ELECTROMAGNETIC INDUCTION

PHYSICS PROJECT REPORT
Submitted
For Class XII

NAME___________________________

SCHOOL NAME_________________________

CERTIFICATE

This is to certify that the PHYSICS project titled ‘ELECTROMAGNETIC INDUCTION’ has been successfully completed by
of Class XII in partial fulfillment of curriculum of CENTRAL BOARD OF SECONDARY EDUCATION (CBSE) for the year

TEACHER IN-CHARGE

ACKNOWLEDGEMENT

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ELECTROMAGNETIC INDUCTION

DEFINITION

Electromagnetic induction (or sometimes just induction) is a process where a conductor placed in a changing magnetic field (or a conductor moving through a stationary magnetic field) causes the production of a voltage across the conductor. This process of electromagnetic induction, in turn, causes an electrical current – it is said to induce the current.

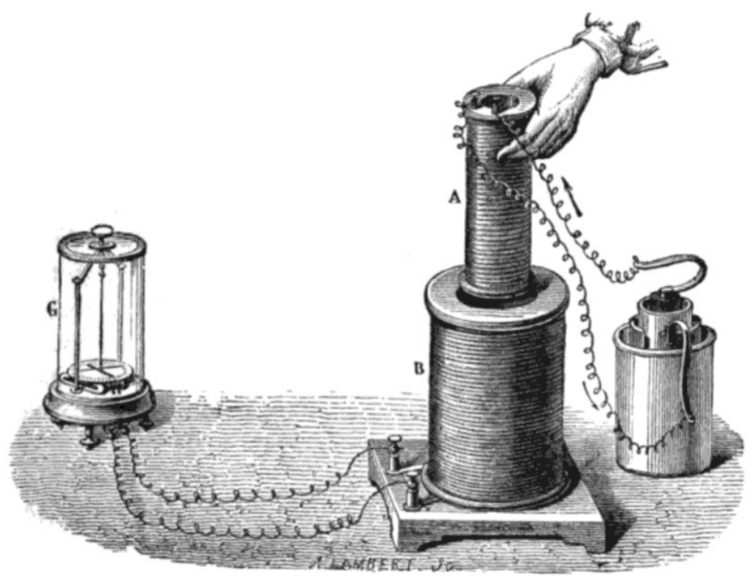
Theory

While Oersted's surprising discovery of electromagnetism paved the way for more practical applications of electricity, it was Michael Faraday who gave us the key to the practical generation of electricity: electromagnetic induction. Faraday discovered that a voltage would be generated across a length of wire if that wire was exposed to a perpendicular magnetic field flux of changing intensity.

An easy way to create a magnetic field of changing intensity is to move a permanent magnet next to a wire or coil of wire. The magnetic field must increase or decrease in intensity perpendicular to the wire (so that the lines of flux "cut across" the conductor), or else no voltage will be induced.

Faraday's Experiment

The following experiment performed by Faraday led to the discovery of the electromagnetic induction.



When the strength of magnetic field is varied

Consider two coils P and S wound on an iron rod. Iron rod is connected with galvanometer, battery and tapping key. When tapping key is pressed and when it is released galvanometer shows deflection showing the presence of induced current.

Explanation:

When the tapping key is pressed then magnetic flux linked with the coil S changed because of increase in magnetic field of coil P and induced current is produced and when it is released magnetic flux is again changed and induced current is produced. But when the tapping key is kept pressed then the magnetic flux linked with coil do not changed and induced current do not produce so galvanometer shows no deflection.

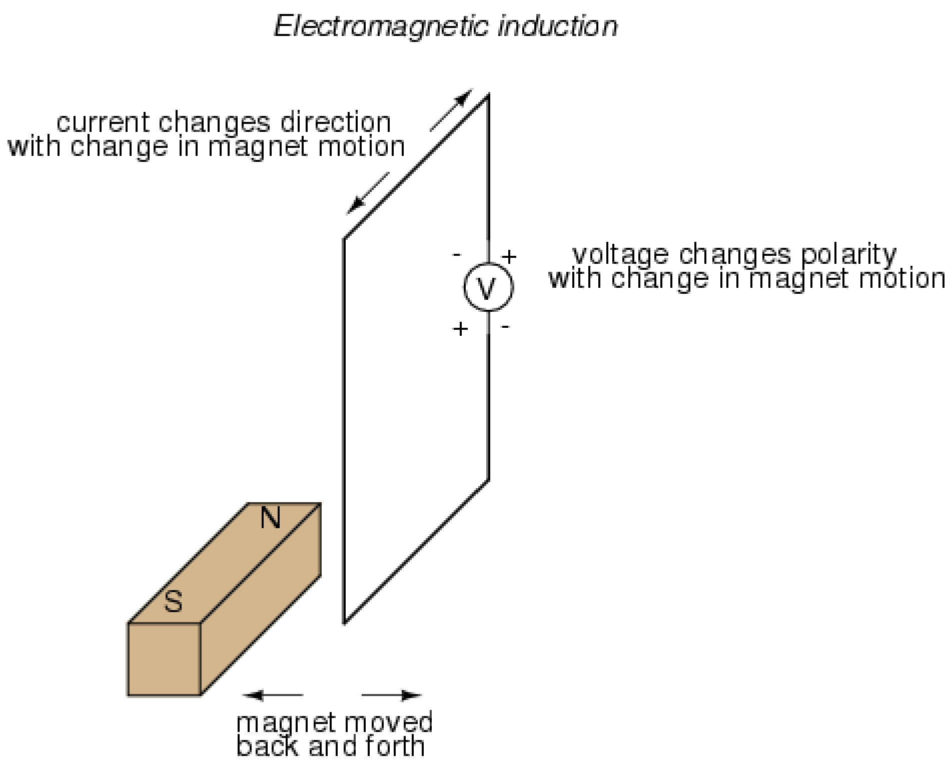
Faraday's Laws of Electromagnetic Induction:

The results of Faraday's experiment on electromagnetic induction are known as "Faraday's Law of Electromagnetic Induction". These are stated as below:

1. Whenever magnetic flux linked with a circuit (a loop of wire or a coil or an electric circuit in general) changes, induced e.m.f. is produced.

2. The induced e.m.f. lasts as long as the change in magnetic flux continuous.

3. The magnitude of induced e.m.f. is directly proportional to the rate of change of magnetic flux linked with the circuit.



Faraday was able to mathematically relate the rate of change of the magnetic field flux with induced voltage (the lower-case letter "e" represents voltage. This refers to instantaneous voltage, or voltage at a specific point in time, rather than a steady, stable voltage.):

$$e = N \frac{d\Phi}{dt}$$

Where,

$e =$ (Instantaneous) induced voltage in volts
$N =$ Number of turns in wire coil (straight wire = 1)
$\Phi =$ Magnetic flux in Webers
$t =$ Time in seconds

The "d" terms are standard calculus notation, representing rate-of-change of flux over time. "N" stands for the number of turns, or wraps, in the wire coil (assuming that the wire is formed in the shape of a coil for maximum electromagnetic efficiency).

A corollary of Faraday's Law, together with Ampere's Law and Ohm's Law is **Lenz's Law**: The EMF induced in an electric circuit always acts in such a direction that the current it drives around the circuit opposes the change in magnetic flux which produces the EMF.

Lenz's Rule:

Lenz's rule is a convenient method to determine the direction of induced current produced in the circuit.

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

On pressing the key the current in the coil P flows in clockwise direction and magnetic lines of force are directed from left to right. Then magnetic flux linked with the coil S changed. The direction of induced current should be such that it should oppose the direction of flow of magnetic field lines. So induced current in the coil S is in the direction opposite to the magnetic field in P. Hence, direction of induced current in coil S is from right to left. So induced current in coil S should flow in anticlockwise direction.

Electromagnetic Induction is put into practical use in the construction of electrical generators, which use mechanical power to move a magnetic field past coils of wire to generate voltage. However, this is not the only practical use for this principle.

The magnetic field produced by a current-carrying wire was always perpendicular to that wire, and that the flux intensity of that magnetic field varied with the amount of current through it, we can see that a wire is capable of inducing a voltage along its own length simply due to a change in current through it. This effect is called self-induction: a changing magnetic field produced by changes in current through a wire inducing voltage along the length of that same wire. If the magnetic field flux is enhanced by bending the wire into the shape of a coil, and/or wrapping that coil around a material of high permeability, this effect of self-induced voltage will be more intense. A device constructed to take advantage of this effect is called an inductor.

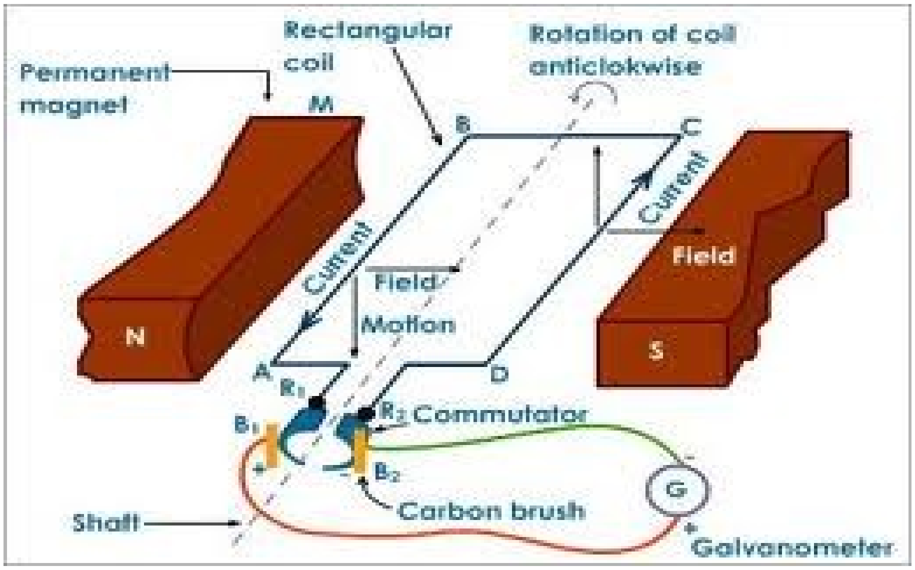
APPLICATIONS OF ELECTROMAGNETIC INDUCTION

The principles of electromagnetic induction are applied in many devices and systems. Induction is used in power generation and power transmission. Electric generators and electric motors are based on electromagnetic induction.

Electric Generator

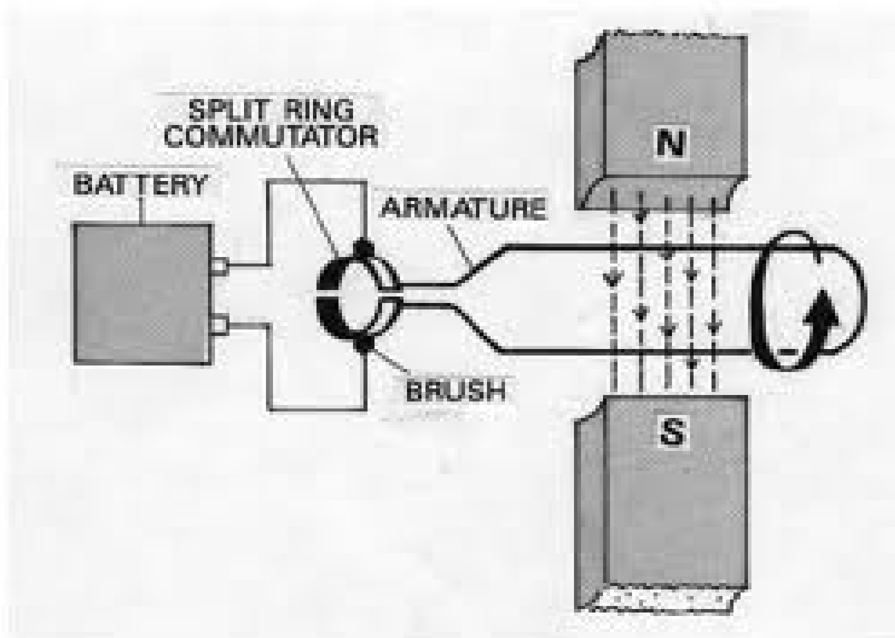
An electric generator is a device for transforming mechanical energy into electrical energy. Generators have a wire coil in a magnetic field. When the device is used as a generator, the coil is spun which induces current in the coil.

An AC (alternating current) generator utilizes Faraday's law of induction, spinning a coil at a constant rate in a magnetic field to induce an oscillating emf. A coil turning in a magnetic field can also be used to generate DC power.



Electric Motor

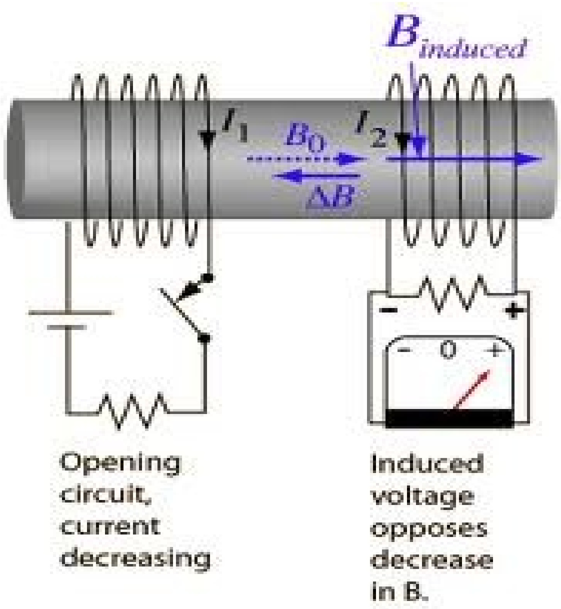
An electric motor is a device which converts electric energy into mechanical energy. It also has a coil. When a current is passed through the coil, the interaction of the magnetic field with the current causes the coil to spin.



Mutual Inductance

Consider two coils P and S are placed very close to each other. Coil P consists of battery and tapping key and coil S consists of galvanometer G. When the key of coil P is pressed then magnetic flux is building and induced e.m.f. produced in it opposes the flow of magnetic flux. Because coil P and coil S are very close to each other. So magnetic flux also changed in coil S and induced current is produced which opposes the direction of flow of magnetic lines of force in coil P.

The phenomenon according to which an opposing e.m.f. is produced in a coil as a result of change in current or magnetic flux linked with a neighboring coil is called mutual induction.



Coefficient of Mutual Induction :

Suppose that current I is flowing through coil P and ϕ be the magnetic flux linked with coil S

$\phi \propto I$

$\phi = MI$

M = Coefficient of mutual induction.

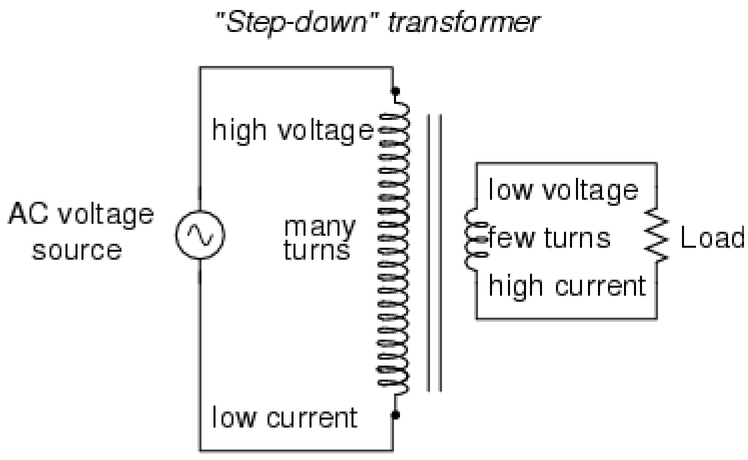
Let ε be the induced e.m.f. in coil S.

$\varepsilon = \frac{d\phi}{dt} = \frac{-d}{dt}(MI)$ – (-ive sign shows opposition of induced e.m.f.)

$M = \varepsilon / \frac{dI}{dt}$

The mutual inductance of two coils is said to be one Henry, if a rate of change of current of 1 ampere per second in one coil induces an e.m.f. of 1 volt in neighboring coil.

A device specifically designed to produce the effect of mutual inductance between two or more coils is called a transformer.



A transformer designed to output more voltage than it takes in across the input coil is called a "step-up" transformer, while one designed to do the opposite is called a "step-down," in reference to the transformation of voltage that takes place. The current through each respective coil, of course, follows the exact opposite proportion.

Self Inductance

Consider a coil connected to a battery and a tapping key. When key K is pressed magnetic lines of forces starts growing through it and induced e.m.f. is produced. Direction of induced e.m.f. is opposite to that of growth of current. On the other hand when key is released the current in the coil decreases and e.m.f. is produced in opposite direction. Thus during both growth and decay of current an opposite induced e.m.f. is produced. This e.m.f. is called back e.m.f.

The phenomenon according to which an opposing induced e.m.f. is produced in the coil as a result of change in current or magnetic flux linked with the coil is called self induction.

Coefficient of Self Induction :

Suppose when key is pressed, current I flows through the coil and magnetic flux ϕ linked with the coil.

$\phi \alpha$ I

ϕ = MI

L is called coefficient of self induction.

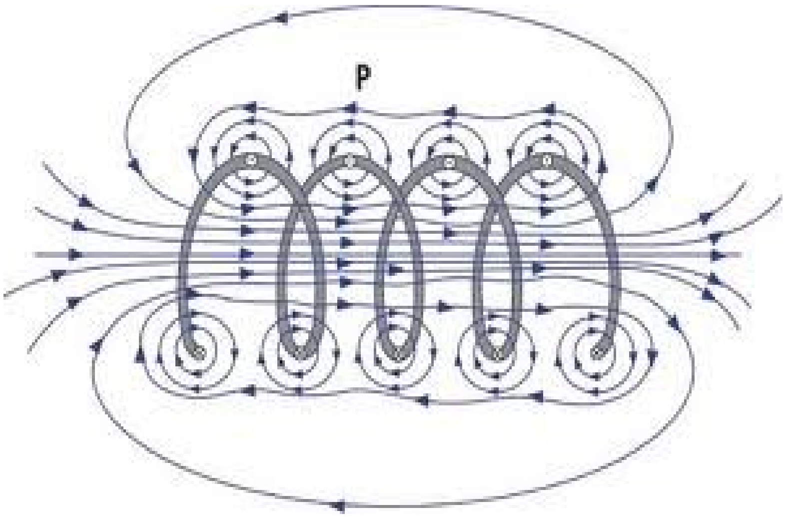
Let ε be the induced e.m.f.

$$\varepsilon = \frac{d\phi}{dt} = \frac{-d}{dt}(LI) = \frac{-LdI}{dt}$$

$\varepsilon = \frac{LdI}{dt}$ (-ive sign shows opposing nature of induced e.m.f.)

M = $\varepsilon / \frac{dI}{dt}$

Self inductance of a coil is said to be one Henry if a rate of change of current of 1 ampere per second induces an e.m.f. of one volt.



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