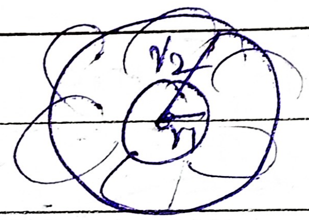
b) long solenoid

$B_{out} = 0.$

$B_{centre} = \mu_0 n I$ $(\theta_1 = \theta_2 \to 0)$

$B_{end\ point} = \frac{1}{2}\mu_0 n I.$

Toroid



$\Rightarrow B_{centre} = 0$

$\Rightarrow$ $r_{av} = \dfrac{r_1 + r_2}{2}$

$\Rightarrow B_{axis} = \mu_0 n I$ $\Rightarrow$ $\dfrac{\mu_0 N I}{2\pi(r_{av})}$

* Lorentz force

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

a) $\vec{v} \perp \vec{B}$, $\Rightarrow$ circular path follows

① $F_m = \dfrac{mv^2}{r}$ $r = mv/qB.$

② $r = \dfrac{\sqrt{2m\Delta K_f}}{qB}$ $K_f = K - K_{initial}$

$p = mv = \sqrt{2mK}$

$M = NIA$ → closed body

$M = \frac{qL}{2m}$ → point charge

$M = m \times l_e$ → bar magnet

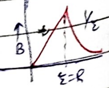
2) Solid pipe | Conducting wire

① $B_{outside} = \frac{\mu_0}{4\pi}\frac{2I}{r}$

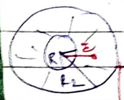
$B_{out} = B_s \times R/r$

$B_{surface} = \frac{\mu_0}{4\pi}\frac{2I}{R}$

$B_{inside} = B_s\, r/R$



3) Annular pipe



$B_{out} = \frac{\mu_0}{4\pi}\frac{2I}{r}$

$B_{inside} = \frac{\mu_0 2I}{4\pi r}\left[\frac{r^2 - R_1^2}{R_2^2 - R_1^2}\right]$

Solenoid

a) finite length's solenoid.

$B_{axis} = \frac{1}{2}\mu_0 nI(\cos\theta_1 + \cos\theta_2)$

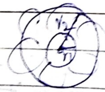
b) long solenoid

$B_{out} = 0$

$B_{centre} = \mu_0 nI$ ($\theta_1 = \theta_2 = 0$)

$B_{end\ point} = \frac{1}{2}\mu_0 nI$

Toroid



⇒ $B_{centre} = 0$

⇒ $r_{av} = \frac{r_1 + r_2}{2}$

⇒ $B_{axis} = \mu_0 nI$ ⇒ $\frac{\mu_0 NI}{2\pi(r_{av})}$

* Lorentz force

$F = qvB\sin\theta$ $\quad \vec{F} = q(\vec{v} \times \vec{B})$

a) $\vec{v} \perp \vec{B}$, ⇒ circular path forms

① $F_m = \frac{mv^2}{r}$ $\quad r = mv/qB$

② $r = \frac{\sqrt{2mK_f}}{qB}$ $\quad K_f = K - K_{initial}$

$P = mv = \sqrt{2mK}$

④ Time period ⇒ $T = \frac{2\pi m}{qB}$

$T \propto$ 1/specific charge

b) Helical path

① $r = \frac{mv_\perp}{qB} = \frac{mv\sin\theta}{qB}$

② Time period

$T = 2\pi m/qB$

③ pitch = speed × Time

$= v_{\parallel} \times T = 2\pi(r)\cot\theta$

$= v\cos\theta \times 2\pi m/qB$

$= 2\pi\left(\frac{mv}{qB}\right)\cos\theta$

$= \frac{2\pi\sqrt{2mK}}{qB}\cos\theta$

Cyclotron

$E_{max} = \frac{q^2B^2r^2}{2m}$

$K_{max} = \frac{q^2B^2r^2}{2m}$

No. of oscillation $= \frac{q^2B^2r^2}{2m}$

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

Force on a straight line

$F = IlB\sin\theta$

or IBl_{eff} $\quad \theta = 90°$ $\quad l_{eff}$

Tension in current carrying ring

$T = RBI$

force b/w 2 ∥el current carrying conductor

$F_1 = F_2 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r} \times l$

Lorentz force (when E.F and M.F.)

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

$\frac{E}{B} = V$ when $E \perp V \perp B$

~~Magnetism – Part ②~~

ⓐ current loop as a magnetic dipole

$M = NIA$

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

② $\tau = NIBA\sin\theta$ ⇒ $MB\sin\theta$

⇒ $W_{max} = +MB(\cos\theta_1 - \cos\theta_2)$

⇒ $U = -M.B.\cos\theta$

Moving coil galvanometer.

① $NIBA = C\phi$ $\quad$ C = torsional const, φ = angle of defln

② current sensitivity $= \frac{\phi}{I} = \frac{NBA}{C}$

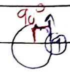
③ Voltage sensitivity ; $\frac{\text{current sensitivity}}{R}$

$I = \left(\frac{C}{NBA}\right)\phi$ ← Galvanometric const.

Biot-Savart law for moving charges

① $B = \frac{\mu_0}{4\pi}\frac{qv\sin\theta}{r^2}$

② Revolving charge



$B = \frac{\mu_0}{4\pi}\frac{qv}{r^2}$

③ angular velocity ($v = r\omega$)

$B = \frac{\mu_0}{4\pi}\frac{q\omega}{r}$

If we have the eqn of orbital motion of e^-, then put $q = e$

④ magnetic dipole moment of Revolving charge

$\frac{M}{L} = \frac{q}{2m}$ $\quad L = I\omega$

point charge	$I = mr^2$
Ring	$I = mr^2$
Disc	$I = \frac{1}{2}mr^2$
Hollow sphere	$I = \frac{2}{3}mr^2$
solid sphere	$I = \frac{2}{5}mr^2$

M value for $e^\ominus$

$M = \left(\frac{eh}{4\pi m}\right)n$ — shell no. not atomic no.

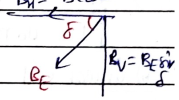
Bar magnet $\quad$ $\frac{\sin(\theta/2)}{(\theta/2)}$

$M_{new} = \frac{M_{original}\sin(\theta/2)}{(\theta/2)}$

The concept E.F and potential same applied to m.f. too.

Earth Magnetism

① $\tan\delta = \frac{B_V}{B_H}$



$B_H = B\cos\delta$

$B_V = B_E\sin\delta$

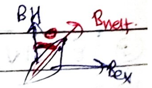
② $B_E = \sqrt{(B_V)^2 + (B_H)^2}$

③ $\tan\delta' = \frac{\tan\delta}{\cos\theta}$ → false angle of dip.

* True angle of dip

$\cot^2\delta_1 + \cot^2\delta_2 = \cot^2\delta$

Tangent law for ⊥er field



$B_{ext} = B_H\tan\theta$

Tangent galvanometer.

$\frac{\mu_0 nI}{2R} = B_H\tan\theta$

For dc current

$\mathcal{E} - \mathcal{E}_{ind} = IR$

$\phi_{single} = BA$

$\phi_{Total} = LI = N\phi$

Electromagnetic Induction

① $\phi = B.A.\cos\theta$

② Induced current. $I_{ind} = \frac{\mathcal{E}_{ind}}{R}$

$$I_{ind} = \left|\frac{\Delta\phi}{\Delta t}\right| \times R$$

③ induced charge

$$q_{ind} = \int I_{ind}.dt = \frac{1}{R}\frac{d\phi}{dt} \times dt = \frac{\Delta\phi}{R}$$

self Induction

① $\mathcal{E}_{ind} = -\frac{\Delta\phi}{\Delta t} = -\frac{L\Delta I}{\Delta t}$

② Induced current

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = -\frac{L\Delta I}{R\Delta t}$$

③ charge flown due to induced current.

$$q_{flown} = \frac{L\Delta I}{R}$$

④ Energy stored $U = \frac{1}{2}LI^2$

⑤ Energy density $U = \frac{B^2}{2\mu_0}$

⑥ coefficient of self Induction (L)

a) for (coil) ← $B = \mu_0 n I$ (solenoid)

$L = \mu_0 n N A$ $(n = N/l)$

b) circular coil ← $B = \frac{\mu_0 I}{2R}$

$L = \frac{\mu_0 \pi R}{2}$

$\phi_{Total} = N\phi_{single} = NBA$, $A = \pi R^2$

coaxial solenoid

$M = \mu_0 n_p N_s A_s$ } Mutual Inductance

A_s = Area in which 2° coil wrapped 1° coil

⑦ $\mathcal{E} = Blv \sin\theta$ $\mathcal{E} = Blv$

motional EMF due to Rotational motion

$$\mathcal{E} = \frac{1}{2}Bl^2\omega$$

$$\mathcal{E}_{ind} = \mathcal{E}_0 \sin(\omega t)$$

$\mathcal{E}_0 = NBA\omega$ ⊣ peak value

Transformer

$$\frac{\mathcal{E}_s}{\mathcal{E}_p} = \frac{N_s}{N_p} = \eta\frac{I_p}{I_s}$$

⊣ $\eta = \frac{P_{output}}{P_{input}}$

L.C. - oscillations

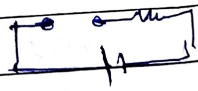
L.C. oscill^n	comparison
① $Q = Q_0 \cos\omega t$	$I = I_0 \sin\omega t$
② $I = \omega\sqrt{Q_0^2 - Q^2}$	$V = \omega\sqrt{A^2 - x^2}$
③ $I = I_0 \sin(\omega t)$	

Q_0 = max. charge

Q = derived from question

How to solve L-R circuit at initial and final stage (Dc-motor)

i) initial stage $(t=0)$



ii) final stage $(t=\infty)$