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→ Application of Ampere's law to find the magnetic field of solenoid and toroid :-

Home Assignment :-

Q1) Ampere's law states that the line integral of magnetic field around any closed path in vacuum is μ_0 times the total current through the closed path.

Applying Ampere's law for solenoid,

$$\oint \vec{B} \cdot \vec{dl} = \oint B\,dl \cos\theta$$

Angle between $\vec{B}$ and $\vec{dl}$ is zero.

$$\oint B\,dl \cos\theta = \oint \vec{B}\,\vec{dl} = B \times r.$$

$$\Rightarrow \oint \vec{B} \cdot \vec{dl} = B \times 2\pi r$$

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

$$= \mu_0 \times n \times I$$

$$= \mu_0 \times (n \times 2\pi r) I$$

$$B \times 2\pi r = \mu_0 \times (n \times 2\pi r) I$$

$$\Rightarrow \boxed{B = \mu_0 n I}$$

which is the magnetic field due to solenoid carrying current.

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Q2) (a) Let I be the current flowing in the solenoid, then by right hand thumb rule, the magnetic field is parallel to the axis of the solenoid.

Field outside the solenoid :- Consider a closed path abcd.

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

As $dl \neq 0 \therefore B = 0$.

This means that the magnetic field outside the solenoid is zero.

Consider a closed path pqrs. The line integral of magnetic field vector B along path pqrs

$\oint_{pqrs} \vec{B} \cdot \vec{dl} = \int_{pq} \vec{B} \cdot \vec{dl} + \int_{qr} \vec{B} \cdot \vec{dl} +$

$\int_{rs} \vec{B} \cdot \vec{dl} + \int_{sp} \vec{B} \cdot \vec{dl}$.

$\therefore \int_{pq} \vec{B} \cdot \vec{dl} = \int B dl = Bl$.

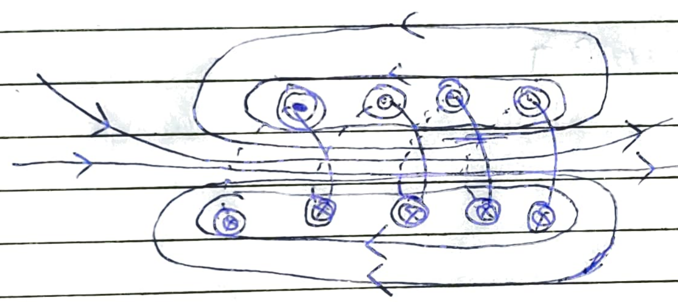
$\Rightarrow \int_{qr} \vec{B} \cdot \vec{dl} = \int_{sp} \vec{B} \cdot \vec{dl} = \int B dl \cos 90° = 0$

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

$\Rightarrow \oint_{pqrs} \vec{B} \cdot \vec{dl} = \int_{pq} \vec{B} \cdot \vec{dl} = Bl$.

$\therefore Bl = \mu_0 (nl I)$ $\therefore B = \mu_0 n I$

(b) In a toroid, magnetic lines do not exist 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 different at the two ends and centre.



(c) The magnetic field lines of toroid are circular having common centre. Inside a given solenoid, the magnetic field may be made strong by

(i) passing large current

(ii) using laminated coil of soft iron.

03) $n = 300$

$I = 5A$

$l = 0.5 m$

$r = 0.1 cm$

$$\frac{l}{r} = \frac{0.5}{0.1 \times 10^{-2}} \Rightarrow 100 \Rightarrow l >> r$$

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$B = \mu_0 n I = 4\pi \times 10^{-7} \times 300 \times 5 = 20 \times 300 \times \pi \times 10^{-7}$

$= 6000 \times \pi \times 10^{-7} = 6\pi \times 10^{-4}$

$= 6 \times \frac{22}{7} \times 10^{-4}$

$= 6 \times 3.14 \times 10^{-4}$

$= \boxed{6.28 \times 10^{-3}\ T}$

Q4) $B = 2.52 \times 10^{-3}\ T$.

$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$

$l = 0.5 m$

$N = 500$

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

$B = \mu_0 n I$

$I = \frac{B}{\mu_0 n} = \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-7} \times 1000} = \boxed{2 A}$