PHYSICS HAND BOOK

MECHANICS

1.0 PRINCIPLA SYSTEM OF UNITS

1.1S.I System:

There are seven fundamental quantities and two supplementary quantities in this system shown below:

S.No.	Fundamental quantity	Fundamental unit	Symbol
1.	Mass	Kilogram	Kg
2.	Length	Meter	M
3.	Time	Second	S
4.	Temperature	Kelvin	K
5.	Luminous Intensity	Candela	cd
6.	Electric Current	Ampere	A
7.	Amount of Substance	Mole	m

SUPPLEMENTARY QUANTITY

1.	Plane Angle	Radian	rad
2.	Solid angle	Steradian	sr

1.2 Standard in S.I System

(i) **1 Kg :** (a) A cylindrical proto type mass made of platinum and Iridium alloys of height 39 mm and diameter 39 mm.

(b) It is mass of 5.0188×10^{25} atoms of carbon-12.

(ii) **1 Metre :** It is the distance that contains 1650763.72 wavelength of organe-red light of Kr-86.

(iii) **1 Second :** 1 Second is the time in which cesium atom vibrates 9192631770 times is an atomic clock.

(iv) **1 Kelvin :** 1 Kevlin is the $\frac{1}{273.16}$ part of the thermodynamic temperature of the triple point of water.

(v) **1 Candela :** 1 Candela is $\frac{1}{60}$ luminous intensity of an ideal source by an area of cm^2 when source is an melting point of plantinum (1760^0C).

(vi) **1 Ampere :** 1 Ampere is the electric current which is maintained in two straight parallel conductors of infinite lengths and of negligible cross section areas placed on metre apart in vacuum will produce between them a force 2×10^{-7} newton per meter length.

(vii) **1 Mole :** It is the amount of substance of a system which contains as many elementary entities (may be atoms, molecules, ions, electron or group of particle) as there are atom is 0.012 kg of carbon isotope ${}_6C^{12}$.

Symbol	Prefix	Multiple	Symbol	Prefix	Sub-Multiple
D	deca	10^1	d	deci	10^{-1}
H	hecta	10^2	c	centi	10^{-2}
K	kilo	10^3	m	milli	10^{-3}
M	mega	10^6	μ	micro	10^{-6}
G	giga	10^9	n	nano	10^{-9}
T	tera	10^{12}	p	pico	10^{-12}
P	peta	10^{15}	f	femto	10^{-15}
E	exa	10^{18}	a	atto	10^{-18}

1.3 other Units

(Length)

(i) 1 micron ($1\,\mu$) = 10^{-6}m

(ii) 1 Angstrom unit = 10^{-10}m

(iii) 1 X-ray unit = 10^{-13}m

(iv) 1 Fermi = 10^{-15}m

(v) 1 Light year = 9.45×10^{15}m

(vi) 1 par second (1 par sec) = 3.26 Light year

(vii) 1 astronomical unit = 1.496×10^{11}m

(Mass)

(i) 1 amu (atomic mass unit) = 1.67×10^{-27}m

(ii) 1 Quintal = 100 kg

(iii) 1 meteric tone = 1000 kg = 10 qunital

(iv) 1 Slug = 14.59 kg

(v) 1 kg wt. 9.8 N.

1.4 Other units

(i) 1 Pascal (1 Pa) = 1 N/m^2

(ii) 1 torr = pressure of 1 mm of Hg

(iii) 1 bar = 10^5 N/m

(iv) 1 k naut = $\frac{1\ nautical\ mile}{1\ hour}$ = 0.512m/s

(v) 1 Nautical mile = 1852 m = 6080 ft

(vi) 1 Shake = 10^{-8} sec

(vii) 1 eV (electron volt) = 1.6×10^{-9}J

(viii) 1 kwh (kilo watt hours) = 3.6×10^6j

(ix) 1 barn (b) = 10^{-28} m^2.

(x) Mack number = $\frac{Speed\ of\ aeroplane}{Speed\ of\ sound}$

Physical quantities, their S.I. Units and Dimensional Formulae.

S.No.	Physical quantity	S.I. Unit	Dimensional Formula
1.	Velocity of Speed v = s/t	m/s	$[LT^{-1}]$
2.	Acceleration a = v/t	m/s^2	$[LT^{-2}]$
3.	Momentum p = mv	Kg. m/s	$[MLT^{-1}]$
4.	Impulse I = F.t	Newton sec or Kg. m/s	$[MLT^{-1}]$
5.	Force F = ma	Newton	$[MLT^{-2}]$
6.	Pressure p = F/A	N/m^2 or Pascal	$[ML^{-1}T^{-2}]$
7.	Work W = F.S	Joule	$[ML^2T^{-2}]$
8.	Kinetic Energy E = $\frac{1}{2}mv^2$	Joule	$[ML^2T^{-2}]$
9.	Potential Energy u = mgh or = $\frac{1}{2}kx^2$ or = $\frac{GMm}{r^2}$	Joule	$[ML^2T^{-2}]$
10.	Power p = w/t	Watt or J/s	$[ML^2T^{-3}]$
11.	Density d = M/V	Kg/m^3	$[ML^{-3}]$

2.0 VECTORS, VELOCITY AND ACCELERATION

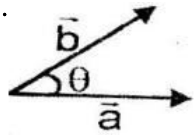
(i) $\vec{a}$ = a . a where $|\vec{a}|$ = a (magnitude of vector) and a = unit vector

(ii) r = $x\hat{i} + y\hat{j} + z\hat{k}$ $|r| = \sqrt{x^2 + y^2 + z^2}$

(iii) θ_x, = $\tan^{-1}\frac{\sqrt{y^2+z^2}}{x}$; $\theta_y = \tan^{-1}\frac{\sqrt{y^2+z^2}}{y}$; $\theta_z \tan^{-1}\frac{\sqrt{y^2+z^2}}{z}$

$\theta_x, \theta_y, \theta_z$ are called direction cosines.

(iv) **Scalar product** of a.b = a.b. cos θ



Thus, = $\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$ = dot product of like unit, vector is 1 and $\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$ dot product of unlike unit vector = 0.

(v) **Cross product** of a×b = |a| |b| sin θ = ab sin θ and (a×b)= - (b×a) ; $\hat{i} \times \hat{j} = \hat{k}\ \hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$; $\hat{j} \times \hat{k} = \hat{i}$; . $\hat{k} \times \hat{i} = \hat{j}$ Cross product of any two unit vector in order is equal to third one.

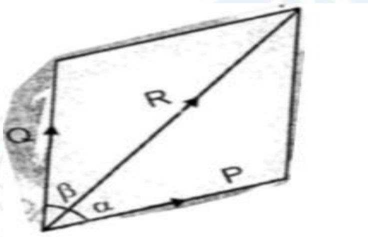
(vi) $a = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$

$b = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$

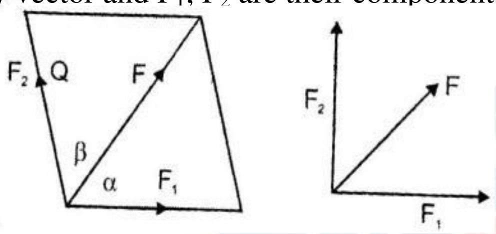
then $a \times b = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}$

(vi) **Resultant of any two vectors**

$R^2 = P^2 + Q^2 + 2PQ\cos\alpha$ and $\tan\theta = \frac{Q\sin\alpha}{P+Q\cos\alpha}$



(viii) If F be any vector and F_1, F_2 are their components at angles α and β , then



$F_1 = \frac{F\sin\beta}{\sin(\alpha+\beta)}$ and $F_2 = \frac{F\sin\alpha}{\sin(\alpha+\beta)}$

If F_1 and F_2 be ⊥ to each other, then $F_1 = F\cos\alpha$ and $f_2 = F\sin\alpha$

(ix) Application of vectors in Physics

(a) Position vector ($\vec{r}$) of point A (x,y,z) : $r_A = x\hat{i} + y\hat{j} + z\hat{k}$

(b) Displacement vector ($\vec{r}_{AB}$) from point A (x_1, y_1, z_1) to $B(x_2, y_2, z_2)$

$$\vec{r}_{AB} = \vec{r}_B - \vec{r} = (x_2 - x_1)$$
$$= \hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$$

(c) Relative velocity $\vec{v}_{AB} = \vec{v}_B - \vec{v}_A$

(d) Work, $W = \vec{F}.\vec{r}$

(e) Power $p = \vec{F}.\vec{v}$

(f) Lorentz force $\vec{F} = q(\vec{E} + \vec{V} \times \vec{B})$

(g) Area of a triangle $= \frac{1}{2}|\vec{A} \times \vec{B}|$

(h) Area of parallelogram $= |\vec{A} \times \vec{B}|$

(i) Volume of a parallelepiped $= \vec{A}(\vec{B} \times \vec{C})$

(j) Gradient operator

$$V = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z} = \vec{E} = -V\phi$$

2.1 (i) Instantaneous velocity $(v_i) = \frac{ds}{dt}$

(ii) **Average velocity** $(v_a) = \frac{Total\ displacement}{total\ time\ taken}$

(iii) **Average speed** $= \frac{Total\ distance\ trvelled}{total\ time\ taken}$

(iv) **Change in velocity** (Δv) = Final velocity (v_2)-Initial velocity (v_1)

(v) **Instantaneous acceleration** $(a_i) = \frac{dv}{dt} = \frac{d}{dt} = (\frac{ds}{dt}) = \frac{d^2s}{dt^2}$

2.2 Equation of Motion

(i) $v = u + at$, u = initial velocity, v = Final velocity after time t

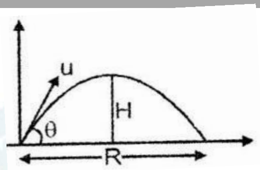
(ii) $s = ut + 1/2\ at^2$, s = distance travelled in time t

(iii) $v^2 = u^2 + 2as$, a = uniform acceleration of body

(iv) $S_n = u + a/2\ (2n-1)$ distance travelled in n^{th} second.

3.0 PROJECTILE MOTION

(i) Time to reach the maximum height $= \frac{u sin\theta}{g}$



(ii) **Total time of flight** $= \frac{2u sin\theta}{g}$

(iii) **Greatest height attained H** $= \frac{(u sin\theta)^2}{2}$ and $H_{max} = \frac{u}{2g}$

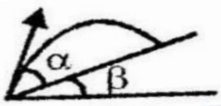
(iv) **Horizontal range** $R = \frac{u^2 sin2\theta}{g}$ and $R_{max} = \frac{U^2}{2g}$

(v) A height 'h' if v be velocity,, then $v^2 = u^2 - 2gh$ and α be dirn, then $\tan\alpha = \frac{\sqrt{u^2 sin^2\theta - 2gh}}{u\cos\theta}$

(vi) Eqn trajectory $y = x\tan\theta = \frac{gx^2}{2u^2cos^2\theta}$ is parabola.

(vii) **Inclined plane** : If β be inclination of plane and α is angle of projection, then time of Flight

$$T = \frac{2u sin(\alpha-\beta)}{g cos\beta}$$



Range of plane $= \frac{2u^2\ sin(\alpha-\beta)cos\beta}{g cos^2\beta}$

(viii) **Projectile thrown parallel to the horizontal**

(a) Equation, $y = \frac{1}{2} g \frac{x^2}{u^2}$

$u_x = u;\ v_x = u$

$u_y = 0;\ v_y = gt$ (downward)

$= -\ gt$ (upward)

(b) Velocity at any time

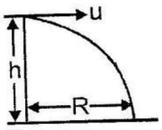
$$V = \sqrt{u^2 + g^2t^2}$$

$$\tan \alpha = \frac{v_y}{v_x}$$

(c) Displacement

$$s = x\hat{i} + y\hat{j} = ut\hat{i} + \frac{1}{2} gt^2\hat{j}$$

(d) Time of flight $T = \sqrt{\frac{2h}{g}}$



(e) Horizontal Range $R = u\sqrt{\frac{2h}{g}}$

4.0 CIRCULAR MOTION

(i) Centripetal or radial Acceleration $a_r = \frac{v^2}{r} = r\omega^2$

(ii) Tangential Acceleration at $= \frac{dv}{dt} = r\frac{d\omega}{dt} = r\,\alpha$, where α = Angular Acceleration,

(iii) Instantaneous Acc. $A = \sqrt{a_r^2 + a_T^2}$

(iv) Centripetal force $= \frac{mv^2}{r} = mr\omega^2 = 4\pi n^2 rm$

(v) Banking of a road $\tan \theta = \frac{v^2}{rg}$

(vi) Maximum speed without overturning $v = \sqrt{\frac{gra}{h}}$

Where 2a distance between wheel and h is height of C.G.

(vii) To avoid slipping $v \leq \sqrt{\mu rg}$

(viii) Vehicle will overturn first if $\sqrt{\frac{gra}{h}} < \sqrt{\mu rg}$ or $\sqrt{\frac{a}{h}} > \sqrt{\mu}$

(x) To perform complete revolution in vertical plane $u \geq \sqrt{5rg}$ and T = 6 mg at lower point.

(xi) At horizontal points minimum velocity $v = \sqrt{3rg}$ and T = 3mg

(xii) For tension general eq^n $T - mg - \cos\theta = \frac{mv}{r}$

(xiii) **Newton's equation in circular motion**

(a) $\omega\ \omega_0 + \alpha t$

(b) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

(c) $\omega^2 = \omega_0^2 + 2\,\alpha\theta$

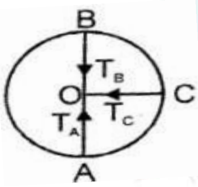
(xiv) **Vertical circular motion in case of string**

(a) $T_A = \frac{mv^2A}{l} + mg$

(b) $T_B = \frac{mv^2A}{l} - mg$

(c) **Tenstion at point C**

$TC = \frac{mv^2C}{l}$



(xv) The minimum velocity at which the circular motion is possible

$V_A$at A = $\sqrt{5gl}$

$V_B$at B = $\sqrt{gl}$

$C_C$at C = $\sqrt{3gl}$

In the case of circular velocity

$T_A = 6mg$

$T_B = 0$

$T_C = 3mg$.

5.0 NEWTON'S LAW OF MOTION.

(i) Force F = ma

Linear momentum P = m.v or f. Δt = Δ (mv).

(ii) wt. of body in lift:

(a) If lift is stationary or moving with constant velocity Apparent wt. = Actual wt. = mg

(b) When lift is accelerated upward, apparent wt. = m (g +a)

(c) When lift is accelerated downward, appearent wt. = m (g - a)

(d) Accelerated downward such that a > g apparent wt. = -ve so man accelerated upward and will stay.

(iii) **Motion on frictionless pulleys**.

For fig. (1) Acc. (a) = $\frac{(m_2-m_1)g}{(m_1+m_2)}$

Where $m_2 > m_1$

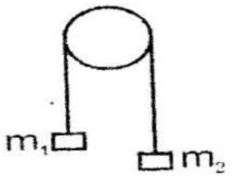


fig 1

Tension T = $\frac{2m_1 m_2 g}{(m_1+m_2)}$

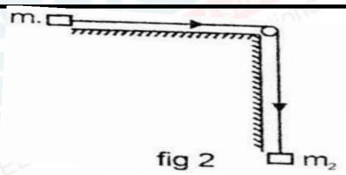


fig 2

For fig. (2) Acc. (a) = $\frac{m_1 m_2 g}{(m_1+m_2)}$

For Fig (3) when $m_2 > m_1$

$M_2g - T_2 = m_3.a$

$T_1 - m_1g = m_1a$:

$T_2 - T_1 = m_3.a$

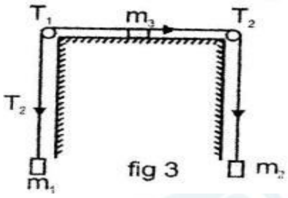


fig 3

6.0 WORK POWER AND ENERGY

(i) **Rate of doing work = power**

$$P = \frac{\Delta W}{\Delta t} = F \times v$$

(ii) **K.E.** = $\frac{1}{2}mv^2$, **potential energy u** = $-\int_{r_0}^{r} F.\,dr$

(iii) **Gravitational P.E.=mgh**, (referred at earth surface P.E. = 0) = $\frac{GMm}{r}$ (referred to zero P.E. at infinity)

(iv) K.E./(E) = $\frac{P^2}{2m}$ or P = $\sqrt{2mE}$

(v) **For elastic collision**

$v_2 = \left(\frac{2m_1}{m_1+m_2}\right) u_1$ and $v_1 = \left(\frac{m_1-m_2}{m_1+m_2}\right) u_1$

(vii) **For inelastic collision, coefficient of restitution** e = $\left(\frac{v_1-v_2}{u_1-u_2}\right)$ and

Loss of energy

$$\Delta E = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 m_2}\right)(e^2-1)\,(u_1-u_2)^2$$

(viii) **Units** : for work : joule (MKS), erg (C.G.S), 1 j = 10^7 erg. Power: joule/sec (watt) (M.K.S.), erg/sec (C.G.S) and in F.P.S.., Horse power (H.P). Where 1 H.P. = 550 × 32.2 ft lb/sec = 746 watt.

(ix) **Conservative and Non-conservative forces**

(a) Work done is path independent.

(b) In a closed path network done is zero.

(c) Potential energy is defined only for conservative foces.

(d) In only conservative force are acting on a system, its mechnaical energy should remain constant.

(xi) **Relation between potential energy (U) and conservative force ($\vec{F}$)**

(a) If U is function of only one variable, then

$$F = -\frac{du}{dr} = -\text{ slope of U}-\text{r graph}$$

(b) If U is a function of three coordinate variables x, y and z then

$$F = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right]$$

7.0 ROTATORY MOTION AND CENTRE OF MASS

(i) **C.M. :** Where whole mass may be supposed to be concentrated

$$x = \frac{m_1x_1+m_2x_2+m_3x_3 \ldots\ldots}{m_1+m_2+m_3+\cdots\ldots\ldots} = \frac{\Sigma m_n x_n}{\Sigma m_n}$$

$$y = \frac{m_1y_1+m_2y_2+m_3y_3 \ldots\ldots}{m_1+m_2+m_3+\cdots\ldots\ldots} = \frac{\Sigma m_n y_n}{\Sigma m_n}$$

(ii) **Angular momentum L** = $mr^2\omega = I\,\omega$

(iii) **Torque J** = $\frac{\Delta L}{\Delta t}$

If Torque J = 0, L = $I_1\,\omega_1 = I_2\omega_2$

(iv) **Radius of gyration** K = $\sqrt{I/m}$

(v) **Theorems on M.I**

(a) Parallel axes theorem $I = I_G + M.H^2$

(b) Perpendicular axes theorem $I_Z = I_x + I_y$

(vi) **Rolling down on an inclined plane**

Transactional	**Motion**	**Rotation**	**Motion**
Displacement	= s	Angular displacement	= θ
Velocity	= v	Angular velcoity	= ω
Accleration	= a	Angular Accleration	= α
Inertial mass	= m	Momentum of Inertia	= I
Force	= F	Torque	= J
Momentum	= m.v	Angular momentum	= I ω
Power	= F.v	Rotation power	= I. ω

Rotational K.E

$= \frac{1}{2}mv^2$ $= \frac{1}{2}\omega^2$

Linear impulse $= F\,\Delta t$ K.E $= J\Delta t$

Angular impulse

Velocity (v) = $\frac{\sqrt{2g\sin\theta}}{1+\left(\frac{K^2}{R^2}\right)}$

and Accleration (a) = $\frac{g\sin\theta}{1+\left(\frac{K^2}{R^2}\right)}$

Where θ is inclindation of plane.

(vii) **Total energy of a rolling body** = $\frac{1}{2}$ mv^2 + $\frac{1}{2}$ I ω^2

(viii) **Angular displacement θ** = $\frac{\text{arc}}{\text{radius}} = \frac{s}{r}$ radian

(ix) **Angular velocity**

Avery angular velocity

$$\bar{\omega} = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta Q}{\Delta t.} \text{ rad/s}$$

Instantaneous angular velocity $\omega = \frac{dQ}{dt}$ rad/s

$$\omega = 2\pi n = \left(\frac{2\pi}{T}\right)$$

(x) **Angular acceleration**

Average angular acceleration

$$\bar{\alpha} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t} \text{ rad/s}^2$$

Instantaneous angular acceleration

$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2} \text{ rad/s}^2$$

(xi) $v = \omega r = 2\pi n r = \frac{2\pi r}{T}$, $\vec{v} = \vec{w} \times \vec{r}$ (relation between linear velocity and angular velocity)

(xii) $a = \frac{dv}{dt} = r\frac{d\omega}{dt}$ $r\alpha$

$$\vec{a}_r = \vec{\alpha} \times \vec{r},\ \vec{a}_r = \vec{\omega} \times \vec{v},\ \vec{a} = \vec{a}_t + \vec{a}_r$$

8.0 SIMPLE HARMONIC MOTION AND PENDULUM

(i) **In SHM**, Acc α: displacement (y) and y = a sin $(\omega t + \phi)$

a = amplitude $(\omega t \pm \phi)$ = phase and ϕ = epoch of initial phase.

(ii) **At mean point y** = 0, and at time t, y = a sin $\omega\, t$

(iii) **velocity v** = a $\omega\cos(\omega t + \phi) = \omega\sqrt{a^2 - y^2}$ and when y = $\pm a$, vmax = a $\omega t + \phi)$ aty = 0, Acc. (a) = 0 → ω a = - $\omega^2 y, y = \pm a, Acc.(a) = \pm a\omega^2$

(v) **Total energy** = KE + PE + $\frac{1}{2}$ m $\omega^2 a^2$(constant)

KE = $\frac{1}{2}$ m $\omega^2(a^2 - y^2)$ and PE = $\frac{1}{2}$ m $\omega^2 y^2$

(vi) **Time period of oscillating spring** T = $2\pi\sqrt{\frac{(m+m_3/3}{K}}$

M = mass suspended

m_s = mass of spring

If springs are in series T = $2\pi\sqrt{\left(\frac{1}{K_1} + \frac{1}{K_2} + \cdots\right)}$

If springs are parallel $T = 2\pi\sqrt{\frac{m}{k_1+k_2+k_3+\cdots}}$

(vii) **simple pendulum** $T = 2\pi\sqrt{\frac{L}{g}}$, in a lift $T = 2\pi\sqrt{\frac{L}{g}}$, (normal)

$T = 2\pi\sqrt{\frac{L}{g+a}}$ (lift ascending)

$T = 2\pi\sqrt{\frac{L}{g-a}}$ (lift descending)

(viii) **Compound pendulum** $T = 2\pi\sqrt{\frac{I^2+K^2}{Lg}}$

L = distance of C.G. from support.

(ix) **Conical pendulum** $T = 2\pi\sqrt{\frac{L\cos\theta}{g}}$

(x) **torsional pendulum** $T = 2\pi\sqrt{\frac{L}{Mgd}}$

(xi) **Potential energy in S.H.M**

$PE = \frac{1}{2}ka^2\sin^2(\omega t + \phi)$

$(PE)_{max} = \frac{1}{2}ka^2 = \frac{1}{2}m\omega^2a^2$

$(PE)_{min} = 0$

(xii) **Total energy in S.H.M** $E = KE + PE = \frac{1}{2}ka^2 = \frac{1}{2}m\omega^2a^2$

(xiii) Period of oscillation of mass joined to a spring $t = 2\pi\sqrt{\frac{m}{k}}$ where k is spring constant

(xiv) Spring constant (k) $k \propto \frac{1}{l}$, is springs cut in two parts I_1 and I_2, then $k_1 = \frac{I}{I_1}k = \frac{I_1+I_2}{I_1}k$, $k_2 = \frac{I_1+I_2}{I_2}k$

If spring cut in to n equal parts then spring constant of each part will be k' = nk.

(xv) **Spring in parallel**

$K' = k_1 + k_2 + \ldots\ldots\ldots + k_n$

$T' = 2\pi\sqrt{\frac{m}{k'}}$, for n identical springs k' = nk

$T' = \frac{T}{\sqrt{n}}$, T → Time period due to one spring only.

(xv) **Two masses connected by two ends of a spring**

$T = 2\pi\sqrt{\frac{\mu}{k}}$

$\mu = \frac{m_1m_2}{m_1+m_2}$ = Reduced mass

(xvii) **Oscillation of a liquid in aU-tube**

$T = 2\pi\sqrt{\frac{h}{g}}$; h is vertical height of liquid column

(xviii) **Oscillation of floating body cylindrical body** $T = 2\pi\sqrt{\frac{m}{adg}} \Rightarrow 2\pi\sqrt{\frac{h}{g}}$

Rectangular body $T = 2\pi\sqrt{\frac{h}{g}}$

Where, d-density of liuid

A → cross sectional area

M → mass of a body

H → a height of block or cylinder inside the liquid

(xix) **Period of a simple pendulum** $T = 2\pi\sqrt{\frac{R}{g(1+\frac{R}{I})}}$

(xx) **Second pendulum**

T = 2 second, I = 96 cm

(xxi) **Conical pendulum**

$$T = 2\pi\sqrt{\frac{r}{g\tan\theta}}$$

$$= 2\pi\left[\frac{\sqrt{L^2-r^2}}{g}\right]^{1/2} = 2\pi\sqrt{\frac{I}{g}}$$

(xxii) Period in a reference frame moving with an acceleration 'a' in a horizontal plane.

$$T = 2\pi\left[\frac{I}{\sqrt{g^2+a^2}}\right]^{1/2}$$

(i) **Newton's Law of Gravitation** $F = G\,\frac{m_1 m_2}{r^2}$

(ii) **At earth surface Acc. Due to gravity** $g\,\frac{GM}{R^2}$, R = Radius

(iii) **At height** h, $g' = g\left(1+\frac{H}{R}\right)^2$ Acc $_{\text{due to gravity}}$ decreases in

(iv) **AT depth** $g' = g\left(1-\frac{h}{R}\right)$

(v) Due to rotation earth $g' = g - R\omega 2 \cos 2\lambda \cdot \lambda$ = Latitude of body, ω= earth angular velocity, difference of g, $\Delta g = g_p = g_e = R\omega^2 = 0.34$ m/s^2

(vi) **Gravitional field strength (Gravitational intensity)** $I = \frac{GM}{r^2}$ (Force on unit mass)

(vii) **Gravitational potential,** $V = \frac{GM}{r}$ and $I = \frac{dv}{dr}$

(viii) **Gravitational potential energy,** $U = \frac{GMm}{r}$

(ix) **Escape velocity,** $v_e = \frac{\sqrt{2GN}}{R} = \sqrt{2Rg}$

(x) **Time period of a statllite** T = $\frac{2\pi(R+h)}{R} = \sqrt{\frac{(R+h)}{g}}$, h = height

(xi) **K.E. of a satellite** = $\frac{GMm}{2r}$ and Pe = - $\frac{GMm}{r}$ where r = R + h, total energy E = $\frac{GMm}{2r}$

(xii) **Satellite revoling near earth surface** $v_0 = \frac{\sqrt{GM}}{R}$ $v_e = \sqrt{2} \times V_0$

(xiii) **Kepler's Law** $T^2 \alpha R^3$ or cube or semi major axis.

(xiv) **Variation of g**

(a) Altitude (height) effect g' = $g\left(1 + \frac{h}{R}\right)^{-2}$ If h << R then g' = $g\left(1 - \frac{h}{R}\right)$

(b) Effect of depth g" = $g\left(1 - \frac{d}{R}\right)$

(c) Latitude effect due to roation of earth $g_\lambda = g - \omega^2 R_e \cos^2\lambda$ due to shape of earth $R_E - R_P$ = 2km $g_E < g_P$

(xv) **Orbital velocity of a satellite** $v_0 = \sqrt{\frac{Gm}{R}} = \sqrt{gR}$ = 8km/sec

(xvi) **Velocity of prjection** $V_p = \left[\frac{2GMh}{R(R+h)}\right]^{1/2} = \left[\frac{2gh}{1+\frac{h}{g}}\right]^{1/2}$ ($\therefore Gm = gR^2$)

(xvii) **Kepler's Laws**

(a) **First Law** : Each planet moves in an elliptical orbit with the sun at one focus of the ellipse

(b) **Second Law** : the radius vector, drawn from the sum of a planet, sweeps out equal areas in equalt time internal ie, areal velocity is constant.

This law is derived from law of conservation of angular momentum. $\frac{dA}{dt} = \frac{L}{2M}$ = constant

Here L is angular momentum and m is mass of planet. c) third law : $T^2 \propto r^3$, where r is semi-major axis of elliptical path.

10. ELASTICITY

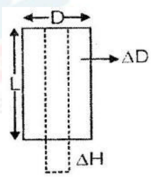
(i) **Strees** = $\frac{R}{A} = \frac{F}{A}$ unit $\frac{N}{m^2}$ Strain = $\frac{\text{Change in some measure}}{\text{Total measure}}$

(ii) **Hooke's Law** Stress = e × strain

(iii) **Young's modulus,** y = $\frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{\frac{F}{A}}{\frac{\Delta V}{V}} = \frac{F.L}{A.\Delta L}$

(iv) **Bulk Modulus,** K = $\frac{\text{Volume stress}}{\text{Volume strain}} = \frac{\frac{F}{A}}{\frac{\Delta V}{V}} = \frac{\Delta PV}{\Delta V}$

(v) **Shear of Modulus of rigidity** $(\eta) = \frac{\text{Shearing stress}}{\text{shearing strain}} = \frac{F}{A \times \theta}$



(vi) **Poisson's ratio,** $\sigma = \frac{\text{Lateral strain}}{\text{Longitudin al strain}} = \frac{\Delta D/D}{\Delta L/L}$, D = diameter of wire

(vii) **Compressibility** $\beta = \frac{1}{K}$

(viii) **Safety factor** = $\frac{Breaking\ stress}{Working\ stress}$

(ix) **P.E. stored or work done** = $\frac{1}{2}$ stress × strain × volume

(x) **Relation between Y, K,** η and σ Y = eK (1 – 2 σ) and Y = 2η (1 + σ)

(xi) By change of temp. $\Delta\theta$, the compression or tension produced F = y. A α $\Delta\theta$, and v = $\sqrt{\frac{y.a.\Delta\theta}{d}}$, α = coefficient of linear exp., d = diensity, ∂= velocity of mechanical wave.

(xii) **Interatomic force constant** K = Yr_0 r_0 = distance between two atoms.

(xiii) **Modulus or Rididity** (η) $\eta = \frac{stress}{Shear\ strain} = \frac{F/A}{\phi} = \frac{F}{A\phi} = \frac{FL}{Al}$

(xiv) **Possion's Ratio**

(a) $\sigma = \frac{Transverse\ or\ lateral\ strain}{Longitudinal\ strain} = \frac{\beta}{\lambda}$

(b) The value of σ lies between -1 and 0.5.

(c) $\sigma = \frac{1}{2}\left[1 - \left(\frac{\Delta V}{V}\right)\left(\frac{L}{\Delta L}\right)\right] = \frac{1}{2}\left[1 - \frac{\Delta V}{A\Delta L}\right]$

(xv) **Relation among various elastic constants**

(a) $\gamma = \left(\frac{9\eta k}{\eta+3k}\right)$

(b) $\sigma = \frac{\gamma}{2\eta} - 1$

(c) $\sigma = \frac{3K-2\eta}{6K+2\eta}$

(d) $\frac{9}{K} = \frac{3}{\eta} + \frac{1}{K}$

(xvi) **Thermal stress** Tension = $\gamma A\alpha(t_2 - t_1) = \gamma A\alpha\Delta t$

(xvii) **Torsion Constant of wire**

(a) C = $\frac{\pi\eta r^4}{2l}$

(b) Torque required for twisting $t = c\theta$

(c) Work done in twisting by an angle θ w = $\frac{1}{2}$ cθ^2

(xviii) **Frequency of vertical oscillation of loaded wire** n = $\frac{1}{2\pi}\sqrt{\frac{\gamma A}{mL}}$

(xix) **Work done in stretching a wire** w = $\frac{1}{2}$Fl

12. SURFACE TENSION,

(i) **Surface tension,** T = $\frac{F}{l}$ unit → $\frac{N}{M}$ or Surface tension, T $\frac{W}{\Delta A}$ unit → $\frac{J}{m^2}$ Surface enegy = $\frac{W}{A} = \frac{J}{m^2}$

(ii) **Excess of pressure** p = 2T $\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$ For spherical soap bubble $r_1 = r_2$ =r, so p = $\frac{4T}{r}$ For liquid drop and air bubble p = $\frac{2T}{r}$

(iii) Rise or fall of liquid in a capillary tube of radius r, T = $\frac{rhdg}{2cos\theta}$, θ = angle of contact, so h = $\frac{2Tcos\theta}{rdg}$

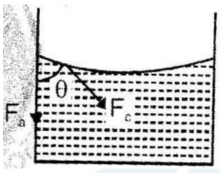
(iv) **Jurin's Law** h $\propto \frac{1}{r}$ or hr = constant.

(v) **Shape of meniscus**

(a) $F_a = \frac{F_c}{\sqrt{2}}$, plane, $\theta = 90^0$

(b) $F_a = \frac{F_c}{\sqrt{2}}$, convex , $\theta > 90^0$

(c) $F_a = \frac{F_c}{\sqrt{2}}$, convave , $\theta < 90^0$



(vi) **Radius of curavture3e of common surface of two bubbles in contact** r = $\frac{r_1 r_2}{r_2 - r_1}$

(vii) **Radius of bubble formed when two bubbles coalesce** r = $\sqrt{r_1^2 + r_2^2}$

(viii) **Work doen in blowing a bubble** w = $8\pi T(r_1^2 + r_2^2)$

(ix) Breaking of a big drop in n droplets n = $\frac{R^3}{r^3}$ increase in area $\Delta A = 4\pi(nr^2 = R^2)$, W = $4\pi TR^3\left(\frac{1}{r} - \frac{1}{R}\right)$

fall in temperature $\Delta\theta = \frac{3T}{\sqrt{sd}}\left(\frac{1}{r} - \frac{1}{R}\right) \Rightarrow \Delta\theta$

(x) Liquid film between parallel plates F = $\frac{2AT}{t}$ (Required to separate the plates)

(xi) Rise of liquid between two plates h = $\frac{2T\,cos\theta}{dg\,t}$ t – width of plate.

1.2 FLOW OF LIQUIDS AND VISCOSITY

(i) Eqn. of continuity, $a_1 \times v_1 = a_2 \times v_2$ or a.v. = constant

(ii) **Bernoulli's theorem**, $P + \frac{1}{2}pv^2 + pgh$ = constant

(iii) **For torricelli's theorem, velocity of efflux**, v = $\sqrt{2gh}$

(iv) **Newton's formula, viscous force**, F = $-\eta A\frac{\Delta v}{\Delta x}$

(v) **For stream line flow**, $v < v_0$, where $BV_c = \frac{k.\eta}{p.\gamma}$; k = reynold number

(vi) **Poiseulli's formula**, rate of flow of liquid v = $\frac{\pi pr^4}{8\eta l} = \frac{P}{R}$

P → pressure, difference across capillary of length I and radius r, R = $\frac{8\eta l}{\pi r^4}$ =fluid resistance.

For capillaries in series $v_1 = v_2$, $p_1 + p_2$ and R = $r_1 + R_2$

For capillaries in parallel, v = $v_1 + v_2$, P = $p_1 = p_2$ and $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

(vii) **For Venturimeter**, Q = $a_1v_1 = a_1a_2\sqrt{\frac{2gh}{a_1^2 - a_2^2}}$

(viii) **Stoke's Law** f = $6\pi\eta av$, v = terminal velocity and $\eta = \frac{2}{9}\frac{a^2t(\rho - \sigma)g}{s}$, where for distance s time taken to fall is t.

13. HYDROSTATICS

(i) **Relative density** = $\frac{Density\ of\ substance}{Density\ of\ water\ at\ 4^0C} = \frac{wt. of\ body\ in\ air}{loss\ of\ wt. of\ body\ in\ water}$

(ii) **Apparent wt**. = Actual wt. – Force of buoyancy= mg- Vpg or = mg $\left(1-\frac{p}{p}\right)$, p' = density of solid, p = density of liquid.

(iii) **Specific gravity or relative density** (s) = $\frac{W}{W-W_1}$ w and w_1 = wt. of body in air and liquid.

(iv) Archimede's prnicIple

According to this principle when a body is immersed wholly or partly in a liquid at rest, it losses some of its weight. The loss in weight of the body in the liquid is equal to the weight of the liquid displaced by the immersed part of the body. Let the true weight of the body be W_b then $w_b = m_b g = v_b \sigma_b g$ weight of the liquid displace $w_L = m_L g = v_L \sigma_L g$ the observed weight of the body $w = w_b - w_L = (v_b\sigma_b - v_L\sigma_L)g$

(v) **Laws of flotation**

(a) $\sigma_b > \sigma_L$ the body will sink to the bottom of the liquid.

(b) $\sigma_b < \sigma_L$ the body will rise above the surface of liquid to such an extent that the weight of the liquid displaced by immersed part of the body becomes equal to the weight of the body

(vi) $\sigma_b = \sigma_L$ in this resultant acting on the body fully immersed in liquid is zero. The body is at rest anywhere within the liquid.

HEAT

(i) **Temperature** – The average K.E. of molecule = heat potential in a body.

(ii) $\frac{Reading\ on\ any\ scale - Lower\ fixed\ point}{Fundamental\ interval\ (upper\ fixed\ point - Lower\ fixed\ point)}$ = constant or $\frac{C-O}{100} = \frac{F32}{180} = \frac{R-0}{80} = \frac{K-273}{100} = \frac{Ra-492}{180}$ Ra = Ranking scale, R= reumer scale or $\frac{\Delta C}{5} = \frac{\Delta F}{9} = \frac{\Delta R}{4} = \frac{\Delta K}{5} = \frac{\Delta Ra}{9}$

(iii) **For constant volume gas thermo**, t = $\frac{P_t - P_0}{P_{100} - P_0} \times 100$ **For platinum resistance thermo**, t = $\frac{R_t - R_0}{R_{100} - R_0} \times 100$

(iv) **Correction for resistance thermometer**, t' = t = $\delta \left[\left(\frac{t\prime}{100}\right) 2 - \frac{t\prime}{100}\right]$ where t = correct temp. by gas thermometer, = δ 1.5 for platinum.

(v) **Coefficient of expansion** $\alpha = \frac{l_t - l_0}{l_0 \times \Delta t}, \beta = \frac{A_t - A_0}{A_0 \times \Delta t}, \gamma = \frac{V_t - V_0}{V_0 \times \Delta t}$

(vi) **For isotropic solid** $\alpha : \beta : \gamma = 1 : 2 : 3$.

(vii) **Density** $d_r = d_0\ (1 - \gamma\Delta t)$

(viii) $\gamma_r = \gamma_a + \gamma_g$

γ_r = coefficient of real expansion,

γ_g = coefficient of vessel,

γ_a = Coefficient of apparent expansion

(ix) **For water volume coefficient below** 4^0C = - ve and above 4^0C = +ve

(x) **Thermocouple thermometer**, e = At +Bt^2

CALORIMETRY

(i) **Unit of Heat**, C.G.S. = Calorie M.K.S = kilo calorie, 4.2 Joule = 1 calorie S.I. = Joule, 4.2 × 10^3 I = 1 k calorie F.P.S. = B.T.U., THERM, C.H.U., 1 BT.U = 252 cals, 1 C.H.U. = 453.6 cals, 1 THERM = 10^5 B.T.U.

(ii) **Sp. Heat capacity** or Sp. Heat s = $\frac{H}{m\times\Delta\theta}$ Unit = K. cal/kg × ^0C

(iii) Thermal capacity or Heat capacity = ms unit = J/K or K cal/^0C

(iv) **Water equivalent** = ms, SI unit = kg

(v) **Latent heat of fusion** (L) = $\frac{H}{m}$ = 80 cal/gm = 3.35 × 10^5 J/kg (for ice)

(vi) **Latent heat of vapourisation** (L) = $\frac{H}{m}$ = 540 cal/gm = 2260 × 10^3 J/kg (water)

(vii) Q = ms$\Delta\theta$=C$\Delta\theta$, when temperature changes without change in state.

(viii) Q=mL, when state changes without change in temperature

(ix) S= specific heat of any substance = heat required to increase the temperature of unit mass by 1^0C or 1k.

(x) C = heat capacity of a body ms = heat required to increase the temperature of whole body by 1^0C or 1k.

(xi) Specific heat of water is 1 $calg^{-10}$ C between, 14.5^0C and 15.5^0C.

(xii) L= latent heat of any substance = heat required to covert unit mass of that substance from one state to another state.

(xiii) Water equivalent of a vessel is mass of equivalent water which takes same amount of heat as taken by the vessel for same rise of temperature.

KINETIC THEORY OF GASES, ISOTHERMAL, ADIABATIC CHANGE

(i) **Pressure exerted by an enclosed gas** P= $\frac{1}{3}$ pC^2 = $\frac{1}{3}\frac{mn}{v}$ C^2 where p =density, n = no. of molecules, m = mass of one molecule, C = root mean square velocity.

(ii) **Average K.E.** of 1 gm mole of gas $\frac{1}{2}$ MC^2 = $\frac{3}{2}$RT

(iii) **Average K.E.** of 1 molecule = $\frac{1}{2}$MC^2 = $\frac{3}{2}$kT, where k = $\frac{R}{N}$

(iv) **For a gas** C= $\sqrt{\frac{3RT}{m}}$, So C2 ∝ T or $\frac{C_1^2}{C_2^2} = \frac{T_1}{T_2}$

(v) **For different gases** $\frac{C_1^2}{C_2^2} = \frac{M_2T_1}{M_1T_2}$

(vi) For ideal gas of 1 mol PV = RT; for n mole of gas PV = nRT, for n molecule of gas PV =nKT

(vii) **For real gas, vander waal gas eqn.** $\left(P + \frac{a}{V^2}\right)$ (V-b) = RT **Critical temperature** $T_c = \frac{8a}{27Rb}$

Critical press, $P_c = \frac{a}{27b^2}$ and **critical volume**, $V_c = 3b$, Boyle's temperature $T_b = \frac{a}{bR}$

(viii) **Mayer's relation** $C_p - C_V = R$

(ix) For isothermal process of perfect gas PV = constant at given T, for adiabatic process, PV? = constant, $TV^{\gamma-1}$ = constant, $T^r.P^{1-r}$ = constant.

(x) Work done in expansion from V_1 to V_2, W= $\int_{V_1}^{4/2} P.dV$

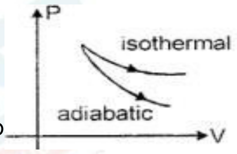
(xi) **For isothermal process** W = nRT $\log_e\left(\frac{V_2}{V_1}\right)$ = 2.303 nRT $\log_{10}\left(\frac{V_2}{V_1}\right)$ or nRT $\log_e\left(\frac{P_1}{P_2}\right)$ = 2.303 nRT $\log_1 0\left(\frac{P_1}{P_2}\right)$

For adiabatic process W = $\frac{1}{1-\gamma}$ (P_2V_2 - P_1V_1) = $\frac{nR}{1-\gamma}(T_2 - T_1)$

(xii) **Slope of process on PV diagram isothermal process** $\left(\frac{dp}{dv}\right)_t = \frac{P}{v}$ **adiabatic process** $\left(\frac{dP}{dv}\right)_s = \gamma\frac{P}{V}$

Isobaric process $\left(\frac{dp}{dv}\right)_p = 0$

Isochoric process $\left(\frac{dp}{dv}\right)_v = \infty$



(xiii) **Heat engine efficiency** $\eta = \frac{w}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1\frac{Q_2}{Q_1}$. For carnot cycle $\left(\frac{Q_2}{Q_1} = \frac{T_1}{T_2}\right)$ **Refrigerator, coefficient of performance**, cop $(\beta) = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$ carnot refrigerator $\beta = \frac{T_2}{T_1 - T_2}$ Q_2 = heat extracted from cold reservoir, W= external work done, Q_1 = heat rejected

(xiv) (a) **for monoatomic gases**, f = 3, $C_v = \frac{3}{2}R$, $C_p = \frac{5}{2}R$, γ= 5/3 = 1.67

(b) **For diatomic gases** f = 5, $C_V = \frac{5}{2}R$, $C_P = \frac{7}{2}R$, γ=7/5 =1.4

(c) **For triatomic or polyatomic gases** f = 6, C_V =3R, C_P = 4R, γ=4/3 =1.33 $\gamma = \frac{2+n}{n}$; n = degree of freedom

(xv) **General properties of gases**

(a) Gases have low density

(b) Gases are homogensous

(c) Gases are capable of indefinite of expansion and also highly compressible.

(d) Gases are capable of undergoing spontaneous intermixing

(e) Gases can liquefied at low temperature and high pressure.

(xvi) **Gas law**

(a) **Boyle's law** $V\alpha\frac{1}{P}$ $V = \frac{K}{P}$ Pv = k, ($P_1V_1 = P_2V_2$)

(b) **Charle's law** V ∝ T V = KT $\frac{V}{T}$= L $\left(\frac{V_1}{T_1} = \frac{V_2}{T_2}\right)$

(c) **Amonton's law** P ∝ T P = KT $\frac{P}{T}$= K $\left(\frac{P_1}{T_1} = \frac{P_2}{T_2}\right)$

(d) **Avagardro's law** V ∝ N

(xviii) Kinetic theory of gases by claussius Maxwell and boltzman it is a theoretical model which tries to explain the experimental observfations regarding the behavior of gasees. Kinetic theory is based upon two hypothesis

(a) Matter consists of molecules and atoms

(b) Heat is form of energy and manifest as kinetic energy of molecules in their random motion.

TRANSFER OF HEAT

(i) **Heat conducted** H = K. A $\frac{(\theta_1-\theta_2)\times t}{d}$ where d = Length of bar, A = Cross sectional area, θ_1, θ_2 = temp. at two ends of bar

(ii) **Thermal resistance**, Rt = $\frac{d}{kA}$ thermal reistrance in series $R_t = R_{t1} + R_{t2} + R_{t3}$ Thermal reistance in parallel $\frac{1}{R_t} = \frac{1}{R_{t1}} + \frac{1}{R_{t2}} + \frac{1}{R_{t3}}$

(iii) $\frac{K}{\sigma T}$ = constant, K = Thermal conducitivity, σ Electrical conducitivity, T = Absolute temperature.

(iv) ***For Inger* Hauz. Experiment** $\frac{K_1}{K_2} = \frac{I_1^2}{I_2^2}$; I_1, I_2 = Length upto which candle metl Rapidity of diffusivity = $\frac{K}{ps}$; s = specific heat and p = density

(v) For forced convectrion (Newton's laws of cooling), $-\frac{d\theta}{dt}$= K $(\theta - \theta)$, for natural convection $\frac{d\theta}{dt} \propto K\,(\theta - \theta_0)^{5/4}$

(vi) Rate of fall of temp. per unit increase in altitude $\frac{dT}{dh} = \frac{Mg}{R}\left(\frac{\gamma-1}{\gamma}\right)$ M = molecule wt. of air, R = Gas constant γ = Ratio of two sp. Heat for air

(vii) **Stefan's Law** E = A σ T4 , unit of $\sigma = \frac{watt}{m^2 \times k^4}$ $or\ \Delta E = \sigma(T^4 - T_0^4), \Delta E$ = Rate of loss of heat per unit area by a black body at temp. T, T_0 = Surrounding temperature.

(viii) **Wien's law** λ_m T= b = 2.94 × 10^{-3} m × k λ_m = Wavelength corresponding to maximum intensity

(ix) **Temperature of sun**, $T^4 = \frac{s}{\sigma}\left(\frac{R}{r}\right)^2$, S = solar constant, R = Mean distance of earth from sun r = Radius of the sun σ = stefan's consant

(x) **Thermal conducitivity of a composite rod**, k $\frac{\Sigma d_1}{\Sigma \frac{\delta_1}{K_1}}$

ELECTRICITY & MAGNETISM

1. **Charge q** = n.e. Where n = no of electron lost/gained,

   (i) Surface charge density $(\sigma) = \frac{Q}{A}$

   (ii) Volume density of charge (p) = $\frac{Q}{v}$

2. **Columb's Law** : Force between two point charge Q_1 and Q_2 at separation r is f= $\frac{1}{4\pi\varepsilon_0 k}\frac{q_1q_2}{R^2} = \frac{1}{4\pi\varepsilon}\frac{q_1q_2}{r^2}$,where k = Dielectric constant or specific inductive capaicity, ε_0 = permittivity of the free space = 8.86 × 10^{-12} $\frac{C^2}{N\times m^2}$ or $\frac{F}{m}$ ε= absolute permittivity of the dielectric of mediuim $4\pi\varepsilon_0 = \frac{1}{9\times10^9}\frac{C^2}{n\times m^2} = \frac{Farad}{metre}$

3. **Electric potential energy** U = $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_{12}}$ for two charges. For a system of n charges U = $\frac{1}{4\pi\varepsilon_0}\Sigma_{i=1}^{n}\Sigma_{i=1}^{n}\frac{q_iq_j}{r_{ij}}$ where j > i

4. **Electric field strength** E = $\frac{lim}{q_0\to0} = \frac{F}{q_0}$ $(q_0 = +ve)$

   (i) For a point charge E = $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ for a system of n charge $\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4....\vec{E}_n$

   (ii) For charged conductor of radius R at distance r E = $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (r > R); E = 0 when (r < R)

   (iii) For a non conducting uniform shpherical charge E = $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (r > R) and E = $\frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3}$ (r < R)

   (iv) For a long line charge of linear charge density qE = $\frac{1}{4\pi\varepsilon_0}\frac{2q}{r}$

   (v) Near a non conducting flat sheet of charge E = $\frac{\sigma}{\varepsilon_0}$

   (vi) Near a conductor of any shape, E $\frac{\sigma}{\varepsilon_0}$

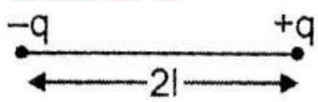
5. **Electric potential** V = $\frac{lim}{q_0\to0} = \frac{W}{q_0}\int_{\infty}^{r} E.dr$

   (i) For a point charge V $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ for a system of n charge V = $v_1 + v_2 + v_3 + ... v_n$

   (ii) For a charged conductor of radius R at distance r v = $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$(r > p) V = $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ $(r \le R)$ (same on surface)

   (iii) For a non conducting spherical charge conductor of radius R $V\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ where (r > R) V $=\frac{1}{4\pi\varepsilon_0}\frac{q(3R^2-r^2)}{2R^3}$ (r < R)

6. **Electric dipole**



   Dipole momentum p = q × 2l (2 l separation)

   (i) Torque on dipole in uniform electric field E, j = PE sin θ

(ii) Work done in rotating through an angle θ , w = pE(1-cos θ)

(iii) Potential energy od dipole U = - PE cos θ = - P.E

(iv) Electrical field at axial position E = $\frac{1}{4\pi\varepsilon_0}\frac{2P}{r^3}$

(v) Electric potential at axial position V = $\frac{1}{4\pi\varepsilon_0}\frac{P}{r^2}$

(vi) Electric field at equational point E = $\frac{1}{4\pi\varepsilon_0}\frac{P}{r^3}$

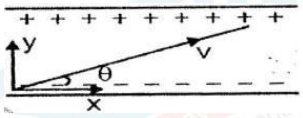
(vii) Electric potential at equational point V = 0

7. **Relation between Electric field and potential** E = - $\frac{\Delta V}{\Delta r}$ = $\frac{V}{d}$(numerically)

8. K. E. gained by a charge q in a P.D.V volt; E_k = q.V

9. 1 eV. (electron volt) = energy gained by an electron P.D. of 1 volt 1 eV. = 1 electron × 1 volt 1.6 × 10^{-19} C × $\frac{1 joule}{1C}$= 1.6 × 10^{-19} Joule.

10. Trajector of an electron particle in a uniform electric field Eqn. y = $\frac{eE}{2mV_x^2}.x^2$ thus eqn. is a parabola, tan θ = $\frac{V_y}{V_x}$ = $\frac{eE_1}{m.V2_x^2}$ V_y = $\sqrt{\frac{2eV}{m}}$; I = length of plate



11. **Units of Electrostatic variables**

Note : 1 colur = 10^{-1} e.m.u of charge 1 volt= 10_8 e.m.u = $\frac{1}{300}$ e.s.u (stat volt) = 3 × 10^9 e.s.u of charge, 1Ω = 10^9 e.m.u. = $\frac{1}{9\times10^{11}}$ e.s.u. of resistances.

CAPACITANCE AND CAPACITORS

(i) **Capacitance of any conductor** C = $\frac{q}{V}$

(ii) **Energy stored in a charge conductor** U = $\frac{1}{2}$ CV^2 = $\frac{q^2}{2c}$ = $\frac{1}{2}q \times V$

(iii) **Capacitance of an isolated sphere of radius r**, c = $4\pi \times \Sigma_0 r$

(iv) If two conductors of different potentials V_1 and V_2 connected, then common potential V = $\frac{q_1+q_2}{c_1+c_2}$ = $\frac{c_1v_1+c_2v_2}{c_1+c_2}$ charge after sharing q1 = C_1V. q_2 = C_2V

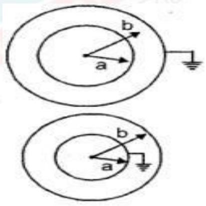
(v) **Loss in energy during sharing** ΔE = $\frac{C_1C_2(V_1-V_2)^2}{2(C_1+C_2)}$

(vi) **Dielectric constant** K = $\frac{C_m}{C_a}$ = $\frac{Capacitance\ in\ dielectric}{Capaci\ tan\,ce\ in\ air}$

(vii) **Parallel plate capacitor** C = $\frac{k\varepsilon_0 A}{d}$

(viii) When parallel plate capacitor partially filled with dielectric of thickness t (<d)c = $\frac{\varepsilon_0 A}{(d-t+\frac{t}{k})}$

(ix) **Induced charge on dielectric** q = - q$\left(1-\frac{1}{k}\right)$



(x) **Capacitance of spherical conductor**

(i) When outer plate earthed C = $\frac{4\pi\varepsilon_0 kab}{(b-a)}$ b = outer radius, a = inner radius

(ii) When inner plate earthed, C $\frac{4\pi\varepsilon_0 k.b^2}{(b-a)}$

(xi) **Combination of capacitors,**

(i) Series v = $v_1 + v_2 + v_3$, $q_1 = q_2 = q_3$, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

(ii) Parallel $v_1 = v_2 = v_3$, q = $q_1 + q_2 + q_3$ C= $C_1 + C_2 + C_3$

(xii) **Capacity of a cylindrical condenser** C = $\frac{2\pi\varepsilon_0 kl}{Log_{(b/a)}}$

(xiii) Force of attraction between the plates of a capacitor F = $\frac{1}{2}\varepsilon E^2$ A = $\frac{Q}{2\varepsilon A} = \frac{1}{2}\frac{CV^2}{d}$ F= $\frac{\sigma^2}{2\Sigma}$A

(xiv) **Spherical capacitor** C= $4\pi\varepsilon_0\varepsilon_r \frac{R_1R_2}{R_2-R_1}(R_2 - R_1)$ when inner sphere is earthed

C= $4\pi\varepsilon_0\varepsilon_r \frac{R_1R_2}{R_2-R_1} + 4\pi\varepsilon_0 R_2$

(xv) **Cylindrical condenser** C= $\frac{2\pi\varepsilon_0\varepsilon_0 l}{log_e(R_2/R_1)}$

ELECTRIC CURRENT AND CIRCUITS

(i) **Current** I = $\frac{q}{t} = \frac{dq}{dt}$, n = nos. of charge carrier per m^3

(ii) **Current density** j = nqV, where V = potential difference, R = resistance

(iii) **Ohm's law** V = R × I; σ = conductivity or J = σ e; E = electric field strength

(iv) **Resistance of a conductor** R = $\rho\ \frac{L}{A}$ L = length of conductor; A = cross-sectional area

(v) **Relation between** p and $\sigma, \sigma = \frac{1}{\rho}$

(vi) **For a metallic conductor** $\sigma = \frac{ne^2 j}{2m}$, n = electron density, J = Relaxation time, e, m = charge and mass of electron

(vii) **Combination of Resistance:**

(i) Series R = $R_1 + R_2 + R_3 + R_4$, V = $V_1 + V_2 + V_3$ and I = same

(ii) Paraller $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$, V = same i= $i_1 + i_2 + i_3$……

(viii) **Kirchhoff's Law** :

(i) At any Jun. the current $\Sigma i = 0$

(ii) In any closed mesh $\Sigma iR = \Sigma E$

(ix) **Combination of cells** – For n identical cells each of e.m.f E and internal resistance r:

(i) Series combinations, i = $\frac{nE}{R+nr}$

(ii) Parallel combination, For identical cells i = $\frac{mE}{mR+r}$

(iii) Mixed $i = \frac{mnE}{mR+nr}$, n = identical cell in one row and m = no. of rosw.

(x) **For maximum current**, $R_{ext} = R_{int}$ and $R = \frac{nr}{m}$ Imax = $= \frac{mE}{2R} = \frac{nE}{2r}$

(xi) **Drift velocity** $v_d = \frac{JM}{nNdq}$

J = current density,

M = atomic wt.,

N = Avogardo's no.

D = density of conductor,

N = nos. of charge carrier available by each atom,

Q = charge on each

(xii) **Terminal pd.** V = iR = E – ir

(xiii) **For a closed circuit**, $I = \frac{E}{R+r}$

(i) If R = 0 (short circuit), i is max, $i_{max} = \frac{E}{r}$

(ii) If R = ∞ (open circuit), i is min, $i_{min} = 0$

HEATING EFFECT OF CURRENT & THERMO ELECTRICITY

(i) Electrical resistance $R_t = R_0 (1 + \alpha.\, t)$; a α = temp. coefficient of resistance,

$\alpha = \frac{R_2 - R_1}{R_1 t_1 - r_2 t_1}$ $unit$:/^{0}C

(ii) Work done (W) q.v. = Vit, = $i^2Rt = \frac{V^2}{R}$ t = pt

(iii) **Power consumed** (p) = $\frac{W}{t}$ = iv = i^2 R = $\frac{V^2}{R}$

(iv) **No. of unit consumed** = $\frac{power\ in\ watt \times times\ in\ hr.}{1000} = kWh$

(v) **Heat produced** H = i^2 rt, if i and t are constants i.e. $\frac{H_1}{H_2} = \frac{R_2}{R_1}$ H ∝ $\frac{1}{R}$; if V and t are constants i.e. $\frac{H_1}{H_2} = \frac{R_2}{R_1}$

(vi) Hot wire instrument (both for A.C and B.C) deflection $\theta \propto H \propto i^2$ i.e. $\frac{\theta_1}{\theta_2} = \frac{l_1^2}{l_2^2}$

(vii) $t_n = \frac{t_1 + t_c}{2}$ where t_n = neutral temperature t_i = inversion temp, t_c = temperature of cold jn.

CHEMICAL EFFECTS OF CURRENTS

(i) **Faraday's Law of electrolysis-**

(a) Ist Law, m = zit; m = mass of ion deposited

(b) IInd Law, $m_1 : m_2 = w_1 : w_2$; i = current passed z = electro chemical, equivalent w_1, w_2 = equivalent wt. of ions.

(ii) Mass liberated at electode = number of ion liberated × mass of one atom, i.e., m= $\frac{Q}{ne} \times \frac{A}{N} = \frac{1}{Ne} \times \frac{A}{n} \times Q = \frac{E}{F} \times Q$ E = eq. wt., F = faraday's constant $\frac{E}{F}$ =Z (Z = electro chemical equivalent, unit kg/C).

MAGNETIC EFFECTS OF CURRENTS AND METERS

(i) Force on a current carrying conductor of length Δl F = i × $\vec{\Delta l} \times \vec{B}$; B = magnetic field induction |F| = I × Δl. B sin θ, F is ⊥ to both Δl and B, θ is angle between Δl and B.

(ii) Force on a moving charge in magnetic field i.e., Lorentz force $\vec{F} = q\vec{v} \times \vec{B}$ | F | = qv B. sin θ, F is ⊥ to both v and B

(iii) If v is ⊥ B path of charge particles is circular q × B = $\frac{mv^2}{r}$, i.e., r $\frac{mv}{qB}$ and time Period T = $\frac{2\pi m}{qB}$, angular speed w = $\frac{Bq}{m}$

(iv) Torque on a current loop j = NiAB sin θ. N

(i) A = area and N = no. of turns , n = unit vector

(ii) Magnetic dipole moment M = NiA, Unit →Amp × m^2,

(v) **Biot Savart Law** : Magnetic field due to a current carrying element Δl at distance r is Δl at distance r is ΔB = $\frac{\mu_0}{4\pi} \times \frac{i\Delta/sin\theta}{r^2}$ $_\Delta$B= magnetic inductiin (in weber/m^2 or tesla) where Δl = small length of conductor, μ_0= permedability of vacuum = 444π×10^{-7} henry/metre.

(vi) **Magnetic induction in some cases** :

(i) **Due to a straight wire**, B = $\frac{\mu_0 i}{4\pi r}$(sin $\alpha + sin\,\beta$) ; α and β are angles made by ends of wire, at point distance r.

(ii) **For infinitely long wire**, B $\frac{\mu_0 i}{2\pi r} = 10^{-7}\ \frac{2i}{r}$

(iii) Due to a circular coil on axis at distance x from centre B = $\frac{\mu_0 i}{4\pi} \times \frac{2\pi nir^2}{(x^2+r^2)^{3/2}}$, n = no of turns, r = radius of coil

(iv) **At centre of coil** B = $\frac{\mu_0 i}{4\pi} \times \frac{2\pi n}{r}$

(v) Due to a solenoid $B_{centre} = \frac{\mu_0 Ni}{l}$, N = total no. of turn $B_{atends} = \frac{\mu_0}{4\pi} = \frac{2\pi Ni}{I} = \frac{\mu_0 Ni}{2l}$ (B_{ends} = B $\frac{B_{centre}}{2}$)

(vi) Force on a charge when both electric fields E and B are $\vec{F} = q\,(\vec{E} + \vec{V} \times \vec{B}\,)$

(vii) **K. E. of particle** = $\frac{p^2}{2m} = \frac{B^2q^2r^2}{2m}$ (momentum P = Bqr)

(viii) **Force between two current carrying parallel conductor per unit length**

$F = \frac{\mu_0}{4\pi} \times \frac{2i_1 i_2}{r} = 2 \times 10^{07} \frac{i_1 \times i_2}{r}$

(ix) **Application of galvanometer**

(i) Moving coil or suspended coil or D' Arsonval galvanometer current $I = \frac{C\theta}{nAB} = K\theta \; i.e. \; i \propto \theta \; or \; \frac{\theta_1}{\theta_2} = \frac{i_1}{i_2}$ n = no. of turns, A = area of coil, C = couple per unit twist

(ii) Tangent galvanometer : $B = B_H \tan\theta$ ($B \perp B_H$) $\frac{\mu_0 ni}{2r} = BH \tan\theta$ or $i = \frac{2rBH_2}{\mu_0} \tan\theta = K \tan\theta$

(iii) Since galvanometer $B = B_H \sin\theta$ or $I = \frac{2rB_H}{\mu_0 n} \sin\theta = K \sin\theta$

(x) **Conversion of Galvanometer into Ammeter** the working eqn. $i_g = \frac{S}{S+G}$ i. thus, $s = \frac{i_g G}{i+g}$

Ig = current galvanometer of full scale deflection,

G = resistance of galvanometer,

S= shunt resistances connected in paralle.

(xii) **Conversion in of Galvanometer into voltmeter the working eqn.** $i_g = \frac{V}{R+G}$ high resistance R connected in series $R \frac{V}{ig} - G$

(xiii) Force and Torque on current carrying coil placed in a uniform magnetic field

(a) Resultant force $F_{net} = 0$

(b) A torque acts on the coil $t = iNAB \sin\theta = MB \sin\theta$ M → magnetic dipole moment in vector form

$t = M \times B$

(c) The work done in turing a loop from angle θ_1 to θ_2 w= MB (Cos θ_1 - Cos θ_2)

(d) Time period of oscillation of a magnetic dipole in uniform M.F. $T = 2\pi\sqrt{\frac{I}{MB}}$ I → moment of inertia.

ELECTRO – MAGNETIC INDUCTION

- Induced emf is generated in the coil only when there is change in magnetic flux associated with it. This phenomenon occurs only during the change in magnetic flux.
- The value of induced current depends upon resistance of the cirucit.
- The electric current developed due to induced emf is called as induced current.

(i) **Faraday's Law:**

(i) Induced emf $e \propto \frac{\Delta\Phi}{\Delta t} = -N\frac{\Delta\Phi}{\Delta t}$ N = nos. of turns $\Delta\Phi$= change in flux, ϕ= B.A. or SI uits of $\Delta\Phi$,

(ii) Induced current, i = $\frac{e}{R} = \frac{N}{R} \times \frac{\Delta \Phi}{\Delta t}$

(iii) Amount of charge that will flow q = i $\Delta t = \frac{N}{R} \Delta \Phi$

(ii) Induced emf in a moving that conducting rod e = B V I sin θ

(iii) When a cot/rotating in uniform magnetic field induced e.f.m. NB A ω sin ωt = e_0 sin ωt, e_0 = N B A ω = peak emf.

(iv) Self inductance L is given by magnetic flux Φ = Li emf. Induced e = -L $\frac{di}{dt}$

(v) **Magnetic energy stored** $U_m = \frac{1}{2} Li^2 = \frac{B^2}{2\mu} \times$ volume coefficient of self induction iL = $\frac{\mu_0}{2} \pi N^2 r$ henry.

(vi) **Mutual inductance** Φ = Mi, induced emf in secondary e = -m$\frac{di}{dt}$

(vii) **Transformer** – It works on A.C. only for an ideal transformer $\frac{V_s}{V_p} = \frac{i_p}{i_s}$ where P = primary coil, s = secondary coil.

(viii) **Transformation ratio** K = $\frac{N_2}{N_1}$, Efficiency n = $\frac{output\ voltage}{input\ voltage} \times 100$

(ix) Power in primary coil = power in secondary coil.

ALTERNATING CURRENT

- An alternating current is one which periodically changes in magnitude and direction.
- It increases from zero to a maximum value, then decreases to zero and reverses in direction, and then decreases to zero.
- The complete set of variations is known as a 'cycle'. Thus, during one-half of the cycle the current flows in one direction and in the following half-cycle it flows in the opposite direction.

(i) Standard Eqn. of E.N.F., E = E_0 sin ωt, E_0 and l_0 are peak current l = l_0 sin $(\omega t + \phi)$ value of emf current.

(ii) I) Average value of A.C. over full cycle = 0

ii) Average value of A.C. over half cycle = $\frac{2l_0}{\pi}$

iii) R.N.S. value of current l_{rms} = l = $\frac{l_0}{\sqrt{2}}$

iv) Form factor = $\frac{R.M.S.value}{average\ value} = 1.1$

(iii) I) **Impedance** Z = $\frac{E}{l}$

ii) Inductive reactance $X_L = \omega L$

iii) Reactance Xc = $\frac{1}{\omega C}$

(iv) i) For a pure resistance circuit Z = R, ϕ = 0

ii) For a pure inductive circuit Z = X_L – ωl, ϕ = π/2

iii) For a pure capacitive circuit Z = $X_C = \frac{1}{\omega C}$, $\phi = +\pi/2$

(v) i) For L.R. circuit, Z = $\sqrt{(R^2 + X_L^2)}$, tanϕ = - $\frac{X_L}{R}$

ii) For R.C. circuit, Z = $\sqrt{(R^2 + X_C^2)}$, tanϕ = - $\frac{X_X}{R}$

iii) For LCR circuit, Z =$\sqrt{(R^2 + X_C - X_L)^2}$, tanϕ = - $\frac{X_C - C_L}{R}$

(vi) i) At resonance ϕ = 0 and $X_C = X_L$, Z_{min} = R $I_{max} = \frac{E}{R}$

ii) Resonant frequency $f_r = \frac{\omega r}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$

(vii) P_{avg} g = $I_{rms} \times E_{rms}$ × `cos ϕ, where power factor cos ϕ= $\frac{R}{Z}$

i) P.D. across resistance V_R =RI

ii) P.D. across inductance $V_L = X_L I = \omega LI$

iii) P.D. across capacoitor $V_C = X_C I = \frac{I}{\omega C}$

(vii) **New applied emf.** E = $\sqrt{[V_R^2 + V_L^2 + (V_C - V_R)^2]}$

(viii) In parallel resonant circuit at resonance I_{min} and impedance Z_{max}, Resonant frequency

Fr = $\frac{1}{2\pi}\sqrt{\left(\frac{1}{LC} - \frac{R^2}{4L^2}\right)}$

MODERN PHYSICS

(i) **For Cathode rays** KE = $\frac{1}{2}$ mv^2 =eV, where v = velocity.

(ii) When no effect of electric and magnetic field on electron beam eE =evB, or v = $\frac{E}{B}$

(iii) Only in magnetic field if r be radius of path, then $\frac{mv^2}{r}$ evB or r = $\frac{mv}{eB}$ or $\frac{v}{rB} = \frac{E}{rB^2}$

(iv) **Photo electric effect**

(i) Einstein photo electric eqn. h∂ = W + E_x or $\frac{hc}{\lambda}$ = W +E_x

(ii) Work function $w_0 = h\nu_0 = \frac{H_c}{\lambda_0}$

(iii) K.E. Ex = $\frac{1}{2}$ = mv^2 max =evs

(iv) **For photo emission**

∂ = incident frequency,

λ= incident wavelength,

h = Planck's constant,

m = mass of electron,

V_s = stopping potential,

v_0 = threshold frequency,

λ_0 = threshold wavelength,

l = intensity of light.

(a) Nos. of electrons emitted ∝ L independent of V

(b) K.E. of emitted electron ∝ L independent of l.

(v) **Bohr's atom model**

(i) **Bhor quantum condition is mvr** = $\frac{nh}{2\pi}$ for H_2 atom

(ii) **Radius of nth orbit** $r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m e^2}$, $r_1 = 5.3 \times 10^{-10}$ m

(iii) **Energy of electron in nth orbit** $E_n = -\frac{Rhc}{n^2} = -\frac{13.6}{n^2}\ ev$

(iv) **Rydberg constant** $R = \frac{me^4}{8\varepsilon_0^2 ch^3}$ 1.1×10^7/m

(v) For H_2 like atom $r_n = \frac{\varepsilon_0^2/h^2n^2}{\pi m Z e^2}$, $E_n = -Z^2Rh\frac{C}{n^2}$ Frequency of emitted or absorbed radiation $E_{n1} = E_{n2}$ $= h\overset{\wedge}{\vee}$ $v = \frac{E_{n_1}-E_{n_2}}{n} = Z^2Rc\ (\frac{1}{n/a(2,2)} \sim \frac{1}{n})\ E_{n_1} \sim E_{n_2} = h, v = \frac{E_{n_1}-E_{n_2}}{h} Z^2Rc(\frac{1}{n_2^2} - \frac{1}{n_1^2})$

(vi) For H_2 atom-frequency of radiation emitted $v = Rc(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ or $\frac{1}{\lambda} = R\ (\frac{1}{n_2^2} - \frac{1}{n_1^2})$

Different series

(i) Lyman series $n_1 = 1$, $n_2 = 2, 3, 4$ ……ultraviolet region

(ii) Balmer series $n_1 = 2$, $n_2 = 3, 4, 5$ …… visible region

(iii) Paschen series $n_1 = 3$, $n_2 = 4, 5, 6$ ….. infrared region

(iv) Brackett series $n_1 = 4$, $n_2 = 5, 6, 7$ ….. for infrared

(v) P fund series $n_1 = 5$, $n_2 = 6, 7, 8$ ……ultraviolet region.

(vii) For series limit $n_2 \Rightarrow \infty$

(viii) **X-rays**

i) Continuous X-rays $\lambda min = \frac{hc}{eV} = \frac{12375}{V}$ Å

ii) Characteristic X-rays $\sqrt{v} = K(Z-\sigma)$ V = frequency for K – series (Moseley's Law) Z = atomic number of element K, σ = constant for, K -series

iii) Bragg's Law 2 d sinθ = nλ n= order of spectrum d = lattice constant.

(ix) **Mater waves**

i) De broglie's relation $\lambda = \frac{h}{mv} = \frac{h}{P}$; λ = de Broglie wavelength, v= accelerating voltage.

ii) $\lambda = \frac{h}{\sqrt{2Vem_0}}$;m = mass of particle m = rest mass, e = charge on particle.

(x) **Radioactivity**

i) Rate of disintegration of radioactive substance $\frac{dN}{dt} = -\lambda N; \lambda$= decay constant N = number of radio atoms present at time t i.e., N = $N_0 e^{-\lambda t}$, N_0 = original number of atom at t = 0.

ii) T1/2 = $\frac{0.693}{\lambda}$ = 0.693T, T1/2 = half life and T = mean life also, $\frac{N}{N_0} = \frac{m}{m_0} = (\frac{1}{2})^n$, n = $(\frac{t}{T_{1/2}})$ number of half-lives 1 Curie = 3.7×10^{10} disintegration/sec 1 Rutherford = 10^6 disintegration/sec

NUCLEAR PHYSICS

(i) **Nucler Energy**

i) Einstein mass energy relation $E = mc^2$

ii) 1 kg mass = 9×10^{16} Joule

iii) 1 amu = $\frac{1}{12}$ (mass of 1 C-atom) = 1.67×10^{-27} kg = 931 MeV.

iv) Mass defect $\Delta m = [Zm_p + (A - Z) m_n - M_{ZA}]$

v) Binding energy per nucleon $B_n = \frac{\Delta mc^2}{A}$

vi) Typical Nuclear Fusion reaction ${}_1H^2 + {}_1H^2 = {}_2He^4$ + 28 MeV

vii) Typical nuclear fission reaction ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1$ + 200 MeV

ii) **Packing fraction** = $\frac{mass\ defect}{mass\ number}$, f = $\frac{\Delta m}{A} = \left(\frac{M-A}{A}\right)$

iii) **Nuclear fusion** $4{}_1H^1 \rightarrow {}_2H^{24} + 2\beta^+$ 2v +Q Q = 24.7 Me per cycle.

ELECTRONICS

(i) **Child Law** $i_p = aV_p^{3/2}$, where i_p = plate current.

(ii) **Richardson's Eqn**, $i_p = AT^2e^{-w/kt}$, w = work function K = Boltzmann constant, T = Absolute temp.

(iii) **Stopping potential** $eV_s = E_k = \frac{1}{2} mV^2_{max}$

(iv) i) **Amplification factor** $\mu = \left(\frac{\Delta V_p}{\Delta V_g}\right)$; i_p = constant

ii) Plate resistance of Anode slope resistance, $r_p = \left(\frac{\Delta V_p}{\Delta V_g}\right)$;

iii) Trans conductance or mutual conductance $g_m = \left(\frac{\Delta V_p}{\Delta V_g}\right)$;

(v) **Voltage amplification**, a = $\frac{output\ voltage}{input\ voltage} = \frac{\mu}{\frac{r_p}{R}+1}$

(vi) **For transistor current gain** $\alpha = \frac{\Delta I_C}{\Delta I_e}$ (common base) Relation $\beta = \frac{\alpha}{1-\alpha}; \beta \left(\frac{\Delta I_C}{\Delta I_B}\right)$ common emitter.

(vii) Conductors do not have a forbidden energy gap between valence and conduction bands.

(viii) Conductivity is very high between 10^6 to 10^8 mho/m.

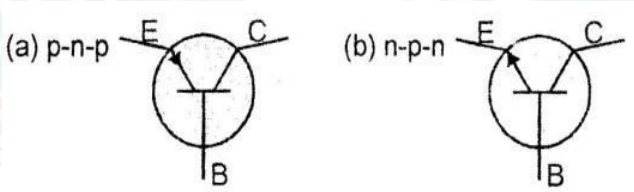
(ix) The forbidden energy gap between valence and conduction bands is very large (~5eV) as compared to thermal energy (~0.25eV).

(x) Conductivity is negligible between 10^{-7} to 10^{-16} mho/m

(xi) **Current density** $j = nq\,(\bar{v}_e + \bar{v}_h)$

(xii) **Conductivity** $\sigma = \frac{J}{E} = nq\,(\mu_e + \mu_h)$

(xiii) **There are two types of transistors**



(xiv) **Common base configuration current gain** $\alpha = \frac{\Delta I_C}{\Delta I_E} \cong 1$ (slightly less than 1)

(xv) **Common emitter configuration current gain** $\beta = \frac{\Delta I_C}{\Delta I_B} >> 1$

LIGHT

(i) **For plane mirror deviation of ray**

i) on single reflection, $D = \pi - 2i = 180 - 2i$

ii) on successive reflection, $D = 2\,(\pi - \theta) = 360 = 2\,\theta$

(ii) **Nos. of images formed by two inclined mirrors**

i) If $\frac{360}{\theta}$ = even, then $n = \frac{360}{\theta} - 1$

ii) If $\frac{360}{\theta}$ = odd, then $n = \frac{360}{\theta} - 1$ (object lies symmetrically) and $n = \frac{360}{\theta}$ (object lies unsymmetrically).

iii) **Refraction at plane surface**

(i) $N = \frac{C_a}{C_m} = \frac{\lambda_a}{\lambda_m}$; n = refractive index of a medium

(ii) ${}_an^b = \frac{R.I.of\ medium\ b}{R.I.of\ medium\ a} = \frac{C_a}{C_m}$

(iii)For different media ${}_1n^2 \times {}_2n^3 \times {}_3n^1 = 1$

(iv)Apparent position for different media is given by $D = \frac{t_1}{n_2} + t_2 n_2 + \frac{t_3}{n_3} \ldots\ldots\ldots = \Sigma \frac{t}{n}$

(v) **Internal reflection** $\frac{t_1}{n_2}$ = sin C; n_1 = R.I. of rare medium, n_2 = R.I. of denser medium. For vacuum

$n_2 = \frac{1}{sinC}$ (C = critical angle)

(vi)Vision of a Fish or Diver, $r = \frac{1}{\sqrt{n^2 - 1}}$

(iv) **<u>For a Prism</u>**

i) $D = i + i' - A$ where i angle of incidence, i' = angle of emergence, A = refracting angle of prism

ii) $A = r + r'$ Angle of refraction of both surfaces

iii) For min. deviation $i = i'$ and $r = r'$, $D_m = 2i - A$

iv) $A_{max} = 2C$, where C = critical angle

v) For thin prism $D_m = A(n - 1)$

vi) Angular dispersion $(\theta) = D_v - D_r = A(n_v - n_r)$

vii) **Dispersive power** (w) $= \frac{Angular\ dispersion}{mean\ deviation} = \frac{D_v - D_r}{D_y} = \frac{n_v - n_r}{n_y - 1}$ = where $n_y = \frac{n_y + n_r}{2}$

(vi) **Lense (Refraction and defects of vision)**

i) Refraction at a single spherical surface $\frac{n_2}{v} - \frac{n_1}{v} = \frac{(n_2 n_r)}{r}$ where n_1, n_2 are R.I. of medium

ii) Focal length of lens in different media fm $= \frac{(a^{n g - 1})a^{n m}}{a^{n g} - a^{n m}}$ fa, (f_a, f_m = Focal lengths in air, media)

iii) When two lenses are separated by a distance 'd' apart $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$ of $p = p_1 + p_2 = dp_1p_2$.

iv) For displacement method X = displacement of lenses, D = distance between object and image

v) Axial chromatic aberration = wf, w = dispersive power

vi) a) when two lenses in contact $\frac{w_1}{f_1} + \frac{w_2}{f_2} = 0$

b) Separated by distance 'd' $\frac{w_1}{f_1} + \frac{w_2}{f_2} - \frac{(w_1 + w_2)}{f_1 f_2} = 0$

(vii) To minimize spherical aberration, $d = f_1 - f_2$.

(vi) **Optical Instruments**

i) Simple microscope magnifying power $m = 1 + \frac{D}{f}$ (distinct vision) $m = \frac{D}{f}$ (normal vision)

ii) Compound microscope magnifying power

a) For distinct vision $M = \frac{v_0}{v_0}\left(1 + \frac{D}{f_e}\right)$ f_e = focal length of eyepiece, u_0, v_0 = object and image distances from objective lense = $m_0 \times m_e$ (magnification by objective and eyepiece)

b) For normal vision (image at infinity) $m = \frac{v_0}{u_0}\left(\frac{D}{f_e}\right)$

iii) **Astronomical Telescope**

a) Normal vision (image $\rightarrow \infty$), $M = \frac{f_0}{f_e}$ $L = F_0 + F_e$

b) Distinct vision, $M = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$ $L = f_0 + u_e$ = Length of Telescope tube.

(iv) Galilea Telescope $m = \frac{f_0}{fe}$ (normal vision) $M = \frac{f_0}{fe}\ (1 - \frac{f_e}{D})$ (distinct vision)

$L = f_0 - f_e = v_0 = u^e$

v) Resolving limit of a telescope $a = 1.22\ (\lambda/d), \lambda$ = wavelength of light used, d = diameter.

(vii) **Photometry**

i) Solid angle $dw = \frac{\Delta A\ cos\theta}{r^2}$ = angle between + ve direction of normal at spherical surface.

ii) Luminous intensity $l = \frac{\Delta F}{\Delta W}$, ΔF = luminous flux

iii) Total flux F = 4 π/lumen

iv) Illumination or luminous flux density $E = \frac{\Delta E}{\Delta A}$ lux, 1 phot = 10^4 lux(phot = $\frac{lm}{cm^2}$

v) Principle of photometry $\frac{l_1}{l_2} = \frac{d_1^2}{d_2^2}$

vi) Lambert'S cosine law, $E = \frac{l\ cos\theta}{r^2}$

(viii) **Wave nature of angle**

i) Young's experiment: Resultant intensity $l = a_1^2 + a_2^2 + 2\ a_1 \cos\delta$, δ= phase difference $l_{max} = (a_1 + a_2)^2$, $\delta = n\pi$ $l_{min} = (a_1 - a_2)^2$, $\delta = (2n-1)\pi$

ii) Fringe – width $w = \frac{\lambda D}{2d}$ D = distance of screen, 2d = distance between two coherent sources,

iii) Displacement of frings, $s = \frac{D}{2d}(n-1)\ t$ S= shift, t = thickness and n = R.I. of plate

iv) Brewster law, $n = \tan i_p$(i_p = angle of polarization).

Sound

i) Wave, motion, velocity of mechanical waves

i) Speed of transverse waves in stretched string, $V = \frac{\sqrt{T}}{m}$ T = tension and m = linear mass density or mass per unit.

ii) Speed of longitudinal wave, $v = \frac{\sqrt{E}}{d}$; for solid $v\ \frac{\sqrt{Y}}{d}$; Y = young's modulus, d = density; for liquid $v\ \frac{\sqrt{B}}{d}$; where B = Bulk.

iii) ∝ (a) pressure – no effect

b) Temperature: $V \propto \sqrt{T}$, at lower temperature $v_t = v_0 + 0.61 \times t$, Velocity increases with increase of Temperature.

c) $\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{d_2}{d_1}}, where$ M_1 and M_2 and d_1 and d_2 are molecular wt. and density of different gases.

d) $v_m > v_d$, where v_m, v_d velocity in moist and dry air,

iv) Eqn of progressive wave, along (+ve) direction of x-axis y = A sin $[\omega t - kx) + \phi]$, k $\frac{\omega}{v} = \frac{2\pi}{\lambda v}$ = propagation constant = A sin $[\frac{2\pi}{\lambda}(vt - x) + \phi]$, λ = wavelength = A sin $[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \phi]$, T = Time period. Φ= phase factor

v) **Phase of wave** $[2\pi(\frac{t}{T} - \frac{x}{\lambda}) + \phi]$

vi) **Excess pressure in longitudinal wave** $\Delta p = -B\frac{\Delta Y}{\Delta X}$, where B = Bulk modulus, $\frac{\Delta Y}{\Delta X}$ = strain.

vii) Relation of phase difference $(\Delta\phi)$ and path difference (Δx) $\Delta x = \frac{\lambda}{2\pi}\Delta\phi$

viii) Audible range= 20 Hz to 20 kHz. Ultrasonic or supersonic wave = 20 kHz and above (at 20 kHz, λ = 1.8 cm, 1 MHz, λ=0.035cm).

ii) **Reflection and Superposition of waves**

i) Eqn of reflected wave, if incident wave is f = a sin $2\pi(\frac{t}{T} - \frac{x}{\lambda})$

a) $Y_r = A_r \sin\{2(\frac{t}{T} + \frac{x}{\lambda}) + \pi\}$ reflected by rigid boundary

b) $Y_r = A_r \sin\{2(\frac{t}{T} + \frac{x}{\lambda}) + \pi\}$ reflected by free boundary

ii) **For echo**, S=$\frac{vxt}{2}$; t = time interval between source and echo of sound at source.

iii) **For interference** if $y_1 = a_1 \sin \omega t$, and $y_2 = a_2 \sin(\omega t + \phi)$ Resultant amplitude A = $\sqrt{a_1^2 + a_2^2 + 2a_1a_2cos\phi}$ or | = $A^2(a_1^2 + a_2^2 + 2a_1a_2cos\phi)$ for Maxima, ϕ = 2nπ or Δx = $n\lambda$, $I_{max} = (a_1 + a_2)^2$ For Minuma ϕ = (2n-1), π Δx = (2n-1)$\frac{\lambda}{2}$, $I_{max} = (a_1 + a_2)^2$

iv) **For Beats**, if $y_1 = a \sin 2\pi n_1 t$ and $y_2 = \sin 2\pi n_2 t$, then $y = y_1 + y_2 = A \cos 2\pi nt$, where $n = \frac{n_1+n_2}{2}$ and amplitude A = 2a cos cos π $(n_1 - n_2)$ t No. of beat product per sec. = $n_1 \sim n_2$

v) For stationary waves : if $y_1 = a \sin(\omega t - kx)$ be incident and $y_2 = \pm a \sin(\omega t + kx)$ is reflected wave, then $y = y_1 + y_2 = 2a \cos kx \sin \omega t$ (reflected from free boundary)

vi) Distance between successive nodes or antinode = $\lambda/2$ Distance between a node and consecutive antinode = $\lambda/4$

vii) At rigid boundary there are nodes, at free boundary antinodes

viii) Stationary wave in string clamped at both ends. Fundamental frequency, n = $\frac{v}{2l} = \frac{1}{2l}\sqrt{\left(\frac{T}{M}\right)}$ Frequency of P^{th} harmonics or $(P-1)^{th}$ overtone $n_p = \frac{p}{2l}\sqrt{\left(\frac{T}{M}\right)}$; P n all odd and even harmonics are present

ix) Stationary wave in organ pipes for open organ pipe : Fundamental frequency n = $\frac{v}{2l}$ where $l = (l_0 + e)$, l_0 = length of pipes and e = ends correction = 0.6r, r = radius of pipes, For p^{th} harmonic or $(p-1)^{th}$ overtone $n_p = p\frac{v}{2l}$ all odd and evel harmonics are present for closed organ pipe Fundamental frequency $n = \frac{v}{4l}$ for r^{th} harmonic $n_r = (2r+1)\frac{v}{2l}$, where r = 1, 2, 3 only odd harmonics are present in closed organ pipe.

x) Law of transverse vibration in a wire, $n = \frac{1}{2l}\sqrt{\left(\frac{Mg}{\pi r^2 d}\right)}$ $n \propto \frac{1}{l}, n \propto \sqrt{T}, n \propto \frac{1}{\sqrt{m}}$

iii) **Doppler's effect and characteristics of musical sound** –

i) Doppler's effect in sound:

a) Source in motion only apparent frequency $n' = n\left(\frac{v}{v \pm v_s}\right)$, source approaching v_s = (-ve), source receding v_s = (+ve)

b) Observer in motion only $n'\left(\frac{v \pm v_0}{v}\right)$ n, observer approaching v_0 = (+ve), observer receding v_0 = (-ve) If w is wind velocity, if w in din of source velocity, then v + w, if opposite (v –w)

ii) Doppler's effect in Light : depends upon relative velocity of source and observer, independent of individual velocity $\Delta V = V' - V = \frac{V}{C}V$ (for approaching); $\Delta V = V' - V = \frac{V}{x}V$ (for receding) or $\Delta\lambda = \lambda - \lambda' = \frac{V}{C}V$ (for approaching); $\Delta\lambda = \lambda - \lambda' = \frac{V}{C}\lambda$ (for receding).