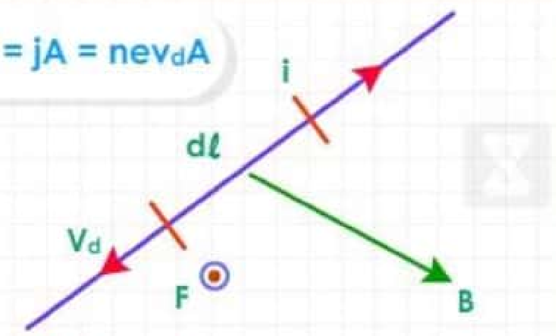
Part I

MAGNETIC PROPERTY

MAGNETIC FORCE ON A CURRENT CARRYING WIRE

$i = jA = nev_dA$

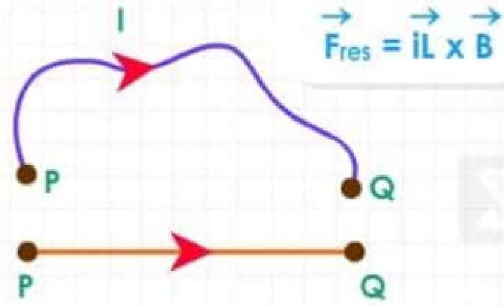


v_d = Drift speed

n = No. of free electrons per unit volume

j = Current density

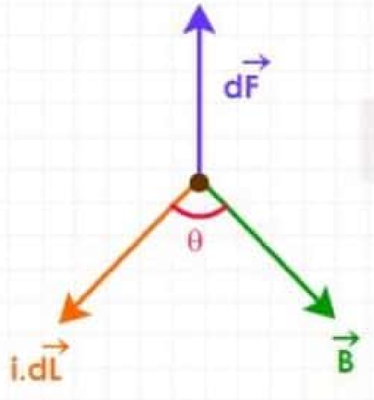
$\vec{F}_{res} = i\vec{L} \times \vec{B}$

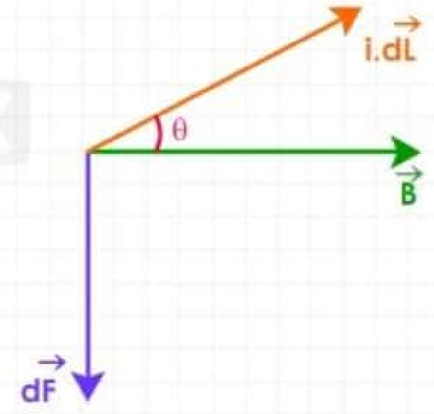


$\vec{L}$ = Vector length of the wire

DIRECTION OF FORCE

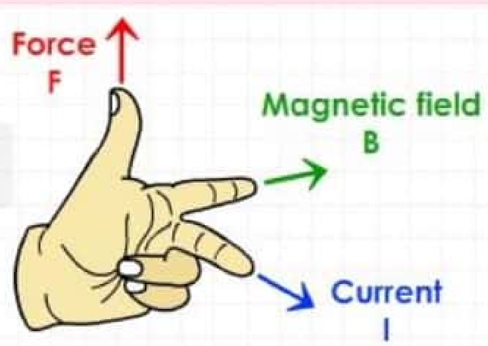
The direction of force is always perpendicular to the plane containing $i.d\vec{L}$ and $\vec{B}$ and is same as that of cross-product of two vectors $(\vec{a} \times \vec{b})$ with $a = i.d\vec{L}$ and $b = \vec{B}$



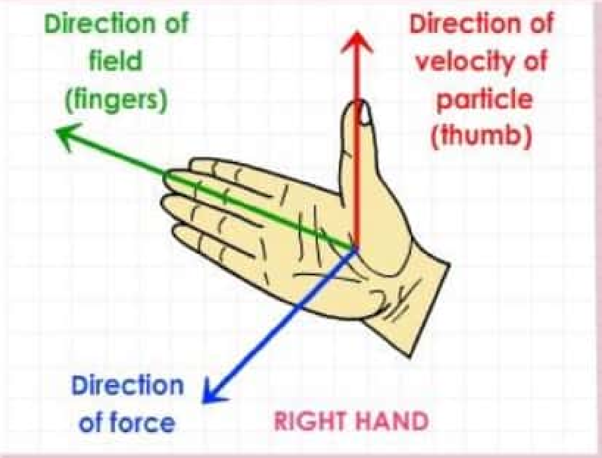


The direction of force when current element $i.d\vec{L}$ and $\vec{B}$ are perpendicular to each other can also be determined by applying either of the following rules:

1. **Fleming's Left-hand Rule** : Stretch the forefinger, central finger and thumb of the left hand mutually perpendicular. Then if the forefinger points in the direction of the field $(\vec{B})$ and the central finger is in the direction of current, the thumb will point in the direction of force (or motion).

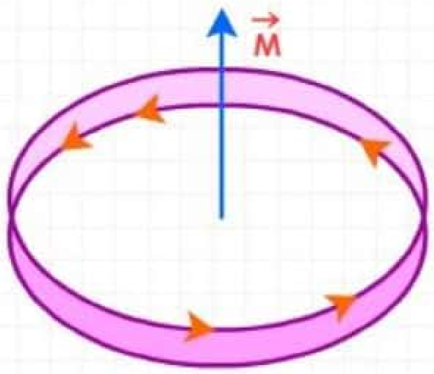


2. **Right-hand Palm rule** : Stretch the fingers and thumb of the right-hand at right angles to each other. To find the direction of the magnetic force on a positive moving charge, the thumb of the right hand ponts in the direction of velocity of particle **v**, the fingers in the direction of Magnetic Field B, then the Force **F** is directed perpendicular to the right hand palm



CURRENT LOOP IN A UNIFORM MAGNETIC FIELD

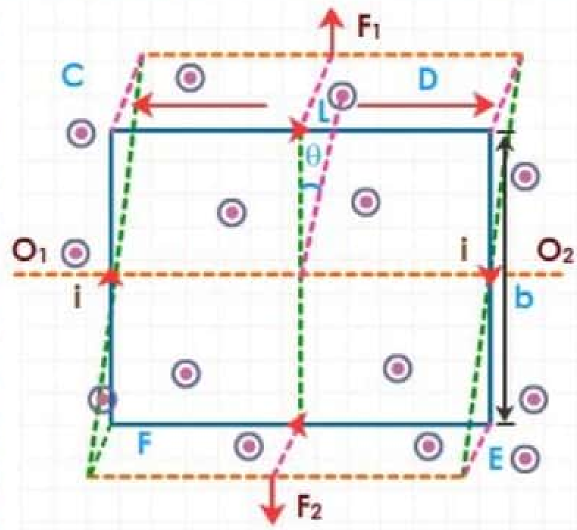
MAGNETIC MOMENT



$$\vec{M} = Ni\pi R^2 = NiA$$

A = Area of loop | R = Radius of loop
N = No. of loops | I = Current

TORQUE ON A CURRENT LOOP

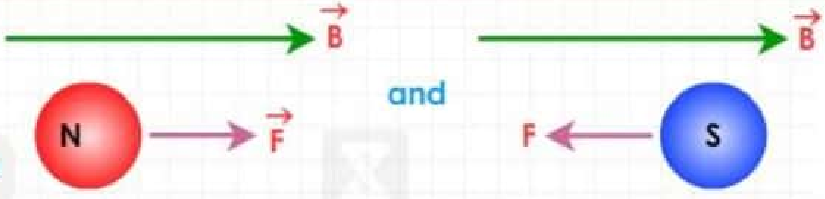


$$\vec{\tau} = \vec{M} \times \vec{B}$$

MAGNETIC FIELD AND STRENGTH OF MAGNETIC FIELD

$$\vec{B} = \frac{\vec{F}}{M}$$

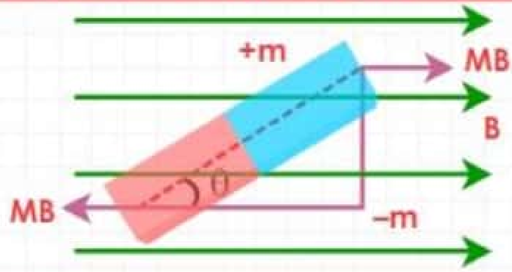
S.I. unit of $\vec{B}$ is Tesla or weber/m^2



MAGNETIC IN AN EXTERNAL UNIFORM MAGNETIC FIELD

$F_{res} = 0$ (for any angle)

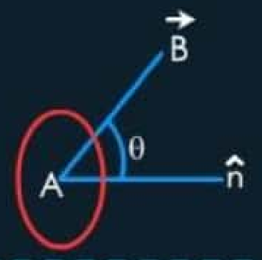
$\tau = MB \sin\theta$



ELECTROMAGNETIC FORCE

MAGNETIC FLUX

Magnetic Flux is the amount of magnetic field passing through a given area.



$$\phi = \int \vec{B}.d\vec{A} \Rightarrow \phi = \vec{B}.\vec{A} = BA\cos\theta$$

Unit ⟶ weber (Wb)

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION

Whenever the flux of a magnetic field through the area bounded by a closed conducting loop changes, an emf is produced in the loop. The emf is given by

$$\varepsilon = -\frac{d\phi}{dt}$$

LENZ'S LAW

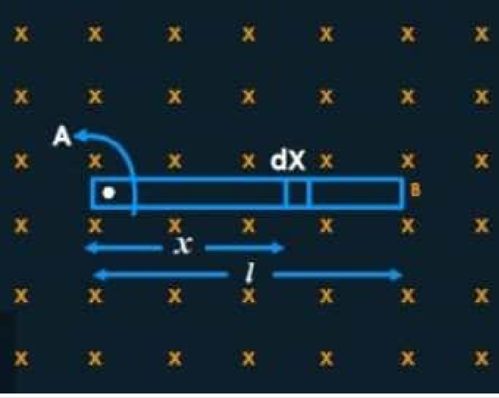
According to lenz's law, if the flux associated with any loop changes than the induced current flows in such a fashion that it tries to oppoose the cause which has produced it.

MOTIONAL EMF

$$E = \int (\vec{v} \times \vec{B}).d\vec{l}$$

EMF developed across the ends of the rod moving perpendicular to magnetic field velocity perpendicular to the rod is $\varepsilon = vB\ell$

INDUCED EMF IN A ROTATING ROD



$$\int dE = \int_0^{\ell} B\omega x dx$$

$$V_A - V_B = \frac{B\omega l^2}{2}$$

INDUCED ELECTRIC FIELD

EMF, $e = \oint \vec{E}.d\vec{l}$

Using Faraday's law of induction

$$\varepsilon = -\frac{d\phi}{dt}$$

or, $\oint \vec{E}.d\vec{l} = -\frac{d\phi}{dt}$