PHYSICS

1. UNIT AND MEASUREMENT

- **Fundamental Units :**

Sr. No.	Physical Quantity	SI Unit	Symbol
1	Length	Metre	m
2	Mass	Kilogram	Kg
3	Time	Second	S
4	Electric Current	Ampere	A
5	Temperature	Kelvin	K
6	Luminous Intensity	Candela	Cd
7	Amount of Substance	Mole	mol

- **Supplementary Units :**

Sr. No.	Physical Quantity	SI Unit	Symbol
1.	Plane Angle	Radian	r
2	Solid Angle	Steradian	Sr

(1). Distance of an object by parallax method, $D = \frac{\text{Basis}}{\text{Parallax angle}}$

(2). Absolute error = True value – Measured value $= [\Delta a_n]$

(3). True value = Arithmetic mean of the measured values

$$a_{mean} = \frac{a_1 + a_2 + ... + a_n}{n}$$

(4). Relative error in the measurement of a quantity $= \frac{\Delta a_{mean}}{a_{mean}}$

(5). Percentage error $= \frac{\Delta a_{mean}}{a_{mean}} \times 100$

(6). Maximum permissible error in addition or subtraction of two quantities $(A \pm \Delta A)$ and $(B \pm \Delta B)$:
$= \Delta A + \Delta B$

(7). When $z = \frac{a^p \cdot b^q}{c^r}$, then maximum relative in z is $\frac{\Delta z}{z} = p\frac{\Delta a}{a} + q\frac{\Delta b}{b} + r\frac{\Delta C}{C}$

2. MOTION IN A STRAIGHT LINE

(1). For objects in uniformly accelerated rectilinear motion, the five quantities, displacement x, time taken t, initial velocity v_0, final velocity v and acceleration a are related by a set of kinematic equations of motions. These are

$$v = v_0 + at$$

$$x = v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2ax$$

The above equations are the equations of motion for particle. If the position of the particle at t = 0 is 0. If the particle starts at $x = x_0$ i.e. if it is at x_0 at t = 0, then in the above equation x is replaced by $(x - x_0)$.

(2). The relative velocity of an object moving with velocity v_A w.r.t. an object B moving with velocity v_B is given by

$$v_{AB} = v_A - v_B$$

3. MOTION IN A PLANE

(1). Law of cosines, if $R = P + Q$ then $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

Here, θ = angle between P and Q

(2). Direction of R $\Rightarrow \tan\alpha = \frac{Q\cos\theta}{P + Q\sin\theta}$: α = angle between R and P

(3). Position of an object at time t, if it is initially at r_0, having initial velocity v_0 and moving with constant acceleration a, is

$r = r_0 + v_0 t + \frac{1}{2} a^2$

4. LAWS OF MOTION

(1). Force: $F = \frac{dp}{dt} = m\frac{dv}{dt} + v\frac{dm}{dt}$, when m is constant $F = m\frac{dv}{dt} = ma$

(2). Conservation of linear momentum: $\sum p_i = \sum p_j$

(3). For motion of a car on level road maximum safest velocity is $v_{max} = \sqrt{\mu_s Rg}$

(4). For motion of a car on banked road maximum safest velocity is $v_{max} = \sqrt{\left[Rg\frac{(\mu_s + \tan\theta)}{1 - \mu_s \tan\theta}\right]}$

Angle of banking: $\theta = \tan^{-1}\frac{v^2}{rg}$

5. WORK ENERGY AND POWER

(1). The **work-energy theorem** states that for conservative forces acting on the body, the change in kinetic energy of a body equal to the net work done by the net force on the body.

$K_f - K_i = W_{net}$

Where K_i and K_f are initial and final kinetic energies and W_{net} is the net work done.

(2). For a conservative force in one dimension, Potential energy function V(x) is defined such that

$$F(x) = -\frac{dV(x)}{dx}$$

(3). Average power of a force is defined as the ratio of the work, W, to the total time ***t*** taken.

$$\Rightarrow P_{av} = \frac{W}{t}$$

(4). The instantaneous power is defined as the limiting value of the average power as time interval approaches zero. $P = \frac{dW}{dt}$

Power can also be expressed as

$$P = F \cdot \frac{dr}{dt} = F \cdot v$$ here, dr is displacement vector.

(5). Work done by Constant Force :

$$W = F \cdot S$$

(6). Work done by multiple forces

$$\Sigma F = F_1 + F_2 + F_3 + ...$$

$$W = [\Sigma F] \cdot S \qquad ...(i)$$

$$W = F_1 \cdot S + F_2 \cdot S + F_3 \cdot S + ...$$

Or $W = W_1 + W_2 + W_3 + ...$

(7). Work done by A variable force

$$dW = F \cdot ds$$

(8). Relation between momentum and kinetic energy

$K = \frac{P^2}{2m}$ and $P = \sqrt{2\,m\,K}$; P = Linear momentum

(9). Potential energy

$$\int_{U_1}^{U_2} dU = -\int_{r_1}^{r_2} F \cdot dr \qquad \text{i.e., } U_2 - U_1 - \int_{r_1}^{r_2} F \cdot dr = -W$$

$$U = -\int_{\infty}^{r} F \cdot dr = -W$$

(10). Conservative Forces

$$F = \frac{U}{r}$$

(11). Work-Energy theorem

$$W_C + W_{NC} + W_{PS} = \Delta K$$

(12). Modified Form of work-Energy Theorem

$$W_C = -\Delta U$$

$$W_{NC} + W_{PS} = \Delta K + \Delta U$$

$$W_{NC} + W_{PS} = \Delta E$$

(12). Power

The average power $(\bar{P}$ or $P_{av})$ delivered by an agent is given by $\bar{P}$ or $p_{av} = \frac{W}{t}$

$$P = \frac{F \cdot dS}{dt} = F\frac{dS}{dt} = F \cdot v$$

6. SYSTEM OF PARTICLES AND ROTATIONAL MOTION

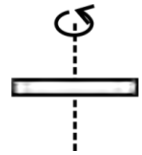
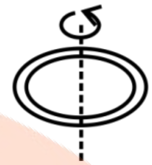
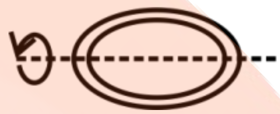
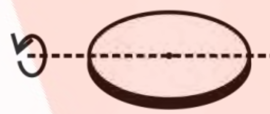
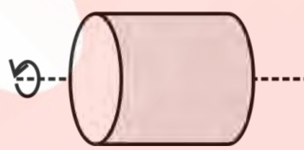
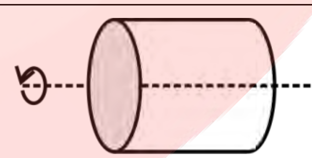
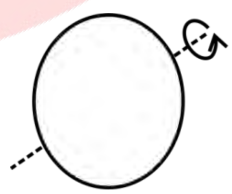
(1). According to the theorem of perpendicular axes moment of inertia of a body about perpendicular axis is $I_z = I_x + I_{y'}$

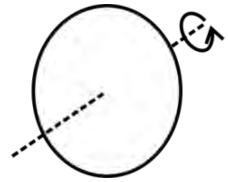
Where $I_x, I_y, I_z,$ are the moment of inertia of the rigid body about x, y and z axes respectively x and y axes lie in the plane of the body and z-axis lies perpendicular to the plane of the body and passes through the point of intersection of x and y.

(2). According to the theorem of parallel axes $I = I_C + Md^c$

Where I_C is the moment of inertia of the body about an axis passing through its centre of mass and d is the perpendicular distance between the two axes.

Table 1: Moment of inertia of some symmetrical bodies

	Body	Axis	Figure	M.I.
(1)	Rod (Length L)	Perpendicular to rod, at the midpoint centre of mass		$\frac{ML^2}{12}$
(2)	Circular ring (radius R)	Passing through centre and perpendicular the plane		MR^2
(3)	Circular ring (Radius R)	Diameter		$\frac{MR^2}{2}$
(4)	Circular Disc (radius R)	Perpendicular to the disc at centre		$\frac{MR^2}{2}$
(5)	Circular Disc (radius R)	Diameter		$\frac{MR^2}{4}$
(6)	Hollow cylinder (radius R)	Axis of cylinder		MR^2
(7)	Solid cylinder (radius R)	Axis of cylinder		$\frac{MR^2}{2}$
(8)	Solid sphere (radius R)	Diameter		$\frac{2}{5}MR^2$

(9)	Hollow sphere (radius R)	Diameter		$\frac{2}{3}MR^2$

(3). Relation between moment of inertia (I) and angular momentum L is given by $L = I\,\omega$

(4). Relation between moment of inertia (I) and kinetic energy of rotation is given by

$$K.E._{rotation} = \frac{1}{2} I\omega^2$$

(5). Relation between of inertia (I) and torque $(\tau) \Rightarrow \quad \tau = I\alpha$

(6). If no external torque acts on the system, the total angular momentum of the system remains unchanged $I_1\omega_1 = I_2\omega_2$

(7). Position vector of centre of mass of a discrete particle system

$$r_{CM} = \frac{m_1 r_1 + m_2 r_2 + \ldots\ldots + m_n r_n}{m_1 + m_2 + \ldots\ldots + m_n} = \frac{\sum_{i=1}^{n} m_i r_i}{\sum_{i=1}^{n} m_i}$$

Where m_i is the mass of the i^{th} particle and r_1 is the position of the i^{th} particle corresponding $x_{CM} \cdot y_{CM}$ and z_{CM} co-ordinates are

$$x_{CM} = \frac{\sum_{l=1}^{n} m_i n_i}{\sum_{i=1}^{n} m_i}, \quad y_{CM} = \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i}, \quad z_{CM} = \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}$$

(8). Velocity of centre of mass, $v_{CM} = \frac{\sum_{i=1}^{n} m_i v_i}{\sum m_i}$

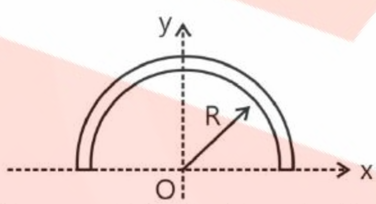
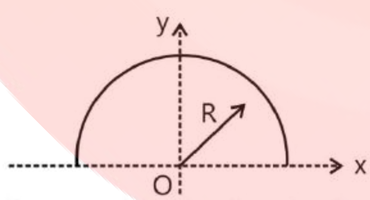
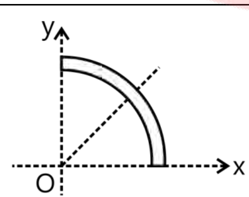
(9). Acceleration of CM, $a_{CM} = \frac{\sum_{i=1}^{n} m_i a_i}{\sum_{i=1}^{n} m_i}$

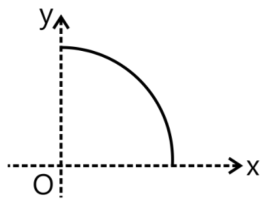
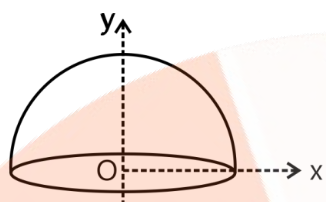
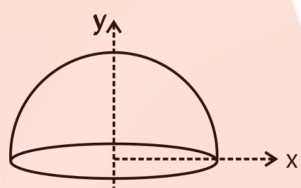
(10). Momentum of system, $P = P_1 + P_2 + ... + P_n = \left(\sum_{i=1}^{n} m_i\right) v_{CM}$

(11). Centre of mass of continuous mass distribution

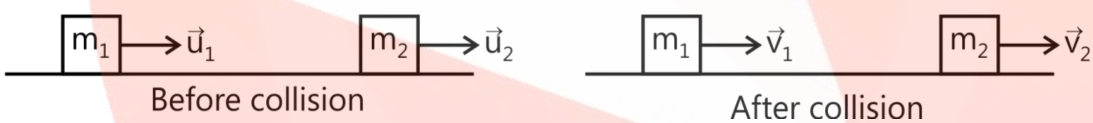
$$r_{CM} = \frac{\int dm\, r_e}{dm},\ x_{CM} = \frac{\int x\, dm}{\int dm},\ y_{CM} = \frac{\int y\, dm}{\int dm},\ z_{CM} = \frac{\int z\, dm}{\int dm}$$

(12). Given below are the positions of centre of mass of some commonly used objects.

S.No.	Object	Location of centre of mass
i.	 Uniform rod of length L	$x_{CM} = \frac{L}{2},\ y_{CM} = 0,\ z_{CM} = 0$
ii.	 Uniform semicircular ring of radius R	$x_{CM} = 0,\ y_{CM} = \frac{2R}{\pi},\ z_{CM} = 0$
iii.	 Uniform semicircular disc of radius R	$x_{CM} = 0,\ y_{CM} = \frac{4R}{3\pi},\ z_{CM} = 0$
iv.	 Uniform quarter of a ring of radius R	$x_{CM} = \frac{2R}{\pi},\ y_{CM} = \frac{2R}{\pi},\ z_{CM} = 0$

v.	 Uniform quarter of a disc of radius R	$x_{CM} = \frac{4R}{3\pi},\ y_{CM} = \frac{4R}{3\pi},\ z_{CM} = 0$
vi.	 Uniform spherical shell of radius R	$x_{CM} = 0,\ y_{CM} = \frac{R}{2},\ z_{CM} = 0$
vii.	 Uniform spherical of radius R	$x_{CM} = 0,\ y_{CM} = \frac{3R}{8},\ z_{CM} = 0$

(13). Head-on collision



Velocity of bodies m_1, m_2 after collision are

$$\vec{v}_1 = \left(\frac{m_1 - em_2}{m_1 + m_2}\right)\vec{u}_1 + \frac{m_2(1+e)}{m_1 + m_2}\vec{u}_2 \quad ; \quad \vec{v}_2 = \left(\frac{m_2 - em_1}{m_1 + m_2}\right)\vec{u}_2 + \frac{m_1(1+e)}{m_1 + m_2}\vec{u}_1$$

Here e is coefficient of restitution.

Loss in kinetic energy, $\Delta KE = \frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}(u_1 - u_2)^2(1 - e^2)$

(14). For elastic collision $\Delta KE = 0$ and e = 1, then velocities after collision are

$$\vec{v}_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)\vec{u}_1 + \left(\frac{2m_2}{m_1 + m_2}\right)\vec{u}_2 \quad ; \quad \vec{v}_2 = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)\vec{u}_2 - \frac{2m_1}{m_1 + m_2}\vec{u}_1$$

(15). For perfectly inelastic collision, e = 0, then velocities after collision are

$v_1 = v_2 = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}$ and loss in kinetic energy is $\Delta KE = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}(u_1 - u_2)^2$

7. GRAVITATION

(1). Newton's universal law of gravitation $F = \frac{Gm_1m_2}{r^2}$

In vector form, $F = \frac{Gm_1m_2}{r^2}\cdot(r)$

(2). According to Kepler's II[nd] law $\frac{dA}{dt} = \frac{L}{2m}$

(3). According to Kepler's III[rd] law $T^2 = \frac{4\pi^2}{GM}R^3 \Rightarrow T^2 \propto R^3$

Where, T = Time period of revolution, and R = Semi-major axis of the elliptical orbit.

Newton's universal law of gravitation $F = \frac{Gm_1m_2}{r^2}$

(4). Acceleration due to gravity 'g' is $g = \frac{GM_e}{R_e^2}$

(5). Variation of g at altitude 'h' is $g_h = g\left[\frac{R_e}{R_e+h}\right]^2$

If $h << R$ then, $g_h = g\left[1 - \frac{2h}{R_e}\right]$

(6). Variation of g at depth 'd' is $g_d = g\left[1 - \frac{d}{R_e}\right]$

(7). Gravitational potential energy $U = W_{AB} = -GMm\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$

If, $r_1 = \infty, r_2 = r \Rightarrow U = -\frac{GMm}{r}$

8. MECHANICAL PROPERTIES OF SOLIDS

(1). Elongation produced in rod of length 'L' due to its own weight is $\Delta L = \frac{\rho g L^2}{2Y} = \frac{MgL}{2AY}$

(2). Thermal Stress $Y \alpha \Delta\theta$

(3). Elastic potential energy density $U = \frac{1}{2}(\text{stress}) \times (\text{strain})$

(4). Bulk modulus, $B = -V\frac{\Delta P}{\Delta V}$

(5). Compressibility $= \frac{1}{B}$

(6). Restoring couple per unit twist $= \frac{\pi\eta r^4}{2}$

(7). $\sigma = -\frac{\Delta r / r}{\Delta L / L}$

(8). Relation between $Y, B, S \Rightarrow Y = \frac{9BS}{3B + S}$

(9). Relation between Y, B, η, $Y = 3B(1 - 2\eta)$

(10). Relation between Y, S $Y = 2S(1 + \sigma)$

(11). Poisson's Ratio $\eta = \frac{3B - 2S}{6B + 2S}$

(12). Depression at the middle of a beam $y = \frac{Wt^3}{4Ybd^3}$

(13) Sheer Modulus $S = \frac{Fh}{Ax}$

(14) Relation between B, S, η, $B = \frac{2S(1 + \eta)}{3(1 - 2\eta)}$

9. MECHANICAL PROPERTIES OF FLUIDS

(1). Relative density of a substance $\rho_{rel} = \frac{\rho_{substance}}{\rho_{water} \text{ at } 4^{\circ}C}$

(2). Gauge pressure $P_g = \rho g h$

(3). Apparent weight of a body of density σ in a fluid of density ρ

$W' = W\left(1 - \frac{\rho}{\sigma}\right)$, W = weight of the body in air

(4). Equation of continuity Av = constant

Here, A = cross-sectional area of pipe and v = fluid velocity

(5). Bernoulli's equation: At any point in a streamline flow

$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}$$

Here, P= pressure, v = fluid velocity and ρ is density.

(6). Coefficient Of viscosity $\eta = \frac{F}{vA}$

Here, F = Viscous force, = Separation between two lamina, A = Area of each lamina and v = Relative velocity of two lamina

(7). According to Stokes'law $F = -6\pi\eta a v$

Here, a = radius a ball or drop and v = velocity of ball or drop

(8). Formula for Terminal velocity is $v_T = \frac{2a^2}{9\eta}(\rho - \sigma)g$

Where, ρ = density of falling body, σ = density of fluid and η = coefficient of viscosity

(9). Reynolds number. $R_e = \frac{\rho v d}{\eta}$ where, d = diameter of the pipe

(10). Excess pressure inside a liquid drop or a cavity of radius R is $\Rightarrow P_i - P_0 = \frac{2S}{R}$ where S is surface tension

(11). Excess pressure inside an air bubble is $P_i - P_0 = \frac{4S}{R}$

(12). Height of a liquid in a capillary tube is $h = \frac{2S\cos\theta}{r\rho g}$

Where, θ = angle of contact, ρ = density of the liquid and g = acceleration due to gravity

10. THERMAL PROPERTIES OF MATTER

(1). Conversion of temperature from one scale to other.

(a) From $^\circ C \leftrightarrow ^\circ F$ $\quad t_C = \frac{5}{9}(t_F - 32)$, & $t_F = \frac{9}{5}t_C + 32$

(b) From $^\circ C \leftrightarrow ^\circ K$ $\quad T = t_C + 273.15$, & $t_C = T - 273.15$

(c)) From $^\circ F \leftrightarrow ^\circ K$ $\quad t_F = \frac{9}{5}T - 459.67$, & $T = \frac{5}{9}t_F + 255.37$

Where T, t_C, t_F, stand for temperature reading on Kelvin scale, Celsius scale, Fahrenheit scale respectively.

(2). $\beta = 2\alpha$, $\gamma = 3\alpha$ (Relation between α, β, γ)

(3). (a) $Q = \frac{kA(T_1 - T_2)t}{x}$

Where Q is the amount of heat that flows in time t across the opposite faces of a rod of length x and cross-section A. T_1 and T_2 are the temperatures of the faces in the steady state and k is the coefficient of thermal conductivity of the material of the rod.

(b) $Q = -kA\left(\frac{dT}{dx}\right)t$ Where $\frac{dT}{dx}$ represents the temperature gradient.

(c) $H = \frac{dQ}{dt} = -kA\left(\frac{dT}{dx}\right)$ H is called the heat current.

(4). (a) Coefficient of reflectivity is $r = \frac{Q_1}{Q}$

(b) Coefficient of absorptivity $a = \frac{Q_2}{Q}$

(c)Coefficient of transitivity $t = \frac{Q_3}{Q}$

Where Q_1 is the radiant energy reflected, Q_2 is the radiant energy absorbed and Q_3 is the radiant energy transmitted through a surface on which Q is the incident radiant energy

(5). (a) $\ln \frac{(T_1 - T_0)}{(T_2 - T_0)} = Kt$

(b) $\frac{(T_1 - T_2)}{t} = K\left(\frac{T_1 \times T_2}{2} - T_0\right)$

The above two equations represents Newton's law of cooling. Here, t is the time taken by a body to cool from T_1 to T_2 in a surrounding at temperature T_0.

11. THERMODYNAMICS

(1). First law of thermodynamics $\Delta Q = \Delta U + \Delta W$

(2). Work done, $\Delta W = P\Delta V$

$\therefore \quad \Delta Q = \Delta U + P\Delta V$

(3). Relation between specific heats for a gas $C_p - C_r = R$

(4). For isothermal process, (i) according to Boyle's law PV = constant

According to Charles law (For volume) $V \propto T$ constant and Charles law (for pressure) $P \propto T$

And (ii) Work done is $W = \mu RT \ln \frac{V_2}{V_1} = 2.303\ \mu RT \log \frac{V_2}{V_1}$

(5). For adiabatic process, (i) According to Boyle's law PV^{γ} = constant Where, $\gamma = \frac{C_p}{C_v}$

And (ii) Work done is $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{\mu R[T_1 - T_2]}{\gamma - 1}$

(6). Slope of adiabatic = γ (slope of isotherm)

(7). For Carnot engine,

(i) Efficiency of engine is $\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T}$ $\left(\frac{Q_1}{Q_2} = \frac{T_1}{T_2}\right)$

(ii) And work done is $W = Q_1 - Q_2$ $\therefore\ \eta = \frac{W}{Q_1}$

(8). For Refrigerator

(i) Coefficient of performance is $\beta = \frac{Q_2}{Q_1 - Q_2} = \frac{Q_2}{W}$ $\Rightarrow \beta = \frac{1-\eta}{\eta}$

(9). For Heat pump $r = \frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2} = \frac{1}{\eta}$

12. KINETIC THEORY OF GASES

(1). Ideal gas equation is $PV = \mu RT$ where μ is number of moles and R is gas constant

Pressure exerted by ideal gas on container is $P = \frac{1}{3}\frac{mM}{V}\overline{v^2}$

(2) R.M.S. velocity $v_{rms} = \sqrt{\frac{3k_BT}{m}}$

(3). Average velocity $v_{av} = \sqrt{\frac{8K_BT}{\pi m}}$

(4). Most probable velocity $v_{mp} = \sqrt{\frac{2K_BT}{m}}$

(5). Mean free path $(\lambda) = \frac{1}{\sqrt{2}n\pi d^2}$

Where n = number density and d = diameter of molecule

Table 2: Some important points about molecules of gas

S.No.	Atomicity	No. of degree of freedom	C_p	C_v	$\gamma = \frac{C_P}{C_v}$
1.	Monoatomic	3	$\frac{5}{2}R$	$\frac{3}{2}R$	$\frac{5}{3}$
2	Diatomic	5	$\frac{7}{2}R$	$\frac{5}{2}R$	$\frac{7}{5}$
3.	Linear molecule (Triatomic)	7	$\frac{7}{2}R$	$\frac{5}{2}R$	$\frac{7}{5}$
4.	Non-linear molecule (Triatomic)	6	4R	3R	$\frac{4}{3}$

(6). For mixture of gas, molar specific heat at constant volume is given by $C_{v(mix)} = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1 + n_2}$

Where n_1 and n_2 are number of moles of two gases mixed together C_{v_1} and C_{v_2} are molar specific heat at constant volume of 2 gas.

(7) For mixture of gases with $n_1, \& n_2$ moles the following relation holds true.

$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

13. OSCILLATIONS

(1) Displacement equation for SHM $x = A\sin(\omega t + \phi)$ Or

$x = A\cos[\omega t + \phi]$ where A is amplitude and $(\omega t + \phi)$ is phase of the wave

(2). Velocity in SHM $v = A\omega\cos\omega t$ and $v = \omega\sqrt{A^2 - x^2}$

(3). Acceleration in SHM is $a = -\omega^2 A\sin\omega t$ and $a = -\omega^2 x$

(4). Energy in SHM is

(i) Potential energy $U = \frac{1}{2}m\omega^2 x^2$

(ii) Kinetic energy $K = \frac{1}{2}m\omega^2(A^2 - x^2)$

(iii) Total energy $E = \frac{1}{2}m\omega^2 A^2$

(5). For Simple pendulum

(i) Time period of pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$

(ii) If L is large $T = 2\pi\sqrt{\frac{1}{g\left[\frac{1}{L} + \frac{1}{R}\right]}}$

(iii) $\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L}$

(iv) Accelerated pendulum $T = 2\pi\sqrt{\frac{L}{g + a}}$

(6). For torsional pendulum, time period of oscillation is $T = 2\pi\sqrt{\frac{I}{k}}$; where I is moment of inertia

(7). For physical pendulum, time period of oscillation is $T = 2\pi\sqrt{\frac{I}{mgd}}$; where I is moment of inertia of body about axis passing through hinge and, d : Distance of centre of mass from hinge

(8). Damped simple harmonic motion

(i) Force action on oscillation body is $m \cdot \frac{d^2x}{dt^2} = -kx - b\frac{dx}{dt}$

(ii) Equation of motion is $x = Ae^{-u/2m}\cos(\omega' t + \phi)$ Where $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

(9). Forced oscillator

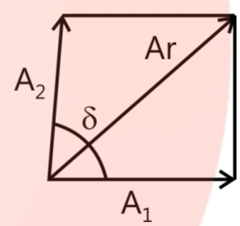
(i) Force acting on body is $\frac{md^2x}{dt^2} = -kx - bv + F_0 \sin \omega t$

(ii) Equation of motion is $x = A\sin[wt + \phi]$ Where $A = \frac{F_\phi}{m\sqrt{(\omega^2 - \omega_0^2)^2 + \left(\frac{b\omega}{m}\right)^2}}$

(10). Superposition of Two SHM's

(i) In same direction

$x_1 = A_1 \sin \omega t$ and $x_2 = A_2 \sin(\omega t + \delta)$



Resultant amplitude is $A_r = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\delta}$

(ii) In perpendicular direction

$x_1 = A_1 \sin \omega t$ and $y_1 = A_2 \sin(\omega t + \phi)$

(a) Resultant motion is SHM along straight line, if $\phi = 0$ or $\phi = \pi$

(b) Resultant motion is circular, if $\phi = \frac{\pi}{2}$ and $A_1 = A_2$

(c) Resultant motion is an (light) elliptical path, if $\phi = \frac{\pi}{2}$ and $A_1 \neq A_2$

14. WAVES

(1). Equation of a plane progressive harmonic wave travelling along positive direction of X-axis is

$$y(x, t) = a \sin(kx - \omega t + \phi)$$

And along negative direction of X-axis is $y(x, t) = a \sin(kx + \omega t + \phi)$

Where, $y(x,t) \rightarrow$ Displacement as a function of position x and time t,

$a \rightarrow$ Amplitude of the wave, $\omega \rightarrow$ Angular frequency of the wave,

$k \rightarrow$ Angular wave number, $(kx - \omega t + \phi) \rightarrow$ Phase,

And $\phi \rightarrow$ Phase constant or initial phase angle

(2). Angular wave number or propagation constant (k) $k = \frac{2\pi}{\lambda}$

(3). Speed of a progressive wave $v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$

(4) Speed of a transverse wave on a stretched string

$v = \sqrt{\frac{T}{\mu}}$ where, $T \rightarrow$ Tension in the string, and $\mu \rightarrow$ Mass per unit length

(5). Speed of sound wave in a fluid

$v = \sqrt{\frac{B}{\rho}}$ where, $B \rightarrow$ Bulk modulus, and $\rho \rightarrow$ density of medium

(6). Speed of sound wave in metallic bar

$v = \sqrt{\frac{Y}{\rho}}$ where, Y = young's modulus of elasticity of metallic bar

(7). Speed of sound in air (or gases) Newton's formula (connected)]

$v = \sqrt{\frac{v}{\rho}}$ where, $P \rightarrow$ Pressure, $\rho \rightarrow$ Density of air (or gas) and $\gamma \rightarrow$ Atomicity of air (or gas)

(8). The effect of density on velocity of sound $\frac{v_2}{v_1} = \sqrt{\frac{\rho_1}{\rho_2}}$

(9). The effect of temperature on velocity of sound $\frac{v_1}{v_0} = \sqrt{\frac{T}{T_0}} = \sqrt{\frac{273+t}{273}}$

(10). If two waves having the same amplitude and frequency, but differing by a constant phase ϕ, travel in the same direction, the wave resulting from their superposition is given by

$$y(x,t) = \left[2a\cos\frac{\phi}{2}\right]\sin\left(kx - \omega t + \frac{\phi}{2}\right)$$

(11). If we have a wave

$y_1(x,t) = a\sin(kx - \omega t)$ then,

(i) Equation of wave reflected at a rigid boundary

$y_r(x,t) = a\sin(kx + \omega t + \pi)$ Or $y_r(x,t) = -a\sin(kx + \omega t)$

i.e. the reflected wave is 180° out of phase.

(ii) Equation of wave reflected at an open boundary $y_r(x,t) = a\sin(kx + \omega t)$

i.e. the reflected wave is a phase with the incident wave.

(12). Equation of a standing wave on a string with fixed ends $y(x,t) = [2a\sin kx]\cos\omega t$

Frequency of normal modes of oscillation $f = \frac{nv}{2L}$ $n = 1,2,3.....$

(13). Standing waves in a closed organ pipe (closed at one end) of length L.

Frequency of normal modes of oscillation. $f = \left(n - \frac{1}{2}\right)\frac{v}{2L}$ $n = 1,2....$

$\Rightarrow f_n = (2n-1)f_1$

Where f_n is the frequency of n^{th} normal mode of oscillation. Only odd harmonics are present in a closed pipe.

(14). Standing waves in an open organ pipe (open at both ends)

Frequency of normal modes of oscillation $f = \frac{nv}{2L}$ $n = 1,2,3....$

$\Rightarrow f_n = nf_1$

Where f_n is frequency of n^{th} normal mode of oscillation.

(15). Beat frequency (m)

$m \to$ Difference in frequencies of two sources

$m = (v_1 - v_2)$ or $(v_2 - v_1)$

(16). Doppler's effect $f = f_0\left[\dfrac{v + v_0}{v + v_s}\right]$

Where, $f \to$ Observed frequency, $f_0 \to$ Source frequency,

$v \to$ Speed of sound through the medium, $v_0 \to$ Velocity of observer relative to the medium

and $v_s \to$ Source velocity relative to the medium

$\Rightarrow$ In using this formula, velocities in the directions (i.e. from observer to the source) should be treated as positive and those opposite to it should be taken as negative.

15. ELECTRIC CHARGES AND FIELDS

(1). Electric force between two charges is given by $F = \dfrac{q_1 q_2}{4\pi\varepsilon_0 R^2}$

And $F = q_1 E$ where $E = \dfrac{q_2}{4\pi\varepsilon_0 R^2}$ is the electric field due to charge q_2

(2) Electric potential energy for system of two charges is $U = -W = \dfrac{q_1 q_2}{4\pi\varepsilon_0}\left(\dfrac{1}{r_1} - \dfrac{1}{r_2}\right)$

For $r_2 = \infty$, $U = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r_1}$

(3) Electrostatic potential is $\Delta V = \frac{\Delta U}{q}$

(4). Electric field on the axis of a dipole of moment $p = 2aQ$ at a distance R from the centre is

$E = \frac{2Rp}{4\pi\varepsilon_0 (R^2 - a^2)^2}$. If R > > a then $E = \frac{2p}{4\pi\varepsilon_0 R^3}$

(5). Electric field on the equatorial line of the dipole at a distance R from the centre is

$E = \frac{-p}{4\pi\varepsilon_0 (R^2 + a^2)^{\frac{3}{2}}}$. If R > > a then $E = \frac{-p}{4\pi\varepsilon_0 R^2}$

(6). Torque τ experienced by a short dipole kept in uniform external electric field E is

$\tau = p \times E = pE \sin 0 \, \hat{n}$

(7). Perpendicular deflection of a charge q in a uniform electric field E after travelling a straight distance x is $y \frac{qEx^2}{2mv_0^2}$, where m is mass of the charge and v_0 is initial speed of perpendicular entry in the electric field.

(8). Electric flux $\phi_E = E \cdot S = ES \cos \theta$. Area vector S is perpendicular to the surface area.

(9). Gauss law : $\int E \cdot dS = \frac{Q}{\varepsilon_0}$. Here E is the electric field due to all the charges inside as well as outside the Gaussian surface, while Q is the net charge enclosed inside Gaussian surface.

(10). Electric field due to infinitely long charged wire of linear charge density λ at a perpendicular distance R is $E = \frac{\lambda}{2\pi\varepsilon_0 R}$

(11). Electric field due to singal layer of surface charge density σ is $\frac{\sigma}{2\varepsilon_0}$. Field due to oppositely charged conducting plates is $\frac{\sigma}{\varepsilon_0}$ in between the gap but zero outside.

(12). Field due to a uniformly charged thin spherical shell of radius R is $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ for outside points and zero inside (r is distance from the centre of shell)

(13). Field due to a charge uniformly distributed in a spherical volume is $E = \frac{d}{dr}\left(\frac{Q}{4\pi\varepsilon_0 R^3} r^2\right) = \frac{\rho r}{3\varepsilon_0}$

for inside points and $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ for outside point.

Here $\rho = \frac{3Q}{4\pi R^3}$ is volume charge density and Q is total charge inside the sphere.

16. ELECTROSTATIC POTENTIAL AND CAPACITANCE

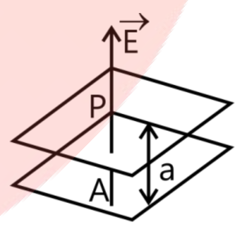
(1). **Electric potential :**

(a) Potential due to a conducting sphere of radius r with charge q (solid or hollow) at a distance r from the centre

$V = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q}{r}$ if (r > R) or $V = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q}{R}$ if (r = R)

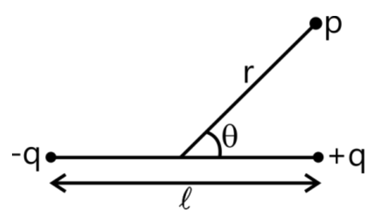
or $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ if (r < R)

(b) Relation between electric field potential $|E| = \left|-\frac{\partial v}{\partial}\right| = +\frac{|\partial v|}{\partial}$



(2). **Electric dipole potential:**

(a) $V = \frac{1}{4\pi\varepsilon_0}\left(\frac{p\cos\theta}{r^2}\right)$



(b) Potential energy of a dipole in an external electric field

$U(\theta) = -P \cdot E$

(3). **Capacitors :**

Capacitance of a potential plate capacitor $C = \varepsilon_0 \dfrac{A}{d}$

(4). **Electric field energy :** (a) $U = \frac{1}{2}QV = \frac{Q^2}{2C} = \frac{1}{2}CV^2$

(b) Energy density of energy stored in electric field $u = \frac{1}{2}\varepsilon_0 E^2$

(5) **Combination of capacitors :**

(a) When capacitors are combined in series, $\dfrac{1}{C_{eq}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3} + ...$

(b) When capacitors are connected in parallel. $C_{eq} = C_1 + C_2 + C_3 + ...$

(c) Capacitance of spherical capacitor,

$C = 4\pi\varepsilon_0 \dfrac{ab}{b-a}$. (When outer shell is earthed). or

$C = 4\pi\varepsilon_0 \dfrac{b^2}{b-a}$. (When inner shell is earthed) or

$C = 4\pi\varepsilon_0 R$ (For a sphere of radius R)

(d) Cylindrical capacitor, $C = \dfrac{2\pi\varepsilon_0}{\ln\left(\dfrac{b}{a}\right)}$

(6). **Dielectrics :**

(a) Induced charge, $q' = q\left(1 - \dfrac{1}{k}\right)$ (b) Polarization $p = \dfrac{\text{Dipole moment}}{\text{Volume}}$

Electric dipole moment is $p = \chi_e E$

$\dfrac{\chi_e}{\varepsilon_0} = K - 1$ where χ_e is electrical susceptibility, and K is dielectric constant.

17. CURRENT ELECTRICITY

(1). Resistance of a uniform conductor of length L, area of cross-section A and resistivity ρ along its length, $R = \rho \frac{\ }{A}$

(2). Current density $j = \frac{di}{ds}$

(3). Conductance $G = \frac{1}{R}$.

i4) Drift velocity $v_d = \frac{eE}{m} t. = \frac{i}{neA}$

(5). Current $i = neAv_d$

(6) Resistivity is $\rho = \frac{m}{ne^2 t} = \frac{1}{\sigma}$ where σ is resistivity.

(7) According to Ohm's law $j = \sigma E$ and $V = iR$

(8) Mobility of free electrons $\mu = \frac{v_d}{E}$

(9) $\sigma = ne\mu$

(10). Thermal resistivity of material is $\rho_T = \rho_0 [1 + \alpha(T - T_0)]$

(11). Potential difference across a cell during discharging $V = \varepsilon - ir = \frac{\varepsilon R}{R + r}$

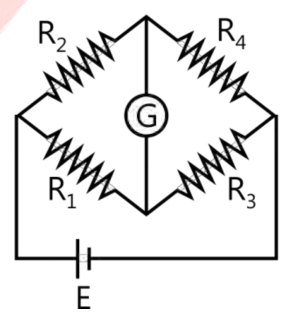
(12). Potential difference across a cell during charging $V = \varepsilon + ir$

(13) For n cells in series across load R, current through load $i = \frac{n\varepsilon}{R + nt}$

(14). For n identical cells in parallel across load R, current through load $i = \frac{n\varepsilon}{nR + r}$

(15). Wheatstone bridge network

For balanced Wheatstone bridge $\frac{R_1}{R_2} = \frac{R_3}{R_4}$



(16). If unknown resistance X is in the left gap, known resistance R is in the right gap of meter bridge and balancing length from left end is l then $X = \frac{R}{100 -}$

(17) **Potentiometer**

(i) Comparison of emf $\frac{\varepsilon_1}{\varepsilon_2} = \frac{1}{2}$ (ii) Internal resistance of cell $r = \left(\frac{1}{2} - 1\right)R$

18. MOVING CHARGES AND MAGNETIC FIELD

S.No.	Situation	Formula
1.	Lorentz force	$q[E + v \times B]$
2.	Condition for a charged particle to go undeflected in a cross electric and magnetic field	$= \frac{E}{B}$
3.	A charge particle thrown perpendicular to uniform magnetic field (i) Path (ii) Radius (iii) Time period	(i) Circular (ii) $r = \frac{mv}{qB}$ (iii) $t = \frac{2\pi m}{qB}$
4.	A charge particle thrown at some angle to a uniform magnetic field (i) Path (ii) Radius (iii) Time period (iv) Pitch	(i) Helix (ii) $r = \frac{mv \sin\theta}{qB}$ (iii) $t = \frac{2\pi m}{qB}$ (iv) $T \cdot v \cos \theta$
5.	Cyclotron frequency	$f = \frac{qB}{2\pi m}$
6.	Maximum kinetic energy of a charged particle in a cyclotron (With R as radius of dee)	$K = \frac{q^2B^2R^2}{2m}$

7.	Force on a straight current carrying conductor in a uniform magnetic field	$F = i(l \times B)$
8.	Force on a arbitrary shaped current carrying conductor in a uniform magnetic field	$F = i\int d\quad \times B = i\quad \times B$
9.	Magnetic moment of a current carrying loop	$M = i\ A$
10.	Torque on a current carrying loop placed in a uniform magnetic field	$\tau = M \times B$
11.	Biot-Savart Law	$dB = \frac{\mu_0 i}{4\pi} \frac{d\quad \times r}{r^3}$
12.	Magnetic field at a point distance x from the centre of a current carrying circular loop	$\frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$
13.	Magnetic field at the centre of a current carrying circular loop	$\frac{\mu_0 i}{2R}$
14.	Magnetic field on the axis of a current carrying circular loop far away from the centre of the loop (Moment behaves as magnetic dipole)	$\frac{\mu_0}{4\pi} \frac{2M}{x^3}$
15.	Magnetic field on the centre of current carrying circular arc	$\frac{\mu_0}{4\pi} \frac{i}{t} \theta$
16.	Ampere's circular law	$\int B \cdot d\quad = \mu_0 i$
17.	Magnetic field due to a long thin current carrying wire	$B = \frac{\mu_0 i}{2\pi r}$
18.	Magnetic field inside a long straight current carrying cylindrical conductor at a distance r from the axis.	$B = \frac{\mu_0}{2\pi} \cdot \frac{i}{R^2} \cdot r$
19.	Magnetic field outside a long straight current carrying conductor at a distance r from the axis	$B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r}$
20.	Magnetic field inside a long solenoid	$B = \mu_0 n i$

21.	Magnetic field inside a toroid	$B = \frac{\mu_0 N i}{2\pi r}$
22.	Force per unit length between two current carrying wire	$F = \frac{\mu_0 i_1 i_2}{2\pi r}$
23.	Current sensitivity of moving coil galvanometer	$\frac{\theta}{i} = \frac{NBA}{k}$
24.	Voltage sensitivity of moving galvanometer	$\frac{\theta}{V} = \frac{NBA}{kR}$
25.	Shunt resistance required to convert galvanometer into ammeter of range i (i_g is the full scale deflected current of galvanometer)	$r_g = \frac{G}{\left(\frac{i}{i_g} - 1\right)}$
26.	Resistance required to convert galvanometer into voltmeter of range V	$R = \frac{V}{i_g} - G$

19. MAGNETISM AND MATTER

(1). **Bar magnet :** The electrostatic Analog

Electrostatics	**Magnetism**
Permittivity = $\frac{1}{\varepsilon_0}$	Permittivity = μ_0
Charge q	Magnetic pole strength (q_n)
Dipole Moment $p = q \cdot l$	Magnetic Dipole Moment $M = q_m l$

$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$	$F = \frac{\mu_0}{4\pi}\frac{q_{m(1)}q_{m(2)}}{t^2}$
$F = qE$	$F = q_m B$
Axial Field $E = \frac{2p}{4\pi\varepsilon_0 r^2}$	$B = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$
Equatorial Field $E = \frac{-p}{4\pi\varepsilon_0 r^2}$	$B = -\frac{\mu_0}{4\pi}\frac{M}{r^2}$
Torque $\tau = p \times E$	$\tau = M \times B$
Potential Energy $U = -p \cdot E$	$U = -M \cdot B$
Work $W = pE(\cos\theta_1 - \cos\theta_2)$	$W = MB(\cos\theta_1 - \cos\theta_2)$

(2). Field due to a magnetic monopole $B = \frac{\mu_0}{4\pi}\frac{q_m}{r^2}\cdot\hat{r}$

(3). B on the axial line or end on position of a bar magnet

$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}r}{(r^2 - l^2)^2}$ $\left(\text{for } r >> l, \vec{B} = \frac{\mu_0}{4\pi}\cdot\frac{2\vec{M}}{r^2}\right)$

(4). B on the equatorial line or broad side on position of a bar magnet

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

(5). Time period angular SHM $T = 2\pi\sqrt{\frac{I}{MB}}$ here I is moment of inertia.

(6). Gauss's law in magnetism $\int B \cdot ds = 0$

(7). For horizontal and vertical component of earth's magnetic field, $\frac{B_V}{B_H} = \tan\delta$

(8). $\tan \delta_1' = \dfrac{\tan \delta}{\cos \alpha}$

(9). $\cot^2 \delta = \cot^2 \delta_1 + \cot^2 \delta_2$

(10). Magnetic intensity is $H = \dfrac{B}{\mu_0} = \dfrac{B}{\mu}$

(11). Relative magnetic permittivity is $\mu_r = \dfrac{\mu}{\mu_0}$

(12). Magnetic Susceptibility $\chi_m = \dfrac{M}{H}$

(13). $\mu_r = 1 + \chi_m$

(14). $\chi \propto \dfrac{1}{(T - T_c)}$

20. ELECTROMAGNETIC INDUCTION

(1). Average induced emf $\bar{e} = \dfrac{-\Delta\phi}{\Delta t} = -\left[\dfrac{\phi_2 - \phi_1}{t_2 - t_1}\right]$

(2). Instantaneous induced emf $e_{(t)} = -\dfrac{d\phi_{(t)}}{dt}$

(3). Motional emf $= B_\perp v_\perp$

(4). Motional emf $e = \int de = \int (v \times B) dl = (v \times B) j$

(5). $\int E \cdot dl = \dfrac{-d}{dt}\phi_B$ [$E \to$ electric (induced) field, $\phi_B \to$ Magnetic flux]

(6). $\phi_B = Li$ $\Rightarrow$ $L \to$ self inductance of the coil

(7). Induced emf $e = -L\dfrac{di}{dt}$

(8). $L = \mu_0 \mu_r n^2 \times A \times i$ Where L coefficient of self-inductance

(9). $\phi_2 = Mi_1$ and $\theta_2 = -M\dfrac{di_1}{dt}$ Where M is co efficient of mutual inductance

(10). The emf induced (in dynamo) $e_{(t)} = BA\omega(\sin \omega t)$

(11). Mutual inductance $M = \mu_0 \mu_1 n_1 n_2 A i$

21. ELECTROMAGNETIC WAVES

(1). Displacement current $I_D = \varepsilon_0 \frac{d\phi_E}{dt} = \varepsilon_0 \frac{d\int E \cdot ds}{dt} = \frac{C\,dV}{dt}$

(2). Maxwell's Equation:

(a) $\int E \cdot ds = \frac{q}{\varepsilon_0}$

(b) $\int B \cdot ds = 0$

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

(d) $\int B \cdot dl = \mu_0 \left(I_c + \varepsilon_0 \frac{d\phi_E}{dt} \right)$

(3). $E_y = E_0 \sin(\omega t - kx)$ and $B_2 = B_0 \sin(\omega t - kx)$

$c_{vacuum} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$; $c_{medium} = \frac{1}{\sqrt{\mu_r \mu_0 \varepsilon_r \varepsilon_0}}$

(4). $\frac{E_\phi}{B_0} = \frac{E_{RMS}}{B_{RMS}} = \frac{E}{B} = c$

(5). Average of wave I_{av} = Average energy density × (speed of light)

Of $I_{av} = U_{av} \cdot = \frac{E_0 B_0}{2\mu_0} = \frac{E_0^2}{2c\mu_0} = \frac{cB_0^2}{2\mu_0}$

(6). Instantaneous energy density $u_{av} = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{B^2}{\mu_0} \right) = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$

Average energy density $u_{av} = \frac{1}{4}\varepsilon_0 E_0^2 + \frac{B_0^2}{4\mu_0} = \frac{\varepsilon_0 E_0^2}{2} = \frac{B_0^2}{2\mu_0}$

(7). Energy = (momentum), c or $U = Pc$

(8). Radiation pressure $R.P. = \frac{I_0}{c}$ where I_0 is intensity of source (when the wave is totally absorbed)

And $R.P. = \frac{2I_0}{c}$ (when the wave is totally reflected)

(9). $I \propto \frac{1}{t^2}$ (for a point source) and $I \propto \frac{1}{r}$ (for a line source)

For a plane source intensity is independent of r.

22. RAY OPTICS AND OPTICAL INSTRUMENTS

(1). The distance between the pole and centre of curvature of the mirror called radius of curvature

$$f = \frac{R}{2}$$

(2). Mirror equation $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (u is Object distance, v is Image distance and f Focal length)

(3). Linear magnification $m = \frac{\text{size of image}}{\text{size of object}} = \frac{\text{image distance}}{\text{Object distance}} = -\frac{v}{u}$

(4). In case of lens $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

(R= Radius of curvature , μ_1 and μ_2 are refractive indices of medium)

(5). Relationship between u, v and focal length f is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ in case lens.

(6). Longitudinal magnification = $(\text{Lateral magnification})^2$

(7) Equivalent lens

(i) Lens in contact $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$ (ii) Lens at a distance d, $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

(8). Reciprocal of focal length is called as power of lens.

$$P = \frac{1}{f(\text{in metres})} = \frac{100}{f(\text{in cm})}$$

(9). For achromatic combination of two lens $\frac{\omega_1}{f_1}+\frac{\omega_2}{f_2}=0$

(10). Refractive index of material of prism $\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$ (δ_m) Minimum deviation angle

(11). For small-angled prism $d=(\mu-1)A$

(where A= Angle of prism and B= Deviation angle)

(12). Dispersive power of prism for two colors (blue and red)

$$\omega=\left[\frac{\delta_V-\delta_R}{d}\right]=\left[\frac{\mu_V-\mu_R}{\mu-1}\right]$$

(13). For simple microscope,

(a) Magnification $m=1+\frac{D}{f}$ (Where D= Least distance of distinct vision. and f= Focal length)

(b) $M=\frac{D}{f}$ for image to form at infinity

(14). For compound microscope.

Magnification of objective $M_O=\frac{v_O}{u_O}$ and Magnification of eye piece $M_e=\left(1+\frac{v_e}{f_e}\right)$

(a) $m=m_o m_e=\frac{v_o}{u_e}\left[1+\frac{D}{f_e}\right]$ for least distance of distinct vision.

(b) $m=\frac{L}{f_o}\times\frac{D}{f_e}$ for image to form at infinite.

(15). Magnifying power of telescope $m=\frac{f_o}{f_e}$ and length of telescope $=L=f_e+f_o$

23. WAVE OPTICS

(1). $\frac{\sin i}{\sin t} = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$ (Snell's law)

(2). Ratio of maximum to minimum intensity $\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$

(3). (a) Fringe width $\beta = \frac{\lambda D}{d}$ (b) Condition of maxima $\Delta\phi = 2n\pi$ where $n = 0, 1, 2..$

(c) Condition of minima $\Delta\phi = (2n+1)\pi$ where $n = 0, 1, 2..$

(d) Intensity of any point of screen $I = 4I_0 \cos^2 \frac{\phi}{2}$

Where $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ is phase difference and Δx is path difference

(4). Doppler's effect for light $\frac{\Delta v}{v} = -\frac{v_{radial}}{c} = -\frac{\Delta\lambda}{\lambda}$

(5). Resolving power of microscope $= \frac{2\mu \sin\beta}{1.22\,\lambda}$

(6). Radius of central bright spot in diffraction pattern $r_0 = \frac{1.22\,\lambda f}{2a}$

(7). Fresnel distance $Z_f = \frac{a^2}{\lambda}$ (8) Malus law $I = I_0 \cos^2\theta$

(9) Brewster's law $\tan i_B = \mu$

24. DUAL NATURE OF RADIATION AND MATTER

(1). Einstein's photoelectric cell equation, $\frac{1}{2}mv_{max}^2 = hf - hf_0$

Where f, f_0 are frequencies of incident radiation.

(2). Work function and threshold frequency or threshold wavelength, $\phi_0 = hf_0 = \frac{hc}{\lambda_0}$

(3). Energy of photon, $E = hf = \frac{hc}{\lambda}$

(4). Momentum of photon, $P = \frac{E}{c} = \frac{h}{\lambda}$

(5). De Broglie wavelength of a material particle, $\lambda = \frac{h}{mv}$

(6). De Broglie wavelength of an electron accelerated through a potential V volt,

$$\lambda = \frac{12.27}{\sqrt{V}} \overset{o}{A} = \frac{1.227}{\sqrt{V}} nm$$

(7). de Broglie wavelength of a particle in terms of temperature (T), $\lambda = \frac{h}{\sqrt{3mkT}}$

(8). de Broglie wavelength in terms of energy of a particle (E), $\lambda = \frac{h}{\sqrt{2mE}}$

25. ATOMS

Rutherford's Model

Distance of closest approach $r_0 = \frac{e^2}{4\pi\varepsilon_0 E}$ where E is the energy of α-particle at a large distance.

Bohr's Model of hydrogen atom

Postulates: (i) Radius of n^{th} orbit, $r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m e^2}$

(ii) Orbital speed, $V_n = \frac{nh}{2\pi m r_n}$

(iii) Energy of n^{th} orbit, $E_n = -\left(\frac{me^4}{8\varepsilon_0^2 h^2}\right)\frac{1}{n^2} = \frac{13.6}{n^2}eV$

(iv) $TE = -KE$

(v) $PE = 2TE$

Rydberg's constant $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ and $R = \frac{me^4}{8\varepsilon_0^2 h^3 c}$

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26. NUCLEI

(1). Nuclear radius (R) is given by $R = R_0 A^{1/3}$ Here $R_0 = 1.2 \times 10^{-15} m$.

(2). Density of all nuclei is constant.

(3). Total binding energy $= [Z\ m_p + (A - Z)m_n - M]c^2$ J

(4). Av. BE/nucleon = Total B.E/A

(5). Radioactivity decay law $\frac{dN}{dt} = -\lambda N \Rightarrow N = N_0 e^{-\lambda t}$

(6). Half life $T_{1/2} = \frac{0.6931}{\lambda}$

(7). Average or mean life is $T_{av} = \frac{1}{\lambda} = 1.44\ T_{1/2}$.

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27. SEMICONDUCTOR ELECTRONICS

- Intrinsic semiconductors : $n_e = n_h = n_i$

  Extrinsic semiconductors: $n_e n_h = n_i^2$
- Transistors : $I_e = I_b + I_c \quad \Rightarrow \Delta I_E = \Delta I_b + \Delta I_c$
- Common emitter amplifier :

  (i) $\beta = \frac{I_c}{I_b}$; $\beta_{ac} = \left(\frac{\Delta I_c}{\Delta I_b}\right)_{vdE}$. (ii) Trans-conductance $g_m = \frac{\Delta I_c}{\Delta V_i}$

  (iii) AC voltage gain $= \beta_{ac} \times \frac{R_{out}}{R_{in}}$ (iv) Power gain = voltage gain × Current gain
- Logic Gates

  For input X and Y, output Z be given by $Z = X + Y$

  OR gate $Z = XY$ AND gate $Z = \overline{X}$

  NOR gate $Z = \overline{(X+Y)}$ NAND gate $Z = \overline{(XY)}$

  NOT gate $Z = \overline{X}$ or $Z = \overline{Y}$

  when either X or Y is present.

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28. COMMUNICATION SYSTEM

(1). The maximum line of sight distance d_M between the two antennas having height h_T and h_R, above the earth, is given by $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

(2). Modulation index $\mu = \frac{A_m}{A_e}$ where A_m and A_c are the amplitudes of modulating signal and carrier wave.

(3). In amplitude modulation $P_1 = P_2\left[1 + \frac{\mu^2}{2}\right]$

(4). Maximum frequency can be reflected from ionosphere $f_{max} = 9(N_{max})^{1/2}$

(5). Maximum modulated frequency can be detected by diode detector $f_m = \frac{1}{2\pi R\mu}$
