Lorentz Force

Lorentz force refers to a combination of magnetic and electric force that acts on a point charge due to the presence of electromagnetic fields. Furthermore, the Lorentz force is also known by experts as the electromagnetic force.

Introduction to Lorentz Force

Experts define Lorentz force as the combination of the magnetic and electric force. Furthermore, this force acts on a point charge due to electromagnetic field.

Lorentz force explains the equations of mathematical nature along with the physical importance of forces which act on the charged particles. Moreover, these particles travel through space which contains electric and magnetic field.

How do we Measure Lorentz Force?

Lorentz force on a moving charge that is present in a B Field

Lorentz force happens when the movement of a charged particle takes place through a magnetic field and cuts through field lines in the process. This force acts at right angles to both the particle velocity, v, and the magnetic field, B.

This force's direction in various situations is dependent on the direction of the velocity of the particle and the magnetic field as well as the sign of the particle's charge. There are two ways of remembering the direction of this force and both these ways are variants of the "left-hand rule".

Thumb, First finger and Second finger:

These are held at right angles to each other and a rotation takes place so that:

- the pointing of the First finger is in the direction of the Magnetic Field
- furthermore, the pointing of the Second finger is in the direction of the Current
- the pointing of the Thumb's direction is in the direction that the Motion would tend to if the magnetic force in case is the only force present.

There is an alternative way of remembering the left-hand rule that involves using the acronym “FBI” to label your fingers. As such, “I” refers to the middle finger, “F” refers to the thumb, and “B” refers to the first finger.

Holding these three fingers at right angles to each other would show the relationship between the directions of the current I, force F, and magnetic field B.

Lorentz Force on a current-carrying wire that is present in a magnetic field:

A current refers to the movement of charged particles, so if a wire which has current is within a magnetic field, then all of the charged particles would be experiencing a Lorentz force.

So, one would need to find out the sum of the forces on the moving charged particles. This is because the sum of the forces on the moving charged particles would be equal to the overall force on the wire.

Lorentz Force by Making Use of Vector Notation

Using vector notation, the force which acts on a moving charge, *q*, in a magnetic field, ***B***, is expressed as:

$$\boldsymbol{F}=q\boldsymbol{v}\times\boldsymbol{B}$$

In accordance with the rules of vector notation, this means that ***F*** should be at right angles to both ***B*** and ***v*** and making use of the right-hand screw rule would provide us with the correct direction for ***F***.

The formula of Lorentz Force

$$F=q(E+v*B)$$

Where,

- F is the force whose effect takes place on the particle
- q is the particle's electric charge
- v is the velocity
- E refers to the external electric field
- B is the magnetic field

Derivation of the Formula of Lorentz Force

Lorentz force on a moving charge that is present in a B Field

The size of the Lorentz Force is expressed as:

$F = qvB\sin\theta$

where theta, θ, refers to the angle between the velocity of the particle and the magnetic field. Furthermore, q refers to the charge of the particle.

If the movement of the particle takes place in the direction of the magnetic field, without cutting across any field lines, theta, equals, 0, $\theta=0$ and there would be no Lorentz Force that acts on the particle.

If the particle is moving perpendicular to the magnetic field, $\sin\theta=1$, the particle will come under circular motion with a radius r. Furthermore, the determination of r can take place by equating the centripetal force and the Lorentz force:

$mv^2/r = qvB$

Lorentz Force on a current-carrying wire that is present in a magnetic field:

This is another way of Lorentz force derivation. For N charged particles, each with a charge q and having a movement at the speed v. Furthermore, its movement takes place along a wire at an angle theta, θ, to a magnetic field of strength B. Therefore, the total force on the wire would be:

$F = NqvB\sin\theta$

The expression of the magnitude of the current travelling down the wire I is as:

$I = nAve$

where n happens to be the number density of free electrons in the wire. Moreover, *A* refers to the wire's cross-sectional area and v refers to the speed of the electrons along the wire. Also, the magnitude of an electron's charge is *e*.

This gives:

$v = I/nAe.$

Substituting this:

$F = NqBI\sin\theta/nAe$

Finally, we get the equation for the magnitude of the force that acts on the wire:

$F = BIl\sin\theta$

Lorentz Force by Making Use of Vector Notation

It is possible to derive this force in vector form. So, the force that acts on a moving charge q, in a magnetic field *B*, can be expressed as:

$F = qv \times B$

The expression of the Lorentz force on a current-carrying wire in a magnetic field *B* can take place in vector notation as:

$F = I\int_{\text{wire}} dl \times B$

where d*l* happens to be an infinitesimal displacement that takes place along the wire. Furthermore, *B* refers to the magnetic field at the relevant point. Also, the integral is taken over the wire's entire length.

Adding the force which acts on a charged particle due to an electric field $F=qE$ would give a total Lorentz force on a particle of:

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