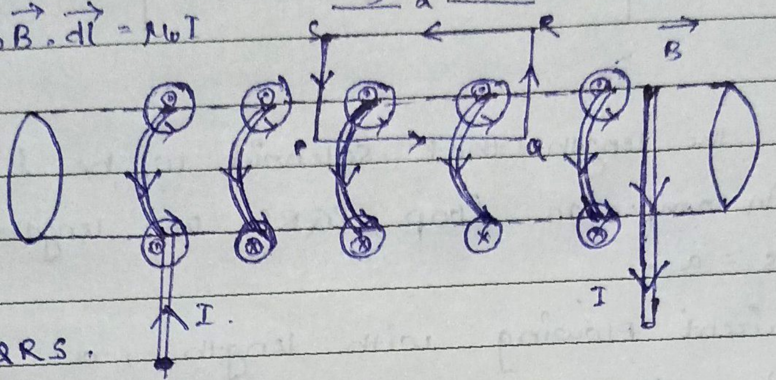
HOME ASSIGNMENT

1. Ampere's Circuital Law :-

It States that the line integral of the magnetic field $\vec{B}$ around any closed circuit is equal to μ_0 times the total current I threading or passing through this closed circuit. $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$



Consider PQRS.

~~$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_0$~~

Let I_0 be the net current threading through the solenoid.

$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_0$.

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

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

$= \oint B \cdot dl$

$= B \cdot a$.

Now, $n = \frac{N}{l}$.

$\Rightarrow N = nl$. where N = total no. of turns.

$\therefore$ Total current $= NI$

$= nlI$.

For length $= a$, total current $= naI$.

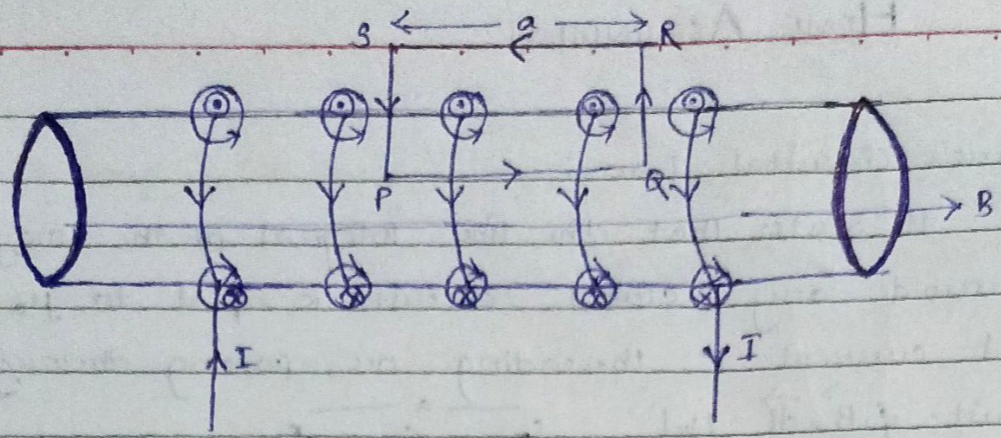
$\Rightarrow \mu_0 I_0 = \mu_0 naI$

So, $\oint \vec{B} \cdot \vec{dl} = \mu_0 I_0$

$\Rightarrow B \cdot a = \mu_0 naI$.

$\Rightarrow \boxed{B = \mu_0 nI}$

2. a)



Lets consider the length that solenoid to be l.

Consider, An amperian loop PQRS of length of side

$PQ = RS = a$.

Now, current flowing with length, $a = I_0$

According to Ampere's circuital law,

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_0$$

So,

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

$$= \oint_{PQ} B \cdot dl \cos 0^\circ + \oint_{QR} B \cdot dl \cos 90^\circ + \oint_{RS} B \cdot dl \cos 0^\circ + \oint_{SP} B \cdot dl \cos 90^\circ$$

$$= B \cdot \oint_{PQ} dl + 0 + 0 + 0$$

$$\Rightarrow \oint \vec{B} \cdot \vec{dl} = Ba.$$

Now, $n = \frac{N}{l}$. [$\because$ n = number of turns per unit length

$\Rightarrow N = nl$. N = total number of turns]

$\therefore$ Total current $= NI = nlI$.

$\Rightarrow$ Current through length 'a' $= naI$.

$\Rightarrow I_0 = naI$,

Thus,

$$\mu_0 I_0 = \mu_0 naI.$$

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

$$\Rightarrow Ba = \mu_0 naI$$

$$\Rightarrow \boxed{B = \mu_0 nI.}$$

Hence, the expression for magnetic field is $B = \mu_0 nI$

b. In a toroid, the magnetic field exists only in the tubular area bounded by the coil and it does not exist in the area outside and inside the toroid.

But in solenoid, the magnetic field exists only inside the solenoid and it is uniform at the centre but it gets half towards the ends and thus does not exist outside the solenoid.

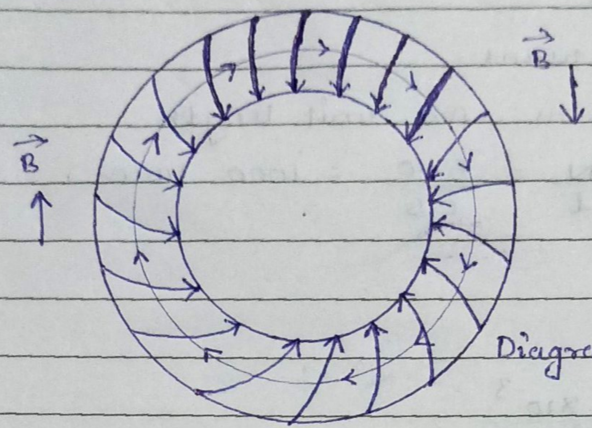


Diagram of toroid.

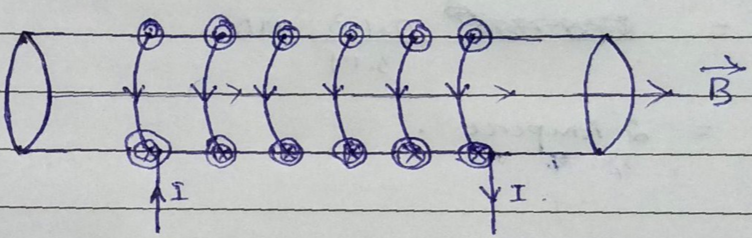


Diagram of solenoid

c. The magnetic field inside the solenoid can be made strong by:

i) Increasing the number of turns per unit length.

ii) Increasing the current through it.

3. Given that,

$n = 300$

$I = 5$ Ampere.

$l = 0.5$ m.

$r = 0.01$ m.

$\frac{l}{r} = \frac{0.5}{0.001} = 100$

Here, $l >> r$, so it is an ideal solenoid.

$\therefore B = \mu_0 n I$

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

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

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

4. Here, $B = 2.52 \times 10^{-3}$ T.

$l = 0.5$ m.

$N = 500$ turns.

$\therefore$ Number of turns per unit length

$(n) = \frac{N}{l} = \frac{500}{0.5} = 1000$ turns.

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

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

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

$= 2$ Ampere.