Ampere's law

- Equation of Ampere's law = $\oint B \cdot dl = \mu_0 I_{enclosed}$

$$BL = \mu_0 I_{enclosed}$$

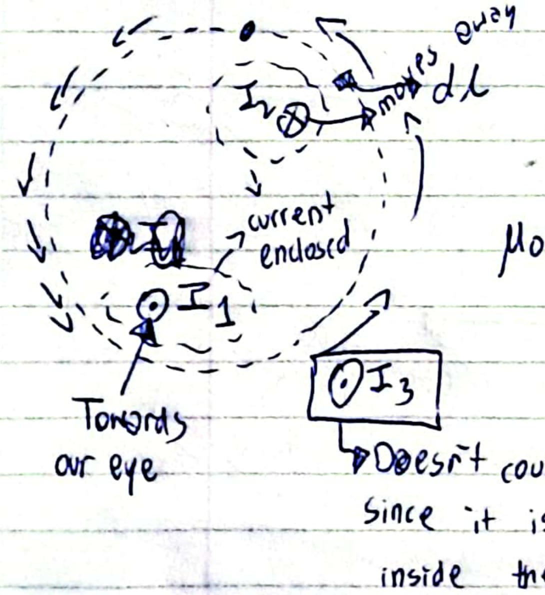
IMPORTANT 1

Ampere's law in detail

$\oint$: closed integration

Main objective

Find the total magnetic field with the total [integrated from the chunk length] length $= \mu_0 I$ encosed



need to find the total magnetic field within the total length

$\mu_0 I \rightarrow$ [indicates the current inside the loop)

Ampere's law
→ Right hand clamp rule
thumb ⇒ current
hands clamped ⇒ magnetic field

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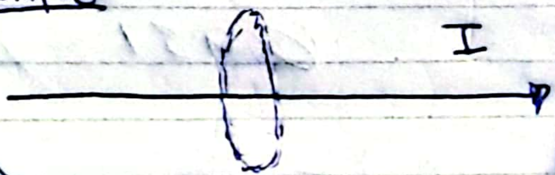
example

(side view)



$$\oint B \cdot dl = \mu_0 I_{en}$$

$$BL = \mu_0 I$$

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

IMPORTANT 2

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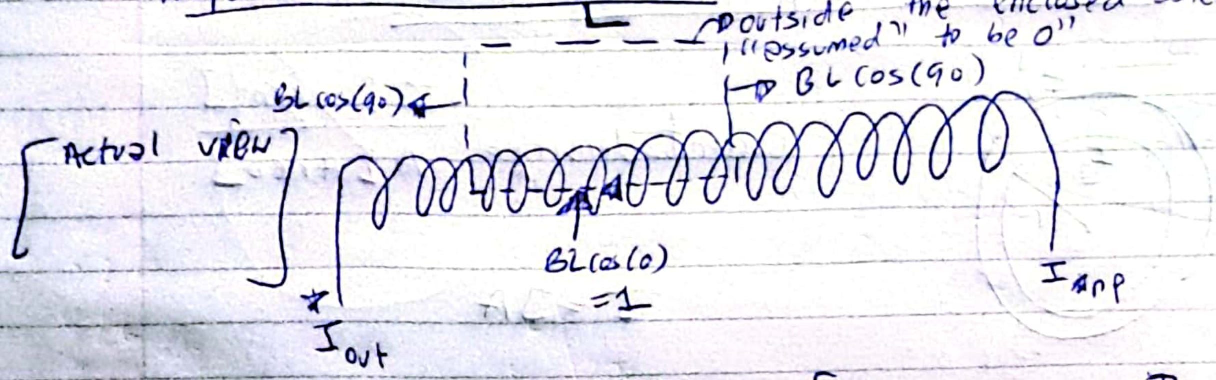
②

Ampere's law in an infinite solenoid



Ampere's law

$\oint B \cdot dl = \mu_0 I$

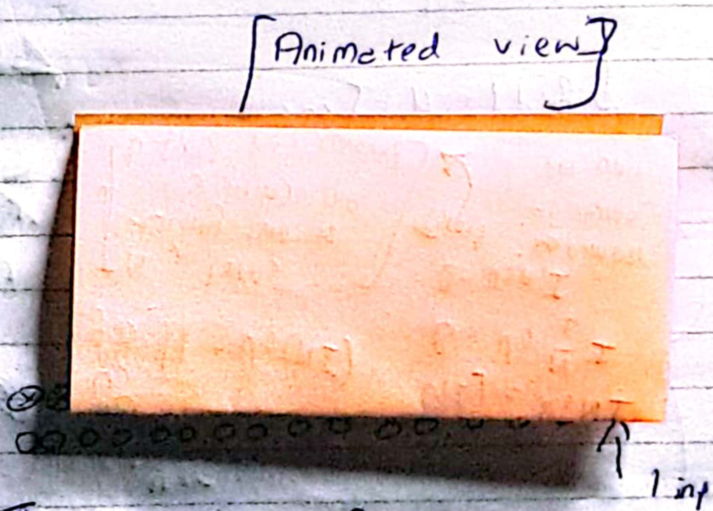
$BL = \mu_0 (NI)_{enclosed}$

$B = \mu_0 \frac{(NI)}{L}$

$B = \mu_0 \frac{N}{L} I_{enc}$

$B = \mu_0 n I_{enc}$

turns per length



The number of magnetic field points the length has "pierced" through

Toroid with N total windings

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

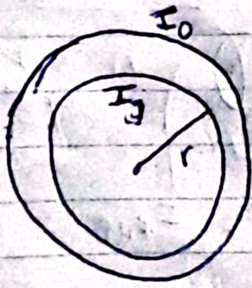
$\oint B \cdot dl = \mu_0 (NI)_{enclosed}$

$BL = \mu_0 (NI)$

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

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

Solid wire carrying uniform current



$$\text{Current density} = \frac{I\ [\text{Current}]}{A\ [\text{Area}]}$$

$$I = JA$$

$$\oint B \cdot dl = \mu_0 I_{enc}$$

$B(2\pi r) = \mu_0 (J)(A)$ $\quad r<R$

$B(2\pi l) = \mu_0 I_0$ $\quad r>R$

$r<R$

$B(2\pi r) = \mu_0 \left(\frac{I}{\pi R^2}\right)(\pi r^2)$ → Area within the enclosed wire

$$J = \frac{\text{Total current}}{\text{Total Radius}}$$

$B(2\pi r) = \mu_0 \left(\frac{I_0}{\pi R^2}\right) \cancel{\pi R^2}$

$= \mu_0 I_0$

Solid wire with uniform current density

$\oint B \cdot dl = \mu_0 I$ $\quad$ [Assume current density is given]

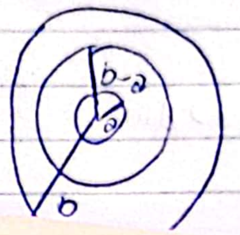
$B[2\pi r] = \mu_0 [J] \times (\pi r^2)$ → Inside the wire

given current densith

$= \mu_0 (J)(\pi R^2)$ → outside the loop

Solid wire with hollow wire uniform current

$$\oint B\cdot dl = \mu_0 I_{enc}$$



Inside the hollow

Just hollow
no ~~charge~~ enclosed

$(r<a) \Rightarrow B(2\pi r) = \mu_0 (0)$ [not e[illegible]ld]

Just hollow
and enclosed $\Rightarrow B(2\pi r) = \mu_0 I_0$ $\quad r>a \quad r<b$

$$= \mu_0\left(\frac{I_0}{(\pi b)^2-(\pi a)^2}\right)\left(\pi r^2-\pi a^2\right)$$

outside
big sphere
enclosed $\Rightarrow B(2\pi r) = \mu_0 I_0$

$$= \mu_0\left(\frac{I_0}{\cancel{(\pi b)^2}}\right)\left(\cancel{\pi b^2}\right)$$

$$= \mu_0 I_0$$

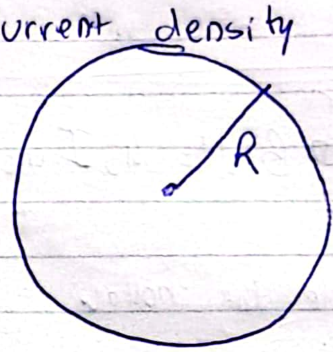
Same with current density $\mu_0 I_0 \Rightarrow J(A)$ with the given current density & Area depending on the shape

—X—X—X—X—X—X—X—X—

Solid wire with non uniform current density

next page

In a non-uniform current density, the current density itself depends on the small radius of the wire



$$I = \int J(r)\, dA$$

$$dA = \pi r^2$$

$$2\pi r\, dr$$

$r < R$

$$B(2\pi r) = \mu_0 \int_0^r J(r)\ 2\pi r\, dr$$

given
Charge density
with the radius
dependant

$r > R$

B

$$B(2\pi r) = \mu_0 \int_0^R J(r)\ 2\pi r\, dr$$

hollow wire

$$B(2\pi r) = \mu_0 \int_0^a (0) \quad [\text{no magnetic field}]$$

$$= \mu_0 \int_a^r J(r)\, 2\pi r\, dr$$

$$= \mu_0 \int_a^b J(r)\, 2\pi r\, dr$$