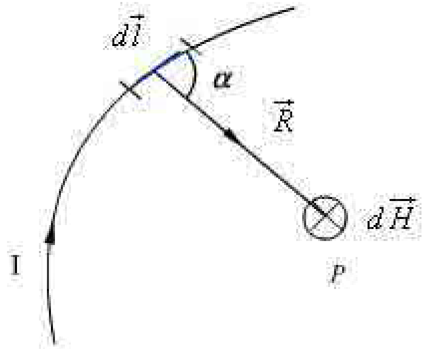
3.3. Biot–Savart's Law

This law relates the magnetic field intensity *dH* produced at a point due to a differential current element as shown in Fig. 3.2.



The magnetic field intensity at P can be written as,

$$d\vec{H} = \frac{Id\vec{l} \times \hat{a}_R}{4\pi R^2} = \frac{Id\vec{l} \times \vec{R}}{4\pi R^3}$$

$$dH = \frac{IdlSin\alpha}{4\pi R^2}$$

$$R = \left|\vec{R}\right|$$

Where is the distance of the current element from the point P.

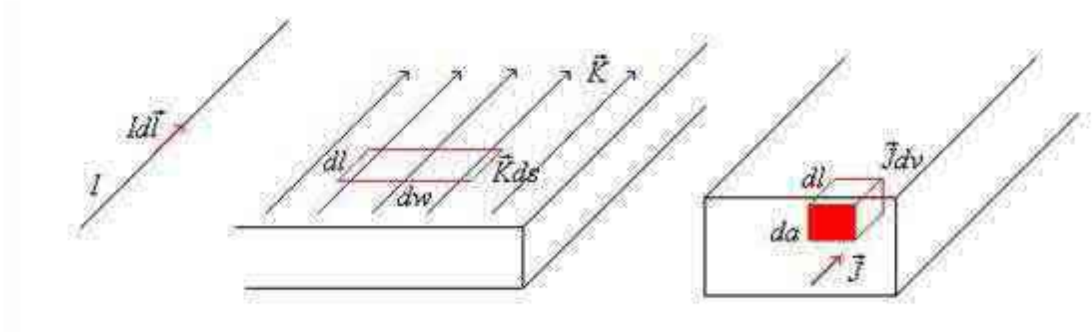
Similar to different charge distributions, we can have different current distribution such as line current, surface current and volume current. These different types of current densities are shown in Fig. 3.3.

By denoting the surface current density as K (in amp/m) and volume current density as J (in amp/m2) we can write:

$$Id\vec{l} = \vec{K}ds = \vec{J}dv$$

Employing Biot-Savart Law, we can now express the magnetic field intensity H. In terms of

These current distributions.



for line current

$$\vec{H} = \int_L \frac{Id\vec{l} \times \vec{R}}{4\pi R^3}$$

for surface current

$$\vec{H} = \int_S \frac{Kd\vec{s} \times \vec{R}}{4\pi R^3}$$

for volume current

$$\vec{H} = \int_v \frac{\vec{J}dv \times \vec{R}}{4\pi R^3}$$

Ampere's Circuital Law:

Ampere's circuital law states that the line integral of the magnetic field (circulation of H) around a closed path is the net current enclosed by this path. Mathematically,

$$\oint \vec{H}.d\vec{l} = I_{enc}$$

The total current I $_{enc}$ can be written as,

$$I_{enc} = \int_S \vec{J}.d\vec{s}$$

By applying Stoke's theorem, we can write\

$$\oint \vec{H}.d\vec{l} = \int_S \nabla \times \vec{H}.d\vec{s}$$

$$\therefore \int_S \nabla \times \vec{H}.d\vec{s} = \int_S \vec{J}.d\vec{s}$$

$$\therefore \nabla \times \vec{H} = \vec{J}$$