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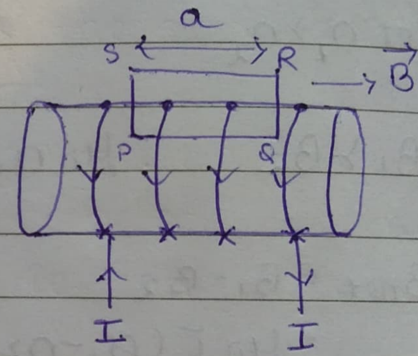
Home Assignment:

1) Ampere's circuital law states that the ~~tarr~~ line integral of resultant magnetic field along a closed plane curve is equal to μ_0 time the total current crossing the area bounded by the closed curve provided the electric field inside the loop remains constant i.e. $\oint B.dl = \mu_0 I$

Let the current flowing in the solenoid having no. of turns per unit length be I. Magnitude of magnetic field inside the solenoid is B whereas outside is zero.



Here the second and fourth term i.e. QR and SP are zero because the angle between $\vec{dl}$ and $\vec{B}$ is 90°

The ~~te~~ third term i.e. SR is also zero as it is out of the solenoid

$$\oint B.\vec{dl} = \int_P^Q \vec{B}.\vec{dl} + \int_Q^R \vec{B}.\vec{dl} + \int_R^S \vec{B}.\vec{dl} + \int_S^P \vec{B}.\vec{dl}$$

$$\Rightarrow \int Bdl\cos 0° + \int Bdl\cos 90° + \int 0\, dl + \int Bdl\cos 90°$$

$$\Rightarrow \int Bdl$$

$$\Rightarrow B\int dl = Ba$$

Total current $= nlI$

For length a $= (\mu_0 I_0) = (naI)\mu_0$

$\therefore$ $\boxed{B = n\mu_0 I}$

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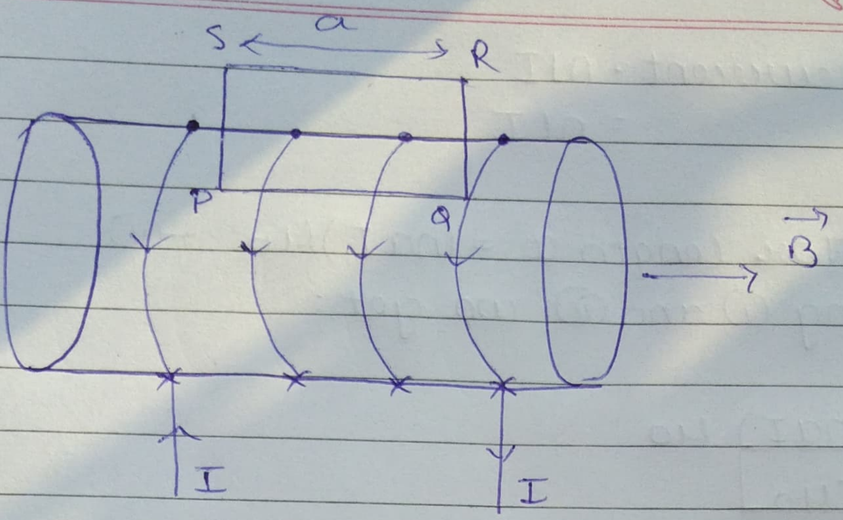


Here,

The current flowing through each current = I
Magnetic field is zero outside the solenoid and is present only in the horizontal axis as, while taking each term the vertical components cancels out each other.

Length of the solenoid = l.
$PQ = RS = a$
Current through length $a = I_0$
According to Ampere's circuital law:

$\oint B dl = \mu_0 I$

LHS: $\oint \vec{B} \vec{dl} = \int_P^Q \vec{B} \cdot \vec{dl} + \int_Q^R \vec{B} \cdot \vec{dl} + \int_R^S \vec{B} \cdot \vec{dl} + \int_S^P \vec{B} \cdot \vec{dl}$

$\Rightarrow \oint B \cdot dl \cos 0^\circ + \oint B \cdot dl \cos 90^\circ + \oint 0 \, dl + \oint B \cdot dl \cos 90^\circ$

$\Rightarrow \oint B dl = B \oint dl$

$= Ba \quad -(1)$

Now, $\oint \vec{B} \cdot \vec{dl} = Ba$

No. of turns per unit length $= \frac{n}{l}$

Total current $= NI$
$= nlI$

~~For~~ For length $a = (naI)\mu_0$ -(ii)
Equating (i) and (ii) we get:

$Ba = (naI)\mu_0$
$\boxed{B = nI\mu_0}$

b) In solenoid, the magnetic field is present inside it, where it is uniformly present at the axis but decreases towards the end, and doesn't exist outside the solenoid.
whereas, In toroid, the magnetic field is present in the tubular area bounded by the coil and is not present inside and outside the toroid

Diagram of solenoid:

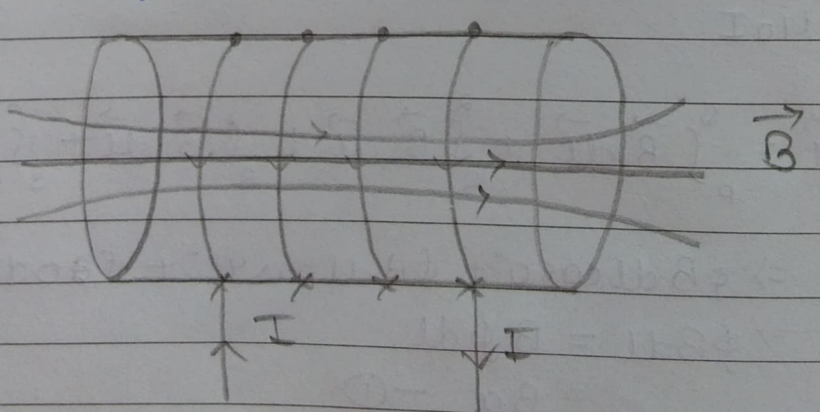
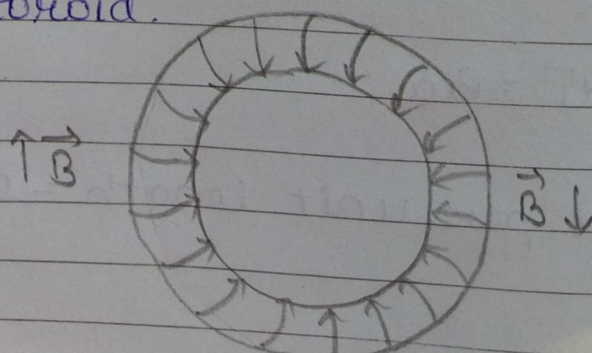


Diagram of toroid.



c) The magnetic field can be increased by:

→ Increasing the no. of turns per unit length
→ Increasing the current through it

3) $n = 300$

$I = 5\ A$

$l = 0.5\ m$

$r = 1\ cm = 0.01\ m$

$l >> r$, so it is a ideal solenoid.

$B = \mu_0 n I$

$= 4\pi \times 10^{-7} \times 300 \times 5$

$= 4 \times 3.14 \times 1500 \times 10^{-7}$

$= 1.88 \times 10^{-3}\ T$

4) $l = 0.5\ m$

$N = 500$

$n = \frac{N}{l} = \frac{500}{0.5} = 1000$

Flux density $(B) = 2.52 \times 10^{-3}$

As we know,

$B = \mu_0 n I$

$\Rightarrow 2.52 \times 10^{-3} = 4\pi \times 10^{-7} \times 1000 \times I$

$\Rightarrow I = \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-7} \times 1000}$

$= \frac{0.63 \times 10}{3.14}$

$= 2\ A$