HANS CHRISTIAN OERSTED
(1777-1851)

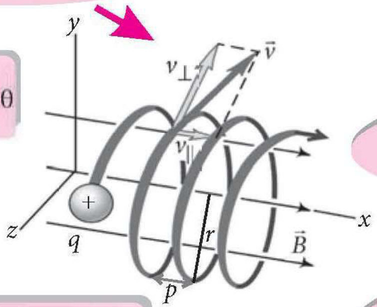
MOVING CHARGES AND MAGNETISM

BRAIN MAP
CLASS XII

Magnetic Force on a charge particle in a uniform magnetic field
$\vec{F} = q(\vec{v} \times \vec{B}),\ F = qvB \sin\theta$

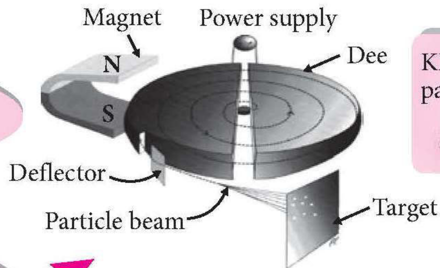
For arbitrary angle θ (< 90°) $F = qvB \sin\theta$ and charge will attain helical path

Pitch $(p) = \dfrac{2\pi mv}{qB}\cos\theta$



For $v \parallel B$, θ = 0° (F = 0) no force is experienced

For $v \perp B$, θ = 90°, $F_{max} = qvB$ charge will attain circular path



KE_{max} of charge particle
$K = \dfrac{q^2B^2R^2}{2m}$

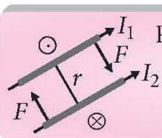
Cyclotron
A device use to accelerate positively charged particles.

- Radius of circular path
$R = \dfrac{mv}{Bq} = \dfrac{\sqrt{2mK}}{qB}$
- Time period of revolution
$T = \dfrac{2\pi R}{v} = \dfrac{2\pi m}{qB}$
- Cyclotron frequency
$\upsilon = \dfrac{1}{T} = \dfrac{qB}{2\pi m}$

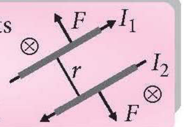
Magnetic field at the centre of a circular coil
$B = \dfrac{\mu_0 I}{2a}$

Magnetic field at a point on the axis of the circular current carrying coil
$B = \dfrac{\mu_0}{4\pi}\dfrac{2\pi NIa^2}{(a^2+x^2)^{3/2}}$

Biot Savart's Law
Magnetic field varies directly with current and length element and inversely with square of the distance.
$d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{Idl \sin\theta}{r^2}$



Parallel currents attract while antiparallel currents repel



The force of attraction or repulsion acting on each conductor of length l due to currents in two parallel conductor is $F = \dfrac{\mu_0}{4\pi}\dfrac{2I_1I_2}{r}l$

Force on a current carrying conductor in a uniform magnetic field
$\vec{F} = I(\vec{l} \times \vec{B}),\ F = IlB \sin\theta$

MAGNETIC EFFECT OF CURRENT

Ampere's Circuital Law
The line integral of magnetic field is equal to μ_0 times the current passing through area bounded by closed path.
$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$

Magnetic field due to an infinitely long straight wire of radius a, carrying current I at a point
$$B = \begin{cases} \dfrac{\mu_0 Ir}{2\pi a^2} & ;\ r < a \\ \dfrac{\mu_0 I}{2\pi a} & ;\ r = a \\ \dfrac{\mu_0 I}{2\pi r} & ;\ r > a \end{cases}$$

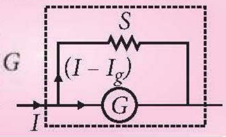
Magnetic field due to a current carrying solenoid and toroid
$B_S = \mu_0 nI = (\mu_0 NI)/l$
$B_T = \mu_0 nI = \dfrac{\mu_0 NI}{2\pi R_m}$

Torque on a current carrying coil placed in a uniform magnetic field
$\tau = NIAB \sin\theta = MB \sin\theta$

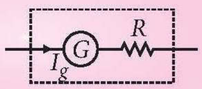
Moving Coil Galvanometer
Current I passing through the galvanometer is directly proportional to its deflection (θ). $I \propto \theta$ or $I = G\theta$.
where $G = \dfrac{k}{NAB}$ = galvanometer constant

Conversion

Galvanometer into Ammeter
$S = \left(\dfrac{I_g}{I - I_g}\right)G$



Galvanometer into Voltmeter
$R = \dfrac{V}{I_g} - G$



Current sensitivity : $I_s = \dfrac{\theta}{I} = \dfrac{NAB}{k}$

Voltage sensitivity : $V_s = \dfrac{\theta}{IR} = \dfrac{NAB}{kR}$