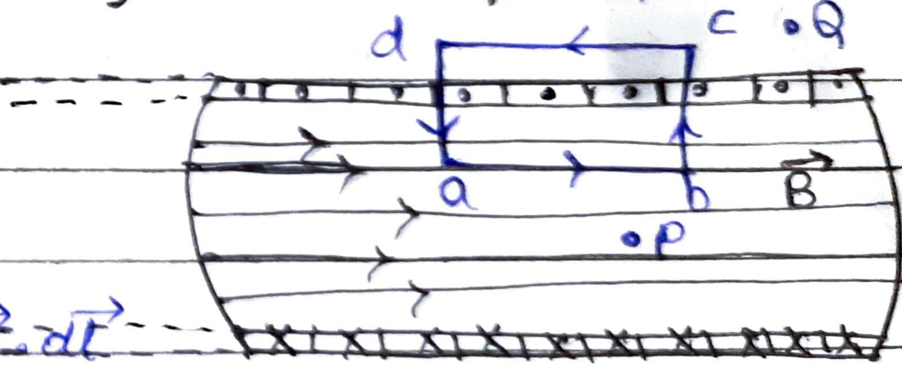
Home Assignment

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

Ans: " The line integral of the resultant magnetic field along a closed plane curve is equal to μ_0 times the total current crossing the area bounded by the closed curve provided the electric field inside the loop remains constant " $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$



According to Ampere's circuital law

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

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

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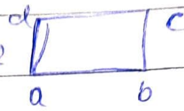
But $\int_b^c \vec{B}\cdot\vec{dl} = \int_b^c B\,dl\cos 90^\circ = 0$, But $\int_d^a \vec{B}\cdot\vec{dl} = \int_d^a B\,dl\cos 90^\circ = 0$

$\int_c^d \vec{B}\cdot\vec{dl} = \int B\,dl\cos 0^\circ = 0 \quad (B=0)$

$\therefore \int_a^b \vec{B}\cdot\vec{dl} = \int_a^b \vec{B}\,dl\cos 0^\circ = B\int_a^b dl = Bl$

l = length of the side ab of the 

no. of turns per unit length = n

" " " in entire length = nl

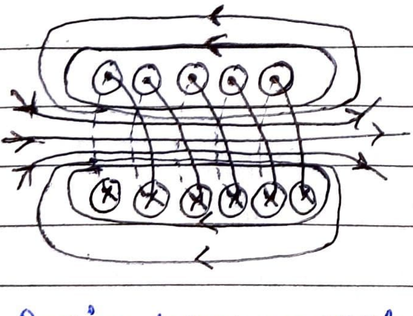
Total current in loop = nlI

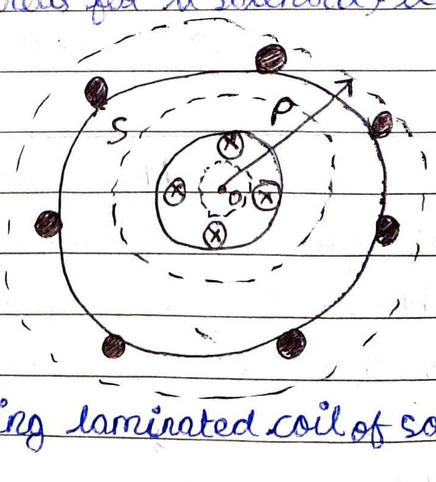
$Bl = \mu_0 nlI$

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

(2) a) Using Ampere's circuital law, obtain the exp for the $\vec{B}$ due to a long solinoid on axis. → [Same as (1)]

b) In a toroid magnetic lines do not exit outside the body. Toroid is closed whereas solenoid is open on both sides. Magnetic field is uniform inside a toroid whereas for a solenoid, it is diff at the two ends and corners





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

Q3) $n = 300$ turns/m $\quad I = 5A \quad l = 0.5m \quad r = 1cm$

$\vec{B} = \mu_0 nI = 4\pi\times10^{-7}\times300\times5 = \boxed{1.9\times10^{-3}\,T}$ Ans

Q4) $l = 0.5m \quad N = 500$ turns $\quad \vec{B} = 2.52\times10^{-3}\,T \quad \mu_0 = 4\pi\times10^{-7}\,Hm^{-1}$

$B = \mu_0 nI \qquad n = \frac{N}{l} = \frac{500}{0.5} = \frac{5000}{5} = 1000$

$2.52\times10^{-3} = 4\pi\times10^{-7}\times1000\times I$

$I = \frac{2.52\times10^{-3}}{4\pi\times10^{-7}\times10^{3}} = \boxed{2.0\,A}$ Ans

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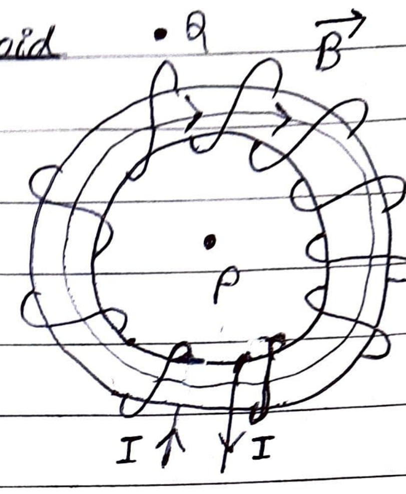
Magnetic field due to a toroidal solenoid

a) For points in the open space interior to the toroid



Length of loop1 $L_1 = 2\pi r_1$

loop encloses no current $= I = 0$

Amperes circuit law :

$$B_1 \times L_1 = \mu_0 I$$

$$B_1 \times L_1 = 0$$

$$\boxed{B_1 = 0}$$

b) For points inside the toroid

Length of loop 2 $L_2 = 2\pi r$

If N is total number of turns · I current in toroid

Total current = NI

$$B \times 2\pi r = \mu_0 N I \qquad \boxed{B = \frac{\mu_0 N I}{2\pi r}}$$

$$N = 2\pi r n \qquad \boxed{B = \mu_0 n I}$$

c) For a point in the open space exterior to the toroid

For each turn the current coming out of the plane of paper is canceled by the current going into the plane of the paper. $I = 0$ $\boxed{B_3 = 0}$