Chapter 1

Atoms Molecules And Nuclei

Bohr's Atom Model

(1) 1st Postulate:

Centripetal force = electrostatic force

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\,\frac{e^2}{r^2}$$

where m = mass of an orbiting electron

v = linear velocity of an orbiting electron

r = radius of orbit

ε_0 = permittivity of free space

e = charge on an electron.

2. 2nd Postulate:

Angular momentum of an orbiting electron = Integral multiple of $\frac{h}{2\pi}$

$$m v r = \frac{nh}{2\pi}$$

where m = mass of an orbiting electron

v = linear velocity of an orbiting electron

r = radius of orbit

n = 1, 2, 3, �� (integer)

h = Planck's constant.

3. Energy of Photon Emitted or Absorbed is Given by:

$E_{n_2} - E_{n_1} = h\upsilon$

where E_{n_2} , E_{n_1} = final and initial energy levels

υ = frequency of radiation.

4. Radius of n^th Orbit of the Electron:

$$r_n = \frac{\varepsilon_0\, n^2\, h^2}{\pi \square m\, e^2}$$

where ε_0 = permittivity of free space

n = 1, 2, 3, � (Integer)

h = Planck's constant

m = mass of an electron

e = charge on an electron.

5. Potential Energy of an Orbiting Electron:

$$P.E. = -\frac{e^2}{4\pi\varepsilon_0 r} = -\frac{me^4}{4\ n^2\ h^2\varepsilon_0^{\ 2}}$$

K.E. energy of the electron

$$K.E. = \frac{e^2}{8\pi\varepsilon_0 r} = \frac{me^4}{8\ n^2\ h^2\varepsilon_0^{\ 2}}$$

Total energy of an orbiting electron

$$E_n = -\frac{e^2}{8\pi\varepsilon_0 r} = -\frac{me^4}{8\ \varepsilon_0^{\ 2}\ n^2\ h^2}$$

$\therefore$ $P.E.$ = – 2 $K.E.$ and $T.E.$ = – $K.E.$

6. Wave Number ($\bar{\nu}$) of the Electromagnetic Radiation:

$$\bar{\nu} = \frac{1}{\lambda} = \frac{\upsilon}{c} = \frac{me^4}{8\varepsilon_0^{\ 2}\ h^3 c}\left[\frac{1}{n_1^{\ 2}} - \frac{1}{n_2 2}\right]$$

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

where R = Rydberg constant $= \dfrac{me^4}{8\varepsilon_0^{\ 2} h^3 C}$

7. Velocity of the Electron:

$$v_n = \frac{e^2}{2h\varepsilon_0}\left[\frac{1}{n}\right] \qquad \therefore v_n \propto \frac{1}{n}$$

8. Angular Speed of the Electron:

$$w_n = \frac{\pi me^4}{2h^3\varepsilon_0^{\ 2}}\left[\frac{1}{n^3}\right] \qquad \therefore w_n \propto \frac{1}{n^3}$$

9. Period of the Revolution of the Electron:

$$T_n = \frac{4h^3\varepsilon_0^{\ 2}}{me^4}(\ n^3\ ) \qquad \therefore T_n \propto n^3$$

10. Centripetal Acceleration:

$$a = \frac{\pi me^6}{4\varepsilon_0^{\ 3} h^4}\left[\frac{1}{n^4}\right] \qquad \therefore a \propto \frac{1}{n^4}$$

11. Energy of the Electron in Ground State:

for ground state, $n = 1$

$$\therefore E_1 = \frac{-\square me^4}{8h^2\varepsilon_0^2}$$

$$\therefore E_1 = -13.6\ eV$$

12. General Expression for Energy, Radius and Velocity

$E_n = E_1/n^2$

$r_n = r_1 \cdot n^2$

$v_n = v_1 / n$

Chapter 2

Circular Motion

1.

Instantaneous Angular Speed, $\omega = \frac{d\,\theta}{dt}$

2.

Instantaneous Angular Acceleration, $\alpha = \frac{d\omega}{dt}$

3.

Angular acceleration $\alpha = \frac{\omega_2 - \omega_1}{t}$ Where ω_1 is the initial angular velocity and ω_2 is the final angular velocity in a time interval t.

4.

Instantaneous Linear Speed $v = \frac{ds}{dt}$

5.

Linear Speed, $v = r\,\omega$ Where r is the radius of the circle.

6.

Instantaneous Linear Acceleration, $a = \frac{dv}{dt}$

7.

Tangential acceleration, $a = r\,\alpha$ Where r is the radius of the circle, α – angular acceleration.

8.

Magnitude of centripetal acceleration,

$$a = \frac{v^2}{r} = \omega^2\, r = v\,\omega$$

9.

Magnitude of centripetal force,

$$f = \frac{mv^2}{r} = m\omega^2\, r = m\,v\,\omega$$

10.

Maximum safe speed on a curved unbanked road, $v_{max} = \sqrt{\mu\, rg}$ Where μ is the coefficient of static friction.

11.

Maximum safe speed on a curved banked road $v_{max} = \sqrt{rg\tan\theta}$

12.

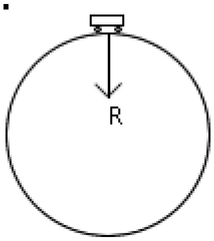
Angle through which a bicyclist has to tilt his cycle while taking a turn on an unbanked road,

$\theta = \tan^{-1}\frac{v^2}{rg}$ Where v is the velocity of the vehicle.

13.

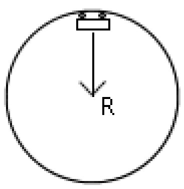
Angle of banking, $\theta = \tan^{-1}\frac{v^2}{rg}$ Where v is the velocity of the vehicle.

14.



$v_{max} = \sqrt{rg}$

15.



$v_{min} = \sqrt{rg}$

16.

$a = \sqrt{a_T^2 + a_R^2}$ where a_T is the tangential acceleration and a_R is the radial acceleration.

Chapter 3

Current Electricity

1. Relationship between current, charge and time:

$$I = \frac{Q}{t}$$

where I = Current (Ampere)
Q = Charge (Coulomb)
t = time (Second)

(Current is defined as rate of flow of charge ∴ $I = \frac{dq}{dt}$)

2. Ohm's law:

$$\frac{V}{I} = R \qquad \text{(Ohm's law)}$$

where V = Potential difference across a conductor.
I = Current flowing through a conductor.
R = Resistance of the conductor.

R is in ohms when V is in volts and I is in amperes.

$$1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ ampere}} \text{ i.e. } 1\ \Omega = \frac{1\ V}{1\ A}$$

3. Specific resistance:

3. $\rho = \frac{RA}{L}$

where ρ = Specific resistance or resistivity (ohm-m)
R = resistance of a conductor (ohm)
A = area of cross-section of a conductor (sq-metre)
l = length of a conductor (metre)

4. Conductance:

$$\mathbf{G = \frac{1}{R} = \frac{I}{V}}$$

G is in Siemens or mho when R is in ohms
OR
G is in Siemens when I is in amperes and V is in volts.

5. Conductivity:

$$\sigma = \frac{1}{\rho} = \frac{L}{RA}$$

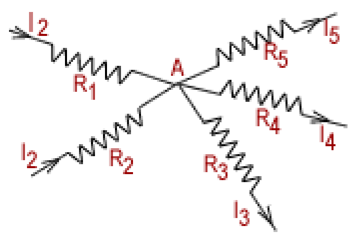
σ is in siemens/metre when ρ is in ohm-metres.
OR
σ is in siemens/metre
when,
L is in metres,

R is in ohms and A is in metre^2.

6. Kirchhoff's 1st law:
The sum of all currents at a node is zero. i.e. $\Sigma I_n = 0$
Sign convention :

Currents entering a node	**+ sign**
Currents leaving a node	**– sign**

Example:



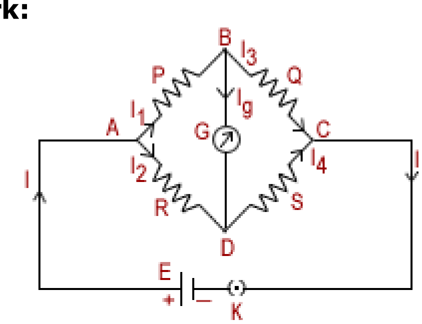
At node A,
$I_1 + I_2 - I_3 - I_4 - I_5 = 0$

7. Kirchhoff's 2nd law:
The algebraic sum of the potential. difference and e.m.f. around any closed loop in an electrical circuit is zero.
Sign convention

$\Sigma I_n R_n + \Sigma E_n = 0$

Across Resistance	In the direction of current	– sign
	Opposite to the direction of current	+ sign
For a cell	From negative terminal to positive terminal	+ sign
	From positive terminal to negative terminal	– sign

8. Wheatstone's Network:

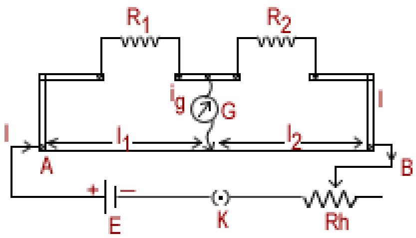


The balancing condition for Wheatstone's bridge

$$\boxed{\frac{P}{Q} = \frac{R}{S}}$$

In this condition $I_g = 0$ and the points B and D are equipotential.

9. Meter Bridge:

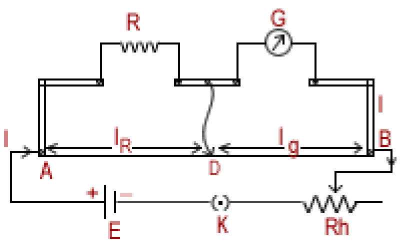


(1) $\frac{R_1}{R_2} = \frac{l_1}{l_2}$ when $i_g = 0$ (i.e. when bridge is balanced)

(2) $l_1 + l_2 = 1$ metre = 100 cm.

where l_1 = length of meter bridge wire from end A (left end) to null-point.
l_2 = length of meter bridge wire from end B (right end) to null-point.
R_1 = resistance in left gap (unknown resistance)
R_2 = resistance in right gap.

10. Kelvin's Method:



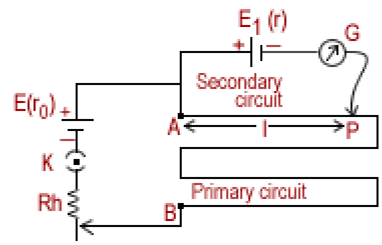
When balance point (D) is obtained,

$$\frac{\mathbf{R}}{\mathbf{G}} = \frac{\mathbf{l_R}}{\mathbf{l_g}}$$

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

where G = resistance of the galvanometer
R = known resistance
l_g = length of meter bridge wire from balance point to one end of the bridge. (opposite to galvanometer).
l_R = length of meter bridge wire from balance point to other end of the bridge (length opposite to R).

11. Potentiometer:



(1) $V_{AP} = \phi\, l_1$
(Principle of Potentiometer)

(2) Potential Gradient = $\frac{V_{AB}}{L}$

Where,
V_{AB} = potential difference between points A and B.
L = total length of potentiometer wire.

(3) $E_1 = V_{AP}$ when galvanometer shows zero deflection.

(4) $E1 = \left(\frac{V_{AB}}{L}\right) \times l$

Where E_1 = e.m.f. of cell connected in the secondary circuit.
$\left(\frac{V_{AB}}{L}\right)$ = potential gradient
l = balancing length measured from point A to point P.

(5) $V_{AB} = IR$

$$\mathbf{V_{AB} = \frac{E}{R_{total}} \times R}$$

$R_{total} = R + R_c + r_0$
R = resistance of the wire
r_0 = internal resistance of a cell of EMF(E)
R_c = control resistance connected in series with Potentiometer wire (in place of Rheostat)

(6) **Potentiometer :** (Internal resistance of a cell)

$r = R\left(\frac{l_1 - l_2}{l_2}\right)$

Where r = internal resistance of the cell
l_2 = balancing length when resistance R is connected across the cell
l_1 = initial balancing length (When $R = \infty$ or key in series with R is open)
R = resistance across the cell when l_2 is measured.

(7) $\mathbf{\frac{E_1}{E_2} = \frac{l_1}{l_2}}$ **(Substituting Method)**

E_1, E_2 = e.m.f.s of the two cells which are being compared.
l_1 = balancing length corresponding to E_1
l_2 = balancing length corresponding to E_2.

(8) $\mathbf{\frac{E_1}{E_2} = \frac{l_3 + l_4}{l_3 - l_4}}$ (Sum and diffrence method)

E_1, E_2 = e.m.f.s of the two cells which are being compared. ($E_1 > E_2$)
l_3 = balancing length corresponding to e.m.f. ($E_1 + E_2$) i.e. cells are assisting.
l_4 = balancing length corresponding to e.m.f. ($E_1 - E_2$) i.e. cells are opposing.

Chapter 4

Elasticity

1. Stress

Stress $= \dfrac{\text{Internal restoring force}}{\text{Area}} = \dfrac{\text{Applied force}}{\text{Area}}$

2. Longitudinal Stress and Volume Stress

Longitudinal stress $= \dfrac{\mathbf{M}g}{\pi \boldsymbol{r}^2}$ where M is a mass attached to a wire of radius $\boldsymbol{r}$.

Volume stress = Change in pressure = Δp

3. Shearing Stress

Shearing stress $= \dfrac{\text{tangential force}}{\text{Area}} = \dfrac{F}{A}$

4. Longitudinal Strain

Longitudinal strain $= \dfrac{\boldsymbol{l}}{\mathbf{L}}$ where $\boldsymbol{l}$ is the extension of a wire of length L.

5. Volume Strain

Volume strain $= \dfrac{d\mathbf{V}}{\mathbf{V}}$ where $\boldsymbol{d}$V is the change in volume of an object of volume V.

6. Shearing Strain

Shearing strain = θ (= tan θ).

7. Young's Modulus

$Y = \dfrac{\mathbf{M}g\mathbf{L}}{\pi \boldsymbol{r}^2 \boldsymbol{l}}$ (symbols have their usual meanings).

8. Bulk Modulus and Compressibility

$K = \dfrac{\mathbf{V}\Delta\mathbf{P}}{\Delta\mathbf{V}}$ (numerically) (symbols have their usual meanings).

Compressibility $= \dfrac{1}{\text{Bulk modulus}}$

9. Modulus of Rigidity

$\eta = \dfrac{F}{\mathbf{A}\theta}$ (symbols have their usual meanings).

10. Lateral Strain

Lateral strain = $\frac{\Delta \mathbf{D}}{\mathbf{D}}$ where ΔD is the change in the diameter D of a wire.

11. Poisson's Ratio

$$\sigma = \frac{\mathbf{L\Delta D}}{\mathbf{D\Delta L}}$$

12. Work Done in Stretching a Wire

Work done in stretching a wire = $\frac{1}{2}$ × force × elongation.

13. Strain Energy Per Unit Volume

Strain energy per unit volume = $\frac{1}{2}$ × longitudinal stress × longitudinal strain

$= \frac{1}{2} \times □\boldsymbol{y} \times$ (longitudinal strain)^2

$$= \frac{1}{2} \times \frac{(\text{longitudinal stress})^2}{\boldsymbol{y}}$$

Chapter 5

Electrons and Photons

1.

Force acting on a charged particle in an electric field $\vec{E}$ is given by

$$\vec{F} = q\,\vec{E}$$

Where q = charge on the particle.

Let e be magnitude of charge on an electron;

$\vec{F} = -e\,\vec{E}$ when an electron is placed in an electric field $\vec{E}$

2.

The force acting on a charged particle in a magnetic field of intensity $\vec{B}$ by

$\vec{F} = q\,\vec{v} \times \vec{B}$

$|\vec{F}| = q\, v\, B \sin\theta$

Where θ = angle between $\vec{v}$ and $\vec{B}$

$\vec{v}$ = velocity of the particle.

If the magnetic field acts in a perpendicular direction, the particle undergoes a circular motion. The centripetal force is provided by the magnetic force.

$$\frac{mv^2}{r} = q\, v\, B$$

(θ = 90�, $\sin\theta = 1$)

Where r = radius of the particle's circular path.

If the charged particle is an electron,

$$\frac{mv^2}{r} = e\, v\, B$$

and $r = \dfrac{mv}{e\,B}$

Where e = magnitude of the charge on the electron.

3.

Electric and magnetic fields act simultaneously on an electron in a mutually perpendicular direction. The direction and magnitude of the forces due to these fields are such that they nullify each other then,

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

Where v = velocity of electron
E = intensity of electric field
B = intensity of magnetic field

4.
When a charged particle is accelerated from rest through a potential difference V, the increase in kinetic energy of the particle is given by

$\frac{1}{2} m v^2 = q V$

5.
Energy of a photon is given by
$E = h\nu$
Where h = Plank's constant
ν = frequency of radiation

$\nu = \frac{C}{\lambda}$

$\therefore E = \frac{hc}{\lambda}$

Where c = velocity of electromagnetic radiation
λ = wavelength of radiation

6.
Einstein's photoelectric equation: $h\nu - W_0 = \frac{1}{2} m (v_{max})^2$

$\therefore h\nu = \frac{1}{2} m (v_{max})^2 + w_0$

Where $h\nu$ = energy of photon of incident radiation
$\frac{1}{2} m (V_{max})^2$ = maximum kinetic energy of emitted photoelectrons
W_0 = work function of the emitting metal.

7.
$e V_s = \frac{1}{2} m (v_{max})^2$
Where e = charge on electron
V_s = stopping potential
$\frac{1}{2} m (v_{max})^2$ = maximum kinetic energy of photoelectrons
m = mass of photoelectrons
V_{max} = maximum velocity of photoelectrons

8.
$W_0 = h\nu_0 = \frac{h\,c}{\lambda}$
Where W_0 = work function of metal
h = Plank's constant
ν_0 = threshold frequency
λ_0 = threshold wavelength

C = velocity of light / electromagnetic radiation.

9.

$h\nu - h\nu_0 = (K.E.)_{max}$

$h\,c\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = (K.E.)_{max}$

$\therefore h\,c\left(\frac{\lambda_0 - \lambda}{\lambda_0 \lambda}\right) = (K.E.)_{max}$

Chapter 6

Electromagnetic Induction

1. Magnetic flux through a plane of coil

$(\phi) = \vec{B} \cdot \vec{A} = BA \cos\theta$:

where B = magnetic induction

A = area of the coil

θ = angle between $\vec{A}$ (normal to the plane) and $\vec{B}$.

2. Induced e.m.f.:

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

where e = e.m.f. induced in a circuit

$\frac{d\phi}{dt}$ = rate of change of flux through the circuit

negative sign indicates the direction of induced current or e.m.f.

3. e.m.f. induced in a straight moving conductor in a perpendicular magnetic field:

$e = Blv$

where e = induced e.m.f .

B= uniform magnetic induction

l = length of the conductor

v = velocity of conductor (at right angles to the uniform magnetic induction $\vec{B}$)

4. e.m.f. induced in a metal rod rotating in a perpendicular magnetic field:

= B � π□$r^2 f$ = BAf

where B = magnetic induction

r = length of the rod

f = frequency of rotation of the rod.

5. Self induction:

(i) The flux linked with a coil is given by ϕ = LI

where L = self inductance of coil

I = current flowing through the coil

(ii) e.m.f. (self induced) = $-L\frac{dI}{dt}$

where L = self inductance of coil

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

6. Mutual induction:

The magnetic flux linked with the secondary (ϕ_s) is given by $\phi_s = MI_p$

where M = mutual inductance

I_p = Current flowing in the primary coil.

e.m.f. induced in secondary = $-M\frac{dI_p}{dt}$

7. Earth coil:

(i) The angle of dip (δ):

$\tan\delta = B_v/B_H$

where B_v = Vertical component of earth's magnetic field

B_H = horizontal component of earth's magnetic field

(ii) $q = k\,\theta$

where q = charge passing through the ballistic galvanometer

θ = throw of the galvanometer

k = constant of the galvanometer

(iii) $k\theta = \frac{\phi_1 - \phi_2}{R}$

where θ = throw of the galvanometer

$\phi_1 - \phi_2$ = change in flux through the earth coil

R = Total resistance of the circuit.

(iv) Determination of B_H and B_v :

$B_H = \left(\frac{KR}{2NA}\right)\theta_1$ $\qquad$ $B_v = \left(\frac{KR}{2NA}\right)\theta_2$

Where B_H = horizontal component of earth's magnetic field

B_v = vertical component of earth's magnetic field
K = constant of the galvanometer
R = resistance of the circuit
N = number of turns of the coil
A = area of cross-section of the coil
θ_1 and θ_2 – deflection in the galvanometer

(v) If the coil is quickly rotated from α_1 to α_2 , the induced charge is given by

$$q = \frac{BnA\,(\cos\alpha_1 - \cos\alpha_2)}{R}$$

where R = total resistance of the circuit containing coil.

a) If the coil is rotated through an angle 90�

$$q = \frac{BnA}{R}$$

b) If the coil is rotator rotated through an angle 180�

$$q = \frac{2BnA}{R}$$

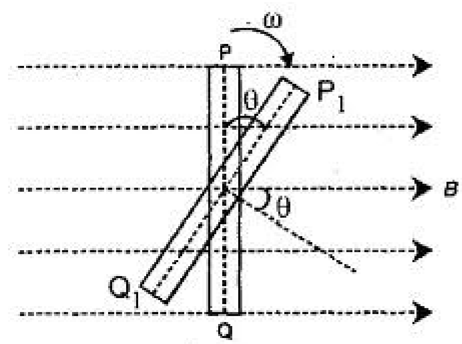


Fig. 17.7 : A coil rotating in a uniform magnetic field.

8. Coil rotating in uniform magnetic induction .

i. The flux passing through, the coil is ϕ = nAB cosωt
ii. E.m.f. induced in the coil e = e_0 sinωt
Where e_0 = BnAω = peak emf
iii. Current flowing through the coil i = i_0 sin ωt

where $i_0 = \frac{e_0}{R}$ peak value of current.

iv.

ω = angular velocity of coil
n = number of turns of coil
A = area of cross-section of coil
B = magnetic induction

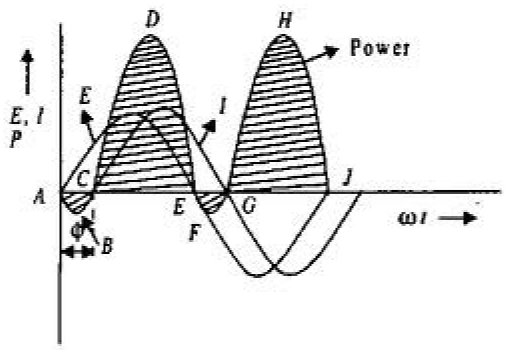


Fig. 17.37

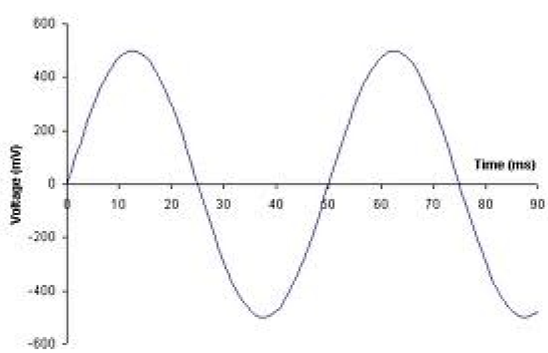
9. rms value of alternating current / e.m.f.

$$i_{rms} = \frac{i_0}{\ } = 0.707\ i_0$$

where i_{rms} = root mean square (rms) value of current
i_0 = peak value of current.

$$e_{rms} = \frac{e_0}{\ } = 0.707\ e_0$$

where e_{rms} = root mean square (rms) value of e.m.f
e_0 = peak value of current.



10. In case of a purely resistive circuit to which an a.c. voltage is applied,

average power P = e_{rms} � i_{rms} $= \frac{e_0}{\ } \rbrace \frac{i_0}{\ }$

$$= \frac{e_0 \square i_0}{2}$$

11. Inductive reactance

$$X_L = \omega L = 2\pi f L$$

where f = frequency of the applied a.c. voltage

L = inductance.

12. Capacitive reactance

$$X_C = \frac{1}{\omega c} = \frac{1}{2\pi f c}$$

where C = Capacitance

f = frequency of the applied a.c. voltage

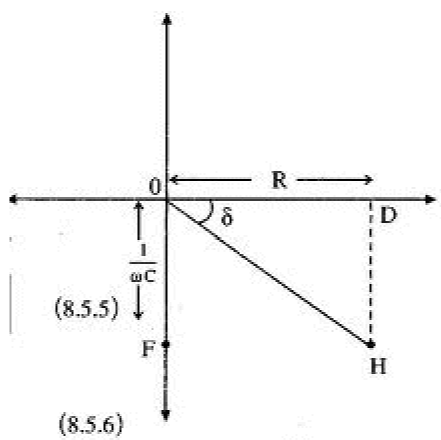


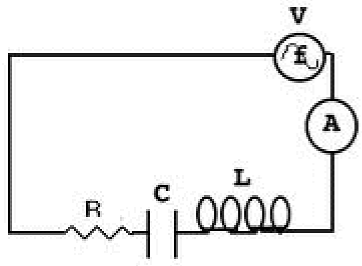
Fig. 8.13

13. Impedance (Z) when L and R are connected in series:

When an inductance L and a resistance R are connected in series, the impedance Z is given by Z =

14. Impedance (Z) when C and R are connected in series:

When a capacitor of capacitance C and a resistance R are connected in series, the impedance Z is given by Z =



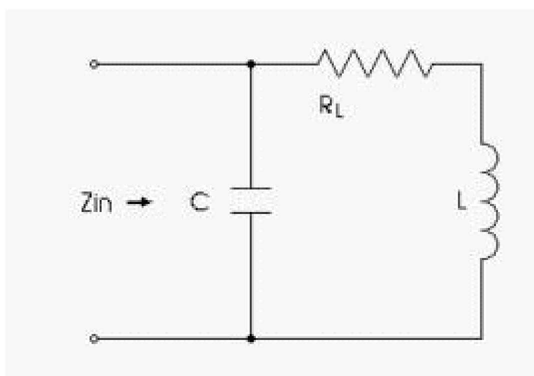
15. In a L-C-R series circuit

$\tan\phi = \frac{X_L - X_c}{R}$ where ϕ = the angle by which e.m.f. leads the current.

Z = where Z = impedance of the circuit resonant frequency $f = \frac{1}{2\pi}$

where L = inductance

C = capacitance



16. Parallel resonant circuit

The resonant frequency $f_r = \frac{1}{2\pi}$

where L = inductance

C = capacitance

Chapter 7

Elecrtostatics

1. Gauss's Theorem:

The total normal electric induction (TNEI) over a closed surface is equal to the algebraic sum of the electric charges enclosed by the surface.

T.N.E.I. $=\Sigma Q_1$

T.N.E.I. $= K\, \varepsilon_0$

Normal component of $\vec{E}$ × surface area

K = dielectrict constant of the medium

ε_0 = Permitivitty of free space

2. Electric intensity at a point due to a charged sphere:

$$E = \frac{q}{4\pi k\, \varepsilon_0\, r^2}$$

Or

$$E = \frac{\sigma R^2}{k\, \varepsilon_0\, r^2} \qquad = \frac{\sigma}{k\varepsilon_0}\left(\frac{R}{r}\right)^2$$

where q : Total charge on the sphere

R : radius of the spherical conductor

r : distance of the point from the centre of the sphere

σ : surface density of charge or the sphere

k : dielectric constant of the medium surrounding the sphere.

Remember:

E =0 inside the charged sphere.

$E = \frac{\sigma}{k\varepsilon_0}$ When point is very close to charged sphere

3. Electric intensity at a point just outside a long cylinder:

$$E = \frac{q}{2\pi k\, \varepsilon_0\, r}$$

Or

$$E = \frac{\sigma R}{k\, \varepsilon_0\, r}$$

where,

q : charge per unit length of cylindrical conductor

R : radius of cross-section of cylindrical conductor

r : distance of point from axis of cylinder

σ : surface density of charge on cylinder

k : dielectric constant of the medium surrounding the cylinder.

4. Electric intensity at a point just outside a closed charged conductor:

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

where σ : surface density of charge on the conductor.

5. Mechanical force per unit surface area of a charged conductor:

$$\frac{F}{ds} = \frac{\sigma^2}{2\varepsilon} = \frac{\sigma^2}{2k\varepsilon_0} = \frac{1}{2}k\varepsilon_0 E^2$$

where E = magnitude of electric intensity at a point just outside the element.
k = dielectric constant of the medium surrounding the conductor.
σ = surface density of charge on the conductor.

6. Energy density of a medium:

Energy per unit volume or Energy density of a medium in which electric field is present

$$dw = \frac{1}{2}\varepsilon_0 k E^2 = \frac{1}{2}\frac{\sigma^2}{k\varepsilon_0}$$

where,
k : dielectric constant of the medium
E : magnitude of electric intensity in the region
σ = surface density of charge

7. Capacity of a conductor:

The capacity of a conductor is defined as the ratio of the charge on the conductorto the potential of the conductor

$$\text{Capacity (C)} = \frac{\text{Charge(Q)}}{\text{Potential(V)}} \qquad C = \frac{Q}{V}$$

$\therefore Q = CV$

$$1 \text{ farad} = \frac{1 \text{ Coulomb}}{1 \text{ Volt}}$$

1 micro farad (μF) = 10^{-6} farad (F)
1 Pico farad (pF) = 10^{-12} farad (F)

8. Capacity of a parallel plate condenser:

Capacity of a parallel plate condenser with a medium of dielectric constant k,

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

$$C_{air} = \frac{A\varepsilon_0}{d}$$

where A : area of each plate

d : distance between the plates,

$C = k\, C_{air}$

9. Energy stored in a charged condenser:

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

$$= \frac{1}{2} CV^2$$

$$= \frac{1}{2} QV$$

where Q : magnitude of charge on each plate
C : capacity of the condenser
V : potential difference between the plates.

10. Equivalent capacity of number of condensers connected in series:

The equivalent capacity of a number of condensers (having capacities C_1, C_2, �,C_n) connected in series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n} \text{ or } \frac{1}{C} = \sum_{i=1}^{n} \frac{1}{C_i}$$

11. Equivalent capacity of number of condensers connected in Parallel:

The equivalent capacity of a number of condensers (having capacities C_1, C_2, �,C_n) connected in parallel

$$C = C_1 + C_2 + \text{�} + C_n \text{ or } C = \sum_{i=1}^{n} C_i$$

Chapter 8

Gravitation

1. Newton's Law of Gravitation

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

Where F – gravitational force of attraction
m_1, m_2 – masses of the bodies
r – distance between bodies
G – gravitational constant

2. Acceleration Due to Gravity

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

Where, g – acceleration due to gravity at the surface
M – mass of the earth
R – radius of the earth

b) $g' = \frac{GM}{(R + h)^2}$

Where, g' – acceleration due to gravity at a height h above the surface of the earth

c) $g' = g\left[\frac{R}{(R + h)}\right]^2$

3. Critical Velocity

a) $V_c = \sqrt{\frac{GM}{R + h}}$

b) $V_c = \sqrt{g'(R + h)}$

c) $V_c = \sqrt{\frac{gR^2}{(R + h)}}$

d) $V_c = 2R\sqrt{\frac{G\pi \rho R}{3(R + h)}}$

Where, ρ – mean density of the earth.

4. Time Period

a) $T = \frac{2\pi}{\sqrt{GM}}(R + h)^{3/2}$

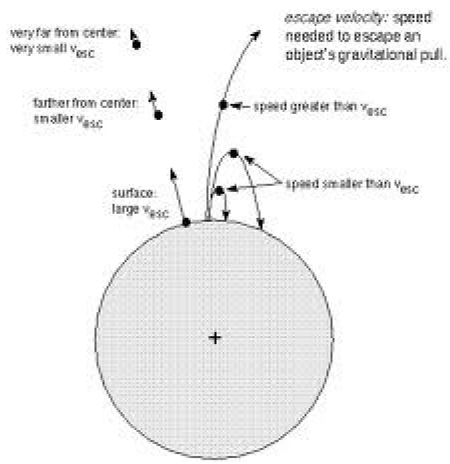
b) $T^2 \alpha r^3$

Where, r – radius of the orbit of the satellite.

5. Binding Energy

a) $\text{B.E.} = \frac{GM\boldsymbol{m}}{R}$ When body is at rest on the surface of the earth.

b) $\text{B.E.} = \frac{GM\boldsymbol{m}}{2(R + \boldsymbol{h})}$ Binding energy of the satellite.



6. Escape Velocity

a) $V_e =$ Escape velocity of a body from the surface of the earth.

$V_e =$

$V_e =$
$2R$

$\mathbf{V_e} =$ V_c Where, V_c is the critical velocity when body is orbiting very close to the surface of the earth.

b) $V_e =$ Escape velocity when body is orbiting round the earth at height '$\boldsymbol{h}$' above the surface of the earth.

7. Total Energy

When body is orbiting around the earth at height '$\boldsymbol{h}$' above the surface of the earth

T.E. = – K.E.
P.E. = – 2 K.E.

where,

$$\text{K.E.} = \frac{1}{2}\boldsymbol{m}V_c^2 = \frac{GM\boldsymbol{m}}{2(R + \boldsymbol{h})}$$

8. Mass of the Earth

$\frac{M}{\ }$ = density (ρ)

V

M = V ρ

Mass of the earth $M = \frac{4}{3}\pi R^3 \rho$

9. Period of Geostationary Satellite

Period of geostationary satellite	= 24 hours
	= 86,400 sec.

Chapter 9

Interference of light

1. Conditions for constructive and destructive interference

i. **Condition for brightness**:
Path difference $= n\lambda$, $\lambda =$ wavelength of light ($n = 0, 1, 2, 3,$ �)
Distance of n[th] bright band from central bright fringe (CBF)

$$x_n = 2n\left(\frac{\lambda}{2}\right)\frac{D}{d} = n\frac{\lambda D}{d}$$

ii.

iii. **Condition for darkness** :

Path difference $= (2n - 1)\ ,\ \frac{\lambda}{2}$, λ = wavelength of light, $n = 1, 2, 3,$ �

iv. Distance of n[th] dark band from central bright fringe (CBF)

$$x_n = (2n-1)\frac{\lambda D}{2d}$$

v.

vi. **Band width** :
Distance between two consecutive bright bands = Distance between two consecutive dark bands
Band width $X = \frac{\lambda D}{d}$,

vii. λ□: wavelength of light
D : Distance between screen and source
d : distance between sources

2.Wavelength of light from biprism experiment

$$\lambda = \frac{Xd}{D}$$

$$= \frac{X\sqrt{d_1 d_2}}{D}$$

X : band width
d : distance between coherent sources
D : Distance between sources and screen
d_1: distance between magnified images

d_2: distance between diminished images

$$d_1 = \frac{vd}{u}$$

$$d_2 = \frac{ud}{v}$$

$u + v = D$

u : Distance between slit and lens
v: Distance between lens and eyepiece

Chapter 10

Kinetic Theory of Gases

1. Pressure Exerted by an Enclosed Gas

$$p = \frac{1}{3}\frac{Nm_0C^2}{V} = \frac{1}{3}\frac{mC^2}{V} = \frac{1}{3}\rho C^2$$

m_0 = mass of gas molecule
m = mass of gas
C = rms velocity of gas molecules
ρ = Density of gas
N = Total number. of gas molecules

2. K.E. Per Unit Volume of a Gas

K.E. per unit volume of a gas = $\frac{3}{2}P$

3. K.E. Per Mole of a Gas

K.E. per mole of a gas = $\frac{3}{2}RT = \frac{1}{2}MC^2$

M = molecular weight

4. K.E. Per Molecule of a Gas

K.E. per molecule of a gas = $\frac{3}{2}\frac{RT}{N_0} = \frac{3}{2}kT = \frac{1}{2}m_0C^2$

N_0 = Avogadro's no.,
$\frac{R}{N_0}$ = k = Boltzmann constant

5. K.E. Per Unit Mass of a Gas

K.E. per unit mass of a gas = $\frac{3}{2}\frac{RT}{M} = \frac{1}{2}C^2$

6. Relation Between K.E. And Temperature

K.E. of a gas molecule is proportional to its absolute temperature (K.E. $\propto$ T)

7. R.M.S. Velocity

a)

RMS velocity C = $\sqrt{\frac{C_1^2 + C_2^2 + \ldots + C_N^2}{N}} = \sqrt{\overline{C^2}}$

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

c) $C = \sqrt{\frac{3RT}{M}}$ R: Universal Gas constant, M: Molecular weight of gas molecule

d) $C \propto \sqrt{T}$

e) $\frac{C}{C_0} = \sqrt{\frac{T}{T_0}}$

f) $C = C_0\sqrt{\frac{T}{T_0}}$

C_0 = R.M.S. speed at 0°C,

C = R.M.S. speed at t°C,

P = pressure,
ρ = density of the gas ,
R = Gas constant,
M = Molecular weight of gas molecule.

8. Ideal Gas Equation

GAS (A) : $P_1V_1 = n_1RT_1$

$$P_1V_1 = \frac{m_1}{M_1}RT_1$$

GAS (B) : $P_2V_2 = n_2RT_2$

$$P_2V_2 = \frac{m_2}{M_2}RT_2$$

$$\therefore \frac{P_1V_1}{P_2V_2} = \frac{m_1}{m_2} \times \frac{M_2}{M_1} \frac{T_1}{T_2}$$

9. Relation Between Pressure and Number of Molecules of the Gas

$P \propto N$

$$\therefore \frac{P_1}{P_2} = \frac{N_1}{N_2}$$

10. First Law of Thermodynamics

dQ = dU + dW (all are in same units)
dQ = total heat energy supplied
dU = increase in internal energy
dW = external work done

11. Mayer's Relation

Mayer's relation (in heat units)

$C'_p - C'_v = R/J$
(Molar sp. heats)

$$C_p - C_v = \frac{r}{J} = \frac{R}{MJ}$$

(Principal sp. heats)

$$C_p - C_v = \frac{P}{\;}$$

ρ□JT
(Principal sp. heats)

12. Change in Internal Energy

$dU = mC_v\,dT$ (joule)

$= \frac{mC_v\,dT}{J}$ (Cal or kcal)

C_v is principal sp. heat at constant volume $\left[\frac{\text{joule}}{\text{kg �K}}\right]$

13. External Work Done

$dU = n\,C'v\,dT$ (joule)

$= n\frac{C'v\,dT}{J}$ (cal or kcal)

C'v is molar sp. heat at constant volume $\left[\frac{\text{joule}}{\text{k – mole K}}\right]$

Work done dW= PdV (joule)

$= \frac{PdV}{J}$ (Cal or kcal)

14. Latent Heat

L = Li + Le
Li = Internal latent heat
Le = External latent heat
Le = PdV (joule)
$= \frac{PdV}{J}$

15. Relation Between Molar Specific Heat and Principal Specific Heat

Molar specific heat = Molecular weight � Principal specific heat

16. Relation Between Mass of the Gas And Molecular Weight

$\frac{m}{M} = n \quad \frac{m}{M} = 1$ (For n = 1)

$\therefore m = M$
Mass of the gas = Molecular weight

Chapter 11

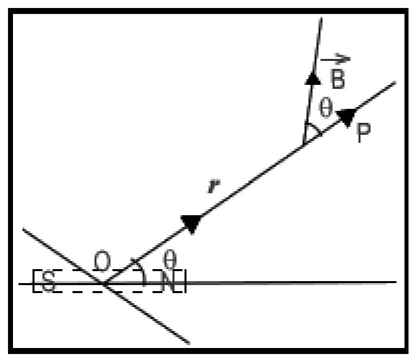
Magnetism

1.

Magnetic moment of a magnetic dipole: M = $\boldsymbol{m}$ � 2 $\boldsymbol{l}$
where $\boldsymbol{m}$ = pole strength of the dipole.
2$\boldsymbol{l}$ = magnetic length of the dipole.
Direction of $\vec{M}$ is from south pole to north pole.

2.

Magnetic induction ($\vec{B}$) at a point P at a distance of 'r' from centre of a short magnetic dipole:



$$B = \frac{\mu_0}{4\pi} \frac{M}{r^3} \sqrt{3\cos^2\theta + 1}$$ (in magnitude)

Where
μ_0 = permeability of free space
M = Magnetic dipole moment of the dipole
θ = angle between the line joining point P and the centre of the dipole and axis of the dipole.

Direction of $\vec{B}$ at P is given by,

$$\tan\phi = \frac{1}{2}\tan\theta$$

The angle made by $\vec{B}$ with axis of the dipole = $\phi + \theta$

Case I: If P is a point on the axis of the dipole, θ = 0� or θ = 180�

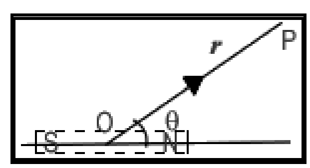
$\therefore B_{axis} = \frac{\mu_0}{4\pi} \frac{2M}{r^3}$; direction along the axis, parallel to $\vec{M}$

Case II: If P is a point on the equator of the dipole, θ = 90�

$\therefore B_{equator} = \frac{\mu_0}{4\pi} \frac{2M}{r^3}$; direction parallel to the axis and opposite to $\vec{M}$.

3.

Magnetic potential (V) at a point P at a distance r from the centre of a short
magnetic dipole is given by,



$$V = \frac{\mu_0}{4\pi} \frac{M\cos\theta}{r^2}$$

Where
μ_0 = permeability of free space

M = Magnetic dipole moment
θ = angle between the line passing through P and the centre of the dipole (O) and the axis of the dipole.

Case I: If P is a point on axis,

$\theta = 0$� or $\theta = 180$�

$V_{axis} = \frac{\mu_0}{4\pi} \frac{M}{\boldsymbol{r}^2}$ (for $\theta = 0$�)

Or

$V_{axis} = -\frac{\mu_0}{4\pi} \frac{M}{\boldsymbol{r}^2}$ (for $\theta = 180$�)

Case II: If P is a point on equator,

$\theta = 90$�

$\therefore V_{equator} = 0$

Chapter 12

Properties Of Fluids

1. Surface Energy

Surface energy = Surface tension × surface area

2. Rise of Liquid in a Capillary

$h = \dfrac{2\,T\cos\theta}{r\,\rho\,g}$, where T is the surface tension of the liquid, θ is the angle of contact, r is the radius of the capillary bore and ρ the density of the liquid.

3. Free Surface Energy

For a drop, $E = 4\pi r^2 T$

For a bubble, $E = 2 \times 4\pi r^2 T$, since a bubble has two free surfaces.

4. Capillary Rise

Difference in heights in the two limbs of a U tube capillary, which is vertical, is

a. given by, $h = \dfrac{2\,T\cos\theta}{\rho\,g}\left[\dfrac{1}{r_1} - \dfrac{1}{r_2}\right]$, where r_1 and r_2 are the radii of the two limbs of the capillary.

b. For two different capillaries: (same liquid)
$h_1 r_1 = h_2 r_2$

5. Total Surface Area of a Soap Bubble

Total surface area of a soap bubble = 2 × surface area

6. Angle of Contact for Water and Glass

For water, angle of contact = $\theta = 0°$ ∴ $\cos\theta = 1$

$\rho = 1$ gm/cc : $T = \dfrac{hrg}{2}$

7. Work Done in Breaking a Liquid Drop

If a liquid drop breaks into number of spherical droplets,
Work done = T × increase in surface area

8. Energy Released During Formation of a Liquid Drop

If liquid drops coalesce to form a single drop,
Decrease in surface energy = T × decrease in surface area

9. Work Done in Increasing the Radius of a Soap Bubble

Work done in increasing the radius of a soap bubble
$= T \times 2 \times$ increase in surface area

Chapter 13

Radiation

1. $a + r + t = 1$

where a = coefficient of absorption
r = coefficient of reflection
t = coefficient of transmission

2. Stefan's Law of Radiation

$Q = \sigma A t T^4$ for a black body
$Q' = e \sigma A t T^4$ for any other body

where, Q = amount of heat radiated
A = area of surface of the body
T = Temperature in K
σ = Stefan's constant
t = time
e = emissivity of the body

3. When a Body is Kept Inside a Constant Temperature Enclosure

$$R = \frac{dQ}{dt} = e \sigma A (T^4 - T_0^4)$$

where, $\frac{dQ}{dt}$ = rate of loss of heat
T_0 = temperature of enclosure in K

4. For Any Body

$$R = \frac{dQ}{dt} \propto T^4 \text{ or } R = \frac{dQ}{dt} \propto (T^4 - T_0^4)$$

$$\therefore □ \frac{R_1}{R_2} = \frac{T_1^4}{T_2^4} \text{ or } \frac{R_1}{R_2} = \frac{T_1^4 - T_0^4}{T_2^4 - T_0^4}$$

5. Newton's Law of Cooling

$$\frac{dQ}{dt} \propto (\theta - \theta_0)$$

$$\frac{dQ}{dt} = ms \frac{d\theta}{dt}$$

$$□ \frac{dQ}{dt} = \frac{K}{ms}(\theta - \theta_0) \propto \frac{d\theta}{dt} \propto (\theta - \theta_0)$$

6. $\theta_1 \xrightarrow{\text{time } t_1} □\theta_2 \xrightarrow{\text{time } t_2} □\theta_3$ $(\theta_1 > \theta_2 > \theta_3)$

$$\therefore \frac{d\theta}{dt} = K(\theta - \theta_0)$$

$$\frac{\theta_1 - \theta_2}{t_1} = K \left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$

$$\frac{\theta_2 - \theta_3}{t_2} = K \left[\frac{\theta_2 + \theta_3}{2} - \theta_0\right]$$

Chapter 14

Rotational Motion

1. Coordinates of the centre of mass

$$x = \frac{\sum_{i=1}^{n} m_i x_i}{\sum_{i=1}^{n} m_i}$$

where x_i y_i and z_i are the x y and z co–ordinates respectively, of the ith particle and m$_i$ is its mass.

$$y = \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i}$$ O

$$z = \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}$$

2. Position Vector of the Centre of Mass

$$\overline{R} = \frac{\sum_{i=1}^{n} m_i \vec{r}_i}{M}$$

where $\vec{r}$ is the position vector of the ith particle and M is the mass of the body.

3. Position Vector for a Rigid Body

$$\overline{R} = \frac{1}{M} \int \vec{r}\, dm$$

where $\vec{r}$ is the position vector of an element of mass dm.

4.

Moment of inertia, $I = \sum_{i=1}^{n} m_i r_i^2$.

5.

Radius of gyration (K) is given by the relation $I = MK^2$

$\therefore K = \sqrt{\frac{I}{M}}$ where I is the moment of inertia and M is the mass of the body.

6.

Kinetic energy of a rotating body, $E = \frac{1}{2} I\omega^2$ where I is the moment of inertia and w is the angular velocity of the rotating body.

7.

Torque acting on a rotating body, $T = I\alpha$ where α is the angular acceleration of the body.

8.

Principle of parallel axes states that, $I_0 = I_c + Mh^2$ where I_0 is the M.I. about an axis through 0, I_c is the M.I. about an axis through the centre of mass, M is the mass of the body and h is the distance between the two parallel axes.

9.

Principle of perpendicular axes states that $I_z = I_x + I_y$ where I_x, I_y and I_z are the moments of inertia about the X, Y and Z axes of a plane lamina such that X and Y axes lie in the plane of the lamina, and Z axis is perpendicular to the plane.

10.

M.I. of a thin uniform rod rotating about a perpendicular axis through its middle

$I = \frac{Ml^2}{12}$, $K = \frac{l}{\sqrt{12}}$

11.

M.I. of a thin uniform rod rotating about a perpendicular axis through one end

$I = \frac{Ml^2}{3}$, $K = \frac{l}{\sqrt{3}}$

12.

M.I. of a thin uniform disc rotating about an axis passing through its centre and perpendicular to its plane,

$I = \frac{MR^2}{2}$, $K = \frac{R}{}$

$\sqrt{2}$

(Note: This formula can also be applied to a cylinder or coin)

13.

M.I. of a thin uniform disc rotating about a diameter,

$I = \frac{MR^2}{4}$, $K = \frac{R}{2}$

14

Angular momentum $L = I\omega$ where I is the moment of inertia and ω is the angular velocity.

15

Equations of rotational motion of a body are

a) $\omega_t = \omega_0 + \alpha t$

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

c) $\omega_t^2 = \omega^2_0 + 2\alpha\theta$

where θ is the angular displacement, ω_0 and ω_t are the angular velocities at t= 0 and t =t, respectively, and α is the angular acceleration

16

Moment of inertia of a ring = MR^2 R → radius of ring

17

M.I. of a hollow sphere = $\frac{2}{3}MR^2$

18

M.I. of a solid sphere = $\frac{2}{5}MR^2$

19

Total K.E. of a rolling body = $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

For a disc: total K.E. = $\frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$

For a ring: total K.E. = $\frac{1}{2}mv^2 + \frac{1}{2}mv^2 = mv^2$

For a sphere: total K.E.= $\frac{1}{2}mv^2 + \frac{2}{10}mv^2 = \frac{7}{10}mv^2$

Chapter 15

Simple Harmonic Motion

1.
Equation of S.H.M., F = $-kx$ where F is the restoring force, k is the force constant and x is the displacement.

2.
Differential equation of S.H.M., $\frac{d^2x}{dt^2} + \frac{k}{m}x = 0$
Where m is the mass of the particle and k is the force constant.

3.
Angular frequency, $\omega = \sqrt{\frac{k}{m}} = \frac{2\pi}{T} = 2\pi n$, where n is the frequency.

4.
Time period, $T = 2\pi\sqrt{\frac{m}{k}}$

5.
Displacement in SHM, $x = A \sin(\omega t + \alpha)$

6.
Phase angle, is $(\omega t + \alpha)$

7.
Initial phase is α (also called epoch)
i) $\alpha = 0$ for a particle starting from the mean position.
ii) $\alpha = \frac{\pi^c}{2}$ for a particle starting from the extreme position.

8.
Velocity of a particle performing linear S.H.M. = v = �$\omega\sqrt{A^2 - x^2} = A\omega \cos(\omega t + \alpha)$

9.
Maximum velocity = $v_{max} = A\omega$ when $x = 0$

10.
Acceleration, $a = -\omega^2 x = -A\omega^2 \sin(\omega t + \alpha)$

11.
Maximum acceleration = $\omega^2 A$ when $x = A$

12.

P.E. of a particle performing S.H.M.,

P.E. $\frac{1}{2} = m\omega^2 x^2 = \frac{1}{2} k x^2$

13.

K.E. of a particle performing S.H.M., K.E. = $\frac{1}{2} m\omega^2 (A^2 - x^2) = \frac{1}{2} k (A^2 - x^2)$

14.

Total energy of a particle in S.H.M,

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

15.

Composition of two SHMs,

$x_1 = A \sin(\omega t + \alpha)$ and $x_2 = B \sin(\omega t + \beta)$

Resultant motion, $x = C \sin(\omega t + \delta)$

where $C = \sqrt{A^2 + B^2 + 2AB \cos(\alpha - \beta)}$

And $\delta = \tan^{-1}\left[\frac{A \sin \alpha + B \sin \beta}{A \cos \alpha + B \cos \beta}\right]$

16.

Period of simple pendulum,

$T = 2\pi \sqrt{\frac{l}{g}}$ l is the length of the pendulum.

17.

For a seconds pendulum, T = 2 seconds

$l = \frac{g}{\pi^2}$

18.

For a magnetic dipole in a uniform magnetic field, B

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

where I is the moment of inertia and M is the magnetic dipole moment.

19.

Differential equation of a body in angular S.H.M.,

$\frac{d^2x}{dt^2} + \frac{k}{I} \theta = 0.$

Chapter 16

Stationary Waves

1. Equation of a wave of wavelength λ, amplitude A and time period T, along x-direction

$$y = A \sin 2\pi \left(\frac{t}{T} \} \frac{x}{\lambda} \right)$$

2. Equation of a stationary wave formed due to the interference of two progressive waves having same amplitude (A), wavelength (λ) and speed but travelling in opposite directions.

$$y = 2A \sin \frac{2\pi t}{T} \cos \left(\frac{2\pi x}{\lambda} \right) \quad \left[\begin{array}{l} y_1 = A \sin \left(\frac{2\pi t}{T} + \frac{2\pi x}{\lambda} \right) \\ y_2 = A \sin \left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} \right) \\ y = y_1 + y_2 \end{array} \right]$$

3. Amplitude of Stationary Waves (Resultant Wave)

$$R = 2A \cos \left(\frac{2\pi x}{\lambda} \right)$$

where, A: amplitude of the progressive waves
λ: wavelength of the progressive waves.

4. Distance between Two Successive Nodes

Distance between any two successive nodes (of stationary waves)
= Distance between any two successive antinodes

$$= \frac{\lambda}{2}$$

5. Distance between a Node and its Adjacent Antinode

Distance between a node and an adjacent antinode $= \frac{\lambda}{4}$

6. Velocity of Transverse Waves in a Vibrating String

$$V = \sqrt{\frac{T}{m}}$$

where, T: tension applied to the wire
m: mass per unit length (linear density) of the wire

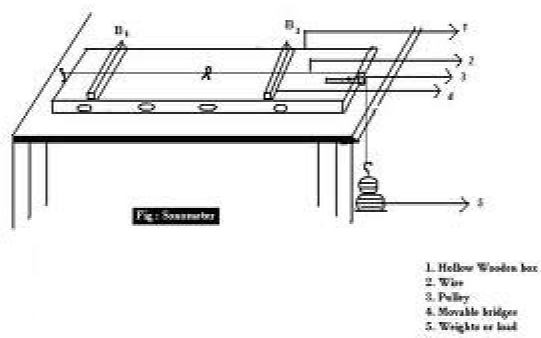
7. Fundamental Frequency of the Vibrating String

$$N = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

where, l: vibrating length

m: mass per unit length of the string

T: tension applied to the string



8. Laws of Vibrating String

Law of length: $n \propto \frac{1}{l}$, if T and m are constant

Law of tension: $n \propto$, if l and m are constant

Law of length: $n \propto \frac{1}{}$, if l and T are constant

where n: fundamental frequency of vibration

l: vibrating length of the string

m: mass per unit length of the string

T: tension applied to the string

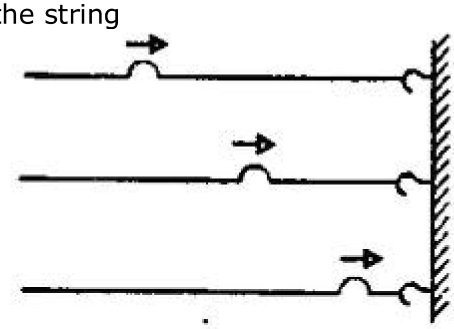


Fig. 29.3. Waves in strings

9. General Expression for the Frequency of Vibration of a Stretched Wire

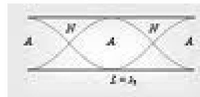
$$n = \frac{p}{2l}$$

where p: number of loops produced along the wire

l: vibrating length of the wire

m: mass per unit length of the wire

T: tension applied to the string



Fundamental frequency or first harmonic $\boldsymbol{n}_1 = \frac{1}{2\boldsymbol{l}}$

($\boldsymbol{p}$ = 1)

Second harmonic or first overtone $\boldsymbol{n}_2 = \frac{1}{2\boldsymbol{l}}$ $= 2\boldsymbol{n}$

($\boldsymbol{p}$ = 2)

10. Fundamental Frequency of Vibrations of an Air Column in a Tube Closed at One End

$\boldsymbol{n}_1 = \frac{V}{4\boldsymbol{l}}$, V = velocity of sound in air

$\boldsymbol{l}$ = length of the air column

for first overtone or third harmonic $\boldsymbol{n}_2 = \frac{3V}{4\boldsymbol{l}} = 3\boldsymbol{n}_1$

(only odd harmonics are present)

11. Fundamental Frequency of Vibrations of an Air Column in a Tube Open at Both Ends

$\boldsymbol{n}_1 = \frac{V}{2\boldsymbol{l}}$, V = velocity of sound in air

$\boldsymbol{l}$ = length of the air column

Second mode of vibration = second harmonic

= first overtone $\boldsymbol{n}_2 = \frac{V}{2\boldsymbol{l}} = 2\boldsymbol{n}_1$

Third mode of vibration = third harmonic

= second overtone $\boldsymbol{n}_3 = \frac{3V}{2\boldsymbol{l}} = 3\boldsymbol{n}_1$

(All harmonics are present)

12. End Correction

End correction for vibrating air column in resonance tube experiment $\boldsymbol{e}$ = 0.3 d
where d: inner diameter of the tube

i. Velocity of sound V = $4\boldsymbol{n}$ ($\boldsymbol{l}$ + 0.3 d)
   where $\boldsymbol{l}$: length of air column
   $\boldsymbol{n}$: frequency of tuning fork
ii. Velocity of sound (eliminating end correction) V = $2\boldsymbol{n}$ ($\boldsymbol{l}_1$ - $\boldsymbol{l}$)
   where $\boldsymbol{n}$: frequency of tuning fork

l: length of air column at 1st resonance

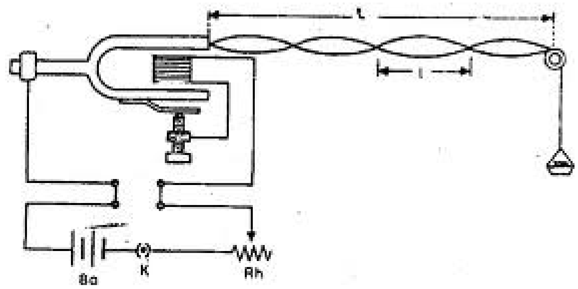
l_1: length of air column at 2nd resonance

iii.

13. End Correction to Vibrating Air Column Length in Case of a Pipe Closed at One End

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

where l_1, l_2 are the vibrating lengths of the pipe resonating with tuning forks of frequencies n_1 and n_2 respectively.



14. Melde's Experiment

For parallel position, frequency of vibrating string $n = \frac{P}{2l}$

Frequency tuning fork: N = $2n$

For a given N, TP^2 = constant (for fixed l and m)

For perpendicular position, frequency of tuning fork N = n

Chapter 17

Thermodynamics

1. Equation of state for a perfect gas

$PV = nRT$

P, V, T – Pressure, volume and temperature of the gas

R – Universal gas constant

n – Number of moles of the gas.

2. Work done in an isothermal process

$$W = 2.303\ nRT \log_{10}\left[\frac{V_2}{V_1}\right]$$

$$= 2.303\ nRT \log_{10}\left[\frac{P_1}{P_2}\right]$$

3. Equation of state for a real gas (one mole gas)

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

a, b are Van der Waals constant

4. Ist law of thermodynamics

$dQ = dU + dW$

dQ – Heat energy supplied

dU – change in internal energy

dW – Work done.

5. External work done

$dW = P\ dV$ joule

$= \frac{P\ dV}{J}$ cal or Kcal

J – Joule's mechanical equivalent of heat.

Chapter 18

Wave Motion

1.

$v = n\lambda = \frac{\lambda}{T}$ where v is the velocity, n is the frequency, T is period of a wave, λ is the wave length of the wave.

2.

Equation of a simple harmonic progressive wave travelling in the **positive direction** of the x–axis,

y = A sin $2\pi(\frac{t}{T} - \frac{x}{\lambda})$ = A sin $\frac{2\pi}{\lambda}(Vt - x)$

3.

For a simple harmonic wave travelling in the **negative direction** of the x-axis,

(the equation is y = A sin $2\pi(\frac{t}{T} + \frac{x}{\lambda})$ = A sin $\frac{2\pi}{\lambda}(Vt + x)$

4.

If two sources of sound have frequencies n_1 and n_2, the number of beats per second is $|(n_1 - n_2)|$.

i.e. $n = |n_1 - n_2|$

5.

Phase difference between two particles which are separated by distance, $x = \frac{2\pi x}{\lambda}$

6.

Velocity of a wave $v = n\lambda$

Velocity of a particle at a distance 'x' from origin which executes SHM is given by $v_p = \frac{dy}{dt}$

or

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

7.

When one of the prongs of the tuning fork is filed, its frequency increases.

8.

When one of the prongs of the tuning fork is loaded, its frequency decreases.

9. Doppler Effect:

$n_a \frac{V}{V - S}$ when source is moving towards a stationary observer.

$n_a \frac{V}{V+S}$ when source is moving away from a stationary observer.

$n_a \frac{n(V+L)}{V}$ when listener is moving towards stationary source.

$n_a \frac{n(V-L)}{V}$ when listener is moving away from a stationary source.

n_a = apparent frequency
n = actual (or true) frequency
s = velocity of source
L = velocity of listener
V = velocity of sound.

Chapter 19

Wave Theory Of Light

1. Refractive Index

n_a = R.I. of medium 'a' w.r. to air or vacuum $= \frac{c}{v_a}$

where c = velocity of light in the air or vacuum and v_a = velocity of light in medium 'a'

2. Snell's Law

Refractive index $n = \frac{\sin i}{\sin r}$ (Snell's law).

where

i = angle of incidence

r = angle of refraction

3. Frequency of a Light Wave

frequency $\nu = \frac{c}{\lambda}$

where

c = velocity of wave (in air)

λ = wavelength

As the ray of light travels from a rarer medium to a denser medium,
its velocity decreases but frequency remains the same.
Frequency of the wave does not depend upon the medium, it depends upon the source.

4. Relation Between ${}_an_g$ and ${}_gn_a$

${}_an_g$ = R.I. of glass w.r. to air

${}_gn_a$ = R.I. of air w.r. to glass

$${}_an_g = \frac{1}{{}_gn_a}$$

5. Relation Between Refractive Index, Velocity and Wavelength of a Wave

${}_an_b = \frac{n_b}{n_a}$ n_b = R. I. medium 'b' w.r. to air or vacuum

n_a = R. I. medium 'a' w.r. to air or vacuum

$= \frac{v_a}{v_b}$ v_a = velocity of light in medium 'a'

v_b= velocity of light in medium 'b'

$= \frac{\lambda_a}{\lambda_b}$ λ_a = wave length of light in medium 'a'

λ_b = wave length of light in medium 'b'

6. Width of Wave Front

Cos i = Width of incident wave front

Cos ***r*** = Width of refracted wave front

where

i = angle of incidence

r = angle of refraction