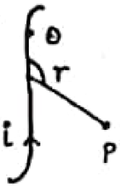
Master Card for quick revision of 3. Magnetic effect of current (8marks)

Magnetic Field : Produced by magnet, moving charge. Vector quantity.
Unit - Tesla (weber/m²), Gauss (maxwell/cm²) $1T = 10^4 G$

Oested Experiment : Current carrying conductor produces magnetic field.

Bio Savart Law: It gives m.f. at a point around current carrying conductor.



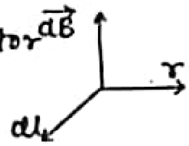
$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}$$

$\frac{\mu_0}{4\pi} = 10^{-7}\ TmA^{-1}$

μ_0 - Permeability of freespace

Direction of B : Perpendicular to dl and r.

$B = 0$ if $\sin\theta = 0$ ie on conductor



$B = max$ $\sin\theta = 1$ $\theta = 90°$ ⊥r to wire.

VECTOR FORM $$\vec{dB} = \frac{\mu_0}{4\pi}\frac{i\vec{dl}\times\vec{r}}{|\vec{r}|^3}$$

Ampere's Circuital Law: $\oint B.dl = \mu_0 i$

The line integral of magnetic field B around any closed circuit is equal to μ_0 times the current i threading through this closed circuit. closed ~~current~~ loop is called Amperian loop.

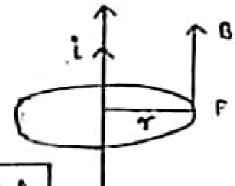
B. Due to Infinitely Long Wire :

Magnetic field at P due to wire

$\int B.dl = \mu_0 i$

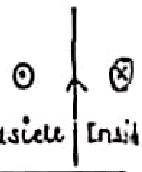
$B\int dl = \mu_0 i$

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



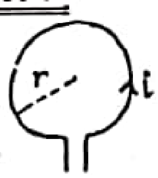
$\therefore$ $$B = \frac{\mu_0}{4\pi}\frac{2i}{r}$$

Direction : Right Hand Thumb Rule
curly finger gives field direction if thumb of right hand points current



Mag. Field At Centre of Coil :-

$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin 90°}{r^2}$



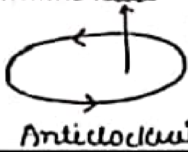
$\therefore B = \Sigma dB = \frac{\mu_0}{4\pi}\frac{i}{r^2}\Sigma dl$

$= \frac{\mu_0}{4\pi}\frac{i}{r^2}(2\pi r)$

$$B = \frac{\mu_0 i}{2r} \quad \text{OR} \quad B = \frac{\mu_0 n i}{2r}$$

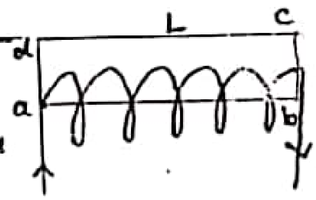
Direction : Right Hand Thumb Rule.

Clockwise



Anticlockwise

B. due To Solenoid :-



$\int B\,dl = B.dl\cos\theta$

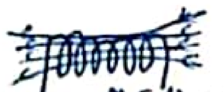
N - Total Turns

$\int_a^d B.dl = \mu_0 i$

$\int_a^b B.dl + \int_b^c B.dl + \int_c^d B.dl + \int_d^a B.dl = \mu_0 (Ni)$

$\int_a^b B.dl + 0 + 0 + 0 = \mu_0 (Ni)$

$(\theta = 0°)$ $(\theta{:}90°)$(outside), $(\theta{:}90°)$



$B.\int_a^b dl = \mu_0 Ni$ $B.L = \mu_0 n i$

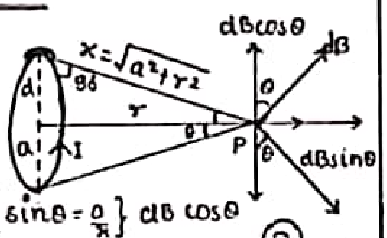
$\therefore B = \mu_0 n i$ $n = \frac{N}{L}$ Turn per unit Length

On Axis of Coil :-

$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin 90°}{x^2}$

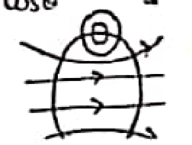
$\therefore B = \Sigma dB\sin\theta$

$= \frac{\mu_0 i(2\pi a)}{4\pi x^2}\cdot\frac{a}{x}$



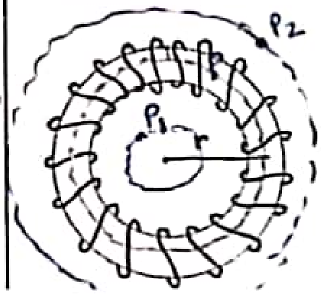
$\{\sin\theta = \frac{a}{x}\}$ dB cosθ

$$B = \frac{\mu_0 n i a^2}{2(a^2+r^2)^{3/2}}$$



Magnetic Field lines ...

B. Due to Toroid : (closed Solenoid)



$\oint B.dl = \mu_0 Ni$

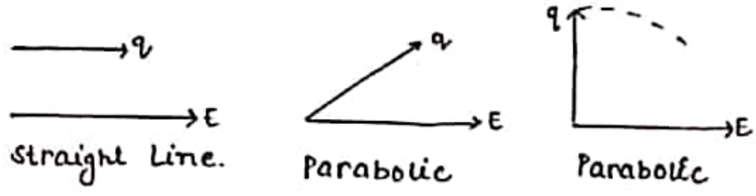
$B(2\pi r) = \mu_0 Ni$

$B = \frac{\mu_0}{2\pi}\frac{Ni}{r}$ $\left\{n = \frac{N}{2\pi r}\right\}$

$B = \mu_0 n i$ - at P

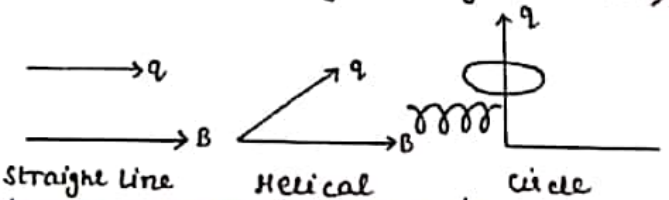
Force on Charge in Electric field

$F = qE$ (both for rest & motion)



Magnetic Field

$F = qvB\sin\theta$ (Only for charge in Motion)



direction - FLHR / RH Palm rule

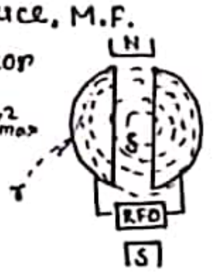
Lorentz Force : $F = qE + qvB\sin\theta = q(E + vB\sin\theta)$ [$V = E/B$ un deflected]

CYCLOTRON :

Used to accelerate charge Particles.

Principle: The repeated motion of charged particles under mag. & elec. field accelerates it. E.F. provides energy while M.F. changes direction.

Construction : Dees, Source, M.F. R.F. Oscillator



Working: Max KE $= 1/2\, m v^2_{max}$

$= \frac{1}{2} m \left(\frac{qBr}{m}\right)^2$

$$\boxed{K.E. = \frac{1}{2}\frac{q^2B^2r^2}{m}}$$

Current Sensitivity : Deflection per unit current

$\left(I_s = \frac{\phi}{I} = \frac{I}{G} = \frac{BAN}{C}\right)$ Radian / Ampere.

Voltage Sensitivity : Deflection per unit voltage.

$\boxed{V_s = \frac{I_s}{R}}$ $\left(V_s = \frac{\phi}{V} = \frac{\phi}{ir} = \frac{BAN}{CR}\right)$ Radian / Ampere × Ω

Limitation : → Only charged particles can be accelerated

→ light particles like e⁻ can't be accelerated

$\left(\frac{mv^2}{r} = qvB,\ \therefore r = \frac{mv}{qB},\ \boxed{r \propto v}\right)$ $\boxed{K.E. = \frac{1}{2}\frac{q^2B^2r^2}{m}}$

∴ Time Period = Dis/velocity $= 2\pi r/v = \frac{2\pi r \cdot m}{r q B}$

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

∴ Frequency of Revolution : $f = \frac{1}{T} = \frac{qB}{2\pi m}$.

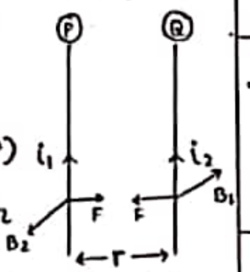
★ **Application :** For nuclear reaction & other research purpose.

Force B/W 2 Parallel Current Carrying Wire:

Force acting on Q due to P.

$F = \left(\frac{\mu_0}{4\pi}\frac{2i_1}{r}\right) i_2 l \sin 90°$

$\boxed{F = \left(\frac{\mu_0}{4\pi}\right)\frac{2 i_1 i_2}{r}}$ ($F = Bil\sin\theta$) for unit length



By Flemings LHR force is of attraction for same direction of current and force of repulsion for opposite direction of current.

if $i_1 = i_2 = 1A$, $r = 1m$.

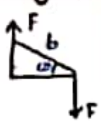
then $\boxed{F = 2 \times 10^{-7} N.}$

Torque Experienced By a Current Loop in Uniform M.F.

$\tau = F \times \perp$ distance

$BIl \times b\sin\theta$

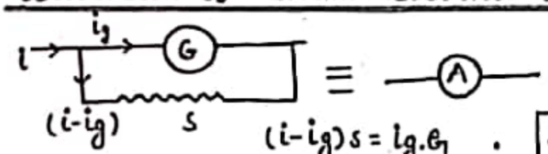
$\boxed{\tau = BiA\sin\theta}$



For N Turns

$\boxed{\tau = BiNA\sin\theta}$

Conversion of Galvanometer Into Ammeter :



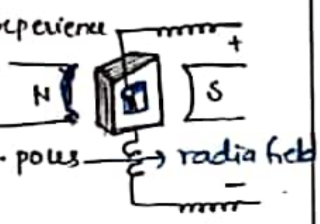
$(i - i_g)S = i_g \cdot G$ ∴ $\boxed{S = \frac{i_g \cdot G}{i - i_g}}$

Resistance of mA > A (as $S \propto \frac{1}{i}$)

Moving Coil Galvanometer :-

Device to detect & measure electric current.

Principle : Current loop experience torque in uniform M.F.



Construction : Concave mag. poles, light coil.

Theory : Deflecting Torque = Restoring force (torque)

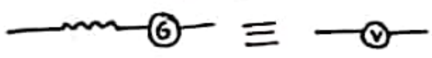
$BiNA\sin\theta = C\phi$

($\theta = 90°$) as field is radial ∴ $BiNA = C\phi$

$i = C\phi$ ...

Conversion Into Voltmeter :-

By connecting high resistance in series :



$V = i_g(R+G)$, $\frac{V}{i_g} = (R+G)$, ∴ $\boxed{R = \frac{V}{i_g} - G}$

{For Ideal Voltmeter, $R = \infty$}

{For Ideal Ammeter $R = 0$}.

Force on current carrying conductor in MF :

...

1