MOVING CHARGES AND MAGNETISM

MAGNETIC FIELD DUE TO A CURRENT ELEMENT, BIOT-SAVART LAW

THE MAGNETIC FIELD

In earlier lessons we found it convenient to describe the interaction between charged objects in terms of electric fields. Recall that an electric field surrounding an electric charge. The region of space surrounding a moving charge includes a magnetic field in addition to the electric field. A magnetic field also surrounds a magnetic substance.

In order to describe any type of field, we must define its magnitude, or strength, and its direction.

Magnetic field is the region surrounding a moving charge in which its magnetic effects are perceptible on a moving charge (electric current). Magnetic field intensity is a vector quantity and also known as magnetic induction vector. It is represented by $\vec{B}$

Umber of lines per unit area crossing a small area perpendicular to the direction of the induction being numerically equal to $\vec{B}$. The number of lines of $\vec{B}$ crossing a given area is referred to as the magnetic flux linked with that area. For this reason, $\vec{B}$ is also called magnetic flux density.

There are two methods of calculating magnetic field at some point. One is Biot-Savart law which gives the magnetic field due to an infinitesimally small current carrying wire at some point and the another is Ampere law, which is useful in calculating the magnetic field of a symmetric configuration carrying a steady current.
The unit of magnetic field is weber/m2 and is known as tesla (T) in the SI system.

BIOT-SAVART LAW

Biot-Savart law gives the magnetic induction due to an infinitesimal current element. Let AB be a conductor of an arbitrary shape carrying a current i, and P be a point in vacuum at which the field is to be determined. Let us divide the conductor into infinitesimal current-elements. Let $\vec{r}$ be a displacement vector from the element to the point P

According to Biot-Savart Law, the magnetic field induction $d\vec{B}$ at P due to the current element $d\vec{\ell}$ is given by

$$d\vec{B} \alpha \frac{i(d\vec{\ell} \times \vec{r})}{r^3} \text{ or } d\vec{B} = K \frac{i(d\vec{\ell} \times \vec{r})}{r^3}$$

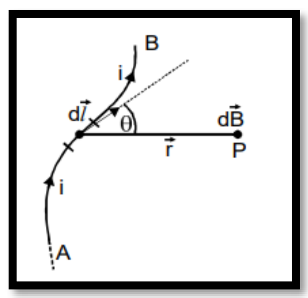
Where k is a proportionality constant. Here $d\vec{\ell}$ vector points in the direction of current i.

In S.I. units,

$$K = 10^{-7} \frac{\text{Wb}}{\text{amp} \times \text{meter}}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i(d\vec{\ell} \times \vec{r})}{r^3} \qquad \dots (1)$$

Equation (1) is the vector form of the Biot-Savart Law. The magnitude of the field induction at P is given by



$$dB = \frac{\mu_0}{4\pi} \frac{i d\ell \times \sin\theta}{r^2}$$

Where θ is the angle between $d\vec{\ell}$ and $\vec{r}$.

If the medium is other than air or vacuum, the magnetic induction is

$$d\vec{B} = \frac{\mu_0 \mu_r}{4\pi} \frac{i(d\vec{\epsilon} \times \vec{r})}{r^3} \qquad \dots (2)$$

Where μ_r is relative permeability of the medium and is a dimensionless quantity.