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Home Assignment

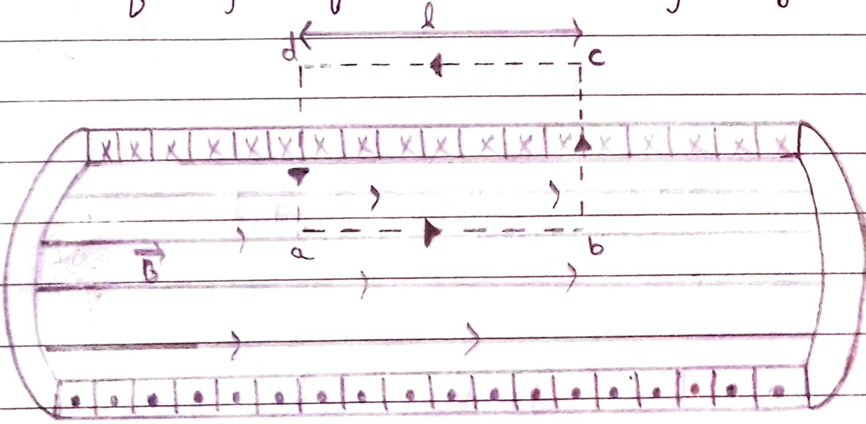
1) State Ampere's circuital law. Show through an example, how this enables an easy evaluation of the magnetic field inside a very long solenoid having n turns per unit length carrying a current I.

ans) Ampere's circuital law:

The line integral of magnetic field of induction $\vec{B}$ around any closed path in free space is equal to absolute permeability of free space μ_0 times the total current flowing through area bounded by the path.

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

Calculation of magnetic field inside a long straight solenoid:-



According to Ampere's circuital law,

$$\int \vec{B} \cdot \vec{dl} = \mu_0 \times \text{total current through the loop abcd}$$

$$\int \vec{B} \cdot \vec{dl} = \int_a^b \vec{B} \cdot \vec{dl} + \int_c^d \vec{B} \cdot \vec{dl} + \int_d^a \vec{B} \cdot \vec{dl}$$

$$\text{But} \int_b^c \vec{B} \cdot \vec{dl} = \int_b^c B\,dl \cos 90° = 0$$

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$$\int_c^d \vec{B} \cdot \vec{dl} = 0$$ as $B = 0$ for points outside the solenoid.

$$\therefore \int \vec{B} \cdot \vec{dl} = \int_a^b \vec{B} \cdot \vec{dl}$$

$$= \int_a^b B\,dl \cos 0^\circ = B \int_a^b dl = Bl$$

Where,

l = length of the side ab of the rectangular loop abcd.

$n = \frac{N}{l}$ (No of turns per unit length)

$N = nl$ (Total no of turns in length l)

Total current flowing $= nlI$

Now, $\int \vec{B} \cdot \vec{dl} = \mu_0 I_{net} = \mu_0 n l I$

$\Rightarrow Bl = \mu_0 n l I$

$\Rightarrow B = \mu_0 n I$

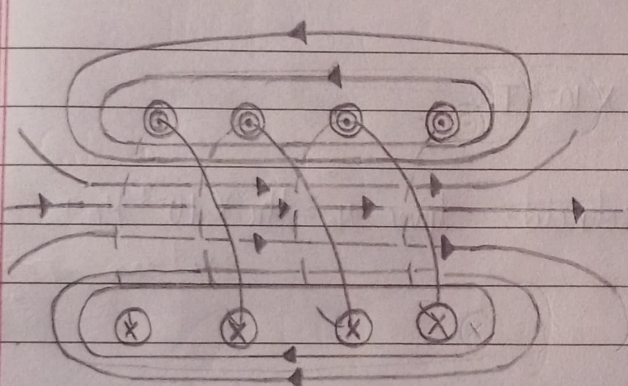
2) Answer the following:

a) Same as 1) 2nd part.

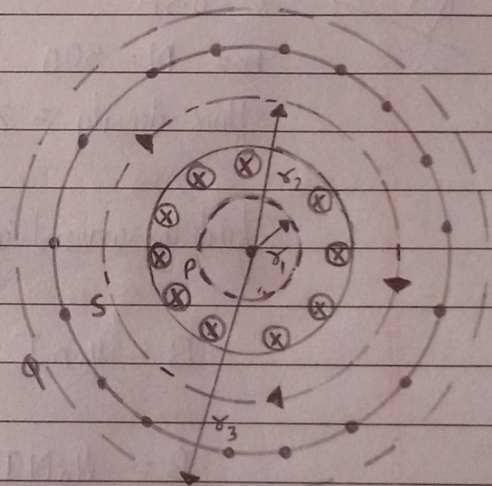
b)
⇒ In a toroid, magnetic lines do not exist outside the body.

⇒ Toroid is close whereas the solenoid is open on both sides.

⇒ Magnetic field is uniform inside a toroid, whereas for solenoid, it is different at the two ends and the centre.



Solenoid



P, Q, S
(Amperian loops) Toroid

c) The magnetic field inside a given solenoid is made strong by:

⇒ Increasing the current in the coil

⇒ Using a soft iron core within the solenoid

⇒ Increasing the no of coils in the solenoid.

Q3. $n = 300$ turns/m $I = 5A$ $l = 0.5m$

$B = \mu_0 n I$

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

$= 18840 \times 10^{-6}$

$= 1.884 \times 10^{-2}\ T$

Q4. $l = 0.5m$

~~B~~ $N = 500$

flux density $= 2.52 \times 10^{-3}\ T$

find the current in the solenoid. Given $\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$

$B = \mu_0 n I$

$B = \frac{\mu_0 N I}{l}$

$2.25 \times 10^{-3} = \frac{4\pi \times 10^{-7} \times 500 \times I}{0.5}$

$I = \frac{0.5 \times 2.25 \times 10^{-3}}{4\pi \times 10^{-7} \times 500}$

$\therefore I = 1.79 \approx 1.8A$