ELECTROMAGNETIC INDUCTION - PART I

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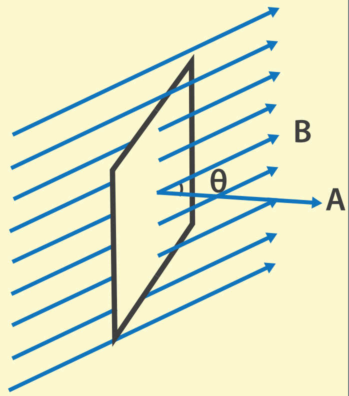
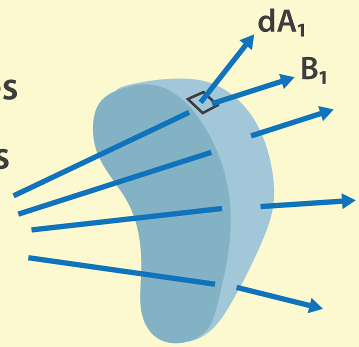
Magnetic flux through a plane of area A placed in a uniform magnetic field B

$$\phi_B = B.A = BA\cos\theta$$



Magnetic flux if the field has different magnitudes and directions at various parts of a surface



$$\phi_B = B_1.dA_1 + B_2.dA_2 + ...$$
$$= \Sigma_{all} B_i.dA_i$$

SI units

Magnetic flux (ϕ_B) = Wb = Tm²

Faraday's Law

1. Whenever there is a change in the magnetic flux associated with a coil and emf is induced in the coil.

$$E = d\phi_B$$

2. The magnitude of the induced emf in a circuit is equal to the time rate of change of magnetic flux through the circuit.

$$E \propto -\frac{d\phi_B}{dt}$$

Induced emf

$$\epsilon = -N\frac{d\phi_B}{dt}$$

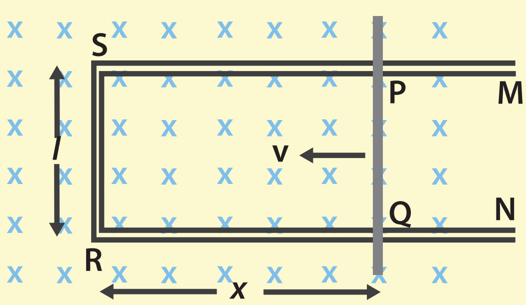
N is the number of turns

Lenz's Law

The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.

Motional Electromotive Force

An emf induced by the motion of the conductor across the magnetic field.



$E = -Blv$ $I = -Blv$

Lorentz force on a stationary charge,

$F = q(E + v \times B) = qE$

Lorentz force on a charge q moving with velocity v, $F = q(v \times B)$

Force experienced by the arm PQ (direction opposite to v),

$$F = BIL = \frac{B^2l^2v}{r}$$

Work done in moving charge from P to Q,

$W = qvBl$

The power required to move a conductor rod in a magnetic field is

$$P = \frac{B^2l^2v^2}{r}$$

Energy dissipated as heat,

$$P_j = \frac{B^2l^2v^2}{r}$$

ELECTROMAGNETIC INDUCTION - PART II

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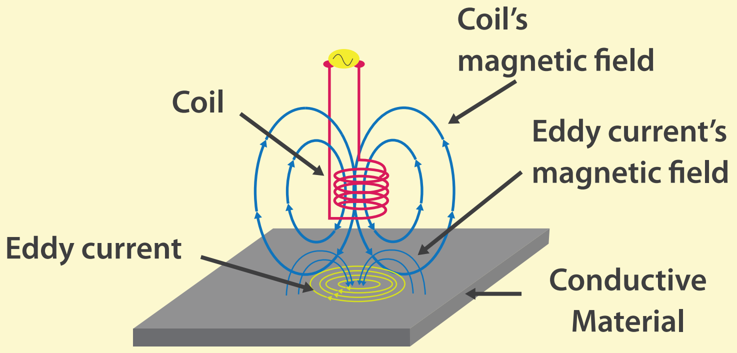
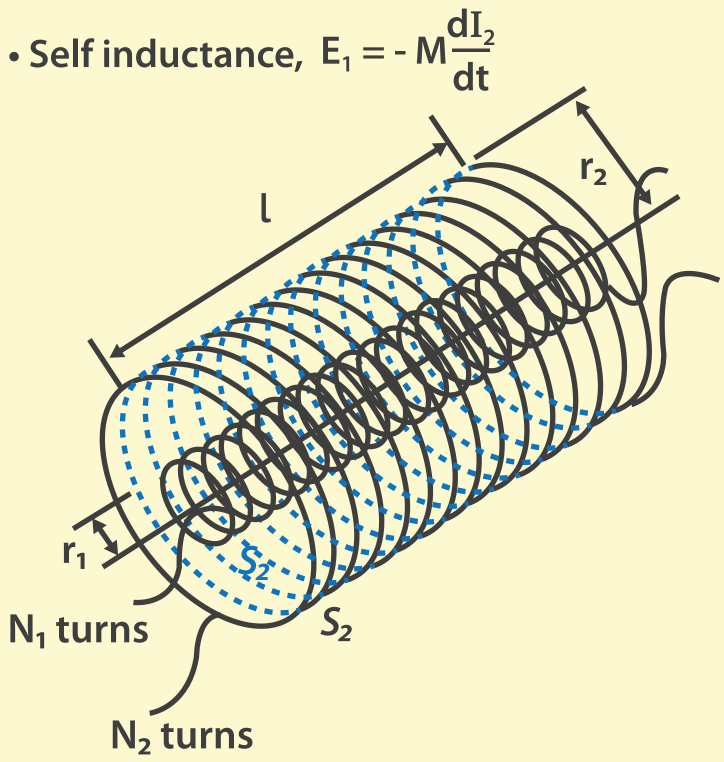
Eddy currents

- An eddy current is a current set up in a conductor in response to a changing magnetic field.
- Eddy currents results in loss of energy



Mutual Inductance

- One coil causes the change in magnetic flux because of which current is induced in the other coil.
- Self inductance, $E_1 = -M\dfrac{dI_2}{dt}$



Flux linkage with solenoid S1 is given by,

- $N_1Ø_1 = M_{12}I_2$, Where "M_{12}" is the mutual inductance of solenoid S_1 wrt S_2.
- $M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

Self Inductance

- Emf induced in a coil because of varying current through same coil.
- $NØ \propto I$, "N" is the number of turns
- $NØ = LI$, "L" is self induction
- Self inductance, $E = -N\dfrac{dØ}{dt} = -L\dfrac{dI}{dt}$
- Self inductance, $L = \mu_r\mu_0 n^2 Al$
- Energy required to build up the current I is,

$$W = \frac{1}{2}LI^2$$

Inductance (I)

- An electric current induced in a coil by flux change produced by another coil in its vicinity or flux change produced by the same coil.

$$Ø_B \propto I$$

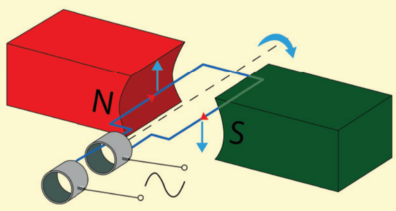
- It is a scalar quantity and it's SI unit is Henry (H).
- $NØ_B \propto I$, "N" is the number of turns
- $A \propto I$, "A" is the marea of the coil.
- $L \propto \dfrac{1}{I}$, "L" is the length of the coil.

AC Generator

- An AC generator is an electric generator that converts mechanical energy into electrical energy in form of alternative emf or alternating current.
- AC generator works on the principle of "Electromagnetic Induction"
- Induced emf is at any time, t

$$E = E_0 \sin \omega t$$

$$\omega = 2\pi v$$



- Induced emf for the rotating coil of N turns is

$$E = -N\frac{dØ_B}{dt} = -NBA\frac{d}{dt}(\cos \omega t)$$

- Instantaneous value of emf

$$E = NBA\ \omega \sin \omega t$$