

Biot-Savart's Law

by

Dr P A Sunny Dayal

Associate Professor, Dept of ECE

Centurion University of Technology and Management

Andhra Pradesh

Biot-Savart's Law

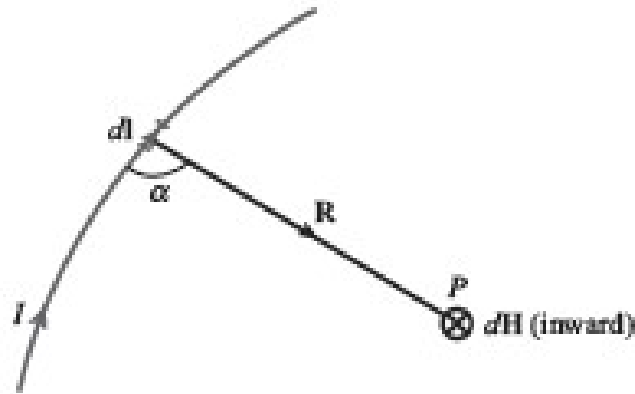


Figure 1 Magnetic field dH at P due to current element $I dl$.

Biot-Savart's law states that the differential magnetic field intensity dH produced at a point P , as shown in Figure 1, by the differential current element $I dl$ is proportional to the product $I dl$ and the sine of the angle α between the element and the line joining P to the element and is inversely proportional to the square of the distance R between P and the element.

$$dH \propto \frac{I dl \sin \alpha}{R^2}$$



$$d\mathbf{H} = \frac{I d\mathbf{l} \times \mathbf{a}_R}{4\pi R^2} = \frac{I d\mathbf{l} \times \mathbf{R}}{4\pi R^3}$$

Statement of Biot-Savart Law

- When a differential current element produces a differential magnetic field, $d\mathbf{H}$, the field magnitude at a point is proportional to the product of $I d\mathbf{l}$ and sine of the angle between the conductor and the line of the point to the conductor.
- It is also inversely proportional to the square of the distance from the element to the point. The direction of $d\mathbf{H}$ is normal to the plane containing $I d\mathbf{l}$ and the unit vector along the line from the element to the point. This normal is in the direction of progress of right handed screw turned from $d\mathbf{l}$ through a small angle to the line from the element to the point. The constant of proportionality is $\frac{1}{4\pi}$

Biot-Savart's Law (Cont'd.)

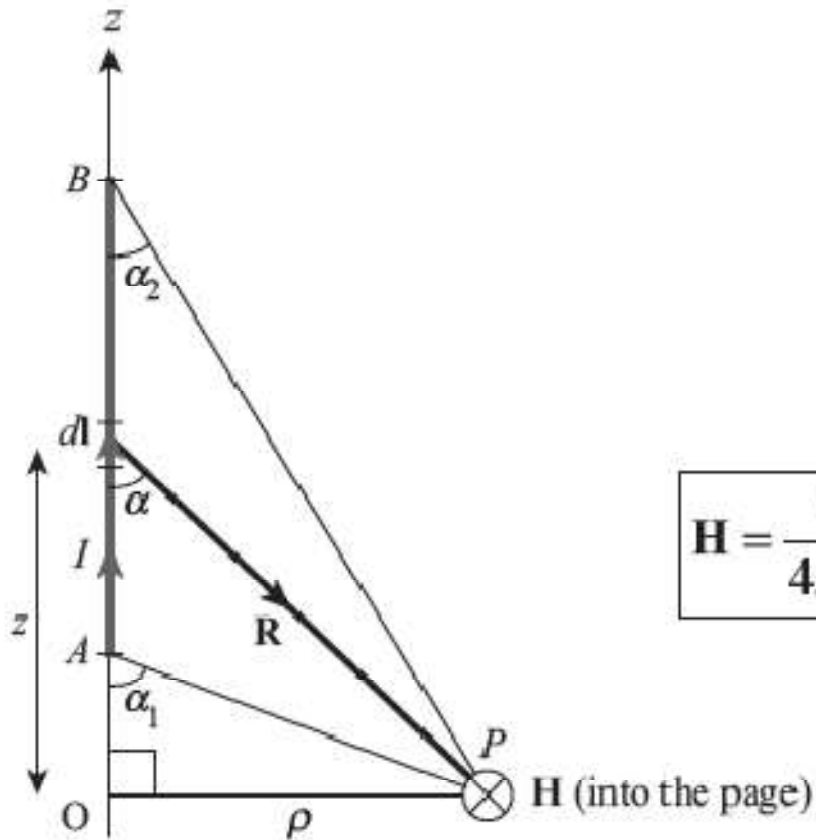
Distributed current sources:

$$\mathbf{H} = \int_L \frac{I d\mathbf{l} \times \mathbf{a}_R}{4\pi R^2} \quad (\text{line current})$$

$$\mathbf{H} = \int_S \frac{\mathbf{K} dS \times \mathbf{a}_R}{4\pi R^2} \quad (\text{surface current})$$

$$\mathbf{H} = \int_V \frac{\mathbf{J} dv \times \mathbf{a}_R}{4\pi R^2} \quad (\text{volume current})$$

Biot-Savart's Law (Cont'd.)



$$\mathbf{H} = \frac{I}{4\pi\rho} (\cos \alpha_2 - \cos \alpha_1) \mathbf{a}_\phi$$

Figure 2 Field at point P due to a straight filamentary conductor.

when the conductor is *infinite* in length.

$$\alpha_1 = 180^\circ, \alpha_2 = 0^\circ.$$

$$\mathbf{H} = \frac{I}{2\pi\rho} \mathbf{a}_\phi$$