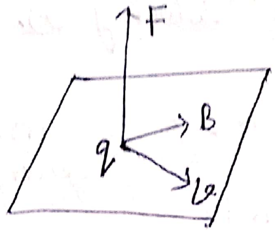
magnetic field :⇒ An electric charge in motion produces magnetic field. It is denoted by $\vec{B}$. The unit of magnetic field is Weber/meter^2 or Tesla(T).

Lorentz force :⇒



Consider a positive charge (q) particle moving with velocity (v) in a magnetic field of strength ($\vec{B}$).
The force experienced by the charge is given by.

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$\vec{F} = q v B \sin\theta \, \hat{n}$$

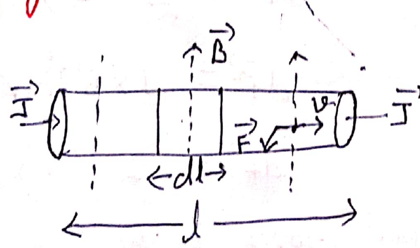
if $v = 0$, $|F| = 0$

if $\theta = 0^\circ$ $|F| = 0$

$\theta = 90^\circ \Rightarrow |F| = qvB$

$$\boxed{|F|_{max} = qvB}$$

Force on a current carrying conductor placed in a magnetic field :⇒



Consider a conductor carrying current (I). Let the magnetic field $\vec{B}$ acting on the conductor.
If N be the number of charges per unit volume then the number of charges(n) in volume dV is given by NdV.

The force due to these charges is

$$d\vec{F} = N\,dV\,(q\,\vec{v} \times \vec{B}) \quad \text{——} (1)$$

Since the current I is steady, all the charges are assume to be moving with the same velocity (v).

but $\vec{J} = Nqv$ (current density) (current per unit area)

$$n = N\,dV$$

$$N = \frac{n}{dV}$$

$dV \rightarrow$ Volume element

Then $$I = \frac{nq}{dt}$$

$$q = \frac{I\,dt}{n}$$

$$\vec{v} = \frac{d\vec{l}}{dt}, \quad J = \frac{I}{A}$$

Now $$d\vec{F} = nq\left(\frac{d\vec{l}}{dt} \times \vec{B}\right)$$

$$d\vec{F} = \frac{nq}{dt}(d\vec{l} \times \vec{B})$$

$$d\vec{F} = \frac{I}{A}(d\vec{l} \times \vec{B})A$$

$$d\vec{F} = (\vec{J} \times \vec{B})\,dl\,A$$

$$d\vec{F} = (\vec{J} \times \vec{B})\,dV \quad \text{——} (11) \quad (dl\,A = dV)$$

$$d\vec{F} = I\,(d\vec{l} \times \vec{B})$$

total force on the conductor of length 'l'

$$\vec{F} = \int d\vec{F}$$

$$\vec{F} = \int I\,(d\vec{l} \times \vec{B})$$

$$\vec{F} = I\,(\vec{l} \times \vec{B})$$

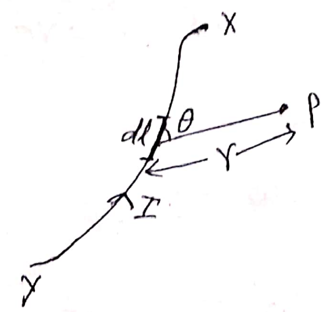
$$\vec{F} = I\,l\,B\,\sin\theta\,\hat{n}$$

$$\boxed{F = BIl\sin\theta}$$

where θ is the angle b/w the direction of current and magnetic field,

$F_{max} = BIl$

Biot-Savart Law :→ According to the Biot-savart law the magnetic field at a point due to current element at distance 'r' from it is



(i) (magnetic field) directly proportional to the current passing through the conductor,

(ii) (magnetic field) directly proportional to the length of current element (dl).

(iii) directly proportional to the sine of the angle between the length element and the line joining the element and the point,

(iv) Inversely proportional to the square of the distance between the current element and the point,

Consider a conductor XY carrying current I. Let dl be the small current element, P be the point at a distance 'r' from the element.

Now the magnetic field $d\vec{B}$ due to current element dl is

$$dB \propto \frac{I\,dl \sin\theta}{r^2}$$

$$dB = K\frac{I\,dl \sin\theta}{r^2}$$

where K is constant.

$$K = \frac{\mu_0}{4\pi}$$

where $\mu_0 \rightarrow$ permeability of free space.

$$\mu_0 = 4\pi \times 10^{-7}$$

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

In Vector notation

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

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

Since $d\vec{B}$ is the cross product of $d\vec{l}$ and $\vec{r}$, the direction of $d\vec{B}$ is along the normal to the plane containing $d\vec{l}$ and $\vec{r}$.