Class : 12th Physics
Chapter- 6 : Electromagnetic Induction

Electromagnetic Induction

Self Inductance of long Solenoid

$L = \mu_0 n^2 \pi r^2 l$

n = no. of turns per unit length

ϕ = flux = $(\mu_0 n i)\, \pi r^2$

r = radius of each loop of solenoid

- Growth of current in LR Circuit

  $i = \frac{E}{R}(1 - e^{tR/L}) = i_0(1 - e^{-t/r})$

- Decay of current

  $i = i_0 e^{-t/r}$

- Energy stored in an Inductor

  $U = \frac{1}{2} L i^2$

Faraday's Law of Electromagnetic Induction

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

The emf is given by $E = -d\phi/dt$

where $\phi = \int \vec{B}.\vec{ds}$

is the flux of the magnetic field through the area.

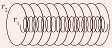
Mutual Inductance

$\phi = Mi$

$\frac{d\phi}{dt} = -M\frac{di}{dt}$

$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

$M_{21} = \mu_0 n_1 n_2 \pi r_2^2 l$



Emf induced in an AC generator, $E = NBA\omega \sin \omega t$

Lenz's Law

The direction of the induced current is such that it opposes the changes that has induced it.

Self Induction

If a solenoid of N turns, the flux through each each turn = $\phi = \int \vec{B}.\vec{ds}$

emf induced between the ends of coil = $E = -N\frac{d}{dt}\int \vec{B}.\vec{ds}$

Contribution

In 1831, Michael Faraday discovered electromagnetic induction and James Clerk Maxwell mathematically described it.

Induced current

$I = \frac{E}{R} = -\frac{1}{R}\frac{d\phi}{dt}$

Eddy Current

It is induced when magnetic flux linked with the conductor changes

Induced EMF

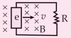
$E = \frac{d\phi}{dt}$

Motional EMF

$E = \left|\frac{d\phi}{dt}\right| = \left|Bl\frac{dx}{dt}\right|$

$= Blv$

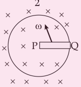
$i = vbl/(R+r)$



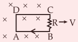
r = resistance of rod moving with velocity v in uniform magnetic field $\vec{B}$

EMF induced in a rotating conductor

$E = \frac{1}{2}B\omega l^2$



Rectangular loop



emf induced

$E = vBl$

$i = \frac{vBl}{R}$

Magnetic force on the loop

$F = B^2 l^2 v/R$

= force required to move the loop with constant velocity (v)

Thermal power developed in the loop is

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