ELECTROMAGNETIC INDUCTION

Michael Faraday demonstrated the reverse effect of Oersted experiment. He explained the possibility of producing emf across the ends of a conductor when the magnetic flux linked with the conductor changes. This was termed as Electromagnetic Induction.

Whenever there is a change in the magnetic flux linked with a closed circuit an emf is produced. This emf is known as the induced emf and the current that flows in the closed circuit is called induced current.

The phenomenon of producing an induced emf due to the changes in the magnetic flux associated with a closed circuit is known as Electromagnetic Induction.

Faraday Discovered the electromagnetic Induction by conducting several experiments

Conclusion of Faraday's Experiment :-

1) Galvanometer shows the deflection whenever magnet is in motion otherwise deflection is disappeared i.e current becomes zero.

2) Higher the velocity of magnet (towards or away) → more is the deflection in galvanometer.

3) When no of turns of coil is increased or soft iron core is inserted in the coil then deflection increases. i.e intensity of current increases

4) If the resistance of coil circuit increases then deflection of current is decreased.

5) If magnet is at rest but coil circuit moves away or towards the magnet then galvanometer also shows the deflection.

FARADAY'S LAWS OF ELECTROMAGNETIC INDUCTION :-

Based on his experimental studies on the phenomenon of electromagnetic induction, Faraday proposed following two laws :-

FIRST LAW :-

Whenever the amount of magnetic flux linked with a closed circuit changes, an emf is induced in the circuit. The induced emf lasts so long as the change in magnetic flux continues.

SECOND LAW :-

The magnitude of emf induced in a closed circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.

The magnetic flux linked with the coil initially $= \phi_1$

The magnetic flux linked with coil after a time $t = \phi_2$

Rate of change of magnetic flux $= \dfrac{\phi_2 - \phi_1}{t}$

According to Faraday's second Law

The magnitude of induced emf

$$e \propto \frac{\phi_2 - \phi_1}{t}$$

If the change in magnetic flux in a time $dt = d\phi$

then

$$e \propto \frac{d\phi}{dt}$$

LENZ'S LAW :-

The russian scientist H. F. Lenz in 1835 discovered a simple law giving the direction of the induced current produced in a circuit.

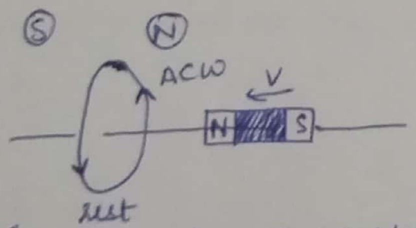
Lenz's law states that the induced current produced in a circuit always flow in such a direction that it opposes the change or cause that produces it.

If the coil has N number of turns and ϕ is the magnetic flux linked with each turn of the coil then, the total magnetic flux linked with the coil at any time $= N\phi$

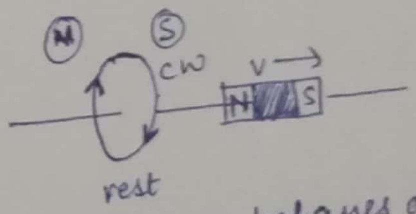
$$\therefore \; e = -\frac{d}{dt}(N\phi)$$

$$e = -N\frac{d\phi}{dt}$$

$$\boxed{e = -N\frac{(\phi_2 - \phi_1)}{t}} \; *$$



(coil face behaves as North Pole to oppose the motion of magnet)



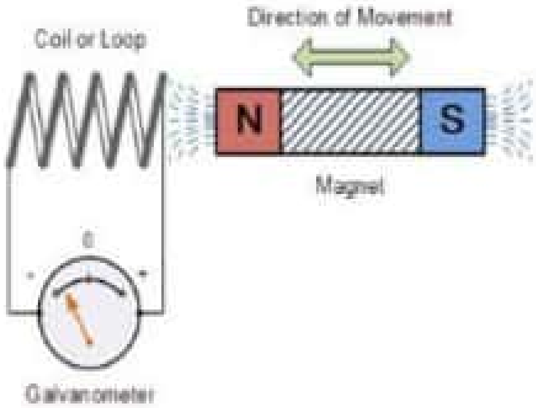
(coil face behaves as South Pole to oppose the motion of magnet)

$$\boxed{e = (-)\frac{d\phi}{dt}}$$

, here negative sign indicates the concept of Lenz's laws

Faraday's Experiment

In this experiment, Faraday takes a magnet and a coil and connects a galvanometer across the coil. At starting, the magnet is at rest, so there is no deflection in the galvanometer i.e the needle of the galvanometer is at the center or zero position. When the magnet is moved towards the coil, the needle of the galvanometer deflects in one direction.



When the magnet is held stationary at that position, the needle of galvanometer returns to zero position. Now when the magnet moves away from the coil, there is some deflection in the needle but opposite direction, and again when the magnet becomes stationary, at that point respect to the coil, the needle of the galvanometer returns to the zero position. Similarly, if the magnet is held stationary and the coil moves away, and towards the magnet, the galvanometer similarly shows deflection. It is also seen that the faster the change in the magnetic field, the greater will be the induced EMF or voltage in the coil.

Position of magnet	Deflection in galvanometer
Magnet at rest	No deflection in the galvanometer
Magnet moves towards the coil	Deflection in galvanometer in one direction
Magnet is held stationary at same position (near the coil)	No deflection in the galvanometer
Magnet moves away from the coil	Deflection in galvanometer but in the opposite direction
Magnet is held stationary at the same position (away from the coil)	No deflection in the galvanometer

Conclusion: From this experiment, Faraday concluded that whenever there is relative motion between a conductor and a magnetic field, the flux linkage with a coil changes and this change in flux induces a voltage across a coil.

Michael Faraday formulated two laws on the basis of the above experiments. These laws are called **Faraday's laws of electromagnetic induction**.