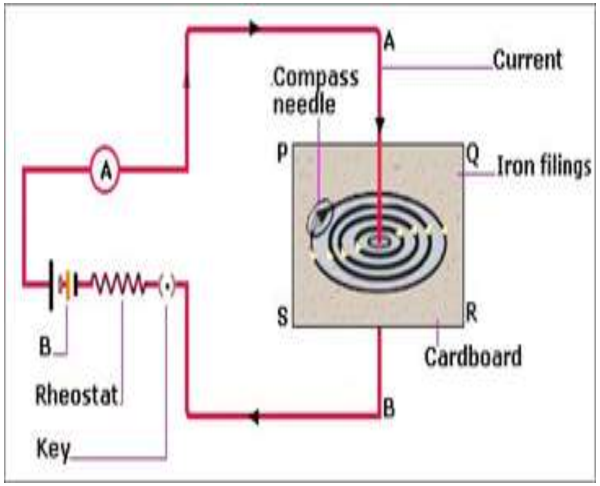
MOVING CHARGES AND MAGNETISM

Introduction: In 1820,Danish Physicist, Hans Christian Oersted was first to observe that the electric current in a straight wire current carrying conductor caused deflection in a magnetic compass needle. He performed experiments with iron fillings sprinkled which was arranged in form of concentric circles with current carrying wire at the centre. The magnetic compass needle placed near current carrying conductor aligned tangentially to these imaginary concetric circle representing magnetic lines of flux.**He concluded that a moving charges or currents produces a magnetic field in the surrounding space.**



Force on a moving charge placed in an Electric Field

Let Q let the source charge. Hence, the electric field due to the source charge is E(r).Let q be a charge which is at P at the position r. If it is at rest. Let electric force on the charge q be $F_{electric}$.As long as the charge q is at rest, the force on the static charge q only electric force.

$$\vec{F}_{elect} = q\overrightarrow{E(r)} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r} \qquad (1)$$

When the electric charge, q moves,it produces its magnetic field of magnetic induction $\overrightarrow{B(r)}$.The charge q is experienced by certain magnetic force,$F_{magnetic}$=q[$\vec{v}$x$\overrightarrow{B(r)}$] (2)

Where $\overrightarrow{v}$=velocity of the moving charge

Force on a moving charge placed in an Electric Field

The total force on the moving charge, $\vec{F}$

$= \vec{F}_{\text{elect}} + F_{\text{magnetic}} = q x \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\,\hat{r} \;+ q x [\vec{v} x \overrightarrow{B(r)}\,]$

$= q x \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\,\hat{r} \;+ qvB(r)\,\sin\theta\,\hat{n}$

$\overrightarrow{F} = q[\frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r} + \mathrm{vB(r)}\sin\theta\,\hat{n}]$ (3)

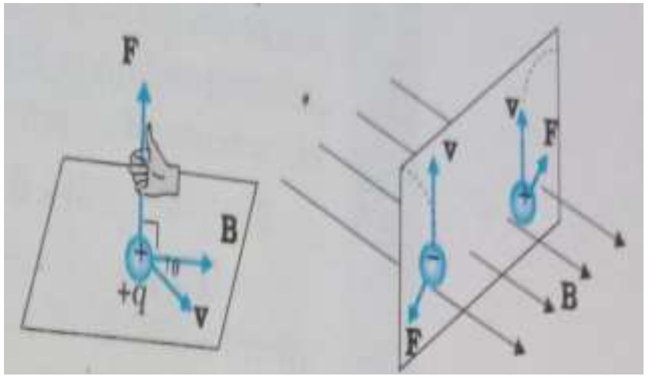
This force on the charge q is called Lorentz force based experiments of H A Lorentz

Magnetic Force on a moving Charge

Let+q coulomb be the electric charge $\overrightarrow{B(\mathrm{r})}$ be magnetic Induction and $\overrightarrow{v}$ velocity of the moving charge. Then $F_{magnetic}$ be the force moving magnetic charge,q

$\vec{F}_{magnetic}$ =q[$\vec{v}$x$\vec{B}$(r)]=qvB(r) $\sin\theta\,\hat{n}$

where θ be angle between $\vec{v}$ and $\vec{B}(\mathrm{r})$ .The direction of Force is perpendicular to the Plane containing $\vec{v}$ and $\vec{B}$(r) given by using Fleming's Right Hand Rule .



Fleming's Right Hand Rule :Stretch the fore finger, middle finger and thumb of the right hand mutually perpendicular to each other.If the fore finger is in the direction of motion of moving positive charge, middle finger gives the direction of magnetic field

Case-I: $\theta =0°$ or 180°,sinθ=0,$F_{magnetic}$ =qvB(r) xsinθ=qvB(r)x0=0

The magnetic force on the charge vanishes i.e becomes zero if the charge moves paralell to the magnetic field or in antiparallel to it.

Case II:If v=0,$F_{magnetic}$=0

Case III:$\theta = 90°$,sin90° $= 1, Maximum$ magnetic force on the moving chage q, $F_{magnetic}$ =qvB(r)