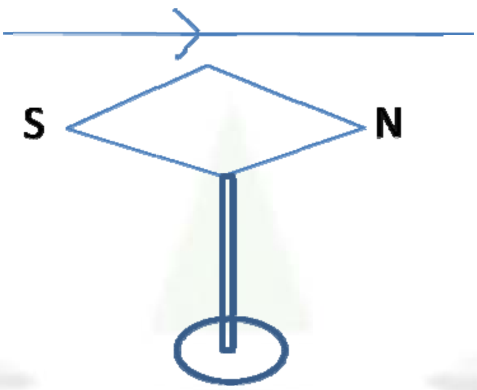
Magnetic effect of current: Oersted first discovered the magnetic effect of current.

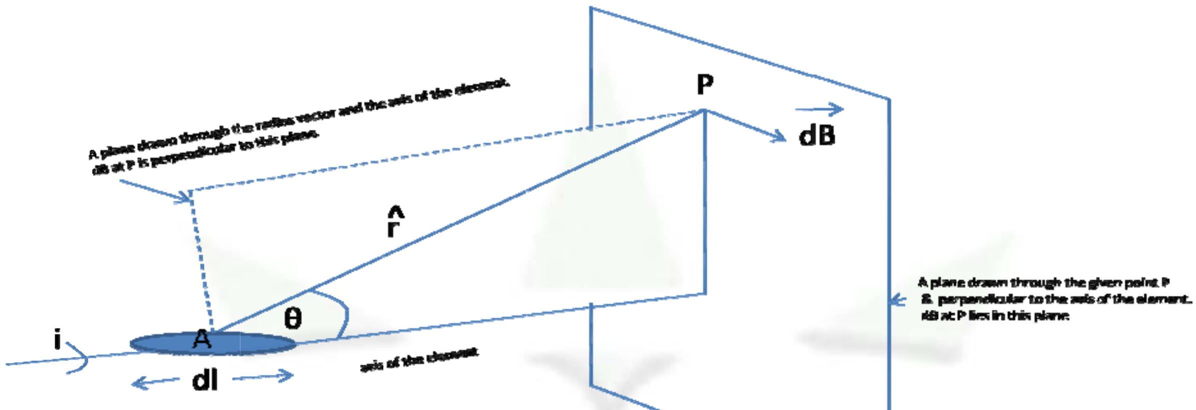
Ampere's experiment: A magnetic needle was kept below a conductor. On passing current through the conductor the needle get deflected.



In order to deflect a magnetic needle a magnetic field is required. Hence it was concluded that on passing current through a conductor a magnetic field is produced. Later experiments by Bio, Savart , Laplace & Ampere gave quantitative explanation of magnetic effect.

Biot's law: We now find the magnetic field at a point due to an element of conductor carrying current.

Let us consider an element of conductor at A carrying a current. P is a point in the surrounding medium where we want to find the magnetic field due to the current element.



Given

i = current flowing through the element

dl = the length of the element of the conductor

r = AP = the distance of the given point from the element of the conductor

$\hat{r}$ = a unit vector along AP

$\hat{dl}$ = a vector of unit length along the axis of the element in the direction of current

θ = the angle between $\hat{r}$ and $\hat{dl}$

Let $\overrightarrow{db}$ = magnetic induction vector at the point P due to the current element

Experimentally it has been found that

$$\left|\overrightarrow{db}\right| \propto i, \left|\overrightarrow{db}\right| \propto dl, \left|\overrightarrow{db}\right| \propto \frac{1}{r^2}, \left|\overrightarrow{db}\right| \propto \sin\theta$$

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

$$db = K' \frac{idl\sin\theta}{r^2} \rightarrow (1)$$

Where K' is a constant of proportionality. The value of K' depends on

(1) Choice of unit

(2) Nature of surrounding medium

In SI system db in tesla, i in ampere, r in meter for free space (air or vacuum)

$$K' = 10^{-7} = \frac{\mu_0}{4\pi} \text{ where } \mu_0 = 4\pi \times 10^{-7} \text{ henry/meter = permiability in free space}$$

$$\text{db} = \frac{\mu_0}{4\pi}\frac{idl\sin\theta}{r^2} \rightarrow (2)$$

Equation(2) which gives magnitude of magnetic field at P is known as Laplace Formula.

The direction of magnetic field at P is found to be as follows

(1) The magnetic field dB at P lies in the plane passing through the given point and is perpendicular to the axis of the element.

(2) The field dB at P is perpendicular to the plane drawn through the radius vector and the axis of the element.

(3) Grasp the conductor at right hand with the thumb in the direction of current the curl of the finger tips give the direction of the magnetic field.

Since the magnetic induction is a vector quantity hence there must be an equation from which both the direction and magnitude can be found.

The vector equation representing the magnetic induction vector was given by Biot

$$\mathrm{db} = \frac{\mu_0}{4\pi}\frac{i}{r^2}\left(\overrightarrow{dl} \times \hat{r}\right) \rightarrow (3)$$