PHYSICS

CLASS NOTES FOR CBSE

Chapter 20. Moving Charges and Magnetism

01. Magnetic Field

Magnetic Field

The magnetic field is a space around a conductor carrying current or the space around a magnet in which its magnetic effect can be felt.

Moving charge is a source of both electric field as well as a magnetic field. Magnetic field denoted by $\vec{B}$ is a vector.

To define the magnetic field $\vec{B}$, we deduce an expression for the force on a moving charge in a magnetic field.

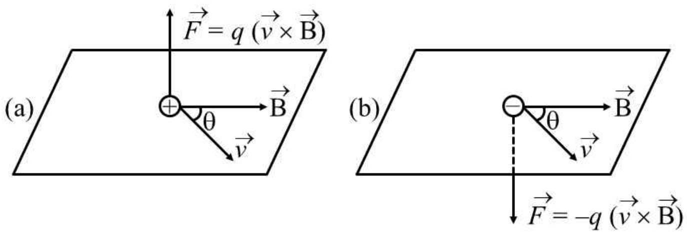
$$F \propto q\ v \sin\theta\ B \quad \text{or} \quad F = k\ q\ v\ B \sin\theta$$

Where k is a constant

$$|\vec{F}| = q\,|\vec{v} \times \vec{B}| \quad \text{or} \quad \vec{F} = q\,(\vec{v} \times \vec{B})$$

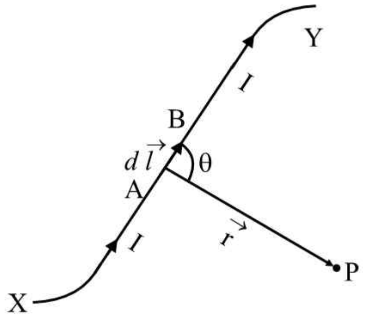
Direction of $\vec{F}$

Given by **the Right-Handed-Screw rule** or **Right-Hand Rule.**



02. Biot-Savart's Law

This law deals with the magnetic field induction at a point due to a small current element.



In SI Units, $$dB = \frac{\mu_0}{4\pi} \times \frac{I\,dl \sin\theta}{r^2}$$

In vector form,

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I(d\vec{l} \times \vec{r})}{r^3}$$

Direction of d$\vec{B}$

Right handed screw rule or **Right Hand Rule**.

Biot Savart's law in terms of charge (q) and its velocity (*v*) is.

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{q(\vec{v} \times \vec{r})}{r^3}$$

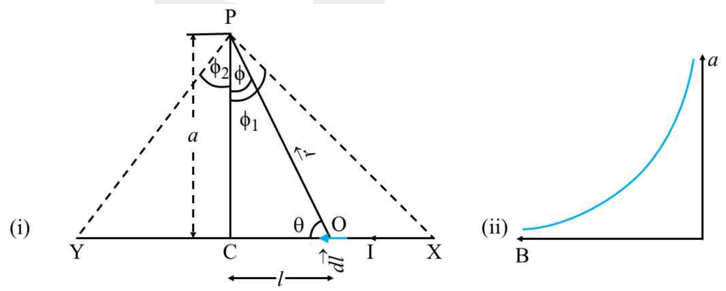
Important features of Biot Savart's law

(i) Biot Savart's law is valid for a symmetrical current distribution.

(ii) This law is analogous to Coulomb's law in electrostatics.

(iii) The direction of d$\vec{B}$ is perpendicular to both $I\,d\vec{l}$ and $\vec{r}$.

03. Magnetic Field Due to a Straight Wire Carrying Current



$$dB = \frac{\mu_0}{4\pi} \times \frac{I\,dl \sin\theta}{r^2}$$

$$\cos\phi = \frac{a}{r} \quad \text{or} \quad r = \frac{a}{\cos\phi}$$

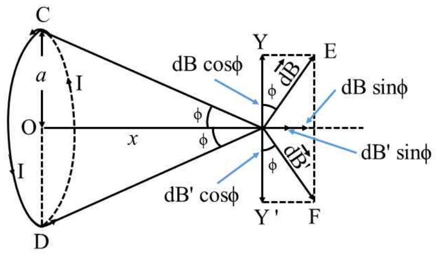
$$\tan\phi = \frac{1}{a} \quad \text{or} \quad l = a\tan\phi$$

$$dB = \frac{\mu_0}{4\pi} \frac{I(a\sec^2\phi\,d\phi)\cos\phi}{\left(\frac{a^2}{\cos^2\phi}\right)} = \frac{\mu_0}{4\pi}\frac{I}{a}\cos\phi\,d\phi$$

$$B = \frac{\mu_0}{4\pi}\frac{I}{a}(\sin\phi_1 + \sin\phi_2)$$

04. Magnetic Field at a Point on the Axis of a Circular Coil Carrying Current

Plane of the coil be perpendicular to the plane of the paper and current I be flowing in there coil in the direction shown.



$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin 90^\circ}{r^2}$$

($\because$ a is small, therefore $\theta = 90°$)

$$= \frac{\mu_0}{4\pi}\frac{I\,dl}{(a^2+x^2)}$$

$$dB = dB' = \frac{\mu_0\,I\,dl}{4\pi\,(a^2+x^2)}$$

$$B = \frac{\mu_0}{4\pi}\frac{2\pi nIa^2}{(a^2+x^2)^{3/2}}$$

Special cases

(i) ***When point P lies at the centre of the circular coil***, then $x = 0$, we have

$$B = \frac{\mu_0}{4\pi}\frac{2\pi nIa^2}{a^3} = \frac{\mu_0}{4\pi}\frac{2\pi\,nI}{a}$$

which is the same as given by above equation.

(ii) ***When point P lies for away from the centre of the coil,*** then $x >> a$. Now $a^2 + x^2 = x^2$ as a^2 can be neglected in comparison to x^2. From above equation, we have

$$B = \frac{\mu_0}{4\pi}\frac{2\pi nIa^2}{x^3} = \frac{\mu_0}{4\pi}\frac{2nIA}{x^3}$$

or $$B = \frac{\mu_0}{4\pi}\frac{2M}{x^3}$$

05. Ampere's Circuital Law

$$\oint \vec{B}.\vec{dl} = \mu_0 I$$

Ampere's circuital law states that the line integral of magnetic field induction $\vec{B}$ around a closed path in vacuum is equal to μ_0 times the total current I threading the closed path.