Self Induction :-

Self induction is the induction of emf in a coil due to its own current change.
If N is the total no. of turns in the coil then total flux through the coil is directly proportional to current.

flux through each coil

$$\therefore N\phi \propto I$$

$$N\phi = LI$$

where, L is the coefficient of self inductance.

If current in a coil changes in time dt then from Faraday's Law, induced emf in the coil is,

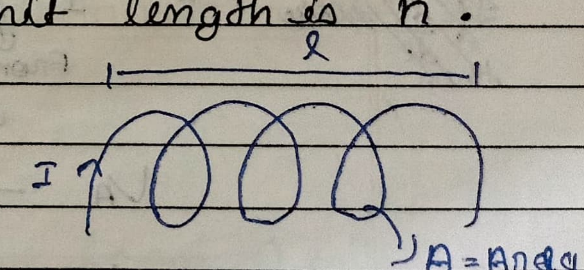
$$\mathcal{E} = -\frac{d(N\Phi)}{dt}$$

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

1. L is a scalar +ve quantity and its S.I. unit is Henry (H) or Wb/A.
2. L does not depend on the current or flux through the coil
3. L depends on the shape, size and no of turns in the loop (and the medium)

Self Inductance of a solenoid :-

Q) Find the self inductance of a solenoid (ideal) of length l cross sectional area A and no of turns unit length is n.



$N = nl$

$B = \mu_0 I n$

$\Phi = BA$

Total flux $(N\Phi) = N(\mu_0 I n)A$

$= (\mu_0 I n)A(nl)$

$= \mu_0 I n^2 A l$

As we know,

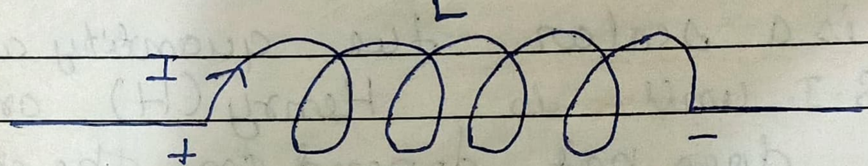
$\mu_0 I n^2 A l = (L) I$

$$\therefore \boxed{L = \mu_0 n^2 A l}$$

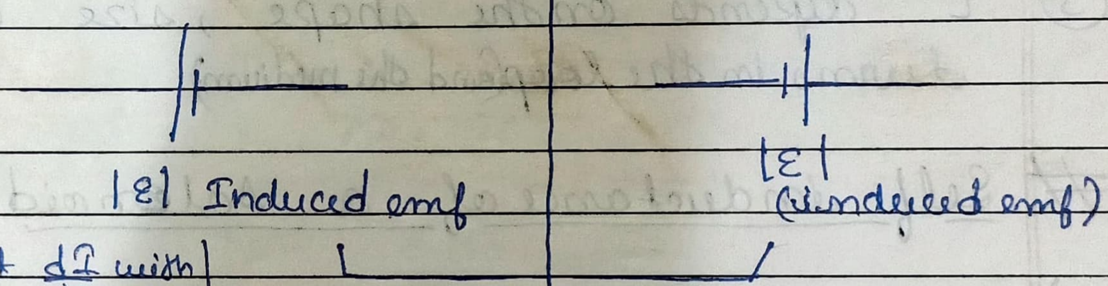
Inductor :-

As we know emf induced in and inductor always opposes the change in current which can be written as $|\mathcal{E}| = L\frac{dI}{dt}$

Symbolic representation of inductor is as shown,

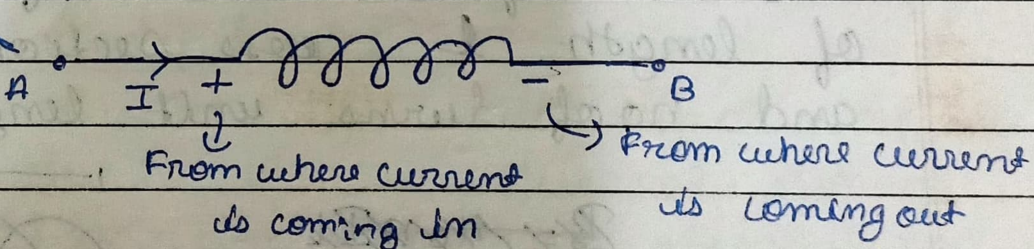


I is increasing | I is decreasing



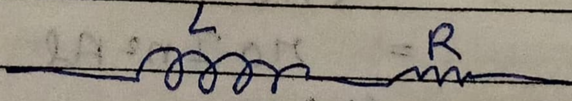
(Note:- Put $\frac{dI}{dt}$ with proper sign)

~~If $\frac{dI}{dt}$ then~~



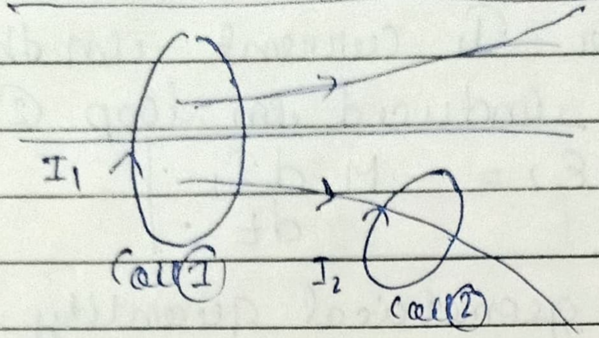
$$V_A - L\frac{dI}{dt} = V_B$$

$$\boxed{V_A - V_B = L\frac{dI}{dt}}$$



inductor ~~[illegible]~~ with resistance

Mutual Inductance :-



Consider two arbitrary conducting loop ① & ②. If I_1 is the instantaneous current flowing in loop ① then magnetic field due to this current, $\vec{B_1} \propto I_1$

Hence flux through the second coil is directly proportional to I_1

i.e. $N_2 \Phi_2 \propto I_1$

$$\boxed{N_2 \Phi_2 = M_{21} I_1}$$

→ Hence mutual inductance can be defined as total flux linked with circuit ② per unit current in circuit ①.

→ Also, M_{21} = mutual inductance of circuit ② wrt circuit ①.

→ If we give instantaneous current I_2 in coil ②, then we can write total flux through coil ① is

$$\boxed{N_1 \Phi_1 = M_{12} I_2}$$

M_{12} = mutual inductance of circuit ① wrt to circuit ②.

☆ Experimentally it is found that

$$\boxed{M_{12} = M_{21} = M}$$