Magnetostatics-2

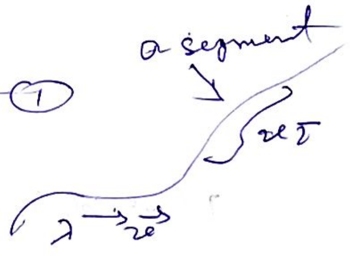
Currents: charges in motion produce currents. The current in a wire may be defined by charge per unit time passing a given point. Its unit is in coulombs per second or ampere (A)

i.e.
$$1A = 1C/s$$

If we assume that a line charge λ travelling down a wire at speed v, then current I is given by
$$I = \lambda v$$

Since ~~in time~~ in time interval τ, a segment of length $v\tau$ carries charge $\lambda v\tau$

We write current in vector form
$$\vec{I} = \lambda \vec{v} \quad \text{——— (1)}$$



→ It is to be noted here that the charge density λ corresponds only for moving charges, e.g., in a metal rod only free electron (i.e. negative charges) contribute to the current. but positive charges ~~...~~ have no contribution to the currents. In special situation where both type of charges contribute to the currents, we write
$$\vec{I} = \lambda_+ \vec{v}_+ + \lambda_- \vec{v}_- .$$

Magnetic force (F_m): Magnetic force on a segment carrying wire is given by
$$\vec{F}_m = \int (\vec{v} \times \vec{B})\, dq$$

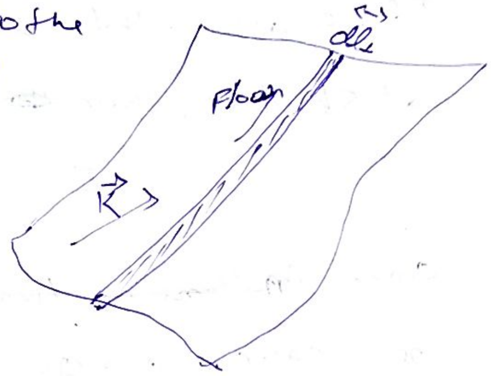
or
$$\vec{F}_m = \int (\vec{v} \times \vec{B})\, \lambda\, dl = \int (\lambda \vec{v} \times \vec{B})\, dl = \int (\vec{I} \times \vec{B})\, dl$$

Since $\vec{I}$ and $d\vec{l}$ (length segment) both points in the same direction, we can write.

$$\boxed{\vec{F}_m = \int I(d\vec{l} \times \vec{B})} \quad \text{--- (2)}$$

Surface current density:

If we consider a ribbon of infinitesimal width $dl_\perp$ which is running parallel to the flow of current and the current in the ribbon is $d\vec{I}$, then the surface current density $\vec{K}$, is given by the following expression.



$$\boxed{\vec{K} \equiv \frac{d\vec{I}}{dl_\perp}} \equiv \text{currents per unit width - perpendicular to the flow} \quad \text{--- (3)}$$

If we define the surface charge density denoted by σ and its velocity as $\vec{v}$, then the surface current density $\vec{K}$ is given by.

$$\boxed{\vec{K} = \sigma\vec{v}} \quad \text{--- (4)}$$

and magnetic force $\vec{F}_m$ in this case is given by

$$\vec{F}_m = \int (\vec{v} \times \vec{B})\sigma\, da$$

or

$$\boxed{\vec{F}_m = \int (\vec{K} \times \vec{B})\, da} \quad \text{--- (5)}$$