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# PHYSICS

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# Electromagnetic Induction

## 01. Magnetic Flux

Proportional to the number of magnetic field lines passing through a surface. Denoted by $\phi_B$.

$$\phi_B = \vec{B}.\vec{A} = BAcos\theta \quad ...(i)$$

Where $\phi_B$ is the magnetic flux through a plane surface of area A placed in a uniform magnetic field B. θ is the angle between $\vec{B}$ and $\vec{A}$. Equation (i) can be extended to curved surfaced and non-uniform fields.

If the magnetic field has different magnitudes and directions at various parts of a surface the magnetic flux through the surface.

$$\phi_B = \vec{B_1}.\vec{dA_1} + \vec{B_2}.\vec{dA_2} + ... = \sum_{ALL} \vec{B_i}.\vec{dA_i}$$

## 02. Faraday's Law of Induction

The magnitude of the induced emf in a circuit is equal to the time rate of change of magnetic flux through the circuit.

$$e_{(t)} = -\frac{d}{dt}\phi_{(t)}$$

The average induced emf $\bar{e} = -\frac{\Delta\phi}{\Delta t} = -\left[\frac{\phi_2 - \phi_1}{t_2 - t_1}\right]$

In case of a closely wound coil of N turns, change of flux.

induced emf $\quad e_{(t)} = -N\frac{d}{dt}\phi_{(t)}$

**Lenz's Law :**

The direction of induced emf (i.e., polarity of induced emf) and hence the direction of induced current in a closed circuit is to oppose the case due to which they are produced. For example, if the flux is increasing, induced emf (and hence induced current) will try to decrease the flux and vice-versa.

**To Change the Magnetic Flux :**

(i) Change the magnitude B of the magnetic field within the coil.

(ii) Change either the total area of the coil or the portion of that area that lies within the magnetic field.

(iii) Change the angle between the direction of the magnetic field B and the plane of coil.

Lenz's law is in accordance with law of conservation of energy. As the induced emf opposes the change in flux, work has to be done against the opposition offered by induced emf/current in changing the flux. The work done appears as electrical energy in the circuit.