Chap-01 - Unit and Measurement

Formulae Chart

1. Distance of an object by parallax method, $D = \dfrac{\text{Basis}}{\text{Parallax angle}}$
2. Absolute error = True value – Measured value = $|\Delta a_n|$
3. True value = Arithmetic mean of the measured values

   $a_{\text{mean}} = \dfrac{a_1 + a_2 + \ldots + a_n}{n}$
4. Relative error in the measurement of a quantity = $\dfrac{\Delta a_{\text{mean}}}{a_{\text{mean}}}$
5. Percentage error = $\dfrac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$.
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 $z = \dfrac{a^p . b^q}{c^r}$, then maximum relative error in z is $\dfrac{\Delta z}{z} = p\dfrac{\Delta a}{a} + q\dfrac{\Delta b}{b} + r\dfrac{\Delta C}{C}$

Chap-02_Motion in a straight line

Formulae Chart

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

Chap-03_Motion in a Plane

Formulae Chart

1. Law of cosines. If $\vec{R} = \vec{P} + \vec{Q}$ then

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

θ = angle between $\vec{P}$ and $\vec{Q}$

2. Direction of $\vec{R}$

$$\tan\alpha = \frac{Q\cos\theta}{P + Q\sin\theta}; \quad \alpha = \text{angle between } \vec{R} \text{ and } \vec{P}$$

3. Position of an object at time t, if it is initially at $\vec{r}_0$, having initial velocity v_0 and moving with constant acceleration $\vec{a}$, is

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

4

Ch-04_Laws of Motion

Formulae Chart

1. Force : $\vec{F} = \frac{d\vec{p}}{dt} = m\frac{d\vec{v}}{dt} + \vec{v}\frac{dm}{dt}$, when m is constant $\vec{F} = m\frac{d\vec{v}}{dt} = m\vec{a}$
2. Conservation of linear momentum : $\Sigma\vec{p}_i = \Sigma\vec{p}_j$
3. Motion of a car on level road : $v_{\max} = \sqrt{\mu_s Rg}$
4. Motion of a car on banked road : $v_{\max} = \left[Rg\frac{(\mu_s + \tan\theta)}{1 - \mu_s\tan\theta}\right]^{1/2}$

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

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Ch-05_Work Energy and Power

Formulae Chart

1. The **work-energy theorem** states that the change in kinetic energy of a body is 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.

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

4. The instantaneous power is defined as the limiting value of the average power as time interval approaches zero.

$$P = \frac{dW}{dt}$$

It can also be expressed as

$$P = \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v}$$ Where $d\vec{r}$ is displacement vector.

Ch-06_System of Particles & Rotational Motion

Formulae Chart

1. According to the theorem of perpendicular axes

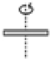
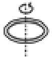
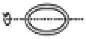
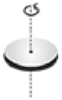
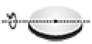
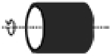
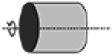
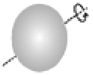
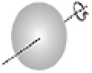
$$I_z = I_x + I_y$$

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

$$I = I_C + Md^2$$

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.

Z	Body	Axis	Figure	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 to 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 $\vec{L}$ is given by $\vec{L} = I\vec{\omega}$.
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 moment of inertia (I) and torque $\left(\vec{\tau}\right)$

$$\vec{\tau} = I\vec{\alpha}$$

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

$$\vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \ldots\ldots + m_n\vec{r}_n}{m_1 + m_2 + \ldots\ldots + m_n} = \frac{\sum_{i=1}^{n} m_i\vec{r}_i}{\sum_{i=1}^{n} m_i}$$

where m_i is the mass of the ith particle and $\vec{r}_i$ is the position of the ith particle corresponding x_{CM}, y_{CM} and z_{CM} co-ordinates are

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

8. Velocity of centre of mass, $\vec{v}_{CM} = \dfrac{\sum_{i=1}^{n} m_i\vec{v}_i}{\sum m_i}$

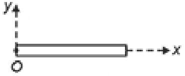
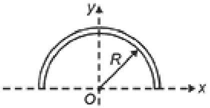
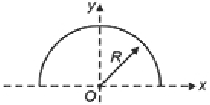
9. Acceleration of CM, $\vec{a}_{CM} = \dfrac{\sum_{i=1}^{n} m_i\vec{a}_i}{\sum_{i=1}^{n} m_i}$

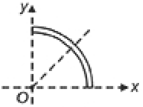
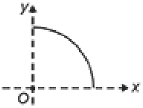
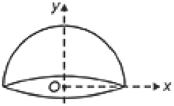
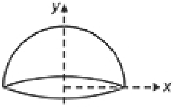
10. Momentum of system, $\vec{P} = \vec{P}_1 + \vec{P}_2 + \ldots\ldots + \vec{P}_n = \left(\sum_{i=1}^{n} m_i\right)\vec{v}_{CM}$

11. Centre of mass of continuous mass distribution

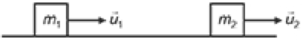
$$\vec{r}_{CM} = \frac{\int dm\vec{r}_o}{dm}, \quad x_{CM} = \frac{\int x\,dm}{\int dm}, \quad y_{CM} = \frac{\int y\,dm}{\int dm}, \quad z_{CM} = \frac{\int z\,dm}{\int dm}$$

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

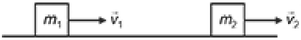
S.No.	Object	Location of centre of mass
i.	 Uniform rod of length L	$x_{CM} = \frac{L}{2}$ $y_{CM} = 0$ $z_{CM} = 0$
ii.	 Uniform semicircular ring of radius R	$x_{CM} = 0$ $y_{CM} = \frac{2R}{\pi}$ $z_{CM} = 0$
iii.	 Uniform semicircular disc of radius R	$x_{CM} = 0$ $y_{CM} = \frac{4R}{3\pi}$ $z_{CM}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

S.No.	Object	Location of centre of mass
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



Before collision



After collision

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

Loss in kinetic energy,

$$\Delta_{KE} = \frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}(\vec{u}_1 - \vec{u}_2)^2(1 - e^2)$$

14. For elastic collision $\Delta_{KE} = 0$,

$$e = 1$$

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

15. For perfectly inelastic collision,

$e = 0$

$$\vec{v}_1 = \vec{v}_2 = \frac{m_1\vec{u}_1 + m_2\vec{u}_2}{m_1 + m_2}; \qquad \Delta_{KE} = \frac{1}{2}\frac{m_1m_2}{m_1 + m_2}(\vec{u}_1 - \vec{u}_2)^2$$

Chap-07_Gravitation

Formulae Chart

1. **Kepler's IInd law**

$$\frac{\overrightarrow{dA}}{dt} = \frac{\vec{L}}{2m}$$

2. **Kepler's IIIrd law**

$T^2 \propto R^3$

where, T = Time period of revolution

R = Semi-major axis of the elliptical orbit.

3. **Newton's universal law of gravitation**

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

In vector form,

$$\vec{F} = \frac{Gm_1m_2}{r^2}\cdot(\hat{r})$$

4. **Acceleration due to gravity 'g'**

$$g = \frac{GM_e}{R_e^2}$$

5. **g at altitude 'h'**

$$g_h = g\left[\frac{R_e}{R_e + h}\right]^2$$

if $h << R$

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

6. **g at depth d**

$$g_d = g\left[1 - \frac{d}{R_e}\right]$$

7. **Gravitational potential energy**

$$U = W_{AB} = -GMm\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$$

if $r_1 = \infty$, $r_2 = r$

$$U = -\frac{GMm}{r}$$

Chap-08_Mechanical Properties of Solids

Formulae Chart

1. Elongation produced due to its own weight

$$\Delta L = \frac{\rho g L^2}{2Y} = \frac{MgL}{2AY}$$

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 $= \frac{\pi \eta r^4}{2l}$
7. $\sigma = -\frac{\Delta r / r}{\Delta L / L}$
8. $Y = \frac{9BS}{3B + S}$
9. $Y = 3B[1 - 2\sigma]$
10. $Y = 2S[1 + \sigma]$
11. $\sigma = \frac{3B - 2S}{6B + 2S}$
12. Depression at the middle of a beam $= \frac{Wl^3}{4Ybd^3}$

Chap-9_Mechanical Properties of Fluids

Formulae Chart

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

   A = cross-sectional area of pipe

   v = fluid velocity

5. Bernoulli's equation

   At any point in a streamline flow

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

   P = pressure

   v = fluid velocity

6. Coeff. of viscosity $\eta = \frac{Fl}{vA}$

   F = Viscous force

   l = Separation between two lamina

   A = Area of each lamina

   v = Relative velocity of two lamina

7. Stokes' law $F = -6\pi\eta av$

   a = radius of ball or drop

   v = velocity of ball or drop

8. Terminal velocity

   $$v_T = \frac{2a^2}{9\eta}(\rho - \sigma)g$$

   ρ = density of falling body

   σ = density of fluid

9. Reynolds number,

   (i) $R_e = \frac{\rho vd}{\eta}$

   d = diameter of the pipe

10. Excess pressure inside a liquid drop or a cavity of radius R

    $$P_i - P_o = \frac{2S}{R}$$

11. Excess pressure inside an air bubble

    $$P_i - P_o = \frac{4S}{R}$$

12. Rise and fall of a liquid in a capillary tube

    $$h = \frac{2S\cos\theta}{r\rho g}$$

    where, θ = angle of contact

    ρ = density of the liquid

g = Acc. due to gravity

Chap-10_Thermal Properties of Matter

Formulae Chart

1. (a) $t_C = \frac{5}{9}(t_F - 32), t_F = \frac{9}{5}t_C + 32$

   (b) $T = t_C + 273.15, t_C = T - 273.15$

   (c) $t_F = \frac{9}{5}T - 459.67,\ T = \frac{5}{9}t_F + 255.37$

   where $T, t_C, t_F,$ stand for temperature readings 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 (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) $r = \frac{Q_1}{Q}$

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

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

   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. Further ; r, a and t denote reflectance, absorptance and transmittance of the surface.

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

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

   The above two equations represent 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.

Chap-11_Thermodynamics

Formulae Chart

1. First law of thermodynamics

$$\Delta Q = \Delta U + \Delta W$$

2. Work done,

$$\Delta W = P\Delta V$$

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

3. Relation between specific heats for a gas

$$C_p - C_v = R$$

4. For isothermal process

$$PV = \text{constant}$$

$$W = \mu RT \ln\frac{V_2}{V_1}$$

$$W = 2.303\ \mu RT \log\frac{V_2}{V_1}$$

5. For adiabatic process

$$PV^{\gamma} = \text{constant}$$

where, $\gamma = \frac{C_p}{C_v}$

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$W = \frac{\mu R[T_1 - T_2]}{\gamma - 1}$$

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

7. Carnot engine

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T}$$

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$$

$$W = Q_1 - Q_2$$

$$\eta = \frac{W}{Q_1}$$

8. Refrigerator

$$\beta = \frac{Q_2}{Q_1 - Q_2} = \frac{Q_2}{W}$$

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

9. Heat pump

$$r = \frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2} = \frac{1}{\eta}$$

Chap-12 - Kinetic Theory

Formulae Chart

1. Pressure exerted by ideal gas

$$P = \frac{1}{3}\frac{mN}{V}\overline{v^2}$$

2. $v_{rms} = \sqrt{\frac{3k_BT}{m}}$

3. $v_{av} = \sqrt{\frac{8K_BT}{\pi m}}$

4. $v_{mp} = \sqrt{\frac{2K_BT}{m}}$

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

n = number density

d = diameter of molecule

S.No.	Atomicity	No. of degree of freedom	C_p	C_v	$\gamma = C_p/C_v$
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. $C_{v(mix)} = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1 + n_2}$

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 and $C_{v(mix)}$: Molar specific heat at constant volume for mixture.

Chap-13 - Oscillations

Formulae Chart

1. Displacement equation for SHM

$x = A\sin[\omega t + \phi]$

or

$x = A\cos[\omega t + \phi]$

2. Velocity in SHM

$$v = A\omega\cos\omega t$$

and $$v = \omega\sqrt{A^2 - x^2}$$

3. Acceleration in SHM

$$a = -\omega^2 A\sin\omega t$$

and $$a = -\omega^2 x$$

4. Energy in SHM

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

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

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

5. Simple pendulum

   (i) $T = 2\pi\sqrt{\frac{L}{g}}$

   (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. Torsional pendulum

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

7. Physical pendulum

$T = 2\pi\sqrt{\frac{I}{mgd}}$; where I : Moment of inertia of body about axis passing through hinge

d : Distance of centre of mass from hinge

8. Damped simple harmonic motion

$$m \cdot \frac{d^2x}{dt^2} = -kx - b\frac{dx}{dt}$$

$$x = Ae^{-bt/2m}\cos(\omega' t + \phi)$$

$$\text{where } \omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

9. Forced oscillator

$$\frac{md^2x}{dt^2} = -kx - bv + F_0 \sin\omega t$$

$$x = A\sin[wt + \phi]$$

$$\text{where } A = \frac{F_0}{m\sqrt{(\omega^2 - \omega_0^2)^2 + \left(\frac{b\omega}{m}\right)^2}}$$

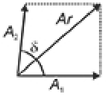
10. Superposition of Two SHM's

(i) In same direction

$x_1 = A_1 \sin\omega t$

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

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



(ii) In perpendicular direction

$x_1 = A_1 \sin\omega t$

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

(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 (right) elliptical path, if $\phi = \frac{\pi}{2}$ and $A_1 \neq A_2$.

Chap-14_Waves

Formulae Chart

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, $y(x, t)$ → Displacement as a function of position x and time t

a → Amplitude of the wave

ω → Angular frequency of the wave

$k \rightarrow$ Angular wave number

$(kx - \omega t + \phi) \rightarrow$ Phase

$\phi \rightarrow$ 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

$$v = \frac{\omega}{k}$$

or $v = \frac{\lambda}{T}$ or $v = \lambda\nu$

4. Speed of a transverse wave on a stretched string

$$v = \sqrt{\frac{T}{\mu}}$$

where, $T \rightarrow$ Tension in the string

$\mu \rightarrow$ Mass per unit length

5. Speed of sound wave in a fluid

$$v = \sqrt{\frac{B}{\rho}}$$

where, $B \rightarrow$ Bulk modulus

$\rho \rightarrow$ Density

6. Speed of sound wave in a 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 (corrected)]

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

where, $P \rightarrow$ Pressure

$\rho \rightarrow$ Density of air (or gas)

$\gamma \rightarrow$ 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

$$\frac{v_t}{v_0} = \sqrt{\frac{T}{T_0}} = \sqrt{\frac{273 + t}{273}}$$

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

$y_i(x, t) = a \sin(kx - \omega t)$ 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 in 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

$$\nu = \frac{nv}{2L} \qquad n = 1, 2, 3 \ldots$$

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

Frequency of normal modes of oscillation.

$$\nu = \left(n - \frac{1}{2}\right)\frac{v}{2L} \qquad n = 1, 2 \ldots$$

$$\boxed{\nu_n = (2n - 1)\nu_1}$$

where ν_n is the frequency of nth 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

$$\nu = \frac{nv}{2L} \qquad n = 1, 2, 3, \ldots$$

$$\boxed{\nu_n = n\nu_1}$$

where ν_n is frequency of nth normal mode of oscillation.

15. Beat frequency (m)

m → Difference in frequencies of two sources

$m = (\nu_1 - \nu_2)$ or $(\nu_2 - \nu_1)$

16. Doppler's effect

$$\nu = \nu_0\left[\frac{v + v_0}{v + v_s}\right]$$

where, ν → Observed frequency

ν_0 → Source frequency

v → Speed of sound through the medium

v_0 → Velocity of observer relative to the medium

v_s → Source velocity relative to the medium

⇒ In using this formula, velocities in the direction *OS* (*i.e.*, from observer to the source) should be treated as positive and those opposite to it should be taken as negative.

Chap-15_Electric Charges & Fields

Formulae Chart

1. Electric field on the axis of a dipole of moment $\vec{p}=2aQ$ at a distance R from the centre is $\vec{E}=\frac{2R\vec{p}}{4\pi\varepsilon_0(R^2-a^2)^2}$. If $R>>a$ then $\vec{E}=\frac{2\vec{p}}{4\pi\varepsilon_0 R^3}$
2. Electric field on the equatorial line of the dipole at a distance R from the centre is $\vec{E}=\frac{-\vec{p}}{4\pi\varepsilon_0\left(R^2+a^2\right)^{\frac{3}{2}}}$. If $R>>a$ then $\vec{E}=\frac{-\vec{p}}{4\pi\varepsilon_0 R^3}$
3. Torque $\vec{\tau}$ experienced by a short dipole kept in uniform external electric field $\vec{E}$ is $\vec{\tau}=\vec{p}\times\vec{E}=pE\sin\theta\,\hat{n}$.
4. 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.
5. Electric flux $\phi_E=\vec{E}\cdot\vec{S}=ES\cos\theta$. Area vector $\vec{S}$ is perpendicular to the surface area.
6. Gauss Law : $\oint\vec{E}\cdot\vec{dS}=\frac{Q}{\varepsilon_0}$. Here $\vec{E}$ 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.
7. Electric field due to infinitely long charged wire of linear charge density λ at a perpendicular distance R is $E=\frac{\lambda}{2\pi\varepsilon_0 R}$.
8. Electric field due to single 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.
9. 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)
10. Field due to a charge uniformly distributed in a spherical volume is $E=\frac{\rho r}{3\varepsilon_0}$ for inside points and $E=\frac{Q}{4\pi\varepsilon_0 r^2}$ for outside points. (ρ is volume charge density and Q is total charge inside the sphere).

Chap-16_Electrostatic Potential & Capacitance

Formulae Chart

1. **Electric potential :**

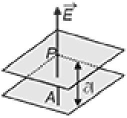
(c) Potential due to a conducting sphere of radius *r* with charge *q* (solid or hollow) at a distance *r* from the centre

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

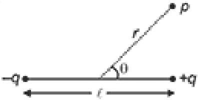
$$V = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q}{R} \qquad \text{if } (r = R)$$

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

(d) Relation between electric field and potential $\left|\vec{E}\right| = \left|-\frac{\partial V}{\partial \ell}\right| = +\frac{|\partial V|}{\partial \ell}$



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

$U(\theta) = -\vec{P}\cdot\vec{E}$

3. **Capacitors :**

Capacitance of a parallel plate capacitor

$C = \varepsilon_0\frac{A}{d}$

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,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots\ldots$$

(b) When capacitors are connected in parallel,

$$C_{eq} = C_1 + C_2 + C_3 + \ldots\ldots\ldots$$

(c) Spherical capacitor,

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

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

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

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

6. Dielectrics :

(a) Induced charge, $q' = q\left(1 - \frac{1}{k}\right)$

(b) Polarisation $P = \frac{\text{Dipole moment}}{\text{Volume}}$

$$\vec{p} = \chi_e \vec{E}$$

$$\frac{x_e}{\varepsilon_0} = K - 1$$

Chap-17_Current Electricity

Formulae Chart

1. Resistance of a uniform conductor of length L, area of cross-section A and resistivity ρ along its length, $R = \rho\frac{l}{A}$.
2. Electrical conductivity $\sigma = \frac{1}{\rho}$.
3. Conductance $G = \frac{1}{R}$.
4. Drift velocity $v_d = \frac{eE}{m}\tau$.
5. $I = neAv_d$
6. $\rho = \frac{m}{ne^2\tau} = \frac{1}{\sigma}$
7. $\vec{j} = \sigma\vec{E}$
8. Mobility of free electrons $\mu = \frac{v_d}{E}$.
9. $\sigma = ne\mu$

10. $\rho_T = \rho_0[1 + \alpha(T - T_0)]$

11. Potential difference across a cell during discharging

$$V = \varepsilon - Ir = \frac{\varepsilon R}{R + r}$$

11. Potential difference across a cell during charging

$$V = \varepsilon + Ir$$

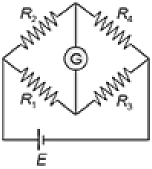
12. For n cells in series across load R, current through load

$$I = \frac{n\varepsilon}{R + nr}$$

13. For n identical cells in parallel across load R, current through load

$$I = \frac{\varepsilon}{R + \frac{r}{n}}$$

14.



For balanced Wheatstone bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

15. 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 $X = \frac{Rl}{100 - l}$.

16. **Potentiometer**

(i) Comparison of emf $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$

(ii) Internal resistance of cell $r = \left(\frac{l_1}{l_2} - 1\right)R$

Chap-18_Moving Charges and Magnetic Field

Formulae Chart

S.No.	Situation	Formula
1.	Lorentz force	$q\left[\vec{E}+\vec{v}\times\vec{B}\right]$
2.	Condition for a charged particle to go undeflected in a cross electric and magnetic field	(speed) $v=\frac{E}{B}$
3.	A charge particle thrown perpendicular to uniform magnetic field (i) Path (ii) Radius (iii) Time period	(i) Circular (ii) $\frac{mv}{qB}$ (iii) $\frac{2\pi m}{qB}$
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) $\frac{mv\sin\theta}{qB}$ (iii) $\frac{2\pi m}{qB}$ (iv) $v\cos\theta T=\frac{2\pi m}{qB}v\cos\theta$
5.	Cyclotron frequency	$\frac{qB}{2\pi m}$
6.	Maximum kinetic energy of a charged particle in a cyclotron	$\frac{q^2B^2R^2}{2m}$ R is radius of the dees
7.	Force on a straight current carrying conductor in a uniform magnetic field	$\vec{F}=i(\vec{l}\times\vec{B})$
8.	Force on an arbitrary shaped current carrying conductor in a uniform magnetic field	$\vec{F}=i\int d\vec{l}\times\vec{B}$ $=i\,\vec{l}_{eff}\times\vec{B}$
9.	Magnetic moment of a current carrying loop	$\vec{M}=i\vec{A}$
10.	Torque on a current carrying loop placed in a uniform magnetic field.	$\vec{\tau}=\vec{M}\times\vec{B}$
11.	Biot-Savart Law	$\vec{dB}=\frac{\mu_0 i}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$
12.	Magnetic field at a point distance x from the centre of a current carrying circular loop	$\frac{\mu_0 iR^2}{2(R^2+x^2)^{3/2}}$
13.	Magnetic field at the centre of a current carrying circular loop	$\frac{\mu_0 i}{2R}$

S.No.	Situation	Formula
14.	Magnetic field on the axis of a current carrying circular loop far away from the centre of the loop	$\frac{\mu_0}{4\pi}\frac{2M}{x^3}$ (moment behaves as magnetic dipole)
15.	Magnetic field on the centre of current carrying circular arc	$\frac{\mu_0}{4\pi}\frac{i}{r}\theta$
16.	Ampere's circuital law	$\oint \vec{B}.\vec{dl} = \mu_0 i$
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	$B = \mu_0 ni$
21.	Magnetic field inside a toroid	$B = \frac{\mu_0 Ni}{2\pi r}$
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 deflection current of galvanometer)	$r_s = \frac{G}{\left(\frac{i}{i_g} - 1\right)}$
26.	Resistance required to convert galvanometer into voltmeter of range *V*	$R = \frac{V}{i_g} - G$

Formulae Chart

1. **Bar magnet :** The Electrostatic Analog

Electrostatics	Magnetism
$\frac{1}{\varepsilon_0}$	μ_0
Charge q	Magnetic Pole Strength (q_m)
Dipole Moment $\vec{p} = ql$	Magnetic Dipole Moment $\vec{M} = q_m l$
$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$	$\vec{F} = \frac{\mu_0}{4\pi}\frac{q_{m(1)}q_{m(2)}}{r^2}$
$\vec{F} = q\vec{E}$	$\vec{F} = q_m\vec{B}$
Axial Field $\vec{E} = \frac{2\vec{p}}{4\pi\varepsilon_0 r^3}$	$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}}{r^3}$
Equatorial field $\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$	$\vec{B} = -\frac{\mu_0}{4\pi}\frac{\vec{M}}{r^3}$
Torque $\vec{\tau} = \vec{p} \times \vec{E}$	$\vec{\tau} = \vec{M} \times \vec{B}$
Potential Energy $U = -\vec{p}\cdot\vec{E}$	$U = -\vec{M}\cdot\vec{B}$
Work $W = pE(\cos\theta_1 - \cos\theta_2)$	$W = MB(\cos\theta_1 - \cos\theta_2)$

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

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

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

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

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

5. Time period of angular SHM $T = 2\pi\sqrt{\frac{I}{MB}}$

6. Gauss's law in magnetism $\oint \vec{B}\cdot\vec{ds} = 0$

7. $\frac{B_V}{B_H} = \tan\delta$

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

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

10. $\vec{H} = \dfrac{\vec{B}}{\mu_0} = \dfrac{\vec{B}}{\mu}$

11. $\mu_r = \dfrac{\mu}{\mu_0}$

12. $\chi_m = \dfrac{M}{H}$

13. $\mu_r = 1 + \chi_m$

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

Chap-20_Electromagnetic induction

Formulae Chart

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 $e_{(t)} = -\dfrac{d}{dt}\phi_{(t)}$

3. Motional emf = $B_\perp v_\perp l$

4. Motional emf $e = \int de = \int(\vec{v} \times \vec{B}).\vec{dl} = (\vec{v} \times \vec{B})\vec{l}$

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

6. $\phi_B = LI$ ⇒ L → self inductance of the coil

7. $e = -L\dfrac{dI}{dt}$

8. $L = \mu_0\mu_r n^2 \times A \times l$ L → self inductance of a coil

9. $\phi_2 = MI_1$ and $e_2 = -M\dfrac{dI_1}{dt}$

⇒ M (Mutual inductance)

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

11. Mutual inductance $M = \mu_0 \mu_r n_1 n_2 A l$

Chap-21_Electromagnetic Waves

Formulae Chart

1. Displacement current $I_D = \varepsilon_0 \frac{d}{dt}\phi_E = \varepsilon_0 \frac{d\oint \vec{E}.\overrightarrow{ds}}{dt} = \frac{CdV}{dt}$

2. Maxwell's Equation

   (a) $\oint \vec{E}.\overrightarrow{ds} = \frac{q}{\varepsilon_0}$

   (b) $\oint \vec{B}.\overrightarrow{ds} = 0$

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

   (d) $\oint \vec{B}.\overrightarrow{dl} = \mu_0\left(I_C + \varepsilon_0 \frac{d\phi_E}{dt}\right)$

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

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

4. $\frac{E_0}{B_0} = \frac{E_{RMS}}{B_{RMS}} = \frac{E}{B} = c$

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

   of $I_{av} = U_{av} \,.\, c = \frac{E_0 B_0}{2\mu_0} = \frac{E_0^2}{2c\mu_0} = \frac{cB_0^2}{2\mu_0}$

6. Instantaneous energy density $u = \frac{1}{2}\varepsilon_0 E^2 + \frac{B^2}{2\mu_0} = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$

   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 = $\frac{\text{Intensity}}{c}$ (when the wave is totally absorbed)

   $= \frac{2(\text{Intensity})}{c}$ (when the wave is totally reflected)

9. Intensity of wave from a source at a distance r from it is proportional to

   $\frac{1}{r^2}$ (for a point source)

   $\frac{1}{r}$ (for a line source)

   For a plane source intensity is independent of r.

Ch-22_Ray Optics & Optical Instruments

Formulae Chart

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

   $f = \dfrac{R}{2}$.

2. Mirror equation $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$ (u) Object distance

   (v) Image distance

   (f) Focal length

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

4. In case of lens $\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{\mu_2 - \mu_1}{R}$ (R) Radius of curvature of spherical surface

   μ_1 (Refractive index of medium in which incident ray travels)

   μ_2 (Refractive index medium in which refracted ray travels)

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

6. Longitudinal magnification = (Lateral magnification)^2

7. Equivalent lens

   (i) Lens in contact $\dfrac{1}{F} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$

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

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

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

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

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

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

    (d) Deviation angle

12. Dispersive power of prism for two colours (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 $m = 1 + \frac{D}{f}$ (D) Least distance of distinct vision.

For least distance of distinct vision (f) Focal length of lens.

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

14. For compound microscope,

Magnification of objective $m_o = \frac{v_o}{u_o}$

Magnification of eyelens $m_e = \left(1 + \frac{v_e}{f_e}\right)$

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

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

15. Magnifying power of telescope $m = \frac{f_o}{f_e}$

Length of telescope $= L = f_o + f_e$

Ch-23_Wave Optics

Formulae Chart

1. $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$ (Snell's law)

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

3. Fringe width $\beta = \frac{\lambda D}{d}$

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

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

where $\phi = \frac{2\pi}{\lambda}\Delta x$

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

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

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

7. Fresnel distance $Z_F = \frac{a^2}{\lambda}$

8. Malus Law $I = I_0\cos^2\theta$

9. Brewster's law $\tan i_B = \mu$

Ch-24_Dual Nature of Radiation and Matter

Formulae Chart

1. Einstein's photoelectric cell equation, $\frac{1}{2}mv_{max}^2 = h\nu - h\nu_0$

2. Work function and threshold frequency or threshold wavelength, $\phi_0 = h\nu_0 = \frac{hc}{\lambda_0}$

3. Energy of photon, $E = h\nu = \frac{hc}{\lambda}$

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,

   $\lambda = \frac{12.27}{\sqrt{V}}\,\text{Å} = \frac{1.227}{\sqrt{V}}$ 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), $\lambda = \frac{h}{\sqrt{2mE}}$

Ch-25_Atoms

Formulae Chart

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

Radius of nth orbit, $r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m e^2}$

Orbital speed, $v_n = \frac{nh}{2\pi m r_n}$

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

TE = –KE

PE = 2TE

Rydberg's constant

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$R = \frac{me^4}{8\varepsilon_0^2 h^3 c}$$

Ch-26_Nuclei

Formulae Chart

1. Nuclear radius (R) is given by $R = R_0 A^{1/3}$, R_0 is a constant whose value is 1.2×10^{-15} m.
2. Density of all nuclei is constant.
3. Total Binding Energy = $[Z m_p + (A - Z) m_n] - m_N] c^2$.
4. Av. BE/nucleon = Total B.E./A
5. Radioactivity decay law $\frac{dN}{dt} = -\lambda N$, $N = N_0 e^{-\lambda t}$
6. Half life $T_{1/2} = \frac{0.6931}{\lambda}$.
7. Average or mean life is $T_{av} = \frac{1}{\lambda} = 1.44\ T_{1/2}$.

Ch-27_Semiconductor Electronics

Formulae Chart

- Intrinsic semiconductors : $n_e = n_h = n_i$

  Extrinsic semiconductors : $n_e n_h = n_i^2$
- Transistors : $I_e = I_b + I_c$

  $\Delta I_e = \Delta I_b + \Delta I_c$

- Common emitter amplifier :

$$\beta = \frac{I_c}{I_b};\ \beta_{ac} = \left(\frac{\Delta I_c}{\Delta I_b}\right)_{V_{CE}}$$, Trans conductance $g_m = \frac{\Delta I_c}{\Delta V_i}$

AC voltage gain = $\beta_{ac} \times \frac{R_{out}}{R_{in}}$

Power Gain = Voltage Gain × Current gain

- Logic Gates

OR gate $Z = X + Y$

AND gate $Z = XY$

NOT gate $Z = \overline{X}$

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

NAND gate $Z = (\overline{XY})$

Ch-28_Communication System

Formulae Chart

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 $\mu = \frac{A_m}{A_c}$ where A_m and A_c are the amplitudes of modulating signal and carrier wave.

3. In amplitude modulation $P_t = P_c\left[1 + \frac{\mu^2}{2}\right]$.

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

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

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