
Home Assignment
Shrabanee Samantaray
"XII" "DB"
School no.: 9888
Date: 6-07-2021...8-07-2021
PHYSICS

Application of Ampere's law to find the magnetic field of solenoid and toroid.

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 04
CHAPTER NAME : MOVING CHARGES AND MAGNETISM

CHANGING YOUR TOMORROW

Home Assignment

1. State Ampere's circuital 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.

Answer 1:-

Ampere's circuit law :- It is the line integral of magnetic field induction along a closed curve is equal to the total current passing through the surface enclosed in the closed curve times the permiability of the medium.

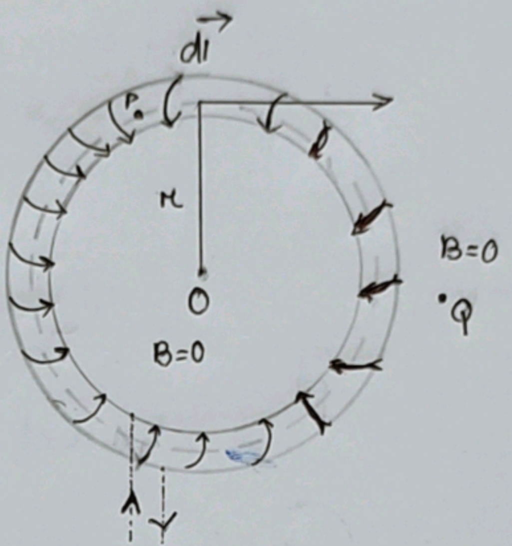
$$\oint \vec{B}\cdot dl = \mu_0 I_{enclosed}$$

Applying Ampere's law for the toroid.

$B(2\pi r) = \mu_0 N I$

But, $N = 2\pi r n$

$B = \mu_0 n I$



can also be written as,

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

Angle θ b/w $\vec{B}$ and $\vec{dl}$ is zero.

$\oint B\, dl \cos\theta = \oint \vec{B}\,\vec{dl} = B \times 2\pi r$ ∵ $2\pi r$ = circumference of circle with radius r.

$\Rightarrow \oint \vec{B}\cdot\vec{dl} = B \times 2\pi r \quad \ldots \langle 1 \rangle$

As per ampere's circuit

$\oint \vec{B}\cdot\vec{dl} = \mu_0 \times$ net current.

$= \mu_0 \times$ total no. of turns $\times I$

$= \mu_0 \times (n \times 2\pi r) I \quad \ldots \langle 11 \rangle$

Comparing ⟨1⟩ and ⟨11⟩, $B \times 2\pi r = \mu_0 \times (n \times 2\pi r) I$

$\Rightarrow B = \mu_0 n I,$

Magnetic field due a toroid carrying conductor.

2. Answer the following:

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

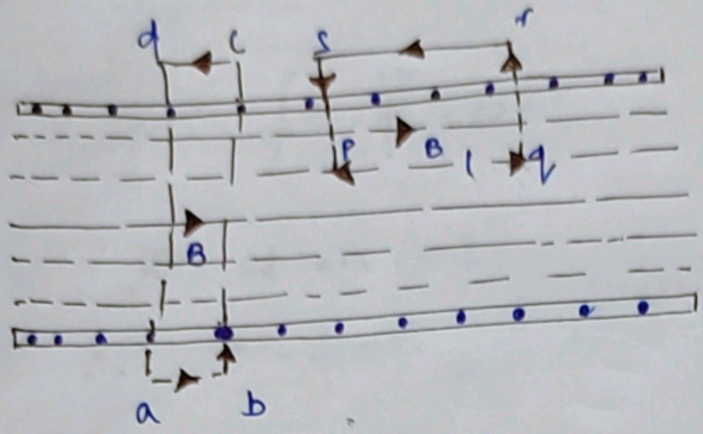
   b) In what respect, is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.

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

Answer 2:-

a) Let's take a symmetrical long solenoid, that has 'n' no. of turns per unit length.

Now ~~[illegible]~~ Let the current flowing in solenoid = I
, by right hand rule. magnetic field ∥ axis of solenoid.



field inside solenoid.
closed path abcd.

Using, Ampere's circuit law,

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

$\therefore \quad B = 0$.

$\Rightarrow$ Magnetic field outside solenoid '0'.

Closed path pqrs.

$\oint_{pqrs} \vec{B} \cdot \vec{dl} = \int_{pq} \vec{B} \cdot \vec{dl} + \int_{qr} \vec{B} \cdot \vec{dl} + \int_{rs} \vec{B} \cdot \vec{dl} + \int_{sp} \vec{B} \cdot \vec{dl} \quad \ldots (1)$

Now Path pq, $\vec{B}$ and $\vec{dl}$ along same direction.

$\int_{qr} \vec{B} \cdot \vec{dl} = \int_{sp} \vec{B} \cdot \vec{dL} = \int B dl \cos 90^\circ$

$= 0^\circ$

path rs. $B = 0$ as outside solenoid field = 0.

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

Now

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

Ampere's Law

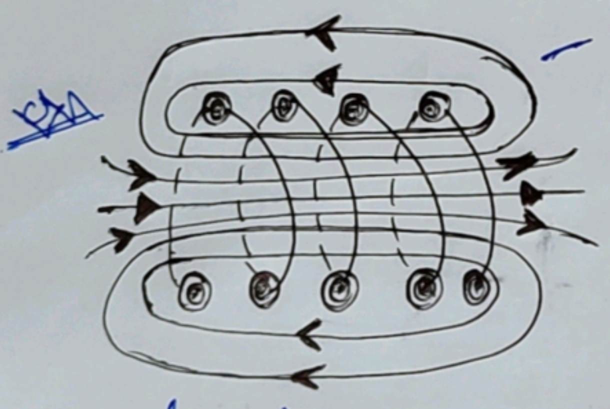
$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

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

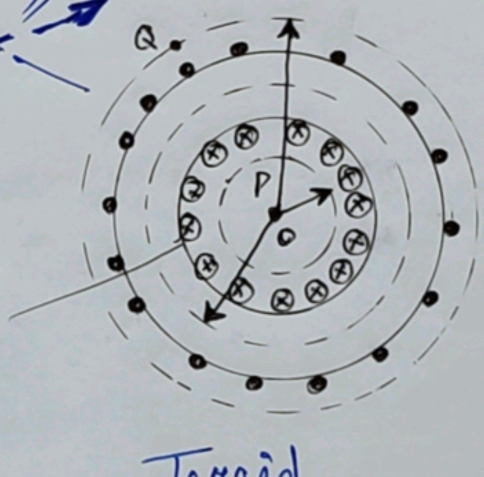
$$\therefore \quad B = \mu_0 n I.$$

b)

Toroid	Solenoid
• Magnetic field lines don't exist outside toroid's body.	• Magnetic field lines may exist outside solenoid body.
• Toroid is closed on both side.	• Solenoid opened on both sides.
• Magnetic field is uniform inside toroid.	• Magnetic field is different at 2 ends and centre.



Solenoid



Toroid

C) The magnetic field inside solenoid is made strong :-

1) passing large current

ii) using laminated coil of soft iron.

Home Assignment

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

Answers :-

Given

$n = 300$

$I = 5 A$

$l = 0.5 m$

$r = 1 cm = 0.1 m.$

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

$\Rightarrow l >> r$

Now

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

$= 20\pi \times 300 \times 10^{-7}$

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

$= ~~8\pi \times 10^{-4}~~ \; 6\pi \times 10^{3} \times 10^{-7}$

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

$= 1.38 \times 10^{-3} T$

Magnitude of magnetic field inside solenoid.

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

Answer 4 :-

A/Q $l = 0.5\,m$, no. of turns $n = N = 500$.

(flux density) $B = 2.52 \times 10^{-3}$

$\mu_0 = 4\pi \times 10^{-7}\ H\,m^{-1}$

$\therefore$ No. of turns per unit length of solenoid.

$$n = \frac{N}{l} = \frac{500}{0.5}$$

Now let 'I' be current through solenoid.

i.e

$$B = \mu_0 n I$$

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

$\therefore$ Current in solenoid = 2 Ampere.


THANK YOU !