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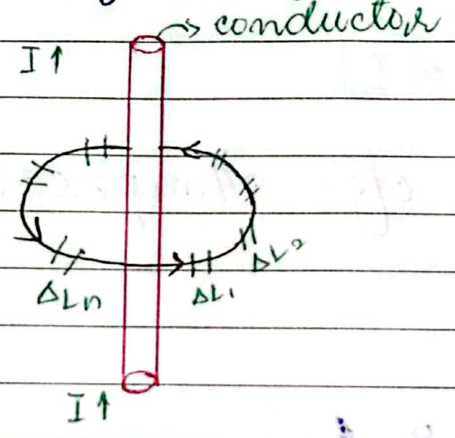
Ampere's Law:

"This law tells the relation b/w magnetic field and current in a conductor."

Ampere's law can be defined as the integral of the magnetic field (B) around a close loop is directly proportional to the total electric current (I) passing through the loop.



Derivation:

As we know that:

$$B \propto 2I \longrightarrow (i)$$

"B" inversly proportional to "r"

$$B \propto \frac{1}{r} \longrightarrow (ii)$$

Combine eqn (i) & (ii)

$$B \propto \frac{2I}{r}$$

constant of proportionality

$$\propto = \frac{\mu_0}{4\pi} \longrightarrow \text{permeability}$$

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

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$$B = \frac{\cancel{2} I \mu_0}{2\cancel{4}\pi r}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

Here,

$$L = \Delta L_1 + \Delta L_2 + \Delta L_3 + \cdots + \Delta L_n$$

$$L = 2\pi r$$

$$B\, 2\pi r = \mu_0 I$$

$$\Sigma B \cdot \Delta L = \mu_0 I$$

$$\boxed{\Sigma B \cdot \Delta L \propto I}$$

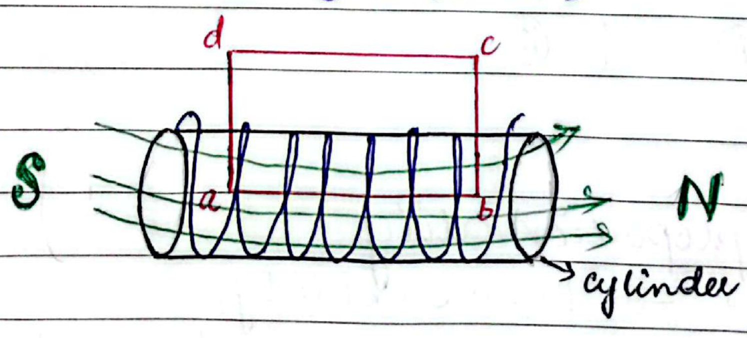
Applications of Ampere's Law:-

(1) Solenoid
(2) Toroid

Solenoid:

A solenoid is a long, tightly wounded coil of wire and often used to generate a uniform magnetic field within the coil interior.

$$B = \mu_0 n I$$



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Derivation:

We use rectangular ampere loop abcd.

As we know that

$$\Sigma B \cdot \Delta L = \mu_o I \longrightarrow (i)$$

For L_{ab}: $\because \theta = 0$

$$B \cdot L_{ab} = B L_{ab} \cos\theta$$

$$= B L \cos(0)$$

$$\boxed{B \cdot L_{ab} = B L_{ab}}$$

For L_{bc}:

$$B \cdot L_{bc} = B L_{bc} \cos(90) \quad \because \theta = 90$$

$$\boxed{B \cdot L_{bc} = 0}$$

For L_{cd}:

$$B \cdot L_{cd} = B L_{cd} \cos(90) \quad \because \theta = 90$$

$$B \cdot L_{cd} = B L_{cd}$$

neglagible, (outside the solenoid)

$$\boxed{B \cdot L_{cd} = 0}$$

For L_{da}:

$$B \cdot L_{ad} = B L \cos(90) \quad \because \theta =$$

$$\boxed{B \cdot L_{ad} = 0}$$

For $\Sigma B \cdot \Delta L$:-

$$B \Sigma \Delta L = B \cdot L_{ab} + B \cdot L_{bc} + B \cdot L_{cd} + B \cdot L_{da}$$

$$B \Sigma \Delta L = B L_{ab}$$

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put $B \Sigma \Delta L = B L_{ab}$ in eqn (i)

$$B L_{ab} = \mu_0 I$$

For Total turn $= N$

$$B L_{ab} = \mu_0 N I$$

$$\therefore n = \frac{N}{L_{ab}}$$ * no. of turn in unit length ab.

$$N = n L_{ab}$$

$$B \cancel{L_{ab}} = \mu_0 n \cancel{L_{ab}} I$$

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

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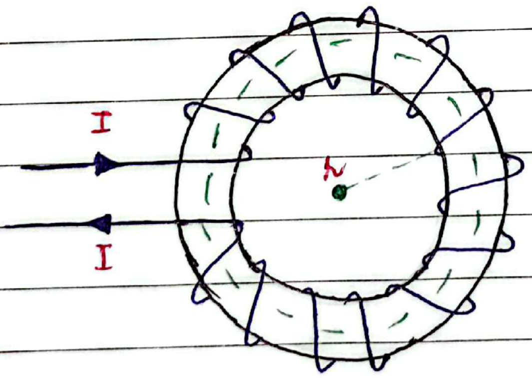
Toroid:

A toroid can be considered as a solenoid on a circular support. It also generates a magnetic field within its interior.

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

Derivation:

Consider a toroid of radius 'r' with 'N' turns of wire also suppose that current passes through the each turn is "I" and due to this current a circular magnetic field produced under some assumptions shown in figure.



Here we use Ampere Law:-

$$\Sigma B \cdot \Delta L = \mu_0 I \longrightarrow (i)$$

For $\Sigma B \cdot \Delta L$:-

$$\Sigma \Delta L = 2\pi r$$

put in eqn (i)

$$B 2\pi r = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r}$$

For total no. of turn "N".

$$\boxed{B = \mu_0 \frac{NI}{2\pi r}}$$