6 July

Home Assignment

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

⇒ Ampere's circuital law states that the line integral of magnetic field $\vec{B}$ around any closed path in vaccum is μ_0 times the total current through the closed path.

Let n be the no. of turns per unit length.
Total no. of turns = nh.
Enclosed current is $I_e = I(nh)$

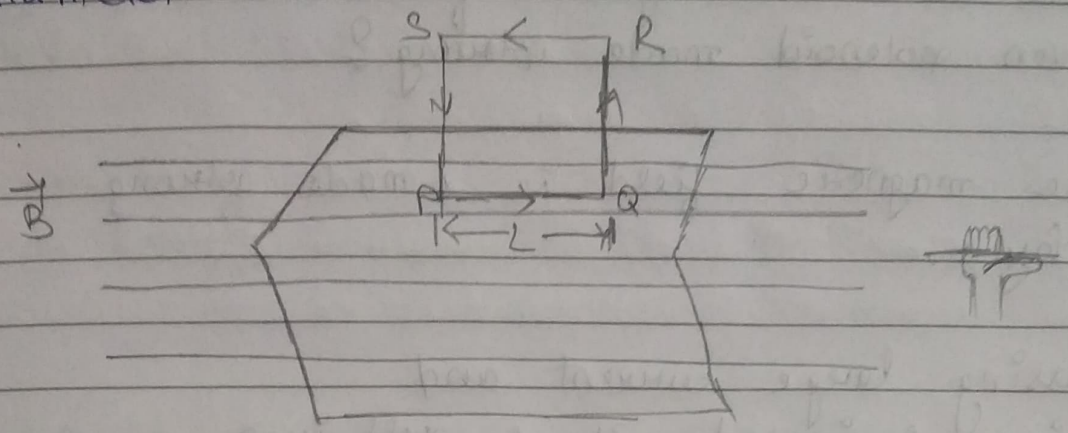
From Ampere's circuital law
$BL = \mu_0 I_e$, $Bh = \mu_0 I(nh)$
$B = \mu_0 nI$

2) a) Using Ampere's circuital law, obtain the expression for the magnetic field due to a long solenoid on its axis.

⇒ Solenoid

- It consists of an insulating long wire closely wound in the form of helix.
- Its length is large as compared to its

diameter.



- Magnetic field due to RQ and QP path is zero because they are perpendicular to the axis of solenoid. Since QR is outside the solenoid, the magnetic field is zero.

- The line integral of magnetic field induction $\vec{B}$ over the closed path PQRS is

$$\oint_{PQRS} \vec{B} \cdot d\vec{L} = \oint_{PQ} \vec{B} \cdot d\vec{L} = BL$$

From Ampere's circuital law,

$\oint_{PQRS} \vec{B} \cdot d\vec{L} = \mu_0 \times$ Total current through rectangle PQRS

$B_L = \mu_0 \times$ Number of turns in rectangle $\times$ current

$B_L = \mu_0 nLI$

$\therefore B = \mu_0 nI$

c) How is the magnetic field inside a given solenoid made strong?

⇒ The magnetic field is made strong by,

i) Passing large current and
ii) Using laminated coil of soft iron.

3) A solenoid coil of 300 turns/m is carrying a current of 5A. The length of the solenoid is 0.5 m and has a radius of 1cm. Find the magnitude of the magnetic field inside the solenoid.

⇒ $n = 300$ $\quad I = 5A$

We know, $B = \mu_0 n I$

$\Rightarrow B = 4\pi \times 10^{-7} \times 300 \times 0.5$

$= 1.18 \times 10^{-4}$ Tesla

4) A 0.5m long solenoid has 500 turns and has a flux density of 2.52×10^{-3} T at the center. Find the current in the solenoid. Given $\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$

⇒ $B = 2.52 \times 10^{-3}$ T $\quad \mu_0 = 4\pi \times 10^{-7} Hm^{-1}$

$l = 0.5$ m

$N = 500$

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

If "i" is the current through the solenoid, then

$$B = \mu_0 n i$$

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