6/7/21

Home Assignment

1) State Ampere's circuit 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.

Ans. The line integral $\oint \vec{B} \cdot \vec{dl}$ for a closed curve is equal to μ_0 times the net current I threading through the area bounded by the curve.

Ampere's Circuit 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 (I_e) = I(nh)

From Ampere's Circuital law
$BL = \mu_0 I_e$, $Bh = \mu_0 I (nh)$
$B = \mu_0 n I$.

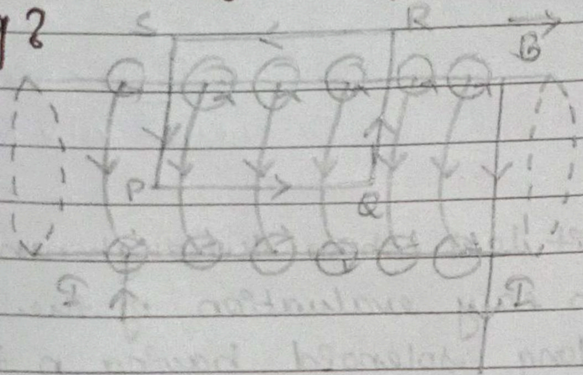
2) Answer the following:

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

b) In what respect, is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.

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

Ans. a)



$$\oint \vec{B}\cdot\vec{dl} = \int_{PQ} \vec{B}\cdot\vec{dl} + \int_{QR} \vec{B}\cdot\vec{dl} + \int_{RS} \vec{B}\cdot\vec{dl} + \int_{SP} \vec{B}\cdot\vec{dl}$$

$$= \int B.dl \cos 0° + \int B.dl \cos 90° + \int B.dl \cos 0° + \int B.dl \cos 90°$$

→ The value of first term $\int_{PQ} B\cdot dl = B.L$.

→ The second term and fourth term are zero because angle between magnetic field and the length loop is 90°.

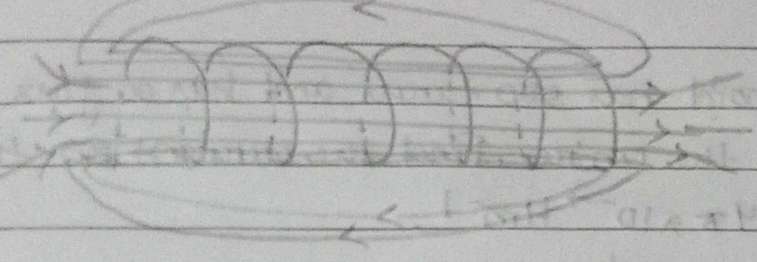
→ The third term is also zero as the value of magnetic field outside the solenoid is 0.

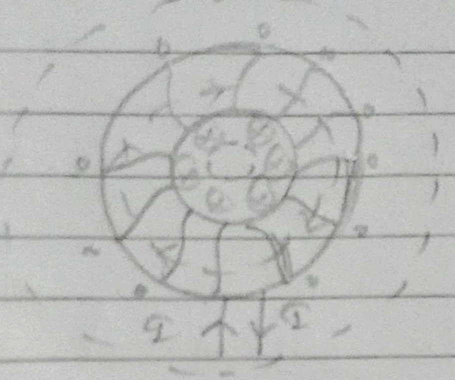
From Ampere's circuital law we get

$BL = \mu_0 (nLI)$

$B = \mu_0 nI$.

b) A toroid is a solenoid bent into the form of a closed ring. The magnetic field lines of solenoid are straight line parallel to the axis inside the solenoid.





c) The magnetic field can be increased by
→ Increasing the no. of turns per unit length of the solenoid.
→ Using a laminated iron core inside a solenoid.
→ Increasing the current magnitude in a solenoid.

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

Ans. No. of turns (n) = 300 turns/m.
Current (I) = 5A

$B = \mu_0 n I$

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

$= 1.9 \times 10^{-3}$ T.

Magnitude $= 1.9 \times 10^{-3}$ T.

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

Ans. $n = \frac{N}{l} = \frac{500}{0.5} = 1000$ turns/m.

As $B = \mu_0 n I$

$I = \frac{B}{\mu_0 n}$

$= \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-7} \times 1000} = 2A$

So, current = 2A.