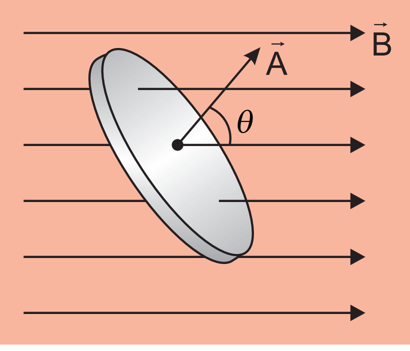
ELECTROMAGNETIC INDUCTION

MAGNETIC FLUX

It is defined as the number of magnetic field lines passing through a surface normally.

$\phi_B = \vec{B} \cdot \vec{A} = BA_{\cos\theta}$



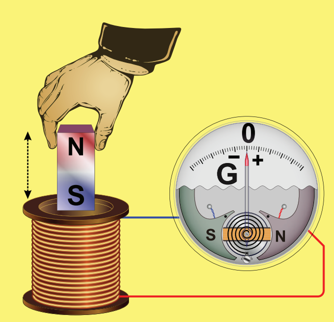
ELECTROMAGNETIC INDUCTION

It is phenomena of inducing an electric field or emf in a conductor by varying the magnetic field.

FARADAY'S LAW

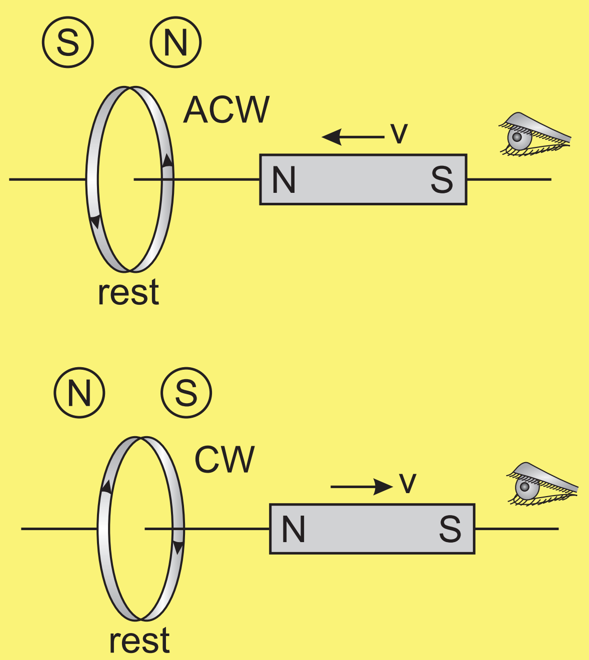
This law states that magnitude of the induced emf in a circuit is equal to the rate of change in magnetic flux through a circuit.

$\varepsilon = \frac{d\phi_b}{dt} = -\frac{d(BA_{\cos\theta})}{dt}$



LENZ'S LAW

This law states that polarity of induced emf is such that it tends to produce a current which apposes the change in magnetic flux that produced it.



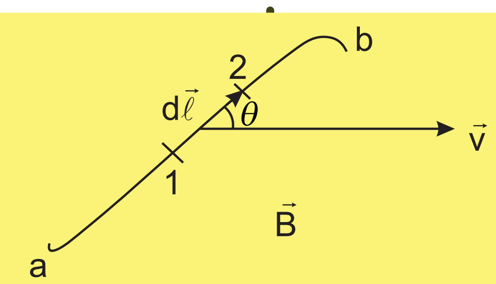
METHODS TO CHANGE IN MAGNETIC FLUX

- Magnetic flux can be increased by increasing the strength of magnetic field and vice – versa.
- The magnetic flux can be increased by increasing the area of coil and vice – versa.
- The magnetic flux can vary from maximum to, minimum value for variation in θ.
- The magnetic flux can be increased by increasing the number of coils.

Induced current: $i = \frac{1}{R}\left(\frac{-d\phi_B}{dt}\right)$

Induce charge: $q = \frac{(\Delta\phi_B)}{R}$

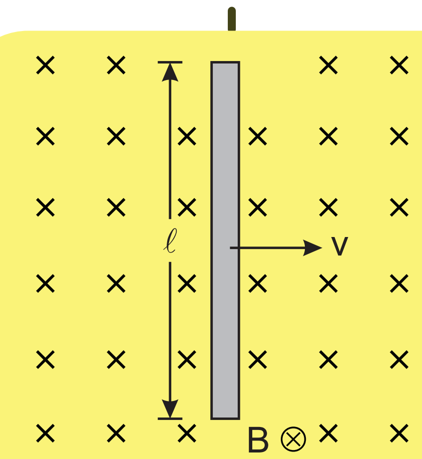
MOTIONAL EMF



- When a conductor moves in a magnetic field it will experience a force and emf is induced in the coil. This emf is know as motional emf.

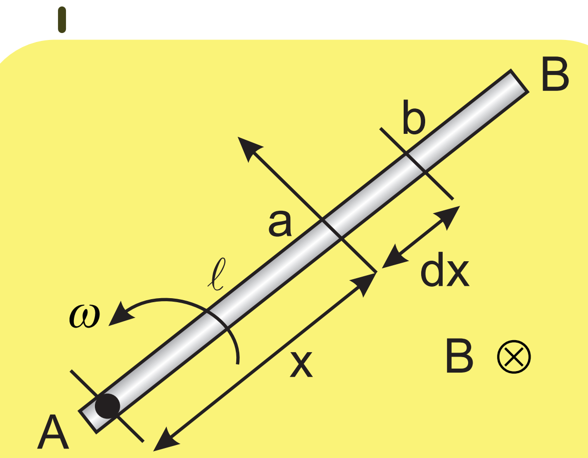
$\varepsilon = \int_b^a (\vec{dl} \times \vec{v}).\vec{B}$

STRAIGHT CONDUCTOR IN $\vec{B}$



Induced emf. $\varepsilon = Bwl^2$

STRAIGHT CONDUCTOR ROTATING IN MAGNETIC FIELD

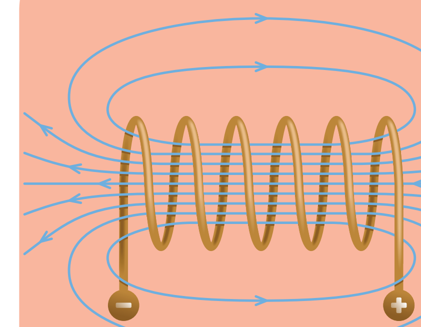


Induced emf. $\varepsilon = \frac{1}{2} Bwl^2$

SELF INDUCTANCE

- Inherent property which the change in current.
- Dimensional formula: $[ML^2T^{-2}A^{-2}]$
- SI unit: henry, Wb/A or S/A²

SOLENOID



- $L = \frac{\mu_0 N^2 A}{l}$

A = Cross-section area
l = length
N = No. of turns

INDUCED ELECTRIC FIELD

When magnetic field in a region varies with time then an electric field will induce within and outside that region.

$\oint \vec{E} \cdot \vec{dl} = \frac{-d\phi}{dt}$

- When current flowing in coil change with respect to rime, then self – inductance:

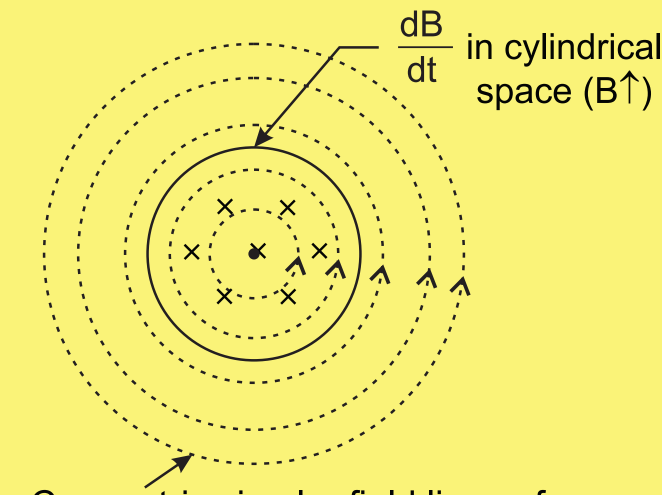
$L = \frac{-\varepsilon}{dI/dt}$

- When current flowing in coil is constant then coefficient of self – inductance:

$L = \frac{\phi_{total}}{I}$

PROPERTIES

- Induced electric field is different from electric field produced due to stationary charges.
- Induced electric field lines always form closed curves.
- For induced electric field $\oint \vec{E} \cdot \vec{dl} \neq 0$ but for electrostatic field $\oint \vec{E} \cdot \vec{dl} = 0$ always.
- The direction of induced electric field will be same as direction of induced current.



Concentric circular field lines of E_{induce} (inside/outside)

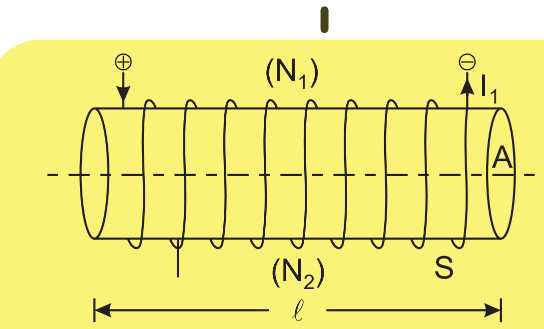
MUTUAL INDUCTANCE

The phenomena in which emf is induced in a circuit due to change in magnetic flux in its neighbouring circuit is called mutual induction.

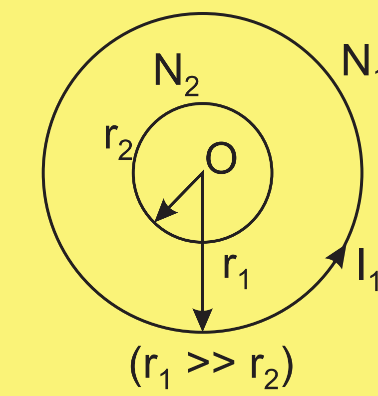
- When current in primary coil is constant, then coefficient of mutual inductance:

$M = \frac{N_2\phi_2}{I_1} = \frac{N_2B_2A_2}{I_1}$

- When current in primary coil change with respect to time, then coefficient of mutual inductance: $M = \frac{-\varepsilon_2}{dI_1/dt}$



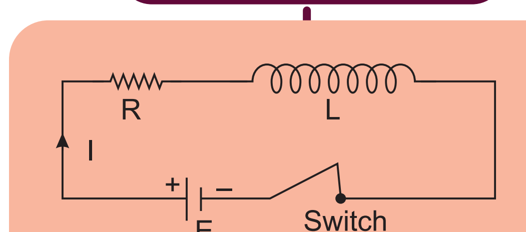
- When coils are co – axial: $M_{12} = \frac{\mu_0 N_1 N_2 A}{l}$



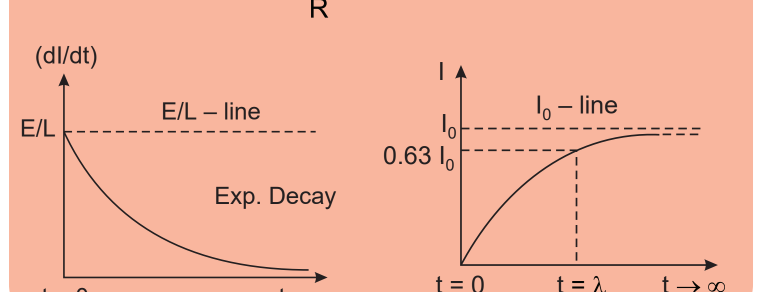
- When coils are concentric and coplanar: $M = \frac{\mu_0 N_1 N_2 \pi r_2^2}{2r}$

R – L DC CIRCUIT

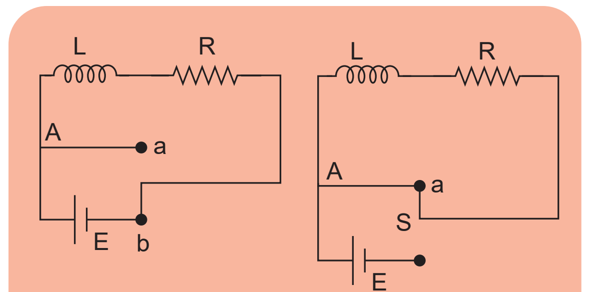
CURRENT GROWTH



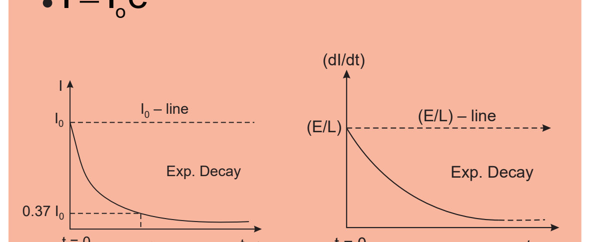
- $I = I_0(I - e^{-t/\lambda})$
- Decay constant $t = \frac{L}{R}$



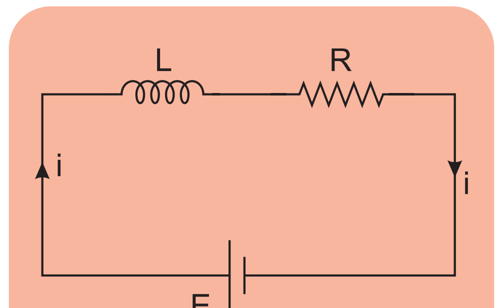
CURRENT DECAY



- $I = I_0 e^{-t/\lambda}$

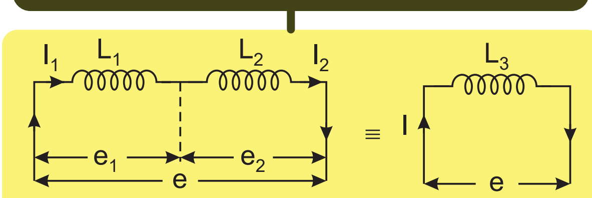


ENERGY STORED IN AN INDUCTOR COIL

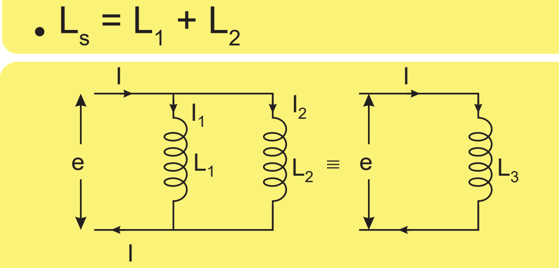


- $U = \frac{1}{2}LI^2$

COMBINATIONS OF INDUCTORS



- $L_s = L_1 + L_2$

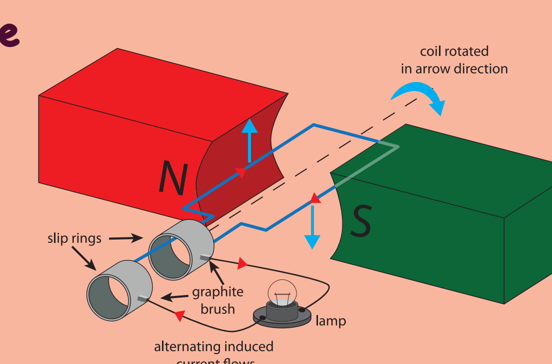


- $\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2}$

AC GENERATOR

- It works on the principle of EMI.
- Magnetic flux. $\phi_B = NBA_{\cos wt}$
- Induced emf $\varepsilon = \frac{-d\phi_B}{dt}$

$= NBA\omega \sin wt$



EDDY CURRENT

The current induced in a conductor when placed in a changing magnetic flux is known as eddy currents.