MAGNETISM LECTURE-22

FORCE ON MOVING CHARGE IN A MAGNETIC FIELD

FORCE ON MOVING CHARGE IN A MAGNETIC FEILD.

Let q is the charge of moving particle.

$\vec{v}$ = velocity vector.

$\vec{B}$ = Magnetic induction.

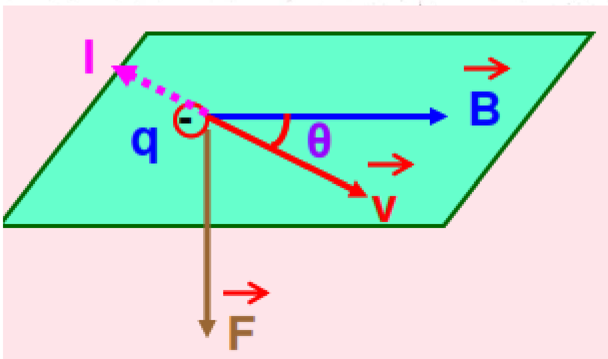
$F \propto q$

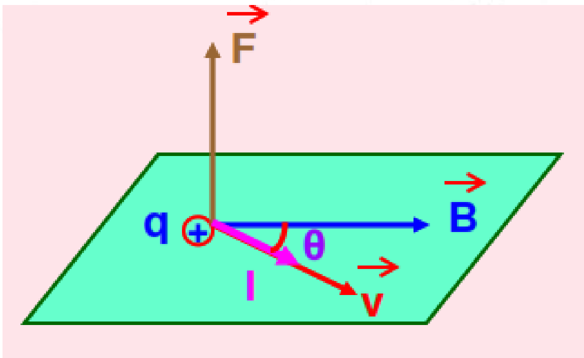
$F \propto v\sin\theta$

$F \propto B$

$F = qvB\sin\theta$

$\vec{F} = q(\vec{v} \times \vec{B})$

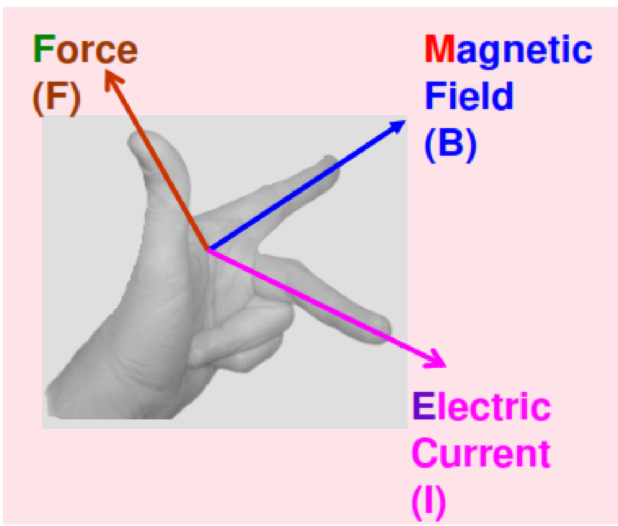




1. If the charge is at rest, the magnetic force is zero.
2. When charge moves parallel or antiparallel magnetic force is zero.
3. Magnetic force is maximum when the velocity is perpendicular to magnetic field.

$$F_{m\,(max)} = q\,v\,B$$

Direction of magnetic force is given by Right Hand Thumb Rule or Flemming's Left Hand Rule.



The direction of magnetic is given by ~~Flet~~ Flemming left hand rule. which states that if thumb indexfinger and middle finger of left hand are mutually perpendicular to each other if index finger indicated the direction magnetic field and middle ~~figre~~ ~~figer~~ finger of ~~ch+ve~~ velocity of p+ve charge. The index figer give direction of magnitude of positive charge

LORENTZ FORCE:

If both electric as well as magnetic feild exist in then the net force experience by a moving charge is called as Lorentz force.

$$\vec{F} = \vec{F_m} + \vec{F_e}$$

$$= q(\vec{v} \times \vec{B}) + q\vec{E}$$

$$F = q[(\vec{v} \times \vec{B}) + \vec{E}]$$

$$\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$$

$$\text{or } \vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

Condition for **VELOCITY SELECTOR**

$$0 = q[\vec{v} \times \vec{B}] + \vec{E}]$$

$$\vec{v} \times \vec{B} = -\vec{E}$$

This condition is used in velocity selector

This condition is used to select charge particles with a particular charge to Mass ratio from a beam of charge particles moving with different velocities. (Mass Spectrometer)

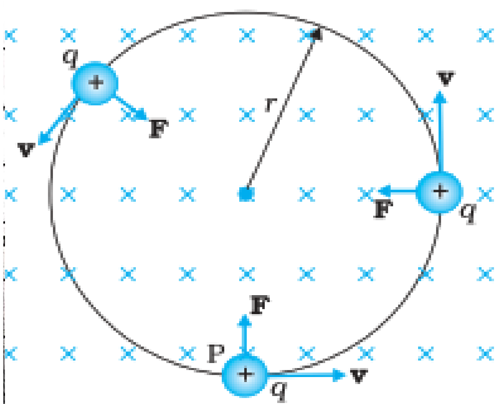
** Motion of charge particle in uniform Magnetic feild.

let $\vec{v}$ = velocity of charged particle ~~be~~

$\vec{B}$ = magnetic feild.

q = charge.

Case I:- $\vec{v} \perp \vec{B}$ (velocity is $\perp$ to magnetic feild **(Circular Motion)**



charge will perform a circular motion

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}.$$

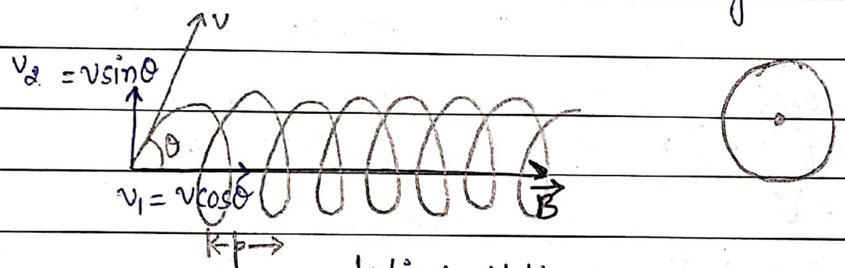
1) Speed will remain constant.
2. Kinetic Energy will be constant
3. Work done by magnetic force is always zero. (nikkama)
4. Velocity and momentum will change continueously due to change in direction.

Time period $= \frac{2\pi r}{v} = \frac{2\pi}{\cancel{v}} \times m\cancel{v}/qB$

$T = \frac{2\pi m}{qB}$

Hence time period is independent to r and velocity ~~an~~. Hence always remains constant.

Case II when $\vec{v}$ is inclined at θ angle with $\vec{B}$ **(Helical Motion)**



helical Motion

$\frac{m v_2^2}{r} = qBv_2$

$r = \frac{mv_2}{qB}$

$= \frac{mv\sin\theta}{qB}$

$T = \frac{2\pi m}{qB}$

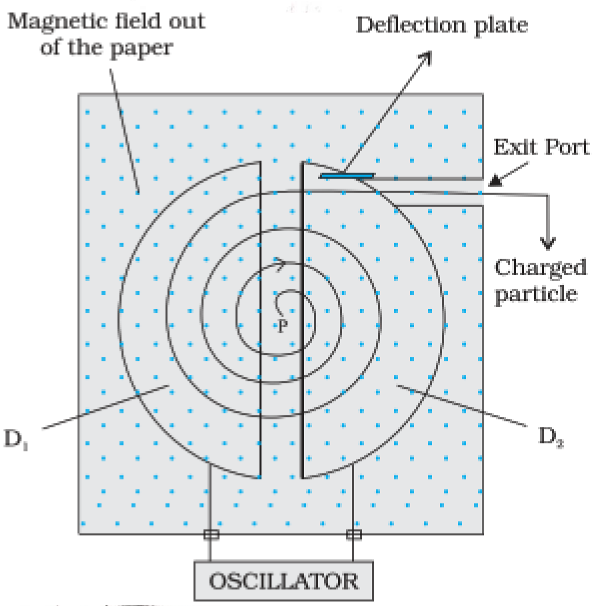
$p = v_1 \times T$ **p= pitch, horizontal distance moved in one revolution.**

$v\cos\theta \times \frac{2\pi m}{qB}$

Case III when $\vec{v}$ is ∥ or antiparallel with $\vec{B}$ **(Straight Line Motion)**

In this case magnetic force acting on charge particle is 0. ∵ $\sin\theta$ = $\theta = 0$ or $180°$ ∴. Hence the particle will move in straight line undeviated.

*** CYCLOTRON :-



Purpose :- (It is used to accelerate charge particle)

This device is used to accelerate charge particle such as protons, alpha particles to a very large extent of Kinetic Energy

Principle :- This device works on the principle that a charge particle can be accelerated by crossing again and again through a High frequency oscillator, moderate electric feild and a strong magnetic feild is used for changing its magnetic feild continously.

Working & Construction :-

1. It consist of two hollow Ds, D_1 and D_2 placed horizontally an seperated by a small gap. These Ds are connected to an High Frequency oscillator. A strong magnetic feild is developed ⊥ to the plane of Ds.
2. When a ~~positive~~ charge is ~~placed~~ particle is placed near the centre of the D. It gets accelerated due to electric feild and moves in circular path due to ~~stor~~ strong magnetic feild.
3. When charged particle reaches to gap HFO changes its the polarity of Ds. Hence particle remains in continous circular accelerated motion.
4. When particle aquires enough kintic energy it is allow to

exit through a window to hit the target.

5. $r = \frac{mv}{qB}$

$T = \frac{2\pi m}{qB}$

$\Rightarrow \therefore$ frequency of cyclotron $(\nu) = \frac{qB}{2\pi m}$

$\Rightarrow$ frequency of HFO $\Rightarrow 2\nu = \frac{qB}{\pi m}$

Maximum KE $= \frac{1}{2} m v_{max}^2$

$= \frac{1}{2} m \left(\frac{qBR}{m}\right)^2$ $\left[\because v_{max} = \frac{qBR}{m} \text{ where } R = \text{radius of Dee} \right]$

$= \frac{q^2 B^2 R^2}{2m}$

Limitation

$\Rightarrow$ Only charge particles can be accelerated i.e neutrons can't be accelerated.

$\Rightarrow$ Charge particle with smaller mass such as electrons cannot be accelerated because they quickly ~~aq~~ acquire higher and starts inteferring with the walls of Dees.

$\Rightarrow$ Speed of the particle cannot be increased comparable with the speed of light because under such situation the mass will no longer be constant. Hence time period will get changed.

$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$