Unit - IV

Magnetic forces and Materials

To study the force a magnetic field exerts on charged particles, current elements and loops.

Its important to problems on ~~charg~~ electrical devices such as ammeters, voltmeters, galvanometers, cyclotrons, plasmas, motors and magnetohydrodynamic generators.

Lorentz Force equation :

* Force on a charged particle:

Electric force F_e on a stationary or moving electric charge Q in an electric field is given by Coulomb's experimental law

$$\vec{F_e} = Q\vec{E}$$

F & E	→ same direct	+ve charge
	opposite "	−ve charge

A magnetic field exert force only on a moving charge.

Magnetic force experienced by a charge Q moving with a velocity v in a magnetic field B is,

$$\vec{F_m} = Q\vec{v} \times \vec{B}$$

F_m is perpendicular to both v & B.

For a moving charge Q in the presence of both electric and magnetic fields, the total force on the charge is given by

$$F = F_e + F_m$$

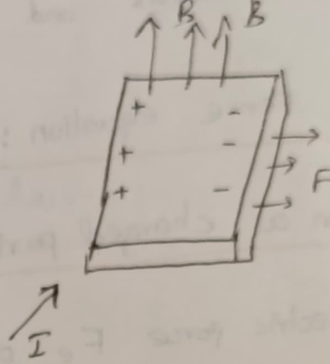
$$F = Q(E + v \times B)$$

This is known as Lorentz force equation.

* Force on a differential current element

Consider a current element placed in a magnetic field,

Force on a small differential element 'dl'



$$dF = dQ(v \times B)$$

$$= dQ\left(\frac{dl}{dt} \times B\right)$$

$$= \frac{dQ}{dt}(dl \times B)$$

$$\vec{dF} = I(\vec{dl} \times \vec{B})$$

If I is along negative x direction and B is along +ve z direction. So F will be along +ve y direction.

$$\vec{F} = I(l(-\hat{a_x}) \times B(\hat{a_z}))$$ $a_x \; a_y \; a_z$

$$= I l B \sin\theta \, \hat{a_y}$$

$$\vec{F} = BIl \sin\theta \, \hat{a_y}$$ (or) $F = I(L \times B)$

The magnitude of force

$$\boxed{F = BIl \sin\theta}$$