Magnetic Field

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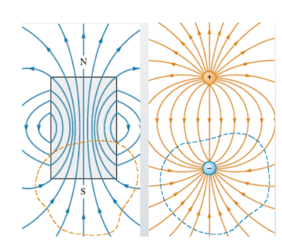
MAGNETIC FIELD:- region or space surrounding any moving electric charge or a magnetic substance

PROPERTIES OF MAGNETIC FORCE ON A CHARGE MOVING IN M.F :-
- $F_B \propto q$ and v of particle
- The magnitude and direction of F_B depends on v and on magnitude and direction of the magnetic field B
- when particle moves parallel, $F_B = 0$
- when particle v vector makes any angle $\theta \neq 0$ with m.f, F_B acts $\perp$ to v and B (right hand rule) and $F_B = qvB\sin\theta$ ($F_B \propto \sin\theta$, where θ is the angle the v vector makes with B)
- m.force on +ve charge is opp in direction to the m.force exerted on -ve charge moving in same direction

DIFFERENCES BTW ELECTRIC AND MAGNETIC FORCES :-
- e.force acts parallel to e.field, whereas m.force acts $\perp$ to m.field
- e.force acts on both stationary / moving charged particles, whereas m.force only acts on moving charged particles
- e.force does work in displacing a charged particle, whereas m.force associated with a steady m.field does no work when a particle is displaced

MAGNETIC FIELD & FORCE :-
- a m.field cannot change speed of a moving charged particle, only direction
- $\Sigma F = m a_r$
- $F_B = |q|vB$ OR $F_B = |q|vB\sin\theta$ where $v \times B$ cross product for vectors
- $F_B = qvB = \frac{mv^2}{r}$
- $r = \frac{mv}{Bq}$
- $\omega = \frac{v}{r} = \frac{qB}{m}$
- $T = \frac{2\pi m}{qB}$
- $\Sigma F = qE + qvB$ (Lorenze force) (e.field + m.field)
- $v = \frac{E}{B}$ (velocity selector)
- $\frac{m}{q} = \frac{rB_0B}{E}$ (mass spectrometer)
- $B = \frac{\mu_0 I}{2\pi r}$ (magnetic field of a long straight wire) (ampere law) $\mu_0 = 4\pi \times 10^{-7}$ T.m/A $F_B = BIL$ (magnetic force on wire)
- $B = \mu_0 \frac{N}{l} I$ OR $B = \mu_0 n I$ (magnetic field of solenoid, lenght l, N turns, independent of position if end effects are neglected) where $n = N/l$ (number of turns per unit length)
- $B = \frac{\mu_0 N I}{2\pi r}$ (toroid, N loops, no end effects, but not constant inside, depends on r)

THE HALL EFFECT:-
- when a current carrying conductor is placed in a m.field, a p.d is generated $\perp$ to both I and m.field, this phenomenon is called hall effect.
- $V_H = \frac{IB}{nqt} = \frac{R_H IB}{t}$ where $R = \frac{1}{nq}$ (hall coefficient)



GAUSS'S LAW IN MAGNETISM :-
- the net magnetic flux through any closed surface is always zero
- $\Phi_m = BA = 0$

Isolated magnetic poles (monopoles) have never been detected and perhaps do not exist. The magnetic field lines of a bar magnet form closed loops. Note that the net magnetic flux through the closed surface (dashed red line) surrounding one of the poles (or any other closed surface) is zero. The electric field lines surrounding an electric dipole begin on the positive charge and terminate on the negative charge. The electric flux through a closed surface surrounding one of the charges is not zero.

CLASSIFICATION OF MAGNETIC SUBSTANCES :-

FERROMAGNETISM :-
- all ferromagnetic materials are made up of microscopic regions called domains
- In these regions, all magnetic moments are aligned
- The boundaries between the various domains having different orientations are called domain walls
- In ferromagnetism, the magnetic diapoles / moments tend to align parallel to each other, resulting in a strong and permanent magnetization, even in the absence of an external magnetic field
- Ferromagnetism is usually observed at low temps, and above Curie temp, lose their ferromagnetic properties
- Iron, cobalt, nickle, gadolinium, dysprosium

PARAMAGNETISM :-
$\mu_m > \mu_0$
- In paramagnetism, the magnetic dipoles tend to align parallel to an external magnetic field, but the alignment is weak and temporary.
- The materials become weakly magnetised in the presence of an external magnetic field and loses its magnetization when the field is removed
- aluminium, platinum.

DIAMAGNETISM :-
$\mu_m < \mu_0$
- Magnetic dipoles tend to align in the opp direction to an external magnetic field, resulting in a weak and temporary repulsion from the field.
- graphite, bismuth

AMPERE'S LAW :-
- relates magnetic field around a closed loop to the electric current passing through the loop.
- m.field created by electric current is proportional to I with $k = \mu_0$.
- $\oint B \cdot dl = \mu_0 I_{enc} \longrightarrow B = \frac{\mu_0 I}{2\pi r}$
- I counts +ve if integration direction is the same as direction of B from right hand rule.