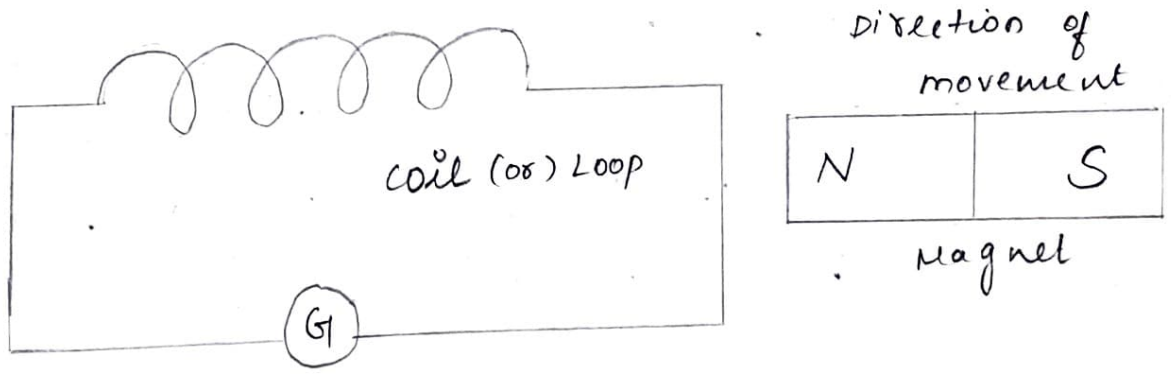
FARADAY'S LAW

Faraday's law of electromagnetic induction also known as Faraday's law. is the basic law of electromagnetism which help us to predict how a magnetic field would intract with electric circuit to produce electromotive force (EMF). This Phenomenon is also known as electromagnetic induction.

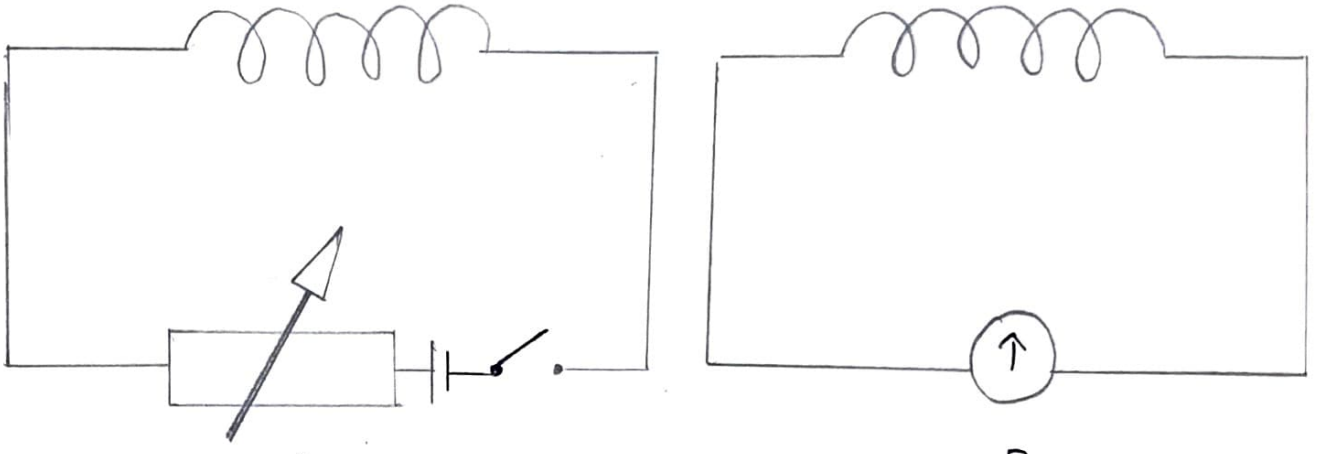
Michael faraday proposed the law of electromagnetic induction in the year of 1831. Faraday's law (or) the law of electromagnetic induction is the observation (or) the result of the experiments conducted by the Faraday. He performed three main experiments to discover the phenomenon of electromagnetic induction.

EXPERIMENT - 1



In this experiment, Faraday connected a coil to a galvanometer. A bar magnet was pushed towards the coil, such that the north pole is pointing towards the coil. As the bar magnet is shifted, the pointer in the galvanometer gets deflected, thus indicating the presence of current in the coil under consideration. It is observed that when the bar magnet is stationary, the pointer shows no deflection and the motion last only only till the magnet is in motion. Here, the direction of deflection of the pointer depends upon the direction of motion of a bar magnet. Also when the south pole of the magnet movided towards (or) away from the coil, the deflection in the galvanometer opposite to the observed with north pole for similar movement. The deflection also depends upon the spied of pulling and taking away from coil. The same effected is observed, when the coil is moved and magnet is held stationary. This shows that the relative motion between the magnet and coil are responsible for generation of current in coil

EXPERIMENT 2



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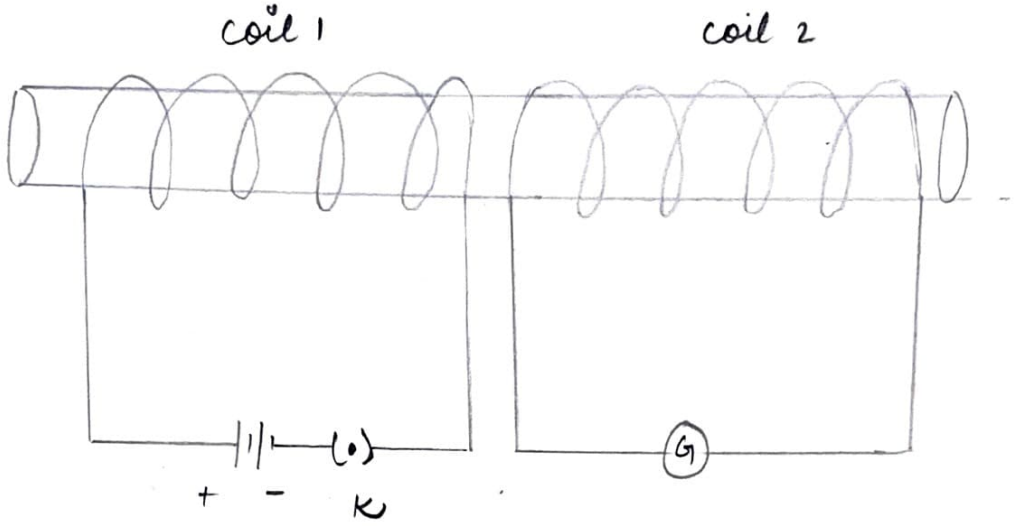
In the second experiment, Faraday replaced the magnet by the second current-carrying coil that was connected to a battery. Here the current in the coil due to the connected battery produced a steady magnetic field, which made the system analogous to previous one. As we move the second coil towards the primary, the pointer of the galvanometer undergoes deflection, which which indicated the presence of current in first coil. Here to the above case the direction of deflection of the pointer depend upon the direction of motion of secondary coil, towards (or) away from primary. Also the magnitude of deflection depends upon speed of coil is moved.

EXPERIMENT 3



From the above two experiment, it is concluded that the relative motion between the magnet and coil resulted in generation of current in primary coil. By another experiment conducted by the Faraday proved that the relative motion between the coil was not really necessary for the current in the primary to be generated. In the experiment, he placed two stationary coils and connected one of them to the galvanometer and other to battery, through push button. As the button was pressed, the galvanometer in the other coil showed the deflection, indicating presence of current in the coil. Also, the deflection in the point was temporary and pressed continuously, pointer show no deflection, when key released, the deflection in opposite direction occurs.

FARADAY'S LAWS OF ELECTROMAGNETIC INDUCTION

First law:

Whenever the magnetic flux linked with a closed circuit changes, an emf (and hence a current) is induced in it which last only so long as the change in flux is taking place. This phenomenon is called electromagnetic induction

Second law:

The magnitude of the induced emf is equal to the rate of change of magnetic flux linked with closed circuit.

Mathematically $|\mathcal{E}| = \frac{d\phi}{dt}$.

MATHEMATICAL FORM OF THE LAWS OF ELECTONAGNETIC INDUCTION : EXPRESSION FOR INDUCED EMF

According to the Faraday's Flux Rule.

Magnitude of induced EMF = Rate of change of magnetic flux

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

Taking into account Lenz's rule for the direction of induced Emf, Faraday's law takes the form:

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

The negative sign indicate that the direction of induced Emf is such that it opposes the change of magnetic flux

If the coil consists of N tightly wound turns, the emf developed in the all these turn equal and in the same direction and hence get added up. Total induced emf will be.

$$\mathcal{E} = -N\frac{d\phi}{dt}.$$

If the flux changes from ϕ_1 to ϕ_2 in time t, then avg. induced emf will be

$$\mathcal{E} = -N\frac{\phi_2 - \phi_1}{t}$$

If ϕ is in webers, t in seconds, then $\mathcal{E}$ will be volts.

FARADAY'S EXPERIMENT: RELATIONSHIP BETWEEN INDUCED EMF AND FLUX

→ In the first experiment, he proved that when the strength of the magnetic field is varied, only then current is induced. An ammeter was connected to a loop of wire. the ammeter deflected when magnet was moved towards the wire.

→ In the second experiment, he proved that passing current through an iron rod would make it electromagnetic. He observed that when a relative motion exist between magnet and coil, the electromotive force will be induced. when magnet rotate about the axis, no emf was observed, when magnet rotate about its own axis, then induced emf was produced. Thus there was no deflection in ammeter, when magnet held stationary.

→ while conducting third experiment, he recorded galvanometer didn't show any deflection and no induced current produced in the coil when coil moved to stationary magnetic field. The ammeter deflected in opposite direction when magnet moved away from the loop.

CONCLUSION:

After conducting all the experiments, Faraday finally concluded that if relative motion existed between conductor and the magnetic field, the flux linked with a coil changed and this change in flux produces the voltage across coil.

It basically state "when the magnetic flux (or) magnetic field change with time, the emf is produced".

APPLICATION OF FARADAY'S LAW

1) Electrical equipment like transformers work on basis of Faraday's law.

2) Induction cooker work on basis of mutual induction which is principle of Faraday's law.

3) By inducing an emf into electromagnetic flowmeter, the velocity of fluid recorded.

4) Electric guitar and violin are musical instrument, find application of Faraday's law

5) Maxwell eq. is based on the converse of Faraday's law which state change in magnetic field bring change in electric field.