Contents

Background

- **Solenoid** is a **coiled** conductor.
- The **magnetic field** of **solenoid** is as that of **bar magnet** .

Magnetic field at axis

- The **magnetic field** is to be calculated at P .
- A small length segment dl is taken.
- Number of turns in dl = n

$$dB = \frac{\mu_0 N I a \sin\theta}{2r^2}$$
$$N = ndl$$
$$dB = \frac{\mu_0 n I a dl \sin\theta}{2r^2}$$
$$BC = dl \sin\theta$$
$$BC = rd\theta$$
$$dl \sin\theta = rd\theta$$
$$dB = \frac{\mu_0 n I a r d\theta}{2r^2}$$
$$dB = \frac{\mu_0 n I a d\theta}{2r}$$
$$\frac{a}{r} = \sin\theta$$
$$dB = \frac{\mu_0 n I \sin\theta d\theta}{2}$$
$$B = \int dB$$
$$B = \int_{\alpha_1}^{\alpha_2} \frac{\mu_0 n I \sin\theta d\theta}{2r}$$
$$B = \frac{\mu_0 n I}{2} \int_{\alpha_1}^{\alpha_2} \sin\theta d\theta$$
$$B = \frac{\mu_0 n I}{2} [\cos\alpha_1 - \cos\alpha 2]$$

- The general **expression** for magnetic field at the axis of a **current** carrying **solenoid** is:

$$B = \frac{\mu_0 n I}{2} [\cos\alpha_1 - \cos\alpha_2]$$

Magnetic Field for long solenoid

- α_1 = 0
- α_2 = π
- The **expression** for **magnetic field** at axis for **long solenoid** is given by:

$$B = \mu_0 n I$$

$$
\begin{aligned}
dB &= \frac{u_0 I dl \sin\theta}{4\pi r^2} \\
dl \sin\theta &= AN \\
d\phi &= \frac{AN}{r} \\
AN &= d\phi r \\
dB &= \frac{u_0 I r d\phi}{4\pi r^2} \\
\cos\phi &= \frac{a}{r} \\
r &= \frac{a}{\cos\phi} \\
dB &= \frac{u_0 I \cos\phi d\phi}{4\pi a} \\
B &= \int_{\phi_1}^{-\phi_2} dB \\
B &= \frac{u_0 I}{4\pi a} \int_{\phi_1}^{-\phi_2} \cos\phi d\phi \\
B &= \frac{u_0 I}{4\pi a} [\sin\phi_1 + \sin\phi_2]
\end{aligned}
$$

- The general expression for **magnetic field** due to a **long straight** conductor is given by:

$$
B = \frac{u_0 I}{4\pi a} [\sin\phi_1 + \sin\phi_2]
$$

Infinite long conductor

$$
\phi_1 = \phi_2 = \frac{\pi}{2}
$$

$$
B = \frac{u_0 I}{4\pi a} \times 2
$$

- The expression for **magnetic field** due to **infinitely** long magnetic field is given by:

$$
B = \frac{u_0 I}{2\pi a}
$$