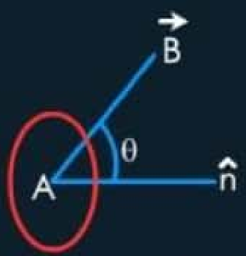
ELECTROMAGNETIC FORCE

MAGNETIC FLUX

Magnetic Flux is the amount of magnetic field passing through a given area.



$$\phi = \int \vec{B}.d\vec{A} \Rightarrow \phi = \vec{B}.\vec{A} = BA\cos\theta$$

Unit ⟶ weber (Wb)

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION

Whenever the flux of a magnetic field through the area bounded by a closed conducting loop changes, an emf is produced in the loop. The emf is given by

$$\varepsilon = -\frac{d\phi}{dt}$$

LENZ'S LAW

According to lenz's law, if the flux associated with any loop changes than the induced current flows in such a fashion that it tries to oppoose the cause which has produced it.

MOTIONAL EMF

$$E = \int (\vec{v} \times \vec{B}).d\vec{l}$$

EMF developed across the ends of the rod moving perpendicular to magnetic field velocity perpendicular to the rod is $\varepsilon = vBl$

INDUCED EMF IN A ROTATING ROD

$$\int dE = \int_0^l B\omega x\,dx$$

$$V_A - V_B = \frac{B\omega l^2}{2}$$

INDUCED ELECTRIC FIELD

EMF, $e = \oint \vec{E}.d\vec{l}$

Using Faraday's law of induction

$$\varepsilon = -\frac{d\phi}{dt}$$

or, $\oint \vec{E}.d\vec{l} = -\frac{d\phi}{dt}$

Part I

SELF INDUCTION

1 SELF INDUCTION

If current in the coil changes by Δi in a time interval Δt, the average emf induced in the coil is given as

$$\varepsilon = -\frac{\Delta(N\phi)}{\Delta t} = -\frac{\Delta(Li)}{\Delta t} = -\frac{L\Delta i}{\Delta t}$$

, S.I unit of inductance is wb/amp or Henry (H)

SELF INDUCTANCE OF SOLENOID

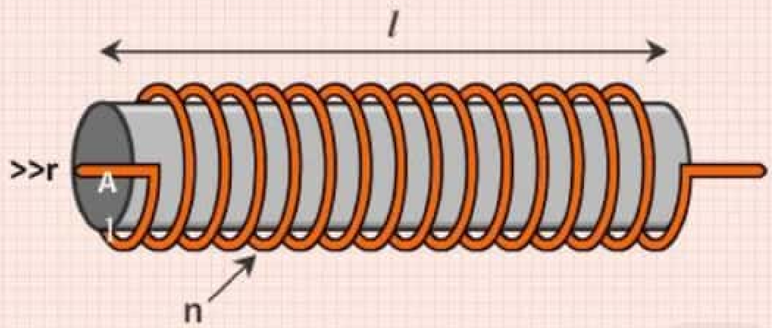
$$L = \mu_o n^2 \pi r^2 l$$

n = no. of turns/length

r = radius ; μ_o = Permeability

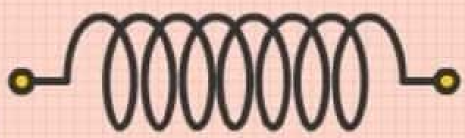
l = length

$$\text{Inductance/Volume} = \mu_o n^2$$



2 INDUCTOR

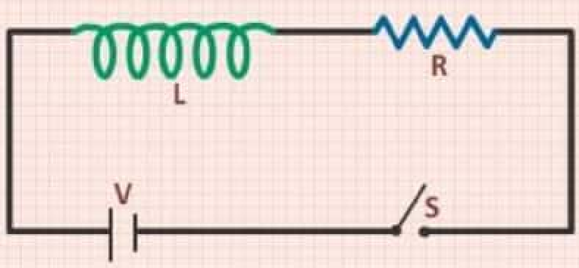
$V_A - L\frac{di}{dt} = V_B$, Energy stored in inductor , $U = \frac{1}{2}Li^2$



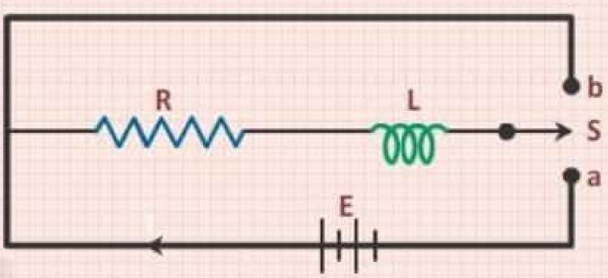
3 L – R CIRCUIT

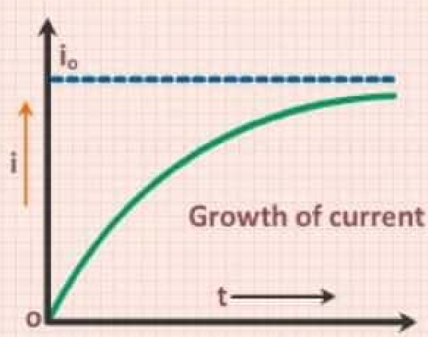
At t = 0, inductor behaves as an open switch.

At t = ∞, inductor behaves as plane wire.



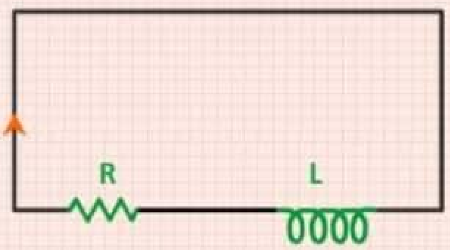
GROWTH OF CURRENT

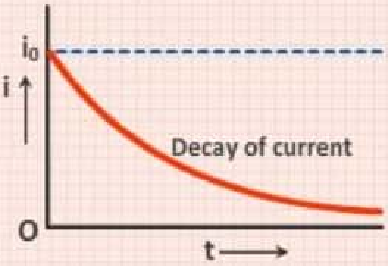




The maximum current in the circuit $i_0 = E/R$. So $i = i_0\left\{1 - e^{-\frac{R}{L}t}\right\}$

4 DECAY OF CURRENT





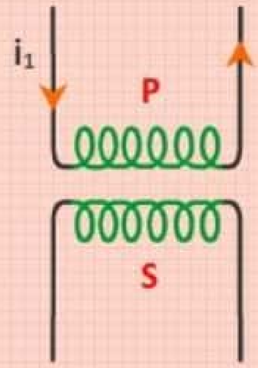
$$i = i_0 e^{-\frac{R}{L}t} = i_0 e^{-\frac{t}{\tau}}$$

5 MUTUAL INDUCTANCE

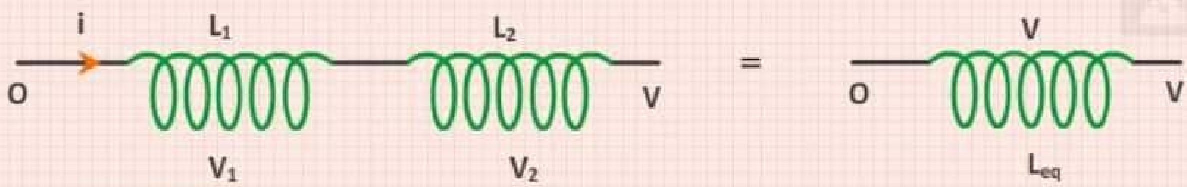
$$\varepsilon = -M\frac{di_1}{dt} = \Rightarrow \quad \phi_2 = Mi_1$$

M = Mutual inductance

Unit of Mutual inductance is Henry (H)



6 SERIES COMBINATION OF INDUCTORS



$$\therefore V = V_2 + V_1$$

$$L_{eq}\frac{di}{dt} = L_1\frac{di}{dt} + L_2\frac{di}{dt} \Rightarrow L_{eq} = L_1 + L_2 + \ldots\ldots$$

7 PARALLEL COMBINATION OF INDUCTOR

$$i = i_1 + i_2 \Rightarrow \frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt}$$

$$\frac{V}{L_{eq}} = \frac{V}{L_1} + \frac{V}{L_2}$$

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \ldots\ldots$$