Self - Induction

The phenomena of production of induced emf in a circuit due to change in current flowing in its own, is called self - induction.

Coefficient of self - Induction : -

The magnetic flux linked with a coil.

$$\phi = LI$$

where, L = co-efficient of self - Induction

The induced emf in the coil,

$$E = -L \frac{dI}{dt}$$

SI unit of self - induction is henry (H) and its dimensional formula is $[M L^2 T^{-2} A^{-2}]$

self - inductance of a long solenoid is given by normal text.

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

where, N = total number of turns in the solenoid, l = length of the coil., n = no. of turns in the coil

& A = Area of cross - section of the coil.

If core of the solenoid is of any other magnetic material, then

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

self - inductance of a toroid, $L = \frac{\mu_0 N^2 A}{2\pi r}$

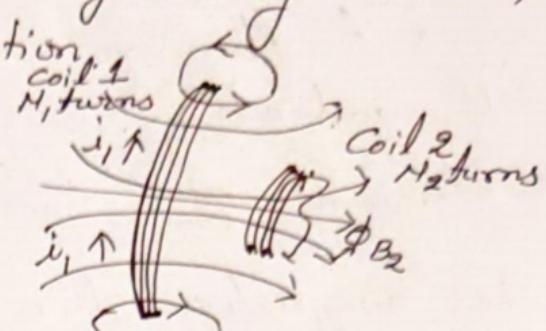
where r = radius of the toroid.

Energy stored in an inductor, $E = \frac{1}{2} L I^2$

—x—

Mutual Induction

The phenomena of production of induced emf in a circuit due to the change in magnetic flux in its neighbouring circuit, is called mutual induction.



$$\mathcal{E}_2 = -N_2 \frac{d\phi_{B2}}{dt} \quad \text{——(i)}$$

$$N_2 \phi_{B2} = M_{21} i_1 \quad \text{——(ii)}$$

$$N_2 \frac{d\phi_{B2}}{dt} = M_{21} \frac{di}{dt} \text{ then from eqn(i)}$$

$$\mathcal{E}_2 = -M_{21} \frac{di}{dt} \quad \text{——(iii)}$$

$$\therefore M_{21} = \frac{N_2 \phi_{B2}}{i_1}$$

Mutually induced emfs :-

$$\mathcal{E}_2 = -M \frac{di_1}{dt} \text{ and } \mathcal{E}_1 = -M \frac{di_2}{dt} \quad \text{——(iv)}$$

where M = Mutual inductance of coil 1 & 2.

Mutual Inductance :-

$$M = \frac{N_2 \phi_{B2}}{i_1} = \frac{N_1 \phi_{B1}}{i_2} \quad \text{——(v)}$$

Co-efficient of Mutual induction :-

If two coils are coupled with each other then magnetic flux linked with a coil (secondary coil)

$$\phi = MI$$

where, M = coefficient of mutual induction
I = current flowing through primary coil.

The induced emf in the secondary coil

$$E = -M \frac{dI}{dt}, \quad \frac{dI}{dt} = \text{The rate of change of current through primary coil}$$

Unit of M is henry (H) & its dimension $[M L^2 T^{-2} A^{-2}]$

It depends on geometry of two coils, distance between two coils & orientation of the two coils.