



FARADAY'S LAW



Introduction to electro dynamic fields

In our study of static fields so far, we have observed that static electric fields are produced by electric charges, static magnetic fields are produced by charges in motion or by steady current. Further, static electric field is a conservative field and has no curl, the static magnetic field is continuous and its divergence is zero.

Concept of Magnetic Circuits

The fundamental relationships for static electric fields among the field quantities can be summarized as:

$$\nabla \times \vec{E} = 0$$

$$\nabla \cdot \vec{D} = \rho_v$$

For a linear and isotropic medium,

$$\vec{D} = \epsilon \vec{E}$$

Similarly for the magnetostatic case

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{H} = \vec{J}$$

$$\vec{B} = \mu \vec{H}$$

It can be seen that for static case, the electric field vectors \vec{E} and \vec{D} and magnetic field vectors \vec{B} and \vec{H} form separate pairs.

In this chapter we will consider the time varying scenario. In the time varying case we will observe that a changing magnetic field will produce a changing electric field and vice versa.

Study on Faraday's law

Michael Faraday, in 1831 discovered experimentally that a current was induced in a conducting loop when the magnetic flux linking the loop changed. In terms of fields, we can say that a time varying magnetic field produces an electromotive force (emf) which causes a current in a closed circuit. The quantitative relation between the induced emf (the voltage that arises from conductors moving in a magnetic field or from changing magnetic fields) and the rate of change of flux linkage developed based on experimental observation is known as Faraday's law. Mathematically, the induced emf can be written as

$$Emf = - \frac{d\phi}{dt} \quad Volts$$

where ϕ is the flux linkage over the closed path.

A non zero $\frac{d\phi}{dt}$ may result due to any of the following:

- (a) time changing flux linkage a stationary closed path.
- (b) relative motion between a steady flux a closed path.
- (c) a combination of the above two cases.

