Force Acting on a Charge Particle Moving in a Uniform Magnetic Field

$F = q(v \times B)$

or $F = |F| = Bqv \sin \theta$

where, B = magnetic field intensity,

q = charge on particle,

u = speed of the particle and

θ = angle between magnetic field and direction of motion.

This force is perpendicular to B as well as v.

Its direction can be obtained from Fleming's left hand rule.

Magnetic force acting on a current carrying conductor in a uniform magnetic field is given by

$F = I (l * B)$

Fleming's left Hand Rule

If we stretch the thumb, the forefinger and the central finger if left hand in such a way that all three are perpendicular to each other, then if forefinger represents the direction of magnetic field, central finger represents the direction of current flowing through the conductor, then, thumb will represent the direction of magnetic force.

Lorentz Force -The total force experienced by a charge moving inside the electric and magnetic fields is called Lorentz force. It is given by $F = q(E + v * B)$

Motion of a Charged Particle in a Uniform Magnetic Field

When charged particle enter normal to the magnetic field it follows a circular path.

The radius of the path, $r = mv / Bq$

$\therefore r \propto mv$

and $r \propto 1 / (q / m)$

Time period, $T = 2\pi m / Bq$

When charged particle enter magnetic field at any angle except 90°, then it follows helical path.

The radius of the path, $r = mv \sin \theta / Bq$

The distance travelled by the charged particle in 1 time period due to component of velocity $v \cos \theta$, is called pitch of the path

Pitch $= T * v \cos \theta = 2\pi mv \cos \theta / Bq$

Cyclotron

Cyclotron is a device used to accelerate positively charged particles such as proton, deuteron etc.

Principle of Cyclotron-

A positively charged particle can be accelerated with high energy in an electric field by crossing it again and again by use of strong magnetic field.

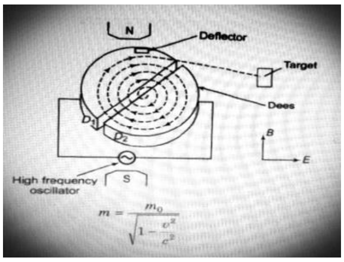
Radius of circular path, $r = mv / Bq$

Cyclotron frequency $v = Bq / 2\pi m$

where m and q are mass and charge of the positive ion and B is strength of the magnetic field Maximum kinetic energy gained by the particle. $E_{max} = (Bqr_0)^2 / 2m$

where, r_0 = maximum radius of circular path.

When a positive ion is accelerated by the cyclotron, it moves with greater and greater speed. As the speed of ion becomes comparable with that of light, the mass of the ion increases according to the relation.



Where, m = mass of the ions . m_0 = maximum mass of the ion. v = speed of Ion and c = speed of light.

Limitations of the Cyclotron

(i) Cyclotron cannot accelerated uncharged particle like neutron.

(ii) The positively charged particles having large mass i.e., ions cannot move at limitless speed in a cyclotron.