Chapter-8- Lorentz force. / → right angle Force. RF & microwave

$\boxed{\text{Sem}-7}$

$F = F_e + F_m$ → lorentz force

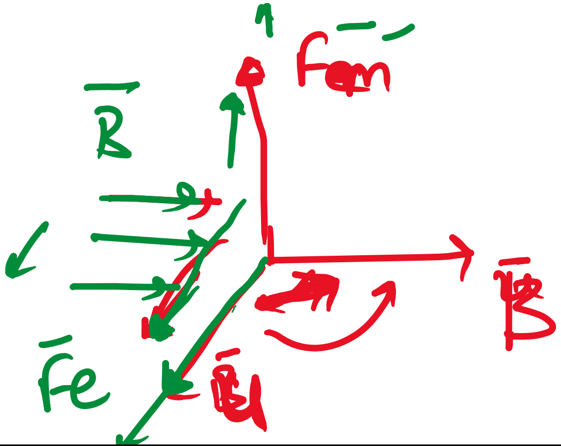
$\bar{F}_e = Q\bar{E}$ ← electric force ← Satationary / non-stationary

→ $F_m = Q\,\bar{u} \times \bar{B}$ ← magnetic force.

Charge, velocity, magnetic flux density.

} This force is only applicable for moving Charge.

→ or $F_m = 0$ for stationary charge.



→ Hall Effect.

$$\boxed{F = Q(\bar{E} + u \times \bar{B})}$$

Forces on current element →

$$I = \frac{dQ}{dt}$$

$$I\,dl = \frac{dQ}{dt}\cdot dl = dQ\left(\frac{dl}{dt}\right)$$

$$\boxed{I\,dl = dQ\cdot u}$$

$$\boxed{dF = I\,dl \times B}$$

$$\boxed{F = \int_L I\,dl \times B}$$

External field

$$F = Q(E + u \times B)$$

$$F = QE + Q\,u \times B$$

no

$$dF = \cancel{dQ}\,E + dQ\,u \times B$$

$$dF = dQ\,u \times B$$

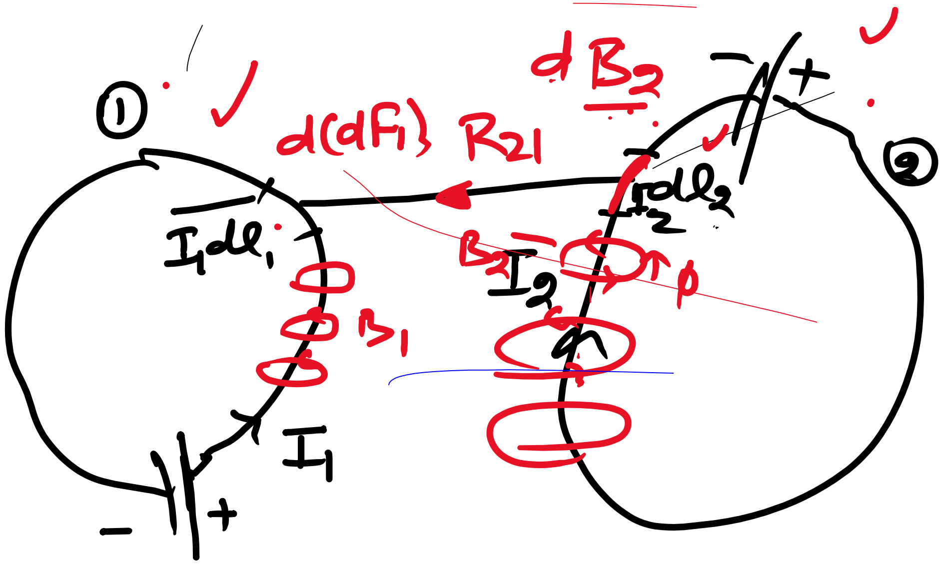
$$dF = I\,dl \times B$$

Force between two current Elements.

Current Element
$I\,dl$

Force on current element ① due to field of ②

$$d(d\vec{F}_1) = I_1 d\vec{l}_1 \times d\vec{B}_2$$



$$d\vec{B}_2 = \frac{\mu_0 I_2 d\vec{l}_2 \times a\hat{R}_{21}}{4\pi R_{21}^3}$$

$$F_1 = ?$$

① I_1 I_2

$F_2 = -F_1$

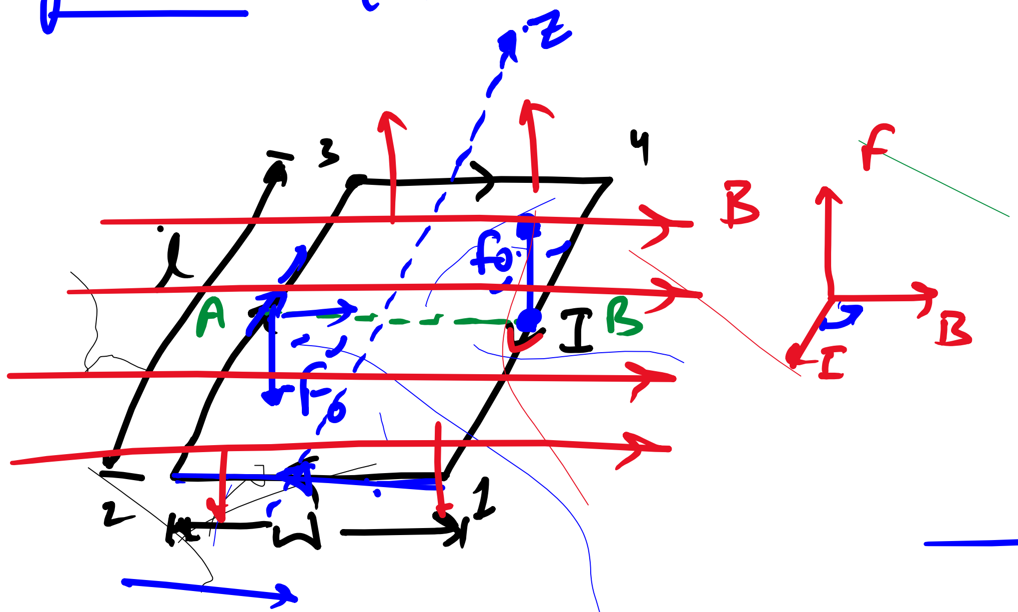
Force on current element ② due to field of ① –

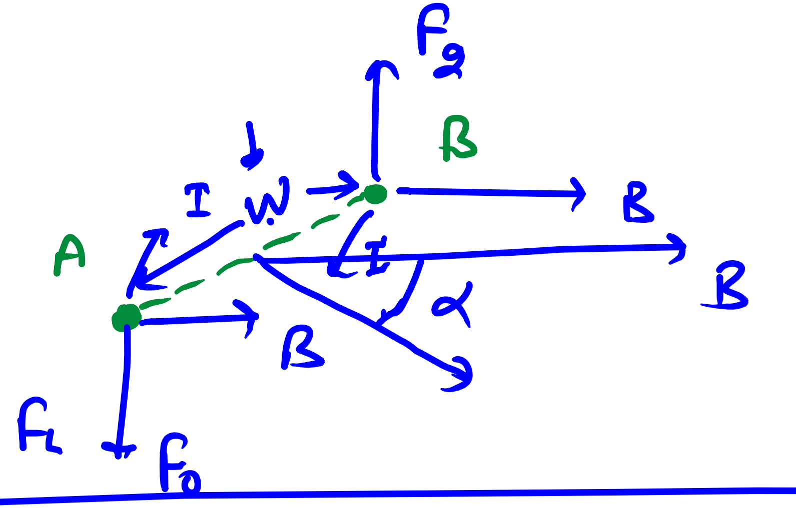
$$\boxed{F_2 = -F_1}$$

② I_1 I_2

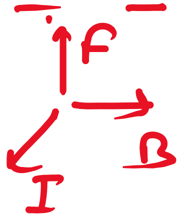
$F_2 = F_1$.

Magnetic Torque & moment -





$$dF = I\,\overline{dl} \times \overline{B} \neq 0$$



$F_1 \neq F_2$

$T \neq 0$

$$\text{Torque} = \vec{r} \times \vec{F}$$

$$dF = I\,dl \times B$$

$$T = W \times F_0 = W F \sin\alpha$$

$$F_0 = BIl$$

$$T = BI(l\,w_0)\sin\alpha$$

$$T = BI(S)\sin\alpha$$

Area of loop.

$$\boxed{\vec{m} = I S \hat{a}_n}$$

magnetic Dipole moment

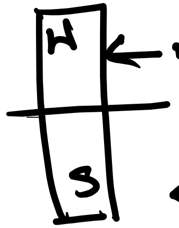
$$F = I\left\{\int_1^2 \cancel{dl} \times B + \int_2^3 \overline{dl} \times B + \int_3^4 \cancel{dl} \times B + \int_4^1 \overline{dl} \times B\right\}.$$

$$\rightarrow F = I\int_0^l dz\,\hat{z} \times B + I\int_l^0 dz\,\hat{z} \times B = F_0 - F_0 = 0$$

Magnetic Dipole →

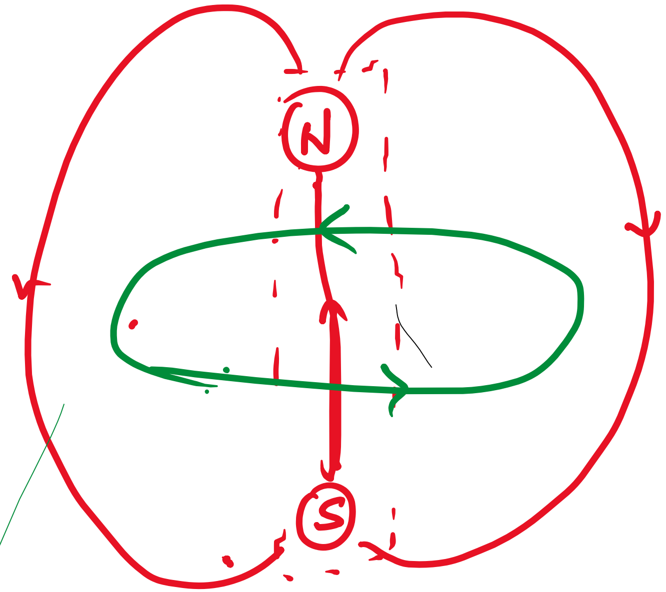
→ Electric Dipole

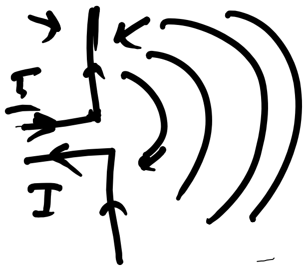
Antenna



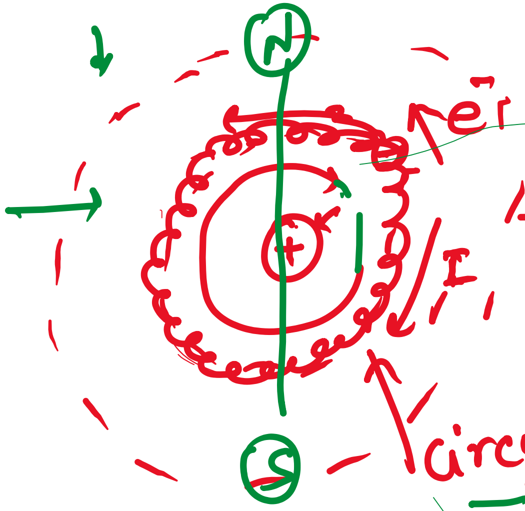
$\nabla\cdot\vec{B} = 0$

$$\oint_s B\cdot ds = 0$$





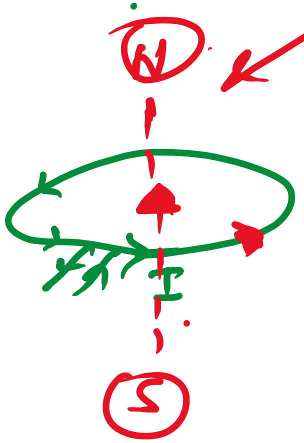
→ magnetic dipole Antenna



atomic

circular Electric loop.

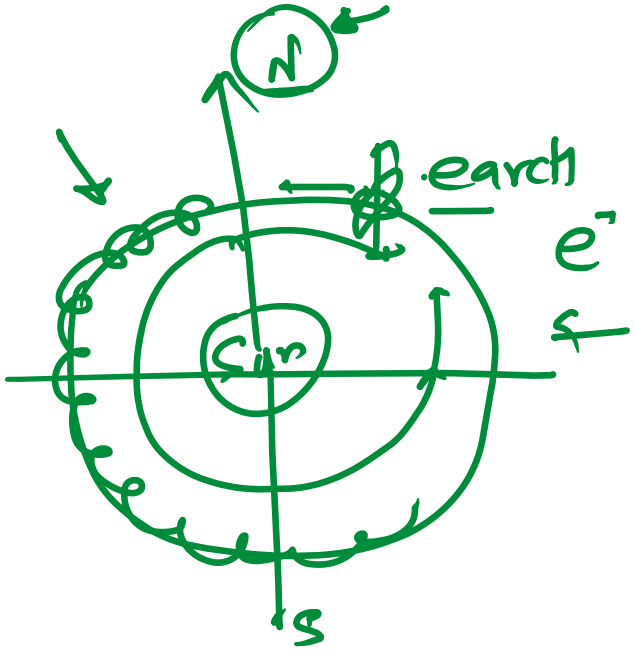
magnetic dipole



Electric Current Carrying loop

$\nabla\times H = J$

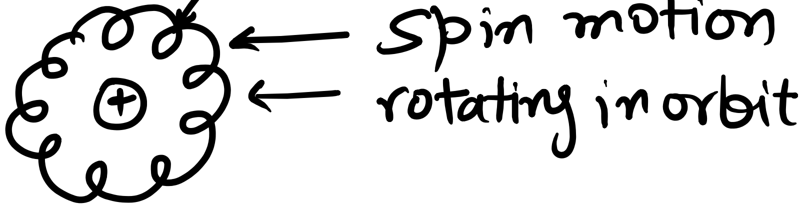
Single electron is creating a magnetic dipole



magnetic dipole

① → internal magnetic field

② → magnetic field due to rotation



$$A = \frac{\mu_0 I}{4\pi} \oint_c \frac{dl}{r}$$

Magnetization of materials - (M)

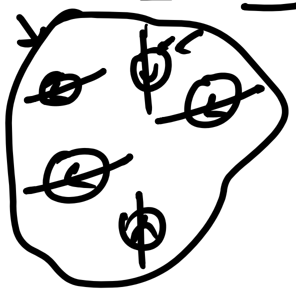
$\vec{m} = I S a_n$

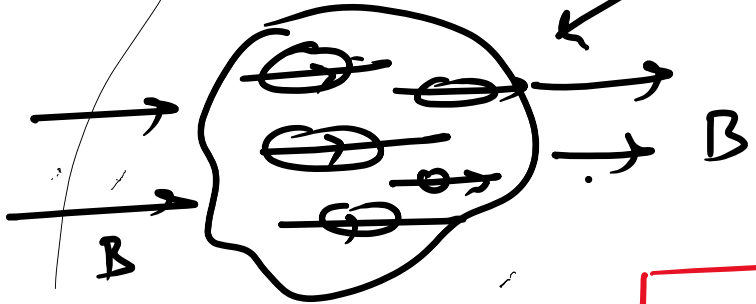
$$\vec{M} = \lim_{\Delta v \to 0} \frac{\sum_{k=1}^{N} m_k}{\Delta v}$$

Polarization of magnetic materials

"magnetization"

$B = 0$ $M = 0$





magnetic material

$$\vec{B} = \mu_0 (H + M)$$

$$\boxed{M = \chi_m H}$$

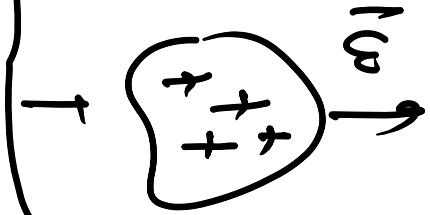
magnetic susceptibility

Sensitivity of magnetic material for the applied magnetic field.

Dielectrics

$$P = \frac{p}{\Delta v}$$

Polarization of dielectrics



$$\vec{D} = \epsilon_0 E + P$$

$$B = \mu_0 (H + \chi_m H) = \underline{\mu_0 (1+\chi_m)} H = \mu H$$

$$\mu = \mu_0 (1+\chi_m)$$

$\mu \to$ permeability of material

$\mu_0 \to$ " " in free-space

$$\underline{1+\chi_m} = \frac{\mu}{\mu_0} = \mu_r$$

relative permi---

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

Classification of magnetic materials -

→ Paramagnetic -

→ $H_{spin} \mp H_{orbital}$. → $\chi_m > 0$, $\mu_r > 1$

air

magnetic materials.

- Linear → $B = \mu_0 H$
  - Diamagnetic: $\chi_m < 0$, $\mu_r \leq 1$
  - Paramagnetic: $\chi_m > 0$; $\mu_r > 1$
- Non-Linear. ($\boxed{B = \mu H}$, μ → tensor)
  - Ferromagnetic: $\chi_m >> 0$; $\mu_r >> 1$

→ Ferromagnetic → Iron

→ Highly influenced by 'B' or 'H'.

→ These are not influenced by the applied 'B'.

→ Internal magnetic field generated due to $\bar{e}$ spin motion will cancel out the magnetic field due to orbital motion.

→ For superconductor at 'absolute zero' temperature perfect diamagnetism occurs. → $\left\{ \mu_r = 0,\ B = 0,\ \chi_m = -1 \right\}$

↑ Perfect Diag.

Magnetic Boundary contions -

① $\oint B\cdot ds = 0$ → Pill box

② $\oint H\cdot dl = I_{enclosed}$ → loop

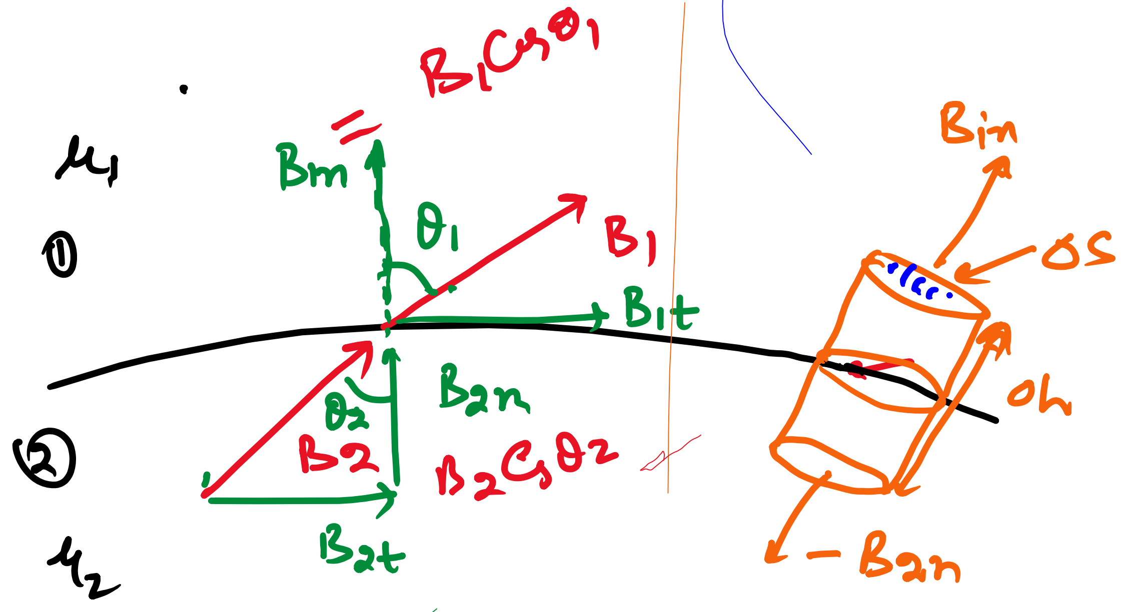
① $\oint D\cdot ds = Q_{enc}$

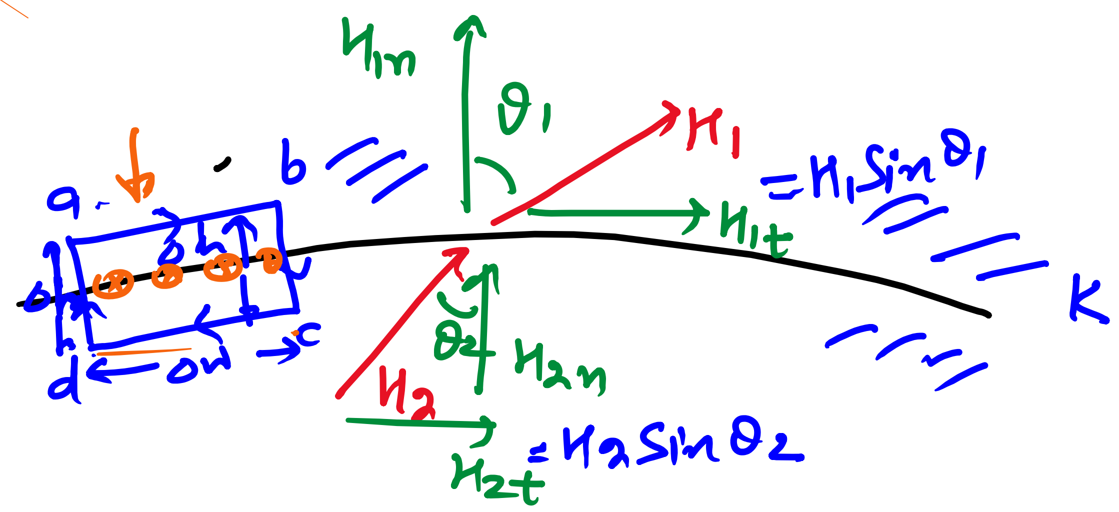
② $\oint E\cdot dl = 0$

$\oint B\cdot ds = 0$

$B_{1n}\Delta S - B_{2n}\Delta S = 0$

$\boxed{B_{1n} = B_{2n}} \Rightarrow \boxed{\mu_1 H_{1n} = \mu_2 H_{2n}}$ — ①





$\oint H\cdot dl = I = K\Delta w \Rightarrow \quad K\Delta w = H_{1t}\Delta w + H_{1n}\frac{\Delta h}{2} + H_{2n}\frac{\Delta h}{2} - H_{2t}\Delta w$

$- H_{1n}\frac{\Delta h}{2} - H_{2n}\frac{\Delta h}{2}$

$$K \Delta W = H_{1t} \Delta W - H_{2t} \Delta W$$

$$\boxed{D_{1n} - D_{2n} = \rho}$$

$$\boxed{H_{1t} - H_{2t} = K}$$

Example - 8.8 & 8.9

If there is no magnetic charge on the interface $\Rightarrow K = 0$

$$\boxed{H_{1t} = H_{2t}} \quad \text{—— (2)}$$

$$\boxed{\frac{B_{1t}}{\mu_1} = \frac{B_{2,t}}{\mu_2}}$$

from (1)

$$B_{1n} = B_{2n}$$

$$B_1 \cos\theta_1 = B_2 \cos\theta_2 \quad \text{—— (3)}$$

from (2)

$$H_{1t} = H_{2t} \Rightarrow \frac{B_{1t}}{\mu_1} = \frac{B_{2t}}{\mu_2}$$

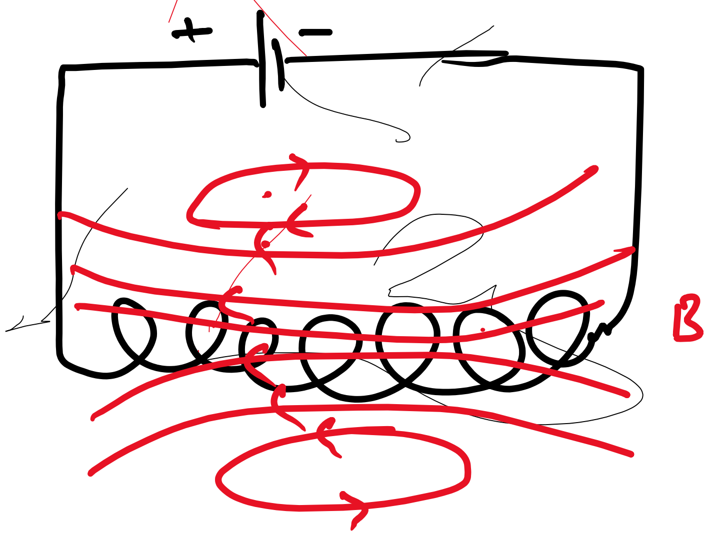
$$\frac{B_1 \sin\theta_1}{\mu_1} = \frac{B_2 \sin\theta_2}{\mu_2} \quad \text{—— (4)}$$

→ from (3) & (4)

$$\frac{\tan\theta_1}{\mu_1} = \frac{\tan\theta_2}{\mu_2} \Rightarrow \boxed{\frac{\tan\theta_1}{\tan\theta_2} = \frac{\mu_1}{\mu_2}}$$

Inductors & Inductance

flux Linkage



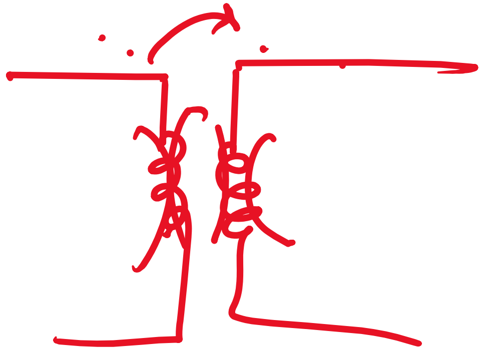
$N \rightarrow$ number of turns of coil

$\psi \rightarrow$ flux

$\lambda \Rightarrow$ flux linkage

$$\boxed{\psi = \oint B \cdot ds}$$

$$\boxed{\lambda = N\psi} \quad \text{--- (1)}$$



$\lambda \propto I$

$$\boxed{\lambda = LI} \quad \text{--- (2)}$$

$LI = N\psi$

$$\boxed{L = \frac{N\psi}{I} = \frac{\lambda}{I}}$$

Assignment → Solve all the Numericals of Chapter - 8. by Sadikey.