Gauss Law in Magnetism

* Alg to this law in Magnetism net M.flux through any close surface is zero.
* We can conclude that from Gauss Law that Isolated M.pole (monopole) doesn't exist.
* M. lines of forces always form close loop. $\oint \vec{B}\cdot d\vec{a} = 0$

Electro

$\Phi = \oint \vec{E}\cdot d\vec{a} = \frac{q_{enc}}{\epsilon_0}$ { doesn't form close loop.

Moving coil Galvanometer

$\tau = C\phi$ ($\tau \propto I$ deflecting) $\phi = \frac{NIAB}{C}$ (deflection)

Current sensitivity [C.S]

$C.S = \frac{\text{deflection}}{\text{current}} = \frac{\phi}{I}$

$C.S = \frac{\phi}{I} = \frac{NAB}{C}$

If $N \to 2N$, C.S → 2 times but N.C → No effect

Voltage Sensitivity [V.S]

$V.S = \frac{\text{deflection}}{\text{Voltage}} = \frac{\phi}{V}$

$V.S = \frac{\phi}{V} = \frac{NAB}{CR}$

bez ($V.S \propto \frac{N^2}{RT}$)

Magnetic Material

(A) Atomic Magnetisation

$I = \frac{ev}{2\pi r}$ I → Equivalent current

$time = \frac{dist}{speed} = \frac{2\pi r}{v}$

$I = \frac{1}{t}$

M.field at the centre

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

$r \propto \sqrt{\frac{V}{B}}$ → self M.field

$r \propto \frac{V}{B}$ → ext. M.field

M.moment due to orbital motion of electron

$M = \frac{1}{2} e v r$ ($M = IA$)

* Due to orbital motion of e^- & spin motion of e^- → Net M.moment

① Each atom का individual M.moment Zero होगा. ↓ Diamagnetic material

Total = 0

② Each atom का individual M.moment होगा ↓ Para / Ferro

Paramagnetic material ↓ due to random orientation ↓ net M.moment of material / block / specimen is (Zero)

Behaviour of Magnetic material in Ext. M.field

Diamagnetic

* Diamagnetic is Universal. It is ⊕ in all materials but it is a weak phenomena & hard to detect if the substance is para & ferro.

③ Loop की Eqm → θ = 0° F = 0, τ = 0 Stable
→ θ = 180° F = 0 τ = 0 Unstable

* If the coil is slightly disturbed from its eqm position then it will SHM. Time Period

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

I → Moment of Inertia
M → Magnetic moment.

* Coil is placed ⊥ to the field (2π) plane of coil is ⊥ to the field.

$\downarrow\downarrow$

$\theta = 0°$

④ Work Done

$$W = MB[\cos\theta_1 - \cos\theta_2]$$

θ_1 → Initial angle
θ_2 → Final angle.

⑤ Potential Energy

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

θ → Angle b/w $\vec{M}$ & $\vec{B}$

$$U = -MB\cos\theta$$

Concept

For a given Perimeter
↳ circle have greatest area.

* Force b/w Parallel moving charges.

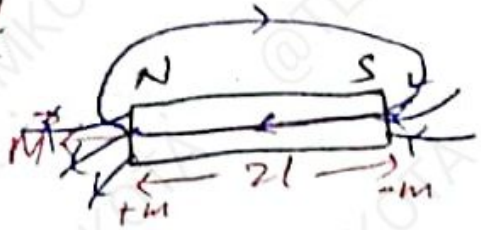
$$\frac{F_{mag}}{F_{electro}} = \frac{v^2}{c^2}$$

$F_{mag} << F_{electro}$

Sec-D

* Bar Maghel

$$\vec{M} = m(2\vec{l})$$



l → दोनों pole के बीच की लंबाई/दूरी
m → pole strength.
M → M. moment.

* m ∝ cross sectional area of maghel

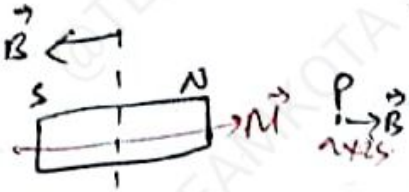
(m ∝ A)

* $\vec{M}$ की पूंछ हमेशा South ⇄ North की तरफ

$$\tau = MB\sin\theta \qquad W = MB(\cos\theta_1 - \cos\theta_2) \qquad U = -MB\sin\theta$$

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

* M. moment of toroid is zero
* M. moment of solenoid (= NIA) along the axis.



$$B_{axis} = 2\left(\frac{\mu_0}{4\pi}\right)\frac{M}{r^3}$$

$\theta = 0°$

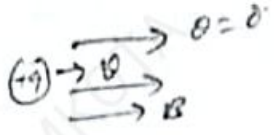
$$B_{equi} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$$

$\theta = 180°$

1 Gauss = 10^{-4} T

Case-2 $\theta = 0$

path → Straight line. $F = qvB\sin\theta$ $(F = 0)$



Case-3

At any angle θ

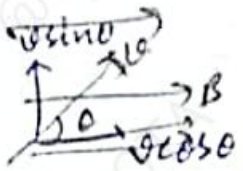
(a) Path → Helical

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

(c) $T = \frac{2\pi m}{qB}$

(d) Pitch = $x = l$ = speed × time

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



$v\sin\theta \Rightarrow$ Circular

$\Rightarrow$ Helical.

$v\cos\theta$

$\Downarrow$

St. line

Force on a current carrying conductor placed in M. field

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

$F = BIL\sin\theta$



ext. field inwise kaam hai

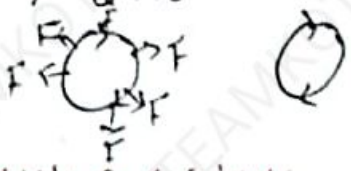
$\vec{l}$ → disp vector.

(Effective length)

Notes

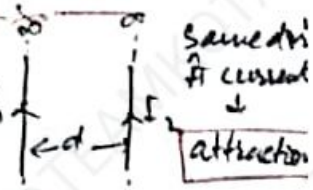
* Whenever a current carrying loop is placed in a Uniform M. field then Net force on the loop is always Zero.

$\text{Tension in loop} = RBI$



Force b/w Parallel current carrying wires.

$\frac{\text{Force}}{\text{Length}} = \frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$ $\quad F = \frac{\mu_0 I_1 I_2 l}{2\pi d}$



Current carrying wire placed on inclined plane.

$mg\sin\theta = BIl\sin\theta$ Smooth & Stationary.

M. moment of current carrying coil.

① $\vec{M} = NI\vec{A}$ * A current carrying coil behave like a Magnet dipole.

Unit → Amp-m²



$M_{net} = \sqrt{M_1^2 + M_2^2}$



② Torque in Ext. M. field

$\tau = BINA\sin\theta$ $\quad \tau = \vec{M} \times \vec{B}$

$\tau = MB\sin\theta$

θ → angle b/w $\vec{M}$ & $\vec{B}$

02-01-...

Sec-A: Magnetic Effect of Current

* Static charge → Produces only E. field.
* Moving charge → Produces both E. field & M. field.
* Current carrying conductor. (Neutral) → Produces only M. field in the surrounding region

BSL

dl → current element

$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{I\,dl\sin\theta}{r^2}$$

Vector Form

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}$$

Idl → current element
B → M. field (Tesla) or Weber/m²
μ_0 → absolute Permeability of free space.

① M. field due to current carrying Wire

case① Finite wire

$$B = \frac{\mu_0 I}{4\pi a}[\sin\theta_1 + \sin\theta_2]$$

θ_1, θ_2 → ⊥ from P

case② Semi-Infinite wire

$$B = \frac{\mu_0 I}{4\pi a}$$

case③ Infinite wire

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

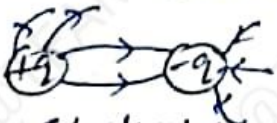
case④ On the axis of wire

$$B_P = 0$$

Dirⁿ of M. field due to current carrying wire

Right Hand Thumb Rule

Thumb → in the dirⁿ of current
Curl Fingers → represent dirⁿ of M. field in the surrounding region



Electrostatic Field lines never form close loop.



M. field lines of forces always form closed loop.

C → cross
c → clockwise
⊙ → anticlockwise

⊗ → ⊥r. to plane & inward
⊙ → ⊥r. to plane & outward.

⊗ - ⊙ Path (Knock Knock Rule)

⊙ ↑ ⊗ ⟶ ⊗ ↓ ⊙

Thumb → in the dirⁿ of current
⊥r. to palm → represent dirⁿ of M. field.

Regular Polygon at Centre.

$$B = n\frac{\mu_0 I}{\pi a}\tan\left(\frac{\pi}{n}\right)\sin\left(\frac{\pi}{n}\right)$$

a → side of Polygon.

② M. field at the centre of current carrying circular coil.



$$B_{centre} = \frac{N\mu_0 I}{2R}$$

Semi-circular coil

$$B_{centre} = \frac{N\mu_0 I}{4R}$$

Arc

$$B_{centre} = \frac{\mu_0 I\theta}{4\pi R}$$

Quadrant

$B_{centre} = \frac{\mu_0 I}{8R}$

Concept

Fix length of wire is bent into circular loop.

$L = 2\pi R$.

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

$B \propto N^2$

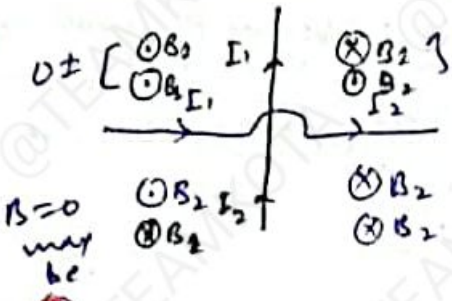
Concept

When plane of circular coils are ⊥r. to each other.

$B_{net} = \sqrt{B_1^2 + B_2^2}$

Concept

Location of Null point



Concept

* If current divide in a regular shaped loop of same material, then net field at centre is always zero.

$B_{centre} = 0$



App-③

M. field on the axis of current carrying circular coil.



x → axial distance.

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

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

* $x << R$

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

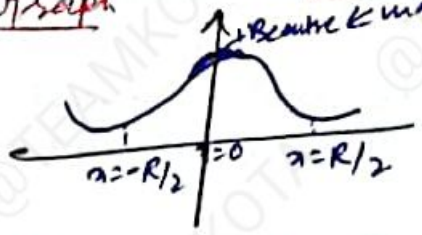
Fractional decrease.

$\frac{\Delta B}{B} = \frac{3}{2}\frac{x^2}{R^2}$

* $x >>> R$

$B_{axis} \propto \frac{1}{x^3}$

Graph



$x = \pm R/2$

↳ 2 point of inflexion ⇒ curvature change.

$B_{centre} = \frac{N \mu_0 I}{2R}$

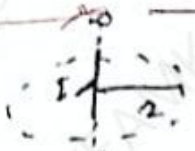
Ampere's Law

$\oint \vec{B} \cdot d\vec{l} = \mu_0 \Sigma I_{enclosed}$

* The line integral of magnetic field over a closed loop is equal to product of permeability of free space & summation of current enclosed by close loop → Ampere's law

M. field due to Infinite current carrying wire.

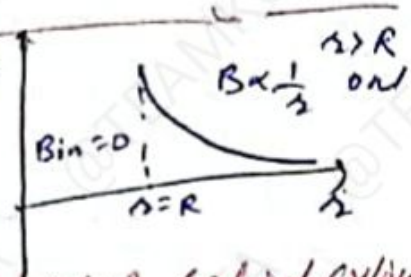
$$B = \frac{\mu_0 I}{2\pi r}$$



M. field due to current carrying Hollow cylinder / Hollow pipe / Thin walled pipe

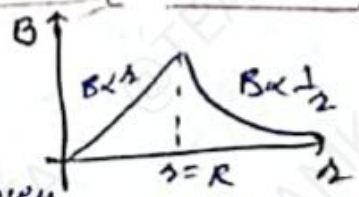
$$B_{in} = 0 \qquad B_{out} = \frac{\mu_0 I}{2\pi r}$$





M. field due to current carrying Long solid cylinder / Thick current carrying cable or St. wire jiska radius diya hua

$$B_{in} = \frac{\mu_0 i r}{2\pi R^2} \qquad B_{out} = \frac{\mu_0 I}{2\pi r}$$



Current carrying → radius given → solid cylinder

$J = \frac{I}{A}$ (J → current density)

$i = J(\pi R^2)$

current carrying wire → Total charge = 0 → E. field ⊥ to current carrying is always zero

$B_{out} \propto (R)^0$

↳ B_{out} does not depend on radius of cylinder.

M. field due to current carrying Solenoid.

Finite Solenoid.



$$B_P = \frac{\mu_0 n I}{2}[\cos\theta_1 + \cos\theta_2]$$

L >>> r → long solenoid.

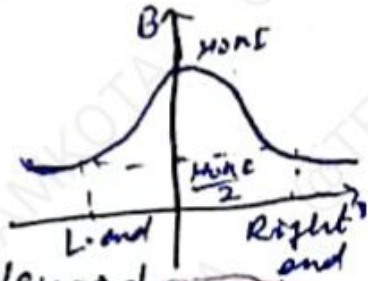
n → no. of turns per unit length

$n \rightarrow \left(\frac{N}{L}\right)$

Infinite Solenoid.

$$B_{centre} = \mu_0 n I$$

$$B_{end} = \frac{1}{2} B_{centre}$$



* M. field ⊗ along the axis of solenoid.

Thick Hollow cylinder.

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

* Outside solenoid → B → 0
* outside Toroid → B = 0

M. field due to Toroid. (endless solenoid)

$$B = \mu_0\left(\frac{N}{2\pi r}\right) I \qquad r = \frac{r_1 + r_2}{2}$$

r → mean radius

* M. field ⊥ r ke ⊥ hoga & vice versa.

Sec-B

* Motion of charge particle in Uniform M. field
[Force on a moving charge]

$\vec{F} = q[\vec{v} \times \vec{B}]$ $\quad F = qvB\sin\theta$ $\quad \theta \rightarrow$ Angle b/w v & B.

* Stionary charge [$v=0$] → Force by M. field is always Zero.

case ① # When charge particle enter ⊥r to the M. field [$\theta = 90$] ($F=0$)

Right Hand Palm Rule

$\vec{F} \perp r \vec{v}$, $F \perp r \vec{B}$ { Fingers → $\vec{B}$; Thumb → dir^n of flow of ⊕ve charge; ⊥r to Palm → Force.

Trick to Find plane of motion: Jisme M. field hai Usko chhorke.

P → momentum $\quad qvB = \frac{mv^2}{r}$

$$r = \frac{mv}{qB} = \frac{P}{qB} = \frac{\sqrt{2mKE}}{qB} = \frac{\sqrt{2mqV}}{qB}$$

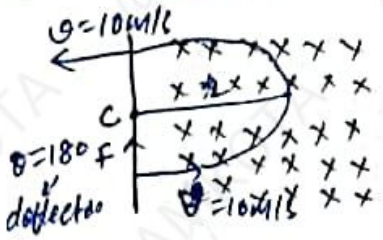
$$T = \frac{2\pi m}{qB} \qquad T \propto (v)^0$$

* Time period doesn't depend on Velocity

$$f = \frac{1}{T} = \frac{qB}{2\pi m} \qquad \omega = \frac{qB}{m}$$ $\omega \rightarrow$ Angular frequency.

$\theta = 90°$ Path → circular

* WD by M. force is always Zero. $WD = 0$
* $KE = const$
* Speed = const
* $\vec{P} \pm const$ (vector)
* $v \pm const$
* $KE_f = KE_i$
* Power = 0





$d < r$

$\alpha = \sin^{-1}\left(\frac{d}{r}\right)$

* Motion of charge particle in combined E. field & M. field

$\vec{F} = \vec{F_E} + \vec{F_B}$

Lorentz Force. $\quad F_{total} = q\vec{E} + q[\vec{v} \times \vec{B}]$

Velocity Selector.

$F_m = F_E$
$qvB = qE$
$v = \frac{E}{B}$ ← Velocity selector.

(a) $\vec{v} \perp r \vec{E} \perp r \vec{B}$
(b) $v = E/B$
(c) $\vec{E} = \vec{B} \times \vec{v}$ ↑ obey.

Charge particle → Undeviated or Undeflected → Velocity Selector

Superconductor.

$\chi_m = -1$ | $M_s = 0$

$\chi_m = 0$ → Non-magnetic substance.

Effect of Temp on Magnetic

(A) Diamagnetic

χ_m → negative होती है

χ_m → Temp पर depend नहीं करता hai.



(B) Pasamagnetic

$\chi_m \propto \frac{1}{Temp}$

Temp ↑ χ_m ↓. magnetisation कम ↓



Curie Law

$\chi_c = \frac{C}{T}$

(C) Fessomagnetic

$\chi_m \propto \frac{1}{T - T_c}$

Curie-Weiss Law

$\chi_m = \frac{C_0}{T - T_c}$

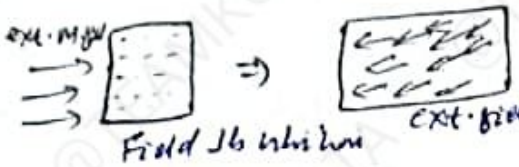
T_c → Curie Temp.

Above curie Temp (T_c) → ~~कभी~~ सभी Fessomagnetic behave as pasamagnetic

$\frac{\text{Magnetic moment}}{\text{Angular momentum}} = \frac{M}{L} = \frac{I}{2m}$ → यह Ratio fix रहता hai always.

Note: मेंढक का हवा में तैरना → Frog Levitation. is diamagnetic

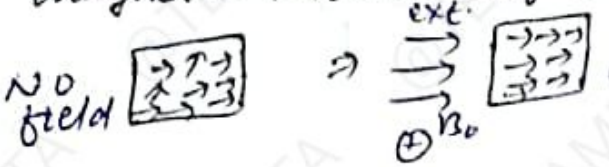
Rahi



→ Weak repulsion krta hai d/i magnetism.

Paramagnetism

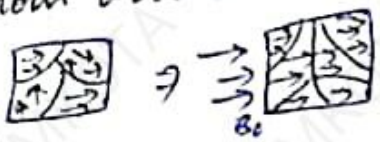
* Each atom have its individual magnetic moment. But net magnetic moment of substance/material is zero.



$M_{net} \neq 0$ → Weak attraction show krta hai

Ferso magnetic

* Each atom have individual magnetic moment but due to random orientation net magnetic moment of material is zero.



exchange coupling
strong attraction.

D/f Terms

$B_0, H, \chi_m, I, \mu_s, \mu_0$

$B_0 = \mu_0 n i$ | $H = ni$ | $B_0 = \mu_0 H$

H → Magnetic Intensity.
Magnetising field
[Amp/m] vector
↳ it does not depend on medium.

Iron Rod

$B = \mu_0 \mu_s n i$ | $I = \chi_m H$ | $\chi_m = \frac{I}{H}$

$B_{induced} = \mu_0 \vec{I}$

$\mu_s = 1 + \chi_m$

$\vec{I}$ → Intensity of Magnetisation
Amp/m

χ_m → Magnetic susceptibility

Magnetising Current (i_m)

$B = \mu_0 n (i + i_m)$

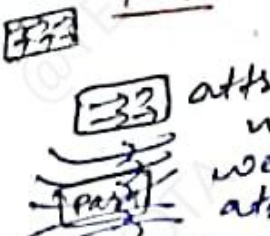
Diamagnetic

* Each atom have zero M. moment.



$B < B_0$
$\mu_s < 1$
$0 < \mu_s < 1$
$\chi_m < 0$

Para



attraction weak.
weak attraction.

$B > B_0$
$\mu_s > 1$
$1 < \mu_s < 2$
$0 < \chi_m < 1$

χ_m → positive

Ferso



$B >>> B_0$
$\mu_s >>> 1$.
$M >> M_0$
$\chi_m >>> 1$