$$or, -\frac{dx}{d\alpha} = a(-cosec^2\alpha)$$

$$or, dx = acosec^2\alpha\ d\alpha -------- (3)$$

Using equation (2) and (3) in (1), we get

$$or, dB = \frac{\mu_0 nIa^2 acosec^2\alpha\ d\alpha}{2(a^2 + (a\cot\alpha)^2)^{3/2}}$$

$$or, dB = \frac{\mu_0 nIa^2 acosec^2\alpha\ d\alpha}{2a^3 cosec^3\alpha}$$

$$or, dB = \frac{\mu_0 nI}{2} sin\alpha\ d\alpha -------- (4)$$

Now, the magnetic field at $'P'$ due to whole length of the solenoid is obtained by integrating equation (4) between the limits $\alpha_1\ to\ \alpha_2$.

i.e. $$B = \int_{\alpha_1}^{\alpha_2} \frac{\mu_0 nI}{2} sin\alpha\ d\alpha$$

$$or,\ B = \frac{\mu_0 nI}{2} \int_{\alpha_1}^{\alpha_2} sin\alpha\ d\alpha$$

$$or,\ B = \frac{\mu_0 nI}{2} [-cos\alpha]_{\alpha_1}^{\alpha_2}$$

$$\boldsymbol{B = \frac{\mu_0 nI}{2} [cos\alpha_1 - cos\alpha_2]}$$

For infinitely long solenoid, $\alpha_1 = 0^0\ and\ \alpha_2 = 180^0$

$$or, B = \frac{\mu_0 nI}{2} [cos0^0 - cos180^0]$$

$$\boldsymbol{B = \mu_0 nI}$$

Note:

- A solenoid consists of an insulated long wire closely wound in the form of a helix.
- Its length is very large as compared to its diameter.
- If the solenoid is sufficiently long, the field within it is uniform (except at the ends).
- The magnetic field lines due to current carrying solenoid resemble exactly with those of a bar magnet.
- The magnetic field at the ends of a very long current carrying solenoid is half of that at the center.
- The magnetic field outside the solenoid is negligible (zero).

Ampere's Circuital Law:

- This is the alternative method to Biot-Savart's law to calculate magnitude of magnetic field.
- This law is more convenient while calculating magnetic fields of current distribution with a high degree of symmetry. It is more useful if direction of field is tangential to length element.

Statement*: It states that the line integral of magnetic field intensity over a closed path in free space is equal to* $\boldsymbol{\mu_0}$ *times the net current enclosed by the closed path. i.e.*

$$\oint \vec{\boldsymbol{B}}.\vec{\boldsymbol{dl}} = \boldsymbol{\mu_0 I_{en}}$$

Where, $I_{en} = net\ current\ enclosed$, and μ_0 is permeability of free space.