MAGNETIC EFFECT OF ELECTRIC CURRENT
Electro Magnetic Induction

ELECTROMAGNETIC INDUCTION:

When an electric current is passed through a conductor, a magnetic field is produced around the conductor. Faraday thought that as a magnetic field is produced by electric current, it should be possible to produce an electric current by the magnetic field. According to him, whenever there is a change in the magnetic lines of force associated with a conductor, an electromotive force (e.m.f.) is set up at the ends of the conductor which lasts as long as the change is taking place. This phenomenon is called electromagnetic induction.

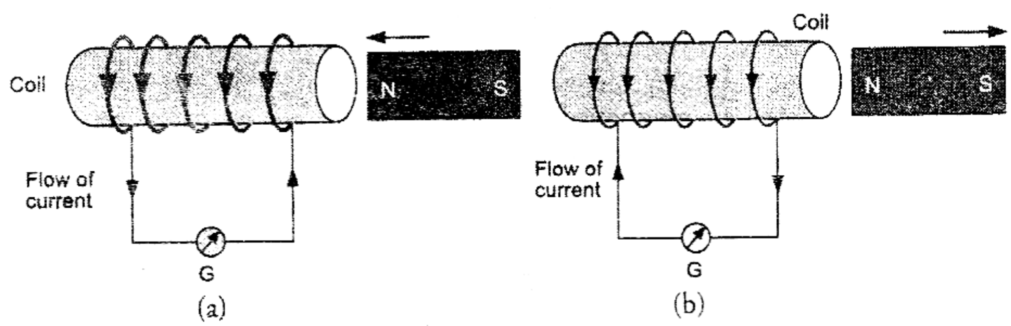
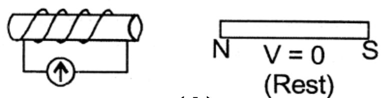


Fig. – Felectromagnetic induction

(a) Faraday's Experiments:

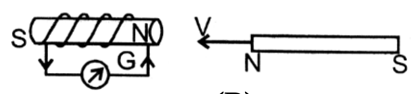
Wind an insulated copper wire on a wooden cylinder so as to form a solenoid coil. Connect the two ends of the coil to the center of galvanometer. A magnet is placed along the axis of the coil.

(i) When the magnet is stationary, there is no deflection in the galvanometer. The pointer reads zero as shown in figure (A).



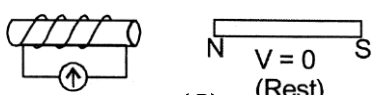
(A)

(ii) When the north pole of the magnet is brought near the coil, the current flows in the coil in direction shown in the figure (B) and the galvanometer shows the deflection towards the right.

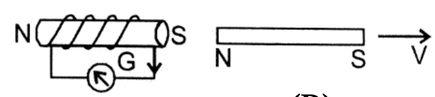


(B)

(iii) If we stop the motion of the magnet, the pointer of the galvanometer comes to the zero position as shown in figure (C). Thus the current in the coil flows so long as the magnet is moving. If the magnet is taken away from the coil, the current again flows in the coil but in the direction opposite to that shown in figure (D) and therefore the pointer of the galvanometer deflects towards the left side.

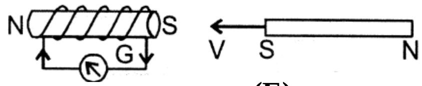


(C)



(D)

(iv) If south pole of the magnet is brought towards the coil, the current in the coil flow in the direction opposite to that shown in figure (E) and so the pointer of the galvanometer deflects towards the left.



(E)

(v) Similar deflection is observed in the galvanometer if the magnet is kept stationary and the coil is moved.

From this experiment Faraday concluded that:

(i) The galvanometer shows a deflection (i.e., current flow in the coil) only when there is relative motion between the coil and the magnet.

(ii) The direction of deflection is reversed if the direction of motion is reversed.

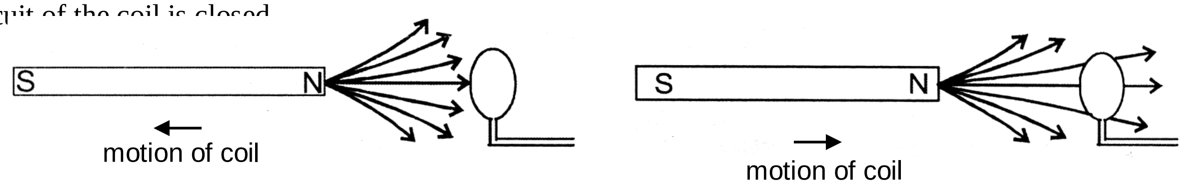
(iii) The value of the current in the coil (i.e. deflection of the pointer) is increased by:

(A) The rapid motion of the magnet or the coil.

(B) the use of a strong magnet.

(C) increasing the area and number of turns in the coil.

When the magnet and coil are relatively at rest, the total number of magnetic lines of force due to the magnet passing through the coil (i.e. the magnetic flux linked with the coil) remains constant, therefore no e.m.f. is induced in the coil and the galvanometer shows no deflection.
When there is relative motion between the coil and magnet, the magnetic flux linked with coil changes. If the coil is moved towards the magnet, the magnetic flux through the coil increases as shown in fig. Due to change in magnetic flux linked with the coil, an e.m.f. is induced in the coil. This e.m.f. causes a current to flow if the circuit of the coil is closed.



(b) Faraday's Laws of Electromagnetic Induction:

Faraday formulated the following two laws of electromagnetic induction:

(i) Whenever there is a change in magnetic flux linked with a conductor, an em.f. is induced. The induced e.m.f. lasts so long as there is a change in magnetic flux cut by the conductor.

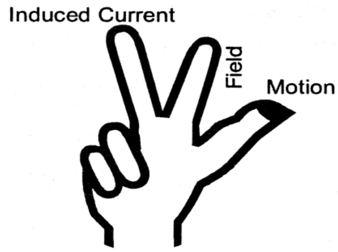
(ii) The magnitude of the e.m.f. induced is directly proportional to the rate of change of magnetic flux cut by the conductor. If the rate of change of magnetic flux remains uniform, a steady e.m.f. is induced. If the circuit of conductor is closed, a current flow in the conductor due to the e.m.f. induced across its ends.

(c) Direction of Induced e.m.f. :

The direction of induced e.m.f. (and hence the direction of induced current) can be obtained by any of the following rules :

(i) Fleming's right-hand rule
(ii) Lenz's law

(i) **Fleming's right-hand rule:** Stretch the thumb, middle finger and the forefinger of your right hand mutually perpendicular to each other as shown in figure. If the forefinger indicated the direction of the magnetic field and the thumb indicated the direction of motion of the conductor, the middle finger will indicate the direction of induced current.



(iii) **Lenz's law:** This law gives us the direction of current induced in a circuit.

According to Lenz's law, the induced current will appear in such a direction that it opposes the change (in magnetic flux) responsible for its production.
The law refers to induced currents, which means that it applies only to closed circuits. If the circuit is open we would fined the direction of induced e.m.f.
For example, in figure, when the magnet is moved towards the loop, a current is induced in the loop. The

induced current produces its own magnetic field with magnetic dipole moment $\vec{M}$ oriented so as to oppose the motion of the magnet. Thus the induced current must be anticlockwise as shown in figure below.