Self Induction

CLASS-XII

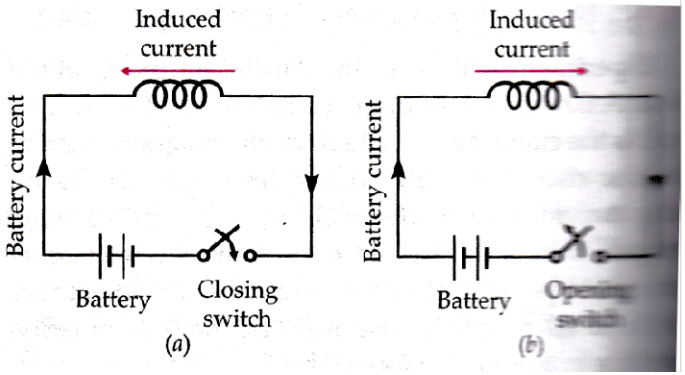
SUBJECT : PHYSICS
CHAPTER NUMBER: 06
CHAPTER NAME : ELECTROMAGNETIC INDUCTION

Self Induction:

Self Induction is the phenomenon of inducing emf in the self coil due to change in current and hence the change in magnetic flux in the coil.

The induced emf opposes the growth or decay of current in the coil and hence delays the current to acquire the maximum value.

Self induction is also called inertia of electricity as it opposes the growth or decay of current.



Self Inductance:

$\Phi \alpha I$ or $\Phi = LI$

If $I = 1$, then $L = \Phi$

(where L is the constant of proportionality and is known as Self Inductance or co-efficient of self induction)

Thus, self inductance is defined as the magnetic flux linked with a coil when unit current flows through it.

Also, $E = - d\Phi / dt$ or $E = - L (dI / dt)$

If $dI / dt = 1$, then $L = E$

Thus, self inductance is defined as the induced emf set up in the coil through which the rate of change of current is unity.

SI unit of self inductance is henry (H).

Self inductance is said to be 1 henry when 1 A current in a coil links magnetic flux of 1 weber.

or

Self inductance is said to be 1 henry when unit rate of change of current (1 A / s) induces emf of 1 volt in the coil.

Self inductance of a solenoid:

Magnetic Field due to the solenoid is

$B = \mu_0 nI$

Magnetic Flux linked across one turn of the coil is

Φ per turn = $B\,A = \mu_0 nIA = \mu_0 NIA / l$

Magnetic Flux linked across N turns of the coil is

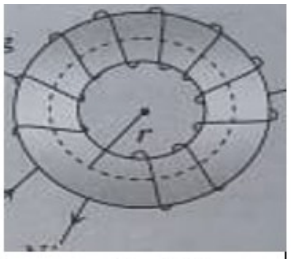
$$\Phi = \mu_0 N^2 IA / l$$

But, $\Phi = LI$

So, $L = \mu_0 N^2 A / l = \mu_0 n^2 Al$

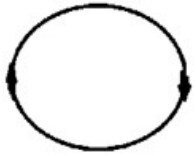
NUMERICAL

Question:-Find the self-inductance of the toroid, circular coil, and a square coil



$$B = \frac{\mu_0 NI}{2\pi r} \quad N\phi = N\left(\frac{\mu_0 NI}{2\pi r}\right)A$$

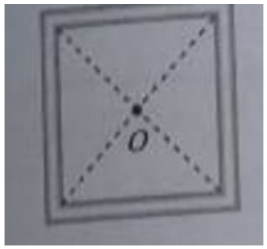
$$L = \frac{\mu_0 N^2 A}{2\pi r}$$



$$B = \frac{\mu_0 NI}{2r}$$

$$N\phi = N\left(\frac{\mu_0 NI}{2r}\right)\pi r^2$$

$$L = \frac{\mu_0 \pi N^2 r}{2}$$



$$B = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}I}{a}N$$

$$N\phi = NBa^2$$

$$\Rightarrow L = \frac{2\sqrt{2}\mu_0 N^2 a}{\pi}$$

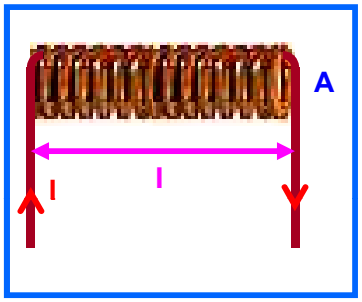
Energy in Inductor:

Small work done dW in establishing a current I in the coil in time dt is

$dW = - EI\, dt$

$dW = LI\, dI$ (since $E = -L(dI / dt)$

$$W = \int_0^{I_0} L\, I\, dI = \tfrac{1}{2} L I_0^2$$



THANKING YOU

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