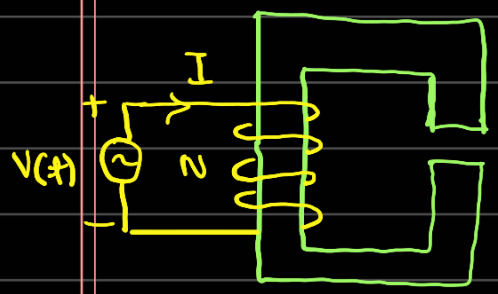
Day – 16

→ **Inductor :**



→ Air gap is introduced to magnetic circuit, to realise inductor, to make inductance not sensitive to variations in core permeability

$$L = \frac{N^2}{\mathcal{R}} = \frac{N^2}{\mathcal{R}_c + \mathcal{R}_g} \simeq \frac{N^2}{\mathcal{R}_g} \quad (\because \mathcal{R}_g >> \mathcal{R}_c)$$

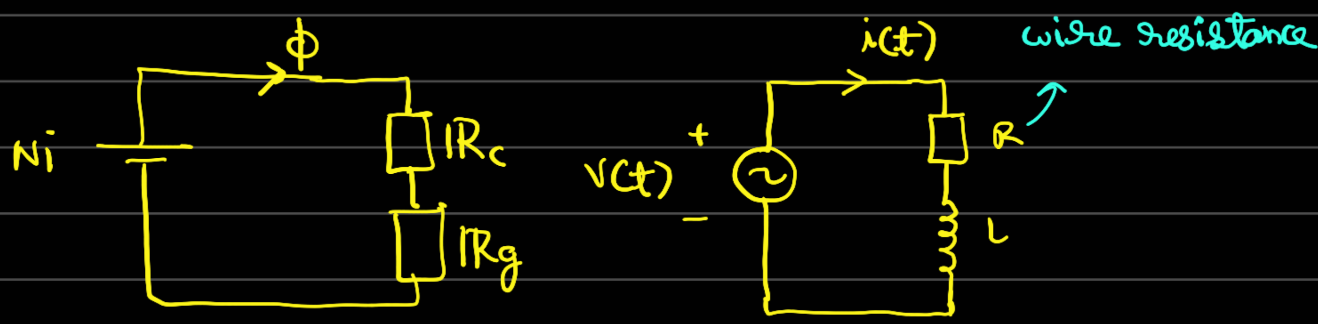
$$\Rightarrow L = \frac{N^2 \mu_0 A_c}{l_g}$$

$$V(t) = i(t)R + \frac{d\psi(t)}{dt}$$

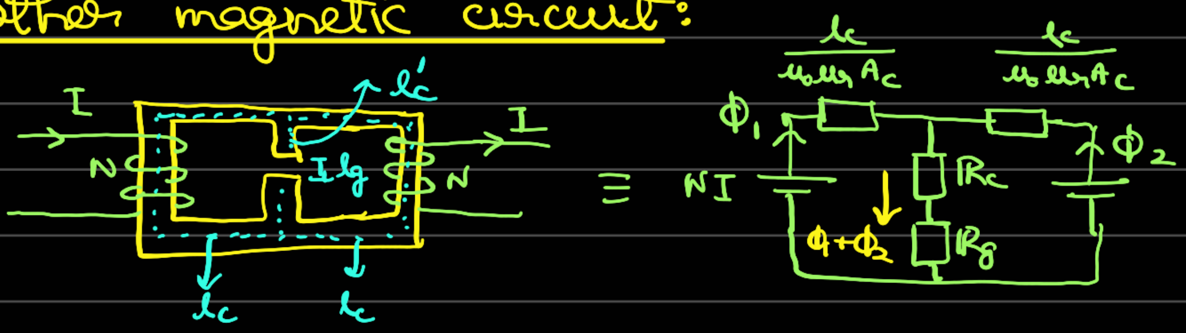
$$\Rightarrow V(t) = i(t)R + L\frac{di(t)}{dt}$$

⇒ Assume linear magnetic circuit (ψ vs i is linear)

☆ **Equivalent circuit :**



☆ **Another magnetic circuit :**

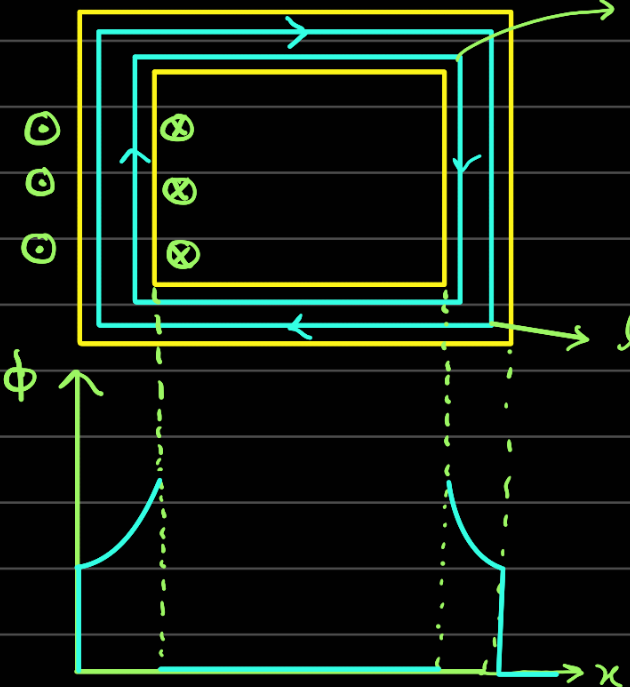


$$\mathcal{R}_c = \frac{l_c'}{\mu_0 \mu_r A_c} \qquad \mathcal{R}_g = \frac{l_g}{\mu_0 A_c}$$

$$\oint_S \vec{B}\cdot d\vec{S} = 0 \equiv \text{KCL}$$

$$\oint_C \vec{H}\cdot d\vec{l} = \int_S \vec{J}\cdot d\vec{S} \equiv \text{KVL}$$

☆ **The original circuit :**

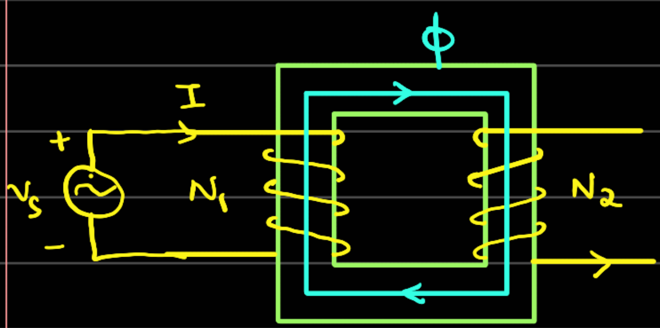


more flux density (l is low)

$$\frac{1}{\phi} \propto \mathcal{R} \propto l$$

less flux density (l is high)

→ **Transformer :**



$$E = N\frac{d\phi}{dt}$$

But ϕ is same (hence $d\phi/dt$)

So $E \propto N$

So $$\frac{V_s}{N_1} = \frac{V_{out}}{N_2} \Rightarrow V_{out} = \frac{N_2}{N_1} V_s$$

☆ **No load operation :**

$$V_s(t) = \cancel{i_s(t)R}_{\approx 0} + \frac{d\psi(t)}{dt} \approx \frac{d\psi(t)}{dt}$$

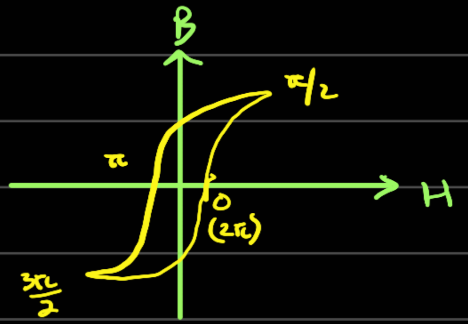
$$= N_1 \frac{d\phi(t)}{dt}$$

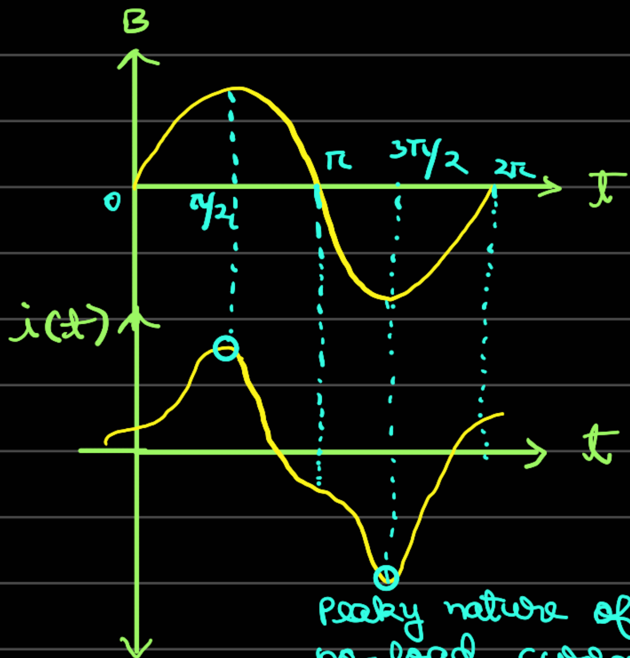
If $V_s(t) = V_m \sin\omega t$

so $\phi(t) = \frac{1}{N_1}\int V_m \sin\omega t \, dt$

$$= -\frac{V_m}{N_1 \omega}\cos\omega t$$

i_s is not actually sinusoidal!





Peaky nature of no-load current in transformer is due to saturation effects of the core

→ **Fourier Series :**

$$i(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos n\omega t + \sum_{n=1}^{\infty} b_n \sin n\omega t$$

$f(\omega t) = -f(\omega t + \pi) \quad \forall\, \omega t \rightarrow$ Half-wave symmetry (H.W.S.)

(Assuming B-H curve is symmetric)

$$\Rightarrow \frac{1}{2\pi}\int_0^{2\pi} i(\omega t)\,d(\omega t) = 0$$

So $a_0 = 0$

If wave-form has H.W.S., then there are only odd harmonics ($\because a_{2k} = 0 \ \forall\ k \in \mathbb{N}$)