1. According to Ampere's circulal law, the line integral of magnetic field induction along a closed curve is equal to the total current passing through the surface enclosed in the closed curve times the permeability of the medium.

'n' be the no. of turns per unit length.

Consider a rectangular Amperian loop abcd. Along cd, the field is zero since the magnetic field is weak outside. Along bc and ad, the field ~~compon~~ component is zero.

For $L = h$

The total no. of turn is 'nh'

The enclosed current is, $I_e = I(nh)$

From Ampere's circuit law,

$$BL = \mu_0 I_e$$

$$Bh = \mu_0 I(nh)$$

$$B = \mu_0 nI$$

2. Consider a symmetrical long solenoid having no. of turns per unit length equal to n.

Let I be the current flowing in the solenoid, they by right hand rule, the magnetic field is parallel to the axis of the solenoid.

Field inside the solenoid:

Consider a closed path abcd.

$$\oint \vec{B} \cdot \vec{dl} = \mu \times 0$$

Therefore, $B = 0$

Consider a closed path $pqrs$.

The line integral of magnetic field is given by

$$\oint_{pqrs} \vec{B} \cdot \vec{dl} = \int_{pq} \vec{B} \cdot \vec{dl} + \int_{qr} \vec{B} \cdot \vec{dl} + \int_{rs} \vec{B} \cdot \vec{dl} + \int_{sp} \vec{B} \cdot \vec{dl} \quad \text{--- (1)}$$

For path pq, $\vec{B}$ and $\vec{dl}$ are along the same direction,

$$\therefore \int_{qr} \vec{B} \cdot \vec{dl} = \int_{sp} \vec{B} \cdot \vec{dl} = \int B \, dl \cos 90^\circ = 0$$

For path rs, $B = 0$ because outside the solenoid field is zero.

$$\therefore \int_{rs} \vec{B} \cdot \vec{dl} = 0$$

Using these eq^n, (1) gives,

$$\oint_{pqrs} \vec{B} \cdot \vec{dl} = \int_{pq} \vec{B} \cdot \vec{dl} = Bl$$

Now, using Ampere's law

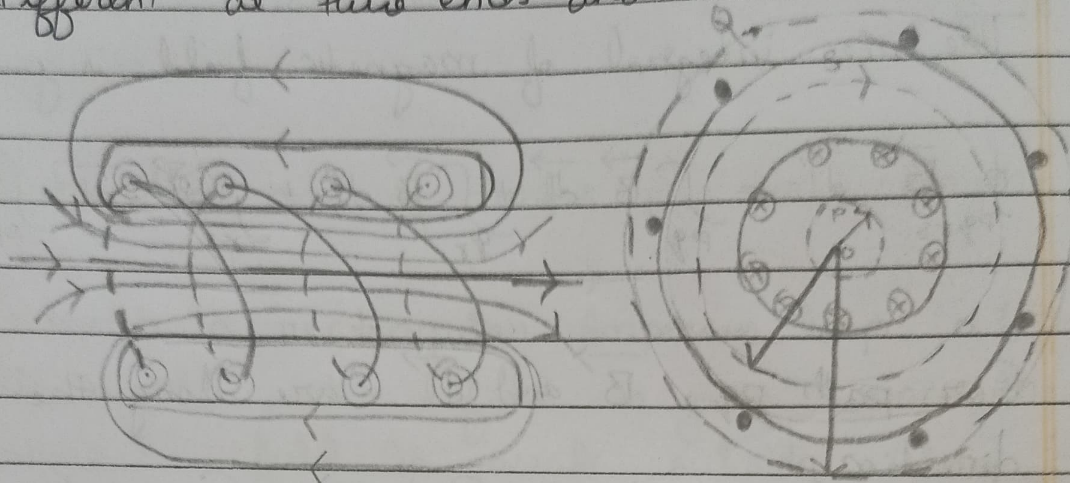
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

This implies,

$$Bl = \mu_0 (nl I)$$

$$\therefore B = \mu_0 n I$$

b) Magnetic lines do not exist outside the body of a toroid. Toroid is closed and solenoid is open on both sides. Magnetic field is uniform inside a toroid whereas, for a solenoid it is different at two ends and centre.



c) The magnetic field is made strong by,

i) passing large current and
ii) using laminated coil of soft iron.

3. $n = 300$ turns / m
$I = 5A$
$l = 0.5$
$r = 10^{-2}$ m

$B = \mu_0 n I = (4\pi \times 10^{-7}) \times 300 \times 5$
$= 1.9 \times 10^{-3}$ T

4. $B = 2.52 \times 10^{-3}$ T
$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
$l = 0.5$ m
$n = 500$
No. of turns per unit length of the solenoid,

$$n = \frac{N}{l} = \frac{500}{0.5} = 1000\ m^{-1}$$

If 'i' is the current through the solenoid then

$$B = \mu_0 n i$$

or $$i = \frac{B}{\mu_0 n} = \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-7} \times 1000} = 2.0A$$