UNIT : II:

Electromagnetism and Electromagnetic Induction

Electromagnetism —

Electromagnetism is the branch of physics which deals with the study of the electromagnetic force.

Electromagnetic force is carried by electromagnetic fields, composed of electric field and magnetic field.

Lorentz force —

when a charged particle passes through a region having both electric and magnetic field then the force acting on particle is the vector sum of force due to electric field and force due to magnetic field.

⟶ force due to electric field $\vec{F_e} = q\vec{E}$

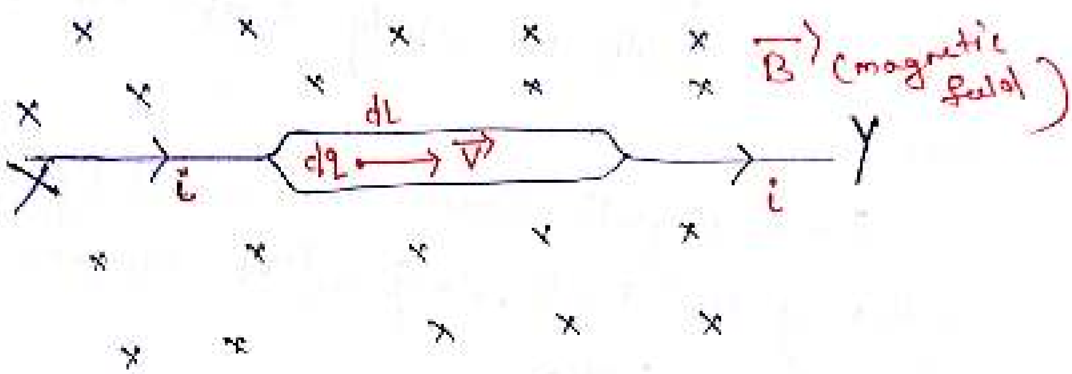
⟶ force due to Magnetic field $\vec{F_m} = q(\vec{v} \times \vec{B})$

i.e $\vec{F} = \vec{F_e} + \vec{F_m}$

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

Force on a Current Carrying Conductor placed in a Uniform magnetic field:—

lets Consider a uniform magnetic field which directed inward and represented by (x).



A Conductor xy Carrying Current i from x to y is placed within the field.

let dq be a small amount of +ve charge that flows from higher to lower potential inside the Conductor with velocity $\vec{v}$.

The force experienced by this charge

$$d\vec{F} = dq\,(\vec{v} \times \vec{B}) \quad \text{—— (1)}$$

Let the charge dq covers a displacement $d\vec{l}$ in time dt.

Then $\boxed{\vec{v} = \frac{d\vec{l}}{dt}}$ —— (2)

The direction of $d\vec{l}$ is along the direction of Current.

Substituting eq^n (2) in eq^n (1)

$$\vec{dF} = dq \left(\frac{\vec{dl}}{dt} \times \vec{B} \right)$$

$$\vec{dF} = \frac{dq}{dt} \left(\vec{dl} \times \vec{B} \right)$$

$$\vec{dF} = i \left(\vec{dl} \times \vec{B} \right) \quad \text{———} \quad (3)$$

Now total force experienced by the conductor can be obtain by integration

$$\vec{F} = \int \vec{dF} = \int i \left(\vec{dl} \times \vec{B} \right)$$

$$\Rightarrow \vec{F} = i \int \left(\vec{dl} \times \vec{B} \right)$$

$$\Rightarrow \vec{F} = i \left(\vec{l} \times \vec{B} \right) \quad \text{———} \quad (4)$$

Now magnitude of force given by

$$\boxed{|\vec{F}| = ilB \sin\theta} \quad \text{———} \quad (5)$$

θ is the angle between $\vec{l}$ & $\vec{B}$

direction :→

The direction of force can be obtain by cross-product rule or by flamming's left hand rule.

Special Case :→

(01) if $\theta = 0^\circ$, $\sin\theta = 0$ $|\vec{F}| = 0$ (minimum)

No force is experienced by a current carrying conductor held parallal to the magnetic field.

(02) If $\theta = 90^\circ$, $\sin\theta = 1$ $|\vec{F}| = ilB$ (maximum)

i.e Maximum forced is experienced by a Current Carrying Conductor held perpendicular to the magnetic field.

Fleming's left hand Rule:—

Fleming's left hand rule states that,

Stretch first finger, Central finger, and thumb of left hand in such a way that they are mutually perpendicular to each other, then the first finger shows the field, Central finger shows the current and thumb gives direction of force.

* Faraday's laws of Electromagnetic Induction :—

- Electromagnetic induction —

It is a phenomenon by virtue of which electricity is produce due to the magnetism. i.e Electricity is induced because of a Changing magnetic field

Faraday's law of Electro-magnetic Induction —

01 → when ever magnetic flux linked with circuit changes, an e.m.f induced in it

02 → The induced e.m.f exists in the circuit so long as the change in magnetic flux linked with it continues.

03 → The induced e.m.f is directly proporsnal to the negative rate of change of magnetic flux linked with the circuit.

$$\boxed{E = -\frac{d\phi}{dt}}$$

Lenz's Law

Lenz's law is the result of Faraday's law of electromagnetic-induction.

It states that the direction of induced e.m.f is such that it tends to oppose the very cause which produces it.

- According to Faraday's 3rd law $E = -\frac{d\phi}{dt}$

—ve sign indicate E oppose the change in flux.

To find the direction of induced current in a conductor, we can use Fleming's right hand rule.

Fleming's right hand rule: —

It states that stretch the first finger, central finger, the thumb of right hand in such a way that they stay perpendicular to each other.

Then first finger shows the direction of magnetic field, thumb will shows direction of motion of conductor and central finger shows the direction of induced current in the conductor.

Fleming's right hand Rule

01) It is used to find the direction of induced Current by motion of Conductor placed in Magnetic field.

02)

Motion of Conductor — known

Magnetic field dirⁿ — known

Direction of induced Current — determined

03) Here we use right hand

04) It is basic principle of generator.

05)

~~First~~ finger — (input) → Dirⁿ of Magnetic field

Middle finger → Current

Thumb — (output) →

Fleming's left hand Rule.

01) It is used to find the force experienced by Current Carrying Conductor placed in uniform Magnetic field.

02)

Current in Conductor — known

Dirⁿ of Magnetic field — known

Motion of Conductor or force — determined

03) Here we use left hand

04) It is basic principle of Motor.

~~05)~~

~~To find the direc~~

F.R.R

Used right hand,

first finger (input) – Direction of Magnetic field

Thum – Direction of Motion of Conductor.

Middle finger – (output) – Direction of induced Current.

F.L.R

Used left hand

first finger – Direction of magnetic feal

Middle finger – Current.

Thum – (output) – Direction of force due to motion of Conductor.