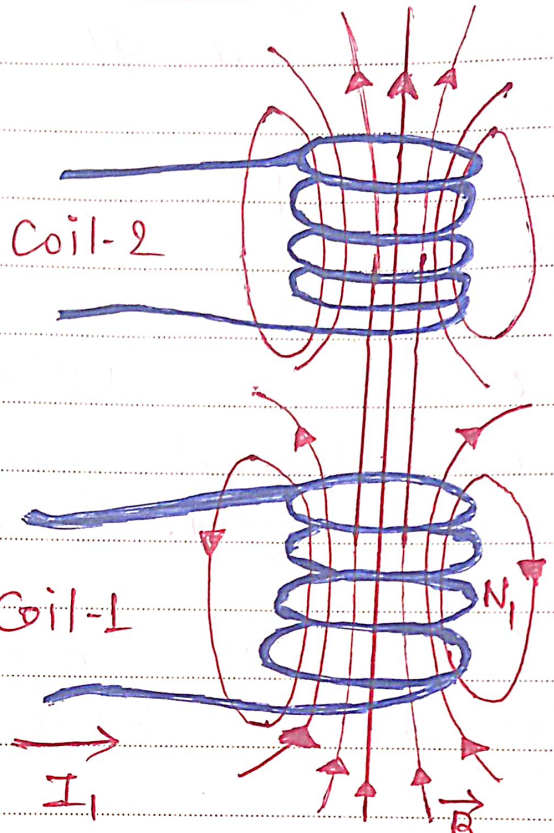
> Date ☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun

Degree-2, Group-B, Current Electricity, Physics

Paper-IV

Topic:- Mutual Induction.



Suppose two coils are placed near each other as show in figure.

This first coil has N_1 turns and carries a current I_1 which gives rise to a magnetic field $\vec{B}_1$. Since the two coils are closed to each other, some of the magnetic field lines through coil 1 will also pass

> Date ☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun

Degree-2, Group-B, Current Electricity Paper-IV

through coil 2.

Let Φ_{21} denote the magnetic flux through one turn of coil 2 due to I_1. Now, by varying I_1 with time, there will be an induced emf associated with the changing magnetic flux in the second coil.

$$\mathcal{E}_{21} = -N_2 \frac{d\Phi_{21}}{dt} = -\frac{d}{dt}\iint_{coil_2} \vec{B_1} \cdot d\vec{A_2} \quad \text{---(1)}$$

The time rate of change of magnetic flux Φ_{21} in coil 2 is proportional to the time rate of change of the current in coil 1.

$$N_2 \frac{d\Phi_{21}}{dt} = M_{21} \frac{dI_1}{dt} \quad \text{---(2)}$$

Where the proportionality constant M_{21} is called the mutul inductance.

$$\text{so } M_{21} = \frac{N_2 \Phi_{21}}{I_1} \quad \text{Mutul Inductance} \quad \text{---(3.)}$$

The SI unit of the inductance is the henery (H).

$$1 \text{ henry} = 1 H = 1 T \cdot m^2/A \quad \text{---(4.)}$$

> Date ☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Su

Degree-2, Group-B, Current Electricity, Paper-IV

If we change the position of the coil. then

$$\mathcal{E}_{12} = -N_1 \frac{d\Phi_{12}}{dt} = -\frac{d}{dt}\int\int_{Coil\,1} \vec{B}_2 \cdot d\vec{A}_1 \quad \text{—— (5)}$$

The changing flux in coil 1 is proportional to the changing current in coil 2.

$$\therefore \quad N_1 \frac{d\Phi_{12}}{dt} = M_{12} \frac{dI_2}{dt} \quad \text{—— (6)}$$

where the proportionality constant M_{12} is another mutul inductance

$$\text{So,} \quad M_{12} = \frac{N_1 \Phi_{12}}{I_2} \quad \text{—— (7)}$$

However, using the reciprocal theorem which combines Ampere's law and the Biot-Savart Law, one may show that the constant are equal.

$$\therefore \quad M_{12} = M_{21} \equiv M \quad \text{—— (8)}$$