PARTICLE NATURE OF LIGHT, ATOM AND NUCLEUS, ELECTROMAGNETIC WAVE COMMUNICATION, SEMICONDUCTORS, MAGNETISM

PARTICLE NATURE OF LIGHT

- photons are packets of energy which are emitted by source of radiations

  (i) Each photon is of energy $E = h\nu = hc/\lambda$

  (ii) All photons travel in straight line with the speed of light in vacuum

  (iii) Different photons travel with different velocity in medium

  (iv) Photons are electrically neutral

  (v) Photons have zero rest mass

  (vi) Photons are not deflected by electric and magnetic field

  (vii) The equivalent mass of photon while moving is given by m

  $$m = \frac{E}{c^2} = \frac{h\nu}{c^2} = \frac{hc}{c^2\lambda} = \frac{h}{c\lambda}$$

  (viii) Momentum of photon = mc = E/c= hν/c = h/λ

  (ix) Number of photons of wavelength emitted in t seconds from a lamp of power P is

  $$n = \frac{Pt\lambda}{hc}$$

- Work function of metal is $\phi_o = h\nu_o$

  value of hc = 1243.1×10^{-9} eV

  (i) Work function varies from metal to metal

  (ii) Caesium has least work function , hence it is best metal for photoelectric emission

  (iii) When atomic number of element increases, the work function decreases

  (iv) When temperature of metal increases, the work function will decrease

- Stopping potential V_s

  (i)The maximum kinetic energy of the emitted photoelectron is equal to the product of charge of electron and stopping potential i.e. maximum K. E. = eV_s

(ii) Stopping potential is directly proportional to the frequency of the incident light and inversely proportional to work function

(iii) Stooping potential is independent of intensity of light, illuminating power of the source and the distance of the source from the metal surface

(iv) The graph between stopping potential and frequency of the frequency of the incident light is a straight line whose slope gives the ratio of Planck's constant to electronic charge

(v) Einstein's photoelectric equation

$$\frac{1}{2}mv^2 = h\nu - \phi_0$$

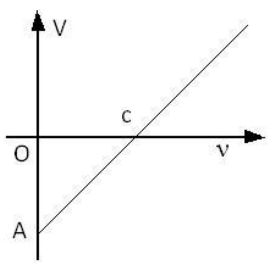
m is mass of photo electron , v is velocity of photoelectron

ν is frequency of incident radiation , ϕ_o is work function

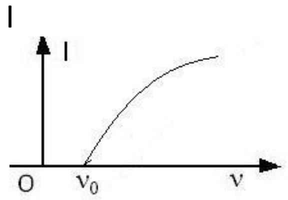
(i) Einstein's photoelectric equation was experimentally verified by Millikan for radiation of lower frequency and De-broglie for higher frequency radiations.

- de-broglie wave length λ = h/mv is independent of the nature and charge of the material particle.

  (i) the de-Broglie wave are not electromagnetic waves
- Out of photon and electron having same de-broglie wavelength, the total energy of electron is more than that of photon
- Out of photon and electron having same de-broglie wavelength, the Kinetic energy of photon is more than that of electron
- Graph between accelerating potential (V) and frequency of photon (ν)



- graph between frequency (ν) of the incident photon and photoelectric current



ATOM,NUCLEUS

- Angular momentum of electron in Bohr orbit

$$nvr = \frac{nh}{2\pi}$$

- radius of nth Bohr orbit r_n

$$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi Z e^2 m}$$

$$r_n \propto \frac{n^2}{Z}$$

- Energy of electron in nth orbit is

$$E_n = -\left(\frac{m\ e^4}{8\ h^2\ \varepsilon_0^2}\right)\frac{Z^2}{n^2}$$

$$E_n = -13.6\frac{Z^2}{n^2}eV$$

$$E_n \propto \frac{Z^2}{n^2}$$

- different spectral Series Formula and their region

  (i) Lyman series is in ultra violet region.

$$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$$

where n = 2, 3, 4, ...

(ii) Balmer series is in Visible region.

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

n = 3, 4, 5, ...

(iii) Paschen series is in Infrared region.

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$$

n = 4, 5, 6,....

(iv) Braket series is in Infrared region.

$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$$

n = 5, 6, 7,....

(v) Pfund series is in Infrared region.

$$\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$$

n = 6, 7, 8, ...

- Radius of nucleus $R = R_0(A)^{\frac{1}{3}}$

  Where Ro = Constant

  Ro = 1.1 fm to 1.2 fm

  A = mass number

- Mass defect $\Delta m = (Zm_p + Nm_n) - M$

  Z = Number of proton, N = Number of neutron, M is atomic mass

  mp is mass of proton, mn mass of neutron

- Binding energy $B.E. = \delta mc^2$

PARTICLE NATURE OF LIGHT, ATOM AND NUCLEUS, ELECTROMAGNETIC WAVE COMMUNICATION, SEMICONDUCTORS, MAGNETISM

- unit of mass in nuclear physics or atomic Physics is amu or u

  1amu = 1u = 1.67×10^{-27} kg

  1u = 931.48MeV = 931.48×10^{6} eV
- B.E Per nucleon is = B.E./ A

  A is atomic number
- Conversion of sub-atomic particles

$$n \rightarrow p + e^{-} + \bar{\nu}$$

$$p \rightarrow n + e^{+} + \nu$$

$$\nu : neutrino$$

$$\bar{\nu} : anti\ neutrino$$

  Here p is proton , n is neutron e^{-} is beta particle , e^{+} is positron

- unit of Radio activity

  1Bq = 1 disintegration/ sec

  1 curie = 3.7×10^{10}disinteglation/sec
- Activity I

$$I = \frac{dN}{dt} = -\lambda N$$

  Where λ is radioactive decay Constant

  number of Atoms or nuclear in a Radioactive sample after time is given by

  $N = N_o e^{-\lambda t}$

  Activity $I = I_o e^{-\lambda t}$

  and mass $m = m_o e^{-\lambda t}$

- Half life

$$\tau_{\frac{1}{2}} = \frac{0693}{\lambda}$$

  Mean life T = 1/λ

  $\tau_{1/2}$ = 0693T

  or T = 1.44 $\tau_{1/2}$

- Nuclear reaction A (a,b) B or A+a → B + b + Q

  A = Target Nucleus, a = Projected Particle

  B = resulting (product) nucleus, b = emitted Particle

  Q = energy equal muss defect

  Q > 0 Exoenergic and Q < 0 Endoenergic

- In α - decay Z decrease by 2 and mass number A decrease by 4

  In β- decay Z increase by 1 and mass number does not change

  In β+ decay Z decrease by 1 and mass number does not change

  In emission of γ - ray or photon, Z and A does not change.

ELECTROMAGNETIC WAVE AND COMMUNICATION

- Ampere-Maxwell law:

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (I + I_D)$$

$$I_D = \frac{\varepsilon_0 \, d\phi_E}{dt}$$

  Here I_D is current

$$\frac{d\phi_E}{dt} \text{ is rate of change of electric flux}$$

  ε_0 is absolute permitivity of space

- Maxwell's equations

$$(i)\ \oint \vec{E}\cdot\vec{ds} = \frac{q}{\varepsilon_0}$$

$$(ii)\ \oint \vec{B}\cdot\vec{ds} = 0$$

$$(iii)\ \oint \vec{E}\cdot\vec{dl} = -\frac{d}{dt}\int_S \vec{B}\cdot\vec{ds}$$

$$(iv)\ \oint \vec{B}\cdot\vec{dl} = \mu_0 I + \mu_0\varepsilon_0\frac{d}{dt}\int_S \vec{E}\cdot\vec{ds}$$

  First equation is Gauss's law in electrostatics

  Second equation is gauss's law in magnetostatics

  Third equation is Faraday's law of electromagnetic induction

  Forth equation is Ampere Maxwell law

  velocity of electromagnetic wave is free space is given by formula

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

  Velocity of light in transparent medium is given by equation

$$v = \frac{1}{\sqrt{\mu\varepsilon}}$$

  Here μ is permeability of the medium

  ε is permitivity of the medium

  c = 3 × 108 m/s

- height of transmission antenna = d = √(2hR)

  d is the radius of the circle on the surface of earth within which the transmitted signal form the transmitting antenna can be received and R is the radius of earth

- Refractive index n

$$n = \sqrt{\mu_r K}$$

PARTICLE NATURE OF LIGHT, ATOM AND NUCLEUS, ELECTROMAGNETIC WAVE

COMMUNICATION, SEMICONDUCTORS, MAGNETISM

- Δp = ΔU/c = F

  Δp is momentum delivered to surface

  ΔU is energy of electromagnetic wave incident on surface of area A in Δt

- Energy density of electromagnetic wave is ρ

$$\rho = \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2}\frac{B_{rms}^2}{\mu_0}$$

$$\rho = \varepsilon_0 E_{rms}^2$$

$$\rho = \frac{B_{rms}^2}{\mu_0}$$

- Intensity of radiation (I) is defined as the radiant energy passing through unit area normal to the direction of propagation in one second

$$I = \frac{Energy/time}{Area}$$

$$I = \frac{Power}{Area}$$

$$I = \rho.c = \varepsilon_0 c E_{rms}^2$$

and

$$I = \frac{cB_{rms}^2}{\mu_0}$$

- Representation of electromagnetic wave in form of equations

  $E_y = E_o \sin(\omega t - kx)$ and $B_z = B_o \sin(\omega t - kx)$

  E and B are related by following equation

  E = B c

  C is velocity of light

- Inductive components : According to Maxwell's theory, these electric and magnetic field do not come into existence instantly. In the region closer to the oscillating charges, the phase difference between $\vec{E}$ and $\vec{B}$ field is π/2 and their magnitude quickly decreases as $1/r^3$ (where r is the distance from source. these components of transmitted waves near their origin (or fields) are called Inductive Components.
- Radiated Components
  At larger distances $\overrightarrow{E}$ and $\vec{B}$ are in phase and the decrease in their magnitude is comparatively slower with distance, as per 1/r. these components are called Radiated components

COMMUNICATION

Bandwidth of signals

speech signal requires a bandwidth of 2800 Hz (3100 Hz– 300 Hz) for commercial telephonic communication.

To transmit music, an approximate bandwidth of 20 kHz is required because of the high

frequencies produced by the musical instruments. The audible range of frequencies extends from 20 Hz to 20 kHz.

Video signals for transmission of pictures require about 4.2 MHz of bandwidth.

A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

Bandwidth of transmission medium

Coaxial cable is a widely used wire medium, which offers a bandwidth of approximately 750 MHz. Such cables are normally operated below 18 GHz.

Communication through free space using radio waves takes place over a very wide range of frequencies: from a few hundreds of kHz to a few GHz.

Optical communication using fibers is performed in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet). An optical fiber can offer a transmission bandwidth in excess of 100 GHz.

Spectrum allocations are arrived at by an international agreement. The International Telecommunication Union (ITU) administers the present system of frequency allocations

$$d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

where h_R is the height of receiving antenna. h_T is the height of transmitting antenna. R is radius of earth
d_M between the two antennas

Area covered by transmission $A = \pi(d_T)^2 = \pi(2h_T R)$
d_T is distance to the horizon

Modulation

Amplitude of carrier wave = A_C , Amplitude of modulating wave = Am

Angular frequency of carrier wave = ω_c,

Angular frequency of modulating wave = Am

modulation index = μ

Standard equation for Amplitude modulated wave,

$$C_m(t) = A_c(1 + \mu \sin\omega_m t)\sin\omega_c t$$

- Amplitude modulated wave have maximum amplitude
  $A_{max} = A_C + A_m$
  Amplitude modulated wave have minimum amplitude
  $A_{min} = A_c - A_m$
- modulation index

$$\mu = \frac{A_m}{A_C} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

$$\mu(\%) = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \times 100$$

SEMICONDUCTOR ELECTRONICS

The forbidden gap energy is of the order of 0.7eV for Ge and 1.1eV for Si.

Doping : pentavalent atoms (bismuth, antimony, phosphorous, arsenic which have five valence electrons) or

trivalent atoms (aluminium, gallium, indium, boron which have three valence electrons).

pentavalent doping atom is known as donor atom, since it donates one electron to the conduction band of pure semiconductor.

The trivalent atom is called an acceptor atom, because it accepts one electron from the pure semiconductor atom.

The electron and hole concentration in a

semiconductor *in thermal equilibrium* is given by $n_e n_h = n_i^2$

The potential barrier is approximately 0.7V for a silicon PN junction and 0.3V for a

germanium PN junction

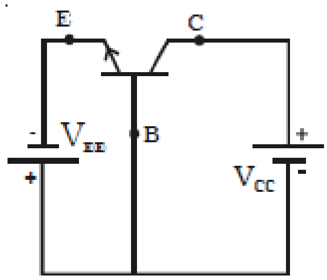
The compound semiconductor Gallium Arsenide – Phosphide ($GaAs_{1-x}P_x$) is used for making LEDs of different colours.

$GaAs_{0.6}P_{0.4}$ (E_g ~ 1.9 eV) is used for red LED.

GaAs (E_g ~ 1.4 eV) is used for making infrared LED

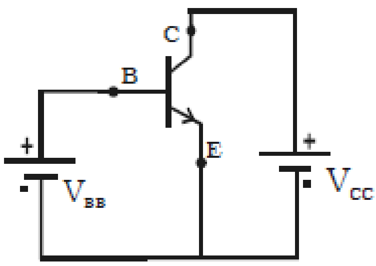
Transistor circuit configurations

There are three types of circuit connections (called configurations or modes) for operating a transistor. They are (i) common base (CB) mode



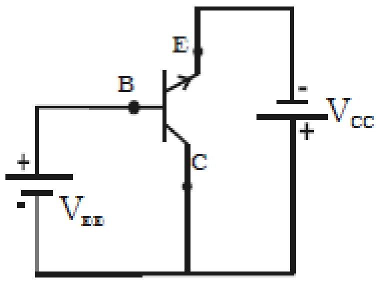
(a) CB mode

(ii)common emitter (CE) mode



(b) CE mode

(iii)common collector (CC) mode.



(c) CC mode

In a similar way, three configurations can be drawn for PNP transistor.

Current gain

If the transistor is connected in common base mode, the current gain α

$$\alpha = \frac{I_C}{I_E}$$

and if the transistor is connected in common emitter mode, the current gain β

$$\beta = \frac{I_C}{I_B}$$

Relation between α and β

$$\beta = \frac{\alpha}{1-\alpha}$$

Usually β lies between 50 and 300. Some transistors have β as high as 1000.

Similarly we can prove

$$\alpha = \frac{\beta}{1+\beta}$$

Input resistance of transistor

$$\boldsymbol{r_i} = \left(\frac{\Delta \boldsymbol{V_{BE}}}{\Delta \boldsymbol{I_B}}\right)_{\boldsymbol{V_{CE}}}$$

The input impedance of the transistor in CE mode is very high.

output impedance, r_o

$$\boldsymbol{r_o} = \left(\frac{\Delta \boldsymbol{V_{CE}}}{\Delta \boldsymbol{I_C}}\right)_{\boldsymbol{I_B}}$$

The output impedance of a transistor in CE mode is low.

Its value can be found out from the input characteristic curve. Normally its value is found between 50kΩ to 100kΩ

The current gain is defined as the ratio of a small change in the collector current to the corresponding change in the base current at a constant V_{CE}.

current gain, β

$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$

The common emitter configuration has high input impedance, low output impedance and higher current gain when compared with common base configuration.

Taking the ratio of β and r_i for ac circuit

$$\frac{\beta}{r_i} = \frac{\Delta I_C / \Delta I_B}{\Delta V_{BE} / \Delta I_B} = \frac{\Delta I_C}{\Delta V_{BE}}$$

Ratio of the change in the current in the output circuit (ΔI_C) to the change in the input voltage (ΔV_{BE}) is known as the trans-conductance g_m its unit is *mho*

$$g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{\beta}{r_i}$$

Power gain (A_P): AS per definition of the gain A_P

$$A_P = \frac{Ouput\ AC\ power}{Input\ AC\ power}$$

$$A_P = \frac{\Delta V_{CE} \Delta I_C}{\Delta V_{BE} \Delta I_B}$$

$$A_P = A_V A_i$$

$$A_P = \left(-\beta \frac{R_C}{r_i}\right)(\beta)$$

$$|A_P| = \beta^2 \frac{R_C}{r_i}$$

The resonance frequency (ν) of this tuned circuit

determines the frequency at which the oscillator will oscillate.

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$

Truth table for

AND gate : Y = A · B

INPUT		OUT PUT
A	B	Y= A · B
0	0	0
0	1	0
1	1	0
1	1	1

OR gate : Y = A + B

INPUT		OUT PUT
A	B	Y= A + B
0	0	1
0	1	1
1	1	1
1	1	0

NOT gate $Y = \bar{A}$

INPUT	OUTPUT
A	$Y = \bar{A}$
0	1
1	0

NAND gate $Y = \overline{AB}$

Note NAND gate and OR gate have same truth table!

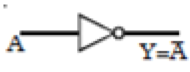
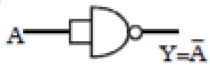
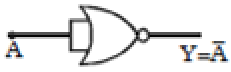
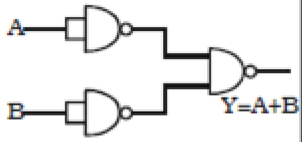
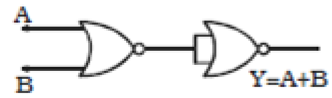
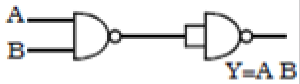
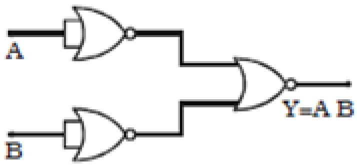
INPUT		OUT PUT
A	B	$Y = \overline{AB}$
0	0	1
0	1	1
1	1	1
1	1	0

NOR gate is $Y = \overline{A + B}$

INPUT		OUT PUT
A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	1	0
1	1	0

NAND and NOR as Universal gates

NAND and NOR gates are called Universal gates because they can perform all the three basic logic functions. Table gives the construction of basic logic gates NOT, OR and AND using NAND and NOR gates

Logic function	Symbol	Circuits using NAND gates only	Circuits using NOR gates only
NOT			
OR			
AND			

De-Morgan's theorems

First theorem

"The complement of a sum is equal to the product of the complements."

If A and B are the inputs, then

$$\overline{\boldsymbol{A}+\boldsymbol{B}} = \overline{\boldsymbol{A}} \cdot \overline{\boldsymbol{B}}$$

Second theorem

"The complement of a product is equal to the sum of the complements." If A and B are the inputs, then $\overline{A\,.\,B} = \bar{A} + \bar{B}$.

Boolean algebra *Basic laws :*

Commutative laws : A + B = B + A ; AB = BA

Associative Laws: A + (B + C) = (A + B) + C ; A (BC) = (AB) C

Distributive law: A (B+C) = AB + AC

Special theorems :

A + AB = A

(A + B) (A + C) = A + BC

A (A + B) = A

A + *A* B = A + B

A (*A* + B) = AB

(A + B) (*A* + C) = AC + *A* B

AB + *A* C = (A + C) (*A* + B)

MAGNETISM

- Bar magnet and its pole strength (m)

  (i) It is the strength of a magnetic pole to attract magnetic material towards itself

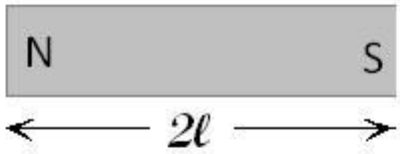
  (ii) Pole strength of the magnet depends on the nature of material of magnet and area of cross-section

  (iii) m does not depend upon length of bar magnet (iv) unit is Ampere × meter or Newton/tesla
- Magnetic dipole moment (M) :

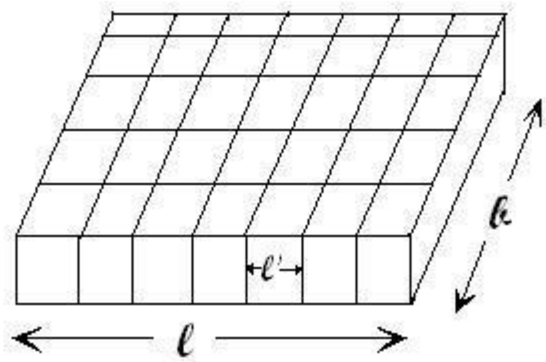
  $\mathbf{M} = m(2\mathbf{l})$

  (i) Direction is from south pole to north pole

(ii) Unit is Amp × meter2 or (Newton ×meter)/tesla



- Cutting of a rectangular bar-magnet. If a bar-magnet of length L and breadth b is cut into n equal parts then



(i) length of each part l' = l/ √n

(ii) Breadth of each part b' = b/√n

(iii)Pole-strength (m) of each part m' = m/√n

(iv)Magnetic moment (M) of each part M'= M/n

(v)Initial (Original) moment of inertia of a bar I

$$I = \frac{1}{12} W(l^2 + b^2)$$

Here W is the weight of bar magnet

(vi) After cutting new moment of inertia I' = I/n^2

- Cutting of a thin bar-magnet for thin bar magnet b = 0

L' = L/n, m'= m/n and I = I/n^2

- Magnetic field and Magnetic flux

(i) Magnetic field is denoted by B and its units are

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$$Tesla = \frac{weber}{m^2} = \frac{Newton}{Amp \times meter}$$

$$Tesla = \frac{joule}{Amp \times meter^2} = \frac{Volt \times \sec}{m^2}$$

1Tesla = 10^4 Gauss

- Intensity of magnetizing field (H) : It is the degree or extent to which a magnetic field can magnetize a substance.

  H = B/μ

  unit is Ampere/meter

  $$unit\ of\ H = \frac{N}{m^2 \times tesla} = \frac{N}{wb}$$

  $$unit\ of\ H = \frac{J}{m^3 \times tesla} = \frac{J}{m \times wb}$$

  CGS unit : Oersted

  1 Oersted = 80 Amp/meter

- Intensity of magnetization (I)

  (i) It is the degree to which a substance is magnetized when placed in a magnetic field.

  (ii) It is also defined as the pole strength per unit cross-sectional area of the substance.

  (iii) It is also defined as Induced dipole moment per unit volume.

  $$I = \frac{magnetic\ moment}{volume} = \frac{\vec{M}}{V}$$

  $$I = \frac{pole\ strength}{area\ cross-section} = \frac{m}{a}$$

  unit is Ampere/meter

- Magnetic susceptibility (χ_m) and permeability

  $\chi_m = I/H$

  Since by definition, I is magnetic moment per unit volume, χ_m is usually called volume susceptibility of the material.

  $\vec{B} = \mu_o(\vec{H} + \vec{I})$

  $\mu_r = 1 + \chi_m$

- Coulomb's law in magnetism.

  $$F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$$

  m_1 and m_2 is pole strength , and r is the distance between two magnetic pole

  value of $\mu_o/4\pi = 10^{-7}$ in SI unit = 1 in cgs unit

- Magnetic field due to bar-magnet

  Let 2l and its pole strength be 'm'. let the point P from the centre of magnet O then

  (i) On axis of a bar-magnet or in end position

  $$B = \frac{\mu_0}{4\pi}\frac{2Mr}{\left(r^2 - l^2\right)^2}$$

- for small $r^2 >> l^2$, therefore

  $$B = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$$

  The direction of **B** is along the joining the two poles from S pole to n pole

  (ii) Equatorial line or Broad side -on position

  $$B = \frac{\mu_0}{4\pi}\frac{M}{\left(r^2 + l^2\right)^{3/2}}$$

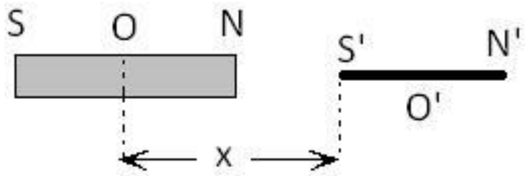
  for small $r^2 >> l^2$, therefore

  $$B = \frac{\mu_0}{4\pi}\frac{M}{r^3}$$

The direction of $\vec{B}$ is parallel to the axis form n pole to S-pole.

- Force between two small magnets

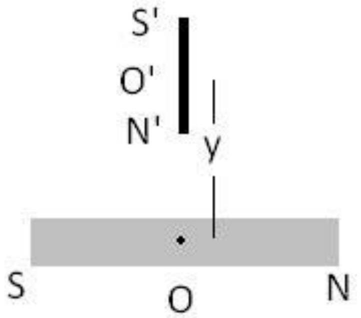
  (i) the magnet being in the End on position with respect another magnet NS see figure



M and M' are magnetic moment then

$$F = \frac{\mu_0}{4\pi}\left[\frac{6MM'}{x^4}\right]$$

(ii) the magnet being in the broadside - on position with respect to the deflecting magnet



y is the distance between magnet , M and M' be the magnetic moment then

$$F = \frac{\mu_0}{4\pi}\left[\frac{3MM'}{y^4}\right]$$

- Magnetic potential

  (i) Magnetic potential due to a point pole

  Magnetic potential due to point pole, at a distance r from the pole of strength m is given by

$$V_m = \frac{\mu_0}{4\pi}\frac{m}{r}$$

unit joule/weber

(ii) Potential due to a magnetic dipole

(a) At a point on axial point or End side position:

r be the distance between point and centre of magnet

$$V_m = \frac{\mu_0}{4\pi}\frac{M}{\left(r^2 - l^2\right)}$$

For a very short magnet $l^2 << r^2$

$$V_m = \frac{\mu_0}{4\pi}\frac{M}{r^2}$$

(b) At a point on equatorial line or in the Broadside -on position

is zero

(c) general point

the magnetic potential at a point lying on a line passing through the centre

and making angle θ with axis

$$V_m = \frac{\mu_0}{4\pi}\frac{M\cos\theta}{\left(r^2 - l^2\right)}$$

for small magnet $r^2 >> l^2$

$$V_m = \frac{\mu_0}{4\pi}\frac{M\cos\theta}{r^2}$$

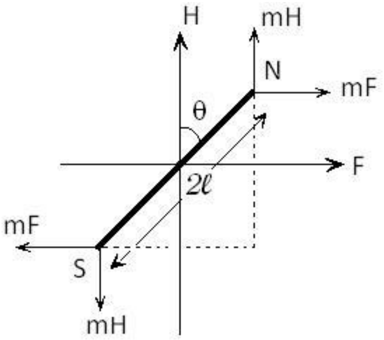
- Bar-magnet in magnetic field.

  (i) Torque $\tau = MB\sin\theta$

  (ii) Work $W = MB(\cos\theta_1 - \cos\theta_2)$

  (iii) Potential energy = $U = -\vec{M}\cdot\vec{B} = -MB\cos\theta$

- Tangent law



If we have two uniform magnetic fields at right angles to one another and if a magnet NS is placed in such a combination of field, the it will be acted upon by two forces (mF, mF) , which are equal, parallel and opposite direction tending to set it parallel to the direction of F, and two other forces (mH, mH) also equal, parallel and opposite, tending to set it parallel to the direction of H . if θ is the angle between H and magnetic dipole moment Then

$$F = H \tan\theta$$

this is called tangent law

- Tangent Galvanometer

In equilibrium

$$B = B_H \tan\theta$$

Here B

$$B = \frac{B_0 n I}{2a}$$

n = no. of turns

a = radius of the coil

I = Current to be measured

θ = angle made by needle from the direction of B and H in equilibrium.

- Deflection magnetometer :

It works on principle of tangent law

(i) A-Position : The magnetometer is set perpendicular to magnetic meridian so that magnetic field due to magnet is in AXIAL position.

$$B = B_H \tan\theta = \frac{\mu_0}{4\pi}\frac{2M}{a^3}$$

(ii) B-position : The arms of magneto meter are set in magnetic meridian so that the magnetic field due to magnet is at its equatorial position.

$$B = B_H \tan\theta = \frac{\mu_0}{4\pi}\frac{M}{a^3}$$

- Vibration Magnetometer :

  Period time

  $$T = 2\pi\sqrt{\frac{I}{MB_H}}$$

  Here I is moment of inertia of bar magnet

  M : is magnetic moment

  BH Horizontal magnetic field of earth

- Comparison of magnetic moment of two magnets of same size and mass

  (i) Substitution method As I and BH is constant

  $$\frac{M_1}{M_2} = \frac{I_1}{I_2}\frac{T_2^2}{T_1^2}$$

  (ii) Sum and Difference Method

  $$\frac{M_1}{M_2} = \frac{T_1^2 + T_2^2}{T_2^2 - T_1^2}$$

- Diamagnetic material :

  (i) magnetic dipole moment M = 0

  (ii)experience force towards weak magnetic field.

  (iii) magnetic susceptibility χ_m is POSITIVE

- Paramagnetic material :

  (i)magnetic dipole moment = M = 0

  (ii)experience force towards strong magnetic field.

  (iii) magnetic susceptibility χ_m is NEGATIVE

- Curi Law in Magnetism

  Intensity of magnetization I of magnetic material is

  (i) Directly proportional to magnetic induction (B) and

  (ii) inversely proportional to the temperature (T) of the material

  Thus from (i) $I \propto B$ and

  From (ii) $I \propto (1/T)$

  combining we get $I \propto B/T$

  AS $B \propto H$, magnetic intensity

  $\therefore I \propto H/T$ or $I/H \propto (1/R)$

  But $I/H = \chi_m$

  $\chi_m \propto 1/T$

  $\chi_m = C/T$

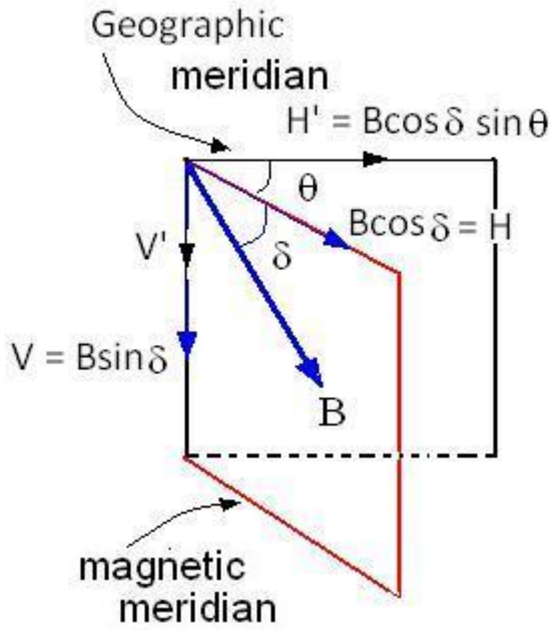
  C is constant of proportionality and is called curie constant

- Curie - weiss law :

  At temperature above curie temperature the magnetic susceptibility of force magnetic material is inversely proportional to (T - Tc)

  $$\chi_m = \frac{C}{T - T_C}$$

- Elements of earth's magnetism



(a) Geographic meridian : A vertical plane passing through the axis of rotation of the earth is called the geographical meridian

(b) Magnetic Meridian: A vertical plane passing through the axis of freely suspended magnet is called the magnetic meridian

(c) Angle of declination: The acute angle between the magnetic meridian and the geographical meridian is called the ' angle of declination' at any place

(d) Angle of dip : The angle between the axis of the freely suspended magnetic needle in the magnetic meridian and the horizontal direction is called the 'angle of dip'

- (i)Horizontal component of earth's magnetic field

  If B is the magnetic field at a point and δ is angle of declination then

  Horizontal component of earth magnetic field denoted by H or $B_H = B\cos\delta$

  (ii) Vertical component $V = B_V = B\sin\delta$

  and $\tan\delta = V/H$