

D.N.R.COLLEGE(A)::BHIMAVARAM-534202

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ELECTROMAGNETIC FIELDS: BIOT - SAVART LAW

(విద్యుదయస్కాంత క్షేత్రములు బయోట్ - సావర్ట్ నియమము)

Some basic points

1. Oersted experiment observed the deflection of compass near current carrying conductor which provided evidence for production of magnetic field by moving charge.
2. When a test positive charge moves with a velocity ‘v’ through a point in a magnetic field ‘B’, the charge experiences a deflecting force ‘F’. these three are related by the relation

$$F = q_0 v \times B \Rightarrow B = \frac{F}{q_0 v}$$

The magnitude of B may written as

$$F = q_0 v B \sin\theta \Rightarrow B = \frac{F}{q_0 v \sin\theta}$$

3. When a charged particle moves in electromagnetic field, it experiences Lorentz force. The force is given by

$$F = q_0 E + q_0 v \times B = q_0 [E + v \times B]$$

then there exists a magnetic field at that point

4. Similar to representation of electric lines of force in electric field, there exist magnetic lines of force in magnetic field. The tangent of magnetic line of force gives the direction of the magnetic induction vector at that point. The number of magnetic lines of force is proportional to the magnitude of ‘B’
5. Magnetic flux: similar to electric flux, magnetic flux is defined. It is represented by the letter Φ_B . It gives total number of magnetic lines of induction passing through a surface. Mathematically it is represented as]

$$\Phi_B = \oint B \cdot dS \text{ weber}$$

Biot – Savart law(బయోట్ - సావర్ట్ నియమము):

Biot-Savart law was given by two French physicists, Jean Baptiste Biot and Felix Savart. After a series of experiments to study the magnetic field produced by various current

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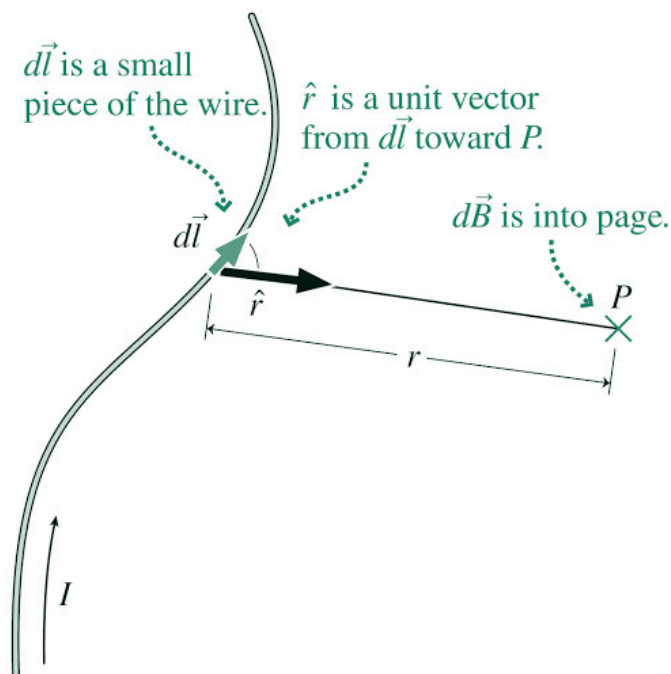
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carrying conductors, they obtained a relation by which ‘B’ can be calculated any point of space around the conductor. Therefore, it is called as Biot-Savart law.

To understand this law, let a current carrying conductor carries a current ‘i’ and ‘P’ be a point at which magnetic induction ‘B’ is supposed to be determined. According to Biot – Savart can be divided into number of short current elements. The magnetic field ‘dB’ due each element is calculated. The following figure shows a current carrying conductor.



Let ‘dl’ the length of one such element and ‘r’ be the displacement vector from the point ‘P’ to the element. Biot – Savart observed that the magnetic induction ‘dB’ at point ‘P’ due to small element of the current carrying conductor depends upon the following factors

1. It is directly proportional to the length of the element dl
$$dB \propto dl$$
2. It is directly proportional to the current i
$$dB \propto i$$
3. It is directly proportional to the sine of the angle ‘ θ ’ between the direction of the current and the vector joining a given point of the magnetic field and the current element
$$dB \propto \sin\theta$$

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4. It is inversely proportional to the square of the distance ‘r’ of the point ‘P’ from the element ‘dl’

$$dB \propto 1/r^2$$

Combining all these, one can get

$$dB \propto \frac{idl \sin \theta}{r^2}$$

When the conductor is placed in vacuum or air, then $dB = \frac{\mu_0}{4\pi} \times \frac{idl \sin \theta}{r^2}$ -----(1)

Here, $\frac{\mu_0}{4\pi}$ is proportionality constant and μ_0 is the permeability of free space.

In vector form,

$$dB = \frac{\mu_0}{4\pi} \times \frac{idl \times \hat{r}}{r^3}$$

where, \hat{r} is the unit vector in the direction of the line drawn from the current element to the point of observation ‘P’ which is commonly known as position vector.

The resultant field at the point ‘P’ can be obtained by integrating equation (1)

$$\therefore B = \int dB = \int \frac{\mu_0}{4\pi} \times \frac{idl \sin \theta}{r^2}, \quad \left(\text{Where, } \frac{\mu_0}{4\pi} = 10^{-7} \frac{\text{weber}}{\text{ampere-meter}} \right)$$

Model questions (మాదిరి ప్రశ్నలు):

- 1) State and explain ‘Biot - Savart law’
- 2) What is Biot - Savart law? Explain.
- 3) Explain Biot – Savart law in detail.

References

1. Unified Physics, Volume III, JAI PRAKASH NATH PUBLICATIONS, MEERUT

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