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Bibliography : Physics Walla (https://www.pw.live)
(Every single line is taken from Physics Walla Website)

"Not only is the Universe stranger than we think,
it is stranger than we *can* think."

***

ATOMIC PHYSICS

Formulae

Thomsons Experiment to determine specific charge of electron (e/m)

1. $\boxed{\frac{e}{m} = \frac{E^2}{2VB^2}}$

$e \rightarrow$ the charge of an electron.

$m \rightarrow$ mass of electron.

$\frac{e}{m} \rightarrow$ specific charge of electron.

$E \rightarrow$ Electric field applied in the discharge tube.

$V \rightarrow$ Potential difference between cathode filament and anode in the discharge tube

$B \rightarrow$ magnetic field induction. The unit of $\frac{e}{m}$ of electron is C/kg.

2. $\boxed{\frac{e}{m} = \frac{E}{rB^2}}$; where r is radius of the circular deflection of electron

$E \rightarrow$ Electric field, $B \rightarrow$ magnetic field of induction.

3. If velocity of an electron (v) magnetic field of induction (B) and radius of circular path of electron are given. The $\frac{e}{m}$ of an electron can be determined by the equation

$\boxed{Bev = \frac{mv^2}{r}}$; $\boxed{\frac{e}{m} = \frac{v}{rB}}$

4. $\frac{e}{m}$ of an electron can also be determined, if applied voltage(V) and velocity of electron are given for that the formula is

$e.V = \frac{1}{2}mv^2$ $\boxed{\frac{e}{m} = \frac{v^2}{2V}}$; $v = \sqrt{\frac{2eV}{m}}$

Radius of the circular path of a charged particle in a perpendicular magnetic field

$r = \frac{m \times v}{Bq}$

5. When both electric field (E) and magnetic field of induction (B) are applied mutually perpendicular to electron beam and if electron beam does not deflect then the formula used is

$\boxed{v = \frac{E}{B}}$

6. The charge of an electron determined by Millikan's oil drop experiment given by

$$\boxed{q = \frac{6\pi\eta\left(v_g + v_e\right)}{E}\left[\frac{9}{2}\frac{\eta v_g}{(\rho - \rho')g}\right]^{1/2}}$$

Where η is the coefficient of viscosity of air.

ρ is density of oil; ρ' is density of air

g is the acceleration due to gravity

v_g, v_e are the terminal velocities of the oil droplet in gravitational field and electric field applied.

I. Photo Electric Effect :

1 Einstein's photo electric equation.

$\boxed{h\upsilon = w + \frac{1}{2}mv^2}$ (or) $\boxed{\frac{hc}{\lambda} = w + \frac{1}{2}mv^2}$

$h \rightarrow$ planck's constant

$\upsilon \rightarrow$ frequency of incident light.

$w \rightarrow$ work function measure in eV

$m \rightarrow$ mass of photo electron

$v \rightarrow$ maximum velocity of emitted photo electron.

$c \rightarrow$ velocity of light

$\lambda \rightarrow$ wave length of incident light

2. Einstein's photo equation can also be written as $\boxed{h\upsilon = w + ev_0}$ (or) $\boxed{\frac{hc}{\lambda} = w + ev_0}$

where $v_0 \rightarrow$ stopping potential.

$\upsilon \rightarrow$ frequency of incident radiation.

$\lambda \rightarrow$ wavelength of incident radiation.

3. When the frequency of incident light is minimum

$h\nu_0 = w$ (or) $\frac{hc}{\lambda_0} = w$

$\nu_0 \rightarrow$ minimum frequency of incident light (or) threshold frequency

$\lambda_0 \rightarrow$ maximum wavelength of incident light (or) threshold wavelength

II. Xray spectra:

Cut off wavelength or minimum wavelength of continuous X ray is given $\lambda_{min} = \frac{hc}{eV}$

h = Planck's constant

c = Velocity of light

e = charge of an electron V=applied voltage.

III. Compton effect :

Compton shift $\Delta\lambda = \frac{h}{m_0 c}[1-\cos\phi]$

$$\lambda^1 - \lambda = \frac{h}{m_0 c}[1-\cos\phi]$$

h $\rightarrow$ planck's constant; c $\rightarrow$ velocity of light.

IV. Cases : 1) If $\theta = 0 \rightarrow \Delta\lambda = 0$

2) If $\theta = 90^0 \rightarrow \Delta\lambda = \frac{h}{m_0 c} = 0.0242\ A^0$

3) If $\theta = 180^0 \rightarrow \Delta\lambda = \frac{2h}{m_0 c} = 0.0484\ A^0$

$m_0 \rightarrow$ electron's rest mass.

$\phi \rightarrow$ angle of scattering

$\lambda, \lambda^1 \rightarrow$ unmodified and modified wavelengths

V. De Broglie's hypothesis :

1. $\lambda = \frac{h}{p}$, $\lambda = \frac{h}{mv}$; where λ is wavelength associated with a moving particle m is mass of the particle. v is the velocity of the particle.

2. $eV = \frac{1}{2}mv^2$; e = charge of an electron; V=potential difference m = mass of electron ; v = velocity of electron.

conceptual points

Millikan's Oil drop method to measure charge of electron:

1. By using Millikan's oil drop method the charge of an electron can be determined.
2. the charge 'e' on an electron is the smallest possible charge.
3. The total charge on a body can be only on integral multiple of 'e' or q = ne where n = 1, 2, 3. .....n an integer. i.e. the charge is quantized.
4. Using Millikan's value of charge of an electron the mass of the electron can be determined as 9.1×10^{-31}kg .

Photoelectric effect:

1. Photoelectric effect is an instantaneous phenomenon.
2. For a given frequency of incident radiation, the photo electric current is proportional to the intensity of incident radiation.
3. The kinetic energy of photoelectrons is independent of the intensity of incident radiation.
4. The kinetic energy of photoelectrons depends on frequency of incident light and nature of metal.
5. Photoelectric effect does not take place below certain minimum frequency (threshold frequency) for a given metal.
6. **Work function:** The minimum energy needed to remove the electron from the metal surface is called work function.
7. **Stopping Potential:** The minimum negative potential given to collector for which photoelectric current becomes zero is called stopping potential (Vo).

X ray spectrum

1. The square root of frequency of characteristic X radiation is proportional to the atomic number of the target atom.

   $\sqrt{\nu}\ \alpha\ Z$

   $\sqrt{\nu} = a\ (Z-b)$, where a, b are constants.

   This is known as Moseley's law.

Compton Effect:

1. Compton shift is independent of the incident wavelength.
2. Compton shift is independent of nature of scatterer.
3. Compton effect depends only on the angle of scattering (f)

CAPACITANCE

Formulae: -

1. $\boxed{c = \frac{q}{V}}$ c = capacity of a condenser (farad)

Capacity of a sperical conductor $C = 4\pi\varepsilon_0 R$

q – charge (coulomb) ,V – potential (volt)

2. $\boxed{C_a = \frac{\in_0 A}{d}}$ C_0 – capacity of a parallel plate capacitor (air is medium)

[A = πr^2 for circular plates]

A–Area of the plates (m^2)

d–distance between the plates (m)

ε_0–Permittivity of free space (f/m)

3. When a medium of dielectric constant 'k' is placed between the plates then its capacity

$$\boxed{c_m = k\, c_a = \frac{k \in_0 A}{d}}$$

4. In series combination of '3' capacitors,

a) Q is same on all the capacitors

i.e, $Q = Q_1 = Q_2 = Q_3$

Ratio of charges is 1 : 1 : 1

b) Total potential, $v = v_1 + v_2 + v_3$

Ratio of potentials $v_1 : v_2 : v_3 = \frac{1}{c_1} : \frac{1}{c_2} : \frac{1}{c_3}$

c) Effective capacity, $\boxed{\frac{1}{c_s} = \frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3}}$

For two capacitors, $C_s = \frac{c_1 c_2}{c_1 + c_2}$

Note: - If all are identical capacitors, then

$C_1 = C_2 = C_3 = C$. Then $C_s = \frac{C}{3}$

$\boxed{C_s = \frac{C}{n}}$ (for 'n' capacitors)

5. In parallel combination of '3' capacitors.

a) 'v' is same across all the capacitors

i.e., $v = v_1 = v_2 = v_3$

- Ratio of potentials is 1 : 1: 1

b) Total charge, $Q = Q_1 + Q_2 + Q_3$

- Ratio of charges = $Q_1 : Q_2 : Q_3 = C_1 : C_2 : C_3$

c) Effective capacity, $\boxed{C_p = C_1 + C_2 + C_3}$

Note: If all are identical capacitors,

Then $C_1 = C_2 = C_3 = C$ and

$C_p = 3C$, $\boxed{C_p = nC}$ [for n capacitors]

6. Energy stored in a capacitor,

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$$

Where C – Capacity of capacitor

V – Potential , Q–Charge, U-Energy stored in J

7. If a dielectric of 'k', thickness 't' is placed between the plates of a parallel plate capacitor then Its capacity is

$$\boxed{C = \frac{\in_0 A}{d - t\left(1 - \frac{1}{k}\right)}}$$

Conceptual points:

8. The capacity of a conductor is the ratio of charge (q) on it to its potential (V). $c = \frac{q}{V}$

9. Unit of capacity is coulomb/volt or farad

10. The capacity of a conductor is one farad when 1 coulomb of charge added to the conductor to raise its potential by 1volt.

11. The capacity of a conductor can be increased by adding more amount of charge by reduction of its potential – Principle of condenser.

12. **Capacity of a parallel plate condenser depends upon**
(a) Area of plates
(b) Distance between the plates
(c) Dielectric medium between the plates.

13. **Uses of capacitors are: -**
(a) They are used to establish strong and uniform electric fields.
(b) They are used for storing electrical energy

14. **The dielectric constant** 'k' of a medium is defined as the ratio of permittivity of the medium $(\in)$ to the permittivity of free space $(\in_0)$.

$$k = \frac{\in}{\in_0} = \in_r \text{ : No unit}$$

Note: k = 1 for free space
k = ∞ for perfect conductor

15. In a parallel plate capacitor, the field is not uniform at the outer edges of the plates this is called 'fringing field'.

16. Dielectric is the material which do not allow electrical charges to easily pass through them.

17. In series combination of capacitors, the same charge appears on each capacitor and the total p.d. across the combination is equal to sum of p.d's across each capacitor.

18. In parallel combination of capacitors, the p.d. is same across each capacitor and total charge flowing in the circuit is the sum of the charges flowing through each capacitor.

19. When a dielectric is placed between the plates of a capacitor, its capacitance increases.

A capacitor of capacity 'C', charged through 'q' to a potential 'V' and Energy stored is 'U'.

1. If the battery is disconnected and a dielectric of dielectric constant 'k' is placed between the plates, then
a) Capacity increases by 'k' times i.e, to kC
b) Charge remains constant i.e., 'q'
c) Potential decreases by 'k' times i.e, to '$\frac{V}{k}$'
d) Energy stored decreases by 'k' times i.e, to U/k

2 If the battery is not disconnected and a dielectric of 'k' is placed between the plates, then.
a) Capacity increases by 'k' times i.e. to 'kC'
b) Charge increases by 'k' times i.e, to 'kq'
c) Potential remains constant i.e, 'V'
d) Energy stored increases by k timesi.e,'kU'

3. A solid dielectric can keep the two metal plates of capacitor at small distance of separation without actual contact.
Capacitors are of four types:
a) Variable capacitor b) Multiple capacitor
c) Paper capacitor d) Electrolyte capacitor

4. The molecules have symmetric charge distributions are called as Non—polar molecules.

5. The molecules have a non uniform distribution of charges are called as polar molecules

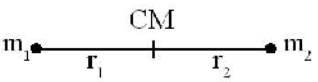
CENTRE OF MASS

1. **Rigid body:**
A body which does not under go deformation when it is subjeced to an external force is called rigid body

2. **Non Rigid body:**
A body which undergoes deformation when subjected to an external force is called non rigid body.

3. A body can execute 3 types of motions
(1) translatory motion (2) rotatory motion (3) vibratory motion
Translatory motion:
A body in which all the particles same displacement in same time is called translatory motion
Rotatory motion:
A body in which the particles move permanently around a fixed point then the motion of the body is called rotatory motion.

4. **Centre of mass:**
Centre of mass is a point with in the boundaries of a system or a body at which its entire mass appears to be concentrated.

5. 

When two particles of masses m_1 and m_2 are located on a straight line, their centre of mass lies on the line joining the two particles. Let r_1 and r_2 be the distances of the particles from their centre of mass respectively, then

$$m_1 r_1 = m_2 r_2$$

6. **Coordinates of centre of mass**
Let us consider a system of n particles of masses m_1, m_2, ..., m_n whose co-ordinates are (x_1, y_1, z_1) (x_2, y_2, z_2), ... , (x_n, y_n, z_n) respectively. Then co-ordinates of their centre of mass are

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + ... + m_n x_n}{m_1 + m_2 + ... + m_n}$$

$$x_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i$$

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2 + ... + m_n y_n}{m_1 + m_2 + ... + m_n}$$

$$y_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i y_i$$

and

$$z_{cm} = \frac{m_1 z_1 + m_2 z_2 + ... + m_n z_n}{m_1 + m_2 + ... + m_n}$$

$$z_{cm} = \frac{1}{M}.\sum_{i=1}^{n} m_i z_i$$

7. **Position vector of centre of mass**
Consider two particles of mass m_1 and m_2 whose position are represented by position vectors $\vec{r_1}$ and $\vec{r_2}$ respectively at an instant, then

$$\vec{r}_{cm} = \frac{m_1 \vec{r_1} + m_2 \vec{r_2}}{m_1 + m_2}$$

8. **Velocity and acceleration of centre of mass**
Velocity of centre of mass

$$\vec{V}_{cm} = \frac{m_1 \vec{V_1} + m_2 \vec{V_2} + ... + m_n \vec{V_n}}{m_1 + m_2 + ... + m_n}$$

$$\vec{V}_{cm} = \frac{1}{M}.\sum_{i=1}^{n} m_i.\vec{V_i}$$

9. **Moment of inertia of some bodies of regular shape**

S.No.	Body	Axis	Moment of inertia
1.	Uniform rod of length ℓ	Perpendicular to rod through its center	$\frac{1}{12}M\ell^2$
2.	Uniform rectangular lamina of length ℓ and breadth b	Perpendicular to lamina and through its center	$M\left(\frac{\ell^2 + b^2}{12}\right)$
3.	Uniform circular ring of radius R	Perpendicular to its plane and through the center	MR^2

4. Uniform circular ring of radius R Diameter $MR^2/2$

5. Uniform circular ring of disc of radius R Perpendicular to its plane and through the center $\frac{1}{2}MR^2$

6. Uniform circular ring of disc of radius R Diameter $\frac{1}{4}MR^2$

7. Hollow cylinder of radius R Axis of cylinder MR^2

8. Solid cylinder of radius R Axis of cylinder $\frac{1}{2}MR^2$

9. Hollow sphere of radius R Diameter $\frac{2}{3}MR^2$

10. Solid sphere of radius R Diameter $\frac{2}{5}MR^2$

10. Acceleration of centre of mass

$$\vec{a}_{cm} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + ... + m_n\vec{a}_n}{m_1 + m_2 + ... + m_n}$$

$$\vec{a}_{cm} = \frac{1}{M}.\sum_{i=1}^{n} m_i.a_i$$

11. Characteristics of centre of mass

a. The position of centre of mass depends up on the shape of the body and the distribution of mass

b. Centre of mass always located towards massive part of the body

c. Matter may or may not present at centre of mass

d. If the origin is at the centre of mass sum of moment of masses of the system about centre of mass is zero.

e. Centre of mass canot be effected by the internal forces

f. When no external force acts on a system the velocity of centre of mass of the system remains constant.

g. The location of the centre of mass is independent of the reference frame used to locate it.

Motion of a cylinder rolling without slipping on an inclined plane

$$a = \frac{mg\sin\theta}{m + I/r^2}$$

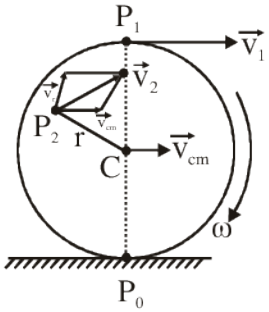
Linear Motion

Rotational Motion

1. Distance/ displacement (s)
2. Angle or angular displacement (θ)
3. Linear velocity, $v = \frac{ds}{dt}$
4. Angular velocity, $\omega = \frac{d\theta}{dt}$
5. Linear acceleration, $a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$
6. Angular acceleration, $\alpha = \frac{d\omega}{et} = \frac{d^2\theta}{dt^2}$
7. Mass (m)
8. Moment of inertia (I)
9. Linear momentum, $p = mv$
10. Angular momentum, $L = I\omega$
11. Force, $F = ma$
12. Torque = $\tau = I\alpha$
13. Also force, $F = \frac{dp}{dt}$
14. Also, torque = $\tau = \frac{dL}{dt}$
15. Translational K.E. = $\frac{1}{2}mv^2 = \frac{p^2}{2m}$
16. Rotatinoal K.E. $= \frac{1}{2}I\omega^2 = \frac{L^2}{2I}$
17. Work done, $W = Fs$
18. Work done, $W = \tau = \theta$
19. Power, $P = Fv$
20. Power, $P = \tau\omega$

12. Rolling Motion

$\vec{v}_{cm} = R\omega$



Kinetic energy of Rolling motion

$K = K_T + K_R$

K.E of translation $K_T = \frac{1}{2}mv_{cm}^2$

$K_R = \frac{1}{2}I\omega^2$

K.E of rolling body , $K = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2$

$K = \frac{1}{2}mv_{cm}^2\left[1 + \frac{k^2}{R^2}\right]$

13. Centre of gravity

Centre of gravity is a point inside the body through which its whole weight acts

a. It refers weight of the body

b. At centre of gravity there must be matter present

c. Centre of mass and centre of gravity coincide for small bodies and they do not coincide for large bodies like planets

COMMUNICATION SYSTEM

Service	Frequency bands	Comments
Standard		
AM broadcast	540-1600 kHz	
FM broadcast	88-108 MHz	
Television	54-72 MHz	VHF
	76-88 MHz	TV
	174-216 MHz	UHF
	420-890 MHz	TV
Cellular Mobile	896-901 MHz	Mobile to base station
	840-935 MHz	Base station to mobile
Satellite	5.925-6.425GHz	Uplink
Communication	3.7- 4.2 GHz	Downlink

1. Bandwidth of video signals is 4.2 MHz
2. Coaxial cable is a widely used wire medium, which offers a bandwidth of approximately 750 MHz
3. 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.
4. To radiate signals with high efficiency, the antennas should have a size comparable to the wavelength λ of the signal (at least $\sim \frac{\lambda}{4}$)
5. If an antenna radiates electromagnetic waves from a height h, then the range d is given by $\sqrt{2Rh}$ where R is the radius of earth.
6. The maximum time of sight distance d_M between the two antennas having heights h_T and h_R above the earth is given by $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$
7. The method in which the amplitude of carrier is varied in accordance with the modulating signal keeping the frequency and phase of carrier wave constant is called **Amplitude modulation** (AM).
8. The method in which the frequency of carrier is varied in accordance to the modulating signal, keeping the amplitude and phase of the carrier the same is called **Frequency modulation** (FM)

CURRENT ELECTRICITY

FORMULAE

1. Electric current $I = \frac{q}{t} = \frac{ne}{t}$

   Where–I-Strength of current; q - charge; t - time.

2. Resistance $R = \frac{V}{i}$, Conductance $G = \frac{1}{R}$

   Where – V - potential difference, i - current

3. Resistance $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

   Where – R - Resistance of the wire; ρ - Resistivity or specific resistance, l-length of the wire, A - area of cross section of the wire

4. **Variation of resistance with temperature:**

   $$R_T = R_0\left[1 + \alpha\,(t)\right]$$

   $$\Rightarrow \alpha = \frac{R_t - R_0}{R_0(t)} / {}^0C$$

   $$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)} / {}^0C$$

   Where – R_t - resistance at temperature $t°$ C, R_0 - resistance at temperature $0°C$, α - temperature coefficient of resistance.

5. **Variation of resistivity with temperature :**

   $$\rho_t = \rho_0\left[1 + \alpha\,(t)\right] \Rightarrow \alpha = \frac{\rho_t - \rho_0}{\rho_0\,(t)} / {}^0C$$

   Where – ρ_t - resistivity at $t°C$, ρ_0 - resistivity at $0°C$, α - temperature coefficient of resistivity.

6. Conductivity = Reciprocal of resistivity.

   i.e. $\sigma = \frac{1}{\rho}$

   Where – σ - conductivity, ρ -resistivity.

7. **Terminal voltage :**

   Case - 1 : When battery is delivering current

   $V = E - ir$ or $i = \frac{E}{R + r}$

   Where – V - terminal P.D., E - emf of the cell, r-internal resistance of the cell, R - external resistance.

   Case - 2 : When battery is charging $V = E + ir$

8. **Kirchhoff's laws :**

   i) Kirchhoff's first law : $\sum i = 0$ at any junction.

   ii) Kirchhoff's second law : $\sum iR = 0$ in a closed circuit.

9. The balancing condition for wheat stone bridge is $\frac{P}{Q} = \frac{R}{S}$, Where P, Q, R and S are the resistances in the bridge.

10. **Meter Bridge :**

    i) $\frac{x}{R} = \frac{l_1}{l_2} \Rightarrow \frac{x}{R} = \frac{l_1}{(100 - l_1)}$

    Where – x - unknown resistance of given wire, R - resistance in the resistance box, l_1 - balancing length from left end of the bridge to Jockey.

    ii) $\rho = \frac{xA}{l} = x\frac{\pi r^2}{l}$

    Where – ρ - resistivity of the wire, x-resistance of wire, A - Area of cross section of the wire, l - length of the wire.

11. **Potentio Meter :**

    emf of the cell in the secondary circuit $E_s = I\rho l$

    i) Comparision of emf's of two cells: $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

    Where – E_1 - emf of first cell, E_2 - emf of second cell, l_1 and l_2 - the balancing lengths of individual cells respectively.

    ii) For determination of internal resistance of a cell :

$$r = \frac{(l_1 - l_2)R}{l_2} \text{ or } r = \left(\frac{E-V}{V}\right)R.$$

12. **Series grouping of n identical cells** :

Total emf = nE

Total internal resistance = n r

Total resistance $R + nr$

Current in the circuit $i = \frac{nE}{R+nr}$

when $R >> r$, $i_{max} = \frac{nE}{R}$

13. **Parallel grouping of n identical cells**

Current in the circuit $i = \frac{nE}{r+nR}$

$i_{max} = \frac{nE}{r}$ when $R << r$

Where – i - current, E - emf, R - external resistance, r - internal resistance, n - number of cells.

14. **Resistivity and Conductivity**

$$R = \left(\frac{m}{ne^2\tau}\right)\frac{\ell}{A}, \text{ where } \frac{m}{ne^2\tau} = \rho.$$

ρ is called resistivity or specific resistance. S.I. unit of resistivity is ohm-meter (© m). Conductivity is inverse of resistivity.

$$\sigma = \frac{1}{p}$$

S.I. unit of conductivity is ohm^{-1} m^{-1}or mho m^{-1} or Sm^{-1}.

CONCEPTUAL points :

Potentiometer :

1. Potentiometer is a device used to measure potential difference.
2. Potentiometer consists of 10 uniform wires each of length 1 m. made of manganin whose specific resistance is high and low temperature coefficient.
3. Principle of potentiometer is :

   p.d. across 'l' is balanced by emf of cell E_0.

   $\therefore E_0$ = potential gradients $\times$ length

   $$E_0 = \left(\frac{V}{L}\right)l$$

   Where E_0 - emf of cell in secondary circuit, V - p.d. across the wire, L - total length of potentiometer wire, l - balancing length.
4. Potentiometer used in :

   i) comparision of emf's of two cells

   ii) Measurement of internal resistance of a cell

surface is called work function.

7. **Stopping Potential:** The minimum negative potential given to collector for which photoelectric current becomes zero is called stopping potential (Vo).

X ray spectrum

1. The square root of frequency of characteristic X radiation is proportional to the atomic number of the target atom.

   $\sqrt{\nu}$ α Z

   $\sqrt{\nu} = a(Z-b)$, where a, b are constants.

   This is known as Moseley's law.

Compton Effect:

1. Compton shift is independent of the incident wavelength.
2. Compton shift is independent of nature of scatterer.
3. Compton effect depends only on the angle of scattering (f)

MEASUREMENTS, UNITS AND DIMENSIONS

1. Fundamental Physical quantites:
The physical quantity which does not depend upon other physical quantities.

2. Derived Physical quantities:
The physical quantities which can be derived from the fundamental quantities are called as derived quantities.

3. System of units.

(a) **The f.p.s system** is the British Engineering system of units, which uses foot as the unit of length pound+ as the unit of mass and second as the unit time.

(b) **The c.g.s system** is the Gauusian system which uses centimeter, gram and second as the three basic units for length, mass and time respectively.

(c) **The m.k.s system** is based on metre, kilogram and second as the fundamental units of length, mass and time respectively.

(d) **International system of units (SI)**

4. Advantages of SI

1. SI is a coherent system of units
2. SI is a rational system of units
3. SI is an absolute system of units
4. SI is a metric system

5. Dimensional formula:
The expression showing the relation between the derived quantity and fundamental quantities by raising the powers of the fundamental quantities is known as dimensional formula.

6. Dimensions:
The dimensions of a physical qunatities are the powers up to which the fundamental quantities are to be raised.

7. Principle of homogeneity,

In any dimensional equation if dimensions of L.H.S terms are same to that of dimensions of R.H.S terms, that is known as principle of homogeneity.

8. Uses of dimentional formula

a. To check the validity of the given equation.

b. To change units of a physical quantity from one system into the other.

c. To derive relationship between the different physical quantities.

9. Limitation of Dimensional Analysis

a. This method gives us no information about the dimensionless constants in the formula, e.g. 1,2,3….π, e, etc.

b. If a quanity depends on more than three factors, having dimensions, the formal cannot be derived. This is because on equating the powers of M,L and T on either side of the dimensional equation, we can obtain three equation, from which only three unknown dimensions can be calculated.

c. We cannot derive the formulae containing trigonometrical functions, exponential functions, log functions etc, which have no dimensions.

d. It gives no information whether a physical quantity is a scalar or vector.

10. Always in a physical quantity the numerial value is inversly proportional to its units.

$$N \propto \frac{1}{U}$$

$$N_1 U_1 = N_2 U_2$$

VECTORS

1. The physical quantities having both magnitude and direction and also obeying laws of vectors are known as vectors.

2. Different types of vectors

a. Parallel vectors:
If two or more vectors are parallel to another, they are said to be parallel vectors.

b. Equal vectors:
If two or more vectors have equal magnitude and acting in the same direction, they are said to be equal vectors.

c. Negative vector:
If two vectors $\vec{A}$ and $\vec{B}$ are such that they have equal magnitude but opposite directions, each vector is negative of the other

d. Null vector:
A vector of zero magnitude with indefinite direction.

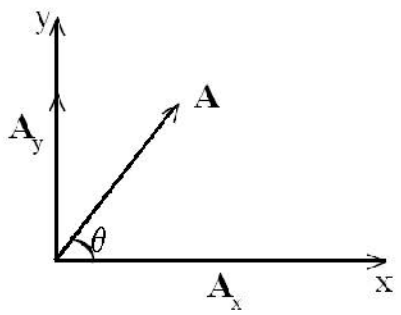
e. Unit vector:
A vector whose origin and terminous lie at same point.

f. Position vector:
The vector used to specify the position of a point with respect to some fixed point (say origin 'O') is called position vector.

3. Resolution of Vectors

Definition: The process of dividing a vector into its components is called resolution of vector.

a. Vector into two components



Horizontal component $A_x = A\cos\theta$

Vertical component $A_y = A\sin\theta$

Always $A = \sqrt{A_x^2 + A_y^2}$

b. Vector into three components

$A_x = A\cos\alpha, A_y = A\cos\beta, A_z = A\cos\gamma$

Direction of cosines

$$Cos\alpha = \frac{A_x}{A};\ Cos\beta = \frac{A_y}{A};\ Cos\gamma = \frac{A_z}{A}$$

Where α, β and γ are the angles made by $\vec{A}$ with x, y and z-axes respectively

4. Parallelogram law of vectors

Statement:
If two vectors are represented in magnitude and direction by the adjacent sides of a parallelogram drawn from a point, the diagonal passing through that point represents their resultant both in magnitude and direction.

Formula: $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$;

$$Tan\theta = \frac{B\sin\theta}{A + B\cos\theta}$$

5. Trianlge law of vector

Statement:
If two vectors are represented in magnitude and direction by the two sides of a triangle taken in order, the third side of the triangle taken in reverse order represents their resultant in mangitude and direction.

Components of vector

6. Vector $\vec{A}$ can be represented as sum of three vectors $\vec{A}_x \vec{A}_y$ *and* $\vec{A}_z$ along the three specified axes x, y and z Thus

$$\vec{A} = \vec{A}_x + \vec{A}_y + \vec{A}_z$$

Vector $\vec{A}_x, \vec{A}_y$ *and* $\vec{A}_z$ are know as components of vectors. At this stage we Define unit vector as a vector having a magnitude of unity with no unit Its only Purpose is describe a direction in space with the help of three unit vectors

$\hat{i}, \hat{j}$ *and* $\hat{k}$, Respectively along x, y and z axis, we can write:

$\overrightarrow{A_x} = A_x\hat{i}, \overrightarrow{A_y}\hat{j}, \overrightarrow{A_z} = A_z\hat{k}$

and $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

giving the modulus of vector $\vec{A}$ as

$$\left|\vec{A}\right| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Also if α, β and γ are angles of $\vec{A}$ with x, y and z-axis, intern, then

$$I = \cos\ \alpha = \frac{A_x}{A}, m = \cos\beta = \frac{A_y}{A},$$

$$n = \cos\gamma = \frac{A_z}{A}$$

Where I, m and n we define as direction cosines of vector giving the relation

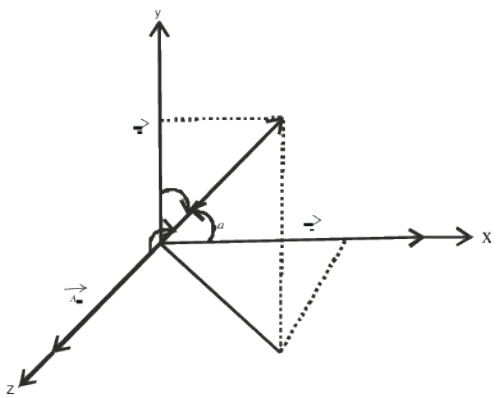
$$I^2 + m^2 + n^2 = 1$$

Resolution of vector in a plane may be expressed as $\vec{A} = A_x\hat{i} + A_y\hat{j}$

Also if vector $\vec{A}$ makes an angle θ with x-axis then

$A_x = A\cos\theta$ *and* $A_y = A\sin\theta$ giving the amplitude

$$A = \sqrt{A_x^2 + A_y^2}$$



7. Relative velocity (man walking in rain)

Formula: $\tan\theta = \dfrac{V_m}{V_r}$

where

V_m = Velocity of man

V_r = Velocity of rain

8. Motion of a boat in a river in shortest path (Up the stream)

Formulae:

a. $Sin\theta = \dfrac{V_w}{V_b}$

where

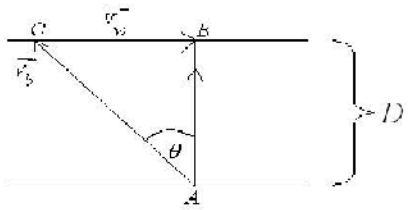
V_w = velocity of water

V_b = velocity of boat

b. V_R = Resultant velocity = $\sqrt{V_b^2 - V_w^2}$

c. time taken to cross the river

$$t = \frac{D}{\sqrt{V_b^2 - V_w^2}}$$

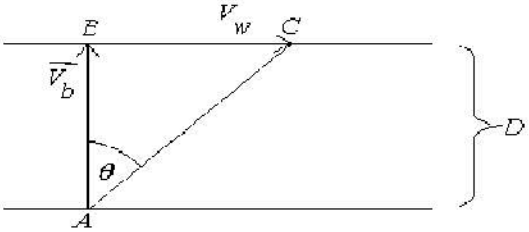


9. Motion of a boat in a river in shortest time (Down the stream)

Formulae:

a. time (minimum) = $t = \dfrac{D}{V_b}$

b. BC = Drift = $D\left(\dfrac{V_w}{V_b}\right)$



10. Dot Product

Definition of dot product:

The dot product of two non zero vectors is defined as the product of their magnitude and cosine of the angle between them.

Formulae: $\vec{A} \cdot \vec{B} = AB\cos\theta$

Dot product of two vectors always yield a scalar.

Dot product obeys

a. commutative law **a.b = b.a**

b. Distributive law **a.(b + c) = a.b + a.c**

c. Dot product can be -Ve, +Ve, and 0

d. Dot product of unit vectors

i.i = j.j = k.k = 1

i.j = j.k = k.i = 0

11. Vector Product

The vector product of two non-zero vectors is defined as the product of their magnitude and angle of sign between them.

Formula: $\vec{A}\times\vec{B} = AB\sin\theta\,\hat{n}$ where $\hat{n}$ is the unit vector perpendicular to plane containing $\vec{A}\times\vec{B}$.

the vector product of two vectors is always a vector.

The directions of vector product always lie perpendicular to the plain containing two vectors in accordance with right handed system.

Properties:

a. does not obeys commutative law

$$\mathbf{a}\times\mathbf{b} \neq \mathbf{b}\times\mathbf{a}$$

b. Obeys distributive law

$$\mathbf{a}\times(\mathbf{b}+\mathbf{c}) = \mathbf{a}\times\mathbf{b}+\mathbf{a}\times\mathbf{c}$$

c. Cross product between unit vectors

$$\mathbf{i}\times\mathbf{j} = \mathbf{k}$$

$$\mathbf{j}\times\mathbf{k} = \mathbf{i}$$

$$\mathbf{k}\times\mathbf{i} = \mathbf{j}$$

If $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

and $\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$

then $\vec{a}\times\vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix}$

$$\therefore \quad \vec{a}\times\vec{b} = \hat{i}\left(a_y b_z - b_y a_z\right) - \hat{j}\left(a_x b_z - b_x a_z\right) + \hat{k}\left(a_x b_y - b_x a_y\right)$$

ELASTICITY

1. **Rigid Body :**
A body whose size and shape cannot be changed, however large the applied force may be is called rigid body.
There is no perfectly rigid body in nature.

2. **Deformation force :**
The force which changes the size or shape or both of a body without moving it as a whole is called deformation force.

3. **Restoring force :**
The force which restores the size and shape of the body when deformation force is removed is called restoring force.
Magnitude of restoring force is equal to the deformation force. But they are in opposite direction. They do not form action, reaction pair. This force is responsible for the elastic nature of the
body.

4. **Elasticity :**
The property of a material by virtue of which it regains its original size and shape when deformation force is removed is called elasticity.
Ex : Steel, Rubber.
No body is perfectly elastic, but quartz is the nearest example.
Elasticity is molecular property of matter.

5. **Plasticity :**
The property of a material by virtue of which it does not regain the size and shape when the de formation force is removed is called Plasticity.
Ex : Putty dough, Chewing gum, Soldering lead
No body is perfectly plastic but putty is nearest example.

6. **Stress :**
The restoring force per unit area is called stress.

$$\text{Stress} = \frac{\text{restoring force}}{\text{area of cross section}} = \frac{F}{A}$$

Unit : N/m^2 or Pascal.

a. If the stress is normal to the surface, it is called normal stress. If the stress is tangential to the surface, it is called tangential stress.

$$\text{Normal stress} = \frac{\text{Normal restoring force}}{\text{Area of cross section}}$$

$$\text{Shearing stress} = \frac{\text{Tangential restoring force}}{\text{Area of cross section}}$$

b. When normal stress changes the volume of the body then it is called Volume Stress or Bulk Stress. It is denoted by 'P'.

c. Longitudinal stress is called tensile stress when there is an increase in length and compresive stress when there is at decrease in length.

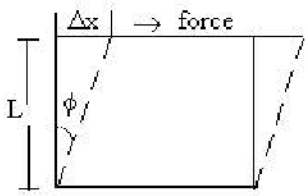
d. Longitudinal stress and bulk stress are normal stresses which produce change in size, shearing stress is a tangential stress which produce change in shape.

7. **Strain :**
The change produced per unit dimension is called strain.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

$$\text{Longitudinal strain} = \frac{\text{change in length}}{\text{original length}} = \frac{e}{\ell}$$

Shearing strain:-



$$\text{Shearing strain} = \frac{\text{relative displacement between two layers}}{\text{distance between the layers}}$$

$$= \frac{\Delta x}{L} = \phi$$

This strain is due to the change in shape of the body.

Volumetric strain (or) Bulk strain

$$= \frac{\text{change in volume}}{\text{original volume}} = \frac{-\Delta V}{V}$$

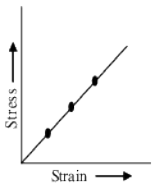
Negative sign indicates decrease in volume

8. **Elastic limit :**
The maximum value of the stress with in which the body regains its original size and shape is
called elastic limit.

9. **Hooke's law :**
With in the elastic limit, stress is directly proportional to strain.

$$\frac{\text{Stress}}{\text{Strain}} = E$$

With in the elastic limit, stress-strain graph is a straight line passing through the origin.



Slope of the graph is E.

10. **Young's modulus (Y) :**

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{F\ell}{Ae}$$

If load attached to the wire is M, then $F = Mg$, and $A = \pi r^2$

$$Y = \frac{Mg\ell}{\pi r^2 e}$$

11. **Rigidity modulus :**
With in the elastic limit, the ratio of tangential stress to the shearing strain is called rigidity modulus.

$$\text{Rigidity modulus} = \frac{\text{tangential stress}}{\text{shearing strain}}$$

$$\Rightarrow \eta = \frac{F}{A\theta}$$

If η is small for a wire, it can be twisted easily.

12. **Bulk modulus (B)**
With in the elastic limit the ratio between volume stress and bulk strain is called bulk modulus.

$$\text{Bulk modulus} = \frac{\text{volume stress}}{\text{bulk strain}}$$

$$B = \frac{\frac{F}{A}}{\frac{-\Delta V}{V}} = -\frac{V}{\Delta V}\frac{F}{A} = \frac{-PV}{\Delta V}$$

(- sign shows decrease in volume)

13. The reciprocal of bulk modulus is called compressibility $K = \frac{1}{B}$

14. **Poisson's ratio (σ)**
The ratio lateral contraction strain to the longitudinal elongation strain is called Poisson'sratio.

$$\sigma = \frac{\text{lateral contraction strain}}{\text{longitudinal elongation strain}}$$

$$= \frac{\text{transverse strain}}{\text{longitudinal strain}} = \frac{\Delta r / r}{\Delta \ell / \ell} = \frac{\Delta r \ell}{\Delta \ell \times r}$$

i) As it is a ratio, it has no units and dimension.

ii) Theoretical limits of $\sigma = -1$ to 0.5

Practical limits of $\sigma = 0$ to 0.5

iii) For an incompressible substance $\sigma = 0.5$

15. **Thermal force :**
When a metal bar is fixed between two supports and heated, it tries to expand and exerts force on the walls. This is called thermal force.

$$F = AY\alpha\theta$$

Thermal force is independent of length of the bar.

Thermal stress (linear compressive stress)

$$\frac{\text{force}}{\text{area}} = \frac{AY\alpha\theta}{A} = Y\alpha\theta.$$

16. The work done in stretching a wire / elastic potential energy in a stretched wire

$$W = \frac{1}{2}\text{Stress x Strain x Volume}$$

Potential

$$W = \frac{1}{2}Fe = \frac{1}{2}\frac{e^2AY}{\ell}$$

17. Strain energy per unit volume (energy density)

$$E = \frac{1}{2}\text{x stress x strain} = \frac{1}{2}Y(Strain)^2$$

Also, $E = \frac{(Stress)^2}{2Y}\left[\therefore Y = \frac{Stress}{Strain}\right]$

ELECTROMAGNETIC INDUCTION

1. $\phi = NAB\cos\theta$

Where A = Area of the coil

B = Magnetic induction field

ϕ = Magnetic flux through the coil

θ = angle between the unit vector $\hat{n}$ and magnetic field $(\overline{B})$

N = number of turns in the coil

2. $\varepsilon = \frac{-Nd\phi}{dt} = \frac{-N(\phi_2 - \phi_1)}{t}$

$(\phi_2 - \phi_1) = d\phi$ = change in magnetic flux

dt = time taken

$\frac{d\phi}{dt}$ = Rate of change of magnetic flux.

The -ve sign is according to Lenz law

3. $\varepsilon = \frac{-d}{dt}(NAB\cos\theta)$

ε = Induced emf.

4. $N\phi = Li$

N = number of turns; ϕ = magnetic flux

L = coefficient of self induction.

i = current

5. **Self Inductance of a Long solenoid:**

$L = \mu_0 n^2 IA$

Ideal inductor: An ideal inductor is one which has only inductance and no resistance.

5. $\varepsilon = -L\left(\frac{di}{dt}\right) \Rightarrow \varepsilon = \frac{-L(i_2 - i_1)}{t}$

$\frac{di}{dt}$ = rate of change of current in the coil

6. $\phi = Mi$

M = coefficient of mutual Induction

7. **Mutual Inductance of Two Long Solenoids:**

$M = \frac{\mu_0 N_1 N_2 A}{I}$

Or $M = \mu_0 n_1 n_2 A\ell$

Were n_1 and n_2 are number of turns per unit length.

8. $\varepsilon = -M\left(\frac{di}{dt}\right) \Rightarrow \varepsilon = \frac{-M(i_2 - i_1)}{t}$

9. Transformer ratio $\frac{\varepsilon_2}{\varepsilon_1} = \frac{N_2}{N_1}$

ε_1 = input voltage across Primary coil

ε_2 = output voltage across Secondary coil

N_2 = number of turns in Secondary coil

N_1 = number of turns in Primary coil

For ideal transformer input power = output power

Efficiency = 100 %

10. **Growth of current in an inductor.**

Instantaneous current $i = i_0\left[1 - e^{-\frac{Rt}{L}}\right]$

Where i_0 = maxmimum current,

R = Resistance, L = Inductance

When $t = \lambda$, $i = 0.63 i_0$

11. **Decay of current in an inductor**

Instantaneous current $i = i_0\left[e^{-\frac{Rt}{L}}\right]$

When $t = \lambda$, $i = 0.37 i_0$

12. **Growth of charge in a capacitor**

Instantaneous Charge $q = q_0\left(1 - e^{-t/CR}\right)$

q_0 = maximum charge

C = Capacitance

Time constant $\lambda = CR$

When $t = \lambda$, $q = 0.63 q_0$

13. **Decay of charge in a capacitor**

Instantaneous charge $q = q_0\left(e^{-t/CR}\right)$

When $t = \lambda$, $q = 0.37q_0$

Alternating Currents :

1. $i = i_0 \text{Sin}\,\omega t$

   i = current at a time 't' seconds.

   i_0 = maximum value of current

   ω = angular frequency

   Where $\omega = 2\pi f$

   f = frequency; T = Timeperiod

2. $e = e_0 \text{Sin}\ \omega t$

   e = emf at a time 't' second

   e_0 = maximum value of emf.

3. $i_{avg} = \frac{2}{\pi} i_0 = 0.63\ i_0$

   i_{avg} = average current

   i_0 = maximum (or) peak value of current

4. $i_{rms} = \frac{i_0}{\sqrt{2}} = 0.707\ i_0$

   i_{rms} = root mean square value of current

5. **L C R circuit**

   Instantaneous a.c current $i = i_0 \sin(\omega t - \phi)$

   where i_0 = maximum current

   ω = angular frequency; t = time

   ϕ = phase difference

6. Max current $i_0 = \frac{e_0}{\sqrt{R^2 + (X_L - X_C)^2}}$

   where e_0 = maximum emf

   R = resistance of resistor

   X_L = Inductive reactance = ωL

   X_C = capacity reactance = $\frac{1}{\omega C}$

7. $\text{Tan}\phi = \frac{(X_L - X_C)}{R}$

   case (i) L - R circuit; $X_c = 0$

   $i = i_0 \sin(\omega t - \phi)$; $i_0 = \frac{e_0}{\sqrt{R^2 + X_L^2}}$

   $\text{Tan}\phi = \frac{X_L}{R}$

   case (ii) L - C circuit ; R = 0

   $i = i_0 \sin(\omega t - \pi/2)$; $i_0 = \frac{e_0}{X_L - X_C}$

   if $X_L = X_C$ then

   resonant frequency $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

8. **Quality Factor (Q)**

   The quality factor Q of series LCR circuit is a measure of sharpness of resonance. It is given by

   $Q = \frac{\omega_r L}{R}$

9. *Power dissipation in an AC circuit*

   In an AC circuit the average power dissipation P_{av} over a cycle can be calculated from the relation

   $$P_{av} = \frac{\int_0^T VIdt}{\int_0^T dt}$$

   $V = v_0 \sin \omega t$ and $I = I_0 \sin(\omega t - \phi)$

   $\Rightarrow\ P_{av} = v_{rms} I_{rms} \cos\phi$

CONCEPTUAL POINTS

1. **Faraday's law or Neumann's law** : The induced emf is equal to negative rate of change

of the flux through the coil of one turn.

2. **Lenz's law :** the direction of induced emf is always such that it tends the oppose the change in the magnetic flux that caused it.

   It is a consequence of law of conservation of energy

3. **Fleming's right hand rule :** According to this rule if fore finger, Central finger and thumb of right hand are stretched mutually perpendicular to each to other, then Fore finger represents direction of magnetic Field, thumb represents direction of Motion of conductor, Central finger represents induced Current

4. **Self inductance :** If current in the loop is changed with time, the flux through the loop also changes and hence emf is induced. Coefficient of self inductance

5. **Mutual Inductance :** Emf induced in one coil by the changing the current in the other coil is called mutual inductance

6. **Transformer :** It is works on the principle of mutual inductance between two coils.

   There are two types of transformers.

   a) Step up Transformer

   b) Step down Transformer

   * Step Up Transformer converts low voltage high current to high voltage low current.

   No. of turns in secondary coil is greater than no. of turns in primary coil.

   *Step down transformer converts high voltage low current to low voltage high current.

   Number of turns in primary coil is greater than no. of turns in secondary coil.

7. **Eddy Currents and Their Effects:**
   The currents induced in the body of a conductor, when the magnetic flux linked with the conductor changes are called eddy currents.
   Eddy currents show both heating and magnetic effects.

   The magnitude of eddy current is

   $$i = \frac{\text{induced emf}}{\text{resistance}} = \frac{e}{R}$$

   But $e = -\frac{d\phi}{dt}$

   $$i = -\frac{d\phi/dt}{r}$$

FLUID MECHANICS

Fluid is the name given to a substance, which begins to flow when external force is applied on it.

Fluids exert thrust

This normal change in momentum transferred to the walls per unit time by the molecules of fluid accounts for the normal force or thrust of fluid on the walls of the container.

Liquid

The normal force 9or thrust) exerted by a liquid at rest per unit area of the surface in contact with their its called pressure of liquid or hydrastatic pressure.

Density and relative density

Density of a substance is defined as the mass per unit volume of the substance, i.e.

$$\text{density, } \rho = \frac{\text{mass}(m)}{\text{volume}(V)} = \frac{m}{V}$$

Relative density of substance is defined as the ratio of its density to the density of water at 4°C,

$$\text{Relative density} = \frac{\text{density of substance}}{\text{density of water at } 4°C}$$

Variation of pressure with depth

The pressure is same at all points inside the liquid lying at the same depth in a horizontal plane.

$P - P_a = h\rho g$. It is called gauge pressure

Gauge pressure at a point in a liquid is the difference of total pressure at the point and atmospheric pressure.

Pressure exerted by a liquid column of height h is independent of area of cross-section A but depends upon the height h of the liquid column and density ρ of the liquid.

Pascal's law

It states that if gravity effect is neglected, the pressure at every point of liquid in equilibrium of rest is same.

Principle of transmission of pressure in liquids or gases.

Pascal's law states that the increase in pressure at one point of the enclosed liquids in equilibrium of rest is transmitted equally to all other points of the liquid and also to the walls of the container, provided the effect of gravity is neglected.

Atmospheric pressure

The gaseous envelope surrounding the earth is called earth's atmosphere.

The atmospheric pressure at any point is equal to the weight of a vertical column of air of unit cross-sectional area extending from that point to the top of the earth's atmosphere.

Buoyancy

This upward force acting on the body immersed in a fluid is called upward thrust or buoyant force or simply buoyancy.

Archimede's Principle*

It state that when a body is immersed wholly or partly in a liquid at rest, it loses some o its weight. The loss in weight of the body in the liquids is equal to the weight of the liquid displaced by the immersed part of the body.

Law of Floatation

When a body of density ρ, volume V is immersed completely in a liquid of density σ, two forces are acting on it.

Case I. If W > w, then W – w is positive. In this case, the body will sink to the bottom of the liquid. If the body is not hollow from inside, then the density of solid body is greater than the density of liquid $(\text{i.e. } \rho > \sigma)$.

Case II. If W<w, then W-w is negative. In this case, the body will rise above the surface of liquid to such an extent that the weight of the liquid displaced by the immersed part of the body.

Case III. If W = w, then W –w = 0. It means the resultant force acting on the boy fully immersed in the lucid is zero. In this case, the body is at rest anywhere within the liquid. The apparent weight of the body is zero at all positions inside the liquid. In this situation, the body will float if its whole volume is just immersed in the liquid. If the is solid then the density of body is equal to the density of liquid (i.e., $\rho = \sigma$

Thus the law of floatation states that a body will float in a liquid, if weight of the liquid

displaced by immersed part of the body is atleast equal or grate than the weight of the body.

Equilibrium of floating bodies if the following conditions are fulfilled.

(i) A body can float if the weight of the liquid displaced by the immersed part of body must be equal to the weight of the body.

(ii) A body can be in equilibrium if the center of gravity of the body and center of buoyancy must be along the same vertical line.

1. Defination of viscosity:

The property of a fluid by virtue of which it opposes the relative motion between its different layers is called viscosity.

2. Coefficient of dynamic viscosity:

The coefficient of viscosity of a liquid is the viscous force acting per unit area between two adjacent layers moving with unit velocity gradient.

3. Formula:

Newton's law of viscosity is given by

$F = -\eta A \frac{dv}{dx}$ [negative sign indicates the oppositeness of F and V]

where

F = Viscous force

η = Coefficient of viscosity

A = Area of a layer

$\frac{dv}{dx}$ = Velocity gradient

4. Formula

Poiseuille's equation is given by

$$V = \frac{\pi \Pr^4}{8\eta L}$$

where

V = Volume of liquid following per sec

P = Pressure difference between the ends of the capillary tube.

L = Length of the capillary tube

r = Radius of capillary tube.

the axis of the tube

2. Velocity of flow must be less than critical velocity

3. Pressure across any cross-section is constant

4. Velocity of a liquid layer in contact with the walls of the tube is zero

Stoke's law

When a small spherical body moves through a viscous medium at rest, layers of the medium touching the body are dragged along with it. But the layers of the medium away form the body are at rest. This causes a relative motion between different layers of medium. As a result of this, a backward dragging force (i.e., viscous drag) comes into play, which opposes the motion of the body. This backward dragging force increases with the increase in velocity of the moving body.

5. Stoke's formula

a) Stoke's formula is given by

$F = 6\pi\eta\, r V_t$

Where F = Viscous force, V_t = terminal velocity

b) $V_t = \frac{2}{9} r^2 \frac{(d_1 - d_2)g}{\eta}$

Where

d_1 = density of solid

d_2 = density of liquid

6. Critical velocity

Critical velocity is defined as the minimum velocity at which the flow of a liquid changes from laminar (or streamline) to turbulent state is called critical velocity

$V_c = \frac{R\eta}{\rho D}$

Where

R = Reynold's Number

η = Coefficient of viscosity

ρ = Density

D = Diameter of the tube

7. Equation of continuity

Equation of continuity is given by

$av = \text{const} \Rightarrow a_1 v_1 = a_2 v_2$

Where

a = area and v = velocity

8. Energy of a Liquid

A liquid in motion may possess three types of energy

(i) Pressure It is the energy possessed by all liquid by virtua of its pressure. It is the measure of work done in pushing the liquid in the vessel against pressure without imparting any velocity to it.

(ii) Potential Energy. It is the energy possessed by liquid by virtue of its height or position above the surface of earth or any reference level taken as zero level.

Potential energy per unit volume of liquid $= \frac{mgh}{V} = \rho gh$ where ρ is the density of liquid.

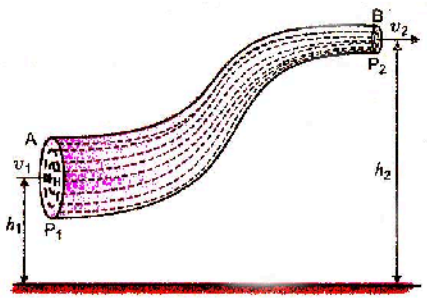
(iii) Kinetic energy It is the energy possessed by a liquid by virtue of its motion or velocity.

K.E. per unit volume of the liquid $= \frac{\frac{1}{2}mv^2}{V} = \frac{1}{2}\rho v^2$

Bernoulli's theorem

Bernoulli's theorem is an outcome of the principle of conservation of energy applied to a liquid in motion.

This theorem states that for the streamline flow of an ideal liquid, the total energy (the sum of the pressure energy, potential energy and kinetic energy) per unit mass remains constant every cross-section throughout the flow.



$$\frac{P}{\rho} + gh + \frac{1}{2}v^2 = \text{a constant}$$

the sum of pressure energy, potential energy and kinetic energy per unit mass is constant at all cross-section in the streamline flow of an ideal liquid. This rpove Bernouli's theorem

$$P + \rho gh + \frac{1}{2}\rho v^2 = \text{a constant}$$

for horizontal tube $P + \frac{1}{2}Pv^2 = const.$

Application of Bernoulli's Theorem

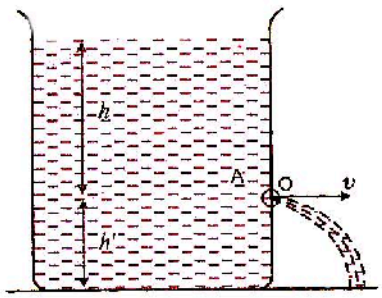
i. Atomiser or sprayer. ii. Lift on an aeroplane wing

iii. Blowing off the roofs during storm.

Venturimeter

It is a device, used for measuring the speed of incompressible liquid and rate of flow of liquid through pipes. Its working is based on Bernoulli's Theorem.

9. Torricelli's theorem



Torricelli's theorem is given by

a. $V = \sqrt{2gh}$ where V = Velocity of efflux

b. $R = 2\sqrt{h(H-h)}$

where

h = depth of orifice from free surface of liquid

H = total height of liquid

R = range of the liquid

10. **Dynamic lift**

Dynamic lift is given by

$$F = \frac{1}{2}d(V_1^2 - V_2^2)A$$

where

F = dynamic lift

V_1 = velocity above wing

V_2 = velocity below wing,

A = area of wing

d = density of air

FRICTION

1. The opposing force which comes into play tangentially between two surfaces so as destory the relative motion between them is called friction.

2. Friction can be reduced by i) polishing the surface in contact, ii) using lubricants between the surfaces in contact, iii) using ball bearing between the surfaces in contact and iv) streaming vahicles.

3. The resistance encountered by a body in static friction while tending to move under the action of an external force is called static fricion. It is always equal and opposite to the applied force till the static friction reaches a maximum value. Static friction is a self adjusting force which increase till it reaches a maximum value.

4. The resistance encountered by a rolling body on a surface is known as rolling friction.

5. Laws of friction: i) The friction force is independent of the area of contact. ii) The fricitional force is directly propoetional to the normal reaction.

6. Laws of rolling friction: i) The smaller the area of contact the lesser will be the rolling friction. ii) The large the radius of the rolling body, the lesser will be the rolling friction. iii) The rolling friction is directly proportional to the normal reaction.

7. The angle made by the resultant of the normal reaction and the limiting friciton with normal reaction is called angle of friction. Coefficient of static friction $\mu_s = \tan\phi$.

8. Acceleration of a body on a rough horizontal force, $a = \frac{P - f_k}{m} = \frac{P - \mu_k mg}{m}$ whe P is the applied force and m is the mass of the body.

9. Angle of repose is defined as the angle if inclination of a plane with respect to horizontal for which the body will be limiting equilibrium on the inclined plane. if α is the angle of repose $\mu_s = \tan\alpha$.

10. If the frictional force between a body and a surface is equal to the weight of the body, what is the coefficient of static friction.

$\because \mu = \frac{f}{N}$; $\mu = 1$

11. How much work is done to move a body up a rough inclined plane of length s, making an angle θ with horizontal is

$\because W = Fs$

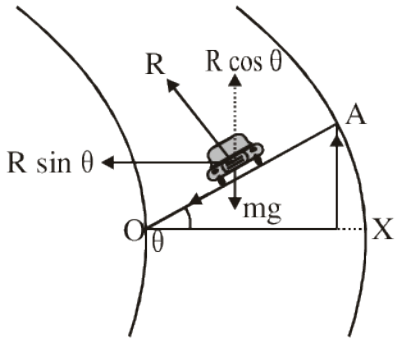
$= mg(\sin\theta + \mu_k \cos\theta)$ s.

12. The acceleration, velocity and time taken by a body sliding along a smooth horizontal surface can be obtained by putting $\mu_k = 0$. i.e. $a = g\sin\theta$, $v = \sqrt{2g\ell\sin\theta}$ and $t = \sqrt{2\ell / g\sin\theta}$. The force to move up the plane with uniform velocity is $F = mg\sin\theta$

13. Pulling force $F = \frac{W\sin\phi}{\cos(\theta - \phi)}$ and pushing force $F = \frac{W\sin\phi}{\cos(\theta + \phi)}$ where W is the weight of body, ϕ is the angle of friction and θ is the angle made by F with the horizontal.

14. Banking of Roads

This phenomenon of raising outer edge of the curved road above the inner edge is called banking of road.



$$v = \left[\frac{rg(\mu_s + \tan\theta)}{(1 - \mu_s \tan\theta)}\right]^{1/2}$$

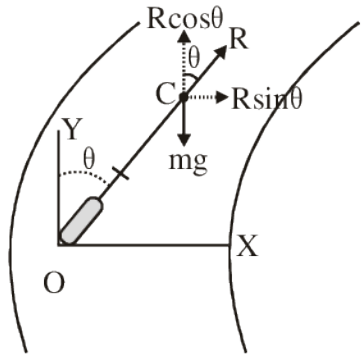
If $\mu_s = 0$, i.e., if banked road is perfectly smooth, then from the above eqn.

$$v_0 = (rg\tan\theta)^{1/2}$$

from equation

$$\tan\theta = v_0^2 / rg$$

Bending of Cyclist



$$\tan\theta = \frac{v^2}{rg}.$$

PHYSICAL OPTICS

FORMULAE :

1. Intensity and amplitude are related as $I \propto a^2$
2. Intensity of the resultant wave at any point is

   $I = 4I_0 \cos^2(\delta/2)$; where $I_0 = a^2$ and δ is phase differece.

   For maxima or bright fringe $I_{max} = 4I_0$

   For minima or dark fringe $I_{min} = 0$

   Intensity ratios :

   1) $\frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2$ 2) $\frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2$

CONCEPTUAL POINTS :

1. Any disturbance in the medium is called a wave.
2. Characteristics of a wave are

   i) amplitude ii) frequency

   iii) wave velocity iv) phase
3. A wavefront is the locus of all points, which are in the same phase.
4. A point source at a finite distance gives rise to a spherical wavefront.
5. An extended source (like slit) at a finite distance gives rise to a cylindrical wavefront.
6. A point source or an extended source at infinity gives rise to a plane wavefront.
7. Huygen's principle states that all points in a wavefront generate secondary waves or wavelets. Which travel normal to a wavefront.
8. Interference is the modification of light intensity due to the superposition of two or more light waves.
9. Condition for maxima or constructive interference is path difference = $n\lambda$ (or) phase difference = $2\pi n$ where n = 0, 1, 2, 3…. (Young's double slit experiment.)
10. Condition for minima or destructive interference is path difference = $(2n + 1)\lambda/2$ (or) phase difference = $(2n + 1)\pi$ where n = 0, 1, 2, 3……(Young's double slit experiment.)
11. The sources of light which emit waves whose phase difference is zero or constant and does not vary with time are known as coherent sources
12. In Young's double slit experiment, the displacements of two waves are

    $y_1 = a \sin \omega t$; $y_2 = a \sin(\omega t + \phi)$

    where a is amplitude of wave

    ω is angular frequency, ϕ is phase difference

    Relation between phase difference and path difference $\phi = \frac{2\pi}{\lambda} \cdot \Delta x$
13. Interference of light is used :

    (i) To determine the thickness of a thin transparent material

    (ii) To determine the refractive index of a liquid or a gas.
14. The bending of light waves around the edges of obstacles is called diffraction.
15. The amount of bending depends upon the size of the obstacle and the wave length of the light.
16. Diffraction phenomena is due to superposition of secondary waves emitted from a wave front.
17. Diffraction can be explained by Huygens' - Fresnel principle. According to this principle each point on a wave front, which is unobstructed, acts as a source of secondary waves. The secondary sources are mutually coherent and the waves emitted by them interfere.
18. Diffraction fringes are of unequal width.
19. Polaroid sheets are used as polarizers and analyzers.
20. Polariods are used

    (i) In sun glasses (ii) 3-D films or pictures.
21. A polaroid or a crystal which produces a polarized light is called a polarizer.
22. A polaroid or a crystal which analyzes the polarized light is called analizer.

GRAVITATION

1. Basic forces in nature :

i) Gravitational force
ii) Electromagnetic force
iii) Strong nuclear force
iv) Weak nuclear force

The ratio strengths of gravitational, weak nuclear , Electro magnetic and strong nuclear forces respectively are $1:10^{31}:10^{36}:10^{38}$

Gravitation

Is the name given to the force of attraction between any two bodies of the universe.

Gravity

Is the force of attraction exerted by earth towards its center on a body lying on or near the surface of earth. Gravity is merely a special case of gravitation and is also called earth's gravitational pull. Weight of a body is defined as the force of attraction exerted by the earth on the body towards in center.

2. Law of Universal Gravitation:

Statement: The gravitational force of attraction between two bodies is directly proportional to the product of their (inertial) masses and inversely proportional to the square of the distance between their centers. This force acts along the line joining the centers of the two bodies.

$$F = \frac{Gm_1m_2}{r^2}$$

3. Definition of G: The universal gravitational constant is numerically equal to the force of attraction between two unit masses separated by unit distance.

4. Value and units of G:

a. In S.I. 6.67 x 10^{-11} newton - m^2 kg^{-2}

5. Relation Between 'G' and 'g':

Relation between 'Gravitational constant' and acceleration due to gravity is.

$$g = \frac{GM}{R^2}$$

6. Variation of 'g':

a. Acceleartion due to gravity at certain altitude (height)'a' is given by

$$\therefore g_a = g\left(1 - \frac{2h}{R}\right)$$

for h << R

b. Acceleartion due to gravity at certain depth 'd' is given by

$$\therefore g_d = g\left(1 - \frac{h}{R}\right)$$

c. Acceleartion due to gravity at certain Latitude ϕ is given by

$$g_\phi = g - R\omega^2 \cos^2 \phi$$

7. Gravitational field strength :

It is defiend as gravitational force per unit mass placed at that point.

$$E = \frac{F}{m}$$

On the surface of the earth

$$E = \frac{F}{m} = \frac{mg}{m} = g$$

8. Chandrashekar limit :

The maximum mass that a white dwarf can have is called chandrashekar limit.
It is equal to 1.4 times the sun mass .

9. Frame of references :

a. A frame of reference describes the posi tion of an object in space.

b. There are two types of reference frames.
i) inertial frame of reference
ii) Non-inertial frame of reference

i) inertial frame of reference :
The frame of reference in which newton's laws hold good is called inertial frame of references
Ex : The reference frame at rest.
ii) Non-inertial frame of reference :
The frame of reference in which newton's laws of motion do not hold good is called non inertial frame of reference.

Ex : The linearly accelerating frame (or) a rotating frame

c. The acceleration of a body in inertial frame of reference is due to real forces.

d. The acceleration of a body in non inertial frame of reference is due to pseudo forces.

10. Mass :

Mass is defiend as the amount of mater contained in a body. mass of a body can be found by two different methods. Those are

i) Inertial mass

ii) Gravational mass

i) Inertial mass :

The property of a body to mesasure its resistance to acceleration is called its inertial mass

ii) Gravational mass :

The property of a body responsible for the gravitonal force it excerts on another body is called gravitonal mass.

a. It has been expermently observed that inertial mass and gravitonal mass are equal

11. Principle of equivalence:

Definition: Experiments conducted in inertial and non- inertial frames of reference under identical conditions, the results obtaine are same, this consequence is called Principle of equivalence.

12. Orbital Velocity:

Definition : The speed of a satellite in its orbit is called orbital velocity. (or) it is the velocity with which a body should be projected in order that it may revolve round the earth in an orbit. $v_0 = \sqrt{gR}$

13. Escape velocity (V_e):

Definition: The minimum velocity with which a body should be projected to overcome the earth's gravitational field is called the escape velocity.

$V_e = \sqrt{2gR}$

14. Geo-Stationary satelite :

A satelite whose period of revolution is equal to period of rotation of earth (or) 24 hours is calld Geo-stationary satelite.

a. They appear stationary for an observer on the earth

KINEMATICS

1. **Distance :**
The length of the path is known as distance. Distance is a scalar.
Displacement:
The distance between two points with specific direction is known as displacement. Displacement is a vector quantity.
Both distance and displaments are same units and dimensions.

2. **Speed :** The rate of distance traveled by a body is known as speed.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Speed is a scalar quantity.

3. **Velocity :** The rate of displacement is known as velocity.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Velocity is vector quantity.
Both speed and velocities have same units and dimensions.

4. Average speed

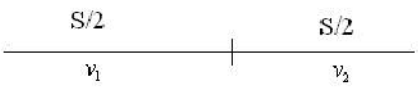
$$= \frac{\text{Total distance travelled}}{\text{Total time}}$$

Distance travelled = Average speed x time S = v x t

5. Average velocity

$$= \frac{\text{Resultant displacement}}{\text{Time}}$$

Resultant displacement = Average velocity X time
If a body cover first half of the total displacement with a velocity v_1 and second half with velocity v_2.Then the average velocity is given by



$V_{av} = \dfrac{2v_1v_2}{v_1 + v_2}$ this is the harmonic mean of v_1 and v_2

7. **Instantaneous velocity :** The velocity of a body at any particular instant in its journey is known as instantaneous velocity.

$$V_{inst} = \frac{ds}{dt}$$

8. **Relative velocity :** velocity of one body with respect to that of another body is called relative velocity. The velocity of `A` with respect to that of `B` is given by

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$

If 'A' and 'B' are moving with speed $V_A + V_B$ at an angle θ with one another.

$$|\vec{V}_{AB}| = \sqrt{V_A^2 + V_B^2 - 2V_AV_B\cos\theta}\ .$$

If α is the angle made $\vec{V}_{AB}$ with $\vec{V}_A$ there

$$\text{Tan}\ \alpha = \frac{V_B}{V_A}.$$

10. **Acceleration :** the rate of change of velocity of a body is called acceleration .
Acceleration

$$= \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time}}$$

The direction of acceleration lie along the direction of change in velocity.

11. **Retardation :** The negative acceelration is known as retardation.
Any body travelling with decreasing velocity possess retardation or deceleration.

12. **Equations of motion** (moving with uniform acceleration)
u = intital velocity, v = final velocity
a = acceleartion , s = displacement ,
t = time of travel

1. $V = u + at$ 2. $S = ut + \frac{1}{2}at^2$

3. $v^2 - u^2 = 2as$ 4. $S_n = u + a\left(n - \frac{1}{2}\right)$

Where S_n is the distance travelled in nth second of its journey.

13. **Equations of motion of a freely falling body** (take u = 0 and a = g)

1. $v = gt$ 2. $S = \frac{1}{2}gt^2$

3. $v^2 = 2gs$ 4. $Sn = g\left(n - \frac{1}{2}\right)$

14. **Equations of motion for a body thrown vertically up** (a = -g , s = h)

1. v = u- gt 2. h = ut - $\frac{1}{2}gt^2$

3. $v^2 = u^2 - 2gh$

4. $h_n = u - g\left(n - \frac{1}{2}\right)$

15. For a body thrown up vertically from the top of a tower (or) a body dropped from a balloon moving vertically up

1. v = - u+gt 2. h = -ut + $\frac{1}{2}gt^2$

3. $v^2 = u^2 - 2gh$

4. $h_n = -u + g\left(n - \frac{1}{2}\right)$

16. **For a body thrown vertically up with velocity 'u'**

a.maximum height : Maximum vertical distance travelled is known as maximum height

$$H = \frac{u^2}{2g}$$

b. Time of ascent : The time taken by a body to the maximum height is known as time of ascent.

$$t_a = \frac{u}{g}$$

c. Time of descent

The time in which body comes down from maximum height is known as time of descent.

$$t_d = \frac{u}{g}$$

d. Time of flight

The total time for which a body re mains in air before reaching the ground is known as time of flight.

$$T = t_a + t_d = \frac{u}{g} + \frac{u}{g} = \frac{2u}{g}$$

17. Time of ascent is always equal to time of descent if resistance forces due to air are neglected.
If we consider the force of buoyancy the time of ascent is less time of descent ($t_a < t_d$).

18. For a body throws vertically up with velocity 'u' the maximum height reached is given by

h = $\frac{u^2}{2g}$ $(or)h \alpha u^2$

19. If a body is thrown vertically up with a velocity 'u' if returns to ground with velocity 'v' which is equal is magnitude of 'u' but opposite in direction (ie) $\vec{v} = -\vec{u}$.

20. For a body falling freely through a height 'h'

The time of descent t = $\sqrt{\frac{2h}{g}}$

The velocity gained $V = \sqrt{2gh}$.

21. If a body is allowed to fall freely from the top of a tower of height 'h' and another is projected simultaneously from the foot of tower in the upward direction with velocity u

then they meet after time t = $\frac{h}{u}$.

22. **Projectile :** The body projected in to air with some velocity at an angle (other than 90^0) with the horizontal is called a projectile.

23. The path of a projectile is a parabola.

24. If a body is projected at an angle 'θ' to the horizontal with velocity 'u' its horizontal and vertical components of initial velocities are u cos θ and u sin θ.

25. After a time 't' the horizantal displacement = x = $(u\cos\theta)t$
vertical displacement =

y = $(u\sin\theta)t - \frac{1}{2}gt^2$.

26. The velocity of projectile is not zero at any point. Its value is minimum ($u\cos\theta$) at the highest point of its path. At this point only vertical component of velocity is zero.

27. At any instant of time 't' the horizontal component of velocity is $V_x = u \cos\theta$.
The vertical component of velocity is
$v_y = u\sin\theta - gt$

The resulant velocity is $V = \sqrt{v_x^{\ 2} + v_y^2}$.

The direction 'v' makes angle α with horizontal

Where Tan $\alpha = \dfrac{V_y}{V_x}$

28. Equation for the trajectory of the body

$y = x \tan\theta - \left(\dfrac{g}{2u^2\cos^2\theta}\right)x^2$

29. Time of ascent = $t_a = \dfrac{u\sin\theta}{g}$

30. Time of desent = $t_d = \dfrac{u\sin\theta}{g}$

31. Time of flight $T = t_a + t_d = \dfrac{2u\sin\theta}{g}$

32. Maximum height reached = H_{max} = $\dfrac{u^2\sin^2\theta}{2g}$

33. horizontal range $R = \dfrac{u^2\sin 2\theta}{g}$

34. Angle of projection for maximum range is $\theta = 45^0$

35. Two angles of projection for same range are $'\theta'\ and (90-\theta)$

36. If the range and maximum height of a projectile are equal, the angle of projection $\theta = \tan^{-1}(4)$

37. The path of a body projected horizontally from the top of a tower of height 'h' is a parabola.

a. The equation of the trajectory is given by

$Y = \left(\dfrac{g}{2u^2}\right)X^2$.

b. The time of descent $t = \sqrt{\dfrac{2h}{g}}$

c. The horizontal range R = u x t = $u\sqrt{\dfrac{2h}{g}}$

d. At any instant 't' horizontal velocity is $v_x = u$, vertical velocity $v_y = gt$

e. The resultant velocity $v = \sqrt{v_x^2 + v_y^2}$

f. The angle made by V with horizontal is given by Tan $\alpha = \dfrac{v_y}{v_x}$.

38. Suppose a bomb is dropped from a plane moving horizontally with uniform velocity 'u'. the path of bomb as observed by a man stationary on ground is parabola and as observed by the pilot of the plane is a vertical straight line.

MAGNETISM

1. Force between magnetic poles

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

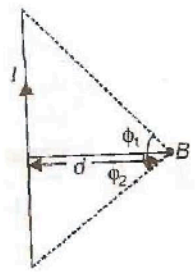
(In air or free space in between magnetic poles)

$\mu_0 \rightarrow$ permeability of free space.

$m_1, m_2 \rightarrow$ are the pole strengths of two magnetic poles.

$d \rightarrow$ distance between the poles

2. **Magnetic field due to a straight conductor Carrying current:**
Magnetic field strength at a distance d from a straight conductor carrying current I is given by



$$B = \frac{\mu_0 I}{4\pi d}(\sin\phi_1 + \sin\phi_2)$$

Direction of magnetic field is suggested by right hand grip/thumb rule.

3. $F = \frac{\mu}{4\pi}\frac{m_1 m_2}{d^2}$ (in the medium)

where $\mu = \mu_0\mu_r$

$\mu \rightarrow$ permeability of the medium

$\mu_r \rightarrow$ relative permeability of the medium

4. Magnetic Induction at a point in a magnetic field $B = \frac{\mu_0}{4\pi}\frac{m}{d^2}$

5. Force experienced by a pole in a magnetic field $F = mB$

$m \rightarrow$ pole strength of the magnetic pole

6. Magnetic moment of the magnet

$M = 2l\,m$

$2l \rightarrow$ magnetic length

$m \rightarrow$ pole strength of the magnet

7. Couple acting on bar magnet placed in uniform magnetic field $C = MB\sin\theta$

$M \rightarrow$ magnetic moment of the bar magnet

$B \rightarrow$ Magnetic field strength

$\theta \rightarrow$ angle between the axis of magnet and direction of magnetic field induction

8. Magnetic Induction due to a bar magnet **on axial line**

$$B_{axial} = \frac{\mu_0}{4\pi}\frac{2Md}{\left(d^2 - l^2\right)^2}$$

for short magnet

$$B_{axial} = \frac{\mu_0}{4\pi}\frac{2M}{d^3} \quad \rightarrow B\alpha\frac{1}{d^3}$$

$B \rightarrow$ magnetic induction

$M \rightarrow$ magnetic moment of the magnet

$d \rightarrow$ distance between the centre of the magnet to the point

$2\,l \rightarrow$ magnetic length

9. Magnetic Induction on equatorial line

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

$M \rightarrow$ magnetic moment of the magnet

$d \rightarrow$ distance between the centre to point.

$2l \rightarrow$ magnetic length

for short bar magnet

$$B_{eq} = \frac{\mu_0}{4\pi}\frac{M}{d^3} \quad \rightarrow B\alpha\frac{1}{d^3}$$

10. **A charge Particle in a uniform Magnetic field:**

When $\vec{v} \perp \vec{B}$, the charged particle following a circular path of radius

$$r = \frac{mv}{qB} = \frac{\sqrt{2mE}}{qB}$$

(a) $\vec{F} = q(\vec{v} \times \vec{B})$

(b) If charge is accelerated by p.d. V, then

$$r = \sqrt{\frac{2mqv}{qB}} = \sqrt{\frac{2mV}{qB^2}}$$

(c) Its radius $r = \frac{mv\sin\theta}{qB}$ or $\frac{mv_\perp}{qB}$

(d) The period of revolution of charge q in a uniform magnetic field B is given by

$$T = \frac{2\pi m}{qB}$$

11. Relation between B and H ; $B = \mu_0 H$

$H \rightarrow$ intensity of magnetic field

12. Tangent Law , $B = B_H \tan\theta$

$B \rightarrow$ magnetic induction field strength of the magnet

$B_H \rightarrow$ horizontal component of earth's magnetic field strength.

$\theta \rightarrow$ angle deflected by magnetic needle from the direction of B_H

13. **Deflection Magnetometer**

Equal distance method (Tan A or Tan B position) $\frac{M_1}{M_2} = \frac{\tan\theta_1}{\tan\theta_2}$

M_1, M_2 are magnetic moments of first and second magnets respectively

θ_1, θ_2 are average deflections produced by first and second magnets respectively

14. Null method (Tan A or Tan B position)

$$\frac{M_1}{M_2} = \frac{d_1^3}{d_2^3}$$

M_1, M_2 are magnetic moment of first and second magnets respectively ; d_1, d_2 are distances of the first and second magnets from the centre of the compass box respectively

15. Equal distance method in Tan A position

$$\frac{\mu_0}{4\pi}\frac{2M}{d^3} = B_H \tan\theta_A \text{ (short bar magnet)}$$

Equal distance method in Tan B position

$$\frac{\mu_0}{4\pi}\frac{M}{d^3} = B_H \tan\theta_B \text{ (short bar magnet)}$$

16. Verification of Inverse square law is

$$\frac{\tan\theta_A}{\tan\theta_B} = 2$$

θ_A, θ_B are average deflections in tanA and tanB positions.

17. **Vibration Magnetometer**

Time period of the magnet $T = 2\pi\sqrt{\frac{I}{MB_H}}$

$M \rightarrow$ magnetic moment of the magnet

$B_H \rightarrow$ horizontal component of magnetic field of earth

$I \rightarrow$ moment of inertia $I = \frac{m(l^2 + b^2)}{12}$

m, l, b $\rightarrow$ mass, length and breadth of the magnet respectively

18. $$B_H = \frac{1}{T(d^2 - l^2)}\sqrt{\frac{2\pi I \mu_0 d}{\tan\theta}}$$

$\theta \rightarrow$ the average deflection of the compass needle in the deflection magneto metre

19. $$M = \frac{2\pi(d^2 - l^2)}{T}\sqrt{\frac{4\pi I \tan\theta}{\mu_0 2d}}$$

20. **Comparision of Magnetic moments of two bar magnets**

i) $\frac{M_1}{M_2} = \frac{T_2^2}{T_1^2}$ (*equal sizes*)

ii) $\frac{M_1}{M_2} = \frac{T_2^2 + T_1^2}{T_2^2 - T_1^2}$ (*unequal sizes*)

19. Magnetic susceptibility (χ_m) = $\frac{H}{I}$

CONCEPTUAL POINTS

1. The magnetism is concentrated at two points called poles of a magnet.
2. The line passing through the two poles of the magnet is called "axial line"
3. The line passing through the equator of the magnet is called "equatorial line"
4. The shortest distance between the "two

poles" is taken as magnetic length($2l$) .

5. **Classification of magnetic materials**

Diamagnetic substances

The diamagnetic substances are those in which the individual atoms/molecules/ions do not possess any net magnetic moment on their own. When such substances are placed in an external magnetizing field, they get feebly magnetized in a direction opposite to the magnetizing field.

Example: Animony, Bismuth, Copper, Lead, Gold, Silver, Diamond, Zinc, Quartz; Water, Alcohol, Mercuty; Air, Hydrogen, Nitrogen and all inert gases like Helium, Neon, Argon etc.

6. **Curie Law in Magnetism**

Intensity of magnetization (I) of a magnetic material is (i) directly proportional to magnetic induction (B), and (ii) inversely proportional to the temperature (T) of the material.

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

This phenomenon of lagging of I or B behind H when a specimen of a magnetic material is subjected to a cycle of magnetization is called hystersis.

DEFLECTION MAGNETOMETER

1. Principle : It works on 'Tangent law"

Tan A Position

2. The arms are placed along East West direction or parallel to the Al - pointer.

Tan B Position

1. The arm are placed along North South direction or parallel to magnetic needle.
2. It is used to compare magnetic moments of two magnets and to verify the Inverse square law

NUCLEAR PHYSICS

Formulae

1. Radius of nucleus $\boxed{R = R_0 A^{\frac{1}{3}}}$ where Ro is a constant, A is the mass number. $R_0 = 1.3 \times 10^{-15} m$
2. Einstien's mass - energy relation $\boxed{E = mc^2}$ where C is velocity of light , m is mass.
3. Mass defect (Δm) = mass of nucleons - mass of a nucleus

   $\Delta m = \left[Zm_p + (A - Z)m_n\right] - m$

   Where Z atomic number, m_p = mass of proton, m_n = mass of neutron, m = mass of neucleus.

   A = mass number
4. Binding energy $\boxed{B = \Delta mc^2}$ where Δm is the mass defect, c is velocity of light.

   If Δm is in a.m.u. Then $\boxed{B = \Delta m x\ 931.5 MeV}$
5. Average Binding energy $\boxed{\overline{B} = \frac{B}{A}}$ where B is the binding energy, A is mass number.
6. Power of a nuclear reactor $\boxed{P = \left(\frac{n}{t}\right) E}$

   Where $\frac{n}{t} \rightarrow$ number of fissions per second

   $E \rightarrow$ energy released in each fission

CONCEPTUAL POINTS

1. 1 amu is defined as 1/12 of the mass of carbon - 12 atom.
2. The volume of the nucleus is proportional to mass number.
3. As density of the nucleus is independent of mass number, so all the nuclei have same density.
4. The energy equivalent to 1 a.m.u = 931.5 MeV.
5. Mass defect is the difference between masses of nucleons and mass of nucleus.
6. Packing fraction is the mass defect per each nucleon.
7. Binding energy is the energy required to split the neucleus into nucleons.
8. Average Binding energy is the measure of stability of nucleus.
9. The process of Breaking a necleus into two or more equal fragments is called fission.
10. Atom bomb is based on nuclear fission
11. Hydrogen bomb is based on fusion
12. Nuclear fusion will be possible only when kinetic energy of nuclei is greater than the repulsive energy.
13. Nuclear fusion takes place at high temperature and high pressure.
14. The energy of Sun and Stars is due to fusion.
15. In proton-proton cycle and in carbon - nitrongen cycle.

    $4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_{+1}e^0 + 26.7 Mev$
16. In carbon -nitrogen cycle carbon acts as catalyst.
17. In nuclear reactor.

    a) Moderator is used to reduce the speed of fast moving neutrons

    b) control rods absorb excess of neutrons.

    c) Neutron multiplication factor

    $K = \frac{\text{rate of production of neutrons}}{\text{rate of loss of neutrons}}$

    d) If K >1 then the reaction is in accelerated state (super critical)

    e) If K = 1 then the reaction is in steady state (critical)

    f) If K < 1 then the reaction is in deccelerated state (sub critical)
18. **Properties of neutrons:**

    a) Neutrons have high penetrating power and low ionisation power.

    b) The average life period of neutrons is above 1,000 seconds.

c) Being uncharged, neutrons are not deflected by electric and magnetic fields.

19. Properties of nuclear forces:

a) These are short range forces

b) These are strongest in nature

c) These are spin dependent

d) These are charge independent

e) These are non central forces.

f) These are exchange forces.

Uses of radio isotopes:

a) Radio iodine is used indetermining size and functioning of Thyroid gland.

b) Radio Phosphorus is used to cure Leukamea.

c) Radio carbon is used to find the age of ancient objects.

20. The elementary particles are classifed into 1) Bosons 2) Fermions

Bosons: These are the particles with angular momentum is equal to integral multiple of $\frac{h}{2\pi}$.

Eg: π-mesons, k - mesons, photons and gravitons

21. Photons and gravitons aremassless bosons.

22. The spin of photon is 1, and graviton is 2

23. **Fermions**: These are the particles with angular momentum half integral multiple of $\frac{h}{2\pi}$.

Eg: Leptons, Baryons (Nucleons, hyperons)

24. Leptons and mesons are called **Hadrons**.

EXPANSION OF SOLIDS

1. TEMPERATURE :

a. It is the thermal condition of a body which determines its ability to transfer heat to other bodies

b. Relation between celsius and Fahrenheit scales is $F = \frac{9}{5}C + 32$

c. General relation for any arbitrary scale of temeprature.

$$\frac{S - L.F.P}{U.F.P - L.F.P} = \text{Constant}$$

Where 's' is reading on a scale.

2. Linear expansion:

$$\alpha = \frac{l_2 - l_1}{l_1(t_2 - t_1)}$$

α : Coefficient of linear expansion.

$l_2 - l_1$: : Increase in length

$t_2 - t_1$: : Increase in Temperature.

3. Superficial or areal expansion:

$$\beta = \frac{a_2 - a_1}{a_1(t_2 - t_1)}$$

β : Coefficient of areal expansion

$a_2 - a_1$: Increase in area

$t_2 - t_1$: in crease in Temperature.

4. Volume Expansion:

$$\gamma = \frac{V_2 - V_1}{V_1(t_2 - t_1)}$$

γ : Coefficient of volume expansion

$V_2 - V_1$: Increase in volume

$t_2 - t_1$: Increase in temperature

5. Relation between α, β *and* γ

$\alpha : \beta : \gamma = 1 : 2 : 3$

α, β and γ are measured $/^0 C$.

6. Variation of density of solids,

$d_0 = d_t (1 + \gamma t)$

d_0 and d_t are densities at 0^0C and t^0C respectively.

γ coefficient of volume expansion.

EXPANSION OF LIQUIDS

1. Liquids have definite volume, but do not have definite Shape. So they have only cubical expansion.

2. When liquid is heated in a container the container also expands. Hence liquids have two types of cubical expansion.

3. On heating liquids expand. The expansion is more than that for solids.

4. There are two coefficients of expansion for a liquid.
i) Coefficient of apparent expansion.
ii) Coefficient of real expansion.

5. Coefficient of apparent expansion (γ_a) : -

The coefficient of apparent expansion of a liquid is the ratio of the apparent increase in the volume of the liquid per degree rise of temperature to its. Original volume.

a. $\gamma_a = \frac{v_2 - v_1}{v_1(t_2 - t_1)} /^0 C$

b. $v_2 = v_1[1 + \gamma_a(t_2 - t_1)]$

Where $v_2 - v_1$ = apparent increase in volume

$(t_2 - t_1)$ = Increase in temperature.

v_1 = volume at $t_1{}^0C$

v_2 = volume at $t_2{}^0C$

6. Coefficient of real expansion (γ_r) :

The coefficient of real expansion of a liquid is the ratio of the real increase in volume of the liquid to its original volume per 1^0C rise of temperature.

(ie) $\gamma_r = \frac{v_2 - v_1}{v_2(t_2 - t_1)} /^0 C$

$v_2 - v_1$ = real increase in volume

$t_2 - t_1$ = increase in temperature.

v_1 = volume at $t_1{}^0C$

v_2 = volume at $t_2{}^0C$

7. Coefficient of apparent expansion and Coefficient of real expansion units $/^0C$ or /k.

8. Relation between γ_a & γ_r :

$$\gamma_r = \gamma_a + \gamma_g \text{ (or)}$$

$$\gamma_r = \gamma_a + 3\alpha \quad [\because \gamma_g = 3\alpha]$$

Where α is the coefficient of linear expansion

9. γ_a is determined using specific gravity bottle method.

$$\gamma_a = \frac{\text{mass of the liquid expelled}}{\text{mass of the liquid remained x temp. difference}}$$

$$= \frac{m_1 - m_2}{m_2(t_2 - t_1)} = \frac{w_2 - w_3}{(w_2 - w_1)(t_2 - t_1)}$$

Where m_1 mass of the liquid at $t_1{}^0C$
Where m_2 mass of the liquid at $t_2{}^0C$
And w_1 = mass of the specific gravity bottle
w_2 = mass of the bottle + liquid at $t_1{}^0C$
t_1 = Initial temperature
w_3 = mass of bottle + liquid at $t_2{}^0C$
t_2 = Final temperature

10. As the temperature of liquid increases its density decreases.

11. Variation of density of liquid with temperature

$$d_2 = \frac{d_1}{1+\gamma_r(t_2 - t_1)} \text{ (or) } d_t = \frac{d_0}{1+\gamma_r t}$$

d_1 is the density of liquid at $t_1{}^0C$
d_2 is the density of liquid at $t_2{}^0C$
γ_r coefficient of real expansion,

12. Coefficient of real expansion of a liquid in terms of density

$$\gamma_r = \frac{d_1 - d_2}{d_2(t_2 - t_1)} /^0 C$$

Where d_1 is density of liquid at $t_1{}^0C$
Where d_2 is density of liquid at $t_2{}^0C$

13. Anomalous expansion of water:
Generally all liquids expand on heating but pure water contracts from 0^0C to 4^0C temperature. This peculiar behaviour of water is called Anomalous expansion of water.

14. Density of water is maximum at 4^0C (or) 277 K And minimum volume at 4^0C (or) 277K

15. Anomalous expansion of water can be demonstrated with Hopes apparatus (or) dilatometer.

EXPANSION OF GASES

1. Gases do not posses finite size and fixed shape. But they posses pressure.
2. While doing experiments, a gas must be taken in a closed container.
3. four parameters which define the state of a gas are P, V, T and n.
4. Pressure of a gas is measured by
   a. manometer Bourdon's gange (highpressure)
   b. M C leod gange (low pressure)
   c. Fortin's barometer (measuring atmo spheric pressure).
5. A moderate fall in the barometer reading indicates an incoming rain and a sudden fall predicts a storm.
6. As we go up in the atmosphere, atmospheric pressure decreases.
7. A balloon bursts as it reaches higher altitudes because of decreases of atmospheric pressure.
8. Volume of the gas is measured using a gas burette or eudiometer.
9. Boyle's law : At constant temperature, the pressure of a given mass of a gas is inversely proportional to its volume.

   (ie) $P \alpha \frac{1}{v}$ or $pv = k$ if n & T are const.

   $$\Rightarrow \quad p_1 v_1 = p_2 v_2$$

10. **Charles I law :** When the pressure of a gas is kept constant the volume of a given mass of gas is proportional to absolute temperature.

    (ie) $\frac{v}{T}$ = constant if n and p are held fixed.

    $$\Rightarrow \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

11. **Charle's II law :** At constant volume, the pressure of a given mass of a gas is directly proportional to its absolute temperature.

$(ie)\ P\alpha T(or)\ \frac{P}{T} = court\ \ (or)\frac{P_1}{T_1} = \frac{P_2}{T_2}$

12. When heat is given to a gas, both its volume and pressure undergo changes.
$\therefore$ A gas has two different coefficients of expansion

a. The coefficient of expansion of a gas at constant pressure called volume coefficient (α) of a gas

b. The coefficient of expansion of a gas at constant volume called pressure coefficient .(β) of a gas.

13. Volume coefficient of a gas : volume coefficient of a gas is the ratio increase in its volume per degree rise of the temperature to its volume at 0^0C when the pressure is kept constant

$$\alpha = \frac{v_t - v_0}{v_0 t}(or)\alpha = \frac{v_2 - v_1}{v_1 t_2 - v_2 t_1}$$

14. Pressure coefficient of a gas : (β): Pressure coefficient of a gas is the ratio of its increase in pressure per degree rise of temperature to its pressure at 0^0C. Keeping the volume constant.

$$\beta = \frac{p_t - p_0}{p_0 t}(or)\beta = \frac{p_2 - p_1}{p_1 t_2 - p_2 t_1}.$$

15. Relation between α *and* β: For all gases

$$\alpha = \beta = \frac{1}{273.15} = 0.00367/^0 C$$

16. If two vessels of same capacity containing a gas at $T_1{}^0$ K and $T_2{}^0$K and at pressures P_1 and P_2 atm are connected then the common pressure 'P' will be P = $\left(\frac{P_1T_2 + P_2T_1}{T_1 + T_2}\right)$

17. **Ideal gas equations is :** $\frac{PV}{T} = R$ Where P is the pressure, V is the volume of 1 gm mole of a gas, T is the absolute temperature and R is the universal gas constant.
R = 8.31 Joule /gm/^{0}K
= 2 cal/gm/mole/^{0}K

18. From gas equation $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

19. If d is the density of the gas $\frac{P}{dT}$ = Constant

(or) $\frac{P_1}{d_1T_1} = \frac{P_2}{d_2T_2}$

20. According to mayor's equation the pressure exterted by a gas is P = nKT
Where n is the no. of molecules per unit volume and k is the Boltzmann's constant

K = 1.38 x 10^{-27} J/k and K = $\frac{R}{N}$ where N = 6.02 x 10^{23} molecules per mole. And N is the avagadro's number.

21. The gas equation for unit mass of a gas is pv = rT.

22. The relation between R and r is R = Mr. Where M is the molecular weight. Number of moles in a gas n = m/M.

23. Vander walls gas equation for a real gas is $\left(P + \frac{a}{v^2}\right)$ (v - b) = RT where a and b are constents.

24. If the volume (v) and temp (T) of a gas constant, then $P\alpha m\ \ (or)\ \frac{p_1}{m_1} = \frac{p_2}{m_2}$

25. Absolute zero : It is the temperature at which the volume of a gas becomes zero at constant pressure (or) pressure becomes to zero at counstant volume.

Ideal gas or perfect gas

An ideal gas or perfect gas is that gas which strictly obeys the gas law, (such as Boyle's law, Charle's law, Gay Lussac's law, etc.)

i. The size or the molecule of a gas is zero.

ii. There is no force of attraction or repulsion amongst the molecules o the gas

Assumptions of Kinetic Theory of Gases

1. A gas consists of a very large number of molecules (of the order of Avogadro's number, 10^{23}), which are perfect elastic spheres.
2. The size of the gas molecules of very small as compared to the distance between them.
3. The molecules of do not exert any force of attraction or repulsion on each other, except during collision.
4. The collision of the molecules with themselves and with the wall of the vessel are perfectly elastic.
5. A molecules moves along a straight lien between two successive collision and the average straight.
6. The collisions are almost instantaneous.

Expression for pressure due to an ideal gas

$$P = \frac{1}{3} mnC^2$$

$$P = \frac{1}{3}\frac{M}{V}C^2 = \frac{1}{3}\rho C^2$$

Relation between pressure and kinetic energy of the gas

From kinetic theory of gases, the pressure P exerted by an ideal gas of density ρ and rms velocity of its gas molecule C is given by

$$P = \frac{1}{3}\rho C^2$$

$$P = \frac{2}{3}E$$

Average kinetic energy per molecule of the gas

$$M = m \times N_A$$

$$P = \frac{1}{3}\rho C^2 = \frac{1}{3}\frac{M}{V}C^2 \text{ or } PV = \frac{1}{3}MC^2$$

$$\frac{1}{2}MC^2 = \frac{3}{2}RT$$

$\therefore$ Average K.E of translation of one mole of the gas $= \frac{1}{2}MC^2 = \frac{3}{2}RT$

$$\therefore \frac{1}{2}mC^2 = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}k_B T$$

$\therefore$ Average K.E of translation of one mole of the gas= $\frac{1}{2}mC^2 = \frac{3}{2}k_B T$

Kinetic Interpretation of temperature

$$PV = \frac{1}{3}MC^2$$

$$\frac{1}{3}MC^2 = RT$$

$$C^2 = \frac{2RT}{M} \text{ or } C^2 \propto T$$

$$C \propto \sqrt{T} \text{ or } \sqrt{T} \propto C$$

Avogardro's law

It states that equal volumes of all gases under identical conditions of temperature and pressure contain the same number of molecules.

$$n_1 = n_2$$

(f) Graham's law of diffusion

It states that the rates of diffusion of two gases are inversely proportional to the square roots of their dustiest.

(g) Dalton's Law of partial Pressure

$$p_1 + p_2 + p_3 + ... = P$$

Mot probable speed, mean speed and RMS speed of gas molecules

(a) Most probable speed $a = \sqrt{\frac{m}{2\pi k_B T}}$

and $b = \frac{m}{2k_B T}$

Most probable speed of the molecules of a gas as that speed which is possessed by maximum fraction of total number of molecules of the gas.

$$C_{m.p} = \sqrt{\frac{2k_BT}{m}}$$

(b) Mean speed or Average speed

Mean speed or Average speed is the average speed with which a molecule of the gas moves.

$$C_{av} = \frac{C_1 + C_2 + ...C_n}{n}$$

$$C_{av} = \sqrt{\frac{8k_BT}{m\pi}}$$

(c) Root Mean square speed

Root mean square speed of gas molecules is defined as the square root of the mean of the squares of the random velocities of the individual moles of a gas.

$$C_{rms} = \sqrt{\frac{C_1^2 + C_2^2 + ...C_n^2}{n}}$$

$$C_{rms} = \sqrt{\frac{3k_bT}{m}}$$

Degrees of Freedom

The number of degrees of freedom of a dynamical system is defined as the total number of co-ordinates or independent quantities required to describe completely the position and configuration of the system.

$$N = 3A - R$$

i. Mono atomic Gases

ii. Di atomic Gases. : $N = 3 \times 2 - 1 = 5$

iii. Tri atomic gases. : $N = 3 \times 3 - 2 = 7$

Law of Equipartition of energy

According to this law, for any dynamical system in thermal equilibrium, the total energy is distrusted equally amongst all the degrees of freedom, and the energy ass-ociated with each molecule per degree of freedom is ½ k_BT, where k_B is Boltzmann constant and T is temperature of the system.

$$E_t = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}mv_z^2$$

Determination of γ from the degree of freedom

$$\gamma = \left(1 + \frac{2}{n}\right)$$

RAY OPTICS

1. Refractive index $= \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$

From Snell's Law

$$\mu = \frac{Sin\ i}{Sin\ r}$$

$i =$ angle of incidence

$r =$ angle of refraction

$d = i - r =$ angle of deviation

Denser $\rightarrow$ rarer medium

light bends away from normal ($d = r - i$)

rarer $\rightarrow$ denser medium

light bends towards normal ($d = i - r$)

2. $_1\mu_2 = \frac{\mu_2}{\mu_1}$

$_1\mu_2 =$ refractive index of 2 medium w.r.t 1

$\mu_1 =$ refractive index of 1 medium

$\mu_2 =$ refractive index of 2 medium

3. No refraction

(a) if light is incident normally on boundary

(b) refractive index of 1st medium = refractive index of 2 medium

4. When light ray undergoes refraction, there is a change in its velocity and wavelength but frequency of the light does not change.

5. $_1\mu_2 = \frac{V_1}{V_2}$ (from wave theory)

V_1 – velocity of light in 1 medium

V_2 – velocity of light in 2 medium

6. $_1\mu_2 = \frac{\lambda_1}{\lambda_2}$

λ_1 – wavelength of light in 1 medium

λ_2 – wavelength of light in 2 medium

7. $\frac{\mu_2}{\mu_1} = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2} \Rightarrow \mu_1 V_1 = \mu_2 V_2$.

Where V_1 – velocity of light in 1 medium

V_2 – velocity of light in 2 medium

8. μ value depends colour (wavelength) of light

μ - maxium for violet and minium for red.

9. **Real and Apparent Depths**

Due to refraction, depth of an optically denser medium appears to be less than its real depth. Consider two media a and b, such that $\mu_b > \mu_a$, then

$$^a\mu_b = \frac{\text{real depth}}{\text{apparent depth}}$$

$$d = t_1\left(1 - \frac{1}{\mu_1}\right) + t_2\left(1 - \frac{1}{\mu_2}\right) + ...$$

10. Critical angle :-

a. Light travels from denser to rarer medium.

b. Angle of refraction in rarer medium is 90^0

c. Emergent ray passes along the surface of separation

$\mu = \frac{1}{SinC}$ C – critical angle of the denser medium

$$\Rightarrow C = Sin^{-1}\left(\frac{1}{\mu}\right)$$

$$C = \sin^{-1}\left(\frac{\mu_r}{\mu_d}\right)$$

d. Critical angle is maximum for red minimum for violet

11. If angle of incidence in denser medium is greater than its critical angle, the light gets reflected back into same medium This phenomenon is called total internal reflection.

12. **Exampuls :**

i) Sparkling of a diamond is due to total internal reflection

ii) Mirage in hot areas and looming in cold areas is due to total internal reflection

iii) Optical fibre works on the principle of total internal reflection

13. **Refraction at Spherical surfaces.**

When light goes from rarer to denser medium through a spherical surface having radius of curvature R. We have relation

$$\frac{n_2 - n_1}{R} = \frac{n_2}{v} - \frac{n_1}{u}$$

Where n_1 and n_2 are refractive indices of rarer and denser medium respectively. (i.e. $n_1 < n_2$) distance of the object from the pole is u and that of the image is v.

$$\frac{n_1 - n_2}{R} = \frac{n_1}{v} - \frac{n_2}{u}$$

14. Lens makers formula

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \text{ where } \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

f - focal length μ -refractive index of material of lens

R_1, R_2 - radii of curvature of the lens

15. **Magnification**

Linear Magnification

"It is ratio of the length of the image formed by a lens to the length of the object"

$$m = \frac{h_1}{h_0}$$

$$m = \frac{v}{u}$$

$$m = \frac{f - v}{f}$$

$$m = \frac{f}{f + u}$$

16. Sign convention

i)distances are mesured from the optic centre

ii) distances in the direction of incident ray are taken positive and opposite to incident ray are taken negative

17. For convex lens :-

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

18. Condition for eliminating spherical aberration

$d = f_1 \sim f_2$

condition for achromatism (elimination of chromatic aberration)

$$d = \frac{f_1 + f_2}{2}$$

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2}$$

d - distance between the two plano convex lenses

f_1, f_2 : focal lengths of the plano convex lenses

19. Effective focal length of a combination of lenses

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

f - effective focal length

20. Magnifying power of a simple microscope is

$m = 1 + \frac{D}{f}$ at near point, $m = \frac{D}{f}$ at far point

where D = The least distance of distinct vision.

21. Magnifying power of a compound microscope is $m = m_0 \times m_e$

m_o = magnifying power of objective, m_e = magnifying power of eyepiece

$$m = -\frac{v_0}{u}\left(1 + \frac{D}{f_e}\right) \approx -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

If the final image is at infinity $m \approx \frac{-LD}{f_0 f_e}$

22. Magnifying power of a telescope is defined as the ratio of the angle subtended by the image at the eye when formed at infinity to the angle subtanded by the object at the eye when imagined to be at infinity.

23. Magnifying power of an astronomical or terrestrial telescope, $m = \frac{f_0}{f_e}$ for normal adjustment or when the image forms at infinity. It

is equal to $= -\frac{f_0}{f_e}\left(1+\frac{f_e}{D}\right)$ when the image forms at the least distance of distinct vision.

24. **Reflecting Type Telescope**

Reflecting type telescope was designed by Newton. It is used for observing distant stars. In normal adjustment, magnifying power of a reflecting type telescope is

$$M = \frac{f_o}{f_e} = \frac{R/2}{f_e}$$

25. distance of cross wires from field lens = $\frac{f}{4}$

$f_1 : f_2 = 1:1 \qquad d = \frac{2f}{3}$

effective focal length = $\frac{3f}{4}$

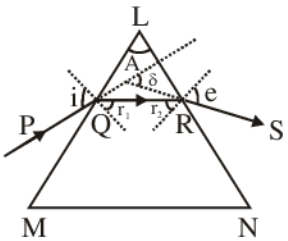
Huygen's eye piece

$f_1 : f_2 = 3:1 \qquad d = 2f$

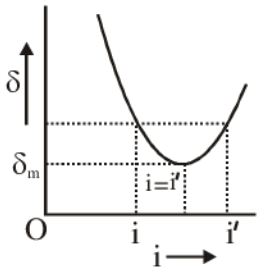
effective focal length = $\frac{3f}{2}$

26. **Refraction through a Prism**

(a) I+e=A+δ



(b) $\mu = \frac{\sin\frac{(A+\delta_m)}{2}}{\sin\left(\frac{A}{2}\right)}$



27. Dispersion of light for small angled prisms

$d = (\mu - 1)A$

d - angle of deviation,

μ - refractive index,

A - angle of prism

28. Angular dispersion :-

for violet and red rays

$\theta = d_v - d_r = (\mu_v - \mu_r)A$

d_v , d_r $\rightarrow$ deviations of violet and red

$\mu_v, \mu_r \rightarrow$ refractive indices of violet and red

29. Dispersive power :-

$$\omega = \frac{angular\ dispersion}{mean\ deviation}$$

$= \frac{d_v - d_r}{d}$ where $d = \frac{d_v + d_r}{2}$ (mean deviation)

$= \frac{\mu_v - \mu_r}{\mu - 1}$ where $\mu = \frac{\mu_v + \mu_r}{2}$ (mean refractive index, for yellow)

ROTATORY MOTION

1. When a rigid body rotates about a fixed axis every particle of the body moves in circular path.
2. The perpendicular distance from axis of ro tation to given point is called radius vector.
3. In rotation of a body about a fixed axis angular variables are same for all particles but linear variables changes
   Relation between angular and linear variables.
   1. $v = r\omega$
   2. $a = r\alpha$
4. Kinematical Equations of rotatory Motion:
   1. $\omega = \omega_0 + \alpha t$
   2. $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
   3. $\omega^2 - \omega_0^2 = 2\alpha\theta$

   When ω_0 : Initial angular velocity
   ω : Final angular velocity
   α : Uniform angular acceleration
   t : time

   Important Points:
5. **Torque:**
   The turning effect of a force about the axis of rotation is called moment of force or torque.

   Torque = Force x Perpendicular distance of line of action of force from axis of rotation.

$$\bar{\tau} = \bar{r} \times \bar{F}$$

$$|\bar{\tau}| = rF\sin\theta$$

$\bar{r}$: Position vector

6. **Couple:**
   Two forces equal in magnitude but opposite in direction acting at two different points of a body constitute coupe
7. **Moment of Couple:**
   The product of magnitude of force in couple and perpendicular distance between them.
8. **Moment of Inertia:**

Def : Inability of a body to change its state of rotation by itself is called moment of inertia (I). Moment of inertia is analogue to mass in translatory motion.

Mathematical Definition:

Moment of inertia of a rigid body about a given axis of rotation is the sum of products of the masses of various particles and square of their perpendicular distance from the axis of rotation

$I = m_1r_1^2 + m_2r_2^2 + \ldots\ldots + m_nr_n^2$ or $I = \sum_{i=1}^{n} m_i.r_i^2$

Units Kg.m^2 Dimensions: M L^2 T^0

9. Moment of intertia of different bodies
   a. Rod – axis Passing through its centre and perpendicular to its lenght $\frac{M\ell^2}{12}$
   b. Rectangular plate or bar – axis Passing through its center and perpenducular to plane $\frac{M\ell^2}{12} + \frac{Mb^2}{12}$
   c. Circular disc – axis Passign through its centre and perpendicular to its plane or transverse axis $\frac{MR^2}{2}$
   d. Solid cylinder – Its own axis $\frac{MR^2}{2}$
10. **Radius of gyration:**
    It is defined as the distance from the axis of rotation to a point where whole mass of the rotating body supposed to be concentrated.
    It is denoted by 'K'
    If 'K' is radius of gyration
    Then I = mK^2

Important Points:

a. Moment of inertia of a body depends on mass of the body and its distribution about the axis of rotation.
b. Moment of inertia changes with change in position of axis of rotation
c. Radius of gyration is not a constant quantity. Its value changes with change in location of axis of rotation.

Relation between τ *and* I . $\tau = I\alpha$.

(It is analogue to F = ma in translatory motion).

11. **Angular momentum (L):**
Moment of linear momentum of a particle in rotation about axis of rotation is known as Angular momentum
Angular momentum = linear momentum x Perpendicular distance from axis of rotation.
Angular momentum is a vector quantity
In vector from $\overline{L} = \overline{r} \times \overline{P}$

$$L = rp\sin\theta$$

$\overline{r}$: Position vector.

r sin θ : Perpendicular distance.

a. Relation between L & I , L= $I\omega$.
b. Linear momentum is measure of motion in linear motion.
c. Angular momentum is the measure of motion in rotation. Newton's second law for rotation $\overline{\tau} = \frac{d\overline{L}}{dt}$. Which gives rate of change of angular momentum is directly proportional to torque.
d. Relation between angular momentum and rotational K.E.

$$\therefore \quad KE = \frac{L^2}{2I}$$

12. For a rolling body it possess both rotational and transnational K.E.

$$E_K = E_t + E_r$$

$$E = \frac{1}{2}mr^2 + \frac{1}{2}I\omega^2$$

Where V: Velocity of centre of mass.

13. **Law of conservation of angular momentum**: As long as external torque acting on a system its zero then the total angular momentum remains constant.

$$\overline{\tau} = \frac{d\overline{L}}{dt}.$$

If $\overline{\tau} = 0$

Where $\frac{d\overline{L}}{dt} = 0 \Rightarrow L$ is constant.

Where L = I ω, $\therefore$ I ω is constant

$I_1 \omega_1 = I_2 \omega_2$

14. **Theorems on moment of inertia**
a. Perpendicular axes theorem:
Statement: moment of inertia of a plane laminar about an axis perpendicular to its plane passing through a point is equal to the sum of moments of inertia of the lamina about any two mutually perpendicular axis in its plane and passing through same point.

$I_Z = I_x + I_y$.

b. Parallel axes theorem:
Moment of inertia of a rigid body about any axis is equal to the sum of its moment of inertia about a parallel axis passing through its centre of mass and the product of the mass of the body and square of the perpendicular distance between the two axes.

$I_Z = I_{Cm} + MR^2$

15. **Motion of a body in vertical circular plane:**
Important Formula:
a. Minimum velocity at lowest point to describe vertical circular motion

$$V_1 = \sqrt{5Rg}.$$

b. Critical velocity at highest point

$$V_2 = \sqrt{Rg}$$

c. Tension in the rope at lowest point

$$T_1 = \frac{mv_1^2}{R} + mg$$

d. Tension in the rope at the highest point

$$T_2 = \frac{mv_2^2}{R} - mg$$

e. At critical velocity tension at highest point in zero

SEMI CONDUCTOR DEVICES

1. Rectifier efficiency $(\eta) = \dfrac{\text{dc output power}}{\text{ac input power}}$

2. Half wave rectifier efficiency

$$(\eta) = \frac{0.406 \text{ x } R_L}{r_f + R_L}$$

r_f = diode forward resistance

R_L = load resistance

3. Full wave rectifier efficiency

$$\eta = \frac{0.812 \text{ x } R_L}{r_f + R_L}$$

4. Current gain $\beta = \left[\dfrac{\Delta I_c}{\Delta I_b}\right]_{V_{ce}}$, $\alpha = \left(\dfrac{\Delta I_c}{\Delta I_e}\right)$

Relation between α & β, $\beta = \dfrac{\alpha}{1-\alpha}$

ΔI_c - Change in Collector current

ΔI_b - Change in Base current

5. Amplification factor $A = \dfrac{V_0}{V_i}$

V_0 - Output voltage; V_i - Input voltage

6. Voltage gain = $\dfrac{\Delta V_{ce}}{\Delta V_{be}} = \beta \times \dfrac{R_L}{R_{in}}$

ΔV_{ce} - Change in output voltage

ΔV_{be} - Change in input voltage

7. Power gain

A_p = Current gain x Voltage gain = $\beta^2 \times \dfrac{R_L}{R_{in}}$

CONCEPTUAL POINTS

1. Semiconductors behave both like conductors and insulators they behave like conductors when temperature is increased. They behave like insulators at low temperature i.e. 0 Kelvin (0 K) ex. Silicon and Germanium.
2. In all solids, different energy levels combine to form two bands.
3. Valence band (VB) contains valence electrons which may be partially or fully filled.
4. Conduction band contains free electrons which may be empty or partially filled.
5. The energy difference between Valence band and Conduction band is called forbidden Energy gap.
6. The forbidden energy gap is less for conductors and large for insulators and in between for semiconductors
7. Pure semiconductors are called Intrinsic semi conductors Ex. Silicon and Germanium (Si and Ge)

P-N Junction Diode :

1. A p-n junction is a single piece of semiconductor one half of which is p-type and the other half is n-type.
2. The region near the junction is called depletion layer.
3. There are two types of connections of diode

   a) Forward bias b) Reverse bias
4. When p-type is connected to positive and n-type connected to negative terminal then it is forward biased.
5. In forward bias it offers minimum resistance conducts heavily, depletion region is narrowed. It is similar to 'on' in an electrical switch.
6. In reverse bias p-type is connected to negative terminal and n-type is connected to positive terminal
7. In reverse bias it offers maximum resistance, does not conduct and depletion region is widened. It is similar to 'off' in an electrical switch.

Zener Diode :

1. A properly and highly doped p-n junction diode which operates in reverse bias condition is called 'Zener diode'
2. Silicon is preferred for making Zener diodes.
3. Zener diode is operated in reverse bias, which operates at a voltage called 'Zener voltage'.

4. Zener diode is used as a 'Voltage regulator'.

Transistors :

1. Transistor means transfer resistor
2. There are two types of transistors called

   a) npn transistor and b) pnp transistor.
3. In transistor there are three terminals called emitter, base and collector.
4. Transistor works as an amplifier.
5. Current gain of common emitter configuration is the ratio of small change in collector current to a small change in base current when collector emitter voltage is constant. It is denoted by b
6. Amplifier is a device which converts weak signals to strong signals, and this process of converting weak signals to strong signals is called amplification.
7. Amplifiers are of two types

   a) Power amplifier b) Voltage amplifier
8. The amplifier which is used to raise the power level is known as 'Power amplifier'.
9. The amplifier which is used to raise voltage level is known as 'Voltage amplifier'.

SIMPLE HARMONIC MOTION

1.Periodic motion:

The motion of a particle which repeats itself along the same path in equal intervals of time is called periodic motion

Ex:a. Rotation of earth around the sun.
b. Oscillations of simple pendulum
c. Vibrations of prongs of a tuning fork
d. Motion of hands in a watch.

2. Displacement of a particle in periodic motion can be mathematically expressed in terms of sine (or) cosine function so that periodic motion is also called haromonic motion.

3. Simple harmonic motion:

The to and fro motion of a particle along the straight line such that its acceleration is always directed towards a fixed point in its path and is directly proportional to the displacement from that fixed point is called simple harmonic motion.

$$a\alpha - y \Rightarrow a = -w^2 y \Rightarrow \frac{d^2 y}{dt^2} + w^2 y = 0 .$$

Simple harmonic motion is of two types:

i) Linear simple harmonic motion:

If the motion is along the straight line path it is called linear simple harmonic motion

Ex: a.Vibrations of string
b. Oscillations of liquid in U. tube
c. Oscillations of loaded spring
d. Vibrations of the prongs of a tuning fork.

ii) Angular simple harmonic motion

If vibrations are angular then it is called angular simple harmonic motion

Ex: a. Oscillations of a torsional pendulum
b. Oscillations of balance wheel in watchs

4. Characteristics of simple harmonic motions:

a. The motion is periodic
b. It execute to and fro motion
c. Acceleration is directed towards the mean point
d. The acceleration is always directly proportional to its displacement and which is opposite in direction to the dispalcement $a\alpha - y$

5. Simple harmonic motion is a periodic motion but every periodic motion is need not be a simple harmonic motion.

6. Displacement:

The maximum distance of the particle from the equilibrium position at any instant is called displacement.

7. Amplitude:

The maximum displacement of the vibrating particle from mean position is called amplitude represented by 'A' (or) a

8. Time period:

The time taken for one oscillation is called time period

$$T = \frac{2\pi}{\omega}$$

9. Frequency:

The number of oscillations completed by a particle in one second is called frequency.

Frequency $f = \frac{1}{T}$ cyeles/s.

10. Phase:

It represents the position and direction of vibrating particle at a particular instant

at the instant of time t = 0 the phase of the particle is called intial phase i.e. 'ϕ' it is also called 'epoch'

11. Displacement, velocity and acceleration of a particle axecuting simple harmonic motion.

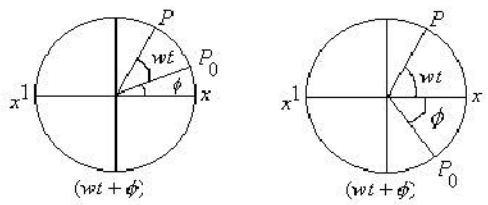
a. Displacement of a particle executing simple harmonic motion is given by

$$y = A\sin(wt \pm \phi)$$

where $\phi \rightarrow$ is initial phase
$\omega \rightarrow$ angular frequency
$A \rightarrow$ ampletude

b. Velocity of the particle executing simple harmonic motion is given by

$$V = \omega\sqrt{A^2 - y^2}$$



Case (i) When particle at mean position :

$$y = 0$$

$\therefore V = \omega\sqrt{A^2 - 0}$

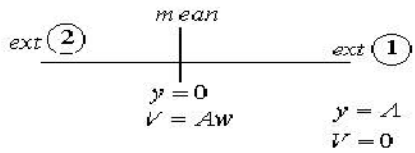
$V = A\omega =$ maximum

Case(ii) When particle at extreme end

$y = A$

$\therefore V = \omega\sqrt{A^2 - A^2}$

V = 0 = minimum



c. Acceleration of a particle executing simple harmonic motion is given by

$a = -A\omega^2 \sin(wt \pm \phi)$

$a = -\omega^2 y$

Case(i) Wehn particle at mean

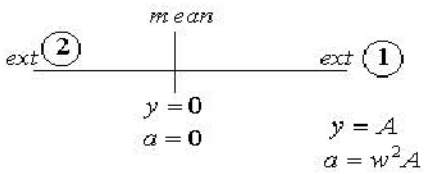
y = 0

a = 0

Case(ii) When particle at extreme

y = A

$a = \omega^2 A$ maximum



12. Time period of a particle executing simple harmonic motion is given by

$$T = 2\pi\sqrt{\frac{y}{a}}$$

Where y = displacement and

a = acceleration

13. Simple pendulum

1time period of simple pendulum executing simple harmonic motion is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where $l \rightarrow$ length of the simple pendulum

$g \rightarrow$ acceleration due to gravity

14. Laws of simple pendulum

a. Time period of a simple pendulum is directly proportional to square root of its lengths $T \propto \sqrt{l}$

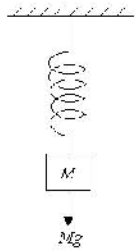
b. time period of simple pendulum is inversely proportion to square root of the acceleration due to gravity

$$T \propto \frac{1}{\sqrt{g}}$$

$$T^2 \alpha \frac{1}{g}$$

c. time period of simple pendulum is independent of mass and shape of the bob.

15. Loaded spring



i) If a mass M is suspended vertically from a spring and if the spring elongates 'x' then spring constant is

$$K = \frac{F}{x}$$

$$K = \frac{Mg}{x}$$

ii) time period of this loaded spring is

$$T = 2\pi\sqrt{\frac{M}{K}}$$

$$= 2\pi\sqrt{\frac{M}{\frac{Mg}{x}}} \Rightarrow T = 2\pi\sqrt{\frac{x}{g}}$$

iii) If a mass m is attached to the end of a spring and oscilates time period is

$$T = 2\pi\sqrt{\frac{m}{K}} \text{ .....(1)}$$

$$T = 2\pi\sqrt{\frac{m}{\frac{Mg}{x}}}$$

$$T = 2\pi\sqrt{\frac{mx}{Mg}} \text{ .....(2)}$$

If m_s is mass of the spring

then $T = 2\pi\sqrt{\frac{\left[m + \left(m_s / 3\right)\right]x}{Mg}}$ .....(3)

16. Energy of a particle executing simple harmonic motion

Let us consider a particle executing simple harmonic motion it posses P. E. and K. E.

$$P.E. = \frac{1}{2}mw^2y^2 \text{ .....(1)}$$

$$K.E = \frac{1}{2}mw^2\left(A^2 - y^2\right) \text{.....(2)}$$

total energy of the particle = PE + KE

$$TE = \frac{1}{2}mw^2A^2 \text{ .....(3)}$$

SURFACE TENSION

Inter-Molecular force

The forces between the molecules of the substances are called intermolecular forces. Types of intermolecular forces

(i) **Force of adhesion or adhesive force**: If is the force of attraction acting between the molecules of different substances.

(ii) **Force of cohesion or cohesive force**. : The force of attraction amongst the molecules of the same substance.

1. **SURFACE TENSION :** Surface tension is the molecule property of free liquid surfaces, by virtue of which it behaves like a stretched elastic membrane with a tendency to contact so as to occupy minimum surface area.

2. **To Measure surface tension:**
Surface tension of a liquid can be measured as the force per unit length on an imaginary line drawn on the liquid surface, which acts perpendicular to the line on its either side at every point and parallel to the liquid the surface.

$$S = \frac{F}{L} \quad units : Nm^{-1}$$

Dimensional formula ML^0T^{-2}

3. **Surface Energy:**
The potential energy per unit area of the surface film is called surface energy
Surface Energy =

$$\frac{\text{Work done in increa sing surface area}}{\text{Increase in surface area}}$$

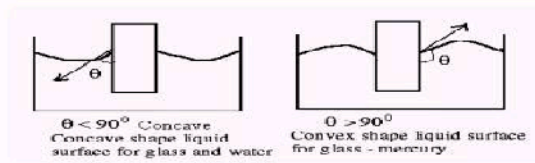
4. Surface tension of a liquid is numerically equal to its surface energy.

5. **Capillary tube:** A tube of very fine bore.

6. **Capillarity:** Rise or fall of a liquid in a tube of very fine bore is called capillarity.

(i) The fine pores of a blotting paper act like capillary tubes. Ink rises in them leaving the paper dray
(ii) A towel soaks water on account of capillarity action
(iii) Oil rises in the long narrow spaces between the threads of a wick, because they acts as fine capillaries.

7. **Angle of contact:**
The angle between the tangent to the liquid surface and tangent to the solid surface at point of contact inside the liquid in know as angle of contact.



(i) depends upon the nature of the liquid and solid in contact
(ii) depends upon the medium which exists above the free surface of liquid.
(iii) Is independent of the inclination of the solid to liquid surface.
(iv) Is fixed for a given pair of solid and liquid ad surrounding medium.

Important Points:

1. The angle of contact changes with the pair of solid and liquid
2. For pure water and glass angle of contact as zero.
3. Angle of contact increases on increasing temperature.
4. Angle of contact changes on adding impurities to liquids
5. If angle of contact is less the 90^0
   a. The liquid wets the solid surface
   b. The liquid spreads on solid surface
   c. There is a capillary rise
   d. The liquid meniscus is concave.
6. If the angle of contact in greater then 90^0.
   a. The liquid does not wet the solid surface
   b.The liquid does not spread on solid surface
   c. There is a capillary dip.
   d. The liquid meniscus is convex up.
7. **IMPORTANT FORMULAE**
   Formula to determine surface tension by capillarity method.

$$S = \frac{hrdg}{2\cos\theta}$$

h : capillary height.

r : radius of bore
d : density of liquid
θ : Angle of contact.

8. **Formation of big drop by a number of smaller drops :** when n small drops each of radius r are combined to form a big drop of radius R, then surface area decreases. Therefore energy releases.
Energy evolved in merging :
$W = 4\pi r^2 S\left[n - n^{2/3}\right]$

9. **Splitting of a bigger drop in to small drops :** When a big drop of radius r splits in to n small drop of same radius then surface area increases therefore energy absorbs.
Work done $W = 4\pi r^2 S\left[n - n^{2/3}\right]$.

10. Excess pressure inside a soap bubble $P_i - P_0 = \Delta P = \frac{4S}{r}$, where 'r' is the radius of the bubble

11. Excess pressure inside a liquid drop $P_i - P_0 = \Delta P = \frac{2S}{r}$ where 'r' is the radius of the drop

12. As temperature increases surface tension decreases exept in the case of molten copper and cadmium

THERMO ELECTRICITY

FORMULAE

1. $T_n - T_c = T_i - T_n$

   T_c - Cold junction temperature T_n - Neutral temperature, T_i - Inversion temperature

2. $e = aT + bT^2$

   e - Thermo emf developed T - Temperature difference between junctions

   a, b - Constants for a given thermo couple

3. At neutral temperature, thermo emf is maximum.

   $$\therefore \frac{d}{dt}(e) = 0 \Rightarrow \frac{d}{dt}\left(aT + bT^2\right) = 0$$

   $$\Rightarrow a + 2bT_n = 0 \quad \Rightarrow a = -2bT_n$$

   $$\Rightarrow T_n = \frac{-a}{2b}$$

4. $W = i^2Rt$

   W - workdone by electricity, i - electric current

   R - Resistance of wire t - Time for which current flows.

5. Duddell's thermo galvanometer :

   From $Q = i^2Rt$

   $\Rightarrow Q \alpha i^2$

   $\Delta T \alpha Q$

   $i_c \alpha \Delta T$

   $\theta \alpha i_C$

   Q = heat produced in heater filament

   i = current through heater filament

   ΔT - Temperature difference between junctions of thermocouple.

   i_c - current flowing through thermocouple.

   θ - deflection produced in thermo couple.

6. Peltier co-efficient (π) :

   $$\pi = \frac{Q}{q}$$

   Q - amount of heat liberated or absorbed

   q - amount of electric charge flowing.

   Unit of π : J/coulomb or volt.

7. Thomson coefficient (σ) :

   $$\sigma = \frac{Q}{it(dT)}$$

   Q - amount of heat liberated or absorbed

   i - electric current

   t - time for which electric current flows

   dT - temperature difference

   unit of σ - volt / kelvin $\left(V/K\right)$ or $V/^{\circ}C$.

CONCEPTUAL POINTS

a. The heat produced in a given resistor in a given time is proportional to the square of the current in it. i.e. $Q \alpha i^2$.

b. The heat produced in a resistor by a given current in a given time is proportional to it's resistance i.e. $Q \alpha R$.

c. The heat produced in a given resistor by a given current is proportional to the time for which current flows in it. i.e. $Q \alpha t$

I. Seebeck Effect:

If two wires of dissimilar metals are joined to form a closed loop and if the junctions are maintained at different temperatures, an emf is developed in the circuit and a current flows through the circuit. This phenomenon is called "**Seebeck effect**"

i) The emf developed is called thermo emf

ii) The current produced is called thermo electric current

iii) The pair of dissimilar metals is called thermo couple.

II. Neutral temperature (T_n):

The temperature of hot junction at which thermo emf in the circuit is maximum is called neutral temperature.

It is constant for a given thermo couple.

III. Inversion temperature (T_i):

The temperature of hot junction at which thermo emf becomes zero and tends to become negative is called inversion temperature.

The difference between neutral temperature

and cold junction temperature is same as the difference between inversion temperature and neutral temperature. $\left(T_C - T_n\right) = \left(T_i - T_C\right)$

IV. Peltier Effect:

When a current is passed across the junctions of a thermo couple,heat is evolved at one junction and absorbed at the other junction. This effect is known as **Peltier effect**.

V. Peltier Coefficient (π):

The amount of heat absorbed or evolved at a juntion of thermo couple when 1 coulomb of charge flows through the junction is called "**Peltier coefficeint**"

i) It is denoted by π

ii) $\pi = \frac{Q}{q}$

iii) Unit of π : J/C or Volt

iv) π is numerically equal to potential difference acorss the junction.

VI. Thomson Effect:

The absorption or evolution of energy (Heat) due to the flow of current in an unequally heated conductor is known as "**Thomson Effect**"

VII. Thomson coefficient (σ):

The energy absorbed or evolved when a current of 1A flows for one second between two points of a conductor which differ in temperataure by 1°C is called as "**Thomson coefficient**".

i) It is denoted by 'σ'

ii) $\sigma = \frac{Q}{it\left(dT\right)}$

iii) unit of σ is V/°C or V/K.

THERMO DYNAMICS

1. **System:**
A particular portion of matter is called a system

2. **Surroundings:**
Every thing outside of the system that may have a direct influence on the system is referred as the surroundings.

3. **Types of systems:**
There are 3 types of systems
   a. Open system:
   A system which exchanges both energy and matter with its surroundings is called as open system
   b. Closed system:
   A system which can exchange energy only and not matter with surrounding is known as closed system.
   c. Isolated system:
   A system which can exchange neither en ergy nor matter with the surroundings is called isolated system.
   Examples: hot box, thermo flask

4. **Thermo dynamics co-ordinates (or) variables:**
The parameters like presure, volume, temperature entropy, internal energy, work, etc characterising. The state of the system are called thermo dynamic variables

5. **Thermo dynamic system:**
A system that can be described in terms of the thermo dynamic co-ordinates is called thermo dynamic system:

6. **Heat:**
Heat is a form of energy which transfer from a body at heigher temperature to a body at lower temperature.
Units: Unit of heat in SI - Joule
Unit of heat in C. G. S - Calorie
1 Cal = 4.2 J

7. **Thermal equillibrium:**
Two bodies are said to be in thermal equilibrium if there is no exchange of heat energy between them when conected thermally with each other.

8. **Zeroth law of thermo dynamics:**
If two systems A and B are in thermal equilibrium with third system C seperately then they (A, B) must be in thermal equilibrium with each other. Mathematical representation

$$f_A(P_AV_A) = f_B(P_BV_B) = f_C(P_CV_C) = T$$

(or)

$$f(P,V,T) = 0$$

9. **Calorie:**
The quantity of heat required to rise the temperature of 1gm of water through 1^0C is called 1 calorie.

10. **Standand Calorie:**
The quantity of heat required to rise the temperature of 1gm of water from 14.5^0C to 15.5^0C is called standrad calorie

11. **External work:**
When the force is exerted by the ststem on its surroundings produces a displacement the work done by the system is called external work.
(or)
When the force is exerted by the surroundings on the system produces a displacement the work done by the surroundings is called external work.
   a. The work done by the system on the sur roundings is taken as '+ve'
   b. The work done by the surroundings on the system is taken as '– ve'

12. **Internal work:**
When the work done by one part of the system on another part of the same system is called internal work.

13. **Internal energy:**
Internal energy of a thermo dynamic system is defined as the energy possessed by the system by virtue of its molecular constitution and the position of the molecules
   a. In a gas the molecules are in the state of random motion hence they posses kinetic energy.
   b. Due to molecular forces of attraction among the molecules they posses potential energy.
   c. The sum of potential energy and kinetic energy of individual molecules in the system is called internal energy.
   Internal energy $U = P.E. + K.E$
   $\therefore$ change in internal energy
   $dU = U_f - U_i$
   where U_f is final internal energy
   U_i is initial internal energy
   d. Internal energy of a system increases with temperature.

14. **Heat capacity (or) thermal capacity**
The quantity of heat required to rise the temperature of a substance through 1^0C is called heat capacity it is represented by 'H'

$$\therefore H = \frac{\text{Change in heat energy}}{\text{rise in temperature}}$$

$$H = \frac{dQ}{dT}$$

Units: J/k in S.I.

$Cal/^0C$ in C. G. S

dimensional formula. $ML^2T^{-2}K^{-1}$

15. Specific heat:

The quantity of heat required to rise the temperature of unit mas of a substance through 1^0C is called its specific heat it is represented by 'c'

$\therefore$ specific heat =

$$\frac{1}{\text{mass}} \times \frac{\text{change in heat energy}}{\text{rise in temperature}}$$

$$\therefore \; c = \frac{1}{m}.\frac{dQ}{dt}$$

Units: $J/kg\,k$ in S.I.

$Cal/gm\,^0C$ in C. G. S

dimensional formula: $\frac{L^2T^{-2}}{M \times K} = L^2T^{-2}K^{-1}$

16. Relation between heat capacity and specific heat:

Specific heat of a substance is given by

$$c = \frac{1}{m}.\frac{dQ}{dt}$$

But $\frac{dQ}{dT} = H$ heat capacity

$$c = \frac{H}{m}$$

$$\therefore H = mc$$

17. Water equivalent:

The mass of water in grams which would require the same amount of heat to raise in temperature through 1^0C as the body when heated through the same temperature is called water equaivalent

a. In C.G. S system, thermal capacity and water equivalent are numerically equal. water equivalent = thermal capacity = mc = $\frac{dQ}{dT}$

b. Of all the solids and liquids water has highest specific heat so that water is used in radiators of motor vehicles

Its value $1Cal/gm\,^0C$ or $4180\ J/kg.k$

c. Specific heat of a substance during its change of state is infinity during change of state dT = 0

$$\therefore c = \frac{1}{m}.\frac{dQ}{0}$$

$$c = \propto$$

18. External work done by an ideal gas during expansion

$$dw = PdV$$

19. First law of thermo dynamics:

A quantity of heat energy is supplied to a system is equal to sum of the external work done by the system and increase in its internal energy this is called first law of thermo dynamics

(or)

When certain amount of heat is given to a system a part of it is used to increase the internal energy and the remaining part is used in doing external work. This is known as first law of thermo dynamics.

a. This law is particular form of the law of conservation of energy.

b. $dQ = dU + dw$

where dQ amount of heat

dU in crease in internal energy

dw = PdV work done

c. $dQ = dU + PdV$

20. Significance:

a. Heat is a form of energy in transit

b. Energy is conserved in thrmo dynamic system

c. Every thermo dynamic system in equilibrium state possesses internal energy.

21. Specific heats of gases: Every gas has two specific heats

a. Specific heat of gas at constant volume

b. Specific heat of gas at constant pressure.

22. Specific heat of gas at constnat volume:

It is defined as the amount of heat required to rise the temperature of unit mass of gas through 1^0C at constant volume

$$C_V = \frac{1}{m}.\frac{dQ}{dT}$$

23. Specifi heat of gas at constant pressure.

It is defined as the amount of heat required to rise the temperature of unit mass of gas through 1^0C at constant pressure.

$$C_P = \frac{1}{m}.\frac{dQ}{dT}$$

24. Molar specific heat at constant volume

a. It is defined as the amount of heat required to rise the temprature of one mole of gas through 1^0C at constant volume.

$$C_V = \frac{1}{n}.\frac{dQ}{dT}$$

b. at constant volume the system uses given heat energy to increase internal energy only and dw = 0

$$\therefore dQ = dU + dw$$

$$dU = dQ$$

$$dU = nC_V.dT$$

25. Molar specific heat at constant pressure.

a. It is defined as the amount of heat required to rise the temperature of one mole of gas through $1^0 C$ at constant pressure.

$$C_P = \frac{1}{n}.\frac{dQ}{dT}$$

b. When system is at constant pressure which uses the given heat energy for the system in two ways a part of it used to increase internal energy remaining part used for doing external work

$$\therefore dQ = dU + dw$$

$$C_P = \frac{1}{n}.\frac{d\theta}{dT}$$

$$dQ = nC_P.dT$$

$$nC_P dT = dU + PdV$$

26. Relation between C_P and C_V

a. to increase internal energy of a system to same level at constant volume and at constnat pressure, the system required more heat energy at constant pressure.

$$\therefore C_P > C_V$$

b. $C_P - C_V = R$

c. The ratio of C_P and C_V is a constant

i.e. $\frac{C_P}{C_V} = \gamma$

27. Law of method of mixtures:

When there is no loss of heat energy to the surroundings the heat lost by the hot body will be equal to the heat gained by the cold body when they are mixed together is called law of method of mixtures.

heat lost by the hot bodies = heat gained by the cold bodies

a. Two substances of masses m_1 and m_2 specific heats c_1 and c_2 are at temperatures θ_1 and θ_2 are mixed then final temperature of mixture is

$$\theta = \frac{m_1c_1\theta_1 + m_2c_2\theta_2}{m_1c_1 + m_2c_2}$$

b. If $c_1 = c_2$ i.e. substances are made of same material then

$$\theta = \frac{m_1\theta_1 + m_2\theta_2}{m_1 + m_2}$$

c. If $m_1 = m_2$, then $\theta = \frac{m(\theta_1 + \theta_2)}{2m}$

$$\theta = \frac{\theta_1 + \theta_2}{2}$$

28. Mechanical equivalent of heat (or) Joules law:

The amount of work performed is directly proportional to the amount of heat generated

$$w \alpha Q$$

$$w = JQ$$

where

J = Joules constant (or) mechanical equivalent of heat

Units: S.I. units of J is unity J = 4.2 J/Cal

29. Isothermal process:

a. The changes in volume and pressure of a gas taking place at constant tempera ture is called isothermal process

b. Isothermal process obeys boyles law i.e PV = constant

c. In this process the system is enclosed with perfect heat conducting walls

d. Due to exchange of heat from system to surroundings (or) vice versa through heat conducting walls so that tempera ture of the system is constant.

$$\therefore dT = 0$$

e. In this process the change in internal energy of the system is zero dU = 0

f. This process is slow process

g. Molar specific heat is infinity in this process

$$C = \frac{1}{n}.\frac{d\theta}{dT} = \frac{1}{n}.\frac{d\theta}{0}$$

h. Work done in isothemal process is

$$w = 2.302\ nRT\ \log_{10}\left(\frac{P_1}{P_2}\right)$$

30. Adiabatic process

a. The changes in pressure, volume of a

gas taking place at constant heat en ergy is called adiabatic process

b. This process do not obey any gas laws but it obeys piossions law

$PV^{\gamma} = \text{constant} \cdot$

c. In this proces the system is enlclosed with bad conductor of heat

d. In this process there will not be any ex change of heat from system to sur roundings & vice versa through bad conductor of head so that heat energy remains constant.

e. Change in heat energy in this process is zero
i.e. dQ = 0

f. Molar specific heat is zero i.e.

$$C = \frac{1}{n} \cdot \frac{dQ}{dT}$$

C = 0

$(\because dQ = 0)$

g. It is quick and sudden process
Ex: When cycle tube bursts suddenly pressure, volume, temperature of the gas changes but heat energy remains same.

h. Work done in adiabatic process is

$$w = \frac{R}{1-\gamma}\left[T_2 - T_1\right]$$

31.Relation between P, V

Relation between P, V is given by PV^{γ} = constant

a Relation between V, T is given by $V^{\gamma-1}T$ = constant

b Relation between P, T is given by $P^{1-\gamma}T^{\gamma}$ = constant

32. Latent heat:

The amount of heat absorbed (or) released by unit mass of a substance during its change of state at constant temperature is called latent heat it is denoted by 'L'

$$\therefore \text{ Latent Heat} = \frac{\text{heat energy}}{\text{mass}}$$

$$L = \frac{Q}{m}$$

Units: J/Kg in S.I.
Cal/ gm in C. G. S

The amount of heat required for a substance of mass m to change its state is
Q = mL

33. Latent heat of ice:

The quantity of heat required to change the state of 1gm of ice into water at 0^0C is called latent heat of ice

in C.G.S $L_{ice} = 80Cal/gm$

in.SI. $L_{ice} = 0.336 \times 10^6 J/Kg$

34. Latent heat of steam:

The quantity of heat required to change the state of 1gm of water into steam at 100^0C is called latent heat of steam.

in C. G. S

$L_{steam} = 540cal/gm$

S.I.

$L_{steam} = 2.268 \times 10^6 J/Kg$

Note: Liquids with low latent heat of steam are called volatile liquids
Ex: Petrol, either, Perfumes

35. Sublimation of heat:

The amount of heat is required to change unit mass of solid into steam directly at given temperatures is called heat of sublimation
Ex: camphor, iodine

36. Triple point:

The pressure and temperature at which the given substance can exists in 3 states (liquid, solid and gas) simultaneously is known as triple point pressure and temperatures of triple point of water are 610.13 Pa and 273.16k

37. Second law of thermo dynamics:

a.Clausius statement

It is impossible for a self acting machine unaided by any external agency to transfer heat from a body at lower temperature to a body at higher temperature
(or)
Heat cannot by it self flow from a colder body to hotter body.

b.Kelvin Flank statement:

It is impossible to construct a heat engine operating in a cycle to convert the heat energy completely into work with out any change of working system.

38. Heat engine is a device used to convert energy into work or mechanical enerty. Its efficiency

$$\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1}$$

Principle of refrigerator (or heat pump)

A refrigerator, as we all know, is a device used for cooling Things. It is also called a heat pump.

Note that water and other food stuff to be cooled in the refrigerator serve as sink at loser temperature. The source in this case is the atmosphere or surrounding air at room temperature T_1.

$$W = Q_1 - Q_2$$

$$\beta = \frac{Q_2}{W} \quad \beta = \frac{Q_2}{Q_1 - Q_2}$$

$$\beta = \frac{T_2}{T_1 - T_2}$$

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

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

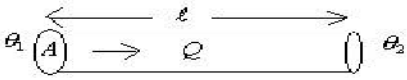
Second law of thermodynamics

This, principle which disallows certain phenomena consistent with the first law of thermodynamics is know as the second law of thermodynamics.

TRANSMISSION OF HEAT

1. Coefficient of Thermal conductivity :

a. In steady state the quantity of heat Q flowing through a metal rod of length ℓ and cross-section A in a time t when its ends are at temperature θ_1 and θ_2 $(\theta_1 > \theta_2)$ is given by



$$Q = \frac{KA(\theta_1 - \theta_2)}{l}t$$

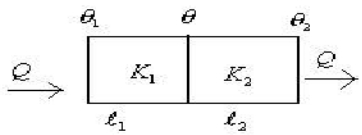
where K is coefficient of thermal conductivity

b. K depends on the nature of the metal.

c. It is defined as the rate of flow of heat per unit area and per unit temperature gradient in steady state.

2. a. If one end of a metal rod is kept in a steam jacket and other end is kept in an ice block, then the amount of ice that melts is $m = \frac{KA(\theta_1 - \theta_2)t}{d.L_{ice}}$

b. Junction temperature : In steady state when conduction takes place through two layers of composite wall with different thermal conductivities, then



$$\theta = \frac{K_1\theta_1 + K_2\theta_2}{K_1 + K_2}$$

3. Thermal Resistance : R

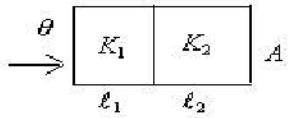
Thermal resistance R of a conductor of length ℓ, cross-section A and conductivity K is given by

$$R = \frac{l}{KA}$$

4. Effective conductivity :

a. Series combination :

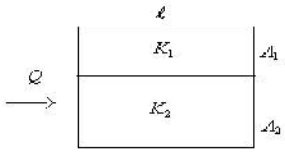
If two rods of same cross-sectional area having lengths l_1 *and* l_2 and conductivities K_1 *and* K_2 are connected in series, then in steady state conductivity of the combination K is given by



$$K = \frac{2K_1K_2}{K_1 + K_2}$$

b. Parallel combination :

If two rods of same length having cross-sectional area A_1, A_2 and conductivities K_1, K_2 are arranged in parallel, then in steady state, the conductivity of the combination is



$$K = \frac{K_1 + K_2}{2}$$

5. EMISSIVE POWER (e_λ) :

a. The amount of energy emitted per second per unit surface area of a body at a given temperature for a given wavelength range $(\lambda \text{ and } \lambda + d\lambda)$ is called emissive power.

b. At a given temperature if the radiations emitted have a wave length difference $d\lambda$, then the emissive power is equal to $e_\lambda d\lambda$.

c. S.I unit of emissive power is Wm^{-2} and its dimensional formula is MT^{-3}.

6. **EMISSIVITY (e):** The ratio of radiant energy emitted by a surface to radiant energy emitted by a black body under same conditions is called emissivity.

a. For a perfect black body emissivity e = 1.

7. ABSORPTIVE POWER (a_λ):

a. At a given temperature, for a given wave-length range, the ratio of energy absorbed to the energy incident on the body is absorptive power.

$$\therefore a_\lambda = \frac{Amount\ of\ radiant\ energy\ absorbed}{Amount\ of\ radiant\ energy\ incident}$$

b. For a perfect black body, the absorptive power, $a_\lambda = 1$.

8. REFLECTING POWER (r):

$$r = \frac{\text{Amount of radiant energy reflected}}{\text{Amount of radiant energy incident}}$$

9. TRANSMITTING POWER (t):

a.

$$t = \frac{\text{Amount of radiant energy transmitted}}{\text{Amount of radiant energy incident}}$$

b. $a_\lambda + r + t = 1$

Here 'a_λ' is absorptive power, 'r' is reflecting power and 't' is the transmitting power.

10. KIRCHOFF'S LAW:

a. At a given temperature, for a given wave length range, the ratio of emissive power to absorptive power of a substance is constant.

b. This constant is equal to the emissive power of a perfect black body at the given temperature and wavelength.

i.e., $\frac{e_\lambda}{a_\lambda} = const = E_\lambda$

Where 'E_λ' is the emissive power of perfect black body. 'e_λ' and 'a_λ' are emissive and absorptive powers of a given substance respectively.

c. Good absorbers are good emitters.

d. Poor absorbers are poor emitters.

11. STEFAN'S LAW:

a. The amount of heat radiated by a black body per second per unit area is directly proportional to the fourth power of its absolute temperature.

$E \propto T^4 \Rightarrow E = \sigma T^4$.

Where

σ = Stefan's constant

$= 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

12. STEFAN - BOLTZMANN'S LAW:

a. If a black body at absolute temperature T is surrounded by an enclosure at absolute temperature T_o, then the rate of loss of heat energy by radiation per unit area is given by.

$E = \sigma(T^4 - T_0^4)$

b. For any hot body, $E = \sigma Ae(T^4 - T_0^4)$

Where 'e' is the emissive power and 'A' is the area of cross-section of the hot body.

13. NEWTON'S LAW OF COOLING:

The rate of cooling of a hot body is directly proportional to the mean excess of temperature of the body above that of the surroundings, provided the difference in temperature of the body and that of surroundings is small.

$$\frac{d\theta}{dt} = K\left(\frac{\theta_1 + \theta_2}{2} - \theta_s\right).$$

here $\frac{d\theta}{dt}$ = Rate of cooling.

θ_1, θ_2 are the initial and final temperatures of the body respectively. θ_s is temperature of surroundings and K is the cooling constant.

WAVE MOTION

I. Formulae in this chapter: -

1. The velocity of sound wave v = n λ where n is frequency and λ is wavelength.
2. Equation of plane progressive wave

$$y = A\sin(\omega t \pm \phi)$$

(i) $y = A \sin \frac{2\pi}{\lambda}(vt \pm x)$

(ii) $y = A \sin \frac{2\pi}{\lambda}\left(\frac{t}{T} \pm \frac{x}{\lambda}\right)$

y – displacement x – position at time t
A – amplitude V – velocity of wave
λ - wavelength T – time period

3. Maximum Particle velocity $v = A\,\omega$
A – amplitude , ω – angular velocity
ϕ - phase difference $\phi = kx$
4. Propagation constant $K = \frac{2\pi}{\lambda}$
5. $V = \frac{\lambda}{T}$ (T – time period)
6. Velocity of transverse wave in stretched string $V = \sqrt{\frac{T}{m}}$. T – tension in string
m – mass per unit length or linear density
7. Frequency of string in one loop = fundamental frequency $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$
l – length of string
8. For p loops frequency $n_1 = \frac{p}{2l}\sqrt{\frac{T}{m}}$
$n_1 = p \times n$
9. Over tone = harmonic + 1
10. $n \propto \sqrt{T}$ if l, m are constants $\frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$
11. $n \propto \frac{1}{\sqrt{m}}$ if T, l are constants $\frac{n_1}{n_2} = \sqrt{\frac{m_2}{m_1}}$
12. $n_1 l_1 = n_2 l_2$ if T, m are constants.
13. Beat frequency = difference in frequencies = $n_1 - n_2$

II. Doppler effect: -

1. General formula for apparent frequency :

$$n^1 = \left(\frac{V \pm W \pm V_O}{V \pm W \pm V_S}\right)n$$

Here n – Original frequency of sound
V – Velocity of sound in air
W – Velocity of wind
Vo – Velocity of the observer
Vs – Velocity of source of sound

2. Sign convention
(i) Source moving towards observer = (- Vs)
(ii) Source moving away = (+ Vs)
(iii) Observer moving towards source = (+Vo)
(iv) Observer moving away = (-Vo)
(v) If air moves in direction of sound(V+W)
(vi) If air moves in opposite direction(V– W)
3. Source moving towards stationary observer
(Vo = 0), $n^1 = \left(\frac{V}{V - V_s}\right)n$
4. Source moving away from stationary observer
(Vo = 0) , $n^1 = \left(\frac{V}{V + V_s}\right)n$
5. Observer moving towards stationary source
(Vs = 0) , $n^1 = \left(\frac{V + V_o}{V}\right)n$
6. Observer moving away from stationary source (Vs = 0) $n^1 = \left(\frac{V - V_o}{V}\right)n$
7. Source and observer moving towards each other Vs, Vo

$$n^1 = \left(\frac{V + V_o}{V - V_s}\right)n$$

8. Source (Vs) and observer (Vo) moving away from each other $n^1 = \left(\frac{V - V_o}{V + V_s}\right) n$

(i) Source (Vs) moving towards observer (Vo) , observer moving away from source,

$$n^1 = \left(\frac{V - V_o}{V - V_s}\right) n$$

9. Source (Vs) moving away from observer(Vo) ; observer moving towards source

$$n^1 = \left(\frac{V + V_o}{V + V_s}\right) n$$

10. If both are at rest there is no change in frequency

III. Echos: (a) time of echo t = $\frac{2d}{V}$.

d – distance of obstacle from which echo is heard , V – velocity of sound in air

b) Shortest distance to hear an echo

d = $\frac{V}{20}$ where V is velocity of sound in air (t = 0.1 s)

IV. Absorption coefficient:

The absorbtion coefficient of a surface a is

a = $\frac{Es}{Ew}$.

Es – sound energy absorbed by surface

Ew – sound energy absorbed by open window equal area in same time

1. For materials in form of sheets

$$a = \frac{4\, i_1\, i_2}{(i_1 + i_2)^2}$$

i_1 – current at antinode , i_2 – current at node (This method is called stationary wave method).

2. Reverberation - time method: -

$$a = \frac{0.17V}{s}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] + a_0$$

T_1 – reverberation time without material

T_2 – reverberation time with material

a_o – absorbtion coefficient of walls of chamber

s – surface area of walls , V–volume of chamber

V. Sabine's formula:

The reverberation time T is:

1. T = $\frac{0.17V}{\sum as}$

V – volume of enclosure

a – absorbtion coefficient ,

s – surface area

2. T = $\frac{0.17V}{A}$

A – total absorbtion , A = $\sum as$

VI. Concepts:

1. When sound travels from one medium to other frequency remains constant
2. We can hear sound of frequencies between 20Hz to 20000Hz called audible range

   If frequency < 20Hz it is infrasonics

   If frequency > 20000Hz it is ultrasonics
3. The characteristics of sound waves are

   (a) Amplitude (b) Phase

   (c) Time period (d) Frequency

   (e) Wavelength (f) Intensity
4. If distance is λ phase difference is 2π rad

   If distance is x phase difference is $\phi = \frac{2\pi x}{\lambda}$

   x is called path difference.
5. Distance between a node and immediate antinodes is $\frac{\lambda}{4}$ and distance between any 2 successive nodes or antinodes is $\frac{\lambda}{4}$
6. Stationary waves cannot transfer energy and all particles within a loop are in phase

7. The no. of beats heard per second is called beat frequency and cannot be recognized by human ear if it exceeds 10. It is the difference of two frequencies. $\Delta n = n_1 - n_2$

8. The human ear cannot distinguish between two sounds if it reaches it within a time interval of 0.1s called persistence of hearing

$$\Delta t = \frac{1}{\Delta n} = \frac{1}{10} = 0.1s$$

9. If one of the prongs of a tuning fork is loaded with wax its frequency decreases.

10. On filing one of the prongs of a tuning fork its frequency increases.

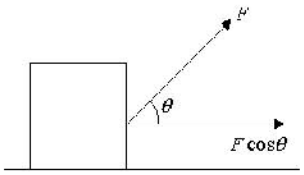
11. The reflection of sound from obstacle is called echo

12. Echo and original sound have same frequency but differ in intensity.

13. Echoes are heard from reflecting surfaces or buildings, surface of water in a well, surface of mountain or cliff.

WORK-POWER-ENERGY

1. When every body is displaced in the directions the force acting on the body, work is said to be done
   Units: S.I. system - Joule
   C.G.S- Erg
   1Joule = 10^{+7} ergs
2. If a force F acts on a body at an angle θ and displaces the body through a distance 'S' work done, $w = (F\cos\theta)s = \vec{F}.\vec{S}$



   When $\theta = 90^0, W = 0$
3. a. The work done is independent of path followed by the body and time taken.
   b. If the work done in moving a body between two given points is independent of path choosen, the force acting on it is a conservative force.
   c. The work done by a conservative force in coming back to same point in closed loop is equal to zero.
   d. If the work done in moving a body between two points is dependent on the path choosen, the force acting on it is called a non-conservative force.
   e. Work done by a non conservative force is equal to force x distance i.e., work done by a non conservation force in a closed loop incoming back to same point it not equal to zero.
4. a. $P = \frac{Fs}{t}$
   b. $P = \frac{w}{t}$
   c. $P = F \times V$
   d. $P = \vec{F} \cdot \vec{V}$
   Power is a scalar. The units of power in SI system are watt.
   1 Horse Power H. P. = 746 watt
5. The power of a machine gun firing 'n' bullets, each of mass 'm' in one second with velocity is
   $p = \frac{1}{2}mnv^2$
6. The capacity of doing work is called energy. It is a scalar, its units are same as those of work.
   SI - Joule
   C. G. S - Erg
   1 K. W. H = $3.6 \times 10^6 J$
7. Energy possesed by a body by virtue of its position or state is known as potential energy.
   a. The P. E. of a body at a height h
      P. E. = mgh, where h is small
   b. The elastic P.E. stored in a compresed spring is
   $$P.E. = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}.\frac{F^2}{K}$$
8. The energy possessed by a body by virtue of its motion is called K.E.
   A flying bird, moving aeroplane, freely falling body, a body moving on an incline, oscillating pendulum posses both P. E. and K. E.
9. The K.E. of a body of mass 'm' moving with velocity 'v' is $E = \frac{P^2}{2m}$
   $E \alpha P^2$ for a given body and $p \alpha \sqrt{E}$
10. If bodies of unequal masses have equal kinetic energies, the heavier body has greater momentum $p^2 \alpha m$ when E is same
11. If bodies of unequal masses have equal momentum the lighter body has greater K. E. $E \alpha \frac{1}{m}$ when P is same.
12. According to law of conservation of energy the total energy of a closed system is constant.
    For a body projected vertically up, the K. E. of projection is equal to P. E. at the maximum height.
13. A body falling from a height 'h' rebounds to a height 'h' from a hard surfac. Energy lost in collision = $mg(h - h^1)$.
14. In perfectly elastic collisions both K. E. and linear momentum is conserved and K. E. is not conserved.
15. A body can have energy without momentum but it cannot have momentum without energy.