8 July 2021

Moving charges & Mangnetism

Home Assignment

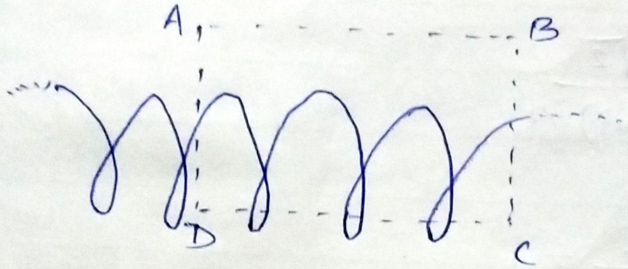
1) given i = current

n = turn density

to find magnetic field = ?

Using Amperian loop law

$B \cdot L = \mu_0 i$



construct amperian circuit ABCDA of rectangle of Length L, Breadth B

$B \cdot L \Big|_D^C + B \cdot B \cdot \cos 90 \Big|_C^B + 0 \Big|_B^A + B \cdot B \cdot \cos 90 \Big|_A^D$

$= \mu_0 N i$

$B \cdot L = \mu_0 n L i$

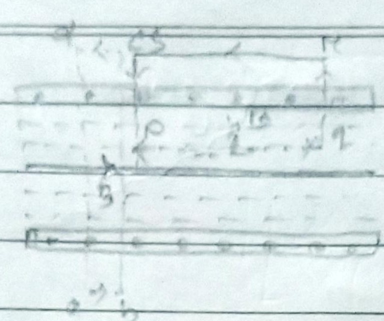
$B = \mu_0 n i$

Hence Magnetic field at any point

$B = \mu_0 n i$.

2) (a) Consider a Symmetrical long solenoid having number of turns per unit length equal to n.

let i be the current flowing in the solenoid, then by right hand rule, the magnetic field is parallel to the axis of the solenoid.



Field inside the Solenoid

Consider a closed path abcd.

Now, using Ampere's circuital law to this path, we have

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

Therefore, $B = 0$

This implies, magnetic field outside the solenoid is 0.

Field inside the solenoid.

Consider a closed path pqrs.

The line integral of magnetic field is given by,

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

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

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

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

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

using these equations, equation (i) gives,

$$\oint_{PQRS} \vec{B} \cdot \vec{dl} = \int_{PQ} \vec{B} \cdot \vec{dl} = Bl$$

Now, using Ampere's law,

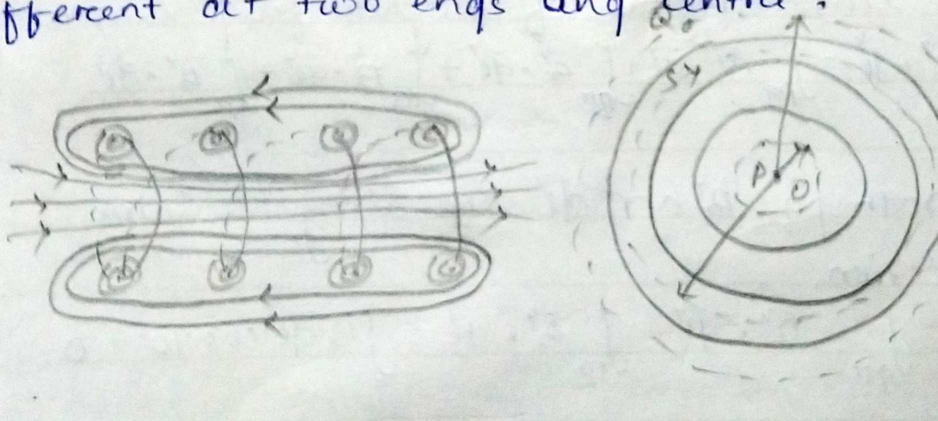
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

This simplifies,

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

$$\therefore \quad B = \mu_0 nI$$

(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.

Date
Page

3) $n = 300$ turns m.

$I = 5A$, $l = 0.5m$, $r = 10^{-2}m$.

The magnetic field inside the solenoid is given by,

$B = \mu_0 n I$

$= (4\pi \times 10^{-7}) \times 300 \times 5$ ($\because \mu_0 = 4\pi \times 10^{-7}$)

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

4) Here, $B = 2.52 \times 10^{-3} T$; $\mu_0 = 4\pi \times 10^{-7} T\,m\,A^{-1}$

Length of the solenoid, $l = 0.5m$;

Total number of turns in the solenoid, $N = 500$

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