FORMULAE IN PHYSICS STD. XII

Chapter 1: Rotational Dynamics

(1) In uniform circular motion,

(a) Angular displacement $(\theta) = \frac{\text{Arc length } (s)}{\text{Radius } (r)}$

i.e. $\theta = \frac{s}{r}$ **or** $s = r\theta$

(b) Angular speed $(\omega) = \frac{\theta}{t}$ **or** $\vec{\omega} = \frac{d\theta}{dt}$

where θ = angular displacement in time t

(c) Angular acceleration $(\alpha) = \frac{\omega}{t}$ **or** $\vec{\alpha} = \frac{d\vec{\omega}}{dt}$

(d) For one complete revolution $\theta = 2\pi$ and $t = \text{T}$

$\therefore \omega = \frac{2\pi}{\text{T}} = 2\pi n$

(e) Frequency $= \frac{1}{\text{Period}}$ i.e.... $n = \frac{1}{\text{T}}$ **or** $\text{T} = \frac{1}{n}$

(f) For one revolution,

Period $(\text{T}) = \frac{2\pi r}{\text{v}}$ **or** $\text{T} = \frac{2\pi}{\omega}$

(2) Linear velocity = Radius × angular velocity

$\text{v} = r\omega$

(3) The magnitude of the centripetal acceleration (a_r)

$a_r = \frac{\text{v}^2}{r} = r\omega^2$

(4) The magnitude of the centripetal force (F)

$\text{C.P.F} = \frac{m\text{v}^2}{r} = mr\omega^2$

(5) The magnitude of the centrifugal force (F)

$$C.F.F. = \frac{mv^2}{r} = mr\omega^2$$

(6) Maximum and minimum speed:

(a) Maximum speed of vehicle on plane horizontal road,

$v_{max} = \sqrt{\mu_s rg}$ where, μ_s = coefficient of static friction.

(b) For well of death minimum speed of vehicle,

$$\text{Minimum speed } (v_{min}) = \sqrt{\frac{rg}{\mu_s}}$$

(c) For Banked road,

(i) Most safe speed $(v_s) = \sqrt{rg\tan\theta}$

(ii) Banking angle $(\theta) = \tan^{-1}\left(\frac{v^2}{rg}\right)$

(iii) Maximum speed of vehicle in terms of coefficient of friction for banked road,

$$v_{max} = \sqrt{rg\left(\frac{\tan\theta + \mu_s}{1 - \mu_s\tan\theta}\right)}$$

(iv) Minimum possible speed in terms of μ_s for banked road.

$$v_{min} = \sqrt{rg\left(\frac{\tan\theta - \mu_s}{1 + \mu_s\tan\theta}\right)}$$

(7) Conical pendulum:

(a) The period of conical pendulum of length (l) and semi vertical angle (θ) is

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}} \quad \text{or} \quad T = 2\pi\sqrt{\frac{r}{g\tan\theta}}$$

(b) Frequency of conical pendulum.

$$n = \frac{1}{2\pi}\sqrt{\frac{g}{l\cos\theta}} \quad \text{or} \quad n = \frac{1}{2\pi}\sqrt{\frac{g\tan\theta}{r}}$$

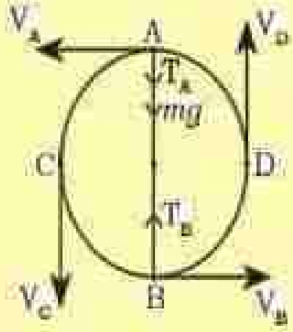
(c) If θ is small $\cos\theta \approx 1$. $\therefore$ Period (T) = $2\pi\sqrt{\frac{l}{g}}$

(8) For vertical circular motion:

Case-I:- Mass tied to a string:-

(a) Difference in tension of lowest and highest point,

$\therefore T_B - T_A = 6mg$



(b) Velocity at highest point or top point (A)

$V_A = \sqrt{rg}$

(c) Velocity at lowest point or Bottom (B)

$V_B = \sqrt{5rg}$

(d) Velocity at point C and D.

$\therefore V_C = V_D = \sqrt{3rg}$

Case-II:- Mass tied to a rod:-

(a) Difference in tension, $T_B - T_A = 6mg$

(b) Velocity at top, $V_A = 0$

(c) Velocity at bottom $V_B = 2\sqrt{rg}$

(d) Velocity at point C and D, $V_C = V_D = \sqrt{2rg}$

(9) Vehicle at the top of a convex over bridge, $V_{at\ top} = \sqrt{rg}$

(10) In vertical circular motion

Total energy is constant and is T.E = $\frac{5}{2}mgr$

(11) Moment of Inertia of a system of n particle.

$I = \sum_{i=1}^{n} m_i r_i^2$ **or** $I = \int r^2 dm$

(12) Kinetic Energy:

(a) K.E of rigid body rotating about a given axis,

$$(K.E.)_{RM} = \frac{1}{2} I\omega^2$$

(b) K.E of rolling body.

$$(K.E)\text{Rolling body} = (K.E.)_{TM} + (K.E.)_{RM}$$
$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

(13) Radius of Gyration: $I = MK^2$

(14) Theorems:

(a) Parallel axes theorem, $I_O = I_C + Mh^2$

(b) Perpendicular axes theorem, $I_z = I_x + I_y$

(15) Angular momentum (L):-

(a) $\overline{L} = \overline{r} \times \overline{p}$ **or** $L = r\,p\sin\theta$

(b) $L = I\omega$

(16) Torque (τ) = M.I × Angular acceleration

$$\tau = I\alpha$$

(17) Body rolling down along an inclined plane:

(a) Linear speed (v) $= \sqrt{\dfrac{2gh}{\left(1 + \dfrac{K^2}{R^2}\right)}}$

where h - vertical distance (height)

(b) Linear distance (s) $= \dfrac{h}{\sin\theta}$

(c) Linear acceleration (a) $= \dfrac{g\sin\theta}{\left(1 + \dfrac{K^2}{R^2}\right)}$

(18) Analogous Kinematical equations:

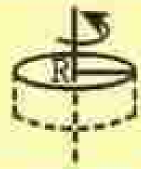
Equation for Translational motion	Analogous Equation for Rotational motion
(1) Average velocity $v_{av} = \frac{u + v}{2}$	(1) Average angular velocity $\omega_{av} = \frac{\omega_0 + \omega}{2}$
(2) 1^{st} Kinematical eq^n. $v = u + at$	(2) $\omega = \omega_0 + \alpha t$
(3) 2^{nd} Kinematical eq^n $s = ut + \frac{1}{2}at^2$	(3) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
(4) 3^{rd} Kinematical eq^n $v^2 = u^2 + 2as$	(4) $\omega^2 = \omega_0^2 + 2\alpha\theta$

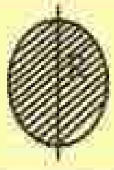
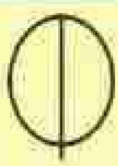
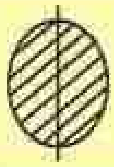
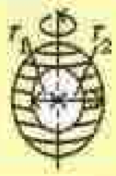
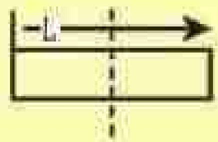
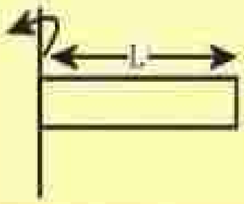
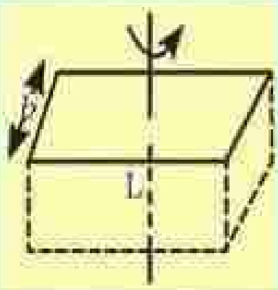
(19) Analogous quantities between translation and rotational motion:

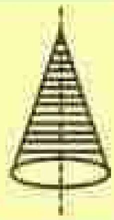
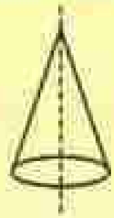
Translational motion		Rotational motion		Inter relation if possible
Quantity	Expression	Quantity	Expression	
Linear displacement	$\vec{s}$	Angular displacement	$\vec{\theta}$	$\bar{s} = \bar{\theta} \times \bar{r}$
Linear velocity	$\vec{v} = \frac{d\vec{s}}{dt}$	Angular velocity	$\vec{\omega} = \frac{d\theta}{dt}$	$\bar{v} = \vec{\omega} \times \bar{r}$
Linear acceleration	$\vec{a} = \frac{d\vec{v}}{dt}$	Angular acceleration	$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$	$\vec{a} = \bar{\alpha} \times \bar{r}$
Mass	m	Momoment of inertia	I	$I = \sum_{i=1}^{n} m_i r_i^2 = \int r^2 dm$

Translational motion		Rotational motion		Inter relation if possible
Quantity	Expression	Quantity	Expression	
Linear momentum	$\bar{p} = m\bar{v}$	Angular momentum	$\bar{L} = I\vec{\omega}$	$\bar{L} = \bar{r} \times \bar{p}$
Force	$\vec{f} = \frac{d\bar{p}}{dt}$	Torque	$\vec{\tau} = \frac{d\bar{L}}{dt}$	$\vec{\tau} = \vec{r} \times \vec{f}$
Work	$W = \bar{f}.\bar{s}$	Work	$W = \vec{\tau}.\bar{\theta}$	-
Power	$P = \frac{dW}{dt}$ $= \vec{f} \cdot \vec{v}$	Power	$P = \frac{dW}{dt} = \vec{\tau}.\vec{\omega}$	-

(20) Expression for moment of inertia for some objects:

Object	Axis	Formula for M.I	Figure
Thin ring or hollow cylinder	Central	$I = MR^2$	
Thin ring	Diameter	$I = \frac{MR^2}{2}$	
Annular ring or thick walled hollow cylinder	Central	$I = \frac{M(r_2^2 + r_1^2)}{2}$	
Uniform disc or solid cylinder	Central	$I = \frac{1}{2}MR^2$	

Object	Axis	Formula for M.I	Figure
Uniform disc	Diameter	$I = \frac{1}{4}MR^2$	
Thin walled hollow sphere	Central	$I = \frac{2}{3}MR^2$	
Solid sphere	Central	$I = \frac{2}{5}MR^2$	
Uniform symmetric spherical shell	Central	$I = \frac{2}{5}M\frac{(r_2^5 - r_1^5)}{(r_2^3 - r_1^3)}$	
Thin uniform rod	Perpendicular to length and passing through centre	$I = \frac{ML^2}{12}$	
Thin uniform rod or rectangular plate	Perpendicular to length and about one end	$I = \frac{ML^2}{3}$	
Uniform plate or rectangular parallelopiped	Central	$I = \frac{M(L^2 + b^2)}{12}$	

Object	Axis	Formula for M.I	Figure
Uniform solid right circular cone	Central	$I = \frac{3}{10}MR^2$	
Uniform hollow right circular cone	Central	$I = \frac{MR^2}{2}$	

Chapter 2: Mechanical Properties of Fluids

(1) Pressure:

(a) Pressure (P) = $\frac{\text{Force (F)}}{\text{Area (A)}}$

(b) Pressure due to liquid column

Pressure (P) = $h\rho g$ where h = depth below free surface
ρ = density of liquid

(c) Gauge pressure = $P - P_0$
= $h\rho g$

(2) Surface tension:

(a) Surface Tension (T)

$T = \frac{F}{L}$ where F = be the force acting at right angle on imaginary line - drawn on surface of liquid.
L = Length of imaginary line drawn on free surface of liquid.

(b) Surface Tension (T) $= \frac{W}{A}$

where W = The surface energy of surface film

A = Area of the film

(c) For equilibrium of the drop

$$\cos\theta = \frac{T_2 - T_1}{T_3}$$

(3) Excess pressure:-

(a) Excess pressure inside a drop

$$(P_i - P_o) = \frac{2T}{r}$$

where P_i - Pressure in side the drop

P_o - Pressure out side the drop

r - Radius of drop.

(b) Excess pressure inside a soap bubble

$$(P_i - P_o) = \frac{4T}{r}$$

(4) Capillary rise :

(a) Expression for capillary rise or fall for a liquid.

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

(b) Surface Tension (T), $T = \frac{hr\rho g}{2\cos\theta}$

where h - rise or fall of liquid inside capillary tube

θ - angle of contact

r - the radius of capillary bore

ρ - density of liquid

(c) Height $\propto \frac{1}{\text{radius}}$ i.e. $h \propto \frac{1}{r}$

(5) Reynold's number and critical velocity of fluid:

(a) Reynolds number $(R_n) = \frac{V_c \rho d}{\eta}$

(b) Critical velocity $(V_c) = \frac{R_n \eta}{\rho d}$

where, V_c = Critical velocity of the fluid

R_n = Reynolds number

η = Co-efficient of viscosity

ρ = Density of liquid

d = Diameter of tube.

(6) Co-efficient of viscosity (η):

$$\eta = \frac{f}{A\left(\frac{dv}{dx}\right)}$$

where f = Viscous force

A = Area of layer

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

(7) Stoke's law:- $F_V = 6\pi\eta r v$

(8) Terminal velocity : $v = \left(\frac{2}{9}\right)\frac{r^2 g(\rho - \sigma)}{\eta}$

where - ρ - density of sphere

σ - density of medium

η - co-efficient of viscosity

(9) Flux and continuity :

(a) Mass flux $= \rho \frac{dv}{dt} = \frac{dm}{dt}$

(b) Volume flux $= \frac{dv}{dt}$

(c) Equation of continuity, $A_1V_1 = A_2V_2$

(10) Work done, Bennoullis equation and Efflux

(a) Work done due to force other than conservative force of gravity

$W = \Delta KE + \Delta PE$

(b) Bernoullis equation

(i) $P_1 - P_2 = \frac{1}{2}\rho(V_2^2 - V_1^2) + \rho g(h_2 - h_1)$

(ii) $P + \frac{1}{2}\rho V^2 + \rho gh = \text{constant}$

(c) Speed of efflux (V) = $\sqrt{2gh}$

(d) Rate of flow of liquid passing through a cross section

$2gh = V_2^2 - V_1^2$

Chapter 3: Kinetic theory of Gases and Radiation

(1) Gas Laws :

(a) Boyle's law: $P \propto \frac{1}{V}$ i.e. PV = constant (at constant temp)

(b) Charle's law: $V \propto T$ i.e. $\frac{V}{T}$ = constant (at constant pressure)

(c) Gay-Lussac's law: $P \propto T$ ie $\frac{P}{T}$ = constant (at const volume)

(d) Ideal gas equation: $PV = nRT$

(e) Number of moles (n) = $\frac{M}{M_0} = \frac{N}{N_A}$

(f) Boltzmann constant (K_B) = $\frac{R}{N_A}$

(2) Mean free path and Rms velocity :

(a) Mean free path (λ) = $\frac{1}{\sqrt{2}\,\pi d^2\left(\frac{N}{V}\right)} = \frac{K_B T}{\sqrt{2}\,\pi d^2 \rho}$

(b) Mean free path (λ) = $\dfrac{AB + BC + CD + ...}{N}$

(c) Mean velocity ($\overline{C}$) = $\dfrac{C_1 + C_2 + C_3 + ... C_n}{N}$

(d) Mean square velocity = $\dfrac{C_1^2 + C_2^2 + C_3^2 + ...}{N}$

(e) RMS velocity (C) = $\sqrt{\overline{C}^2} = \sqrt{\dfrac{C_1^2 + C_2^2 + C_3^2 + ...}{N}}$

(3) The pressure exerted by gas.

(a) $P = \dfrac{1}{3}\rho c^2$ **(b)** $P = \dfrac{1}{3}\dfrac{Nmc^2}{V}$ **(c)** $P = \dfrac{1}{3}\dfrac{M}{V}c^2$

(4) Rms, velocity and speed of sound :

(a) RMS velocity (C), = $\sqrt{\dfrac{3\,RT}{M_0}}$ where $M_0 = N_A m$ = Molar mass of gas

(b) $C = \sqrt{\dfrac{3P}{\rho}}$

(c) Speed of sound in a gas (V_S) = $\sqrt{\dfrac{\gamma\,RT}{M_0}}$

where $\gamma = \dfrac{C_P}{C_V}$ adiabatic constant

(5) Kinetic Energy:

(a) K.E per unit volume = $\dfrac{3}{2}$ RT

(b) K.E of one mole **or** one kilomole of gas = $\dfrac{3}{2}$ RT

(c) K.E per molecules = $\dfrac{3}{2}$ K.T

(d) K.E per unit mass = $\dfrac{3RT}{2M}$

(6) Mayer's relation

(a) $C_P - C_V = R$

where, C_P = Specific heat of a gas at constant pressure

C_V = Specific heat of a gas at constant volume

(b) $C_P - C_V = \frac{R}{J}$

where, J = Mechanical equivalent of heat

(c) $S_P - S_V = \frac{R}{M_0 J}$

where, S_P and S_V = are the principal specific heats at constant pressure and volume respectively

(7) Monoatomic, diatomic and polyatomic gases :

(a) For monoatomic gases,

(i) Total internal energy = $\frac{3}{2} K_B T \times N_A$

(ii) $\gamma = \frac{C_P}{C_V} = \frac{5}{3}$

(b) For Diatomic gases:

* For rigid gas:

(i) Total internal energy = $\frac{5}{2} K_B T \times N_A$

(ii) $\gamma = \frac{C_P}{C_V} = \frac{7}{5}$

* For non rigid gas:

(i) Total internal energy = $\left(\frac{5}{2} K_B T + K_B T\right) N_A$

(ii) $\gamma = \frac{C_P}{C_V} = \frac{9}{7}$

(c) For polyatomic gases,

(i) Total internal energy energy = $\left(\frac{3}{2} K_B T + \frac{3}{2} K_B T + f K_B T\right) N_A$

(ii) $\gamma = \frac{C_P}{C_V} = \frac{4+f}{3+f}$

(8) Co-efficients of absorption, reflection and transmission:

(a) Co-efficient of absorption (a) = $\frac{Q_a}{Q}$

(b) Co-efficient of reflection (r) = $\frac{Q_r}{Q}$

(c) Co-efficient of transmission (t) = $\frac{Q_t}{Q}$

(d) $Q_a + Q_r + Q_t = Q$

(e) $\therefore\ a + r + t = 1$

where Q_a Q_r & Q_t = quantity of heat absorted, reflected & transmitted respectively.

(9) Emissive power and Kirchhoff's low :

(a) Emissive power (R) = $\frac{Q}{At}$ **or** $E = \frac{Q}{At}$

(b) Coefficient of emission (e) = $\frac{R}{R_B}$ **or** $e = \frac{E}{E_b}$

(c) Kirchhoff's law of radiation, $a = e$

(10) Wien's displacement law:-

$$\lambda_{max} = b \times \frac{1}{T} \quad \textbf{or} \quad \lambda_{max} T = b$$

where λ_{max} = maximum wave length

b = Wien's constant

T = absolute temperature

(11) Stefan-Boltzmann Law:-

(a) $R = \sigma T^4$ **or** $\frac{Q}{At} = \sigma T^4$

(b) For ordinary body

$R = e\sigma T^4$ **or** $\frac{Q}{At} = e\sigma T^4$

Chapter 4: Thermodynamics

(1) Quantity of heat and work done :

(a) First law of thermodynamics

$$Q = \Delta U + W$$

where Q = The quantity of heat supplied to the system.

ΔU = Increase in internal energy.

W = Work done.

(b) Work done (W) = pdv

(2) Ideal gas equation, $pV = nRT$

(3) First law of thermodynamics:

The first law of thermodynamics, when applied to an isothermal process,

$$Q = W = nRT \log\left(\frac{V_f}{V_i}\right)$$

(4) Isothermal work may also be expresed as,

$$W = nRT \log\left(\frac{p_i}{p_f}\right)$$

(5) Thermodynamics of Isobaric process

$$Q = nC_p (T_f - T_i) = nC_p \Delta T$$

(6) Thermodynamics of Isochoric process,

$$Q = nC_v \Delta T$$

(7) Thermodynamic of Adiabatic process

$$W = \frac{nR(T_f - T_i)}{(1-\gamma)} = \frac{(p_f V_f - p_i V_i)}{(1-\gamma)}$$

(8) Thermal efficiency (η) of the heat engine.

$$\eta = \frac{W}{Q_H} = 1 + \frac{Q_C}{Q_H} = 1 - \frac{|Q_C|}{|Q_H|}$$

(9) **Performance of a Refrigerator:-**

(a) Co-efficient of performance (K) = $\frac{|Q_C|}{W}$

(b) $K = \frac{|Q_C|}{|Q_C| - |Q_H|}$

(10) For air conditioner:-

$K = \frac{H}{P}$ where, H= Rate of heat removed

P = Power required to remove heat

(11) Efficiency of a carnot cycle/engine.

$$\eta = \frac{W}{Q_H} = 1 - \frac{|Q_C|}{|Q_H|} = 1 - \frac{T_C}{T_H}$$

(12) Co-efficient of performance of a carnot refrigerator.

$$K = \frac{|Q_C|}{|Q_C| - |Q_H|} = \frac{T_C}{T_H - T_C}$$

Chapter 5: Oscillations

(1) In linear SHM,

$F = -kx$ where k is force constant

(2) The differential equation of a linear SHM is

$$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0 \quad \textbf{or} \quad \frac{d^2x}{dt^2} + \omega^2 x = 0$$

where $\omega^2 = \frac{k}{m}$ ie $\omega = \sqrt{\frac{k}{m}}$

(3) The period of linear SHM and frequency of SHM:

$$\text{Period, } T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$$

$$\text{and Frequency } (n) = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

(4) Simple Harmonic motion (S.H.M.) :

(a) Acceleration of SHM $(a) = -\omega^2 x$

(b) Velocity of SHM $(v) = \pm\omega\sqrt{A^2 - x^2}$

(c) Displacement of SHM, $x = A\sin(\omega t + \phi)$

(5) Extreme values of displacement, velocity and acceleration:

At mean position	At extreme position
$x_{min} = 0$	$x = \pm A$
$v_{max} = \pm A\omega$	$v_{min} = 0$
$a_{min} = 0$	$a_{max} = \pm\omega^2 A$

(6) Composition of SHM:

$x_1 = A_1\sin(\omega t + \phi_1)$

$x_2 = A_2\sin(\omega t + \phi_2)$ are the equations of SHM

(a) Equation of Resultant amplitude,

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\phi_1 - \phi_2)}$$

(b) If $(\phi_1 - \phi_2) = 0$ then $R = A_1 + A_2$

(c) If $(\phi_1 - \phi_2) = \pi$ then $R = A_1 - A_2$

(d) If $(\phi_1 - \phi_2) = \frac{\pi}{2}$ then $R = \sqrt{A_1^2 + A_2^2}$

(e) $\delta = \tan^{-1}\left(\frac{A_1\sin\phi_1 + A_2\sin\phi_2}{A_1\cos\phi_1 + A_2\cos\phi_2}\right)$

(7) Energy of particle performing SHM:

(a) Kinetic energy,

$$E_K = \frac{1}{2} m\omega^2 A^2 \cos^2(\omega t + \phi)$$

(b) Potential energy,

$$E_P = \frac{1}{2} m\omega^2 A^2 \sin^2(\omega t + \phi)$$

(c) Total energy,

$$E = E_K + E_P = \frac{1}{2} m\omega^2 A^2$$

(d) $E = \frac{1}{2} m(2\pi n)^2 A^2 = 2\pi^2 n^2 A^2 m$

(8) Simple pendulum:

(a) Period (T) $= 2\pi\sqrt{\frac{l}{g}}$

(b) Frequency (n) $= \frac{1}{2\pi}\sqrt{\frac{g}{l}}$

(9) For seconds pendulum, T = 2sec

length (l) $= \frac{g}{\pi^2}$

(10) Period of angular S.H.M.

(a) Differential equation of angular SHM

$$\frac{d^2\theta}{dt^2} + \frac{c}{I}\theta = 0$$

(b) Period (T) $= \frac{2\pi}{\sqrt{\text{Angular acc}^n \text{ per unit displacement}}}$

(11) Period of magnet vibrating in uniform magnetic field:-

Period (T) $= 2\pi\sqrt{\frac{I}{\mu B}}$

(12) Damped Oscillations:

(a) Damped force(F_d) = $-bv$

(b) The force on the block from the spring is

$$f_s = -kx$$

(c) Total force acting on mass at any time is

$$F = F_d + F_s$$

(d) Differential equation, $m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + Kx = 0$

(e) Angular frequency (ω') = $\sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$

(f) Period (T) = $\frac{2\pi}{\sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}}$

Chapter 6: Superposition of Wave

(1) Wave motion :

(a) Speed of wave $v = n\lambda$ where n = Frequency of wave

λ = Wavelength of wave

(b) Frequency (n) = $\frac{1}{\text{Period (T)}}$

(c) Distance covered in N vibration, $d = N\lambda$

(d) Number of waves = $\frac{d}{\lambda}$

(e) Phase difference in terms of distance, $\delta = \frac{2\pi x}{\lambda}$

(f) Phase differences in terms of time, $\delta = \frac{2\pi}{\lambda}\Delta t$

(2) Amplitude of the Resultant wave produced due to super position of two waves:

$Y_1 = A_1 \sin\omega t$ and $Y_2 = A_2 \sin(\omega t + \phi)$

(a) Resultant wave $Y = A\sin(\omega t + \phi)$

(b) Resultant amplitude is $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\phi}$

(c) $\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2}$

(3) Equation of stationary wave:

$Y = A\sin(2\pi nt)$ where $A = 2a \cos\left(\frac{2\pi x}{\lambda}\right)$

(a) At node $A = 0$

(b) At antinode $A = 2a$

(c) Distance between two adjacent node or antinode $= \frac{\lambda}{2}$

(d) Distance between adjacent antinodes and node $= \frac{\lambda}{4}$

(4) Vibrations of air column in a pipe:

(a) When a pipe is closed at one end:-

(i) Fundamental frequency $n = \frac{v}{4L}$ where $L = l + e$

(ii) In this case only odd harmonics are present.

(b) When a pipe is open at both end:

(i) Fundamental frequency $n = \frac{v}{2L}$ where $L = l + 2e$

(ii) In this case all harmonics are present.

(5) End correction (e):

(a) $e = 0.3d$ where d = inner diameter of pipe

(b) For pipe closed at one end,

$$e = \frac{n_1 l_1 - n_2 l_2}{2(n_2 - n_1)} = \frac{n_2 l_2 - n_1 l_1}{2(n_1 - n_2)}$$

(c) For a pipe open at both end,

$$e = \frac{n_1 l_1 - n_2 l_2}{2(n_2 - n_1)} = \frac{n_2 l_2 - n_1 l_1}{2(n_1 - n_2)}$$

(6) Vibrations produced in a string:

(a) Speed of wave along string $v = \sqrt{\frac{T}{m}}$

where T = Tension applied to string,

m = Mass per unit length of sting.

(b) Fundamental frequency (n):-

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$ where - l = vibrating length of string

(c) When string vibrates, all harmonious are present.

(7) Laws of a vibrating string:

(a) Law of length:- $n \propto \frac{1}{l}$ **or** nl = constant

(b) Law of tension:- $n \propto \sqrt{T}$ **or** $\frac{n}{\sqrt{T}}$ = constant

(c) Law of linear density, $n \propto \frac{1}{\sqrt{m}}$

(d) Also $n \propto \frac{1}{\sqrt{\rho}}$ and $n \propto \frac{1}{r}$

(8) Beats:

(a) Resultant eq^n $y = A\sin(2\pi n t)$

(b) Period of beat (T) $= \frac{1}{n_1 - n_2}$

(c) Frequency of beat (n) = $n_1 - n_2$

Chapter 7: Wave Optics

(1) Refractive index of medinm with respect to air is

(a) ${}_a\mu_m = \frac{\sin i}{\sin r}$ **(b)** ${}_a\mu_m = \frac{V_a}{V_m}$ **(c)** ${}_a\mu_m = \frac{\lambda_a}{\lambda_m}$

(d) Refractive index of glass *w.r.* to water, ${}_w\mu_g = \frac{\mu_g}{\mu_w}$

(2) Wave number and Critical angle:

(a) Wave number $(\bar{v}) = \frac{1}{\lambda}$

(b) Number of wave in path $d = \frac{d}{\lambda}$

(c) Critical angle, $\sin c = \frac{1}{\mu}$

(d) Intensity $\propto$ (amplitude)^2

(3) Wave vector and electric filed:

(a) Wave vector $(K) = \frac{2\pi}{\lambda}$

(b) The magnitude of electric field

$$E = E_0 \sin (Kx - \omega t)$$

where E_0 = amplitude of wave

K = Wave vector

(4) Brewster's law:

(a) $\mu_2 = \tan p$ **or** $\tan p = \frac{\mu_2}{\mu_1}$

(b) $r + p = 90°$

(5) Conditions :

(a) Condition for bright point or constructive interference path difference (P.D.) = $n\lambda$.

i.e P.D is equal to even multiple of $\frac{\lambda}{2}$

(b) Condition for dark point or destructive interference path difference (P.D) = $(2n-1)\frac{\lambda}{2}$

i.e P.D is equal to odd multiple of $\frac{\lambda}{2}$

(c) Path difference (P.D) = $S_2P - S_1P$

(d) Path difference (P.D) = $\frac{yd}{D}$

(e) Equation for n^{th} bright band $y_n = \frac{Dn\lambda}{d}$

(f) Equation for n^{th} dark band $y_n = \frac{D(2n-1)\lambda}{2d}$

(6) Fringe width (W):

$$W = \frac{\lambda D}{d}$$

(7) Optical path = $\mu \times d_{med}$

(8) Path difference = $d(\mu - 1)$

(9) Maxima and minima :

(a) Equation of n^{th} minima, $\sin\theta_n = \frac{n\lambda}{a}$

(b) Equation of n^{th} maxima, $\sin\theta_n = \frac{(2n+1)\lambda}{2a}$

(c) Width of the central bright band = $\frac{2\lambda D}{a}$

(10) Limit of resolution and Resolving power.

(a) For microscope:

(i) Limit of resolution = $\frac{\lambda}{2\mu\sin\theta}$

(ii) Resolving power = $\frac{2\mu\sin\theta}{\lambda} = \frac{2(N.A.)}{\lambda}$

where μ = Refractive index of medium.

θ = Semi vertical angle.

λ = Wave length.

$\mu \sin\theta$ = N.A. = Numerical aperture

(b) For Telescope:

(i) Limit of resolution $= \frac{1.22\lambda}{D}$

(ii) Resolving power $= \frac{D}{1.22\lambda}$

where D = diameter of the telescope objective

λ = wavelength.

(11) Resolving power $= \frac{1}{\text{limit of resolution}}$

Chapter 8: Electrostatics

(1) Charge (q) :

(a) Charge $(q) = \pm ne$ where, e = charge of electron $= 1.6 \times 10^{-19}$ C

(b) $q = It$ $n = 1, 2, 3$ .....

(2) $\begin{pmatrix}\text{Number of} \\ \text{electric lines} \\ \text{of forces}\end{pmatrix} = \begin{pmatrix}\text{Number} \\ \text{of tube of} \\ \text{forces}\end{pmatrix} = \begin{pmatrix}\text{Number} \\ \text{of tube of} \\ \text{induction}\end{pmatrix} = \frac{q}{K\varepsilon_0}$

(3) Charge density and Electric intensity

(a) Electrostatic force (F) $= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

(b) Dielectric constant (K) $= \frac{\varepsilon}{\varepsilon_0} = \frac{C}{C_{air}} = \frac{F_{air}}{F_{med}}$

(c) Linear charge density $(\lambda) = \frac{q}{l}$

(d) Surface charge density $(\sigma) = \frac{q}{A}$

(e) Volume charge density $(\rho) = \frac{q}{V}$

(f) Electric Intensity $(E) = \frac{F}{q_0} = \frac{V}{d} = \frac{\phi}{A}$

(4) Gauss's low and Electric intensity :

(a) Gauss's law : $\oint \sigma E \cos\theta ds = \sum_{i=1}^{n} q_i$

(b) Electric intensity due to charged sphere, $E = \frac{\sigma R^2}{\varepsilon_0 r^2} = \frac{q}{4\pi\varepsilon_0 r^2}$

(c) Electric intensity due to an infinite long straight charged wire,

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

(d) Electric intensity due to charged infinite plane sheet,

$$E = \frac{\sigma}{2\varepsilon_0}$$

(5) Electric potential energy $(U) = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

(6) Electric potential due to point charge, $V = \frac{q}{4\pi\varepsilon_0 r}$

(7) Relation between E and V :-

$$E = -\frac{dv}{dx}$$

(8) Electric potential due to an electric dipole:-

$$V_{dipole} = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$$

where $p = q \times 2l$ = Electric dipole moment

(9) Electrostatics potential due to a system of charge,

$$V_{system} = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_i}$$

(10) Potential energy :

(a) Potential Energy of two point charges, = $U = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}}$

(b) Potential energy for a system of N charges,

$$U = \frac{1}{4\pi\varepsilon_0} \sum_{\text{all } j<k} \frac{q_j q_k}{r_{jk}}$$

(c) Potential energy of dipole in an external field,

Potential energy (U) = $pE(\cos\theta_0 - \cos\theta)$

(11) Electric susceptibility $\chi_e = \frac{P}{E}$

(12) Capacitance (C) = $\frac{Q}{V}$

(13) Capacitors in series and parallel :

(a) When Capacitors in series:-

Equivalent capacitance,

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots \frac{1}{C_n}$$

(b) When Capacitors in parallel:-

Equivalent capacitance,

$$C_p = C_1 + C_2 + C_3 + \ldots\ldots C_n$$

(c) If all capacitors are equal then.

(i) For series, $\frac{1}{C_S} = \frac{n}{C}$

(ii) For parallel, $C_p = nC$

(iii) Relation between C_S and C_p is

$$C_p = n^2 C_S$$

(14) Capacitance of a parallel plate capacitor without dielectric.

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

(15) Capacitance of parallel plate capacitor with a dielectric slab between the plates,

$$C = \frac{A\varepsilon_0}{\left(d - t + \frac{t}{k}\right)}$$

(16) Displacement and conduction current :

(a) Displacement current, $I_d = Ak\varepsilon_0 \frac{dE}{dt}$

(b) Conduction current, $I_C = \frac{dq}{dt}$

(17) Energy stored in capacitor (U)

(a) $V = \frac{1}{2}\frac{Q^2}{C}$ **(b)** $U = \frac{1}{2}Q.V$ **(c)** $U = \frac{1}{2}CV^2$

(18) Energy per unit volume or Energy density

$$\frac{dU}{dv} = \frac{1}{2}k\varepsilon_0 E^2$$

Chapter 9: Current Electricity

(1) **Ohms law:** V = IR $\therefore$ Resistance (R) = $\frac{V}{I}$

(2) Conductance (K) = $\frac{1}{R}$

(3) Specific resistance (ρ) = $\frac{RA}{l}$

(4) Conductivity (σ) = $\frac{1}{\rho} = \frac{l}{RA}$

(5) Kirchhoff's laws:

(a) Kirchhoffs current law:-

$$\Sigma I = 0$$

(b) Kirchhoffs voltage law.

$$\Sigma emf + \Sigma P.D = 0$$

(6) Wheatstone's bridge :

(a) Wheatstone network condition:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \textbf{or} \quad \frac{P}{Q} = \frac{S}{R}$$

(b) In meter bridge; condition is

$$\frac{X}{R} = \frac{l_X}{l_R} \qquad \therefore\ X = R\frac{l_X}{l_R}$$

(c) In Kelvins method, condition is

$$\frac{G}{R} = \frac{l_g}{l_R} \qquad \therefore\ G = R\frac{l_g}{l_R}$$

(7) Potentiometer :

(a) Principle of potentiometer

$$V \propto l \quad \text{or} \quad \frac{V}{l} = \text{constant}$$

(b) Comparison of emf by potentiometer:

(i) Individual method, $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

(ii) Sum and difference method, $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}$

(c) Internal resistance, $r = R\left(\frac{l_1}{l_2} - 1\right)$

(8) Moving coil Galvanmeter (MCG)

(a) Conversion of MCG into ammeter:

(i) Shunt (S) = $\left(\frac{I_g}{I - I_g}\right) G$

(ii) Shunt (S) = $\frac{G}{n - 1}$

(iii) Fraction of total current through shunt resistance,

$$\frac{I_s}{I} = \frac{G}{S + G}$$

(iv) Fraction of total current through galvanometer,

$$\frac{I_g}{I} = \frac{S}{S+G}$$

(b) Conversion of MCG into voltmeter:

(i) High resistance $(X) = \frac{V}{I_g} - G$

(ii) High resistance $(X) = G(n-1)$

Chapter 10: Magnetic fields due to electric current

(1) Magnetic, electric and Lorentz force:

(a) Magnetic force $F_m = q(\bar{V} \times \bar{B}) = qVB\sin\theta$

(b) Force due to electric field, $F_E = Eq$

(c) Lorentz force, $\vec{F} = \vec{F}_m + \vec{F}_E$

$$= q\vec{E} + q(\vec{V} \times \vec{B})$$

$$= q\left[\vec{E} + (\vec{V} \times \vec{B})\right]$$

(2) Cyclotron formula

$mv = qBR$ i.e. $p = qBR$

(3) Cyclotron Accelerator :

(a) Period $(T) = \frac{2\pi m}{qB}$ **(b)** Frequency $(n) = \frac{qB}{2\pi m}$

(c) K.E of ions $= \frac{1}{2}mv^2 = \frac{q^2B^2R^2}{2m}$

(4) Magnetic force :

(a) Magnetic force in terms of current I,

$$F_m = \vec{I}\,(l \times \vec{B}) = IlB\sin\theta$$

This is force acting on straight wire.

(b) Force on arbitrarily shaped wire,

$$\vec{F}_m = I\left[\int \vec{dl}\right] \times \vec{B}$$

(d) Force between two long parallel wires,

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

(9) Magnetic field (B) :

(a) Magnetic field produced by current in a circular arc of a wire,

$$B = \frac{\mu_0}{4\pi} \frac{I\theta}{r}$$

(b) Magnetic field at the centre of circle of wire,

$$B = \frac{\mu_0 I}{2r}$$

(c) Axial magnetic field produced by current in circular loop:-

$$B = \frac{\mu_0 IR^2}{2(Z^2 + R^2)^{3/2}}$$

(10) Ampere's Law and Magnetic field of solenoid and toroid:

(a) Ampere Law,

$$\oint \overline{B}.\overline{ds} = \mu_0 I$$

(b) Magnetic field of a solenoid

$$B = \mu_0 nI \qquad \text{where } n = \frac{N}{L}$$

(c) Magnetic field of a toroid,

$$B = \mu_0 nI \qquad \text{where } n = \frac{N}{2\pi r}$$

(d) Magnetic field outside the solenoid and outside the toroid is zero, i.e. $B = 0$

Chapter 11: Magnetic Materials

(1) Magnetic dipole moment (M) :

(a) (Magnetic length) $= \frac{5}{6}$ (Geometric length)

$$2l = \frac{5}{6} L$$

(b) Magnetic dipole moment $(M) = 2l\, m$

(2) Torque, angular acceleration and period :

(a) Torque acting on magnetic dipole in uniform magnetic field,

$$\tau = MB\sin\theta$$

(b) Magnetic potential energy $(U_m) = -MB\cos\theta$

(c) Angular acceleration $= -\left(\frac{MB}{I}\right)\theta$

(d) Period of angular oscillations of bar magnet,

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

(3) Magnetic moment of orbiting electron:

(a) $M_{orb} = IA = \frac{1}{2}evr$

(b) $M_{orb} = \left(\frac{e}{2m_e}\right)L = \frac{enh}{4\pi m_e}$

(c) Gyromagnetic ratio $= \frac{M_{orb}}{L} = \frac{e}{2m_e}$

(4) Magnetization, magnetic intensity and magnetic susceptibility

(a) Magnetization $(M_z) = \frac{\text{Net magnetic moment } (M_{net})}{\text{Volume } (V)}$

(b) Magnetic intensity $(H) = nI$

(c) $B = B_0 + B_M$ and $B = \mu_0 (H + M)$

(d) Magnetic susceptibility $(\chi) = \frac{M}{H}$

(e) $B = \mu_0 (1 + \chi)H$

(f) $B = \mu H$ and $\mu = \mu_0(1 + \chi)$

(5) Curies Low and Curie temperature :

(a) Curies Law: $M_z = C\frac{B}{T}$ **(b)** $\chi = \mu_r - 1 = C\frac{\mu_0}{T}$

(c) $\chi = \frac{C}{T - T_C}$ where, C = Curie constant

T_C = Curie temperature

(d) $H = \frac{B}{\mu_0} - M$

Chapter 12: Electromagnetic Induction

(1) Magnetic flux and Magnetic induction :

(a) Magnetic flux $(\phi) = B\,A$

(b) $\therefore$ Magnetic induction $B = \frac{\phi}{A}$

(2) Faraday's law:

Magnitude of induced emf is

$e = \frac{d\phi}{dt}$ ....(for one turn)

$e = n\frac{d\phi}{dt}$ ....(for n turns)

(3) emf and power:

(a) emf induced in the coil,

$e = Blv$

(b) Motional emf in a rotating bar,

$e = \frac{1}{2} B\omega l^2$

(c) emf induced in a secondary coil in a changing magnetic field,

$e_0 = \frac{2\pi\theta_0}{T}$

(d) emf induced in rotating coil in magnetic field,

$e = e_0 \sin\omega t$

(e) Power $= \vec{F}.\vec{V} = \frac{B^2L^2V^2}{R}$

(4) Self inductance:

(a) $\phi = LI$ OR $L = \frac{\phi}{I}$

(b) $e = -L\frac{dI}{dt}$ $\therefore$ $L = \frac{|e|}{\left|\frac{dI}{dt}\right|}$

(c) Energy of circuit $= \frac{1}{2}LI^2$

(d) Inductances of a solenoid: $L = \mu_0 n^2 lA$

(e) Inductances in series: $L = L_1 + L_2 + L_3 + \ldots..$

(f) Inductances in parallel: $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + ...$

(g) Energy density of magnetic field $(u_B) = \frac{1}{2}\frac{B^2}{\mu_0}$

(5) Mutual Inductance:

(a) $\phi_S = MI_P$ or $M = \frac{\phi_S}{I_P}$

(b) $e_S = -M\frac{dI_P}{dt}$ $\therefore$ $M = \frac{|e_s|}{\left|\frac{dI_P}{dt}\right|}$

(c) Co-efficient of coupling between two circuits,

$L \propto N^2$ or $N \propto \sqrt{L}$

$\therefore$ $N_1N_2 = \sqrt{L_1L_2}$

$\therefore$ $M = \sqrt{L_1L_2}$ (As K = 1)

(6) For Transformer:-

(a) $\frac{e_s}{e_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S} = K$

where K is called transformer ratio

(b) Power of transformer, $\eta = \frac{P_{out\,put}}{P_{input}} \times 100$

Chapter 13: AC Circuits

(1) Induced emf in rotating coil placed in uniform magnetic field,

$e = e_0 \sin\omega t$

where e_0 is the peak value of emf.

(2) The current in circuit connected to generator,

$I = I_0 \sin(\omega t)$

(3) Average and Rms Values of Ac :

(a) Average value of AC

$e_{av} = 0.637\, e_0$ and $I_{av} = 0.637\, I_0$

(b) RMS values -

$$e_{rms} = \frac{e_0}{\sqrt{2}} \quad \text{and} \quad I_{rms} = \frac{I_0}{\sqrt{2}}$$

(4) Resistive, inductive and capacitive circuit:

(a) For pure resistive circuit, $I_0 = \frac{e_0}{R}$

(b) For pure inductive circuit, $I_0 = \frac{e_0}{\omega L}$

(c) For pure capacitive circuit, $I_0 = \frac{e_0}{\frac{1}{\omega C}}$

(d) (i) Inductive reactance $X_L = \omega L = 2\pi f L$

(ii) Capacitive reactance $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

(5) LCR circuit:

(a) Impedance (Z) $= \sqrt{R^2 + (X_L - X_C)^2}$

(b) $Z = \frac{e_0}{I_0}$ **(c)** $\tan\phi = \left(\frac{X_L - X_C}{R}\right)$

(6) LR and CR circuit:

(a) For LR circuit

$$Z = \sqrt{R^2 + X_L^2}$$

(b) For CR circuit $Z = \sqrt{R^2 + X_C^2}$

(7) Average power and power factor:

(a) Average power in AC circuit with resistance

$$P_{av} = e_{rms} \times I_{rms}$$

(b) Average power in AC circuit with inductor

$$P_{av} = 0$$

(c) Average power in AC circuit with capacitor

$$P_{av} = 0$$

(d) Average power in LCR circuit

$$P_{av} = e_{rms} \times I_{rms} \times \cos\phi$$

(e) Power factor $(\cos\phi) = \frac{R}{Z} = \frac{\text{True power}}{\text{Apparent power}}$

(8) Resonant frequency and power factor :

(a) Resonant frequency $(f_r) = \frac{1}{2\pi\sqrt{LC}}$

(b) Sharpness of Resonance:

$$\text{Q factor} = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{\omega_r}{2\,\Delta\,\omega} = \frac{\text{Resonant frequency}}{\text{Band width}}$$

(c) For choke coil:

(i) Power factor $(\cos\phi) = \frac{R}{\sqrt{R^2 + X_L^2}}$

(ii) Average power $= I_{rms} \times e_{rms} \times \cos\phi$

Chapter 14: Dual Nature of Radiation and Matter

(1) Photon energy $= h\nu = \frac{hc}{\lambda}$

(2) Photo electric work function $(\phi_0) = h\nu_0$

where h - Planck's constant

ν_0 - Threshold frequency

ν - Frequency of radiation

(3) Threshold frequency $(\nu_0) = \frac{c}{\lambda_0}$

(4) Einstein photo electric equation:

$$\frac{1}{2}mv^2_{max} = h\nu - \phi_0$$
$$= h\nu - h\nu_0$$

(5) Stopping potential (V_S)

$$eV_S = \frac{1}{2}mv^2_{max}$$

(6) De - Broglie Hypothesis:

(a) $p = \frac{E}{c}$ where, p - momentum

E - energy of photon

c - velocity of radiation

(b) $p = \frac{h}{\lambda}$

(c) $p = mc$

(d) $\lambda = \frac{h}{\sqrt{2mE_K}} = \frac{h}{\sqrt{2meV}} = \frac{1.228}{\sqrt{V}}$ (in nm)

Chapter 15: Structure of Atoms and Nuclei

(1) Bohr's postulates:

(a) First postulate, $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$

(b) Second postulate, $mvr = \frac{nh}{2\pi}$

(c) Third postulate, $h\nu = E_n - E_p$

(2) Radius of n^{th} orbit,

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi\, m_e Ze^2}$$

(3) Velocity (v) = $\frac{Ze^2}{2\varepsilon_0 nh}$9

(4) Energy of an electron:

For n^{th} orbit $E_n = -\frac{m_e Z^2 e^4}{8\,\varepsilon_0 n^2 h^2}$

For hydrogen atom Z = 1

$$\therefore \quad E_n = -\frac{m_e e^4}{8\,\varepsilon_0 n^2 h^2}$$

(5) Rydberg's formula:

$$\frac{1}{\lambda} = R\,Z^2\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$ Where R is Rydberg constant

For hydrogen atom Z = 1

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

(6) Five series:

(a) Lyman series $n = 1$, $m = 2, 3, 4, \ldots\ldots \infty$

(b) Balmer series $n = 2$, $m = 3, 4, 5, 6 \ldots\ldots \infty$

(c) Paschen series $n = 3, \quad m = 4, 5, 6 \ldots\ldots \infty$

(d) Brachett series $n = 4, \quad m = 5, 6, 7, \ldots\ldots \infty$

(e) Pfund series $n = 5, \quad m = 6, 7, 8, \ldots\ldots \infty$

(7) Debroglie hypothesis:

(a) $\lambda_n = \dfrac{2\pi r_n}{n}$ (b) $\lambda = \dfrac{h}{P}$ (c) $L_n = P_n r_n = \dfrac{nh}{2\pi}$

(8) Mass number (A) = Z + N

(9) Size of nucleus:

(a) Radius of nucleus X, is

$R_X = R_o A^{1/3}$

(b) Density inside nucleus $\rho = \dfrac{3mA}{4\pi R_X^3}$

(10) Mass defect (Δm):

$\Delta m = Zm_p + Nm_n - M$

(11) Binding energy:

(a) Binding energy $(E_B) = \Delta m\, c^2$

$= (Zm_p + Nm_n - M)c^2$

(b) B.E per nucleon $= \dfrac{B.E}{A}$

(12) Q - value = K.E = $[m_x - m_y - m_{He}]c^2$

(13) Law of Radioactive decay:

(a) $\dfrac{dN}{dt} = -\lambda N$ (b) $N_{(t)} = N_o\, e^{-\lambda t}$ (c) $A_{(t)} = A_o\, e^{-\lambda t}$

(d) Half life period (T) $= \dfrac{0.693}{\lambda}$ (e) Average life $(\tau) = \dfrac{1}{\lambda}$

(14) Energy released in the nuclear reaction:-

$Q = [m_u - m_i - m_y - 2m_n]c^2$

Chapter 16: Semiconductor Devices

(1) $V = IR$

(2) Power (P) = VI

(3) Output voltage, $V_O = I_L R_L$

(4) $I_E = I_C + I_B$

(5) $\alpha_{DC} = \frac{I_C}{I_E}$ and $\beta_{DC} = \frac{I_C}{I_B}$

(6) $\alpha_{DC} = \frac{\beta}{\beta + 1}$ and $\beta_{DC} = \frac{\alpha}{\alpha - 1}$

(7) Current and voltage gain:

(a) Current gain $(A_i) = \frac{\Delta I_C}{\Delta I_B}$

(b) Voltage gain $(A_v) = \frac{\Delta V_O}{\Delta V_i}$

(8) Input and output resistance:

(a) Dynamic input resistance

$$r_i = \frac{\Delta V_{BE}}{\Delta I_B}$$

(b) Dynamic output resistance

$$r_O = \frac{\Delta V_{CE}}{\Delta I_C}$$

Useful Information

(1) Fundamental constants

Quantity	Symbol	Approximate value
Acceleration of free fall (Earth's surface)	g	9.81 m s^{-2}
Gravitational constant	G	6.67 x 10^{-11} N m^2 kg^{-2}
Avogadro's constant	N_A	6.02 x 10^{23} mol^{-1}
Gas constant	R	8.31 $JK^{-1}mol^{-1}$
Boltzmann's constant	k_B	1.38 x 10^{-23} JK^{-1}
Stefan - Boltzmann constant	σ	5.67 x 10^{-8} W m^{-2} K^{-4}
Coulomb constant	k	8.99 x 10^{9}N m^2 C^{-2}
Permittivity of free space	ε_0	8.85 x $10^{-12}C^2N^{-1}m^{-2}$
Permeability of free space	μ_0	4π x 10^{-7} T m A^{-1}
Speed of light in vacuum	c	3.00 x 10^{8}m s^{-1}
Planck's constant	h	6.63 x 10^{-34}J s
Elementary charge	e	1.60 x 10^{-19}C
Electron rest mass	m_e	9 .110 x 10^{-31}kg
Proton rest mass	m_p	1.673 x 10^{-27}kg
Neutron rest mass	m_n	1.675 x 10^{-27}kg
Unified atomic mass unit	u	1.661 x 10^{-27}kg
Solar constant	S	1.36 x 10^{3} W m^{-2}
Fermi radius	R_0	1.20 x 10^{-15}m

(2) Metric (SI) multipliers

Prefix	Abbreviation	Value
Peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

(3) Unit conversions

1 radian (rad) = $\dfrac{180^0}{\pi}$

Temperature (K) = temperature (^{0}C) + 273

1 light year (ly) = 9.46×10^{15}m

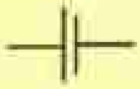
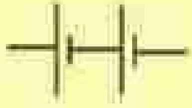
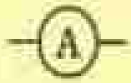
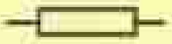
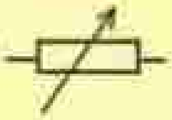
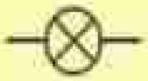
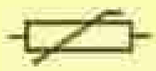
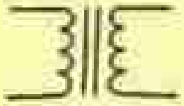
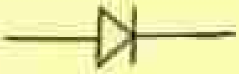
1 parsec (pc) = 3.26 ly

1 astronomical unit (AU) = 1.50×10^{11}m

1 kilowatt-hour (kWh) = 3.60×10^{6}J

$hc = 1.99 \times 10^{-25}$ Jm = 1.24×10^{-6} eVm

(4) Electrical Circuit symbols

Cell		battery	
ac supply		switch	
voltmeter		ammeter	
resistor		variable resistor	
lamp		potentiometer	
light-dependent resistor(LDR)		thermistor	
transtrormer		heating element	
diode		capacitor	

(5) Chemistry Notation

Symbol	Term	Unit (s)
c	specific heat capacity	J/(g.°C) or J/(g.K)
E^{o}	standard electrical potential	V or J/C
E_k	kinetic energy	kJ
E_p	potential energy	kJ
ΔH	enthalpy (heat)	kJ
$\Delta_f H^{o}$	standard molar enthalpy of formation	kJ/mol
I	current	A or C/s
K_c	equilibrium constant	____
K_a	acid ionization (dissociation) constant	____
K_b	base ionization (dissociation) constant	____
M	molar mass	g/mol
m	mass	g
n	amount of substance	mol
P	pressure	kPa
Q	charge	C
T	temperature (absolute)	K
t	temperature (celsius)	°C
t	time	s
V	volume	L
C	amount concentration	mol/L

Symbol	Term
Δ	delta (change in)
°	Standard
[ ]	amount concentration

(6) Miscellaneous

25.00 °C is equivalent to 298.15 K

Specific Heat capacities at 298.15 K and 100.000 kPa

C_{air} = 1.01 J/(g.°C)

$C_{polystyrene\ foam\ cup}$ = 1.01 J/(g.°C)

C_{copper} = 0.385 J/(g.°C)

$C_{aluminum}$ = 0.897 J/(g.°C)

C_{iron} = 0.449 J/(g.°C)

C_{tin} = 0.227 J/(g.°C)

C_{water} = 4.19 J/(g.°C)

Water Autoionization Constant (Dissociation Constant)

$K_w = 1.0 \times 10^{-14}$ at 298.15 K (for ion concentrations in mol/L)

Faraday Constant

$F = 9.665 \times 10^4$ C/mol e^-

Quadratic Formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Colours of Common Aqueous Ions

Ionic species	Solution Concentration	
	1.0 mol/L	0.010 mol/L
romate	yellow	pate yellow
romium (III)	blue-green	green
romium (II)	dark blue	pale blue
alt (II)	red	pink
per (I)	blue-green	pale blue-green
per (II)	blue	pale blue
hromate	orange	pale orange
n (II)	lime green	colourless
n (III)	orange-yellow	pale yellow
nganese (II)	pale pink	colourless
kel (II)	blue-green	pale blue-green