18.ELECTROMAGNETIC INDUCTION

1. **Magnetic flux** is mathematically defined as $\phi = B.ds$

2. **Faraday s laws of electromagnetic induction**

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

3. **Lenz s Law (**conservation of energy principle)

   According to this law, emf will be induced in such a way that it will oppose the cause which has produced it.

   Motional emf

4. **Induced emf due to rotation**

   Emf induced in a conducting rod of length l rotating with angular speed ω about its one end, in a uniform perpendicular magnetic field B is 1/2 B $\omega \ell^2$.

   1. **EMF Induced in a rotating disc :**

   Emf between the centre and the edge of disc of radius r rotating in a magnetic field B = $\frac{B\omega r^2}{2}$

5. **Fixed loop in a varying magnetic field**

   If magnetic field changes with the rate $\frac{dB}{dt}$, electric field is generated whose average tangential value along a circle is given by $E = -\frac{B}{2}$

   This electric field is non conservative in nature. The lines of force associated with this electric field are closed . curves

6. **Self induction**

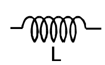
$$\varepsilon = -\frac{\Delta(N\phi)}{\Delta} = -\frac{\Delta(LI)}{\Delta} = -\frac{L\Delta I}{\Delta}.$$

The instantaneous emf is given as $\varepsilon = -\frac{(N\phi)}{\ } = -\frac{(LI)}{\ } = -\frac{L\ I}{\ }$

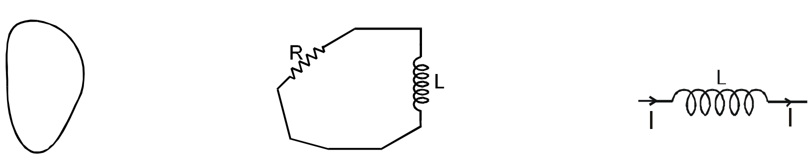
Self inductance of solenoid = $\mu_0 n^2 \pi r^2 \ell$.

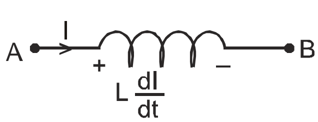
6.1 Inductor

It is represent by



electrical equivalence of loop





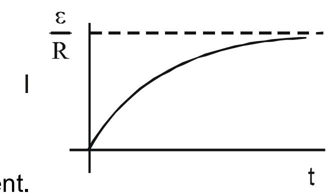
$$V_A - L\frac{dI}{dt} = V_B$$

Energy stored in an inductor $= \frac{1}{2} LI^2$

7. Growth Of Current in Series R L Circuit

If a circuit consists of a cell, an inductor L and a resistor R and a switch S ,connected in series and the switch is closed at t = 0, the current in the circuit I will increase as $I = \frac{\varepsilon}{R}(1 - e^{\frac{-Rt}{L}})$

The quantity L/R is called time constant of the circuit and is denoted by τ.
The variation of current with time is as shown.



1. Final current in the circuit = $\frac{\varepsilon}{R}$, which is independent of L.
2. After one time constant , current in the circuit =63% of the final current.
3. More time constant in the circuit implies slower rate of change of current.

8 Decay of current in the circuit containing resistor and inductor:

Let the initial current in a circuit containing inductor and resistor be I_0. Current at a time t is given as $I = I_0 e^{\frac{-Rt}{L}}$

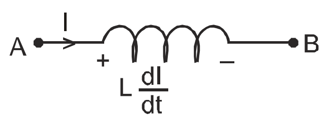
Current after one time constant : $I = I_0{}^{-1}$ =0.37% of initial current.

9. Mutual inductance is induction of EMF in a coil (secondary) due to change in current in another coil (primary). If current in primary coil is I, total flux in secondary is proportional to I, i.e. N ϕ (in secondary) **I**.

or N ϕ (in secondary) = M I.

The emf generated around the secondary due to the current flowing around the primary is directly proportional to the rate at which that current changes.

10. Equivalent self inductance :



$$L = \frac{V_A - V_B}{dI/dt} \quad ..(1)$$

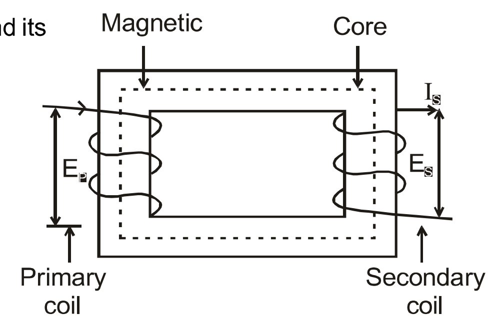
1. Series combination : $L = L_1 + L_2$ (neglecting mutual inductance)

$L = L_1 + L_2 + 2M$ (if coils are mutually coupled and they have winding in same direction)

$L = L_1 + L_2 \;\; 2M$ (if coils are mutually coupled and they have winding in opposite direction)

2. Parallel Combination : $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$ (neglecting mutual inductance)

For two coils which are mutually coupled it has been found that M $\sqrt{L_1 L_2}$ or M =k $\sqrt{L_1 L_2}$ where k is called coupling constant and its value is less than or equal to 1.



$\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$,where denotations have their usual meanings.

$N_S > N_P$ $E_S > E_P$ for step up transformer.

12. LC Oscillations

$$\omega^2 = \frac{1}{LC}$$