NEET / JEE Main & Adv.

**AAJ KA TOPPER**

# PHYSICS

# QUICK REVISION

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# Quick Revision UNITS AND MEASUREMENTS

## TERMINOLOGY

$d\theta$ = Plane Angle

$ds$ = Arc Length

$r$ = Radius

$d\Omega$ = Solid Angle

$D$ = Distance between two planet

$b$ = Diameter Of Planet

$|\Delta a|$ = Absolute error

$\Delta a_{mean}$ = Mean absolute error

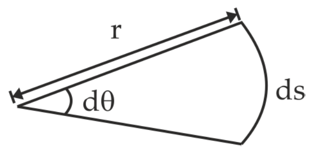
$Z$, $A$ & $B$ = Physical Quantities

## DEFINITIONS

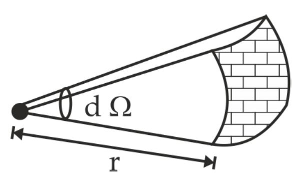
1) **System of Units :** A complete set of units both fundamental and derived for all kinds of physical quantities is called system of units.
2) **Unit :** The reference standard used for the measurement of a physical quantity is called a unit.
3) **Fundamental Quantities :** The physical quantities which do not depend on any other physical quantities for their measurements are known as fundamental quantities.
4) **Derived Quantities :** The physical quantities which depends on one or more fundamental quantities for their measurements are known as derived quantities.
5) **Parallax Method :** The method used to measure large distances are called Parallax Method.
6) **Dimensional Analysis :** The dimensions of a physical quantity are the powers to which fundamental units must be raised in order to obtain the unit of the given physical quantity.
7) **Order of Magnitude :** The value of its magnitude rounded off to the nearest integral power of 10.
8) **Significant Figures :** Figure which is of some significance but it does not necessarily denote a certainty.
9) **Error :** The difference between the true value and measured value of physical quantity is called error.
10) **Absolute error :** The magnitude of the difference between the individual measurement and the true value of the quantity is called absolute error.
11) **Mean absolute error :** The arithmetic mean of all the absolute errors is called mean absolute error.
12) **Relative error :** The ratio of mean absolute error in the measurement of a physical quantity to its most profable value is called relative error.
13) **Percentage error :** The relative error multiplied by 100 is called the percentage error.

## FORMULAE

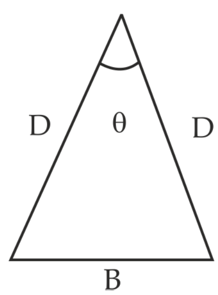
1) **Plane Angle :** $d\theta = \dfrac{ds}{r}$




2) **Solid Angle :** $d\Omega = \dfrac{dA}{r^2}$




3) **Parallax Method :** $D = \dfrac{d}{\theta}$



4) **Error Analysis :** $a_1, a_2, a_3, \ldots\ldots a_n$ values obtained in measurement.

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

$$|\Delta a_1| = a_1 - a_{\text{mean}}$$

$$|\Delta a_2| = a_2 - a_{\text{mean}}$$

$$|\Delta a_n| = a_n - a_{\text{mean}}$$

$$\Delta a_{\text{mean}} = \frac{|\Delta a_1| + |\Delta a_2| + \ldots\ldots + |\Delta a_n|}{n}$$

Relative error $= \dfrac{\Delta a_{\text{mean}}}{a_{\text{mean}}}$

Percentage error $= \dfrac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$

**Combination of Errors:**

1) Error of sum or difference

$Z = A + B$

$\Delta Z = \Delta A + \Delta B$

2) Error of product

$Z = AB$

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

3) Error of Division

$$Z = \frac{A}{B} \qquad \therefore \frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

4) Error in case of raised power

$$Z = \frac{A^p B^q}{C^r} \qquad \therefore \frac{\Delta Z}{Z} = p \cdot \frac{\Delta A}{A} + q \cdot \frac{\Delta B}{B} + r \cdot \frac{\Delta C}{C}$$

## DIMENSIONAL ANALYSIS

| Dimension | Quantity |
|---|---|
| $[M^0L^0T^{-1}]$ | Frequency, angular frequency, angular velocity, velocity gradient and decay constant |
| $[M^1L^2T^{-2}]$ | Work, internal energy, potential energy, kinetic energy, torque, moment of force |
| $[M^1L^{-1}T^{-2}]$ | Pressure, stress, Young's modulus, bulk modulus, modulus of rigidity, energy density |
| $[M^1L^1T^{-1}]$ | Momentum, impulse |
| $[M^0L^1T^{-2}]$ | Acceleration due to gravity, gravitational field intensity |
| $[M^1L^1T^{-2}]$ | Thrust, force, weight, energy gradient |
| $[M^1L^2T^{-1}]$ | Angular momentum and Planck's constant |
| $[M^1L^0T^{-2}]$ | Surface tension, Surface energy (energy per unit area) |
| $[M^0L^0T^0]$ | Strain, refractive index, relative density, angle, solid angle, distance gradient, relative permittivity (dielectric constant), relative permeability Poisson's ratio etc. |
| $[M^0L^2T^{-2}]$ | Latent heat and gravitational potential |
| $[ML^2T^{-2}\theta^{-1}]$ | Thermal capacity, Boltzmann's constant and entropy |
| $[M^0L^0T^1]$ | $\sqrt{l/g}, \sqrt{m/k}, \sqrt{R/g}$, where $l$ = length, $g$ = acceleration due to gravity, $m$ = mass, $k$ = spring constant, $R$ = Radius of earth |
| $[M^0L^0T^1]$ | $L/R, \sqrt{LC}, RC$ where $L$ = inductance, $R$ = resistance, $C$ = capacitance |
| $[ML^2T^{-2}]$ | $I^2Rt, \dfrac{V^2}{R}t, VIt, qV, LI^2, \dfrac{q^2}{C}, CV^2$ where $I$ = current, $t$ = time, $q$ = charge, $L$ = inductance, $C$ = capacitance, $R$ = resistance |

# Quick Revision — SCALARS AND VECTORS

## TERMINOLOGY

$\vec{A}$ & $\vec{B}$ : Are two vectors

$\theta$ : Angle between $\vec{A}$ and $\vec{B}$

$\vec{R}$ : Resultant of vectors.

$\alpha$ : Angle made by vector with $x$-axis

$\beta$ : Angle made by vector with $y$-axis

$\gamma$ : Angle made by vector with $y$-axis

$i$ : unit vector along $x$ axis

$j$ : unit vector along $y$ axis

$k$ : unit vector along $z$ axis

## DEFINITIONS

1) **Scalar Quantity :** A physical quantity which can be completely described by its magnitude only is known as scalar quantity.

2) **Vector Quantity :** A physical quantity which has magnitude and direction and obeys all the laws of vector algebra is called vector quantity.

3) **Parallel Vector :** Those vectors which have the same directions are called as parallel vectors.

4) **Equal Vector :** Vectors which have equal magnitude and same direction are called equal vectors.

5) **Anti-parallel Vectors :** Those vectors wich have the opposite directions are called as Anti-parallel vectors.

6) **Opposite Vectors :** Vectors have equal magnitude but opposite directions are called as opposite vectors.

7) **Unit Vectors :** Vectors whose magnitude is one is called a unit vector.

8) **Rectangular components of vector :** When a vector is splitted into components which are right angle to each other then the components are called rectangular components of vectors.

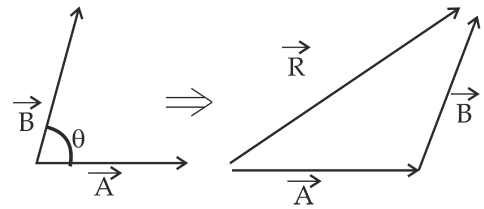
9) **Dot Product :** The dot product of two vectros can be defined as the product of their magnitudes with cosine angle between them.

10) **Cross Product :** the cross product of two vectors can be defined as the product of their magnitudes with sine angle between them.

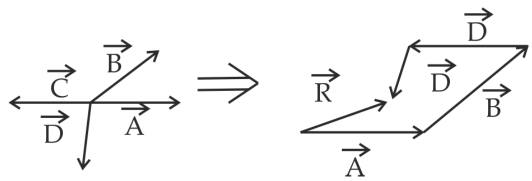
## FORMULAE

1) **Unit vectors :** $\hat{A} = \dfrac{\vec{A}}{A}$

2) **Law of Triangle :** $\vec{R} = \vec{A} + \vec{B}$

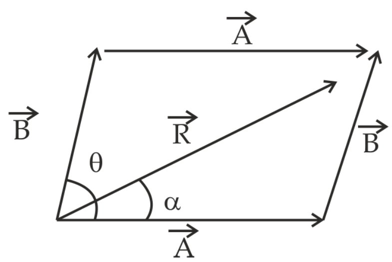



3) **Law of Polygon :** $\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$




4) **Law of Parallelogram :** $\vec{R} = \vec{A} + \vec{B}$

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$




$$\tan\alpha = \frac{A\sin\theta}{B + A\cos\theta}$$

*Cases*

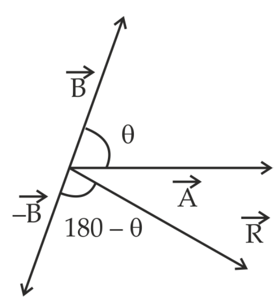
1) If $\theta = 0$, $R = A + B$

2) If $\theta = 90$, $R = \sqrt{A^2 + B^2}$

3) If $\theta = 180$, $R = A - B$

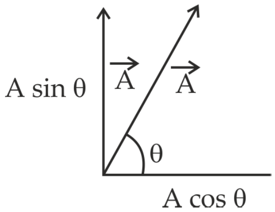
5) **Substraction of vectors :**

$$R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$



**6) Resolution of vectors**

a) Two dimensions




b) Three dimensions

$$\vec{A} = A_x i + A_y j + A_z k$$

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$$\cos\alpha = \frac{A_x}{A}$$

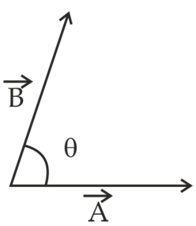
$$\cos\beta = \frac{A_y}{A}$$

$$\cos\gamma = \frac{A_z}{A}$$

$$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$$

$$\sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$$

**7) Dot Product :** $\vec{A}\cdot\vec{B} = AB\cos\theta$




***Key points***

1) If $Q = 0,\ \vec{A}\cdot\vec{B} = AB$

If $Q = 90,\ \vec{A}\cdot\vec{B} = 0$

If $Q = 180,\ \vec{A}\cdot\vec{B} = -AB$

2) Angle between two vectors

$$\cos\theta = \frac{\vec{A}\cdot\vec{B}}{AB}$$

3) It is commulative

$$\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$$

4) It is Distributive

$$\vec{A}\cdot(\vec{B}+\vec{C}) = \vec{A}\cdot\vec{B} + \vec{B}\cdot\vec{C}$$

5) It is associative

$$(\vec{A}+\vec{B}(\vec{C}+\vec{D}) = \vec{A}\cdot\vec{C} + \vec{A}\cdot\vec{D} + \vec{B}\cdot\vec{C} + \vec{B}\cdot\vec{D}$$

6) In case of orthogonal vectors

$$i\cdot j = j\cdot k = k\cdot i = 0$$

7) Scalar product of a vector by itself

$$\vec{A}\cdot\vec{A} = A^2$$

8) Incase of unit vector

$$i\cdot i = j\cdot j = k\cdot k = 1$$

9) Interms of components

$$\vec{A}\cdot\vec{B} = (A_x i + A_y j + A_z k)\cdot(B_x i + B_y j + B_z k)$$

$$\vec{A}\cdot\vec{B} = A_x B_x + A_y B_y + A_z B_z$$

10) Projection of vector

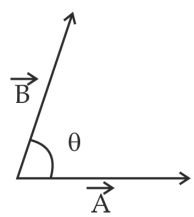
Projection of $\vec{B}$ on to $\vec{A} = B\cos\theta = \dfrac{\vec{A}\cdot\vec{B}}{A}$

Projection of $\vec{A}$ on to $\vec{B} = A\cos\theta = \dfrac{\vec{A}\cdot\vec{B}}{B}$

**8) Cross product :**

$$\vec{C} = \vec{A}\times\vec{B}$$

$$C = |\vec{C}| = AB\sin\theta$$




***Key points***

1) If $\theta = 0,\ |\vec{C}| = |\vec{A}\times\vec{B}| = 0$

If $\theta = 90,\ |\vec{C}| = |\vec{A}\times\vec{B}| = AB$

If $\theta = 180,\ |\vec{C}| = |\vec{A}\times\vec{B}| = 0$

2) Angle between the vectors

$$\sin\theta = \frac{|\vec{A}\times\vec{B}|}{AB}$$

3) It is anti-commutative

$$\vec{A}\times\vec{B} = \vec{B}\times\vec{A}$$

4) It is distributive

$$\vec{A}\times(\vec{B}+\vec{C})\vec{A}\times\vec{B} + \vec{A}\times\vec{C}$$

5) It is associative

$$(\vec{A}+\vec{B})\times(\vec{C}+\vec{D}) = \vec{A}\times\vec{C} + \vec{A}\times\vec{D} + \vec{B}\times\vec{C} + \vec{B}\times\vec{D}$$

6) Incase of orthogonal vector

$i \times j = k$

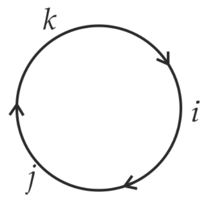
$j \times k = i$

$k \times i = j$

$j \times i = -k$

$k \times j = -i$

$i \times k = -j$




7) Vector product of a vector by itself

$\vec{A} \times \vec{A} = 0$

8) Incase of unit vector

$i \cdot i = j \cdot j = k \cdot k = 0$

9) In terms of components

$\vec{A} \times \vec{B} = (A_x i + A_y j + A_z k) \cdot (\vec{B}_x i + B_y j + B_z k)$

$$\vec{A} \times \vec{B} = \begin{vmatrix} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$= i[A_y B_z - A_z B_y] - j[A_x B_z - A_z B_x] + k[A_x B_y - A_y B_x]$$

10) If two vectors are parallel

$\vec{A} = A_x i + A_j j + A_z k$

$\vec{B} = B_x i + B_j j + B_z k$

then $\frac{A_x}{B_x} = \frac{A_y}{B_y} = \frac{A_z}{B_z}$

11) $\vec{A}, \vec{B}$ and $\vec{C}$ are coplanar then $\vec{A} \cdot (\vec{B} \times \vec{C}) = 0$

12) Angle between $(\vec{A} + \vec{B})$ and $(\vec{A} \times \vec{B})$ is 90°.

13) Formuale to find area

i) If $\vec{A}$ and $\vec{B}$ are two sides of triangle then its area $= \frac{1}{2}|\vec{A} + \vec{B}|$

ii) If $\vec{A}$ and $\vec{B}$ are two adjacent sides of parallelogram then its area $= |\vec{A} + \vec{B}|$

iii) If $\vec{A}$ and $\vec{B}$ are diagonals of a paralelogram then its area $= \frac{1}{2}|\vec{A} + \vec{B}|$

# Quick Revision MOTION IN A STRAIGHT LINE

## TERMINOLOGY

$S$ : Displacement
$v$ : Velocity
$u$ : Initial velocity
$t$ : Time taken
$a$ : Acceleration
$g$ : Acceleration due to gravity
$v_{AB}$ : Velocity of 'A' with respect to 'B'
$v_{BA}$ : Velocity of 'B' with respect to 'A'
$|v|$ : Speed
$v_o$ : Initial velocity or velocity at $t = 0$

## DEFINITIONS

1) **Distance :** It is the length of actual path traversed by a body between its initial and final position. Distance is a scalar quantity.
2) **Displacement :** It is the shortest length between initial and final position of body. It is a vector quantity.
3) **Speed :** The rate of change of position of an object with time in any direction is called its speed. It is equal to distance travelled per unit time.
4) **Average speed :** For an object moving with variable speed, the average speed is total distance travelled per unit time.
5) **Instantaneous speed :** The speed of an object at any particular instant of time or at particular point of path is called instantaneous speed.
6) **Velocity :** The rate of change of position of object with time in a given direction is called velocity. It is equal to displacement per unit time.
7) **Average velocity :** Average velocity is called at the ratio of total displacement to the total time interval of the body.
8) **Instantaneous velocity :** The velocity of an object at a particular instant of time or at a particular point on its path is called instantaneous velocity.
9) **Uniform motion:** An object is said to be in uniform motion if it covers equal distance in equal intervals of time however small these intervals may be.
10. **Non-uniform motion:** A body is said to be in non uniform motion if it covers unequal intervals in equal periods of time. In this motion, its velocity changes with time.
11) **Acceleration :** The rate of change of velocity of an object with time is called acceleration. In S.I unit, it is the change in velocity in one second.
13) **Free fall:** When a body released near the earth's surface, it accelerates downwards towards earth. In the absence of air resistance its velocity continuously increases. The motion of the body is called free fall.

## FORMULAE

1) $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$

2) $\text{Velocity} = \dfrac{\text{Displacement}}{\text{Time}}$

3) $\text{Velocity} = \dfrac{d(\vec{s})}{dt}$

4) Speed = |Velocity|

5) $\text{Acceleration} = \dfrac{v-u}{t}$

6) $\vec{a} = \dfrac{d\vec{v}}{dt}$

7) $\text{Average velocity} = \dfrac{\vec{s}_1 + \vec{s}_2 + \vec{s}_3 + \ldots\ldots \vec{s}_n}{t_1 + t_2 + t_3 + \ldots . t_n}$

8) $v = u + at$
9) $v^2 - u^2 = 2as$

10) $s = ut + \dfrac{1}{2}at^2$

11) $s_{n\text{th}} = u + \dfrac{a}{2}(2n-1)$

12) $v_{AB} = v_A - v_B$
13) $v_{BA} = v_B - v_A$

14) $\text{Relative velocity} = \dfrac{\text{Relative change in sepration}}{\text{Time}}$

*For motion under gravity*

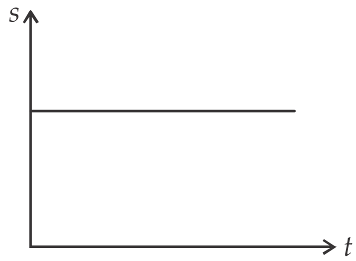
I) $v = u - gt$
II) $v^2 - u^2 = -2gs$

III) $s = ut - \dfrac{1}{2}gt^2$

IV) $s_{n\text{th}} = u - \dfrac{g}{2}(2n-1)$

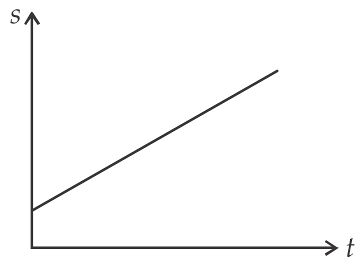
## DISPLACEMENT–TIME GRAPH

I)



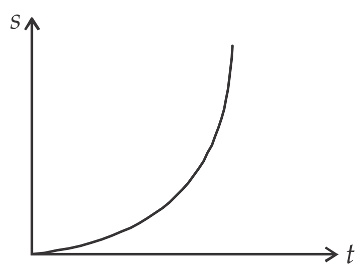

Object at Rest

II)



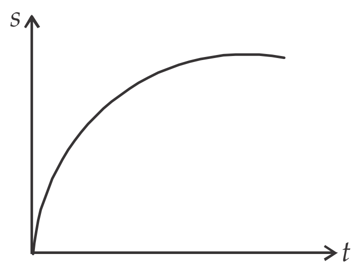

Object moving with uniform velocity

III)




Object moving with uniform +ve acceleration

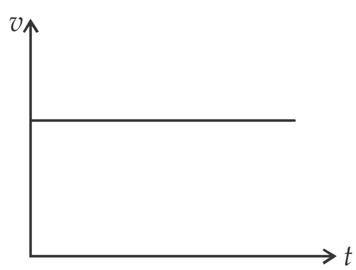
IV)




Object is moving with decreasing velocity

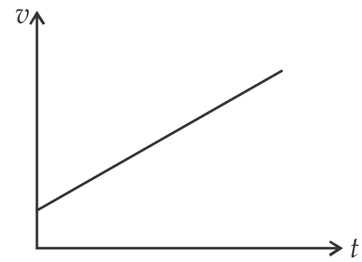
## VELOCITY–TIME GRAPH

I)



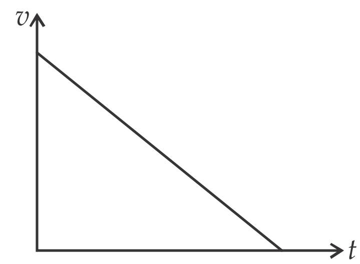

Object moving with constant velocity

II)




Uniformly increasing velocity

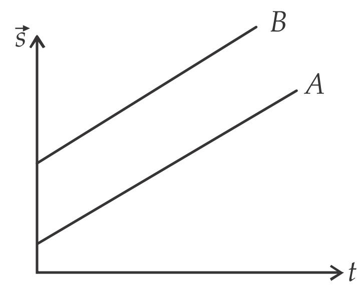
III)




Uniformly decreasing velocity

* **Relative Velocity Graphs**

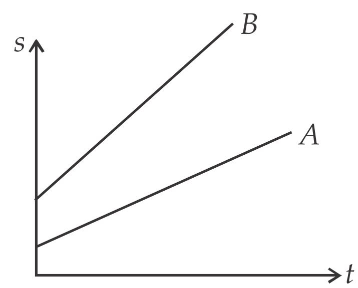
I)




$v_A = v_B$

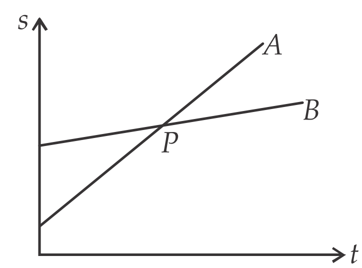
Relative velocity is zero

II)




$v_B > v_A$ $\quad$ $v_B - v_A = +ve$

III)




$v_A > v_B$ $\quad$ $v_A - v_B = +ve$

$P$ = Point of overtaking

# Quick Revision MOTION IN A PLANE

## TERMINOLOGY

$\Delta\vec{r}$ : Displacement Vector
$\vec{r}_1$ or $\vec{r}_0$ : Initial position vector
$\vec{r}_2$ : Final position vector
$\vec{v}$ : Velocity vector
$v_x$ : $x$-component of velocity
$v_y$ : $y$-component of velocity
$\vec{a}$ : Acceleration vector
$a_x$ : $x$-component of acceleration vector
$v_y$ : $y$-component of acceleration vector
$R$ : Range of Projectile
$T$ : Time of light
$u$ : Initial velocity
$t$ : Half time of projectile or Instantaneous time
$m$ : slope

## DEFINITIONS

1) **Projectile :** A projectile is the name given to any body which since thrown its space with some initial velocity moves thereafter under the effect of gravity alone, without being propelled by any engine or fuel. The path followed is called trajectory.
*Assumptions used in projectile motion:*
a) There is no air resistance on the projectile.
b) The effect due to earth's curvature is negligible.
c) The effect due to rotation of earth is zero.
d) Acceleration due to gravity is constant in all points of motion.
2) **Time of flight :** It is the total time which the projectile remains in the flight.
3) **Horizontal Range :** It is the horizontal distance covered by the projectile during its time of flight.
4) **Horizontal component :** It is the component of velocity which remain constant and is parallel to surface of earth.

## FORMULAE

1) $\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$

2) $\Delta\vec{r} = \Delta x\hat{i} + \Delta y\hat{j}$

3) $\vec{v} = v_x\hat{i} + v_y\hat{j}$

4) $\vec{v} = \dfrac{\Delta\vec{r}}{\Delta t}$

5) $\underset{\lim \Delta t\to 0}{\vec{v}} = \dfrac{d\vec{r}}{dt}$

6) $\underset{\lim \Delta t\to 0}{\vec{a}} = \dfrac{d\vec{v}}{dt}$

7) $Speed = |v| = \sqrt{v_x^2 + v_y^2}$

8) $\vec{a} = a_x\hat{i} + a_y\hat{j}$

9) $a_x = \dfrac{dv_x}{dt}$

10) $a_y = \dfrac{dv_y}{dt}$

11) $\vec{a} = \dfrac{dv_x}{dt}\hat{i} + \dfrac{dv_y}{dt}\hat{j}$

12) $\vec{v} = \vec{v}_0 + \vec{a}t$

13) $\vec{r} - \vec{r}_0 = \Delta\vec{r}$

14) $\vec{r} - \vec{r}_0 = \left(\dfrac{\vec{v} + \vec{v}_o}{2}\right)t$

15) $v^2 - v_o^2 = 2\vec{a}.(\vec{r} - \vec{r}_o)$

16) $m = \tan\theta = \dfrac{v_y}{v_x}$

## ANGULAR PROJECTILE

1) $R = \dfrac{u^2 \sin 2\theta}{g}$

2) $R = \dfrac{2u\sin\theta . u\cos\theta}{g} = \dfrac{2u_y u_x}{g}$

3) $T = \dfrac{2u\sin\theta}{g} = \dfrac{2u_y}{g}$

4) $t = \dfrac{T}{2} = \dfrac{u\sin\theta}{g} = \dfrac{u_y}{g}$

5) $H = \dfrac{u^2\sin^2\theta}{2g}$

6) $H = \dfrac{u_y^2}{2g}$

7) $T = 2\sqrt{\dfrac{2H}{g}}$

8) $y = x\tan\theta\left(1-\frac{x}{R}\right)$

9) $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

## HORIZONTAL PROJECTILE

1) $t = \frac{x}{u}$

2) $T = \sqrt{\frac{2h}{g}}$

3) $v = \sqrt{v_x^2 + v_y^2}$

4) $v_y = \sqrt{2gh}$

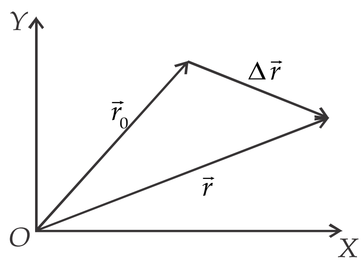
5) $v_y = gt$

6) $R = v\sqrt{\frac{2h}{g}}$

7) $\tan\beta = \frac{v_y}{u} = \frac{gt}{u}$

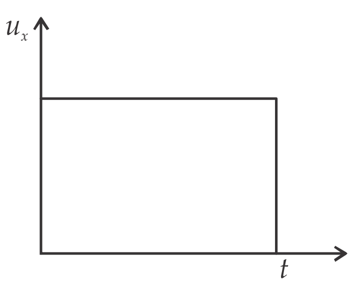
## GRAPHS

1)



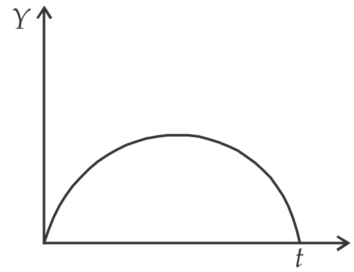

$\vec{r}_o$ = Initial Position
$\Delta\vec{r}$ = Displacement vector
$\vec{r}$ = Final position

2)



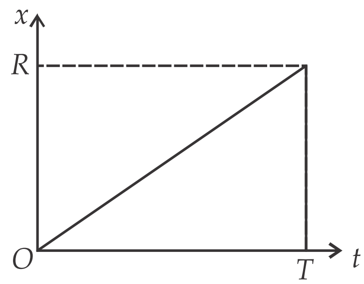

Horizontal velocity in projectile w.r.t. time

3)



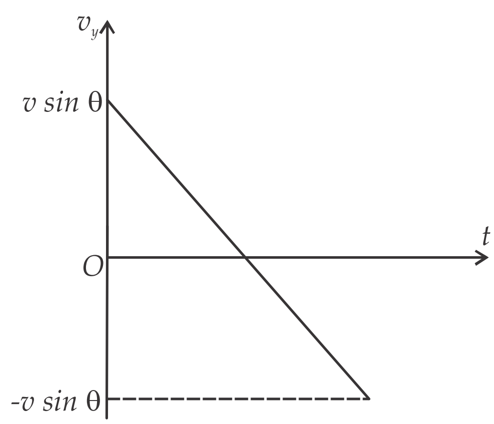

Vertical distance with time.

4)




Horizontal distance with time.

5)




Vertical velocity with time

# Quick Revision CIRCULAR MOTION

## TERMINOLOGY

| | | |
|---|---|---|
| $\theta$ | : | Angular Displacement [rad] |
| $\omega_i$ | : | Initial Angular Velocity [rad/s] |
| $\omega_f$ | : | Final Angular Velocity [rad/s] |
| $\alpha$ | : | Angular Acceleration [rad/s²] |
| $V$ | : | Linear Velocity [m/s] |
| $r$ | : | Radius [m] |
| $a_{cp}$ | : | Centripetal Acceleration [m/s²] |
| $a_t$ | : | Tangential Acceleration [m/s²] |
| $F_{cp}$ | : | Centripetal Force [N] |
| $W_{cp}$ | : | Work Done by Centripetal Force [ J ] |
| $P_{cp}$ | : | Power by centripetal Force [W] |
| $F_t$ | : | Tangential force [N] |
| $s$ | : | Displacement [m] |
| $\mu$ | : | Coefficient of Friction |
| $\theta_b$ | : | Angle of Banking |
| $m$ | : | Mass [kg] |
| $q$ | : | Charge [coulomb] |

## DEFINITIONS

1) **Circular Motion :** Movement of an object along the circumference of a circle or rotation along a circular path is calloed as circular motion.
2) **Uniform Circular Motion :** Periodic motion of a particle movin g along circumference of a circle with constant angular speed is called as uniform circular motion.
3) **Non-uniform Circular Motion :** Motion of a particle moving along circumference of a circle with variable angular speed is called as Non-uniform circular motion.
4) **Angular Displacement ($\theta$) :** The angle described by radius vector in a given time at the center of circle is called as angular displacement.
5) **Angular velocity [ $\omega$ ] :** The time rate change of limiting angular displacement is called angular velocity.
6) **Angular Acceleration [$\alpha$] :** The time rate change of an angular velocity is called angular acceleration.
7) **Centripetal Force :** Force acting on a particle performing circular motion which is along radius of circle and directed towards.
8) **Centrifugal force :** The pseudo force in circular motion which acts along radius and directed away from the center of circle is called as centrifugal force.
9) **Angle of Banking :** The angle made by the surface of road with the horizontal surface of road is called angle of banking.
10) **Banking of Road :** The process of raising outer edge of road over its inner edge through certain angle is called as Banking of road.

## FORMULAE

1) **Kinematics of Circular Motion**

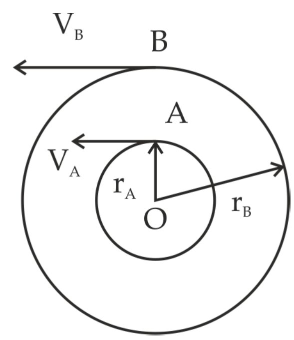
$$\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f^2 = \omega_i^2 + 2\alpha\theta$$

$$\theta n^{th} = \omega + \frac{\alpha}{2}(2n-1)$$

$$\omega_{\text{relative}} = \frac{V_{\text{relative}}}{r_{\text{relative}}}$$

$$= \frac{V_B - V_A}{r_B - r_A}$$




2) **Uniform Circular Motion**

$$\alpha = \frac{d\omega}{dt} = 0$$

$$a_t = r \cdot \frac{d\omega}{dt} = 0$$

$$a_{cp} = \omega^2 r = \frac{V^2}{r} = \omega V$$

$$\vec{a}_{cp} = -\omega^2 \vec{r} = -\frac{V^2}{r}\hat{r} = \vec{\omega} \times \vec{V}$$

$$F_{cp} = \frac{mv^2}{r} = m\omega^2 r = mv\omega$$

$$W_{cp} = 0$$

$$P_{cp} = 0$$

**3) Non-uniform Circular Motion**

$$\vec{\alpha} = \frac{d\vec{\omega}}{dt} = \frac{\vec{\omega}_2 - \vec{\omega}_1}{t}$$

$$a_t = r \cdot \frac{d\omega}{dt}$$

$$\vec{a}_{cp} = -\omega^2 \vec{r} = -\frac{v^2}{r}\hat{r} = \vec{\omega} \times \vec{v}$$

$$\overrightarrow{a_t} = \vec{\alpha} \times \vec{r}$$

$$\vec{a}_{net} = \vec{a}_{cp} + \vec{a}_t$$

$$\vec{F}_{cp} = m\vec{a}_{cp}$$

$$\vec{F}_t = m\vec{a}_t$$

$$W_{cp} = 0$$

$$W_t = F_t \cdot S$$

$$P_{cp} = 0$$

$$P_t = \frac{W_t}{t} = F_t \cdot V$$

$$p = P_{cp} + P_t$$

**4) Banking of Road**

Horizontal curve road

$$V = \sqrt{\mu r g}$$

Banked road

$$V = \sqrt{\frac{rg(\mu + \tan\theta)}{(1 - \mu\tan\theta)}}$$

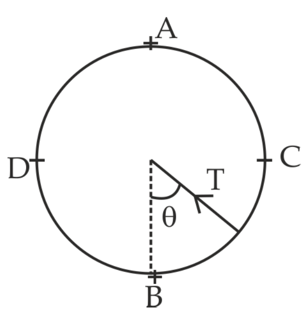
If $\mu = 0$

$$\tan\theta = \frac{V^2}{rg}$$

Pendulum in a car

$$\tan\theta = \frac{V^2}{rg}$$

**5) Verticle Circular Motion**




| Position | Angle | Velocity | Tension |
|---|---|---|---|
| B | 0 | U | $mv^2/l + mg$ |
| C | 90 | $\sqrt{U^2 - 2gl}$ | $mv^2/l - 2mg$ |
| A | 180 | $\sqrt{U^2 - 4gl}$ | $mv^2/l - 5mg$ |
| D | 270 | $\sqrt{U^2 - 2gl}$ | $mv^2/l - 2mg$ |

For condition of slack

$$T_A = 0,\ V_A = \sqrt{gl}$$

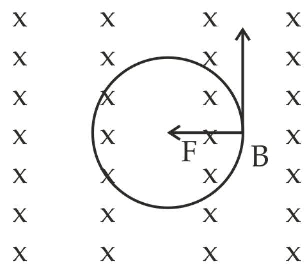
$$V_B = \sqrt{5gl}$$

For any condition

$$T_B - T_A = 6mg$$

**6) Motion of a Charged aprticle in a magnetic field**

$$qvB = \frac{mv^2}{r}$$

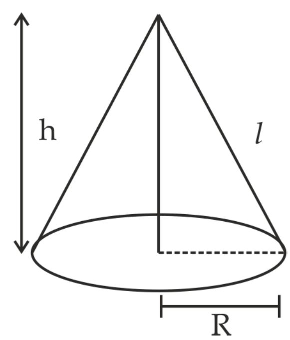



**7) Conical Pendulum**

$$\tan\theta = \frac{V^2}{rg}$$

$$\omega = \sqrt{\frac{g}{h}}$$

$$T = 2\pi\sqrt{\frac{\mu\cos\theta}{g}}$$




$$\text{Tension} = mg\sqrt{1 + \left(\frac{r}{h}\right)^2}$$

**8) Change in vector quantities**

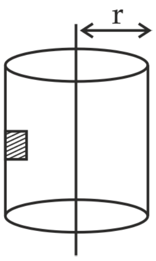
$$\text{Change in velocity} = \Delta V = 2V\sin\left(\frac{\theta}{2}\right)$$

$$\text{Change in radial vector} = \Delta V = 2r\sin\left(\frac{\theta}{2}\right)$$

$$\text{Change in momentum} = \Delta P = 2mv\sin\left(\frac{\theta}{2}\right)$$

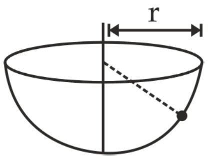
**9) Death Well :**

$$V = \sqrt{\frac{rg}{\mu}}$$



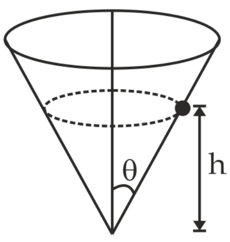

**10) Hemispherical Vessel :**

$$\omega = \sqrt{\frac{g}{R\cos\theta}}$$




**11) Inverted Cone :**

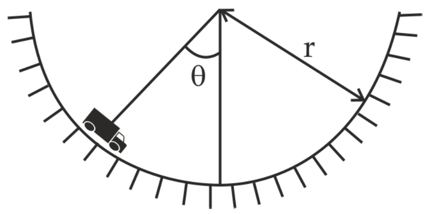
$$V = \sqrt{gh}$$




**12) Reaction of road on car**

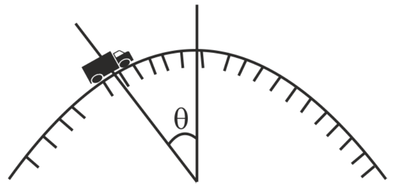
1) car on a concave bridge

$$R = mg\cos\theta + \frac{mv^2}{r}$$




2) car on a convex bridge

$$R = mg\cos\theta - \frac{mv^2}{r}$$

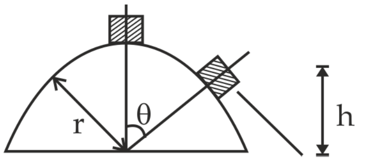



**13) Motion of a block on frictionless hemisphere**

$$h = \frac{2}{3}r$$

$$\cos\theta = \frac{h}{r}$$

$$\theta = \cos^{-1}\left(\frac{2}{r}\right)$$



# Quick Revision NEWTON'S LAWS OF MOTION

## TERMINOLOGY

| | | |
|---|---|---|
| $F$ | : | Force [N] |
| $m$ | : | Mass [kg] |
| $dv$ | : | Change in velocity [m/s] |
| $p$ | : | Linear momentum [kg m/s] |
| $I$ | : | Impulse [N-s] |
| $dp$ | : | Change in momentum [N-s] |
| $W$ | : | Weight [N] |
| $T$ | : | Tension [N] |
| $L$ | : | Length [m] |
| $a$ | : | Acceleration [m/s²] |
| $\theta$ | : | Angle |
| $m_0$ | : | Initial mass of rocket [kg] |
| $\frac{dm}{dt}$ | : | Rate of fuel consumption [kg/s] |
| $V_r$ | : | Velocity of gases relative to rocket |
| $N$ | : | Normal reaction [N] |

## DEFINITIONS

1) **Force :** Force is a push or pull which tries or change the state of rest or uniform motion of a body.

2) **Weight :** Force given by earth towards its centre on an object is called weight.

3) **Reaction :** If a body is pressed against a rigid support, the body experienced a force which is perpendicular to surface in contact is called reaction or normal reaction.

4) **Linear Momentum :** The quantity of motion present in a body is called as Linear Momentum.

5) **Impulse :** When a large force acting for a short interval of time is called impulse.

6) **Intertial frame of reference :** A non-accelerating frame of reference is called inertial frame of reference.

7) **Pseudo Force :** Those force which do not actually act on the particles but appear to be acting on the particles due to accelerated motion of frame of reference are called pseudo force.

## FORMULAE

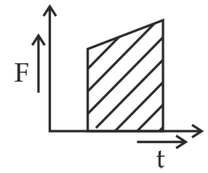
1) $\vec{F} = \frac{d\vec{p}}{dt} = m\frac{d\vec{V}}{dt} = m\vec{a}$

2) $\vec{p} = m\vec{V}$

3) $I = Ft = mV - mu$

$I = \int F \cdot dt$

Area under $F$-$t$ graph will give impulse.




4) $W = mg$

5) $F_{\text{pseudo}} = ma_{\text{frame}}$

6) Law of conservation of momentum

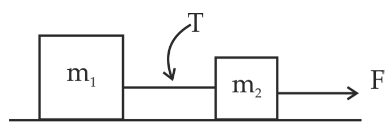
$m_1u_1 = m_1v_1$

7) Motion of connected bodies

i) For two bodies

$$a = \frac{F}{m_1 + m_2}$$

$$T = \frac{m_1F}{m_1 + m_2}$$

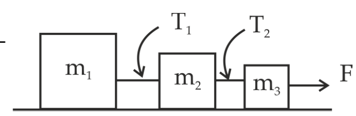



ii) For three bodies

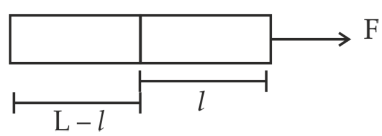
$$a = \frac{F}{m_1 + m_2 + m_3}$$

$$T_1 = \frac{m_1F}{m_1 + m_2 + m_3}$$

$$T_2 = \frac{(m_1 + m_2)F}{m_1 + m_2 + m_3}$$




8) Rope on a horizontal surface




$$T = \left(1 - \frac{l}{L}\right)F$$

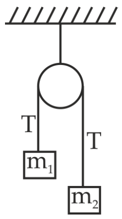
9) Pulleys

***Case - I***

$m_1 = m_2 = m$

$T$ = mg

$a$ = 0

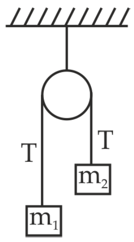



***Case - II***

$m_1 > m_2$

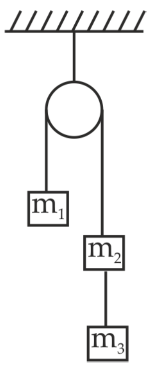
$$a = \frac{(m_1 - m_2)}{(m_1 + m_2)} g$$

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




***Case - III***

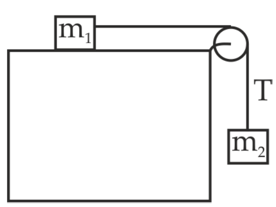
$$a = \frac{(m_2 + m_3 - m_1)}{(m_1 + m_2 + m_3)} g$$




***Case - IV***

$$a = \frac{m_2 g}{m_1 + m_2}$$

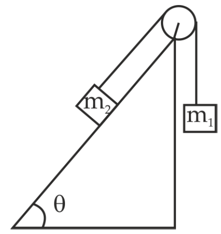
$$T = \frac{m_1 m_2}{(m_1 + m_2)} g$$




***Case - V***

$$a = \frac{(m_1 - m_2 \sin\theta)}{(m_1 + m_2)} g$$

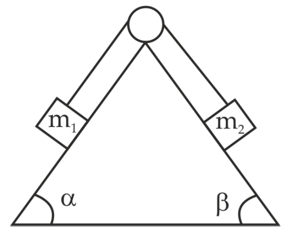
$$T = \frac{(m_1 m_2)(1 + \sin\theta)}{(m_1 + m_2)} g$$




Case - VI

$$a = \frac{(m_1 \sin\alpha - m_2 \sin\beta)}{(m_1 + m_2)} g$$

$$T = \frac{m_1 m_2 (\sin\alpha + \sin\beta)}{(m_1 + m_2)} g$$




10) Tension in lift wire

i) Lift is stable : $T = mg$

ii) Lift moving up : $T = m(g + a)$

iii) Lift moving down : $T = m(g - a)$

11) Apparent weight

i) Lift is stable : $N = Mg$

ii) Lift moving up

$N = M(g + a)$

iii) Lift moving down

$N = M(g - a)$

12) Rocket propulsion

$$\text{acceleration of rocket} = -\frac{V_r}{m} \cdot \frac{dm}{dt}$$

$$\text{Thrust on rocket} = ma = -V_r \cdot \frac{dm}{dt}$$

If gravitational force is considered acceleration

$$\text{of rocket} = -\frac{V_r}{m} \cdot \frac{dm}{dt} - g$$

$$m = m_0 - \left(\frac{dm}{dt}\right) t$$

# Quick Revision — FRICTION

## TERMINOLOGY

| | | |
|---|---|---|
| $F$ | : | Force (N) |
| $\mu$ | : | Coefficient of friction |
| $N$ | : | Normal reaction (N) |
| $\mu_k$ | : | Coefficient of kinetic friction |
| $\mu_s$ | : | Coefficient of static friction |
| $m$ | : | Mass (kg) |
| $W$ | : | Weight (N) |
| $\theta$ | : | Angle of repose |
| $v$ | : | Velocity (m/s) |
| $s$ | : | Distance (m) |
| $t$ | : | Time (s) |
| $f_s$ | : | Static friction |
| $f_k$ | : | Kinetic friction |

## DEFINITIONS

**1) Friction:**

The resistive force which will act when two bodies tries to slide is called friction.

**2) Static friction:**

The frictional force acting between two surfaces at rest is called as static friction.

**3) Kinetic friction:**

The frictional force acting between two surfaces in relative motion is called kinetic friction.

**4) Rolling friction:**

The frictional force acting when object perform rolling motion is called rolling friction.

**5) Limiting friction:**

The maximum force of static friction upto which body does not move is called limiting friction.

**6) Angle of friction:**

The angle which the resultant contact force makes with the normal reaction is called angle of friction.

**7) Angle of repose:**

The maximum angle of inclination of a plane with the horizontal at which the object placed on it just begin to slide down is called as angle of repose.

## FORMULAE

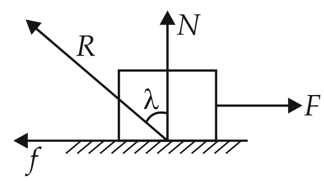
**1) Friction:**

$$f_s = \mu_s N$$

$$f_k = \mu_k N$$

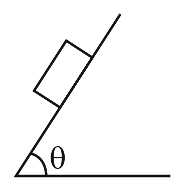
**2) Angle of friction:**

$$\lambda = \tan^{-1}(\mu)$$



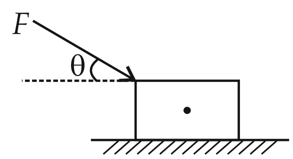

**3) Angle of repose:**

$$\theta = \tan^{-1}(\mu_s)$$

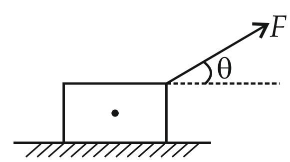



**4) Pull is easier than push:**

$$F_{\text{Push}} = \frac{\mu mg}{\cos\theta - \mu\sin\theta}$$

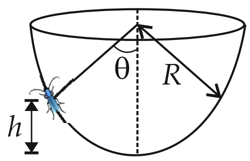



$$F_{\text{Pull}} = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$$



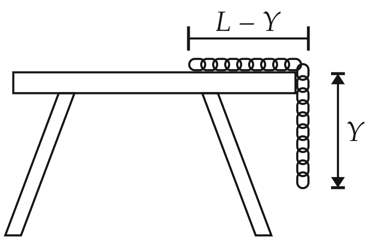
**5) Motion of an insect in the rough bowl:**

$$h = R\left(1 - \frac{1}{\sqrt{\mu^2 + 1}}\right)$$




**6) Maximum length (Y) hung from table:**

$$Y = \frac{\mu L}{\mu + 1}$$




**7) Stopping of block due to friction:**

$$s = \frac{v^2}{2\mu g}$$

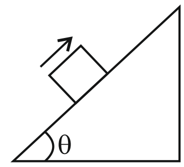
$$t = \frac{v}{\mu g}$$

$$a = \mu g$$

**8) Friction on an inclined surface:**

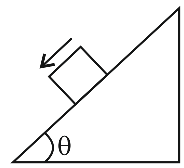
i) Object moving up

$$a = g[\sin\theta + \mu\cos\theta]$$



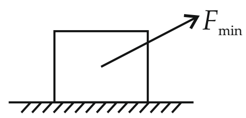

ii) Object moving down

$$a = g[\sin\theta - \mu\cos\theta]$$

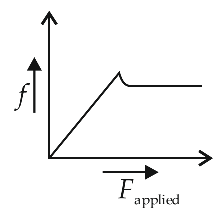



**9) Minimum force to move:**

$$F_{\min} = \frac{\mu mg}{\sqrt{\mu^2 + 1}}$$




**10) $f$ Versus $F_{\text{Applied}}$:**



# Quick Revision WORK, ENERGY AND POWER

## TERMINOLOGY

$W$ : Work done
$P$ : Power
$s$ : Displacement
$ds$ : Small change in displacement
K.E. : Kinetic energy
T.E. : Total energy
T.M.E. : Total mechanical energy
P.E. : Potential energy
$p$ : Momentum
$KE_F$ : Final kinetic energy
$KE_I$ : Initial kinetic energy
$U$ : Potential energy
$\frac{\partial U}{\partial x}$ : Partial derivative of energy w.r.t. $x$
$\frac{\partial U}{\partial y}$ : Partial derivative of energy w.r.t. $y$
$\frac{\partial U}{\partial z}$ : Partial derivative of energy w.r.t. $z$
00

## DEFINITIONS

1) **Work:**

Work is said to be done whenever a force acts on a body and body moves through some distance in the direction of force.

2) **Positive work:**

The force acting on a body has component in the direction of displacement. The work done is called positive work.

3) **Negative work:**

If the force acting on a body has the component opposite to direction of displacement then work done is called negative work done.

4) **Zero work:**

When force or displacement for cos θ, either of them is zero then work done is zero.

5) **Work energy principle:**

Work done by net force acting on a body is equal to change in kinetic energy of body.

6) **Conservative forces:**

A force is conservative if work done by force in displacing a particle from one point to another is independent on the path followed by particle and depends only on the initial and end points.

6) **Non-conservative forces:**

If the amount of work done in moving an object against a force from one point to another point depends along the path along which the body moves, then such a force is called non-conservative force.

7) **Conservation of mechanical energy:**

This principle states that when only conservative forces are acting on body then its net mechanical energy (potential energy + kinetic energy) remains constant.

8) **Power:**

It is the rate of doing work. In other words, if work done or energy consumed per unit time.

9) **Watt:**

Watt is S.I. unit of power. The power of an agent is one watt if it does work at the rate of 1 joule per second.

10) **Kilowatt-hour:**

Kilowatt-hour is the commercial unit of energy. One kilowatt hour is the electrical energy consumed by an appliance of 1000 watt in 1 hour.

## FORMULAE

1) $W = \vec{F} \cdot \vec{s}$

AAJ KA TOPPER

2) $W = |F|\,|s|\cos\theta$

3) $W = \int_{\vec{s}_1}^{\vec{s}_2} \vec{F} \cdot d\vec{s}$

4) K.E. $= \frac{1}{2}mv^2 = \frac{p^2}{2m}$

5) $p=\sqrt{2m(K.E.)}$

6) $W=\frac{1}{2}mv^2-\frac{1}{2}mu^2$

7) $\vec{F}_{net}.\vec{s}=\frac{1}{2}m(v^2-u^2)=\Delta\text{K.E.}$

8) P.E. of spring = $\frac{1}{2}kx^2$

9) $U=\frac{1}{2}kx^2=\frac{1}{2}Fx=\frac{F^2}{2k}$

10) $\Delta\text{P.E.}=mgh_2-mgh_1=mg\Delta h$

11) $P=\frac{W}{t}=\frac{dW}{dt}$

12) $P=\vec{F}.\vec{v}$

13) $\vec{F}=\frac{-dv}{d\vec{s}}$

14) $F_x=\frac{-\partial U}{\partial x}$

$F_y=\frac{-\partial U}{\partial y}$

$F_z=\frac{-\partial U}{\partial z}$

15) For equilibrium,

$F=0\Rightarrow\frac{-dU}{ds}=0$

# Quick Revision CENTRE OF MASS AND COLLISION

## TERMINOLOGY

$F_{net}$ : Net force on a particle ($F_{ext}$ + $F_{int}$)
$m$ : Total mass
$\vec{r}_{com}$ : Position of center of mass
$x_{com}$ : Coordinates of Centre of mass on $x$-axis.
$y_{com}$ : Coordinates of Centre of mass on $y$-axis.
$z_{com}$ : Coordinates of Centre of mass on $z$-axis.
$m_1$, $m_2$ : Mass of particles
$\vec{r}_1, \vec{r}_2$ : Position of individual particle
$d_1$ : Distance of centre of mass $m_1$.
$d_2$ : Distance of centre of mass $m_2$.
$\mu$ : Linear mass density.
$R$ : Radius of circle, semicircle, disc, sphere, hemisphere and ring.
$h$ : Height of triangle, hollowand solid cone.
$\rho$ : Density of material
$A$ : Area
$V$ : Volume
$V_{com}$ : Velocity of centre of mass
$a_{com}$ : Acceleration of centre of mass

## DEFINITIONS

1) **Particle :**
Is defined as an object whose mass in finite but size and structure is neglected.

2) **System :**
Is a collection of very large no of particle, having finite size and structure.

3) **Internal force :**
The mutual force exerted by particles of system on one another is called as internal force.

$\Rightarrow \vec{F}_{net(\text{Internal})} = 0$ .... always on system

$\Rightarrow ex.$ - Intermolecular force
- Friction
- Explosion
- Electrostatic
- Gravitation

4) **External force :**
The outside force exerted on a system by external agent is called external force.

$\Rightarrow \vec{F}_{net(\text{Internal})} = m\vec{a}$

5) **Centre of Mass :**
Is a point where whole mass of a body is supposed to be concentrated is called centre of mass.

6) **Centre of gravity :**
A point where whole weight of body is act or supposed to be concentrated is called centre of gravity.

*OR*

Is a point at which resultant of gravitational force of all the particles of a body act.

7) **Velocity of centre of mass :**
Taking time defivative of position vector of centre of mass will get the velocity vector of centre of mass.

8) **Acceleration of centre of mass :**
Taking time derivative of velocity vector of centre of mass will get the acceleration of centre of masss.

## CONCEPT

1) Two particle system : Centre of mass divide the distance between particles in inverse ratio of there masses.
Centre of mass is closer to a massive body.
2) Applied force is in line with centre of mass then body will travel in translational motion.
3) For small body centre of mass and centre of gravity both one same.
4) Try to place particles on co-ordinates system, so that we get maximum no. of zero.
5) Try to find symmetry.
6) Centre of mas of a two particle always lie on line joining of these two particle.
7) Internal force is action reaction pair.

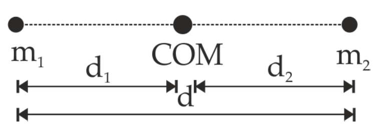
## FORMULAE

1) $\vec{r}_{com} = \dfrac{m_1\vec{r}_1 + m_2\vec{r}_2 + .......}{m_1 + m_2 + ......}$ Weighted average

2) $x_{com} = \dfrac{m_1x_1 + m_2x_2 + .......}{m_1 + m_2 + m_3 + ......}$

3) $y_{com} = \dfrac{m_1y_1 + m_2y_2 + .......}{m_1 + m_2 + ......}$

4) Centre of mass of two particle system




$$\Rightarrow d_1 = \frac{m_2 d}{m_1 + m_2}, \Rightarrow d_2 = \frac{m_1 d}{m_1 + m_2}$$

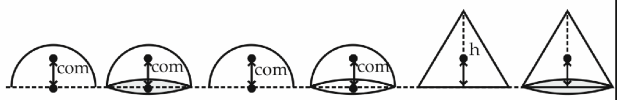
$$\Rightarrow \frac{d_1}{d_2} = \frac{m_2}{m_1} \text{ or } m_1 d_1 = m_2 d_2$$

5) Centre of mass of a continious body

$$\vec{r}_{\text{com}} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \ldots\ldots\ldots m_n\vec{r}_n}{m_1 + m_2 + \ldots\ldots\ldots\ldots\ldots\ldots m_n}$$

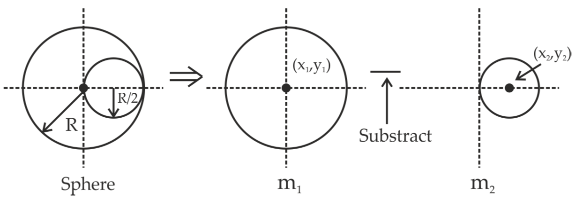
$$x_{\text{com}} = \frac{\int x \cdot dm}{\int dm},\ y_{\text{com}} = \frac{\int y \cdot dm}{\int dm}$$

**Trick : For regular shape body**

| Ring Semicircular | Sphere Solid Hemisphere | Disc Semicircular | Hollow Hemisphere | Triangle or Hollow cone | Cone Solid |
|---|---|---|---|---|---|
|  | | | | | |
| $\frac{2R}{\pi}$ | $\frac{3R}{8}$ | $\frac{4R}{3\pi}$ | $\frac{R}{2}$ | $\frac{h}{3}$ | $\frac{h}{4}$ |

6) Centre of mass a remaining portion

a) For solid body

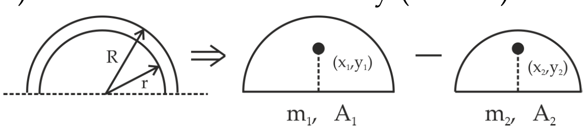



$$\vec{r}_{\text{com}} = \frac{m_1\vec{r}_1 - m_2\vec{r}_2}{m_1 - m_2}$$

$$x_{\text{com}} = \frac{m_1x_1 - m_2x_2}{m_1 - m_2}$$

$$y_{\text{com}} = \frac{m_1y_1 - m_2y_2}{m_1 - m_2}$$

b) For two dimensional body (lamina)




$$\vec{r}_{\text{com}} = \frac{m_1\vec{r}_1 - m_2\vec{r}_2}{m_1 - m_2}$$

$$x_{\text{com}} = \frac{m_1x_1 - m_2x_2}{m_1 - m_2} \text{ or } x_{\text{com}} = \frac{A_1x_1 - A_2x_2}{A_1 - A_2}$$

$$y_{\text{com}} = \frac{m_1y_1 - m_2y_2}{m_1 - m_2} \text{ or } y_{\text{com}} = \frac{A_1y_1 - A_2y_2}{A_1 - A_2}$$

7) Motion of centre of mass

a) Velocity of centre of mass

$$\vec{V}_{\text{com}} = \frac{m_1\vec{V}_1 + m_2\vec{V}_2 + \ldots\ldots}{m_1 + m_2 + \ldots\ldots}$$

$$\vec{P} = M\vec{V}_{\text{com}}$$

b) Acceleration of centre of mass

$$\vec{a}_{\text{com}} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + \ldots\ldots}{m_1 + m_2 + \ldots\ldots}$$

$$\vec{F}_{\text{net}} = M\vec{a}_{\text{com}}$$

$$\vec{F}_{\text{net}} = \vec{F}_{\text{external}} + \vec{F}_{\text{internal}}$$

$$\vec{F}_{\text{internal}} = 0$$

**Cases:**

If $\vec{F}_{\text{external}} = 0$

Then $\vec{a}_{\text{com}} = 0$

$\swarrow$ $\vec{V}_{\text{com}} = \text{const.}$ $\qquad$ $\searrow$ $\vec{V}_{\text{com}} = 0$

Irrespective of the individual acceleration of particle.

a) $\vec{V}_{\text{com}} = \text{const}$ :

If initially $V_{\text{com}}$ = constant then it will remain always constant.

b) $\vec{V}_{\text{com}} = 0$

If initially $V_{\text{com}} = 0$ then it will remain always zero.

ex. - Particles is at rest initially

Initial velocity is zero

Body is at rest.

Quick Revision

# ROTATIONAL MOTION

## TERMINOLOGY

$\omega$ : Angular velocity [rad/s]
$\omega_2$ : Final angular velocity [rad/s]
$\omega_1$ : Initial angular velocity [rad/s]
$T$ : Time period [s]
$f$ : Frequency [1/s]
$\alpha$ : Angular acceleration [rad/s²]
$m$ : Mass [kg]
$I$ : Moment of inertia [kg m²]
$r$ : Perpendicular distance [m]
$I_0$ : Moment of inertia of an object through point $O$.
$I_c$ : Moment of inertia of an object through centre of mass.
$I_z$ : Moment of inertia of an object through $z$ axis.
$I_x$ : Moment of inertia of an object through $x$ axis
$I_y$ : Moment of inertia of an object through $y$ axis
$m_1$ : Mass of first particle [kg]
$m_2$ : Mass of second particle [kg]
$\tau$ : Torque [N-m]
$F$ : Force [N]
$r_1$ : Perpendicular distance [m]
$\theta$ : Angle
$k$ : Radius of gravition [m]
$h$ : height [m]
$v$ : Velocity [m/s]

## DEFINITIONS

1) **Rotation Motion :** The change in the orientation of body during its motion is called rotational motion.
2) **Moment of Inertia :** The property of body due to which it oposees any change in its state of rest or of uniform rotation is called moment of ienrtia.
3) **Radius of Gyration :** The distance from an axis of rotation where entire mass of the body supposed to be concentrated and the value of moment of inertia is same that due to actual distribution of masses of body is called radius of gyration.
4) **Torque :** If a pivoted, hinged or suspended body tends to rotate under the action of force it is said to be acted on by a torque.
5) **Angular Momentum :** The moment of linear momentum of body with respect to any axis of rotation is called as angular momentum.
6) **Kinetic Energy of Rotation :** The energy which a body has by virtue of it rotational motion is called as kinetic energy of rotation.
7) **Rolling Motion :** When a body perform translational and rotational motion is called as rolling motion.

## FORMULAE

1) Fundamental of rotational motion

$$\omega = \frac{2\pi}{T} = \frac{\theta_2 - \theta_1}{t}$$

$$f = \frac{1}{T}$$

$$\alpha = \frac{\omega_2 - \omega_2}{t}$$

Comparison of linear and rotational motion

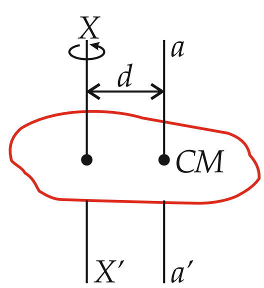
| Linear motion | Rotational Motion |
|---|---|
| $V = u + at$ | $\omega_2 = \omega_1 + \alpha t$ |
| $V^2 = u^2 + 2as$ | $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ |
| $S = ut + \frac{1}{2}at^2$ | $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$ |

2) Moment of inertia of a particle

$$I = mr^2$$

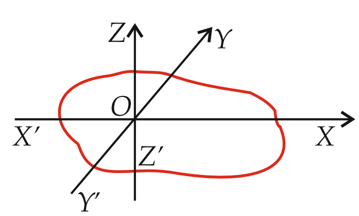
3) Theorem of parallel axis

$$I_0 = I_c + Mh^2$$

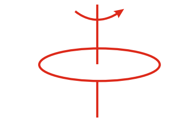
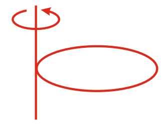
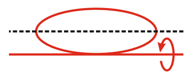


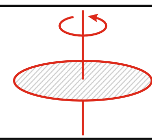
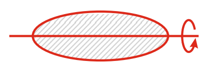
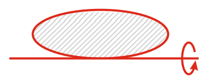
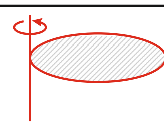

4) Theorem of perpendicular axis

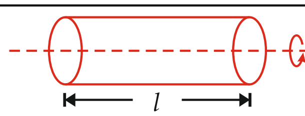
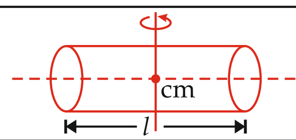
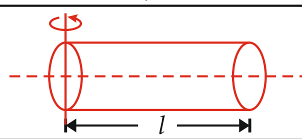
$$I_z = I_x + I_y$$

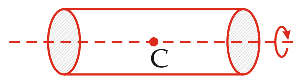
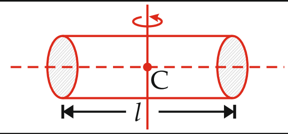
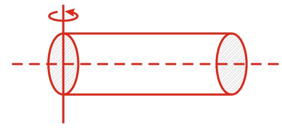


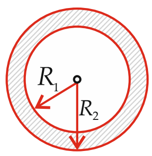
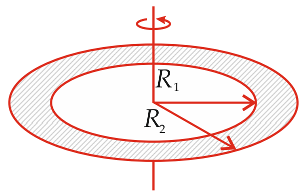
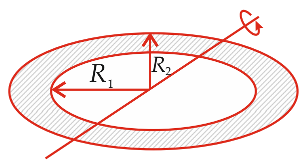

Formula for moment of inertia of regular bodies

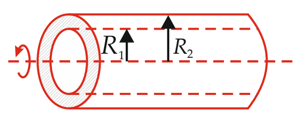
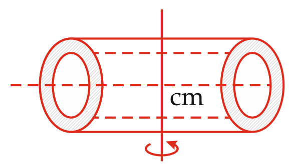
| Shape Of Body | Axis Of Rotation | Figure | Moment Of Inertia ($I$) | Radius Of Gyration |
|---|---|---|---|---|
| **(1) Circular Ring** $M$ = Mass $R$ = Radius | 1. Passes through the centre & perpendicular to plane |  | $MR^2$ | $R$ |
| | 2. About it's diameter in it's own plane |  | $(1/2)MR^2$ | $R/\sqrt{2}$ |
| | 3. About a tangential axis perpendicular to its own plane |  | $2MR^2$ | $\sqrt{2}R$ |
| | 4. About a tangential axis in its own plane |  | $\frac{3}{2}MR^2$ | $\sqrt{\frac{3}{2}}R$ |

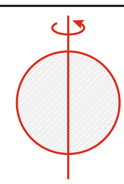
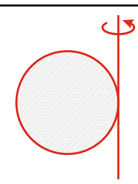
| Shape Of Body | Axis Of Rotation | Figure | Moment Of Inertia ($I$) | Radius Of Gyration |
|---|---|---|---|---|
| **(2) Circular Disc** $M$ = Mass $R$ = Radius | 1. Passing through the centre and perpendicular to the plane |  | $\frac{MR^2}{2}$ | $\frac{R}{\sqrt{2}}$ |
| | 2. About diameter |  | $\frac{MR^2}{4}$ | $\frac{R}{2}$ |
| | 3. About a tangential axis lying its own plane |  | $\frac{5}{4}MR^2$ | $\frac{\sqrt{5}}{2}R$ |
| | 4. About a tangential axis perpendicular to its own plane |  | $\frac{3}{2}MR^2$ | $\sqrt{\frac{3}{2}}R$ |

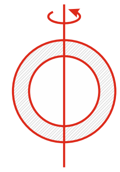
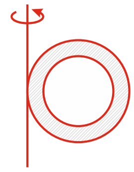
| Shape Of Body | Axis Of Rotation | Figure | Moment Of Inertia ($I$) | Radius Of Gyration |
|---|---|---|---|---|
| **(3) Hollow Cylinder** $M$ = Mass $R$ = Radius $L$ = Length | 1. About its geometrical axis |   | $MR^2$ | $R$ |
| | 2. About an axis passing through its CM and perpendicular to its length |   | $\left(\frac{MR^2}{2}+\frac{Ml^2}{12}\right)$ | $\sqrt{\frac{R^2}{2}+\frac{l^2}{12}}$ |
| | 3. About an axis perpendicular to its length and passing through one end of the cylinder |   | $\left(\frac{MR^2}{2}+\frac{Ml^2}{3}\right)$ | $\sqrt{\frac{R^2}{2}+\frac{l^2}{3}}$ |

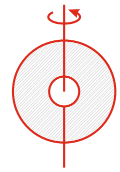
| | | | | |
|---|---|---|---|---|
| **(4)**<br>**Solid Cylinder**<br>**$M$ = Mass**<br>**$R$ = Radius**<br>**$L$ = Length** | 1. About its geometrical axis |   | $\frac{MR^2}{2}$ | $\frac{R}{\sqrt{2}}$ |
| | 2. About an axis passing through its CM and perpendicular to its length |   | $\frac{MR^2}{4}+\frac{Ml^2}{12}$ | $\sqrt{\frac{R^2}{4}+\frac{l^2}{12}}$ |
| | 3. About an axis perpendicular to its length and passing through one end of the cylinder |  | $M\left[\frac{R^2}{4}+\frac{l^2}{3}\right]$ | $\sqrt{\frac{R^2}{2}+\frac{l^2}{3}}$ |

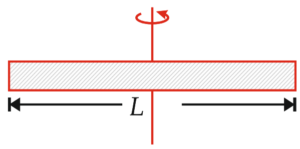
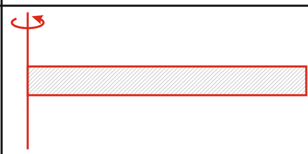
| | | | | |
|---|---|---|---|---|
| **(5)**<br>**Annular disk**<br> <br>**$M$ = Mass**<br>**$R_1$ = Internal Radius**<br>**$R_2$ = Outer Radius** | 1. Passing through centre and perpendicular to the plane |   | $\frac{M}{2}[R_1^2+R_2^2]$ | $\sqrt{\frac{R_1^2+R_2^2}{2}}$ |
| | 2. About its diameter |   | $\frac{M[R_1^2+R_2^2]}{4}$ | $\frac{\sqrt{R_1^2+R_2^2}}{2}$ |

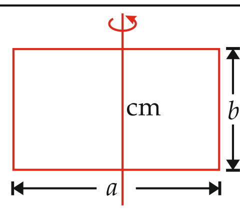
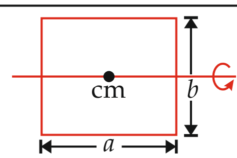
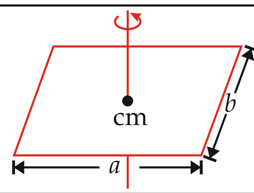
| | | | | |
|---|---|---|---|---|
| **(6)**<br>**Hollow Cylinder**<br>**$R_1$ = Internal Radius**<br>**$R_2$ = Outer Radius**<br>**$M$ = Mass**<br>**$L$ = Length** | 1. About its geometrical axis or about the axis which is passing through centre |   | $\frac{M[R_1^2+R_2^2]}{2}$ | $\sqrt{\frac{R_1^2+R_2^2}{2}}$ |
| | 2. Passing through centre of mass and perpendicular to its length |   | $M\left[\frac{L^2}{12}+\frac{(R_1^2+R_2^2)}{4}\right]$ | $\sqrt{\frac{L^2}{12}+\frac{R_1^2+R_2^2}{4}}$ |

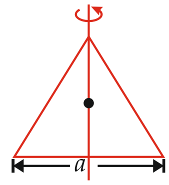
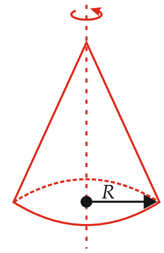
| | | | | |
|---|---|---|---|---|
| **(7)**<br>**Solid Sphere**<br>**$M$ = Mass**<br>**$R$ = Radius** | 1. About its axis OR diameter which is passing through which is |  | $\frac{2}{5}MR^2$ | $\sqrt{\frac{2}{5}}R$ |
| | 2. About tangential axis |  | $\frac{7}{2}MR^2$ | $\sqrt{\frac{7}{5}}R$ |

| | | | | |
|---|---|---|---|---|
| **(8)**<br>**Thin Spherical Shell**<br>**(Hollow Sphere)**<br>**$M$ = Mass**<br>**$R$ = Radius**<br>**(Thickness negligible)** | 1.Passing through axis or diameter |  | $\frac{2}{3}MR^2$ | $\sqrt{\frac{2}{3}}R$ |
| | 2.About tangential axis |  | $\frac{5}{3}MR^2$ | $\sqrt{\frac{5}{3}}R$ |

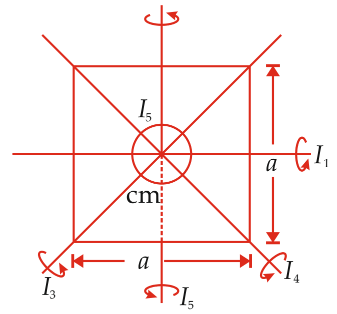
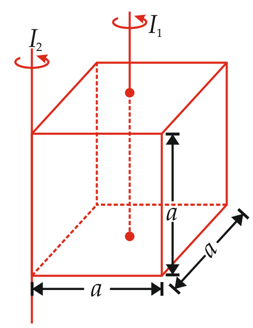
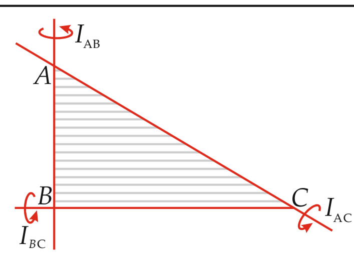
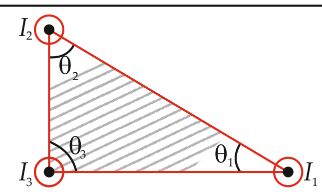
| | | | | |
|---|---|---|---|---|
| **(9)**<br>**Solid Sphere With Cavity**<br>**$r$ = Internal Radius**<br>**$R$ = Outer Radius**<br>**$M$ = Mass** | About passing through centre OR about diameter |  | $\frac{2}{5}M\frac{[R^5-r^5]}{[R^3-r^3]}$ | $\sqrt{\frac{2}{5}\frac{(R^5-r^5)}{(R^3-r^3)}}$ |

| | | | | |
|---|---|---|---|---|
| **(10)**<br>**Thin Rod**<br>**[Thickness is negligible w.r.t. length]** | 1.Passing through centre of mass and perpendicular to length |  | $\frac{ML2}{12}$ | $\frac{L}{2\sqrt{3}}$ |
| | 2.Passing through its one end and perpendicular to axis |  | $\frac{ML^2}{3}$ | $\frac{L}{\sqrt{3}}$ |

| | | | | |
|---|---|---|---|---|
| **(11)**<br>**Rectangular Plate**<br>**$a$ = Length**<br>**$b$ = Width**<br>**$M$ = Mass** | 1.About an axis passing through CM and perpendicular to side $a$ in its plane |  | $\frac{Ma^2}{12}$ | $\frac{a}{2\sqrt{3}}$ |
| | 2.About an axis passing through CM and perpendicular to side $b$ in its plane |  | $\frac{Mb^2}{12}$ | $\frac{b}{2\sqrt{3}}$ |
| | 3.About an axis passing through CM |  | $\frac{M(a^2+b^2)}{12}$ | $\sqrt{\frac{a^2+b^2}{12}}$ |

| | | | | |
|---|---|---|---|---|
| **(12) Triangular Prism** $a$ **= (Side of base and height)** | Passing through centre of mass and perpendicular triangular base face |   | $\frac{Ma^2}{6}$ | $\frac{a}{\sqrt{6}}$ |
| **(13) Cone** $R$ **= Radius** $h$ **= Height** | About the line joining of top of the cone and mid-point of base |   | $\frac{3}{10}MR^2$ | $\sqrt{\frac{3}{10}} \times R$ |

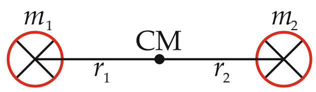
Moment of inertia of some special bodies

| | | | |
|---|---|---|---|
| **(a)** | Moment of inertia of square plate | $I_1 = I_3 = I_4 = \frac{Ma^2}{12}$ <br> $I_5 = \frac{Ma^2}{6}$ |   |
| **(b)** | Moment of inertia of cube | $I_1 = \frac{Ma^2}{6}$ <br> $I_2 = \frac{2Ma^2}{3}$ |   |
| **(c)** | In a triangle, M.I. will be maximum relative to smallest side | If $AC > BC > AB$, $I_{AC} < I_{BC} < I_{AB}$ |   |
| **(d)** | In triangle, M.I. will be maximum relative to that perpendicular axis which passes through least angle | If $\theta_1 < \theta_2 < \theta_3$, $I_1 > I_2 > I_3$ |   |
| **(e)** | Greater the mass away from axis of rotation, more will be M.I. | | |

5) Radius of gyration [k]

$$I = mk^2$$

6) Moment of inertia of two point masses




$$r = r_1 + r_2$$

$$m_1 r_1 = m_2 r_2$$

$$r_1 = \frac{m_2 r}{m_1 + m_2}$$

$$r_2 = \frac{m_1 r}{m_1 + m_2}$$

$$I = m_1 r_1^2 + m_2 r_2^2$$

$$I = \left[\frac{m_1 m_2}{m_1 + m_2}\right] r^2 = mr \cdot r^2$$

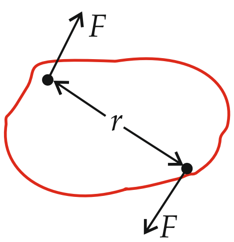
7) Torque

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\tau = rF\sin\theta$$

$$\tau = F \cdot r_1$$

Moment of couple $= Fr$




8) Angular momentum [L]

$$\vec{L} = \vec{r} \times \vec{p}$$

$$L = rmv\sin\theta$$

$$L = mvr\sin\theta$$

Law of conservation of angular momentum if there is no external torque.

$$I_1\omega_1 = I_2\omega_2$$

9) Kinetic energy of rotation

$$K.E. = \frac{1}{2}I\omega^2 = \frac{1}{2}mk^2 \cdot \frac{V^2}{R^2}$$

$$= \frac{1}{2}mV^2 \cdot \frac{k^2}{R^2} = \frac{L^2}{2I}$$

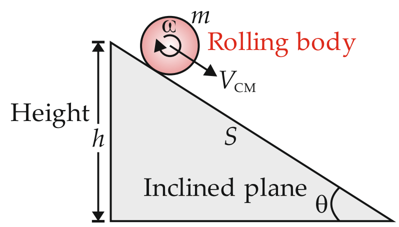
10) Rolling motion

i) Kinetic energy in rolling motion

$$K.E._{\text{rolling}} = \frac{1}{2}I\omega^2 + \frac{1}{2}MV^2$$

$$= \frac{1}{2}MV^2\left[1 + \frac{k^2}{R^2}\right]$$

ii) Rolling : motion on an inclined plane



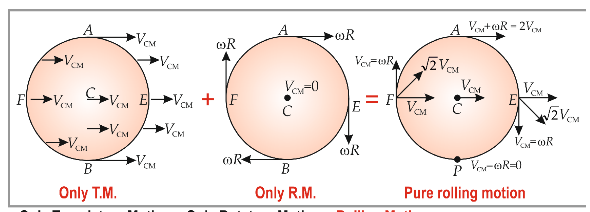

$$a = \frac{g\sin\theta}{1 + \frac{k^2}{R^2}}$$

$$V = \sqrt{\frac{2gh}{1 + \frac{k^2}{R^2}}}$$

$$t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1 + \frac{k^2}{R^2}\right)}$$

iii) Pure rolling

$$V = R\omega$$




Only Translatory Motion + Only Rotatory Motion = Rolling Motion

iv) Energy distribution in rolling motion

| Body | $\frac{K^2}{R^2}$ | $\frac{E_{\text{trans}}}{E_{\text{rotation}}} = \frac{1}{K^2/R^2}$ | $\frac{E_{\text{trans}}}{E_{\text{total}}} = \frac{1}{1+\frac{K^2}{R^2}}$ | $\frac{E_{\text{rotation}}}{E_{\text{total}}} = \frac{K^2/R^2}{1+\frac{K^2}{R^2}}$ |
|---|---|---|---|---|
| Ring | 1 | 1 | $\frac{1}{2}$ | $\frac{1}{2}$ |
| Disc | $\frac{1}{2}$ | 2 | $\frac{2}{3}$ | $\frac{1}{3}$ |
| Solid Sphere | $\frac{2}{5}$ | $\frac{5}{2}$ | $\frac{5}{7}$ | $\frac{2}{7}$ |
| Spherical Shell | $\frac{2}{3}$ | $\frac{3}{2}$ | $\frac{3}{5}$ | $\frac{2}{5}$ |
| Solid cylinder | $\frac{1}{2}$ | 2 | $\frac{2}{3}$ | $\frac{1}{3}$ |
| Hollow Cylinder | 1 | 1 | $\frac{1}{2}$ | $\frac{1}{2}$ |

# Quick Revision GRAVITATION

## TERMINOLOGY

$F$ : Force due to gravitation

$G$ : Universal gravitational constant $\left(\frac{20}{3}\times10^{-11}\right)$

$M$ : Mass of earth ($6 \times 10^{24}$ kg)

$m$ : Mass of object

$g$ : Acceleration due to gravity

$\rho$ : Density of object

$g'h$ : Acceleration due to gravity at height $h$ above

$g'd$ : Acceleration due to gravity at depth $d$

$h$ : Height above the earth surface

$d$ : Depth below the earth surface

$R$ : Radius of earth (6400 km)

$E$ : Gravitational field.

$V$ : Graivtational potential

$U$ : Gravitational potential energy.

$W$ : Work done

$V_e$ : Escae velocity

$V_c$ : Orbital or critical velocity.

$C$ : Speed of light ($3 \times 10^8$ m/s)

$\omega$ : Angular velocity

$B.E.$ : Binding energy

$K.E.$ : Kinetic energy

$V_P$ : Velocity of projection

$V_H$ : Horizontal velocity

$T$ : Time period of satellite or planet.

$a$ : Semi-major axis.

$b$ : Semi-minor axis.

$V_A$ : Areal velocity $\left(\frac{dA}{dt}\right)$

$L$ : Angular momentum.

$g'_R$ : Acceleration due to gravity due to rotation.

$g'_P$ : Acceleration due to gravity due to at a pole

$g'_{eq}$ : Acceleration due to gravity due to at a equator

$R_p$ : Radius of earth at pole.

$R_{eq}$ : Radius of earth at equator.

## DEFINITIONS

1) **Newton's law of gravitation :**

Law states that every particle on planet or universe attract every other partical by a force which is directly preportional to product of their masses and inversely proportional to square of distance between them.

2) **Acceleration due to Gravity :**

Acceleration produced in body due to gravity or gravitational pull is called as acceleration due to gravity.

3) **Gravity or Gravitational pull :**

The force of attraction due to earth on a body is called as gravity or gravitational force or gravitational pull.

4) **Gravitational field :**

The gravitational force of attraction per unit mass is called as gravitational field.

OR

A gravitational field is defined as a sphere of influence around a mass in which gravitational force has been experienced.

5) **Gravitational potential :**

Gravitational potential at a point in a gravitational field of a body is defined as amount of wokdone required to bring a mass from infinity to that point per unit mass.

6) **Gravitational potential energy :**

GPE of a body is defined as amount of workdone required to bring a mass from infinity to that point.

7) **Escape velocity :**

The minimum velocity with which a body projected to just overcome the gravitational pull of planet.

8) **Orbital velocity (critical velocity) :**

The velocity of sattelite required to put this satellite in to a circular orbit around the planet.

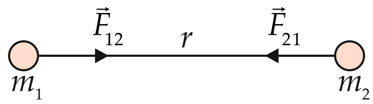
9) **Binding energy :**

The minimum amount energy required to remove a satellite from earth's gravitational influence.

## FORMULAE

**1)** $F = \dfrac{Gm_1 m_2}{r^2}$

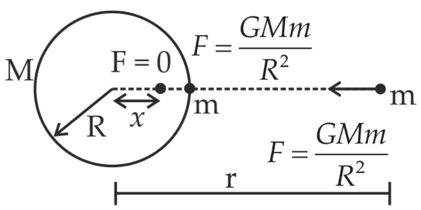
$\vec{F} = \dfrac{Gm_1 m_2}{r^2}(-\hat{r})$




**2)** Null point

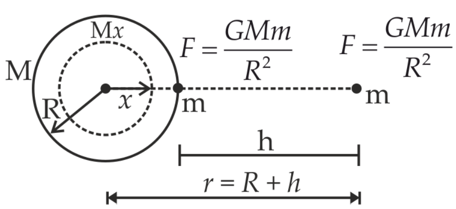
$$x = \frac{r}{\sqrt{\dfrac{m_2}{m_1}} + 1}$$

**3)** Gravitational force between spherical shell and point mass.




| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $F = 0$ | $F = \dfrac{GMm}{R^2}$ | $F = \dfrac{GMm}{R^2}$ |

**4)** Gravitational force between solid sphere and point mass.




$\rho = \rho$

$$\frac{M}{\frac{4}{3}\pi R^3} = \frac{Mx}{\frac{4}{3}\pi x^3}$$

| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $F = \dfrac{GMm}{R^3}$ | $F = \dfrac{GMm}{R^2}$ | $F = \dfrac{GMm}{R^2}$ |

**5)** Acceleration due to gravity

$\Rightarrow g = \dfrac{GM}{R^2}$ ... Surface

$\Rightarrow g'_h = \dfrac{GM}{(R+h)^2}$ or $g\dfrac{R^2}{(R+h)^2}$ .... height '$h$'

a) if $h <<<< R$

then $g'_h = g\left(1 - \dfrac{2h}{R}\right)$

$\Rightarrow g'_d = \dfrac{4}{3}\rho G(R-d)$ or $g\left(1 - \dfrac{d}{R}\right)$ .. At depth '$d$'

$g'_R = g - \omega^2 R\cos^2\theta$ ... Due to rotation of Earth

$\theta$ = Latitude

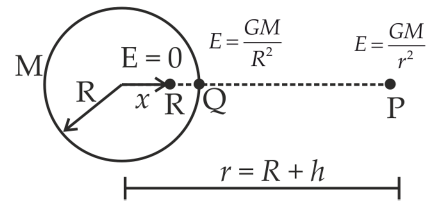
$\Rightarrow g'_p = \dfrac{GM}{R_p^2}$, $g'_{eq} = \dfrac{GM}{R_{eq}^2}$

**6)** Gravitational field : $E = \dfrac{F}{m}$

i) For point mass

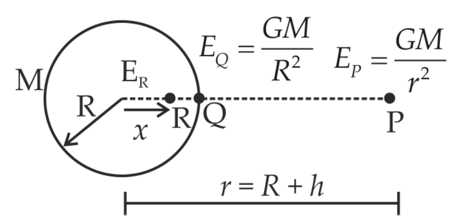

$\vec{E} = \dfrac{GM}{r^2}(-\hat{r})$

ii) For spherical shell




| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $E = 0$ | $E = \dfrac{GM}{R^2}$ | $E = \dfrac{GM}{r^2}$ |

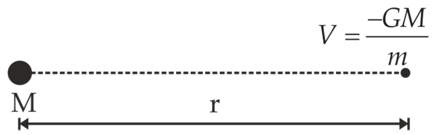
iii) For solid sphere



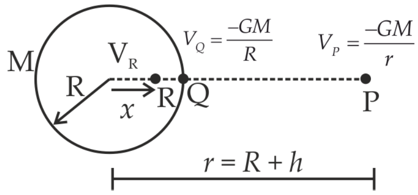

| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $E = \dfrac{GMx}{R^3}$ | $E = \dfrac{GM}{R^2}$ | $E = \dfrac{GM}{r^2}$ |

**7)** Gravitational Potential $= V = \dfrac{W}{m}$

i) For point mass :

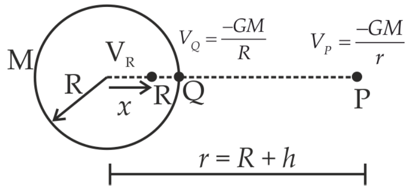



ii) For spherical shell :




| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $V_R = \dfrac{-GM}{R}$ | $V_Q = \dfrac{-GM}{R}$ | $V_P = \dfrac{-GM}{r}$ |

iii) For solid sphere :




| $x < R$ | $x = R$ | $x = r$ |
|---|---|---|
| $V_R = \dfrac{W_{\infty - R} + W_{R-x}}{m}$ $= -\dfrac{GM}{2R}\left[2 - \dfrac{x^2}{R^2}\right]$ | $V_Q = \dfrac{W_{\infty - R}}{m}$ $V_Q = -\dfrac{GM}{R}$ | $V_P = \dfrac{W_{\infty - r}}{r}$ $V_P = -\dfrac{GM}{r}$ |

**8)** Relation between V and E

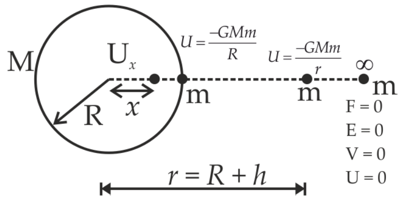
$$E = -\frac{dv}{dr}$$

$$V = -\int E\,dr$$

**9)** Gravitational potential energy

i) $U = W_{\infty - r} = -\dfrac{GMm}{r}$ ...... point mass

ii) For solid sphere (earth)




$U_x = -\dfrac{GMm}{2R}\left[3 - \dfrac{x^2}{R^2}\right]$ ..... inside earth

iii) Relation between GP and GPE

$U = Vm$

iv) $U$ on the earth surface

$U = -mgR$

v) $U$ at height ($h << R$)

$U = mgh$

**10)** Escape velocity

$V_e = \sqrt{\dfrac{2GM}{R}}$ .... from surface

$V'_e = \sqrt{\dfrac{2GM}{R+h}}$ ... from height '$h$' above

**11)** Orbital velocity

$V_C = \sqrt{\dfrac{GM}{r}}$ ...... $r = R + h$

$T = 2\pi\sqrt{\dfrac{r^3}{GM}}$

Kinetic Energy $= \dfrac{GMm}{2r}$

Potential Enegy $= \dfrac{-GMm}{r}$

Total Energy $= \dfrac{-GMm}{2r}$

Binding Energy = – Total Energy

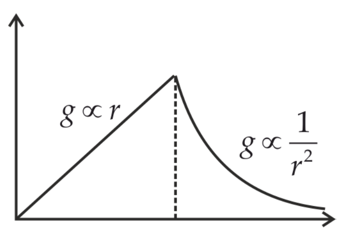
$KE = -TE = -2PE = BE$

**12)** Areal Velocity :

$V_A = \dfrac{dA}{dt} = \dfrac{L}{2m}$

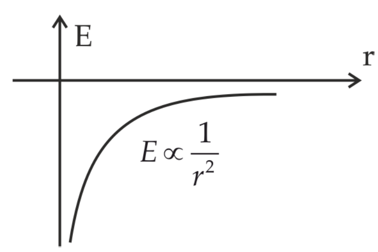
## GRAPHS

i) Acceleration due to gravity Vs. distance from center

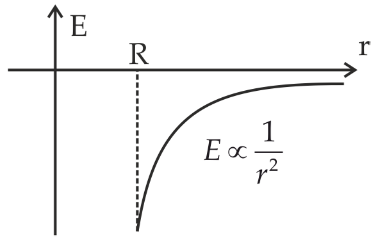



ii) E vs. Position Vector

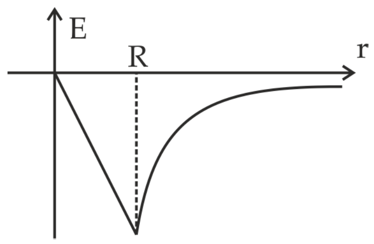
a) Point mass



b) Spherical Shell

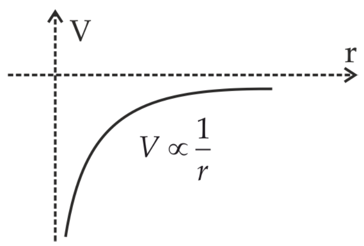



c) Solid Sphere

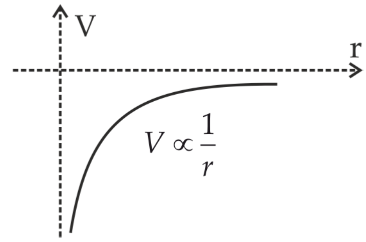



iii) $V$ vs. position (Distance)

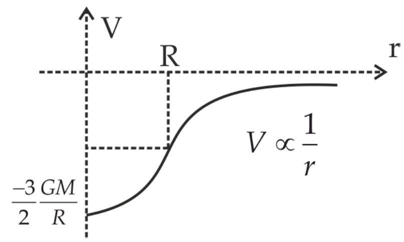
a) Point mass



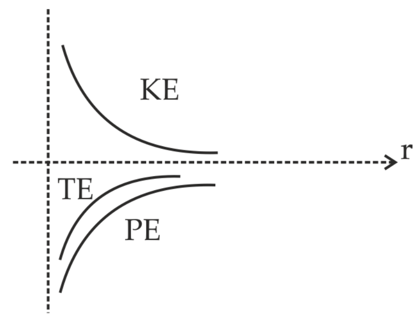

b) Spherical shell




c) Solid sphere




iv) Energy



# Quick Revision MECHANICAL PROPERTIES OF SOLIDS

## TERMINOLOGY

| | | |
|---|---|---|
| $F$ | : | External force |
| $A$ | : | Area of cross section |
| $\Delta l$ | : | Change in length |
| $L$ | : | Original length |
| $\Delta V$ | : | Change in volume |
| $V$ | : | Original volume |
| $\theta$ | : | Shear strain |
| $Y$ | : | Young's modulus |
| $K$ | : | Bulk modulus |
| $\eta$ | : | Shear modulus |
| $E$ | : | Modulus of elasticity |
| $\sigma$ | : | Poisson's ratio |
| $P$ | : | Breaking stress |
| $C$ | : | Compressibility |
| $\alpha$ | : | Angle of twist |
| $\beta$ | : | Angle of shear |
| $W$ | : | Work done |
| $U$ | : | Elastic potential energy |
| $\rho_f$ | : | Final density |
| $\rho_i$ | : | Initial density |
| $K_t$ | : | Isothermal elasticity |
| $K_\phi$ | : | Adiabatic elasticity |
| $v$ | : | Heat capacity |

## DEFINITIONS

1) **Elasticity:**
The property of matter by virtue of which body regains its original size and shape after removal of deforming force is called as elasticity.

2) **Deforming force:**
The force which produces deformation is called as deforming force.

3) **Deformation:**
The change in size, shape or both in a body arising due to external force called as deformation.

4) **Plasticity:**
The property of matter to undergo a permanent deformation after removal of deforming force is called as plasticity.

5) **Rigid body:**
The body which is having regular shape.

6) **Stress:**
Internal restoring force (external force) per unit area.

7) **Longitudinal stress:**
When applied force / deforming force produces change in length of body is called as longitudinal force.

8) **Volume stress:**
When deforming force produces change in its volume of body is called as volume stress (also called as change in pressure).

9) **Shear stress:**
When applied force produces change in its shape only of body is called shear stress.

10) **Strain:**
The ratio of change in dimension by original dimension is called strain.

11) **Longitudical strain:**
Longitudinal strain or tensile strain is the ratio of change in length to the original length.

12) **Volume strain (Bulk strain):**
It is the ratio of change in volume to the original volume.

13) **Shear strain:**
Ratio of change in shape by original shape.

*OR*

The applied force produces change in shape (cube to parallelopiped) the strain is called as shear strain.

14) **Elastic limit:**
The maximum deforming force up to which body regains its original size and shape is called as elastic limit.

15) **Hooke's law:**
It states that within elastic limit stress is directly proportional to strain.

16) **Modulus of elasticity:**

It is a slope of stress-strain graph within elastic limit.

17) **Young's modulus:**

Within elastic limit, it is the ratio of longitudinal (tensile) stress to longitudinal strain.

18) **Bulk modulus:**

Within elastic limit, it is the ratio of volume stress to the volume strain.

It measures the resistance offered by solid, liquid and gas to change its volume.

19) **Shear modulus (Modulus of rigidity):**

Within elastic limit, it is the ratio of shear stress to shear strain.

It measures the resistance offered by solids to change in its shape.

20) **Compressibility:**

The reciprocal of bulk modulus of elasticity is called compressibility.

21) **Poisson's ratio:**

Within elastic limit, it is the ratio of lateral strain to longitudinal strain.

22) **Lateral strain:**

Strain developed in the direction perpendicular to the applied deforming force.

23) **Longitudinal strain:**

Strain developed in the direction of applied deforming force.

24) **Strain energy:**

It is defined as elastic potential energy stored by wire during elongation or compression by deforming force.

Area of stress-strain graph gives work done or elastic potential energy stored in stretched wire per unit volume.

Molecules having mininum potential energy when they are in stable equibrium position, for any other position potential energy increases.

## FORMULAE

1) Stress = $\dfrac{F}{A_{C/S}}$

= Longitudinal stress

2) Volume stress = $\dfrac{F}{\text{Total area}} = \Delta P$

3) Shear stress $= \dfrac{\text{Tangential force}}{A} = \dfrac{F_t}{A}$

4) Longitudinal strain = $\dfrac{\Delta l}{L}$

5) Volume strain = $-\dfrac{\Delta V}{V}$

6) Shear strain $= \theta = \dfrac{\Delta x}{L}$

7) $E = \dfrac{\text{Stress}}{\text{Strain}}$

8) $Y = \dfrac{FL}{A\Delta L}$

9) Breaking stress $= P = \dfrac{\text{Breaking force}}{\text{C/ S Area}}$

10) $K = \dfrac{\Delta P}{-\Delta V / V}$

11) $C = \dfrac{1}{K}$

12) $\rho_f = \rho_i[1 + C\Delta P]$

13) $K_t$ = Pressure

14) $K_\phi = v \times$ Pressure

15) Shear modulus, $\eta = \dfrac{F_t}{A\theta}$ or $\dfrac{F_t L}{A\Delta x}$

16) $\beta = \dfrac{\alpha r}{L}$ = Angle of shear

**17)** Relation between $Y$, $K$ and $\eta$:

$$\frac{9}{Y} = \frac{3}{\eta} + \frac{1}{K}$$

**18)** $\sigma = \dfrac{\Delta r / r}{\Delta L / L}$ Value $0 \le \sigma \le 0.5$

**19)** Relation between $Y$, $K$, $\eta$ and $\sigma$:

$$Y = 3K(1 - 2\sigma)$$

$$Y = 2\eta(1 + \sigma)$$

**20)** Work done = Change in potential energy

$$W = U = \frac{1}{2} \times \text{Force} \times \text{Elongation}$$

$$W = U = \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume}$$

$$W = U = \frac{1}{2Y} \times \text{Stress}^2 \times \text{Volume}$$

$$W = U = \frac{1}{2} \times Y \times \text{Strain}^2 \times \text{Volume}$$

**21)** Elongation due to self weight

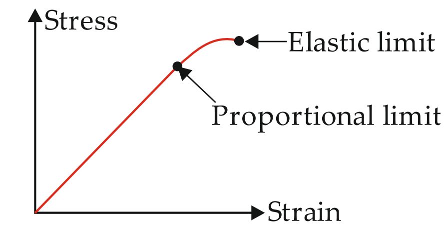
$$\Delta L = \frac{Mg \times L}{2AY}$$

**22)** Breaking stress due to self weight

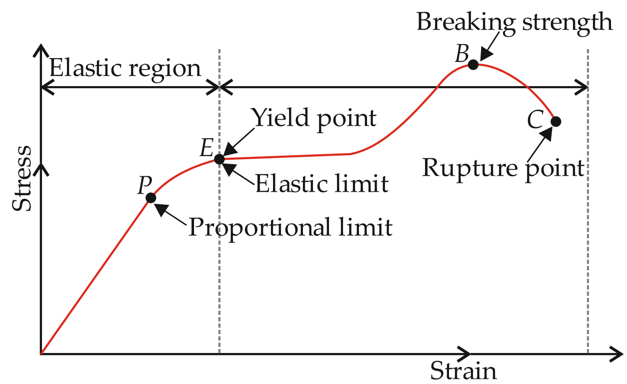
$$P = \frac{Mg}{A}$$

## GRAPHS

**1) Hooke's law:**



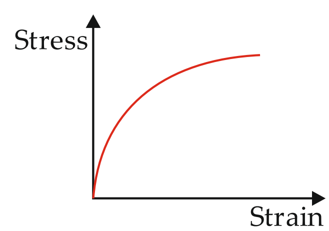

**2) Stress–Strain Graph:**




$B$ & $C$ Distance
- → Small then material is brittle
- → Large then material is ductile
- → Very very small then elastomer

**3) Elastomer:**

⇒ Stress is not directly proportional to strain
Does not obey Hooke's law.



# Quick Revision MECHANICAL PROPERTIES OF FLUIDS

## TERMINOLOGY

| | | |
|---|---|---|
| $dv/dt$ | : | Velocity Gradient |
| $A$ | : | Area |
| $\eta$ | : | Coefficient of Viscosity |
| $\tau$ | : | Shearinag stress |
| $F_v$ | : | Viscous force |
| $W$ | : | Weight |
| $F_B$ | : | Buoyancy force |
| $V_t$ | : | Terminal velocity |
| $\sigma$ | : | Density of ball (spherical object) |
| $\delta$ | : | Density of fluid |
| $r$ | : | Radius of sphere |
| $g$ | : | Acceleration due to gravity |
| $R_e$ | : | Reynold's number |
| $P$ | : | Pressure |
| $Q$ | : | volumetric flow (Discharge) |
| $L$ | : | Length |
| $V_{sub}$ | : | Submerged volume |
| $H$ | : | Total height of tank |
| $h$ | : | Height of hole |

## DEFINITIONS

1) **Viscosity :**
The characteristic of fluid by virtue of which relative motion between different layers is opposed is known as viscosity.
Viscosity is internal friction of a fludi in motion.

2) **Critical Velocity :**
The maximum velocity up to which fluid motion is steady is called critical velocity.

3) **Laminar flow :**
Flow in which one liquid particle never cross a path of other liquid particle.

4) **Reynold's number :**
It can be defined as a ratio of inertia force to viscous force.

$R_e \le 2000$ ... Laminar flow

$3000 > R_e > 2000$ ... transition flow

$R_e > 3000$ ... Turbulent flow

## FORMULAE

1) $F_v = -\eta A \dfrac{dv}{dt}$

2) $\tau = \dfrac{F_v}{A} = \eta \dfrac{dv}{dt}$

3) 1 poise = 0.1 N.s/m$^2$

4) $F_v = 6\pi\eta r v$

5) $F_B = \rho V_{sub} g$ $\quad$ $\rho$ = density of liquid

6) $R_e = \dfrac{\rho V d}{\eta}$

7) $V_t = \dfrac{2r^2(\sigma - \rho)g}{g\eta}$

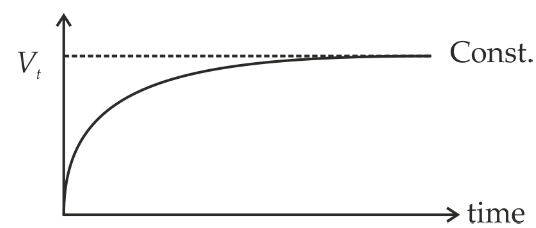
8) $Q = AV$

9) Velocity of efflux $V = \sqrt{2gh}$

10) Range of efflux $R = 2\sqrt{h(H-h)}$

11) $Q = A_1 A_2 \sqrt{\dfrac{2gh}{A_1^2 - A_2^2}}$

## GRAPHS



# Quick Revision SURFACE TENSION

## TERMINOLOGY

T or $\sigma$ or $s$ : Surface Tension

$F$ : Force due to surface tension

$l$ : Length of object in contact with liquid surface (for circular object it is circumference)

$W$ : Work done

$\Delta A$ : Total change in surface area.

$\Delta Q$ : Increase or decrease in temperature

$J$ : Mechanical equivalent of heat.

$V$ : Volume

$d$ or $\rho$ : Density

$S$ : Spacific heat

$\Delta P$ : Pressure difference

$\theta$ : Angle of contact

$h$ : Rise in capillary

$t$ : Thickness between two plate.

## DEFINITIONS

1) **Surface Tension :**

Surface tension of liquid is measured by the force acting per unit length on either side of an imaginary line drawn on the free surface of liquid.

2) **Surface Energy :**

The potential energy stored in surface film per unit surface area is called as surface energy per unit area.

3) **Angle of Contact :**

When liquid is in contact with solid, the angle between tangent drawn to the free surface of liquid and the surface of solid at the point of contact measured inside the liquid.

4) **Capillarity :**

The phenomena of rise or fall or a liquid inside a capillary tube when it is dipped in the liquid is called capillaryity.

5) **Sphere of Influence :**

An imaginary sphere around a molecule in which intermolecular force has been experienced is called as sphere of influence.

## FORMULAE

1) Surface Tension (T) = $\frac{F}{l}$

2)

| Name of object | Length |
|---|---|
| i) Wire | $2l$ |
| ii) Ring | $2\times 2\pi r$ |
| iii) Circular plate | $2\pi r$ |
| iv) Hollow disc | $2\pi r_1 + 2\pi r_2$ |
| v) Square plate | $4l$ |
| vi) Square frame | $8l$ |

3) $W = T\times\Delta A$

4)

| Name of object | Surface Area |
|---|---|
| Droplet | $4\pi r^2$ |
| Bubble | $2\times 4\pi r^2$ |
| Air bubble inside liquid | $4\pi r^2$ |

5) Formation of smaller droplet from bigger

$W = 4\pi T[nr^2 - R^2]$ ... Energy absorbed

Or

$$W = 3VT\left[\frac{1}{r}-\frac{1}{R}\right]$$

$$\Delta\theta = \frac{3T}{JSd}\left[\frac{1}{r}-\frac{1}{R}\right]$$ ... Temperature Decreased

6) Formation of bigger droplet from smaller

$W = 4\pi T[nr^2 - R^2]$ ... Energy released

Or

$$= 3VT\left[\frac{1}{r}-\frac{1}{R}\right]$$

$$\Delta\theta = \frac{3T}{JSd}\left[\frac{1}{r}-\frac{1}{R}\right]$$ ... Temperature increased

7) Excess pressure ( $\Delta P$ )

$\Delta P = \frac{2T}{r}$ ... For droplet and Air bubble inside liquid

$\Delta P = \frac{4T}{r}$ ... For bubble

**8)** $h = \dfrac{2T\cos\theta}{\rho r g}$

$h \propto \dfrac{1}{r}$ or $hr$ = constant or $h_1 r_1 = h_2 r_2$

| $h\downarrow$ | $r\uparrow$ | $\theta\uparrow$ |
|---|---|---|
| (tube) | (meniscus radius) | (Angle of contact) |

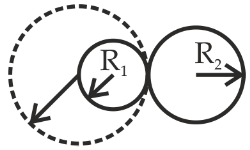
**9)** Formation of single bubble or droplet from two bubble or droplet in isothermal condition


$c = \sqrt{a^2 + b^2}$

**10)** Formation of Double bubble :

$\dfrac{1}{R} = \dfrac{1}{R_1} - \dfrac{1}{R_2}$

$R = \dfrac{R_1 R_2}{R_2 - R_1}$

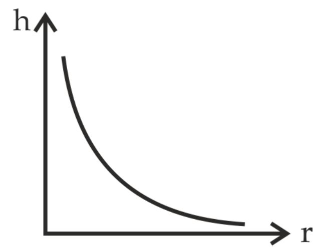



**11)** Force required to pull two plate (JEE concept)

$F = \dfrac{2TA}{t}$

## GRAPHS

Rise in capillary Vs radius of tube



# Quick Revision THERMAL PROPERTIES OF MATTER

## TERMINOLOGY

$T_C$ : Temperature in °C
$T_k$ : Temperature in °K
$x_0$ : Thermometric property at 0°C
$x_{100}$ : Thermometric property at 100°C
$x_t$ : Thermometric property at t°C
$l$ : Length
$V$ : Volume
$P$ : Pressure
$R$ : Resistance
$\alpha$ : Linear expansion coefficient
$\beta$ : Coeficient of areal expansion
$\gamma$ : Coeficient of volume expansion
$\rho$ : Density
$T$ : Time period
$Y$ : Young's modulus
$v_{app}$ : Apparent coefficient of volume expansion
$W$ : workdone
$J$ : Mechanical equivalent of heat (4.2 J/cal)
$Q$ : Heat
$S$ : Specific heat capacity
$\Delta\theta$ : Change in temperature
$C$ : Molar heat capacity
$M$ : Molecular weight
$L$ : Latent heat
$L_F$ : Latent heat of fusion
$K$ : Coefficient of thermal conductivity
$A$ : Area of cross-section
$i$ : Heat current
$R$ : Thermal resistance
$E$ : Emissive power
$\Delta U$ : Energy radiator
$a$ : Absorptive power
$\sigma$ : Stefans constant (5.67 × $10^{-8}$ W/m$^2$k$^4$)
$e$ : Emmissivity of the surface
$S$ : Solar constant

## DEFINITIONS

1) **Temperature :**
It is defined as degree of coldness or hotness of a body and it is measured by thermometer.

2) **Zeroth law of Thermodynamics :**
If two bodies $x$ and $y$ are are in equlibrium and $x$ and $z$ are in equilibrium then $y$ and $z$ are in equilibrium.

3) **Heat :**
is energy in transit which is transfered from one body to other due to temperature difference between them.

4) **Heat Capacity :**
The heat required to raise the temperature of body by 1°C is called heat capacity.

5) **Water equivalent :**
Water equivalent of a body is the mass of water having the same heat capacity as a given body

6) **Latent heat :**
The amount of heat required to change the state of unit mass of a substance at a constant temperature is called latent heat.

7) Thermal conductivity is a measure of the ability of a substance to conduct heat through it.

8) **Black body :**
A body which absorb all the radiation falling on it is caused black body.

8) **Emissive power :**
Emissive is the energy radiated per unit area per unit time per unit solid angle along the normal to the area.

9) **Absorptive power :**
Absorptive power is a fraction of the incident radiation that is absorbed by the body.

## FORMULAE

1) $$t=\frac{t_t-t_0}{t_{100}-t_0}\times 100°C$$

2) $$\frac{C-0}{100-0}=\frac{F-32}{212-32}=\frac{K-273.15}{373.15-273.15}$$

3) Liquid thermometer : $t=\dfrac{l-l_0}{l_{100}-l_0}\times 100°C$

4) Gas thermometer : $t=\dfrac{V-V_0}{V_{100}-V_0}\times 100°C$

$$t=\frac{P-P_0}{P_{100}-P_0}\times 100°C$$

5) Resistance thermometer : $t=\dfrac{R-R_0}{R_{100}-R_0}\times 100°C$

6) Thermal expansion

a) Linear expansion $L_2 = L_1[1+\alpha\Delta\theta]$

b) Area expansion $A_2 = A_1[1+\beta\Delta\theta]$

c) Volume expansion $V_2 = V_1[1+\gamma\Delta\theta]$

d) pendulum clock time period

$$T_2 = T_1\left[1+\frac{1}{2}\alpha\Delta\theta\right]$$

e) Density $\rho_2 = \rho_1[1-\gamma\Delta\theta]$

7) Thermal stress $\sigma_t = \gamma\Delta\theta$

8) $\Delta V_{app} = V\gamma_{app}\Delta\theta$ where $\gamma_{app} = \gamma_1 - \gamma_\rho$

9) $W = JQ$

10) $\theta = ms\Delta\theta$, $\theta = nc\Delta\theta$, $\theta = mL$

11) Heat lost = Heat gained
While solving problems, when temperature change is involved, use $\theta = ms\Delta\theta$ or $nc\Delta\theta$, when state change is involved, use $\theta = mL$

12) $\dfrac{\Delta\theta}{\Delta t} = \dfrac{KA(\theta_1-\theta_2)}{L}$

$$\frac{d\theta}{dt} = -KA\frac{d\theta}{dx}$$

$$\Delta\theta = \frac{\Delta\theta}{\Delta t}\times\frac{L}{KA} = iR$$

13) $K_{eq}$

a) Series $\dfrac{1}{K_{eq}} = \dfrac{1}{K_1}+\dfrac{1}{K_2}$.........

b) Parallel $K_{eq} = K_1 + K_2 + K_3$......

14) $E = \dfrac{\Delta U}{\Delta A\Delta t\Delta\omega}$

15) $u = \sigma AT^4$

16) Rate of cooling $-\dfrac{dT}{dt} = \dfrac{e\sigma A}{ms}(T^4 - T_0^4)$

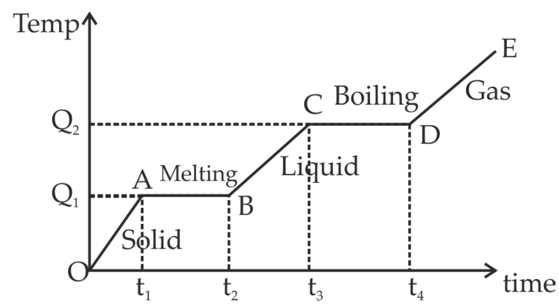
Newtons law $-\dfrac{dT}{dt} = -K(T-T_0)$

$$K = \frac{4e\sigma AT_0^3}{ms}$$

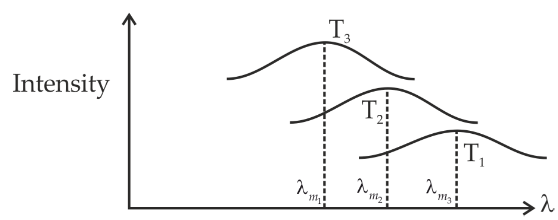
17) Wien's law $\lambda_m T$ = b = constant
b = 0.288 cm-k

## GRAPHS

1) **Heating Curve**




2)



# Quick Revision THERMODYNAMICS

## TERMINOLOGY

| | | |
|---|---|---|
| $n$ | : | Number of moles of gas. |
| $c$ | : | Molar specific heat capacity. |
| $c_p$ | : | Molar specific heat capacity at constant pressure. |
| $c_v$ | : | Molar specific heat capacity at constant volume. |
| $R$ | : | Universal gas constant. |
| $T$ | : | Absolute temperature of gas. |
| $Q$ | : | Heat energy supplied to the gas. |
| $w$ | : | Work done by the gas. |
| $u$ | : | Internal energy of gas. |
| $\Delta u$ | : | Change in internal energy of gas. |
| $\eta$ | : | Efficiency |
| $\gamma$ | : | Adiabatic exponent $\left(\gamma = \frac{c_p}{c_v}\right)$ |
| $P$ | : | Pressure exerted by gas. |
| $V$ | : | Volume occupied by gas. |
| $f$ | : | Degree of freedom. |
| $k$ | : | Boltzmann constant $\left(k = \frac{R}{N_A}\right)$ |
| F.L.T. | : | First law of thermodynamics. |

## DEFINITIONS

1) **Heat ($\theta$) :**
It is the energy which is transfered from a system to surroundings (or) vice versa due to temperature difference between system and surroundings.
→ It is a macroscopic quantity.
→ Path dependent.

2) **Work :**
Work is the energy that is transmitted from one system to other by a force moving its points of application.
→ It is a macroscopic quantity.
→ Path dependent.

3) **Internal energy :**
The total kinetic energy of gas and gas molecule. $u \propto T$

4) **Isothermal process :**
A thermodynamic process in which the temperature of the system remains constant throughout.

5) **Adiabatic process :**
If system is completely isolated from surroundings so that no heat flows 'in' or 'out', then any change that the system undergoes is called an adiabatic process.

6) **Iso-baric process :**
A process taking place at constant pressure throughout.

7) **Isochoric (Isometric) process :**
Thermodynamic process in which volume of the system remains constant throughout.

8) **Cyclic process :**
The process in which the initial and final states of gas after traversing a cycle are same.

9) **Second laws of thermodynamics :**
It states that it is impossible for a self acting machine unaided by any external agency, to transfer heat from a body at lower temperature to a body at higher temperature. It is decided from this law that, the efficiency of any heat engine can never be 100%.

10) **Heat engine :** It is a device which converts heat energy into mechanical energy.

11) **Refrigerator :**
Refrigerator is a heat engine running in backward direction i.e., working substance takes heat from cold body and gives out to hotter body with the help of external agency.

12) **Carnot's theorem :**
It states that no heat engine can have efficiency greater than carnot's engine working between same hot and cold reservair.

13) **Reversible process :**
A process which can proud in opposite direction in such a way, that the system passes through the same states as in the direct process and finally the system and surroundings acquire the initial conditions.

14) **Irreversible process :**
The process which cannot be traced back in the opposite direction.

## FORMULAE

**1)** First law of thermodynamics

$\theta = \Delta u + \omega$

$\theta = nc\Delta T \Rightarrow$ heat energy supplied to gas.

$\Delta u = nG\Delta T \Rightarrow$ change in internal energy of gas.

$\omega = \int_{v_1}^{\frac{1}{2}} \rho dV \Rightarrow$ work doen by the gas.

**2)** Isothemal process :

a) condition T = constant throughout

b) State equation $pv$ = constant

$(P_1V_1 = P_2V_2)$

c) F.L.T. $\Rightarrow \Delta u = nc_v \Delta T = 0$ ; $(\because \Delta T = 0)$

$\therefore \theta = \omega$

d) Work done by the gas $\omega = \eta RT \ln\left(\frac{u_2}{u_1}\right)$

$= \eta RT \ln\left(\frac{P_1}{P_2}\right)$

**3)** Iso-baric process :

a) Condition $p$ = constant throughout

b) State equation $\frac{V}{T}$ = constant. $\left(\frac{V_1}{T_1} = \frac{V_2}{T_2}\right)$

c) F.L.T. $\Rightarrow \theta = \Delta u t \omega$

d) Work done by the gas $\omega = P(\Delta V) = \eta R(\Delta T)$

**4)** Iso-choric process : (Isometric process)

a) Condition : $v$ = cconstant throughout

b) State equation $\frac{P}{T}$ = constant $\Rightarrow \left(\frac{P_1}{T_1} = \frac{P_2}{T_2}\right)$

c) F.L.T. $\Rightarrow \theta = \Delta u; (\because \omega = 0)$

d) Work done by the gas $\Rightarrow \omega = 0$ ;

$(\because$ $v$ = constant)

**5)** Adiabatic process :

a) Condition $\Rightarrow \theta = 0$

b) State equation $\Rightarrow PV^{\gamma}$ = constant

$TV^{\gamma-1}$ = constant

$P^{1-\gamma}T^{\gamma}$ = constant

c) F.L.T. $\Rightarrow \Delta u + \omega = 0$ ; $(\because \theta = 0)$

d) work done by the gas

$$\omega = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{\eta R(T_1 - T_2)}{\gamma - 1}$$

**6)** Cyclic process :

a) Initial and final states are same.

b) $\Delta u = 0$

c) Work done by gas = Area inside cycle.

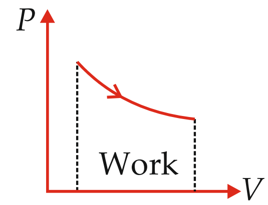
$\omega$ = +ve for clockwise cycle and –ve for anti-clockwise cycle.

d) $\theta_{net} = \omega$ ; $(\theta_{net} = \theta_{supplied} - \theta_{released})$

e) $\eta_{cycle} = \frac{\omega}{\theta_{supplied}}$

**7)** Molar specific heat capacity for a polytropic process with state equation $PV^h$ = constant is given by $C = C_V + \frac{R}{1-n}$

**8)** Area covered by $P$-$V$ graph with volume axis gives work done by the gas.




**9)** Bulk modulus of gas $B_{isothermal} = P$

$B_{adiabatic} = \gamma P$

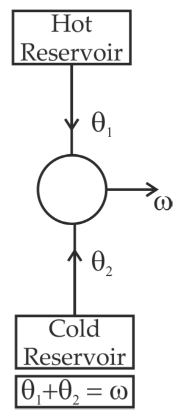
**10)** Efficiency of heat engine :

efficiency $= \frac{c/p}{i/p} \Rightarrow \eta = \frac{\omega}{\theta_1}$

$\therefore \eta = \frac{\omega}{\theta_1} = 1 - \frac{\theta_2}{\theta_1}$

for carnot engine '$\eta$' is maximum is given by

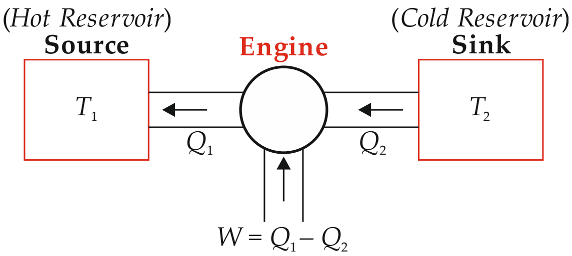
$\eta_{max} = 1 - \frac{\theta_2}{\theta_1} = 1 - \frac{T_2}{T_1}$




**11)** Refrigerator

Co-efficient of performance

$\beta = \frac{\theta_1}{\omega} = \frac{\theta_1}{\theta_2 - \theta_1}$ $\Rightarrow \beta = \frac{T_1}{T_2 - T_1}$

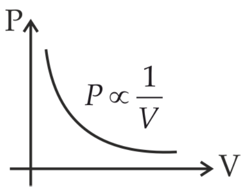


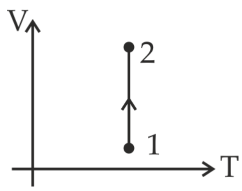

**12)** Relation between "$\eta$" and "$\beta$"

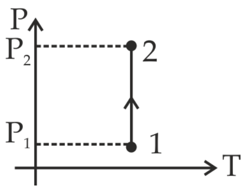
$\beta = \frac{1-\eta}{\eta}$

## GRAPHS

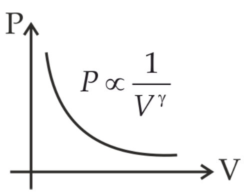
**1)** Iso-thermal process :



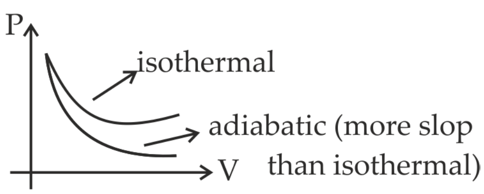



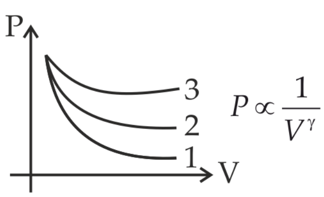

**2)** Adiabatic process :




**3)** Iso-thermal and Adiabatic comparison :




**4)** Comparison of mono, dia and polyatomic gases for adiabatic process




more $\gamma \rightarrow$ more slope $\therefore\ \gamma_1 > \gamma_2 > \gamma_3$

$\therefore$ 1 $\rightarrow$ monoatomic $\Rightarrow \gamma = \frac{5}{3}$

2 $\rightarrow$ diatomic gas $\Rightarrow \gamma = \frac{7}{5}$

3 $\rightarrow$ polyatomic gas $\Rightarrow \gamma = \frac{4}{3}$

**5)** What does the slope of $P$-$V$ graph gives ..?

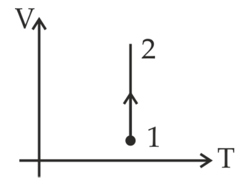
a) for isothermal process graph

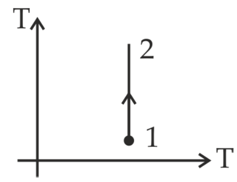
$$\text{slope} = \frac{dP}{dV} = -\frac{P}{V}$$

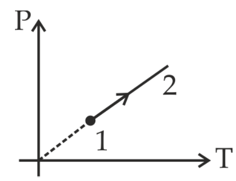
b) for adiabatic graph

$$\text{slope} = \frac{dP}{dV} = -\gamma\left(\frac{P}{V}\right)$$

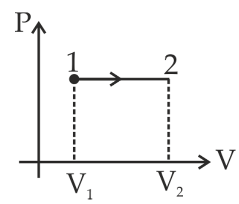
**6)** Iso-choric process :

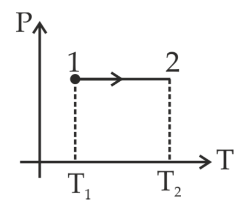


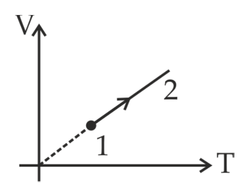




**7)** Iso-baric process :



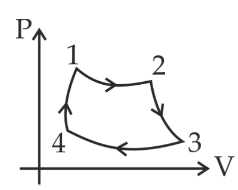




**8)** Carnot's cycle :

$T_1 = T_2 = T_H$ (temperature of hot reservior)

$T_3 = T_4 = T_C$ (temperature of cold reservior)

$$\eta_{\text{cycle}} = 1 - \frac{T_C}{T_H}$$




1 $\rightarrow$ 2 $\Rightarrow$ isothermal expansion
2 $\rightarrow$ 3 $\Rightarrow$ adiabatic expansion
3 $\rightarrow$ 4 $\Rightarrow$ isothermal compression
4 $\rightarrow$ 1 $\Rightarrow$ adiabatic compression

Quick Revision

# KINETIC THEORY OF GASES

## TERMINOLOGY

$P$ : Pressure exerted by the gas
$V$ : Volume occupied by the gas
$n$ : Number of moles of the gas
$R$ : Universal gas constant
$T$ : Absolute temperature of gas
$M$ : Molar mass of the gas
$m$ : Mass of gas sample
$\mu$ : Molecular mass of the gas
$K$ : Boltzmann constant
$C$ : Specific heat capacity
$C_p$ : Specific heat capacity at constant pressure
$C_v$ : Specific heat capacity at constant volume
$\rho$ : Density of gas
$N$ : Number of molecules
$N_A$ : Avagadro's number
$\gamma$ : Adiabatic exponent ($C_p / C_v$)
$f$ : Degree of freedom
$v$ : Speed of gas molecules
$Q$ : Heat energy
$U$ : Internal energy of gas

## DEFINITIONS

1) **Gas:**
Type of matter that does not have any fixed shape or volume.

2) **Ideal gas:**
Gas in which, size of molecule and force of interaction between molecules is considered zero.

3) **Real gas:**
The gas that shows deviation from ideal gas behaviour is called a real gas.

4) **Avagadro's number ($N_A$):**
It is the number of carbon atoms contained in 12 gms of C-12 carbon.
$N_A = 6.023 \times 10^{23}$

5) **Boyle's law:**
It states that the volume of a given amount of gas varies inversely as its pressure, provided its temperature is kept constant.
$PV = \text{Constant}$

6) **Charle's law:**
It states that, volume of given mass of gas varies directly proportional to its absolute temperature, given its pressure is constant.

$$\frac{V}{T} = \text{Constant}$$

7) **Dalton's law of partial pressure:**
Partial pressure of a gas is the pressure which it would exert if contained alone in the given confined space.
$P = P_1+P_2+P_3$
$P$ = Total pressure of mixture of gases
$P_1+P_2+P_3$ = Partial pressure of individual gases in mixture

8) **Graham's law of diffusion:**
Graham's law of diffusion states that, rate of diffusion of gas varies inversely as the square root of density of gas.

$$r \propto \frac{1}{\sqrt{\rho}}$$

9) **Avagadro's law:**
It states that under similar conditions of pressure and temperature equal volumes of all gases contain equal number of molecules.
$PV = nRT$

10) **Root mean square speed ($v_{rms}$):**
It is the square root of the mean of squares of individual speeds of the molecules of gas.

11) **Average speed:**
It is the arithmetic mean of speed of the molecules of a gas.

12) **Most probable speed:**
It is the speed possessed by maximum number of molecules of a gas sample.

13) **Degree of freedom:**
Number of possible independent ways in which the position and configuration of the system may change.

14) **Law of equipartition of energy:**
In a gas sample, in thermal equilibrium, the total internal energy of the gas is divided equally among all the degree of freedom.

15) **Gram specific heat capacity ($c$):**
Amount of heat energy required by unit mass of gas to rise its temperaure by 1°C (or) 1 K.

**16) Molar specific heat capacity ($c$):**
Amount of heat energy required by 1 mole of gas in order to rise its temperature by 1°C or 1 K.

**17) Heat capacity:**
Heat energy consumed by gas sample to rise is temperature by 1°C or 1 K.

**18) Adiabatic exponent ($\gamma$):**
It is the ratio of $C_p$ to $C_v$ of a gas.

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

## FORMULAE

**1)** Ideal gas equation:

a) $PV = nRT$

b) $P = \frac{\rho RT}{M}$

c) $P = \frac{\rho KT}{\mu}$

d) $PV = NKT$

**2)** Real gas equation:

$$\left[P + \frac{n^2 a}{V^2}\right](V - nb) = nRT$$

where $a$, $b$ are Vander waal's constants

**3)** Pressure exerted by a gas

$$P = \frac{2}{3}e$$

where $e$ is translational KE per unit volume of gas.

and $P = \frac{1}{3}\rho v_{rms}^2$ ; $\rho$ = Density of gas

**4)** R.M.S. speed,

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3KT}{\mu}}$$

Average speed,

$$v_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8P}{\pi\rho}} = \sqrt{\frac{8KT}{\pi\mu}}$$

Most probable speed,

$$v_{mp} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2P}{\rho}} = \sqrt{\frac{2KT}{\mu}}$$

**5)** In a given gas sample $v_{rms} > v_{avg} > v_{mp}$

$$v_{rms} : v_{avg} : v_{mp} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$$

**6)** Translational K.E. of a gas,

$$\text{K.E.}_T = \frac{3}{2}nRT$$

**7)** Energy per molecule per degree of freedom is

$$\frac{1}{2}KT$$

**8)** Energy per mole per degree of freedom is

$$\frac{1}{2}RT$$

**9)** Internal energy ($U$):

For one molecule $= \frac{f}{2}KT$

For $n$ moles of gas $= \frac{f}{2}nRT$

**10)** Change in internal energy of a gas sample is,

$$\Delta U = \frac{f}{2}nR\Delta T = nC_v\Delta T$$

**11)** For a given gas,

a) $C_v = f\frac{R}{2}$

b) $C_p - C_v = R$
(If $C_p$ & $C_v$ are molar specific heat capacities)

c) $C_p - C_v = \frac{R}{M}$
(If $C_p$ & $C_v$ are gram specific heat capacities)

d) $\frac{C_p}{C_v} = \gamma$

e) $\gamma = 1 + \frac{2}{f}$

f) $C_v = \frac{R}{\gamma - 1}$ ; $C_p = \frac{\gamma R}{\gamma - 1}$

**12)** Degree of freedom ($f$) (Excluding vibrational energies):

i) Monoatomic = 3, (3 Translational)

ii) Diatomic (or) polylinear = 5, (3 Translational + 2 Rotational)

iii) Poly non-linear = 6, (3 Translational + 3 Rotational)

**13)** For a mixture of gases:

$$C_{p(\text{mix.})} = \frac{n_1 C_{p_1} + n_2 C_{p_2} + \ldots..}{n_1 + n_2 + \ldots..}$$

$$C_{v(\text{mix.})} = \frac{n_1 C_{v_1} + n_2 C_{v_2} + \ldots..}{n_1 + n_2 + \ldots..}$$

$$\gamma_{\text{mix}} = \frac{C_{p(\text{mix})}}{C_{v(\text{mix})}}$$

Absolute temperature of mixture,

$$T_{\text{mix.}} = \frac{f_1 n_1 T_1 + f_2 n_2 T_2 + \ldots..}{f_1 n_1 + f_2 n_2 + \ldots..}$$

**14)** Heat energy supplied to a gas

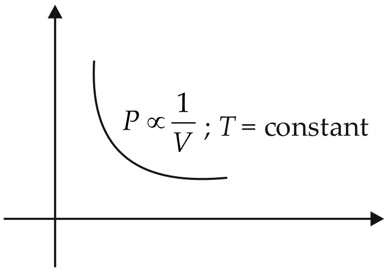
$Q = mC_{ab}\Delta T$ or $Q = nC_{\text{molar}}\Delta T$

$C_{ab}$ = gram sp. heat capacity

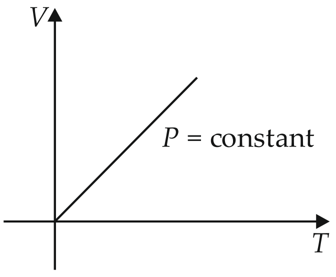
$C_{\text{molar}}$ = molar sp. heat capacity

## GRAPHS

**1)** Boyle's law:




**2)** Charle's law:



# Quick Revision SIMPLE HARMONIC MOTION

## TERMINOLOGY

| | | |
|---|---|---|
| $T$ | : | Time period [s] |
| $\omega$ | : | Angular frequency [rad's] |
| $x$ | : | Displacement of particle from mean position [m] |
| $V$ | : | Velocity [m/s] |
| $a$ | : | Acceleration [m/s$^2$] |
| $k$ | : | Spring constant [N/m] |
| $m$ | : | Mass of block [kg] |
| $Ms$ | : | Mass of spring [kg] |
| $F$ | : | Force [N] |
| $A$ | : | Amplitude [m] |
| $\alpha$ | : | Initial phase or epech |
| $K.E.$ | : | Kinetic energy [ J ] |
| $P.E.$ | : | Potential energy [ J ] |
| $T.E.$ | : | Total energy [ J ] |
| $R$ | : | Resultant amplitude [m] |
| $s$ | : | Resultant initial phase angle |
| $F_d$ | : | Damped force [N] |
| $b$ | : | Damping constant |
| $F(t)$ | : | External force [N] |
| $F_0$ | : | Amplitude of external force [N] |
| $\omega_d$ | : | Forced frequency |
| $\omega_0$ | : | Natural frequency |
| $I$ | : | Moment of inertia |
| $C$ | : | Torsinal constant |

## DEFINITIONS

**1) Periodic motion :**

A motion that repeat itself at regular interval of time is called periodic motion.

**2) Time period :**

The smallest time interval after which the motion repeats itslef is called the time period.

**3) Simple harmonic motion :**

Incase of motion of particle moves back and forth about fixed point throught a force which is directly proportional to displacement but opposite in direction the motion is called as simple harmonic motion.

**4) Amplitude :**

The maximum value of displacement from equilibrium position is called as amplitude.

**5) Phase :**

The state of particle with respect to its position and direction of motion is called as phase.

**6) Initial phase :**

The initial state of particle is said to be initial phase.

**7) Free oscillation :**

When a system is displaced from its equilibrium position and released, it oscillates with the natural frequency and the oscillations are called as free oscillation.

**8) Forced or driven oscillation :**

If an external agency maintain the oscillations then it is called as forced or driven oscillation.

**9) Resonance :**

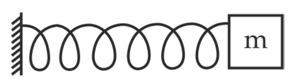
The phenomenon of increase in amplitude when driving force is close to natural frequenccy of oscillator is called resonance.

## FORMULAE

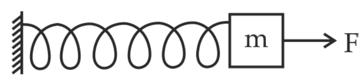
**1)** Linear simple harmonic motion

$F = -kx$

$$a = \frac{F}{m} = \frac{-kx}{m} = -\omega^2 x$$




$$\omega = \sqrt{\frac{k}{m}}$$




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


$F = -kx$

$ma = -kx$

$$a = \frac{-k}{m}x$$

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

$$\frac{d^2x}{dt^2} + \omega^2 x = 0$$

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

$$x = A\sin(\omega t + \alpha)$$

**2)** Equation of SHM

i) Particle starting from extreme right

$$x = A\cos(\omega t)$$

Angle measured from positive $x$ axis.

ii) Particle starting from mean position

$$x = A\sin\omega t$$

Angle measure from negative $y$ axis.

**3)** Energy in SHM

If $x = A\sin\omega t$

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

$$K.E. = \frac{1}{2}K(A^2 - A^2\sin^2\omega t)$$

$$= \frac{1}{2}KA^2\cos^2\omega t$$

$$P.E. = \frac{1}{2}m\omega^2x^2 = \frac{1}{2}kx^2 = \frac{1}{2}KA^2\sin^2\omega t$$

$$T.E. = K.E. + P.E. = \frac{1}{2}KA^2$$

$$K.E._{\text{average}} = \frac{1}{4}KA^2$$

$$P.E._{\text{average}} = \frac{1}{4}KA^2$$

**4)** Comparison of two SHM

$$x_1 = A_1\sin(\omega t + \alpha_1)$$

$$x_2 = A_2\sin(\omega t + \alpha_2)$$

$$x = x_1 + x_2$$

$$x = A_1\sin(\omega t + \alpha_1) + x = A_2\sin(\omega t + \alpha_2)$$

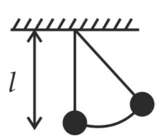
$$x = R\sin(\omega t + \alpha)$$

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\alpha_1 - \alpha_2)}$$

$$\tan\alpha = \frac{A_1\sin\alpha_1 + A_2\sin\alpha_2}{A_1\cos\alpha_1 + A_2\cos\alpha_2}$$

**5)** Simple pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$




**6)** Pendulum in lift

i) If lift is at rest

$$T = 2\pi\sqrt{\frac{l}{g}}$$

ii) If lift is moving upward with an acceleration [a]

$$T = 2\pi\sqrt{\frac{l}{g+a}}$$

iii) If lift is moving downward with an acceleration [a]

$$T = 2\pi\sqrt{\frac{l}{g-a}}$$

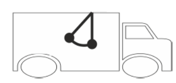
iv) If lift is under free fall

$$T = \infty$$

$$t = \frac{1}{T} = \frac{1}{\infty} = 0$$

v) Pendulum accelerating horizontally

$$T = 2\pi\sqrt{\frac{l}{(g^2 + a^2)^{\frac{1}{2}}}}$$



**7)** Second pendulum

$$T = 2\ S$$

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

**8)** Pendulum of large length

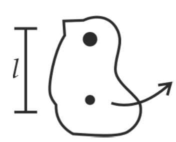
$$T = 2\pi\sqrt{\frac{1}{g\left[\frac{1}{l} + \frac{1}{R}\right]}}$$

if $l = \infty$

$$\therefore\ T = 2\pi\sqrt{\frac{R}{g}} = 84.6\,\text{min}$$

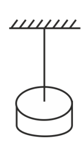
**9)** Compound pendulum

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



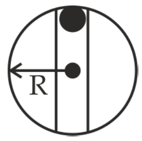

**10)** Torsional pendulum

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



**11)** Motin of a ball in a tunnel through earth

$$T = 2\pi\sqrt{\frac{R}{g}} = 84.6\,\text{min}$$




**12)** Oscillating of a floating body in a liquid

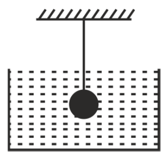
$$T = 2\pi\sqrt{\frac{h\,\rho_s}{g\,\rho_l}}$$

**13)** Oscillating of a liquid column in a V-tube.

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

**14)** Simple pendulum in a liquid

$$T = 2\pi\sqrt{\frac{l}{g}\frac{\rho_s}{(\rho_s - \rho_l)}}$$

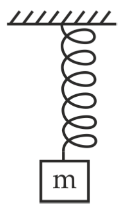


**15)** Spring System

$$F = -kx$$

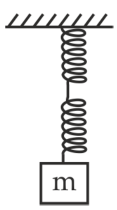
$$\omega = \sqrt{\frac{k}{m}}$$

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




Spring in sereis

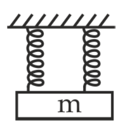
$$\frac{1}{K_{\text{eff}}} = \frac{1}{K_1} + \frac{1}{K_2}$$






Spring in a parallel

$$K_{\text{eff}} = K_1 + K_2$$

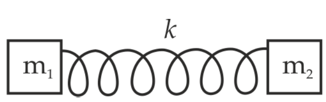



If mass of spring [Ms] considered then

$$T = 2\pi\sqrt{\frac{m + \frac{Ms}{3}}{K}}$$

Reduced mass

$$T = 2\pi\sqrt{\frac{M_r}{K}}$$




$$M_r = \frac{M_1 M_2}{M_1 + M_2}$$

**16)** Damped simple harmonic motion

$$F = F_d + F_s$$

$$M_a = -bV - kx$$

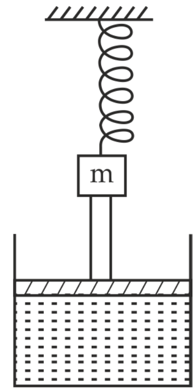
$$M\frac{d^2x}{dt^2} = -b\frac{dx}{dt} - kx$$

$$M\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$

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

$$\omega' = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

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




**17)** Forced oscillation and resonance

$$F(t) = F_0\cos(\omega t)$$

$$m\frac{d^2x}{dt^2} + b\cdot\frac{dx}{dt} + kx = F_0\cos\omega t$$

$$x(t) = A\cos(\omega_d t + \phi)$$

$$A = \frac{F_0}{[m^2(\omega^2 - \omega_d^2)^2 + \omega_d^2 b^2]^{\frac{1}{2}}}$$

$$\tan\phi = \frac{-v_0}{\omega_d x_0}$$

$V_0$ = Initial velocity

i) Small damping driving frequency far from natural frequency

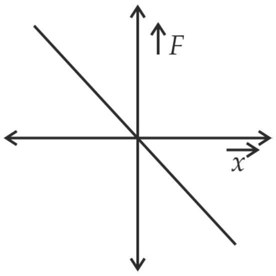
$$A = \frac{F_0}{M(\omega^2 - \omega_d^2)}$$

ii) Driving frequency closed to natural frequency

$$A = \frac{F_0}{\omega_d b}$$

## GRAPHS

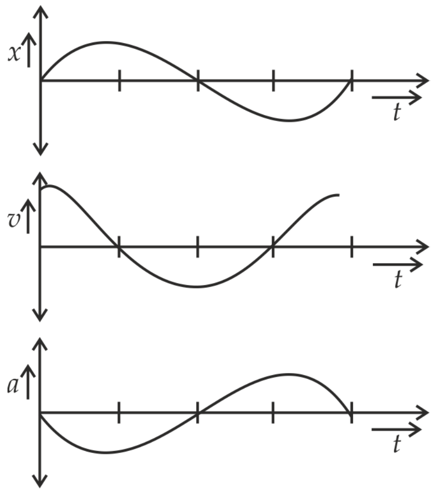
**1)** $F$ Vs $x$




**2)** $x = A\sin\omega t$

$V = \omega A\cos\omega t$

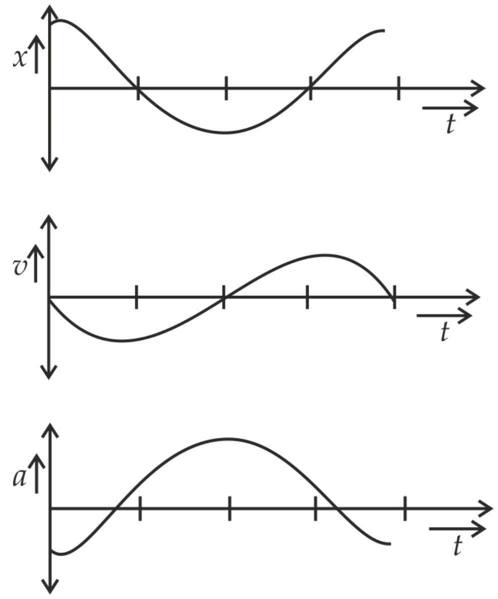
$a = -\omega^2 A\sin\omega t$




**3)** $x = A\cos\omega t$

$V = -\omega A\sin\omega t$

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



# Quick Revision — WAVES

## TERMINOLOGY

$A$ : Amplitude
$\lambda$ : Wavelength
$v$ : Wave velocity
$K$ : Wave number
$T$ : Tension in string
$\mu$ : Mass per unit length
$\rho$ : Density of medium
$Y$ : Young's modulus of elasticity
$B$ : Bulk modulus of elasticity
$P$ : Pressure
$R$ : Universal gas constant
$T$ : Temperature
$M$ : Molar mass
$I$ : Intensity
$\omega$ : Angular
$\eta$ : Modulus of rigidity

## TYPES OF WAVES

1) ***On The Basis Of Medium:***
   **i) Mechanical Waves :** Required medium for their propagation ex.: Waves on string, and spring etc.
   **ii) Non-mechanical Waves :** Do not require medium for their propagation ex.: Light, radio waves, X-rays etc.
2) ***On The Basis Of Vibration Of Particle:***
   **i) Transverse waves :** Particle of medium vibrates in a direction perpendicular to the direction of propagation of waves ex.: movement of string of sitar
   **ii) Longitudinal waves :** Particles of medium vibrate in the direction of wave motion. ex.: sound wave travel through air.
3) ***On The Basis Of Energy Propagation:***
   **i) Progressive wave :** These waves propagates energy in medium. Ex. : Sound wave
   **ii) Stationary wave :** Energy is not propagated by these waves. ex.: waves in a string, waves in organ pipes.
4) **Amplitude :** Maximum displacement from mean position.
5) **Wavelength :** It is equal to the distance travelled by the wave during the time in which any particle of medium completes one vibration.
6) **Angular wave number :** Number of wavelengths in the distance $2\pi$.
7) **Wave velocity ($v$) :** It is the distance travelled by the disturbance in one time period.

## FORMULAE

1) Wave velocity ($v$) :

$$v = f\lambda = \frac{\lambda}{T} = \frac{\omega}{k}$$

2) Intensity of wave ($I$) :

$$I = 2\pi^2 f^2 A^2 \rho v$$

3) Energy density :

$$\text{Energy density} = \frac{2\pi^2 f^2 a^2 \rho v}{V}$$

4) Velocity of transverse wave :

$$v = \sqrt{\frac{T}{\mu}} \qquad \text{(in stretched string)}$$

$$v = \sqrt{\frac{\eta}{\rho}} \qquad \text{(in solid)}$$

5) Velocity of sound wave :

$$v = \sqrt{\frac{\text{Elasticity of medium}}{\text{Density of medium}}}$$

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

$$v = \sqrt{\frac{Y}{\rho}} \qquad \text{(in solids)}$$

$$v = \sqrt{\frac{B}{\rho}} \qquad \text{(in liquid and gaslong medium)}$$

6) Newton's formula :

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

7) Laplace correction :

$$v = \sqrt{\frac{YP}{\rho}} \qquad Y = 1.41 \text{ for air}$$

$$v = \sqrt{\frac{YRT}{M}}$$

8) Equation of plane progressive wave :

$$y(x_1 t) = A\sin(\omega t \pm kx \pm \phi) \quad \text{(general equation)}$$

where $\phi$ = Initial phase
$\omega$ = Wave number
$A$ = amplitude

**Various Form**

i) $y = A\sin(\omega t - kx)$, Let $\phi = 0$

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

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

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

**9)** Particle velocity

$V_P = -v \times$ slope of wave at that point.

**10)** Interference of sound waves : When two waves of same frequency, same velocity moves in same direction.

$$y_1 = A_1\sin(\omega t)$$

$$y_2 = A_2\sin(\omega t + \phi)$$

after superposition.

$$A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

Intensity $(I) = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

**Constructive interference:**

Phase difference $\phi = 0°$ or $2n\pi$

Path difference $= \eta\lambda$ (even multiple of $\frac{\lambda}{2}$)

Resultant amplitude,

$$A_{max} = A_1 + A_2$$

Resultant intensity

$$I_{max} = I_1 + I_2 + 2\sqrt{I_1I_2}$$

$$= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

**Destructive interference:**

Phase difference, $\phi = 180°$ or $(2n-1)\pi$

$\eta = 1, 2, 3, .........$

Path difference $= (2n-1)\frac{\lambda}{2}$ (odd multiple of $\frac{\lambda}{2}$)

$$A_{min} = A_1 - A_2$$

$$I_{min} = I_1 + I_2 - 2\sqrt{I_1I_2} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$$

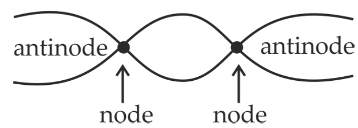
**11)** Stationary wave :

equation, $y = \underbrace{2A\sin kx}_{\text{Amplitude of wave}}\cos\omega t$

Node : The points where amplitude is minimum

Distance between two successive nodes is $\frac{\lambda}{2}$

Antinode : The points of maximum amplitude. Distance between two successive antinodes is $\frac{\lambda}{2}$.



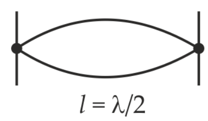

**12)** Stenting wave can string

frequency of vibration = frequency of wave

$$= \frac{v}{\lambda} = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

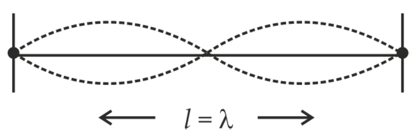
**13)** i) Fundamental frequency or first harmonic

$$n_1 = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$




ii) Second harmonic or first overtone :

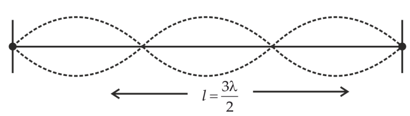
$$h_2 = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$




$$h_2 = \frac{1}{l}\sqrt{\frac{T}{\mu}} = 2n_2$$

iii) Third harmonic or second over tone.

$$h_3 = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$



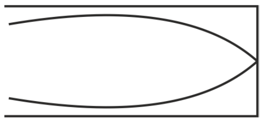

$$h_3 = \frac{3}{2l}\sqrt{\frac{T}{\mu}} = 3n_1$$

**14)** Standing wave in organ pipe :

Closed organ pipe $\{V_s$ = Velocity of sound$\}$

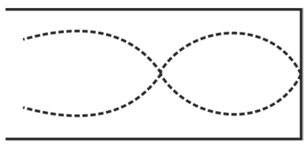
Resonance frequency

$$f_1 = \frac{V_s}{4l} \text{ [fundamental frequency } 1^{st} \text{ harmonic]}$$



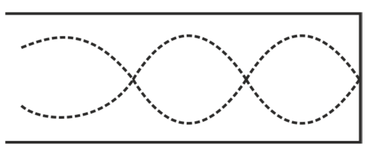
$$\longleftarrow l = \frac{\lambda}{4} \longrightarrow$$

$$f_2 = \frac{3V_s}{4l} \text{ [}3^{rd} \text{ harmonic or } 1^{st} \text{ over tone]}$$



$$\longleftarrow l = \frac{3\lambda}{4} \longrightarrow$$

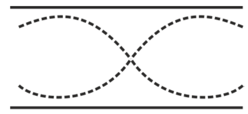
$$f_3 = \frac{5V_s}{4l} \text{ [}5^{th} \text{ harmonic or } 2^{nd} \text{ overtone]}$$



$$\longleftarrow l = \frac{5\lambda}{4} \longrightarrow$$

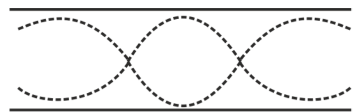
Open organ pipe

$$f_1 = \frac{V_s}{2l} \text{ [fundamental frequency or } 1^{st} \text{ harmonic]}$$



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

$$f_2 = \frac{2V_s}{2l} \text{ [}2^{nd} \text{ harmonic or } 1^{st} \text{ overtone]}$$



$$l = \lambda$$

**15)** Beat frequency

Beat frequency = No. of beats per second

= Difference in frequency of two source

$= |n_1 - n_2|$

Doppler effect :

apparent frequency

$$f_{app} = \left( \frac{v \pm v_0}{v \pm v_{source}} \right) f_{actual}$$

Note : choose plus / minus signs based on situation

$v$ = velocity of sound.

# Quick Revision ELECTROSTATICS (I+II)

## TERMINOLOGY

$Q/q$ : Charge
$F_c$ : Force between the charges
$E$ : Electric field intensity
$\lambda$ : Linear charge density
$\sigma$ : Surface charge density
$\rho$ : Volume charge density
$\varepsilon_0$ : Permittivity of free space
$\varepsilon$ : Permittivity of medium
$\varepsilon_r$ : Relative permittivity
$k$ : Dielectric constant
$\phi$ : Electric flux
$\hat{n}$ : Unit vector along normal
$r$ : Distance from charge / body centre
$R$ : Radius
$\nabla$ : Gradient
V : Electric potential / Potential difference (Voltage)
$d\vec{r}$ : Small change in position vector
$W$ : Work done
$\vec{p}$ : Dipole moment
$u$ : Potential energy
C : Capacitance
b/w : Between

## DEFINITIONS

1) **Charge :**
It is the fundamental property of matter due to which matter experiences the effect of electric and magnetic fields.

2) **Linear charge density:**
Charge per unit length of a body.

3) **Surface charge density:**
Charge per unit surface area at the body.

4) **Volume charge density:**
Charge per unit volume of the body.

5) **Electric field:**
The region of influence surrounding a charged body upto which it can influence other charge particles.

6) **Electric field intensity:**
Number of field lines passing throught uniform.
or
Force acting per unit charge placed in the field.

7) **Neutral point (Null point):**
Point where resultant electric field intensity is zero.

8) **Electric flux:**
Flux linking an area is defined as the number of field lines passing through given area perpendicularly.

9) **Gauss's law :** Flux linking any closed surface is always equal to $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the surface.

10) **Electric potential:**
Electric potential at a point in a field is defined as the amount of work done in bringing a unit positive test charge from infinity to that point.

11) **Potential difference:**
The potential difference between two points is defined as the amount of work done in bringing unit positive charge from one point to another.

12) **Electric potential energy:**
Work done in bringing a charge particle from infinity to a point in field, will store as potential energy in the charge.

13) **Equipotential surface:**
It is the surface where the potential at any point of the surface has the same value.

14) **Electric dipole:**
Two equal and opposite charges, separated by a finite distance constitute a dipole.

15) **Dipole moment:**
Product of magnitude of either of the charges in a dipole and the dipole length is known as dipole moment.

16) **CORONA Discharge:**
When the electric field on the surface of conductor $(\sigma / \varepsilon_0)$ exceeds the electric strength of air, the air becomes conducting and the surface of conductor loses charge. This action usually occurs at sharp points, where $\sigma$ will be high. This phenomena is known as 'CORONA Discharge'.

17) **Capacitance:**
Capacitance of a body is defined as the amount of charge required per unit rise of potential of the body.

18) **Condenser OR Capacitor:**
An arrangement of conductors which increases the capacity of the one conductor at relatively low potential is called as capacitor or condenser.

**19) Series Combination:**

Two or more capacitors are said to be in series if same amount of charge passes through all the capacitors one after the other.

**20) Parallel Combination:**

Two or more branches are said to be in parallel if they are connected between same set of points (or) if they have same voltage across them.

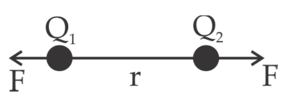
## FORMULAE

**1) Quantization of charge :**

net charge on any body is given by $\theta = \pm ne$

$n$ : number of electrons supplied to the body or removed from the body.

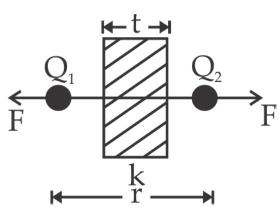
**2) Coulomb's law :** Force between two charges




$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2} \quad \text{(for air medium)}$$

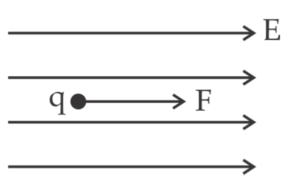
$$F = \frac{1}{4\pi(k\varepsilon_0)}\frac{Q_1Q_2}{r^2} \quad \text{(for other media)}$$

**3)**




$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{(r - t + t\sqrt{k})^2}$$

**4)** Force on a charge particle placed in electric field.

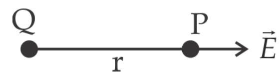



$F = qE$

in vector form $\vec{F} = q\vec{E}$

direction of $\vec{F}$ and $\vec{E}$ is same if $q$ is +ve and opposite if $q$ is –ve.

**5)** Electric field intensity due to point charge

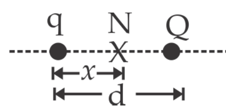



$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

direction : away from charge if $q$ is +ve towards charge if $q$ is –ve.

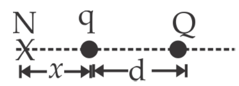
**6)** Null point : $(|q| < |Q|)$

Like charge




$$x = \frac{d}{\sqrt{\left|\frac{Q}{q}\right|} + 1}$$

Unlike charge



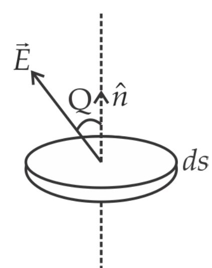

$$x = \frac{d}{\sqrt{\left|\frac{Q}{q}\right|} - 1}$$

**7)** Electric flux :

For a closed surface

$$\phi = \int (E)d\cos\theta = \int \vec{E}\cdot d\vec{s}$$

$$d\vec{s} = ds \cdot \hat{n}$$




**8)** Electric flux for uniform field is

$$\phi = ES\cos\theta = \vec{E}\cdot\vec{S}$$

$\phi_{max} = \pm ES$ when lines are perpendicular to surface.

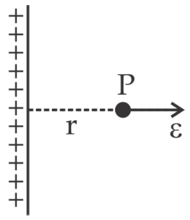
$\phi_{min} = 0$ when liens are parallel to surface.

$\phi = +\text{ve}$ for leaving flux.

$\phi = -\text{ve}$ for entering flux.

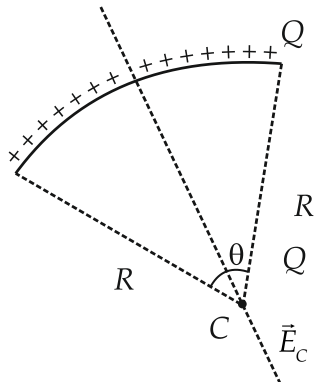
**9)** Number of field lines coming out (or) entering in for a charge '$q$' is $\frac{q}{\varepsilon_0}$.

**10)** Electric field due to charged wire / cyling




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

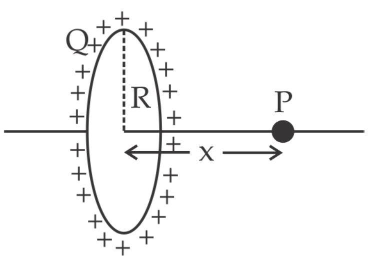
**11)** Field due to charged circular arc at centre $C(E_C)$




$$\vec{E}_C = \frac{2kQ}{\theta R^2}\sin\left(\frac{\theta}{2}\right)$$

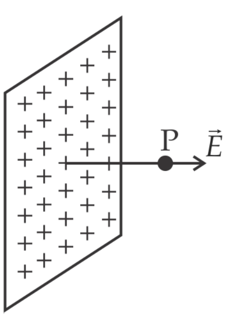
where $k = \dfrac{1}{4\pi\varepsilon_0}$ and $\phi$ should be in radian.

**12)** Field due to uniformly charged ring at a point an axis.



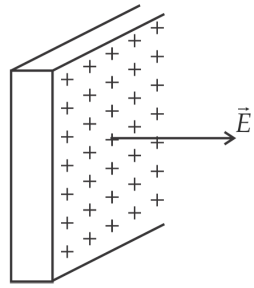

$$E_{axis} = \frac{Q}{4\pi\varepsilon_0}\frac{x}{(R^2+x^2)^{\frac{3}{2}}}$$

**13)** Field due to uniformly charged sheet



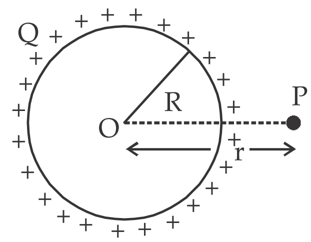

$$E = \frac{\sigma}{2\varepsilon_0}$$

**14)** Field due to uniformly charged conducting plate




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

**15)** Field due to uniformly charged conducting sphere / spherical shell

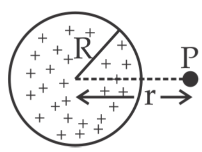



$E = 0$ (inside point; $r < R$)

$= \dfrac{\sigma}{\varepsilon_0} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{R^2}$ (at surface; $r = R$)

$= \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r^2}$ ; (at outside; $r > R$)

**16)** Electric field due to uniformly charged non-conducting sphere

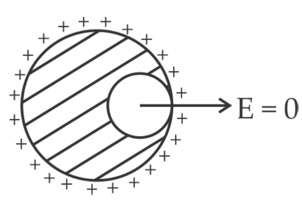



$E = \dfrac{\rho r}{3\varepsilon_0}$ ; (at inside point ; $r < R$)

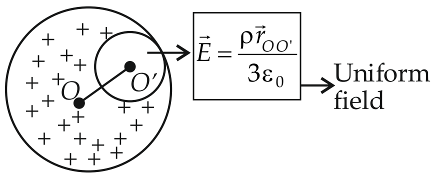
$= \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{R^2}$ ; (at surface; $r = R$)

$= \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r^2}$ ; (at outside; $r > R$)

**17)** Electric field at a point inside the cavity of conducting sphere



**18)** Field inside the cavity of uniformly charged non-conducting sphere




$O$ - centre of sphere

$O'$ - centre of cavity

Note : In all above formulae, incase of any other medium than air, replace $\varepsilon_0$ with $k\varepsilon_0$.

K = dielectric constant.

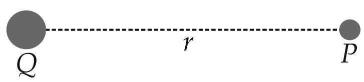
**19)** Electric potential at any point '$p$':

$$V_p = \frac{W_{\infty \to p}}{q_0}$$

Where $W_{\infty \to p}$ is work done in bringing charge $q_0$ from $\infty$ to point $p$.

**20)** Potential due to point charge:

$$V_p = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$




**21)** Potential difference between two points $A$ & $B$:

$$V_B - V_A = \frac{W_{A \to B}}{q_0}$$

where $W_{A \to B}$ is work done in moving charge $q_0$ from $A$ to $B$.

**22)** Electric field due to group of charges $q_1$, $q_2$, $q_3$, ......., $q_n$ is

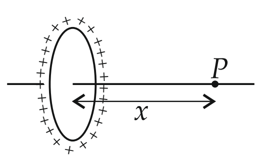
$$V = V_1 + V_2 + V_3 + ...... + V_n$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + ...... \frac{q_n}{r_n}\right)$$

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

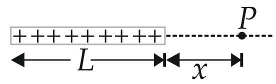
**23)** Potential due to uniformly charged ring:

$$V_p = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{R^2 + x^2}}$$



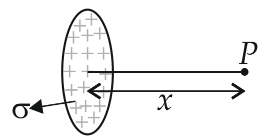

$$V_{\text{centre}} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

**24)** Potential due to charged wire / rod:




$$V_p = \frac{\lambda}{4\pi\varepsilon_0}\ln\left(\frac{x+L}{x}\right)$$

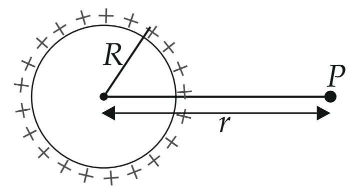
**25)** Potential due to charged disc:




$$V_p = \frac{\sigma}{2\varepsilon_0}\left(\sqrt{R^2 + x^2} - x\right)$$

$$V_{\text{centre}} = \frac{\sigma R}{2\varepsilon_0}$$

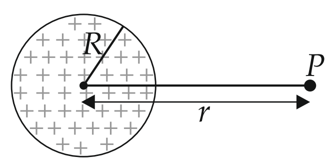
**26)** Potential due to uniformly charged conducting sphere (Or) spherical shell:




$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$ (At any point inside sphere: $r \le R$)

$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ (At point outside sphere: $r > R$)

**27)** Potential due to uniformly charged non-conducting sphere:




$$V = \frac{Q}{4\pi\varepsilon_0 R^3}\left(\frac{3R^2 - r^2}{2}\right)$$

(At any point inside sphere : $r < R$)

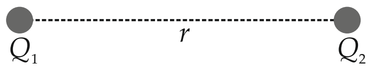
$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$ (At point on surface: $r = R$)

$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ (At point outside sphere: $r > R$)

$$V_{\text{centre}} = \frac{3}{2}V_{\text{surface}}$$

**28)** Potential energy stored between two point charges:

$$U = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r}$$

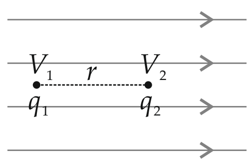



**29)** Potential energy of a charge placed in electric field:

$U = qV$

$V$ - Potential at point where charge is placed

**30)** Potential energy of two charge system placed in external field:




$$U = q_1v_1 + q_2v_2 + \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$$

**31)** Work to be done by external agent to change the distribution of charges in a system:

$W = U_f - U_i$

$U_f$ : Final potential energy of system

$U_i$ : Initial potential energy of system

**32)** Work done in moving a charge particle between two points in a field:

$W_{A\to B} = q(V_B - V_A) \Rightarrow$ By external agent

$= -q(V_B - V_A) \Rightarrow$ By electric field

Where, $W_{A\to B}$ : Work done in moving charge $q$ from $A$ to $B$.

**33)** Gain in kinetic energy of a charge particle when accelerated through a potential difference of $\Delta V$ volt is

$$\Delta \text{K.E.} = q(\Delta V)$$

**34)** Relation between electric field and potential is

$$\vec{E} = -\nabla V$$

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

$$V = -\int \vec{E}.d\vec{r}$$

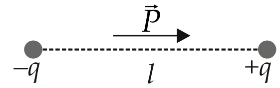
$$V_A - V_B = \int_{\vec{r}_A}^{\vec{r}_B} \vec{E}.d\vec{r}$$

where, $d\vec{r} = dx\hat{i} + dy\hat{j} + dz\hat{k}$

**35)** $n$ small drops of $V$ volt each are combine to form big drop, then potential of big drop is

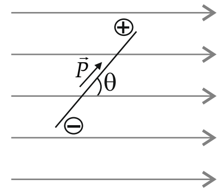
$$V_{\text{Big}} = n^{2/3}V_{\text{small}}$$

**36)** Electric dipole moment:




$P = ql$

**37)** Dipole placed in uniform field:




(i) Torque = $\vec{\tau} = \vec{P}\times\vec{E} \Rightarrow \tau = PE\sin\theta$

$\tau_{\text{max}} = PE$ at $\theta = 90°$

$\tau_{\text{min}} = 0$ at $\theta = 0°/180°$

(ii) $F_{\text{net}} = 0$ at any value of $\theta$.

(iii) Potential energy of dipole

$U = -PE\cos\theta = -\vec{P}.\vec{E}$

$U_{\text{max}} = PE$ at $\theta = 180°$

$\Rightarrow$ Unstable equilibrium position

$U_{\text{min}} = -PE$ at $\theta = 0°$

$\Rightarrow$ Stable equilibrium position

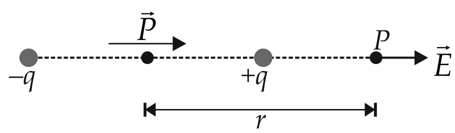
(iv) Time period of oscillations performed by dipole when disturbed at stable equilibrium position ($\theta = 0°$) is

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

where $I$ is moment of inertia of dipole.

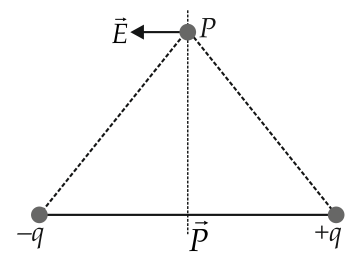
**38)** Electric field due to dipole:

(i) Axial line (End-on position):




$$F_{\text{Axis}} = \frac{1}{4\pi\varepsilon_0}\frac{2P}{r^3}$$

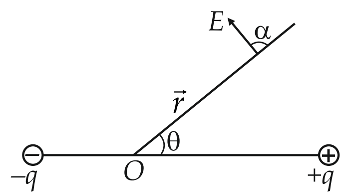
(ii) Equitorial line (Broad-on Position)




$$E_{\text{eq.}} = \frac{1}{4\pi\varepsilon_0}\frac{P}{r^3}$$

Angle between $\vec{P}$ and $\vec{E}$ is 180°.

(iii) At any point:

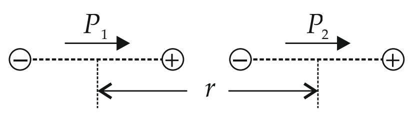



$$E=\frac{1}{4\pi\varepsilon_0}\frac{P}{r^3}\sqrt{3\cos^2\theta+1}$$

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

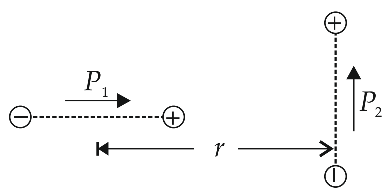
**39)** Electric force between two dipoles:

(i)




$$F=\frac{1}{4\pi\varepsilon_0}\frac{6P_1P_2}{r^4}$$

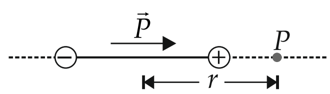
(ii)



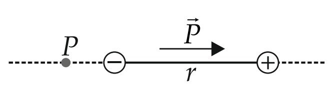

$$F=\frac{1}{4\pi\varepsilon_0}\frac{3P_1P_2}{r^4}$$

**40)** Electric potential due to dipole:

(i) Axial line:




$$V_P=\frac{1}{4\pi\varepsilon_0}\frac{P}{r^2}$$

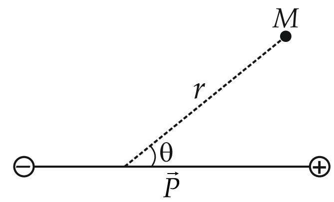



$$V_P=-\frac{1}{4\pi\varepsilon_0}\frac{P}{r^2}$$

(ii) Equitorial line:

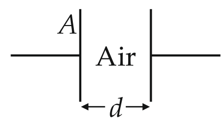
$V=0$ (At any point on equitorial line)

(iii) At any point:

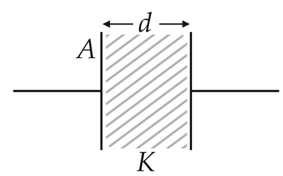



$$V_M=\frac{1}{4\pi\varepsilon_0}\frac{P\cos\theta}{r^2}$$

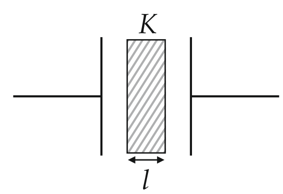
**41)** Capacitance of parallel plate capacitor:



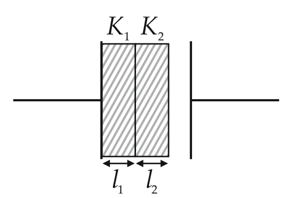

$$C=\varepsilon_0\frac{A}{d}$$




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




$$C=\frac{\varepsilon_0 A}{d-l+\frac{l}{K}}$$




$$C=\frac{\varepsilon_0 A}{d-(l_1+l_2+...)\left(\frac{l_1}{K_1}+\frac{l_2}{K_2}+...\right)}$$

**42)** Relation between voltage on a capacitor and charge stored in it:

$Q=C.V$

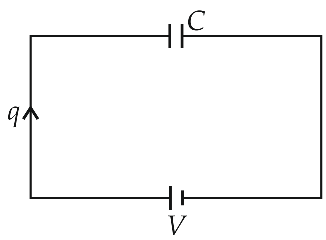
**43)** In Series combination

$$\frac{1}{C_{\text{eff.}}}=\frac{1}{C_1}+\frac{1}{C_2}+.....+\frac{1}{C_n}$$

In Parallel combination

$$C_{\text{eff.}}=C_1+C_2+.....+C_n$$

**44)** Charging of a capacitor:

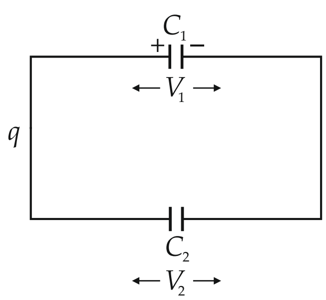



Total work done by battery = $CV^2$

Energy stored in capacitor = $\frac{1}{2}CV^2$

Heat loss in process = $\frac{1}{2}CV^2$

**45)** Sharing of charges:




Let $(V_1 > V_2)$
Sharing takes place until both the capcitors get a common voltage across them.
The common voltage is given by

$$V_C = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

Loss in energy in the process is

$$\text{Heat loss} = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$$

Initial charge on capacitors:

$$Q_1 = C_1V_1$$

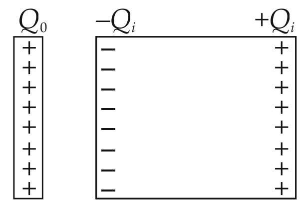
$$Q_2 = C_2V_2$$

Final charges (after sharing):

$$Q'_1 = C_1V_C = \frac{C_1}{C_1 + C_2}(Q_1 + Q_2)$$

$$Q'_2 = C_2V_C = \frac{C_2}{C_1 + C_2}(Q_1 + Q_2)$$

**46)** Induced charge on dielectric:




$$\boxed{Q_i = Q_0\left(1 - \frac{1}{K}\right)}$$

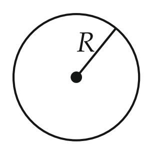
**47)** Effect of dielectric on capacitor:

| Physical Quantity | Before Dielectric Placed | After Dielectric Placed | |
|---|---|---|---|
| | | With cell | Without cell |
| Capacitance | $C_0 = \varepsilon_0 A / d$ | $KC_0$ | $KC_0$ |
| Voltage | $V_0$ | $V_0$ | $V_0 / K$ |
| Charge stored | $Q_0 = C_0V_0$ | $KQ_0$ | $Q_0$ |
| Electric field between plates | $E_0 = V_0 / d$ | $E_0$ | $E_0 / K$ |
| Energy stored | $U_0 = \frac{1}{2}C_0V_0^2$ | $KU_0$ | $U_0 / K$ |
| Force between the plates | $F_0 = \frac{Q_0^2}{2A\varepsilon_0}$ | $KF_0$ | $F_0 / K$ |

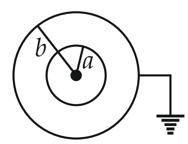
**48)** Force between the plates of capacitor:

$$F = \frac{Q^2}{2A\varepsilon_0}$$

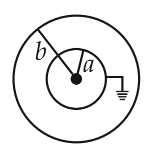
**49)** Capacitance of spherical capacitor:



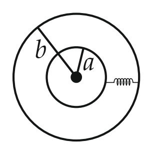

$$C = 4\pi\varepsilon_0 R$$




$$C = 4\pi\varepsilon_0\left(\frac{ab}{b-a}\right)$$



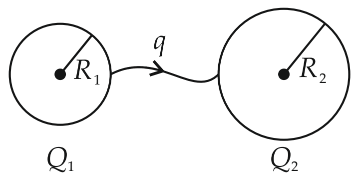

$$C = 4\pi\varepsilon_0\left(\frac{b^2}{b-a}\right)$$




$$C = 4\pi\varepsilon_0 b$$

**50)** $n$ identical small drops are combined to form a big drop, then
$C_{Big} = n^{1/3}\ C_{Small}$
$V_{Big} = n^{2/3}\ V_{Small}$
$U_{Big} = n^{5/3}\ U_{Small}$

**51)** Sharing of charges:




Common potential

$$V_C = \frac{R_1V_1 + R_2V_2}{R_1 + R_2}$$

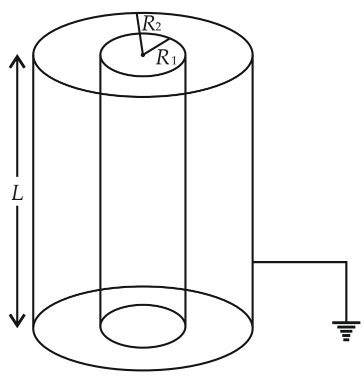
Heat loss = $2\pi\varepsilon_0 \frac{R_1R_2}{K_1 + R_2}(V_1 - V_2)^2$

Final charges

$$Q_1^1 = \frac{R_1}{R_1 + R_2}(Q_1 + Q_2)$$

$$Q_2^1 = \frac{R_2}{R_1 + R_2}(Q_1 + Q_2)$$

**52)** Capacitance of cylindrical capacitor:




$$C = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{R_2}{R_1}\right)}$$

**53)** Energy density (energy stored or unit volume)

$$= \frac{1}{2}\varepsilon_0 E^2$$

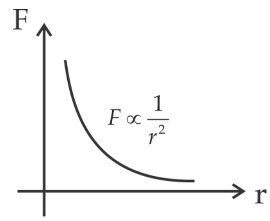
where, $E$ : Electric field intensity in medium

*Note:*

All the formulae given are for air medium. In case of another medium, replace $\varepsilon_0$ with $K\varepsilon_0$, where $K$ is dielectric constant of the given medium.

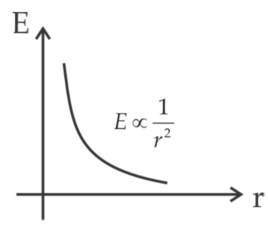
## GRAPHS

**1)** Force between two charges (vs) distance between them



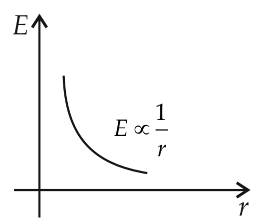

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$$

**2)** $\vec{E}$ due to point charge w.r.t. distance



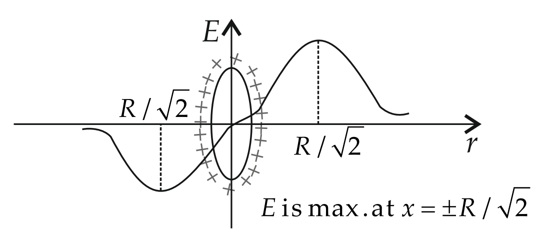

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

**3)** $\vec{E}$ due to charged wire w.r.t. distance



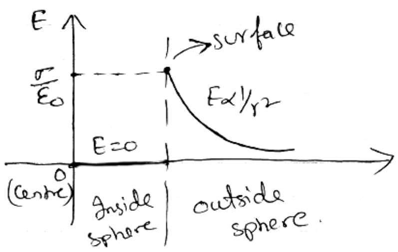

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

**4)** $\vec{E}$ due to uniformly charged ring on axis (vs) distance from centre:

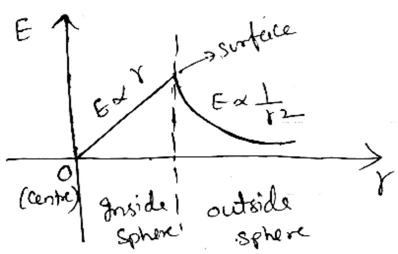



$$E = \frac{Q}{4\pi\varepsilon_0}\frac{x}{(R^2 + x^2)^{3/2}}$$

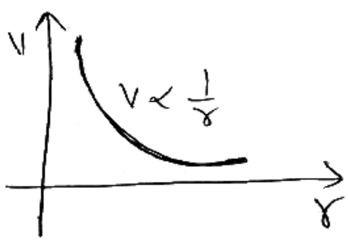
5) $\vec{E}$ due to conducting sphere / spherical shell w.r.t. distance from centre:




6) $\vec{E}$ due to uniformly charged non-conducting sphere:

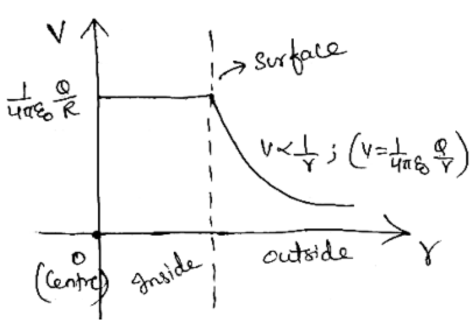



7) Potential due to point charge ($V$) versus distance ($r$):

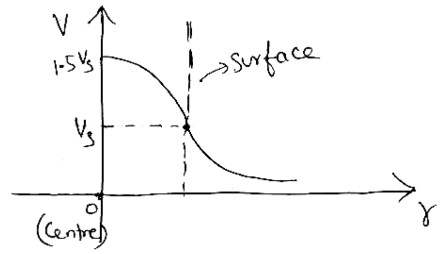



$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

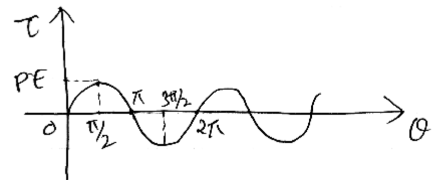
8) Potential due to conducting sphere/spherical shell (vs) distance from centre:




9) Potential due to uniformly charged non-conducting sphere (vs) distance from centre:

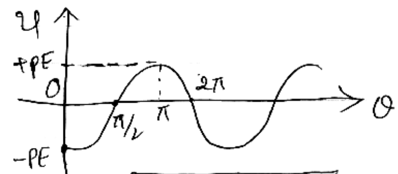



10) Torque on dipole (vs) angle ($\theta$) made by dipole with field:



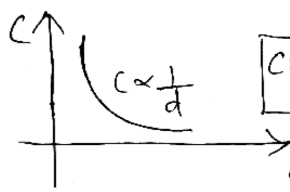

$$\boxed{\tau = PE\sin\theta}$$

11) Potential energy of dipole (vs) angle ($\theta$) made by dipole with electric field:



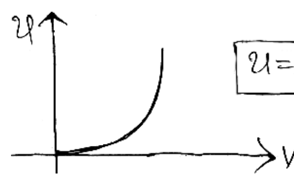

$$\boxed{U = -PE\cos\theta}$$

12) Capacitance of parallel plate capacitor ($C$) vs. distance between the plates:




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

13) Energy stored ($U$) vs. voltage across capacitor:




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

# Quick Revision CURRENT ELECTRICITY

## TERMINOLOGY

| | | |
|---|---|---|
| $Q$ / $q$ | : | Charge |
| $V$ | : | Voltage / Potential difference OR Potential |
| $\varepsilon$ / $E$ | : | e.m.f. |
| $i$ | : | Electric current |
| $R$ / $r$ | : | Electric resistance |
| $G$ | : | Conductance |
| $\rho$ | : | Resistivity |
| $\sigma$ | : | Conductivity |
| $V_d$ | : | Drift velocity |
| $\tau$ | : | Relaxation time |
| $j$ | : | Current density |
| $A$ | : | Area of cross-section |
| $H$ | : | Heat energy released across resistor |
| $P$ | : | Power |
| $K$ | : | Potential gradient |

## DEFINITIONS

1) **Electric current:**
It is defined as the rate of flow of charge with respect to time.

2) **Current density:**
Current density at a point inside the conductor is defined as the amount of current flowing per unit area in a direction normal to the current.

3) **Drift speed ($v_d$):**
The free electrons within the metal, in addition to its random motion, acquires a small velocity towards the positive end of conductor. This velocity is called drift velocity.

4) **Relaxation time:**
The average time gap between two successive collisions of free electrons is known as relaxation time.

5) **Ohm's law:**
Under given physical conditions, the current produced in the conductor is proportional to the potential difference across the conductor.

6) **Electrical resistance:**
The hindrance offered by a conductor to the flow of current is called the electrical resistance of the conductor.

7) **Resistivity:**
Resistivity of any material is defined as the resistance of that material having unit length and unit area of cross-section.

8) **Series combination:**
Two or more resistors are said to be in series, if same current flows through all of them.

9) **Parallel combination:**
Two or more branches are said to be in parallel, if they are connected between same set of points (or) if they have same potential difference (voltage) across them.

10) **Effective resistance:**
The total hindrance/opposition faced by current in the circuit.

11) **Ohmic and non-ohmic conductor:**
Conductors that obey Ohm's law are known as ohmic conductors and those do not obey Ohm's law are known as non-ohmic conductors.

12) **Resistor:**
A resistor is a two terminal electrical component that implements electrical resistance as a circuit element.

13) **Cell / Battery:**
It is the source of electrical energy. It converts chemical energy to electrical energy.

14) **Electromotive force (e.m.f.):**
The total work that the cell can do on one coulomb of charge in driving the charge through circuit.

15) **Internal resistance:**
The resistance offered by the cell to the current in circuit is known as internal resistance.

16) **Terminal voltage:**
The potential difference between the terminals of the cell.

17) **Maximum power transfer theorem:**
The power delivered across external resistance is maximum, when the value of external resistance will be equal to the internal resistance of cell.

18) **Kirchhoff's first law:**
At any junction, the sum of currents entering the junction must be equal to the sum of currents leaving the junction.

19) **Kirchhoff's second law:**
The algebraic sum of voltages around any closed loop of a circuit must be equal to zero.

20) **Potential gradient:**
Potential drop per unit length.

## FORMULAE

**1)** Electric current:

$$i = \frac{dq}{dt} \quad \text{or} \quad i = \frac{Q}{t}$$

**2)** If charge $q$ is moving in a circle of radius $r$ with speed $v$, the current is

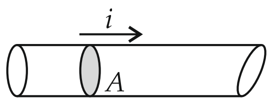
$$i = \frac{qv}{2\pi r}$$

**3)** Ohm's law

$$I = \frac{V}{R}$$

$V$ - Voltage (potential difference) across body

**4)** Relation between electric current & drift speed:




$$i = neAV_d$$

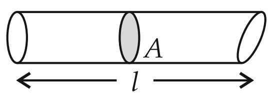
$n$ : Density of free electrons

**5)** Relation between current density & drift speed:

$$J = neV_d = \frac{I}{A}$$

**6)** Resistance of a conductor:

$$R = \frac{\rho l}{A}$$




**7)** Conductance, $G = \frac{1}{R}$

**8)** $\text{Conductivity} = \frac{1}{\text{Resistivity}} \Rightarrow \sigma = \frac{1}{\rho} = \frac{l}{RA}$

**9)** Relation between current density and electric field:

$J = \sigma.E$ (Another form of Ohm's law)

**10)** Mobility of a free electron:

$$\mu = \frac{V_d}{E}$$

**11)** Temperature co-efficient of resistance:

$$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$$

$R_1$ : Resistance at temperature $t_1$

$R_2$ : Resistance at temperature $t_2$

**12)** Effective resistance in series combination:

$$R_{\text{eff.}} = R_1 + R_2 + \ldots\ldots + R_n$$

**13)** Effective resistance in parallel combination:

$$\frac{1}{R_{\text{eff.}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots + \frac{1}{R_n}$$

**14)** Terminal voltage ($V$) of a cell:

$V = E - ir \Rightarrow$ While discharging of cell

$V = E + ir \Rightarrow$ While charging of cell

$V = E \Rightarrow$ When cell is open branch

$V = 0 \Rightarrow$ When cell is short circuited

**15)** Energy delivered across a resistor:

$$H = i^2Rt = \left(\frac{V^2}{R}\right)t = Vit$$

**16)** Power delivered across a resistor:

$$P = i^2R = \frac{V^2}{R} = Vi$$

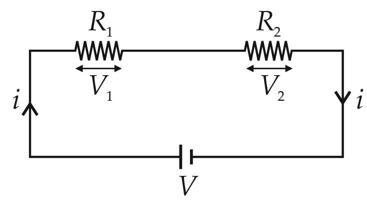
**17)** Resistance of a bulb (or) any device:

$$R = \frac{V^2_{\text{rated}}}{P_{\text{rated}}}$$

$V_{\text{rated}}$ = Rated voltage of bulb

$P_{\text{rated}}$ = Rated power of bulb

**18)** Voltage division rule:

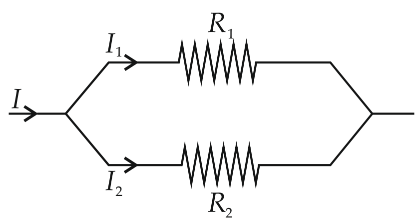



In series
$v \propto R$

$$\therefore \frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$\Rightarrow V_1 = \frac{R_1}{R_1 + R_2}V \quad \text{And} \quad V_2 = \frac{R_2}{R_1 + R_2}V$$

**19)** Current division rule:

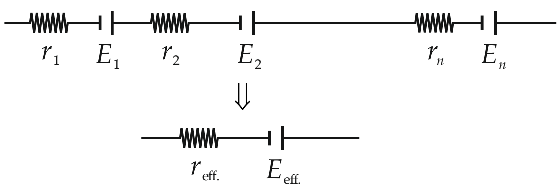



In parallel, $I \propto \frac{1}{R}$ $\qquad \therefore \frac{I_1}{I_2} = \frac{R_2}{R_1}$

$$I_1 = \frac{R_2}{R_1 + R_2}.I$$

$$I_2 = \frac{R_1}{R_1 + R_2}.I$$

**20)** Cells in series:

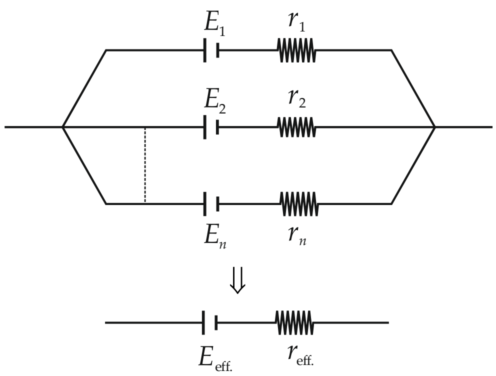



$r_{eff.} = r_1 + r_2 + ...... + r_n$

$E_{eff.} = E_1 + E_2 + ...... + E_n$

*Follow sign convention for $E_{eff.}$

**21)** Cells in parallel:

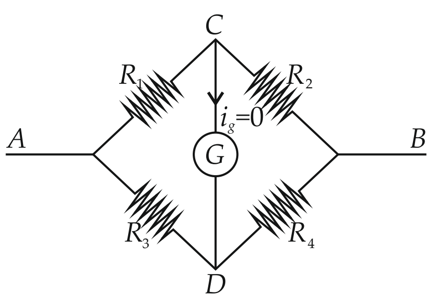



$$\frac{1}{r_{eff.}} = \frac{1}{r_1} + \frac{1}{r_2} + ...... + \frac{1}{r_n}$$

$$E_{eff.} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2} + ...... + \frac{E_n}{r_n}}{\frac{1}{r_1} + \frac{1}{r_2} + ...... + \frac{1}{r_n}}$$

*Follow sign convention while taking values of emf.

**22)** In a balanced Wheatstone bridge:

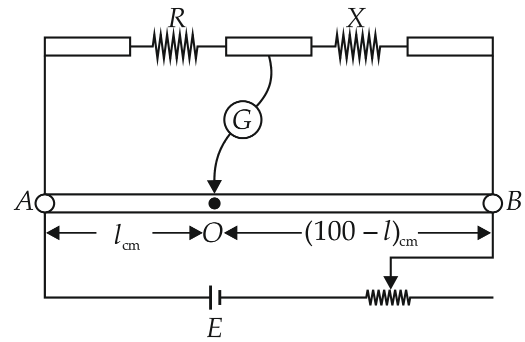



* $i_g = 0$

* $V_C = V_D \Rightarrow V_C - V_D = 0$

* $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ (Or) $R_1R_4 = R_2R_3$

**23)** In a balanced meter bridge:




$$\frac{R}{X} = \frac{l}{100 - l}$$

**24)** Potential gradient of potentiometer wire $AB$ is

$$K = \frac{V_{AB}}{L_{AB}}$$

$V_{AB}$ : Voltage on wire $AB$

$L_{AB}$ : Length of wire $AB$

**25)** In potentiometer experiment, comparison of emfs of two cells:

* $\frac{E_1}{E_2} = \frac{l_1}{l_2}$ (Direct method)

$l_1$ : Balancing length for cell $E_1$

$l_2$ : Balancing length for cell $E_2$

* $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}$ (Sum of difference method)

$l_1$ : Balancing length when $E_1$ supports $E_2$

$l_2$ : Balancing length when $E_1$ opposes $E_2$

**26)** In potentiometer experiment, the value of unknown emf is given by

$E = K.l_{bal.}$

where, $l_{bal.}$ = Balancing length

**27)** In potentiometer experiment, internal resistance of a cell can be determined using,

$$r = R_{Sh}\left(\frac{l_1}{l_2} - 1\right)$$

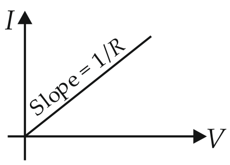
$R_{Sh}$ : Shunt resistance

$l_1$ : Balancing length without shunt

$l_2$ : Balancing length with shunt

## GRAPHS

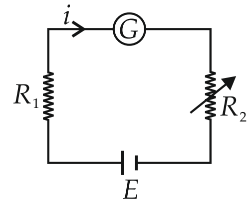
**1)** Current ($I$) vs voltage ($V$) for an ohmic conductor:

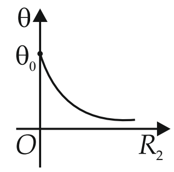



**2)** Area under current–time graph gives amount of charge passed through the conductor.

$$Q = \int_{t_1}^{t_2} i.dt$$

**3)** Deflection of galvanometer ($\theta$) vs resistane $R_2$. $R_2$ is variable and deflection is $\theta_0$ when $R_2 = 0$.




$$i = \frac{E}{R_1 + R_2}$$

$$i \propto \theta$$

$$\therefore \theta \propto \frac{E}{R_1 + R_2}$$

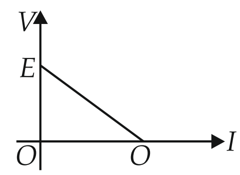
**4)** The terminal voltage ($V$) of a cell vs. current drawn from cell:

$$V = E - Ir$$

$$V = -Ir + E$$

$$\Downarrow$$

$$y = -mx + C$$



# Quick Revision MAGNETIC EFFECT OF ELECTRIC CURRENT

## TERMINOLOGY

| | | |
|---|---|---|
| $B$ | : | Magnetic field |
| $\mu_0$ | : | Permeability of vacuum |
| $n$ | : | Number of turns per unit length |
| $\nu$ | : | Frequency |
| $u$ | : | parallel component of velocity |
| $l$ | : | Length of conductor |
| $\tau$ | : | Torque |
| $m$ | : | magnetic moment |
| $k$ | : | Spring constant |
| $N$ | : | Number of total turns |
| $I_s$ | : | Current sensitivity |
| $V_s$ | : | Voltage sensitivity |
| $\phi$ | : | Deflection produced |
| $S$ | : | Shunt resistance |
| $G$ | : | Galvanometer resistance |
| $A$ | : | Ammeter resistance |
| $I_g$ | : | Galvanometer current |
| $I_s$ | : | Shunt current |
| $I$ | : | Total current |

## DEFINITIONS

**1) Biot-Savart Law:**
According to this law, the magnitude of magnetic field $\vec{B}$ is
I) Directly proportional to current I through the conductors.
II) Directly proportional to length of conductor.
III) Directly proportional to sin θ
IV) Inversely proportional to square of the distance of point '*p*' from current element.

$$dB \propto \frac{Idl\sin\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

**2) Tesla:**
One tesla is the amount of magnetic field in which when a charge of 1 coulomb moves with velocity of 1 m/s in a direction perpendicular to magnetic field, experiences a force of a 1 N.

**3) Right hand thumb rule:**
If we hold the straight conductor in the grip of our right hand in such a way that the extended thumb points in the direction of thumb current, then the direction of finger curl will give the direction of magnetic field.

**4) Maxwell's cork screw rule:**
If a right handed screw be rotated along the wire so that it advanced in the direction of current, when the direction in which the thumb rotated give the direction magnetic field.

**5) Clock rule :**
This rule gives the polarity of any face of the coil in anticlockwise direction it behavers like a north pole, if the current flows in clockwise direction, it behaves like south pole.

**6) Ampere's circuital law:**
It state that the line integral of the magnetic field $\vec{B}$ around any closed circuit is equal to $\mu_0$ times the total current threading or passing through this closed circuit.

**7) Lorentz force:**
The total force experienced by a charged particle moving in a region where both electric and magnetic field is present is called Lorentz force.

**8) Cyclotron:**
It is device used to accelerate charged particles like, protons, deuterons and alpha particles to very high speeds. Its working based on principle that charged particle can be accelerated to very high energies by making it pass through the moderate electric field a number of times. This can be done with the help of perpendicular magnetic field which throws the charged particle in circular path.

**9) Ampere:**
One ampere is that value of steady current. Which on flowing in each of two parallel infinitely long conductors of negligible cross-section placed in vacuum at distance of 1 m apart from each other, attracts or repel each other with a force of $2 \times 10^{-7}$ N between per meter of their length.

**10) Principle of moving coil galvanometer:**
A current carrying coil placed in a magnetic field experiences a current dependent torque, which tends to rotate the coil and produces angular deflection.

**11) Sensitivity of galvanometer:**
A galvanometer is said to be sensitive it is shows large scale deflection even when a small current is passed through it or a small voltage is applied across it.

**12) Current sensitivity:**
It is the deflection produced per unit current applied in galvanometer.

**13) Shunt:**
A very low resistance connected in parallel to galvanometer to convert it into ameter.

**14) Radial magnetic field:**
A magnetic field which always remain perpendicular to plane of coil . It is achieved by inserting soft iron core between moving coil galvanometer. Concave shaped magnets are used to achieve this.

## FORMULAE

1) $dB = \frac{\mu_o}{4\pi}\frac{Idl\sin\theta}{r^2}$

2) Magnetic field due to long straight conductor
$B = \frac{\mu_o}{4\pi}\frac{I}{a}[\sin\theta_1 + \sin\theta_2]$

3) Infinitely long conductor : $B = \frac{\mu_o I}{2\pi a}$

4) Circular loop centre : $B = \frac{\mu_o I}{2r}$

5) Axis of ring : $B = \frac{\mu_o I a^2}{2(r^2+a^2)^{3/2}}$

6) Solenoid interior : $B = \mu_o nI$

7) Solenoid end : $B = \frac{1}{2}\mu_o nI$

8) Force on moving charge in magnetic field
$F = B qv \sin\theta$
$\vec{F} = q(\vec{v}\times\vec{B})$

9) $r = \frac{mv}{Bq} \Rightarrow v = \frac{Bqr}{m}$ $\quad \therefore T = \frac{2\pi m}{Bq}$

10) K.E. $= \frac{B^2q^2r^2}{2m}$

11) Pitch $= v_{\parallel}T = \frac{2\pi mv\cos\theta}{Bq}$

12) Force current carrying wire
$\vec{F} = I(\vec{l}\times\vec{B})$ $\quad \therefore F = BIl\sin\theta$

13) Force per unit length
$f = \frac{\mu_0 I_1 I_2}{2\pi r}$

14) Force on wire of length 'L'
$f = \frac{\mu_0 I_1 I_2 L}{2\pi r}$

15) $\tau = NIBA\sin\theta$
$\tau = MB\sin\theta$
$\vec{\tau} = \vec{M}\times\vec{B}$

16) In M.C.G.
$I = \frac{k}{NBA}\phi$

Figure of merit $(G) = \frac{k}{NBA}$

Current sensitivity $(I_s) = \frac{\phi}{I} = \frac{NBA}{k}$

Voltage sensitivity $(V_s) = \frac{\phi}{V} = \frac{\phi}{IR} = \frac{I_s}{R}$

**17) Conversion to ammeter**

$S = \frac{I_g G}{I - I_g}$, $\quad A = \frac{GS}{G+S}$

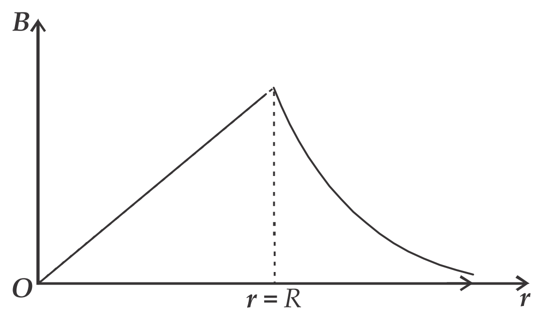
$I_g = \frac{IS}{G+S}$

**18) Conversion to voltmeter**

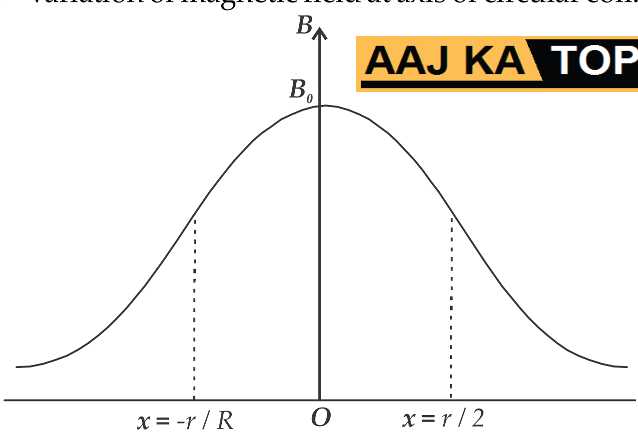
$R = \frac{V}{I_g} - G$, $\quad I_g = \frac{V}{R+G}$, $\quad V_R = G + R$

## GRAPHS

1) Variation of magnetic field from centre of wire




2) Variation of magnetic field at axis of circular coil.



# Quick Revision MAGNETISM AND MATTER

## TERMINOLOGY

| | | |
|---|---|---|
| $B$ | : | Magnetic field |
| $q_m$ | : | Pole strength |
| $\mu_o$ | : | Permeability of vacuum |
| $t$ | : | Time taken |
| $\tau$ | : | Torque |
| $e$ | : | Charge on electron |
| $h$ | : | Planck's constant |
| $B_H$ | : | Horizontal component of magnetic field |
| $B_v$ | : | Vertical component of magnetic field |
| $\delta$ | : | Angle of dip |
| $V$ | : | Volume |
| $m$ | : | Pole strength |
| $I$ | : | Intensity of magnetisation |
| $M$ | : | Magnetic dipole moment |
| $\chi_m$ | : | Susceptibility |
| $H$ | : | Magnetising force |
| $C$ | : | Curie's constant |

## DEFINITIONS

1) **Magnetic field:** The space around a magnet in which its influence can be felt.
2) **Uniform magnetic field:** A magnetic field is said to be uniform if it has same magnitude and direction at all points of that region.
3) **Magnetic poles (*m*):** The regions of apparently concentrated magnetic strength in a magnet where magnetic attraction is maximum.
4) **Magnetic axis :** The line passing the poles of magnet is called the magnetic axis of magnet.
5) **Magnetic length:** The distance between two poles of a magnet is called magnetic length.
6) **Coulomb's law of magnetic force:** The law states that the force of attraction or repulsion between two magnetic poles is directly proportional to their pole strength and inversely proportional to square of distance between them.

$$F = \frac{\mu_o}{4\pi}\frac{q_{m_1}q_{m_2}}{r^2}$$

7) **Unit pole strength:** Unit magnetic pole strength may be defined as that pole strength which when placed in vacuum at a distance of 1 meter apart from identical pole, repels it from a force of $10^{-7}$ newton.
8) **Magnetic dipole:** An arrangement of equal and opposite magnetic poles separated by a certain distance called a magnetic dipole.
9) **Magnetic dipole moment (*M*):** The magnetic dipole moment of a magnetic dipole is defined as the product of its pole strength and its magnetic length. S.I. unit of magnetic dipole moment is $Am^2$.
10) **Magnetic field lines:** Magnetic field lines may be defined as the curve, the tangent to which at any point gives the direction of magnetic field at that point. It may also be defined at the path along which a unit magnetic pole would tend to move if free to do so.
11) **Bohr Magneton:** It is defied as the magnetic moment associated with an electron due to its orbital motion in the first orbit of hydrogen atom.
12) **Magnetising field (*H*):** When a magnetic material is placed in magnetic field a magnetism induced in it. The magnetic field that in vacuum and induced magnetism is called magnetising field.
13) **Magnetic Induction (*B*):** The total magnetic field inside a magnetic material is the sum of equal magnetic field and additional magnetic field produced by magnetisetion of material , and is called magnetic induction *B*.
14) **Magnetising field intensity:** The ability of magnetising field to magnetise a material medium is called magnetising field intensity. Its magnitude may be defiled as number of ampere turns flowing round the unit length of solenoid required to produce given magnetic field.

15) **Intensity of magnetisation (*I*):** The magnetic moment developed per unit volume of material when placed in magnetising field is called intensity of magnetisation.

Intensity of magnetisation may also be defined as the pole strength developed per unit cross section of material.

16) **Magnetic permeability:** The magnetic permeability of a material is defied at the ratio of its magnetic induction $B$ to magnetic intensity $H$.

17) **Relative permeability:** It is defined as the ratio of permeability of the medium to the permeability of free space.

18) **Magnetic Susceptibility:** It is defiled as the ratio of intensity of magntisation to the magnetic field intensity $H$.

19) **Diamagnetic materials:** These are those substances which develop feeble magnetisation in the opposite direction of magnetising field. Such substance are free to repelled by magnets and tend to move from stronger to weaker parts of field.

20) **Paramagnetic material:** These are those substances which develop feeble magnetisation in the direction of magnetising field. Such substances are freely attracted by magnets and tend to move from weaker to a strong magnetic field.

21) **Ferromagnetic substance:** There are those materials which develop strong magnetisation in the direction of magnetising field. They are attracted by magnets and tend to move from weaker to stronger part.

## FORMULAE

Magnetic dipole moment : $M = q_m \times 2l$

$$F = \frac{\mu_0}{4\pi}\frac{q_{m_1}q_{m_2}}{r^2}$$

$$B_{\text{axis}} = \frac{\mu_0}{4\pi}\frac{2Mr}{(r^2-l^2)^{3/2}}$$

$$B_{\text{eq.}} = \frac{\mu_0}{4\pi}\frac{M}{(r^2+l^2)^{3/2}}$$

when $l << r$

$$B_{\text{axis}} = \frac{\mu_o}{4\pi}\frac{2M}{r^3}$$

$$B_{\text{eq.}} = \frac{\mu_o}{4\pi}\frac{M}{r^3}$$

Torque = $MB \sin\theta$

$W = \Delta U = -MB(\cos\theta_2 - \cos\theta_1)$

$M = NIA$

$$\mu_l = \frac{neh}{4\pi m_e} \qquad \therefore \phi_B = \oint \vec{B}.\vec{ds} = 0$$

$$\frac{B_v}{B_H} = \tan\delta \qquad \therefore B = \sqrt{B_H^2 + B_v^2}$$

$$B_H = \frac{\mu_0}{4\pi}\frac{2Mr}{(r^2-l^2)} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$$

$$\mu = \frac{B}{H} = \mu_0(1+\chi_m)$$

$$\therefore \mu_r = \frac{\mu}{\mu_0} = 1+\chi_m$$

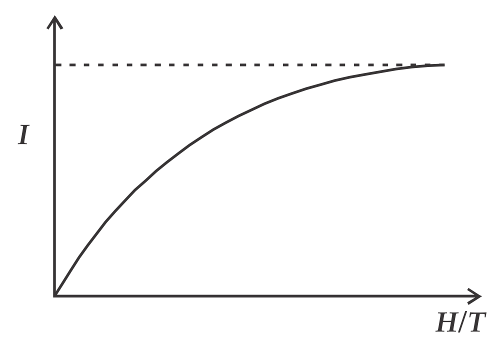
$$\chi_m = \frac{I}{H}$$

$$\therefore \chi_m = \frac{C}{T} \text{ (Curie's Law)}$$

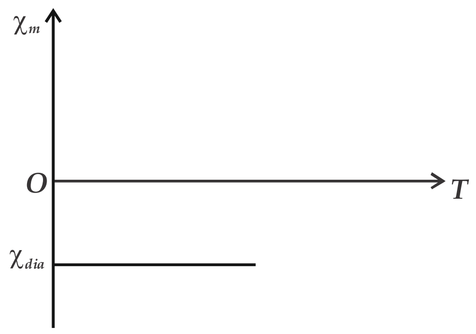
$$B = \mu_0(H+I)$$

## GRAPHS

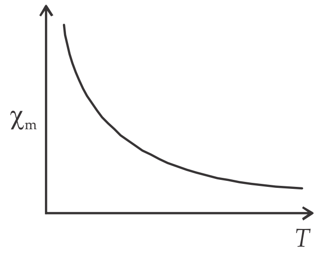
1) Intensity of magnetisation as a function of $H/T$



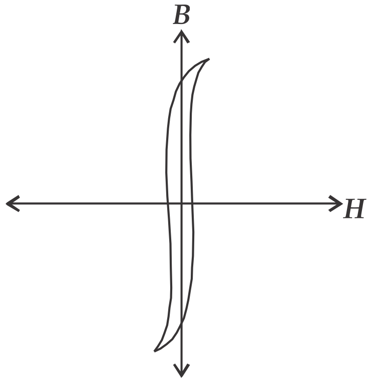
**2)** $\chi_m - T$ graph for diamagnetic material



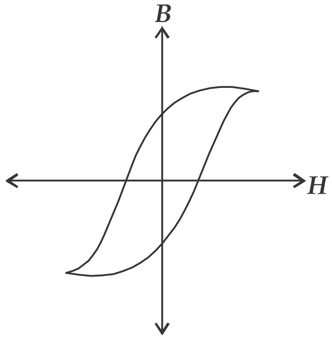

**3)** $\chi_m - T$ graph for paramagnetic material




**4)** Hysteresis curve for soft iron core




**5)** Hysteresis curve for ferromagnetic material



# Quick Revision ELECTROMAGNETIC INDUCTION

## TERMINOLOGY

| | | |
|---|---|---|
| $B$ | : | Magnetic Field |
| $\phi$ | : | Magnetic flux |
| $\theta$ | : | Angle between area vector & magnetic field |
| $N$ | : | Number of turns of coil |
| $n$ | : | Number of turns per unit length |
| $e$ | : | e.m.f (Induced) |
| $E$ | : | e.m.f. (Induced) |
| $e_0$ | : | $E_0$ = maximum e.m.f. |
| $\phi_1$ | : | Initial flux |
| $\phi_2$ | : | Final flux |
| $\omega$ | : | Angular velocity |
| $\nu$ | : | f = Frequency of revolutions |
| $L$ | : | Self inductance |
| $M$ | : | Mutual Inductance |
| $K$ | : | Coefficient of coupling |
| $v$ | : | Velocity of motion |
| $\mu_o$ | : | Magnetic permeability of free space |

## DEFINITIONS

1) **Magnetic flux (ϕ):** It is the number of magnetic field lines passing through a surface perpendicularly. Its S.I. unit is weber (Wb). Its CGS unit is maxwell. 1 weber = $10^8$ maxwell.

2) **Faraday's first law:** Wherever the amount of magnetic lines of force (magnetic flux) passing through a a coil changes an emf called induced emf is produced in the circuit. This induced emf exists as long as the change of flux continues.

3) **Faraday's second law:** The magnitude of induced emf is directly proportional to rate of change of magnetic flux.

4) **Lenz's law :** The direction of induced current is such that it tends to oppose the cause of its creations.

5) **Fleming's right hand rule:** According to this rule if we stretch thumb and first two fingers of our right hand in three mutually perpendicular directions such that the first finger points in direction of magnetic field and thumb shows the direction of motion of conductor, than central finger points in the direction of induced current.

6) **Eddy currents:** Eddy currents are the induced current set up inside the body of conductor wherever the magnetic flux linked with it changes.

7) **Inductance:** It is the inherent property of all the coils by virtue of which they opposes any change in the strength of current flowing through the coil. Its S.I. unit is Henry (H).

8) **Mutual inductance:** Wherever there is change in current flowing in one coil, an induced emf appears in neighbouring coil. This property is called as mutual inductance. Its SI unit is also Henry (H).

9) **Motional E.M.F.:** The emf induced across the ends of a conductor due to its motion in magnetic field is called motional e.m.f. Its magnitude is same as given by Faraday's second law.

*Methods of generating induced em.f.:*

i) Changing the magnetic field

ii) Changing the area in magnetic field

iii) Changing the relative orientation of $\vec{B}$ & $\vec{A}$

10) **Sparking:** When the break of a circuit is very quick, the circuit is switched off, a large self induced emf is set up in the circuit in the same direction as original emf. It creates a big spark across the switch.

11) **Coefficient of coupling:** Coefficient of coupling of two coils gives us a measure of manner in which two coils are coupled together. It relates their coefficient of self inductance to mutual inductance.

12) **Electromagnetic damping:** When the coil of galvanometer oscillates between magnetic field, an induced current sets up in coil which opposes it's motion. This phenomenan is called electromagnetic damping.

## FORMULAE

1) $\phi = \vec{B}.\vec{A} = BA\cos\theta$

2) $e = -\dfrac{Nd\phi}{dt}$

3) $e = -\left[\dfrac{\phi_2 - \phi_1}{t}\right]$

Negative sign indicates that induced emf. opposes the change in magnetic flux.

4) $e = E = Blv$

5) $I = \dfrac{e}{R} = \dfrac{Blv}{R}$

6) $I = -\dfrac{[\phi_2 - \phi_1]}{tR} = -\dfrac{N}{R}\dfrac{d\phi}{dt}$

7) $e = \dfrac{1}{2}Bl^2\omega$ [ e.m.f is induced across the rod of length '$l$']

8) $E = E_o \sin\omega t$

$\omega = 2\pi v$ or $\omega = 2\pi f$

9) $E_o = NBA\omega$

10) $I_o = \dfrac{E_o}{R} = \dfrac{NBA\omega}{R}$

11) $I_o = \dfrac{E_o}{R}$

12) $\phi = LI$

13) $e = -\dfrac{LdI}{dt}$

14) $L_1 + L_2 + L_3 + ............L_n = L$

when inductors are in series

15) $L = \dfrac{L_1L_2}{L_1 + L_2}$ when

when inductors are in parellel

16) $L = \dfrac{\mu_o N^2 A}{l}$

17) $U = \dfrac{1}{2}LI^2$

18) $e = -\dfrac{MdI}{dt}$

19) $M = \dfrac{\mu_o N_1 N_2 A}{l} = \mu_o n_1 n_2 A l$

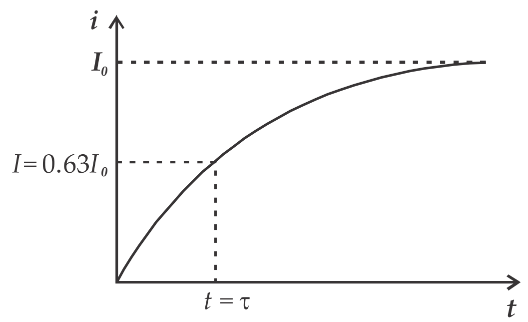
20) $K = \dfrac{M}{\sqrt{L_1 L_2}}$

21) $I = I_o\, e^{-(R/L)\,t}$

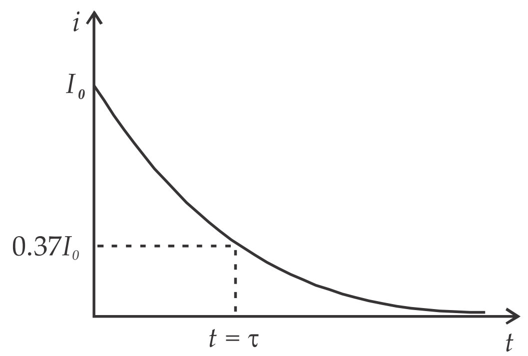
22) $I = I_o\,[\,1 - e^{-Rt/L}]$

## GRAPHS

I)




II)



# Quick Revision ALTERNATING CURRENT

## TERMINOLOGY

$E_{av.}$ : Average EMF
$E_{rms}$ : RMS EMF
$I_{av.}$ : Average current
$I_{rms}$ : RMS current
$I_0$ : Peak current / Max. Current / Amplitude
$E_0$ : Peak voltage / Max. Voltage / Amplitude voltage
$\nu$ : Frequency
$\omega$ : Angular frequency
$X_L$ : Inductive reactance
$X_C$ : Capacitative reactance
$Q$ : Quality factor
$\omega_r$ : Angular resonance frequency
$\nu_r$ : Resonance frequency
$\phi$ : Phase angle
$Z$ : Impedance
$U_L$ : Energy of inductor
$U_C$ : Energy of capacitor

## DEFINITIONS

1) **Alternating current:**
A current whose magnitude changes continuously and direction changes periodically.

2) **Amplitude:**
The maximum value attained by alternating current in either direction is called its amplitude or peak value denoted by $I_0$.

3) **Time period:**
Time taken by alternating current to complete one cycle of its variations is called its time period and is denoted by $T$.

4) **Frequency:**
The number of cycles completed per second by an alternating current.

5) **Average voltage of AC:**
It is defined as the value of direct current which sends same charge in a circuit in same time as is sent by the given alternating current in its half time period.

6) **R.M.S. value of AC:**
It is defined as that value of AC current which produces the same heating effect in a given resistors as is produced by the given alternating current when passed for the same time.

7) **Argand diagram:**
A diagram that represents alternating current and voltage of the same frequency as rotating vectors along with proper phase angle between them is called phasor diagram or argand diagram.

8) **Inductive reactance:**
It is a measure of effective opposition offered to current flow by the inductor. It has same unit as resistance. But it differs from resistance at it doesn't generate any heat when current passes through them.

9) **Capacitative reactance:**
It is the measure of effective opposition offered to current flow by a capacitor. It also has same unit as resistance. It doesn't disssipate heat, so its power consumption is zero.

10) **Susceptance:**
Reciprocal of reactance of AC circuit is called susceptance.

11) **Admittance:**
Reciprocal of impedance of AC circuit is called admittance.

12) **Resonance:**
A series L-C-R circuit is said to be in resonance condition when current through it becomes maximum.

13) ***Q*–Factor:**
Q-factor is the ratio of resonant frequency to the difference in frequency taken on both sides of resonant frequency, such that at each frequency, the current amplitude becomes $\frac{1}{\sqrt{2}}$ times the value at resonant frequency.

14) **Power factor:**
Power factor is the ratio of true power frequency to apparent frequency power at the constant frequency. For pure inductive and pure capacitative circuit, it is always zero.

15) **Wattless current:**
The current in circuit is said to be wattless if the average power consumed in the circuit is zero.

16) ***L–C* oscillations:**
When a charged capacitor is allowed to discharge through a non-resistive inductor, electrical oscillations of constant amplitude and frequency are produced. These are called *L–C* oscillations.

## FORMULAE

1) $I_{\text{rms}} = \dfrac{I_0}{\sqrt{2}} = 0.707 I_0$

2) $E_{\text{rms}} = \dfrac{E_0}{\sqrt{2}} = 0.707 E_0$

3) $I_{\text{av}} = \dfrac{2I_0}{\pi} = 0.637 I_0$

4) $E_{\text{av}} = \dfrac{2E_0}{\pi} = 0.637 E_0$

5) $X_L = 2\pi\nu L$

In pure inductor,

$$I = \frac{E}{X_L} = \frac{E}{2\pi\nu L}$$

6) $X_C = \dfrac{1}{2\pi\nu C}$

In pure capacitor,

$$I = \frac{E}{X_C} = E.2\pi\nu C$$

7) In $R$–$L$ circuit,

$$E = E_0 \sin \omega t$$

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

$$Z = \frac{E_{\text{rms}}}{I_{\text{rms}}} = \sqrt{R^2 + X_L^2}$$

$$\tan\phi = \frac{X_L}{R} = \frac{2\pi\nu L}{R}$$

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

8) In $R$–$C$ circuit,

$$E = E_0 \sin \omega t$$

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

$$Z = \frac{E_{\text{rms}}}{I_{\text{rms}}} = \sqrt{R^2 + X_C^2} \;, \quad \text{where } X_C = \frac{1}{2\pi\nu C}$$

$$\tan\phi = \frac{X_C}{R} = \frac{1}{2\pi\nu CR}$$

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_C^2}}$$

9) In $L$–$C$–$R$ circuit,

$$Z = \frac{E_{\text{rms}}}{I_{\text{rms}}}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \left(2\pi\nu L - \frac{1}{2\pi\nu C}\right)^2}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$

$$\cos\phi = \frac{R}{Z}$$

10) $L$–$C$–$R$ at resonance,

$$X_L = X_C$$

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$

$$Z = R$$

$$\phi = 0$$

$$\tan\phi = 0$$

$$\cos\phi = 1$$

11) $Q - \text{factor} = \dfrac{\omega_r}{\omega_2 - \omega_1} = \dfrac{\omega_r L}{R} = \dfrac{1}{R}\sqrt{\dfrac{L}{C}}$

12) Power in LCR,

$$P_{av} = E_{av} I_{av} \cos\phi$$

13) R.M.S. Power = $P_{\text{rms}} = E_{\text{rms}} I_{\text{rms}} \cos\phi$

Power factor,

14) $\cos\phi = \dfrac{R}{Z} = \dfrac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$

15) $U_L = \dfrac{1}{2} LI^2$

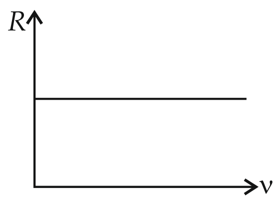
16) Average power in inductive circuit = 0

17) Average power in capacitative circuit = 0

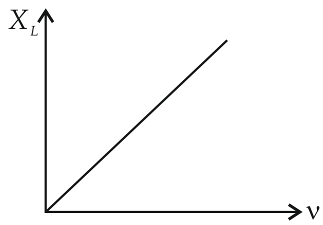
18) $U_C = \dfrac{1}{2} CV^2 = \dfrac{Q^2}{2C}$

## GRAPHS

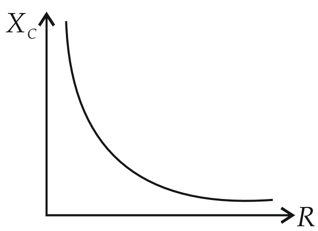
1) Variation of resistance v/s frequency:



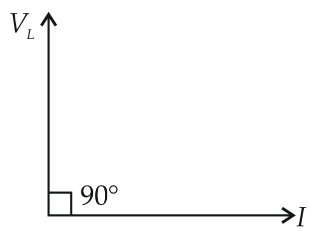

2) Inductive reactance v/s frequency



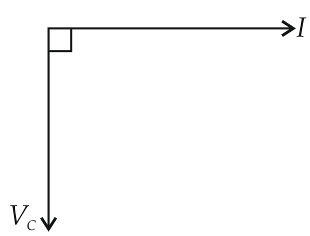

3) Capacitative reactance v/s frequency




4) Purely inductive circuit. Voltage leads by 90°.

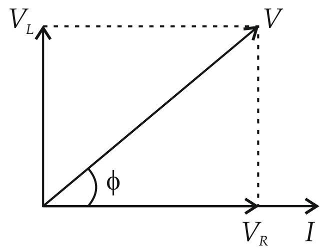



5) In purely capacitative circuit, voltage lags by current by 90°.

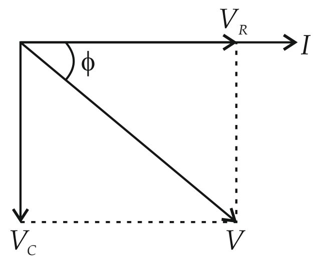



6) In purely resistive circuit, voltage and current are in same phase.

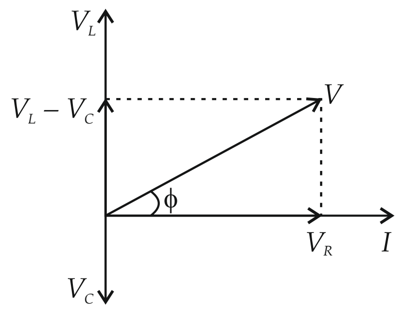

7) In $R$–$L$ circuit, voltage leads by some angle $\phi$.



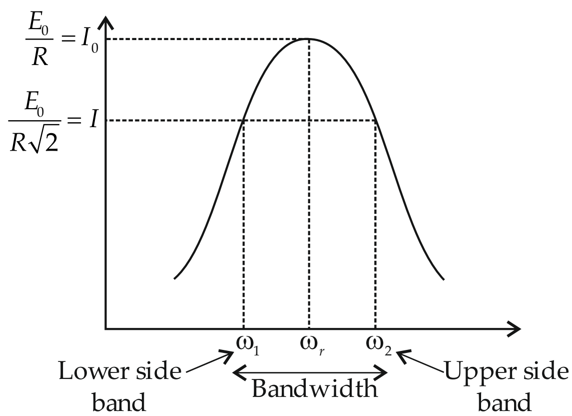

8) In purely capacitative resistance circuit, voltage lags by current.




9) $L$–$C$–$R$ circuit voltage and current




10) Band width of a series resonant circuit



# Quick Revision ELECTROMAGNETIC WAVES

## TERMINOLOGY

$I_D$ : Displacement current
$I_C$ : Conduction current
$E$ : Electric field
$\phi_E$ : Electric flux
$A$ : Area
$C$ : Capacitance
$c$ : Speed of light
$K$ : Propagation constant
$\lambda$ : Wavelength
$\mu_0$ : Permeability of free space
$\varepsilon_0$ : Permittivity of free space-
$\vec{s}$ : Direction of propagation of wave
$U_E$ : Average energy density of electric field
$U_B$ : Average energy density of magnetic field
$B$ : Magnetic field
$p$ : Momentum
$U$ : Energy
$I$ : Intensity

## DEFINITIONS

**1) Displacement current:**

It is the current which comes into existance, in addition to conduction current, whenever the electric field and hence flux changes with time.

**2) Property of continuity:**

The sum of conduction current and displacement current remain continuous along any closed path while, conduction current and displacement current might not be individually continuous.

**3) Maxwell's equation:**

1) *Gauss's law of electrostatics:*

The electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge contained inside the surface.

2) *Gauss's law of magnetism:*

The net magnetic flux through any closed surface is always zero.

3) *Faraday's law of electromagnetic induction:*

This law states that emf produced in any coil is directly proportional to rate of change of magnetic flux.

4) *Modified Ampere's Law:*

This states that line integral of magnetic field around any closed circuit is equal to $\mu_0$ times the sum of conduction current and displacement current.

**4) Electromagnetic wave:**

An electromagnetic wave is a wave radiated by an accelerated charge and which propagates through space as coupled electric and magnetic fields, oscillating perpendicular to each other and to the direction of propagation of the wave.

**5) Radio waves:**

These are produced by accelerated charges in conducting wires. Frequency ranges from 500 KHz to 1000 MHz.

**6) Microwaves:**

These gigahertz range waves are produced by klystron and magnetron diodes. They are used in radar and microwave ovens.

**7) Infrared waves:**

These are emitted by atoms and molecules of hot bodies. These are used in physical therapy.

**8) Visible rays:**

That part of electromagnetic waves which can be detected by human eye and its wavelength ranges from 400 to 700 nanometer.

**9) Ultraviolet rays:**

These are produced by special lamps and very hot bodies like sun. It is harmful for humans. It's wavelength ranges from 400 nm to 0.6 nm.

**10) *X*-rays:**

These are produced by fast moving electrons when they strike metal target.

Wavelength varies from 10 nm to $10^{-4}$ nm.

**11) Gamma rays:**

These are produced by nuclear reaction and radioactive nuclei. Wavelength ranges from $10^{-10}$ m to $10^{-14}$ m.

## FORMULAE

1) $I_0 = \varepsilon_0 \dfrac{d\phi_E}{dt}$

2) $I_0 = \varepsilon_0 \dfrac{d}{dt}(EA) = \varepsilon_0 A \dfrac{dE}{dt}$

3) $I_0 = C\dfrac{dV}{dt}$

4) $\oint \vec{B}.d\vec{l} = \mu_0(I_C + I_D)$

5) $K = \dfrac{2\pi}{\lambda}$

6) $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$ in vacuum

7) $c = \dfrac{1}{\sqrt{\mu_r \mu_0 \varepsilon_r \varepsilon_0}}$ in material medium

8) $E_y = E_0 \sin(kx - wt)$

9) $B_z = B_0 \sin(kx - wt)$

(For a wave propagating along $x$-axis)

10) $U_E = \dfrac{1}{4}\varepsilon_0 E_0^2 = \dfrac{1}{2}\varepsilon_0 E_{\text{r.m.s.}}^2$

11) $U_B = \dfrac{1}{4\mu_0} B_0^2 = \dfrac{1}{2\mu_0} B_{\text{rms}}^2$

12) $U_{av.} = \dfrac{1}{2}\varepsilon_0 E_{\text{rms}}^2 + \dfrac{1}{2\mu_0} B_{\text{rms}}^2 = \dfrac{B_{\text{rms}}^2}{\mu_0}$

13) $p = \dfrac{U}{c}$

14) Intensity of wave $(I) = \dfrac{p}{A}$

15) $I = U_{av} C = \varepsilon_0 E_{\text{rms}}^2 C$

16) $\vec{s} = \dfrac{1}{\mu_0}(\vec{E} \times \vec{B})$

Quick Revision

# RAY OPTICS

## TERMINOLOGY

$U$ = Object distance
$v$ = Image distance
$vi$ = Object velocity
$\theta$ = angle
$h$ = No. of images
$v_m$ = Velocity of mirror
$i$ = Angle of incidence
$r'$ = angle of reflection
$r$ = Angle of refraction
$f$ = Focal length
$m$ = Magnification = transverse
$m'$ = Magnification - lateral
$\chi_1$ = Distance of object from focus
$\chi_2$ = Distance of image from focus
$\mu_2$ = Refractive Index of medium in which refracted ray is hare
$\mu_1$ = Refractive index of medium in which incident ray is hare
$\delta$ = Deviation
$h$ = height of object
$h'$ = Height of image
$t$ = Thickness of glass slab
$i_c$ = Critical angle
$R_1$ = Radius of curvature of first surface
$R_2$ = Radius of curvature of second surface
$f_l$ = Focal length of lens
$f_m$ = Focal length of mirror
$P$ = Power of lens
$f_{eq}$ = Equivalent focal length
$P_{eq}$ = Equivalent power
$\lambda$ = wavelength
$h_1$ = Height of first image
$h_2$ = Height of second image
e = Angle of imergence
$\delta_m$ = Minimum deviation
$\delta_v$ = Deviation for violet colour
$\delta_R$ = Deviation for red colour
$\mu_R$ = Refractive index of red colour
$\delta_{mean}$ = Mean deviation
$\mu_v$ = Refractive index of violet colour
$f_o$ = Focal length of objective piece
$f_e$ = focal length of eyepiece
$\mu_y$ = Refractive index of yellow colour
$D$ = Last distance of distinct vision
$m_o$ = Magnification of object piece
$m_i$ = Magnification of object eyepiece

## DEFINITIONS

1) **Reflection:**
Ray of light after incidenting on loundary separating two media comes back into the same media then it is called as reflection of light.

2) **Refraction:**
The bending of light ray passing from one medium to other medium is called refraction.

3) **Optically rares medium:**
A medium in which velocity of light is more is called optically rarer medium.

4) **Optically denser medium:**
A medium is which velocity of light is less is called optically denser medium .

5) **Optical path:**
The distance travelled by light in vacuum in the same time in which it travels a given path length in a medium is called optical path.

6) **Critical Angle:**
The angle of incidence at which refracted angle is 90° when light travels from denser to rarer medium is called critical angle.

7) **Total internal reflection:**
When angle of incidence is greater then critical angle then the ray come back in the same medium after reflection is called as total internal reflection

8) **Dispersion:**
When white light incident on prism then it splitted into its own component is called dispersion of light.

## FORMULAE

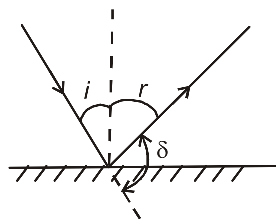
### Reflection

**I) Plane Mirror:**

**i)** Object distance = Image distance

**1) Deviation**

$\delta = 180 - 2i$ $\longrightarrow$




**2) Image formed by two mirror**

m = $m = \dfrac{360}{\theta}$

a) If $\dfrac{360}{\theta}$ = even than n = m – 1

b) If $\dfrac{360}{\theta}$ = odd then

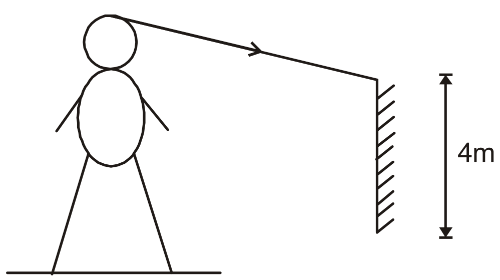
i) n = m –1, if object is at angle bisector

ii) n = m, if object is not at angle bisector

**3) Height of plane mirror**

i) To see complete image in a plane mirror

Height of mirror $= \dfrac{\text{Height of person}}{2}$




ii) To see complete wall behind himself

Height of mirror $= \dfrac{\text{Height of wall}}{3}$

**4) Object time and image time**

i) If object time is in hour

∴ Image time = $12^h$ – Object time

ii) If object time is in hour and minute

∴ Image time $11^h 60^m$ – Object time

iii) If object time is in hour, minute and second

∴ Image time = $11^h 59^m 60^s$ – object time

**5) Object and image velocity**

i) Velocity of object ($v_0$) = velocity of image ($v_1$)

ii) $v_1 = 2v_m$ if mirror moves towards stationary object

**6. Rotation of mirror : -**

If plant mirror rotated by an angle θ keeping incident ray constant then reflected ray rotated by an angle 2θ

**7. Law of reflection**

$\angle i = \angle r$

**II) Spherical Mirror:**

**1) General equation**

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

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

**2) Magnification**

i) Transverse magnification

$$m = \frac{h'}{h} = \frac{-v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$$

ii) Longitudinal magnification

$$m' = \frac{(v_2 - v_1)}{(u_2 - u_1)}$$

If object is small

$$m' = \left(\frac{v}{u}\right)^2$$

iii) Areal magnification

$M = m^2$

**3) Velocity of image**

$$v_1 = -m^2 v_o = \frac{v^2}{u^2}.v_o$$

**4) Newton's formula**

$$f = \sqrt{x_1 x_2}$$

### Refraction

**I) Shell's Law and Law of Refraction**

i) Absolute refractive index

If comparison with vaccum

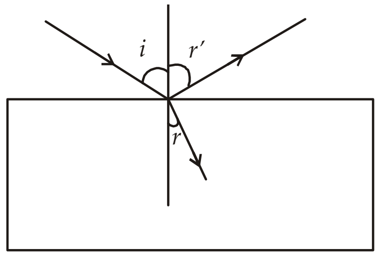
Ex : - $\mu_w = \dfrac{4}{3}$, $\mu_g = \dfrac{3}{2}$

ii) Relative refractive index

$${}_1\mu_2 = \frac{\mu_2}{\mu_1}$$

iii) Snell's Law

$${}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$




iv) δ = $i - r$, Light travels from rarer to denser
δ = $r - i$, Light travels from denser to rarer

v) Apparent Depth:
Observer in rarer medium

$$\mu = \frac{h}{h'},$$ $h$ = Actual height

$h'$ = Apparent height

Shift $= h\left(1 - \frac{1}{\mu}\right)$

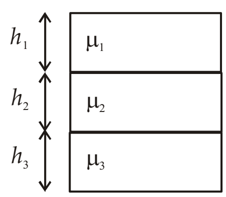
Observer in denser medium

$$\mu = \frac{h'}{h}$$

Shift $= h\ (\mu - 1)$

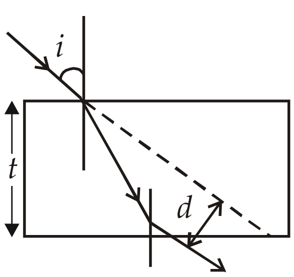
vi) Equivalent refractive index:
Observer in a rarer medium.

$$\mu_{eff} = \frac{h_{eff}}{h'_{eff}} = \frac{h_1 + h_2 + h_3}{\frac{h_1}{\mu_1} + \frac{h_2}{\mu_2} + \frac{h_3}{\mu_3}}$$




vii) Lateral shift:

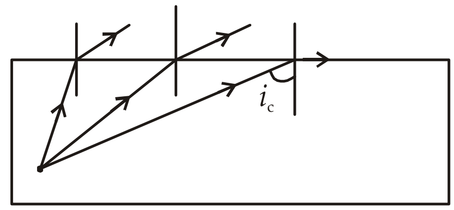
$$d = \frac{t\sin(i - r)}{\cos r}$$



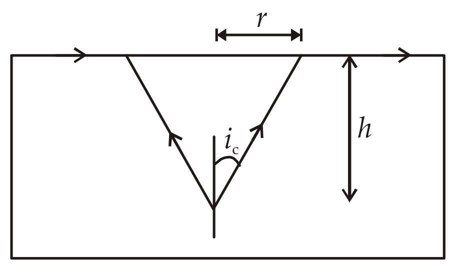

viii) Optical path:
Optical path = μx

## II) Total internal reflection

$$\sin ic = \frac{1}{\mu}$$

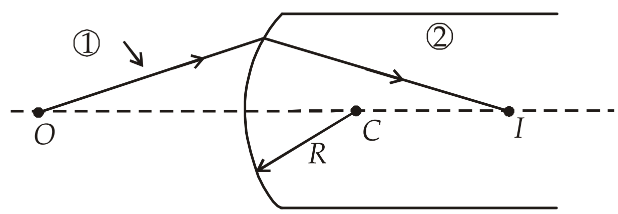



Height ($h$) = $r\sqrt{\mu^2 - 1}$




## III) Refraction through spherical surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{v} = \frac{\mu_2 - \mu_1}{R}$$




## IV) Lens

i) Lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

ii) Magnification:
Transverse magnification

$$m = \frac{h'}{h} = \frac{f}{f + u} = \frac{f - v}{f}$$

Longitudinal magnification

$$m' = \left(\frac{v}{u}\right)^2$$

Areal magnification

$m_a = m^2$

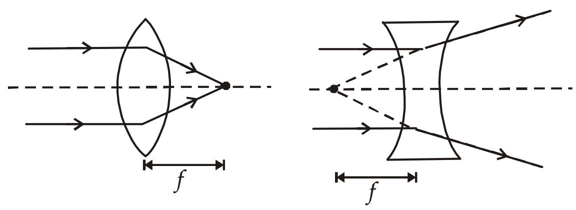
iii) Lens maker's formula

$$\frac{1}{f}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

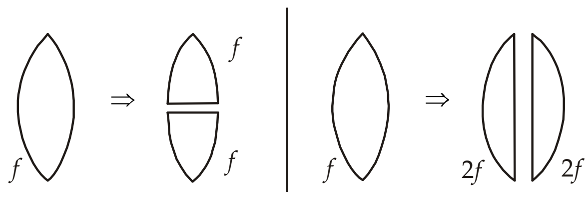
Refractive index of lens = $\mu_2$
Refractive index of surrounding medium = $\mu_2$
If $\mu_2 = \mu$ and $\mu_1 = 1$ (air)

then $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

vi) Focus




v) Cutting of lens

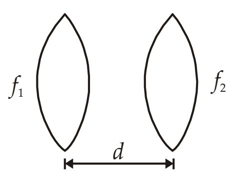



vi) Combination of Lens

$$\frac{1}{f_{eq}}=\frac{1}{f_1}+\frac{1}{f_2}+..........$$

$P_{eq} = P_1 + P_2 + ...........$

When lens are at distance '$d$'



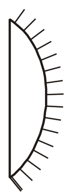

$$\frac{1}{f_{eq}}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$$

$P_{eq} = P_1 + P_2 - dP_1 P_2$

vii) Silvering of lens

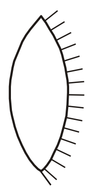
$$\frac{1}{f_{eq}}=\frac{2}{f_l}+\frac{1}{f_m}$$

*Plane convex lens*



$$f_{eq}=\frac{R}{2\mu}$$

*Convex lens*

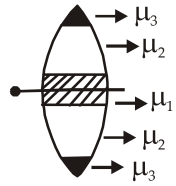


$$f_{eq}=\frac{R}{2(2\mu-1)}$$

viii) Power of lens

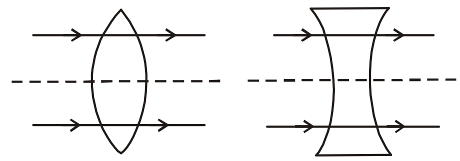
$$P=\frac{1}{f(m)}$$

ix) No. of images
No. of images = No. of material

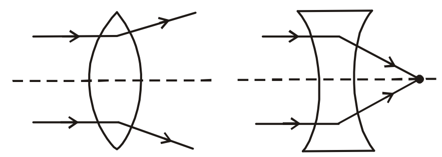



x) Refractive index of medium is same as that of surrounding

$f = \infty$



xi) Refractive index of surrounding greater than lens
$f = -$ *ive*



xii) Focal length depends on medium

$$f \propto \frac{1}{\lambda}$$

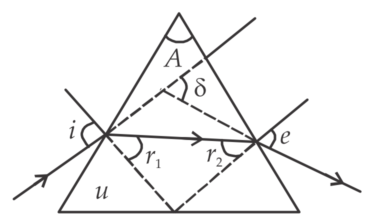
xiii) Newton's formula

$$f=\sqrt{x_1 x_2}$$

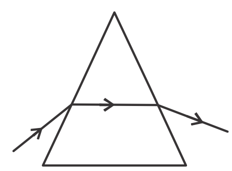
xiv) Displacement method

$$h=\sqrt{h'_1 h'_2}$$

## VI) Prism




i) General Equation



$A = r_1 + r_2$
$i + e = A + \delta$

$$\frac{\mu_2}{\mu_1}=\frac{\sin i}{\sin r}$$

ii) Minimum Deviation

$i = e$ , $\delta = \delta_m$ , $\qquad r_1 = r_2 = r$

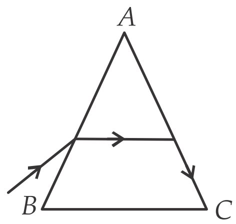
$\therefore\ r = A / 2$

$\delta_m = 2\,i - A$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

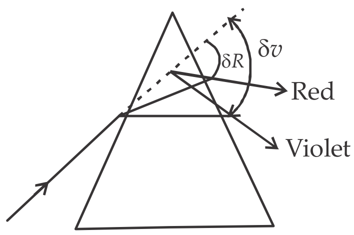
iii) Condition for grazing emergence

$$i = \sin^{-1}[\sqrt{\mu^2 - 1}\sin A - \cos A]$$




iv) Angular Dispersion

$\theta = \delta_r - \delta_R = A\ (\mu_v - \mu_R)$




v) Dispersive power (ω)

$$\omega = \frac{\theta}{\delta_{mean}}$$

a) If $\delta_{mean} = \delta_y$

$$\omega = \frac{\theta}{\delta_y} = \frac{A(\mu_v - \mu_R)}{A(\mu + 1)} = \frac{\mu_v - \mu_R}{\mu_y - 1}$$

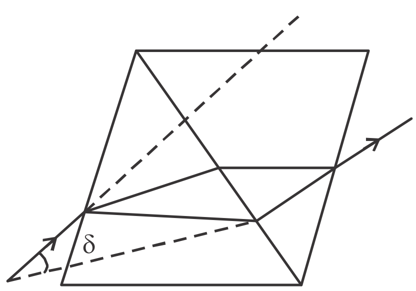
b) If $\delta_{mean} = \dfrac{\delta_v + \delta_R}{2}$

vi) Deviation without dispersion

$\theta_c = -\theta_f$

$(\delta_v - \delta_R)_{crown} = (\delta_v - \delta_R)_{flimt}$

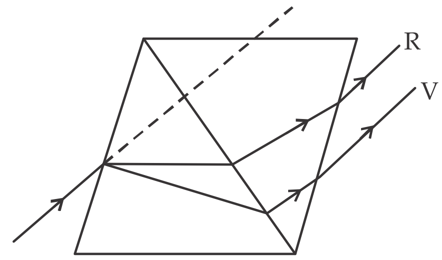
$A\ (\ \mu_v - \mu_R\ ) = A'\ (\ \mu'_v - \mu'_R\ )$




vii) Dispersion without deviation

$\delta_y = \delta'_y$

$A\ (\ \mu_y - 1\ ) = A'\ (\ \mu'_y - 1\ )$




## V) Defects in eyes

i) Myopia or short sightedness

$V = \infty$

$v = f$ = shifted for point

ii) Hyper metropia or for sightdness

$V = D = 25$ cm

$v$ = shifted near point

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

## VI) Optical Instrument

**i)** *Microscope*

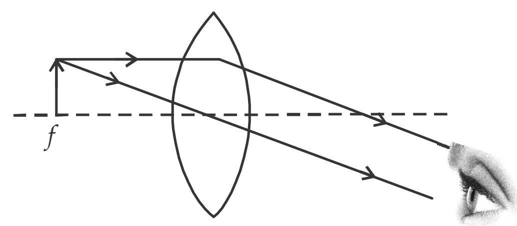
• Simple microscope

a) Image at infinite

$V = f$

$v = \infty$

$$m = \frac{D}{f}$$

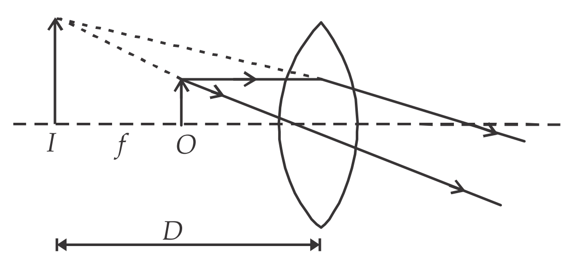



b) Image of D

$V < f$

$v = D$

$$m = 1 + \frac{D}{f}$$



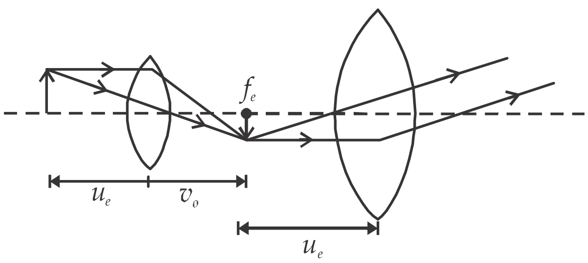
- Compound microscope

a) Image of infinite

$$\frac{v_o}{V_o}\left(\frac{D}{f_e}\right)$$

$$L = v_o + f_e$$

$$m = \frac{L - f_o - f_e}{f_o} \cdot \frac{D}{f_e}$$

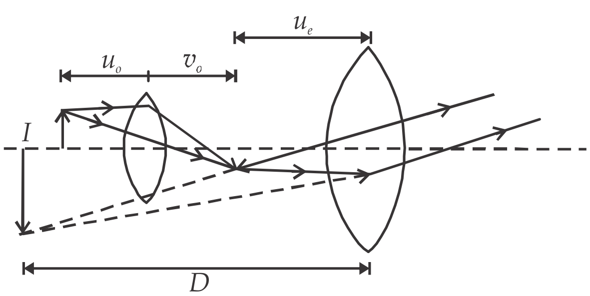



b) Image of D

$$\frac{v_o}{V_o}\left(1 + \frac{D}{f_e}\right)$$

$$L = v_o + V_e$$

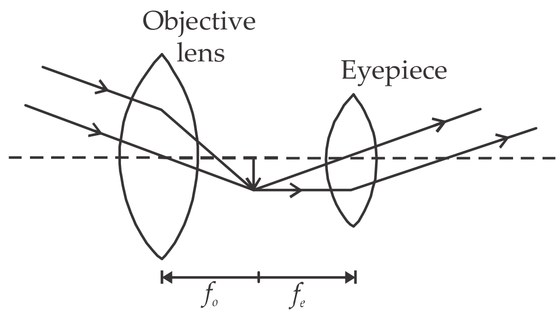
$$m = -\frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$$




## VII) Telescope

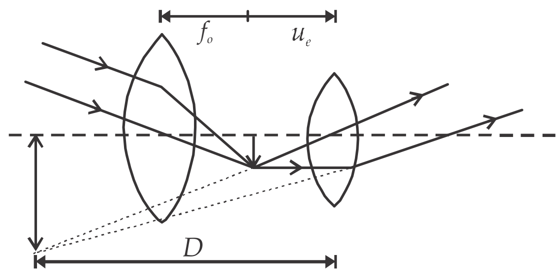
a) Image of infinite

$$m = \frac{f_e}{f_o}$$




b) Image of D

$$m = \frac{-f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$



# Quick Revision — WAVE OPTICS

## TERMINOLOGY

| | | |
|---|---|---|
| $Y_1$ | : | Displacement of first wave |
| $Y_2$ | : | Displacement of second wave |
| $a_1$ & $a_2$ | : | Amplitude of first and second wave |
| $R$ | : | Resultant amplitude |
| $I_1$ & $I_2$ | : | Intensity of the first and second wave |
| $I_R$ | : | Resultant intensity |
| $I_{max}$ | : | Maximum intensity |
| $I_{min}$ | : | Minimum intensity |
| $r$ | : | Amplitude ratio |
| $d$ | : | Distance between slit |
| $\beta$ | : | Fringe width |
| $D$ | : | Distance between source and screen |
| $\mu$ | : | Refractive index |
| $t$ | : | Thickness of glass slab |
| $a$ | : | Slit width |
| $\propto$ | : | Semi-angle made by object to the lens |

## DEFINITIONS

1) **Wavefront:**
A locus of all the points of medium to which waves reaches simultaneously so that all points are in same phase is called wavefront.

2) **Wave normal:**
A perpendicular drawn to the surface of wavefront at any point of a wavefront in the direction of propagation of light is called wave normal.

3) **Path difference:**
The difference in the path lengths of two waves meeting at a point is called path difference.

4) **Interference of light:**
The modification in the intensity of light [redistribution of light energy] produced by the superposition of two or more light waves is called interference of light.

5) **Constructive interference:**
The points of which resultant displacement is maximum, the waves reinforce each other and the interference is called constructive interference.

6) **Destructive interference:**
The points at which resultant displacement is minimum the waves reinforce each other and the interference is called destructive interference.

7) **Coherent sources:**
Two source of light most be emitting light waves of equal frequency and which are in the same phase or with constant phase difference are known as coherent sources.

8) **Monochromatic light:**
The light waves of only one wave is called monochromatic light.

9) **Fringe width:**
The distance between the centre of two adjacent bright or dark bonds is called as fringe width.

10) **Diffraction of light:**
The bending of light near the edges of an obstacle or slit and spreading into the region of a geometrical shadow is known as diffraction of light.

11) **Limit of resolution:**
The smallest angular or linear separation between the two points objects at which they appear to be just resolved is called limit of resolution.

12) **Resolving power:**
The reciprocal of the limit of resolution is called resolving power.

13) **Polarisation of light:**
The phenomenon of limiting the vibration of electric field vector in one direction in a plane perpendicular to the direction of propagation of light wave is called polarisation of light.

## FORMULAE

1) **Superposition of wave**

$Y_1 = a_1 \sin \omega t$

$Y_2 = a_2 \sin (\omega t + \phi)$

$Y = Y_1 + Y_2$

$Y = R \sin (\omega t + \phi)$

$$R = \sqrt{a_1^2 + a_2^2 + 2a,a_2 \cos\phi}$$

$I_1 = Ka_1^2,\ I_2 = Ka_2^2,\ I_R = K R^2$

$I_R = a_1^2 + a_2^2 + 2a,a_2 \cos\phi$

For constructive interference $[\phi = 0, 2\pi, .....]$

$I_{max} = (a_1 + a_2)^2$

$$\frac{I_{\max}}{I_{\min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(r+1)^2}{(r-1)^2}$$

$$r = \frac{a_1}{a_2}$$

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

If $= I_1 = I_2 = I$

$$I_R = 4I\cos^2\left(\frac{\phi}{2}\right)$$

$I_{max} = 4\ I$

$I_{min} = 0$

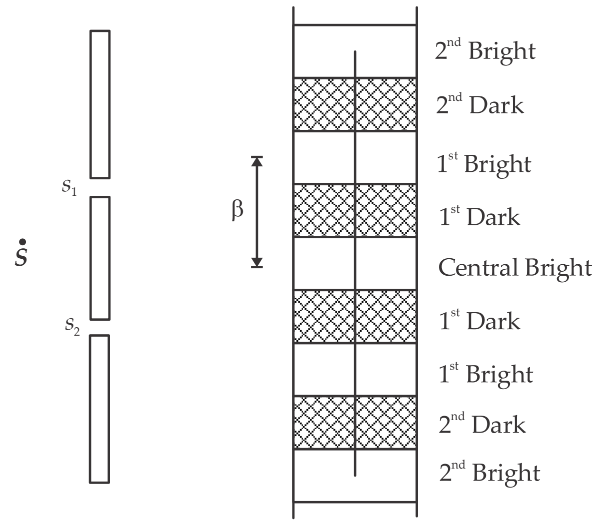
## 2) Young double slit experiment

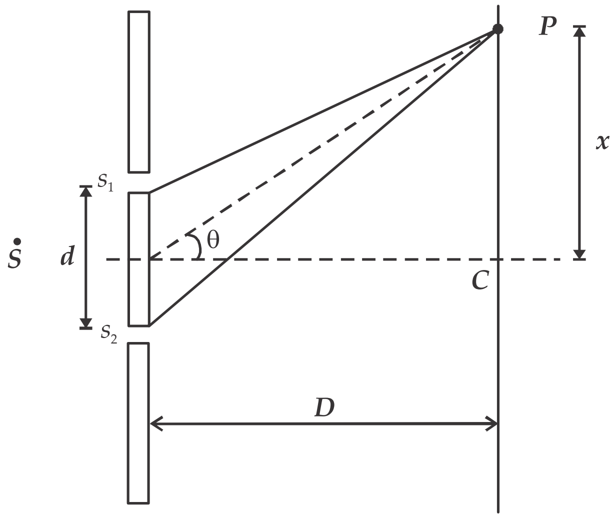
Constructive pattern

Path difference = n λ,  n = 0, 1, 2, 3 ......

Destructive pattern

Path difference = (2n – 1) $\frac{\lambda}{2}$,  n = 1, 2, ......




**a)** $n^{\text{th}}$ bright fringe from central maxima

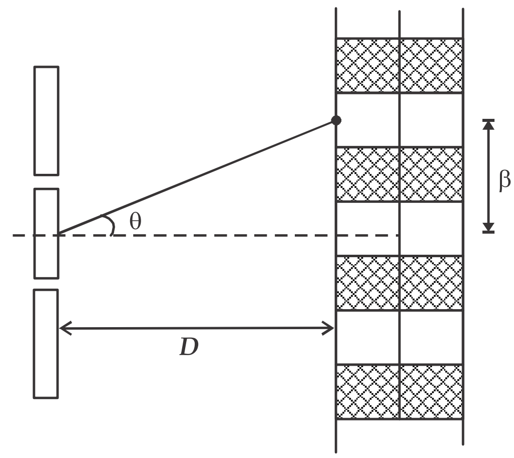
$$x_n = \frac{n\lambda D}{d}, \qquad n = 0, 1, 2............$$

**b)** $n^{th}$ fringe from central maxima

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

**c) Fringe width**

$$\beta = \frac{\lambda D}{d}, \qquad \theta = \frac{\lambda}{d} = \frac{\beta}{D}$$



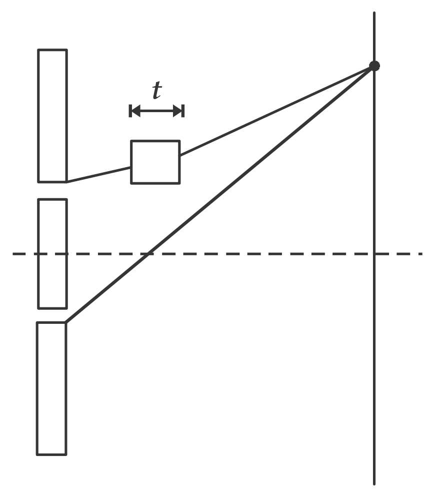

**d)** In *YDSE* if $n_1$ fringes are visible in a field of view with light of wavelength $\lambda_1$, while -$n_2$ with light of wavelength $\lambda_2$ in the same field then

$$n_1\lambda_1 = n_2\lambda_2$$

**e)** If whole YDSE set up taken is taken in another medium then λ changes os fringe with [β] changes

$$\frac{\mu_2}{\mu_1} = \frac{\lambda_2}{\lambda_1} \qquad \therefore \ \mu \propto \frac{1}{\lambda}$$

**f) Shifting of fringe pattern**



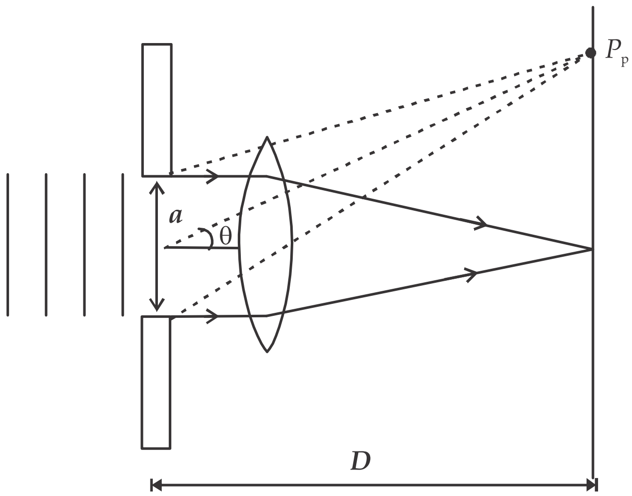

Fringe shift = $\frac{D(\mu-1)t}{d} = \frac{\beta(\mu-1)t}{\lambda}$

Additional path difference = (μ – 1)$t$

If shift equivalent to m fringes then

$$m = \frac{(\mu-1)t}{\lambda}$$

## 3) Fraunhoffer diffraction [Single slit]




**a)** Secondary minima

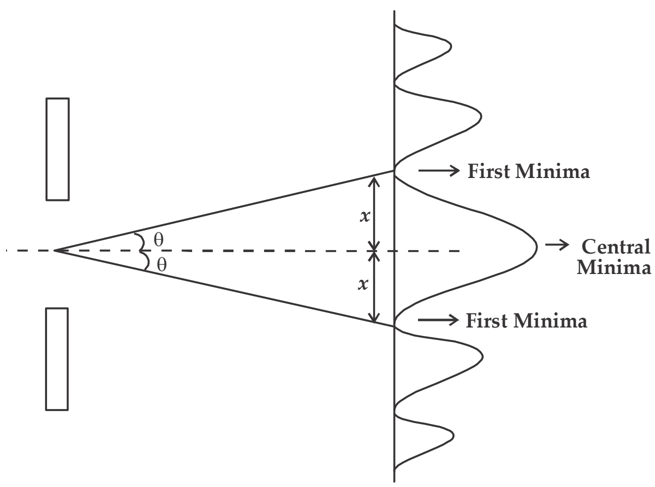
$a \sin\theta_n = n\lambda$ , $n$ = 1, 2, 3.......

If $\theta_n$ is small then a . $\theta_n = n\lambda$

**b) Secondary minima**

$a \sin\theta_n = (2n+1)\dfrac{\lambda}{2}$ , $n$ = 1, 2, 3.......

**c) Width of central maximum**

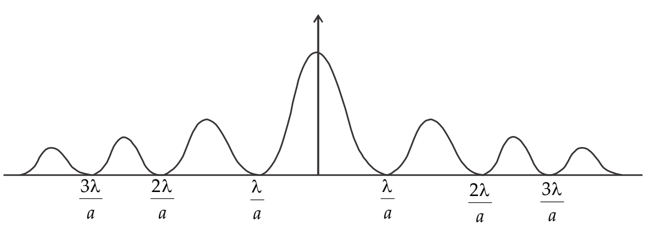



Width of central maxima $= \text{w} = 2x = \dfrac{2\lambda D}{a} = \dfrac{2\lambda f}{a}$

$f$ = focal length of lens used

Angular width = $2\,\theta = \dfrac{2\lambda}{a}$

**d) Intensity graph**




## 4) Resolving power of optical instrument

**a) Telescope**

Resolving limit = $d\theta = \dfrac{1.22\lambda}{a}$

Resolving power = $\dfrac{1}{d\theta} = \dfrac{a}{1.22\lambda}$

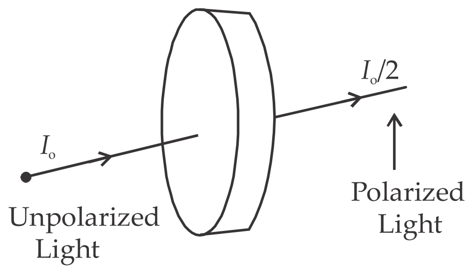
$a$ = diameter of objective lens

**b) Microscope**

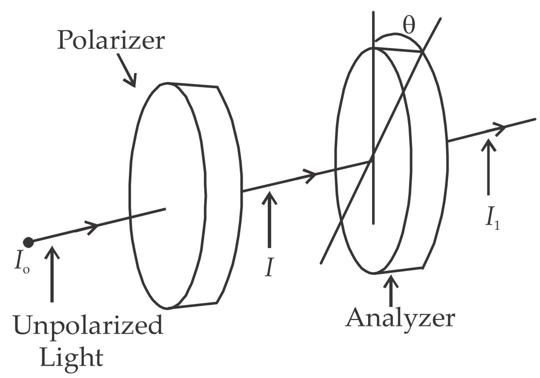
Resolving limit $= \dfrac{\lambda}{2\mu\sin\alpha}$

Numerical aperture = $\mu\sin\alpha$

## 5) Polarisation of light



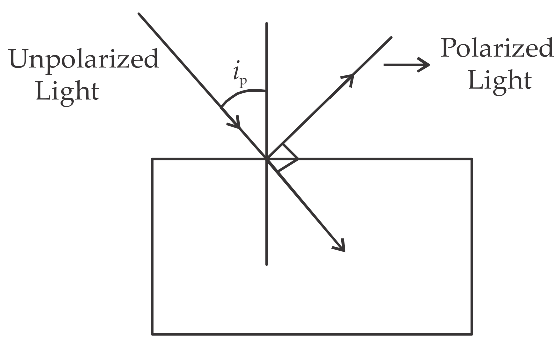

Malu's Law:




Malus Law , $I_1 = I\cos^2\theta$

## 6) Brewster's Law

$\mu = \tan i_p$




## 7) Doppler's Law

$$\frac{\Delta v}{v} = \frac{\Delta\lambda}{\lambda} = \frac{Vr}{C}$$

# Quick Revision DUAL NATURE OF RADIATION & MATTER

## TERMINOLOGY

| | | |
|---|---|---|
| $E$ | : | Energy of photon |
| $\lambda$ | : | Wavelength |
| $\nu$ | : | Frequency of photon |
| $c$ | : | Speed of light |
| $m$ | : | Mass of particle |
| $h$ | : | Plank's constant |
| $p$ | : | Momentum |
| $I$ | : | Intensity |
| $n$ | : | Number of emitted photons |
| $P$ | : | Radiation power |
| $W_0$ | : | Work function |
| $\nu_0$ | : | Threshold frequency |
| $\lambda_0$ | : | Threshold wavelength |
| $V$ | : | Potential |
| $V_0$ | : | Stopping potential |
| $T$ | : | Absolute temperature |
| $k$ | : | Boltzmann's constant |
| $\theta$ | : | Glancing angle OR Bragg's angle |
| $d$ | : | Distance between diffracting planes |

## DEFINITIONS

1) **Threshold frequency ($\nu_0$):**
The minimum frequency of incident radiation required to eject the electron from metal surface.

If incident frequency $\nu < \nu_0 \Rightarrow$ No photoelectric effect.

2) **Threshold wavelength ($\lambda_0$):**
The maximum wavelength of incident radiation required to eject the electron from metal surface.

If incident wavelength $\lambda > \lambda_0 \Rightarrow$ No photoelectric effect

3) **Photo-electric effect:**
The photo-electric effect is the emission of electrons from metal surface. These electrons are called photo electrons. Photo electric effect occurs when light strikes a metal surface.

4) **Work function ($W_0$):**
The minimum energy of incident radiation, required to eject the electrons from metallic surface is known as work function.

5) **Photon:**
According to Einstein's quantum theory, light propagates in the form of packets of energy, each packet being called photon.

6) **Matter waves (De Broglie waves):**
According to De Broglie a moving material particle sometimes acts as a wave and sometimes as a particle.
The wave associated with moving particle is called matter wave or De Broglie wave.

7) **Davisson–Germer experiment:**
This experiment performed to verify the wave nature of electron and concluded that electron exhibit wave nature also, thus supporting the hypothesis given by de-Broglie regarding wave particle duality of matter.

## FORMULAE

1) **Work function ($W_0$):**

$$W_0 = \hbar\nu_0 = \frac{\hbar c}{\lambda_0}$$

2) **Einstein's photoelectric equation:**

$$E = W_0 + K_{max}$$

$$\hbar\nu = \hbar\nu_0 + K_{max}$$

$$K_{max} = \hbar(\nu - \nu_0)$$

where, $E$ = Energy of photon, $K_{max}$ = Maximum kinetic energy of emitted electron

3) **Energy of photon:**

$$E = \hbar\nu = \frac{\hbar c}{\lambda}$$

$$E\,(\text{in eV}) = \frac{12400}{\lambda\,(\text{Å})}$$

4) **mass of photon:**
Rest mass of photon is zero. But its effective mass is given by

$$m = \frac{E}{c^2} = \frac{\hbar\nu}{c^2} = \frac{\hbar}{c\lambda}$$

5) **Momentum of photon:**

$$p = mc = \frac{E}{c} = \frac{\hbar\nu}{c} = \frac{\hbar}{\lambda}$$

6) **Number of emitted photons:**
Number of emitted photons emitted per second from a source of monochromatic radiation of wavelength $\lambda$ and power $P$ is given by

$$n = \frac{P}{E} = \frac{P}{\hbar\nu}$$

**7) Intensity:**

$$I = \frac{E}{At} = \frac{P}{A}$$

**8) de-Broglie wavelength:**

$$\lambda = \frac{\hbar}{p} = \frac{\hbar}{mv} = \frac{\hbar}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{p} \propto \frac{1}{v} \propto \frac{1}{\sqrt{E}}$$

**9) de-Broglie wavelength associated with the charged particles:**

$$\lambda_{\text{electron}} = \frac{12.27}{\sqrt{V}}\ \text{Å} \quad \Big|\ \text{By } \lambda = \frac{\hbar}{\sqrt{2mqV}}$$

$$\lambda_{\text{proton}} = \frac{0.286}{\sqrt{V}}\ \text{Å}$$

$$\lambda_{\text{Deutron}} = \frac{0.202}{\sqrt{V}}\ \text{Å}$$

$$\lambda_{\alpha-\text{particle}} = \frac{0.101}{\sqrt{V}}\ \text{Å}$$

**10) de-Broglie associated with uncharged particles:**

$$\lambda_{\text{neutron}} = \frac{0.286}{\sqrt{E\,(\text{in eV})}}\ \text{Å}$$

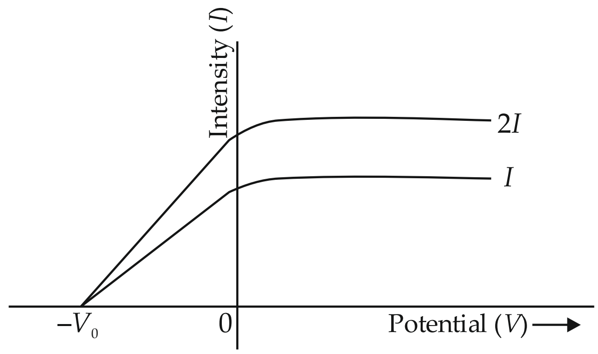
$$\lambda_{\text{thermal neutron}} = \frac{30.86}{\sqrt{T}}$$

**11) Bragg's law:**

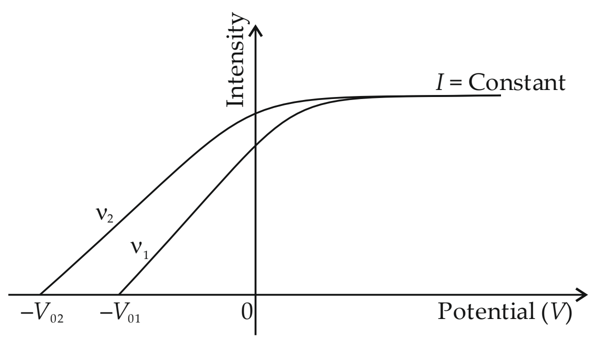
$$2d\sin\theta = n\lambda$$
$$D\sin\phi = n\lambda \quad \Big|\ D = \text{Interatomic distance}$$

## GRAPHS

**1) Effect of intensity ($\nu$ = Constant):**




**2) Effect of frequency:**



# Quick Revision ATOMS

## TERMINOLOGY

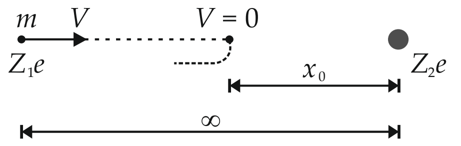
$e^-$ : Charge on electron ($1.6 \times 10^{-19}$ C)
$m_e$ : Mass of electron
$b$ : Impact parameter
$\theta$ : Scattering angle
$x_0$ : Distance of closest approach
$Z$ : Atomic number
$n$ : Principal quantum number
$r_n$ : Radius of $n^{th}$ orbit (Stationary orbit radius)
$V_n$ : Velocity of $e^-$ in $n^{th}$ orbit
$C$ : Speed of light
$\varepsilon_0$ : Permittivity of free space
$h$ : Plank's constant
$\Delta E = E_2 - E_1$ : Energy of emitted photon (Radiation)
$L$ : Angular momentum
$\nu$ : Frequency of emitted photon (Radiation)
$\lambda$ : Wavelength of emitted photon (Radiation)
$T$ : Time period of electron
K.E. : Kinetic energy of $e^-$
P.E. : Potential energy of $e^-$
T.E. : Total energy of $e^-$
$R$ : Rydberg's constant ($1.09 \times 10^7$ m$^{-1}$)
I.P. : Ionization potential
I.E. : Ionization energy
E.E. : Excitation energy
E.P. : Excitation potential
B.E. : Binding energy
$N$ : Number of spectral lines obtained due to transition of $e^-$ from $n^{th}$ orbit to lower
$\omega_n$ : Angular velocity of $e^-$ in $n^{th}$ orbit

## DEFINITIONS

1) **Bohr's postulates:**
   a) Electron revolves around the nucleus in circular orbit.
   b) The orbit of the $e^-$ around the nucleus can take one some special values of radius, that orbit is called as stationary orbit.
   $e^-$ does not radiate energy from this orbit.
   c) The energy of the atom has a definite value in a given stationary orbit ($e^-$ can jump from one orbit to another).
   d) In stationary orbit, the angular momentum of $e^-$ about the nucleus is an integral multiple of $h/2\pi$.
2) **Ground state:**
   The state of an atom with the lowest energy (–13.6 eV) is called its ground state.
3) **Excited state:**
   The state with higher energies than ground state is called as excited state.
4) **Excitation energy:**
   The energy required to take the $e^-$ or atom froom ground state to excited state is called excitation energy.
5) **Excitation potential:**
   The potential through which an $e^-$ should be accelerated to acquire this much energy is called as excitation potential.
6) **Ionization energy:**
   The minimum energy required to inize an atom is called ionization energy.
7) **Ionization potential:**
   The potential difference through which $e^-$ should be accelerated to acquire this much energy is called as ionization potential.
8) **Binding energy:**
   The minimum amount of energy required to separate $e^-$ from atom is called binding energy.
9) **Quantized energy level:**
   Energy of $e^-$ in hydrogen atom in 1st, 2nd and 3rd orbit called quantized energy level.
10) **Hydrogen spectrum:**
   Hydrogen gas enclosed in a flask and heated to high temperature, it emits radiation.
   If these radiations are passed through prism and thus we get hydrogen spectrum.
   The most important feature in this spectrum is that any some sharply defined wavelength exist in the radiation (656.3 nm or 486.1 nm).
11) **Lyman series:**
   Series arises due to transition of $e^-$ from different outer orbit to first Bohr's orbit is called lyman series.
12) **Balmer series:**
   Series arises due to transition of $e^-$ from different outer orbits to second orbit is called Balmer series.
13) **Paschen series:**
   Series arises due to transition of $e^-$ from different outer orbit to third orbit is called as Paschen series.
14) **Series limit:**
   The smallest wavelength emitted in series is called as series limit.

## FORMULAE

**1)**




$$x_0 = \frac{Z_1Z_2e^2}{2\pi\varepsilon_0 mV^2} \quad \text{.....} \therefore\ x_0 \propto \frac{1}{m}$$

**2)** $b$ is less , $\theta$ is more

$b = 0$ , $\theta = 180°$ Head on collision

**3)** $$r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m e^2 Z} \quad \text{....}\ r_n \propto \frac{n^2}{Z}$$

$$= 0.53\ \text{Å}\left(\frac{n^2}{Z}\right)$$

**4)** $$V_n = \frac{Ze^2}{2\varepsilon_0 hn} \quad \text{.....}\ V_n \propto \frac{Z}{n}$$

$$= 2.2\times10^6\left(\frac{Z}{n}\right)\text{m/s}$$

**5)** $$E_2 - E_1 = \frac{hc}{\lambda} \quad \text{.....Radiation}$$

**6)** $$L = mV_n r_n = \frac{nh}{2\pi}$$

**7)** Time period, $T = \dfrac{2\pi r_n}{V_n}$ ..... $T \propto \dfrac{n^3}{Z^2}$

**8)** $$\text{K.E.} = \frac{1}{2}m_e V_n^2 = \frac{m_e Z^2 e^4}{8\varepsilon_0^2 h^2 n^2}$$

**9)** $$\text{P.E.} = -\frac{1}{4\pi\varepsilon_0}\frac{Ze\times e}{r} = -\frac{m_e Z^2 e^4}{4\varepsilon_0^2 h^2 n^2}$$

**10)** $$\text{T.E.} = \text{K.E.} + \text{P.E.} = \frac{-m_e Z^2 e^4}{8\varepsilon_0^2 h^2 n^2}$$

**11)** Relation : $\text{T.E.} = -\text{K.E.} = \dfrac{\text{P.E.}}{2}$

**12)** $$\text{T.E.} = -13.6\ \text{eV}\left(\frac{Z^2}{n^2}\right)$$

For hydrogen atom,

$E_1 = -13.6$ eV

$E_2 = -3.4$ eV

$E_3 = -1.51$ eV

$E_4 = -0.85$ eV

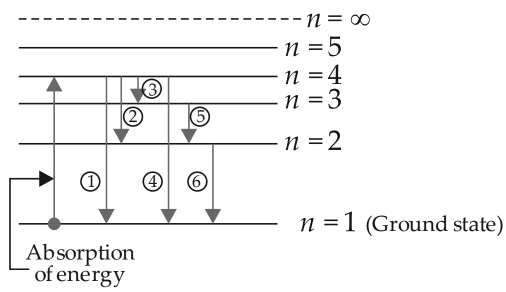
$E_5 = -0.54$ eV

**13)** $$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \quad \text{.....}\ n_2 > n_1$$

**14)** Number of spectral lines ($N$) = $\dfrac{n(n-1)}{2}$

*Ex.:* $n = 4$

$N = 6$



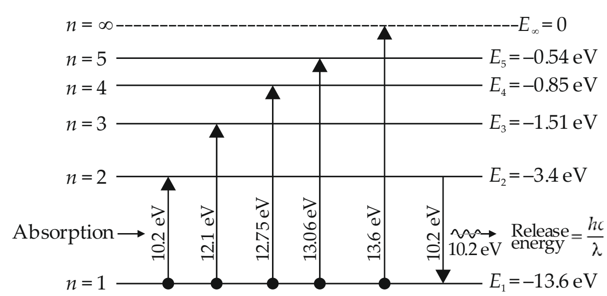

**15)** Series:

| Name Of Series | $n_1$ | $n_2$ | Region |
|---|---|---|---|
| 1) Lyman series | 1 | 2, 3, 4, ..... ∞ | Ultra violet |
| 2) Balmer series | 2 | 3, 4, 5, ..... ∞ | Visible |
| 3) Paschen series | 3 | 4, 5, 6, ..... ∞ | Infra red |
| 4) Brackett series | 4 | 5, 6, 7, ..... ∞ | Infra red |
| 5) P-Fund series | 5 | 6, 7, 8, ..... ∞ | Infra red |

**16)** For hydrogen atom:

$Z = 1$

$n = 1, 2, 3, 4, \ldots\ldots, \infty$



# Quick Revision — NUCLEI

## TERMINOLOGY

$Z$ : Atomic number
$A$ : Mass number
$R$ : Radius of nucleus
$R_0$ : $1.1 \times 10^{-15}$ m
$\rho$ : Density of nucleus
$\Delta m$ : Mass defect
$m_p$ : Mass of proton
$m_n$ : Mass of neutron
$E$ : Energy
$C$ : Speed of light
$\frac{dN}{dt}$ : Rate of disintegration
$N$ : Number of atoms present at that time
$\lambda$ : Decay constant
$N_0$ : Number of atoms present at initially
$t_{1/2}$ : Half life
$t_{Avg.}$ : Mean life
$M_N$ : Mass of nucleus

## DEFINITIONS

**1) Isotopes:**
The atoms of an element, which have the same atomic number but different mass numbers, are called isotopes.
Ex.: (i) $_8O^{16}$, $_8O^{17}$, $_8O^{18}$
(ii) $_{17}O^{35}$, $_{17}Cl^{37}$

**2) Isotones:**
The atoms whose nuclei have same number of neutrons are called isotones.

**3) Isobars:**
The atoms which have same mass number but different atomic numbers, are called isobars.
Ex.: (i) $_1H^3$, $_1He^3$
(ii) $_2Li^7$, $_4Be^7$

**4) Atomic mass unit (a.m.u.):**
It is defined as $(1/12)^{th}$ of mass of one $_6C^{12}$ atom.
1 a.m.u. = $1.660565 \times 10^{-27}$ kg

**5) Energy equivalent of atomic mass unit:**
According to Einstein's mass-energy equivalence reaction, the energy equivalent of mass $m$ is given by
$E = mc^2$
1 a.m.u. = 931.5 MeV

**6) Mass defect ($\Delta m$):**
The difference between the sum of masses of nucleons constituting a nucleus and the rest mass of nucleus is known as mass defect.

**7) Binding energy:**
The energy equivalent to the mass defect of the nucleus.

**8) Binding energy per nucleon:**
It is the average energy required to extract one nucleon from the nucleus.

**9) Radioactivity:**
The spontaneous transformation of an element into another with the emission of some particles is called radioactivity.

**10) Laws of radioactivity decay:**

(i) When a radioactive atom disintegrates, $\alpha$-particle (nucleus of helium) then its atomic number decreases by 2 units and atomic mass decreases by 4 units.

$$_ZX^A \xrightarrow{\alpha-\text{decay}} {}_{Z-2}Y^{A-4}$$

(ii) The emission of $\beta$-particle by radioactive atom results in a daughter atom, whose atomic number is 1 unit more but mass number is same as that of the parents atom.

$$_ZX^A \xrightarrow{\beta-\text{decay}} {}_{Z+1}Y^{A}$$

(iii) $^AX_Z \xrightarrow{\gamma-\text{decay}} {}_ZY^A$

Because of $\gamma$-emission, there will no change in atomic number and atomic mass.

(iv) According to radioactive decay law, the rate of disintegration at any time $t$ is directly proportional to the number of atoms present at that time $t$.

$$\frac{dN}{dt} \propto N \quad \text{or} \quad \frac{dN}{dt} = -\lambda N$$

or, $N = N_0 e^{-\lambda t}$

**11) Half life:**
Time interval in which the number of atoms reduces to half of its initial value is called half life.

**12) Mean life or average life:**

Average time for which the nuclei of the atoms of radioactive substance exist, known as mean life or average life.

**13) Activity of radioactive substance:**

It is defined as the number of disintegrations takes place in the given sample per second.

**14) Nuclear fission:**

The process of splitting of a heavy nucleus into two or more than two nuclei with liberation of energy is called nuclear fission.

$$Ex.:\ {}_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{141} + {}_{30}Kr^{141} + 3\,{}_0n^1 + Q$$

**15) Neutron reproduction factor ($K$):**

$$K = \frac{\text{Rate of production of neutrons}}{\text{Rate of loss of neutrons}}$$

If $K = 1$ ; Reaction will steady

$K > 1$ ; Reaction will accelerate

$K < 1$ ; Reaction will retard

**16) Nuclear fusion:**

In nuclear fusion two or more than two lighter nuclei combine to form a single heavy nucleus.

**17) Nuclear reactors (Main parts & their function):**

(i) Fuel : It is a fissionable material ($U^{235}$)

(ii) Moderator : Used to slow down the neutrons

Ex.: Water, heavy water, graphite

(iii) Control rods: These rods controls the reaction by absorbing neutrons.

Ex.: Cadmium or Boron rods

(iv) Coolent: The most commonly used coolents are liquid sodium and heavy water

## FORMULAE

1) Radius of nucleus:

$$R = R_0 A^{1/3}$$

2) Nuclear density:

$$\rho = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}} = 2.97 \times 10^{17}\ \text{kg/m}^3$$

3) $E = mc^2$

4) Mass defect ($\Delta m$):

$$\Delta m = [Zm_p + (A - Z)m_n - M_N]$$

5) Binding energy $= \Delta m \times 931.5$ (in Mev)

$$= [Zm_p + (A - Z)m_n - M_N] \times 931.5$$

6) Binding energy per nucleon:

$$= \frac{\text{Binding energy}}{A}$$

7) Packing fraction $= \dfrac{\text{Mass defect}}{A}$

8) Law of radioactivity decay:

$$\frac{dN}{dt} = -\lambda N$$

$$N = N_0 e^{-\lambda t}$$

9) Half life ($t_{1/2}$):

$$t_{1/2} = \frac{0.693}{\lambda}$$

10) $t_{avg.} = \dfrac{1}{\lambda}$

11) Activity of radioactive substance ($A$):

$$A = -\frac{dN}{dt}$$

$$A = \lambda N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}, \qquad \text{where} \quad \lambda N_0 = A_0$$

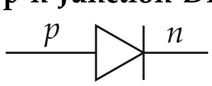
# Quick Revision SEMICONDUCTOR DEVICES

## TERMINOLOGY

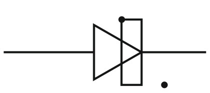
$n_e$ : Concentration of free electrons
$n_h$ : Concentration of free holes
$n_i$ : Intrinsic concentration
$\mu_e$ : Mobility of electrons
$\mu_h$ : Mobility of holes
$v_e$ : Drift speed of electrons
$v_h$ : Drift speed of holes
$F_g$ : Energy gap (OR) Forbidden gap
$V_\sigma$ : Knee voltage
$E$ : Emitter
$B$ : Base
$C$ : Collector
$I$ : Current
$I_b$ : Base current
$I_c$ : Collector current
$I_E$ : Emitter current
$V$ : Voltage
$R$ : Resistance
$i/p$ : Input
$o/p$ : Output
$R_L$ : Load resistance
α : Current transfer ratio
β : Current amplification factor (Current gain)
$A_V$ : Voltage gain
$f$ : Frequency
η : Efficiency
$Y$ : Output
S.C. : Semiconductor

## SYMBOLS

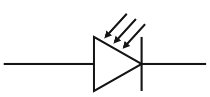
1) **p-n Junction Diode:**



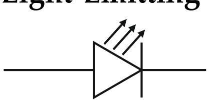

2) **Zener Diode:**



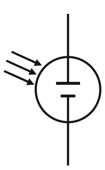
3) **Photo Diode:**



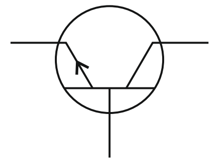
4) **Light Emitting Diode (LED):**



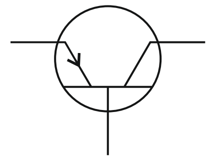
5) **Solar Cell:**



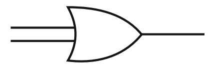
6) ***n–p–n* Transistor:**



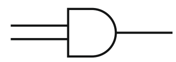
7) ***p–n–p* Transistor:**



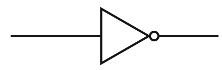
8) **OR Gate:**



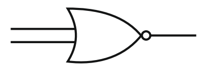
9) **AND Gate:**



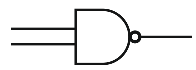
10) **NOT Gate:**



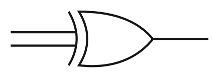
11) **NOR Gate:**



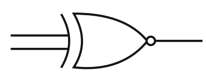
12) **NAND Gate:**



13) **X–OR Gate:**



14) **X–NOR Gate:**



## DEFINITIONS

1) **Energy Band Gap:** ($E_g$) (Forbidden Energy Gap)
The gap between the top of valence band and bottom of conduction band is called the energy band gap.

2) **Conductors:**
Solids in which conduction band and valence band overlap i.e., band gap is zero.

3) **Insulators:**
Solids in which band gap is greater than 3 eV.

4) **Semi Conductors:**
Solids in which band gap is less than 3 eV.

5) **Hole:**
The vacancy in valence orbit of semiconductor atom with the effective positive electronic charge is called a hole.
It behaves as an apparent free particle with effective positive charge.

6) **Intrinsic Semi Conductor:**
Pure semi conductors are known as intrinsic semi conductor.

7) **Extrinsic Semi Conductor:**
Impure semi conductors i.e., semi conductor obtained after doping is known as extrinsic semi conductor.

8) **Doping:**
The process of adding impurities to intrinsic semi conductor in order to rise its conducting levels is known as doping.

9) ***n*–Type Semiconductor:**
The extrinsic semiconductor obtained after adding pentavalent impurities to an intrinsic semiconductor is known as $n$-type semiconductor.

10) ***p*–Type Semiconductor:**
The extrinsic semiconductor obained after adding trivalent impurities to an intrinsic semiconductor is known as $p$-type semiconductor.

11) **Trivalent Impurities:**
Atoms with valency 3.
Ex.: Indium (In), Boron (B), Aluminium (Al)

12) **Pentavalent Impurities:**
Atoms with valency 5.
Ex.: Arsenic (As), Antimony (Sb), Phosphorus (P)

13) **Depletion Region: (Junction Barrier)**
The space-charge region on either side of the junction together is known as depletion region.

14) **Biasing:**
In electronics, biasing is the setting of initial operating condition (current and voltage) of an active device.

15) **Forward Bias:**
When $p$-terminal of a diode is at higher potential than $n$-terminal then the diode is said to be in forward bias.

16) **Reverse Bias:**
When $n$-terminal of a diode is at higher potential than $p$-terminal, then the diode is said to be in reverse bias.

17) **Forward And Reverse Voltage:**
The voltage across diode in forward bias condition and reverse bias conditions are known as forward voltage an reverse voltage respectively.

18) **Forward And Reverse Current:**
The current passing through device in its forward bias and reverse bias conditions are known as forward current and reverse current respectively.

19) **Forward Resistance And Reverse Resistance:**
The resistance of the diode in forward and reverse bias conditions are known as forward resistance and reverse resistance respectively.

20) **Cut-in Voltage OR Threshold Voltage: ($V\gamma$) (Knee Voltage):**
The forward voltage at which the diode current increase significantly (exponentially) even for a small resistance in the diode bias voltage.

21) **Reverse Breakdown Voltage ($V_{RB}$):**
The reverse voltage at which, the reverse current increases sharply and the diode gets destroyed is known as reverse breakdown voltage.

22) **Rectifier:**
A device (or) circuit which converts A.C. voltage to D.C. voltage.

23) **Zener Voltage ($V_Z$):**
The reverse voltage point at which the voltage across zener diode becomes stable and reverse current rises sharply is called the zener voltage ($V_Z$).

24) **Avalanche Breakdown:**
It is the phenomenon of current carries multiplication due to collision of thermally generated minority carries with crysted ions in a reverse biased zener diode.
It takes place at zener voltage.

25) **Transistor:**
It is a three terminal semiconductor device which can be used as an electronic switch (or) an amplifier.

26) **Emitter:**
Region in a transistor which supplies majority charge carries for current flow.

27) **Base:**
Region in a transistor which acts as a link between the emitter and collector.

28) **Collector:**
It is the region in a transistor, which collects majority of charge carriers.

29) **Amplifier:**
Device which enhances the amplitude of input signal voltage. Transistor in active region acts as an amplifier.

30) **D.C. Current Gain ($\beta_{DC}$):**
Ratio of output current to input current in a transistor.

31) **A.C. Current Gain ($\beta_{AC}$):**
It is the ratio of change in output current to the change in input current of a transistor.

**32) A.C. Voltage Gain ($A_V$):**
It is the ratio of change in output voltage to change in input voltage in a transistor.

**33) Power Gain:**
It is the ratio of output power to input power for a transistor operating in active region.

**34) Transconductance ($g_m$):**
It is the ratio of change in output current to the change in input voltage of a transistor.

**35) Oscillator:**
It is a device which delivers a.c. output wave form of desired frequency from d.c. power.

**36) Logic Gates:**
Logic gates are the building blocks of digital-electronics, which work in accordance with some logical relationship between i/p and o/p voltages.

**37) Truth Table:**
In logic gates, the relation between the possible values of i/p and corresponding o/p voltages are expressed in the form of a table called truth table.

## FORMULAE

1) For intrinsic semiconductor,

$$n_e = n_h = n_i$$

2) For extrinsic semiconductor,

$$n_e . n_h \simeq n_i^2$$

3) In $p$-type semiconductor,

$$n_h >> n_e$$

Holes : Majority carriers
Electrons : Minority carriers

4) In $n$-type semiconductor,

$$n_e >> n_h$$

Electrons : Majority carriers
Holes : Minority carriers

5) In semiconductors,

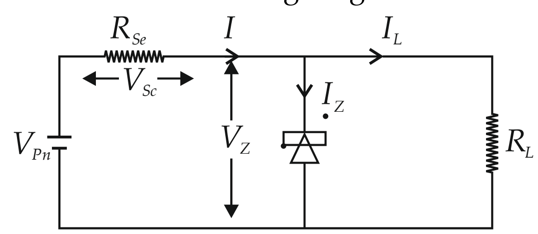
$$I = I_e + I_h$$

Conductivity, $\sigma = e(n_e \mu_e + n_h \mu_h)$

6) In $p$–$n$ junction diode
- Forward current $\Rightarrow$ Diffusion current
- Reverse current $\Rightarrow$ Drift current
- Reverse resistance $\neq \infty$

7) In $p$–$n$ junction diode
- In forward bias acts as closed switch
- In reverse bias acts as open switch

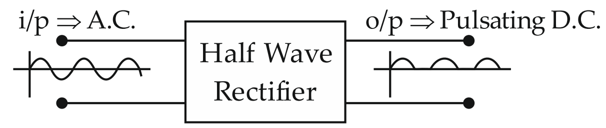
8) Zener diode as voltage regulator:




$$V_{in} = V_{Se} + V_Z \quad = I_{R_{Se}} + I_L R_L$$

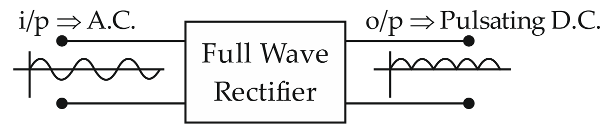
$$I = I_Z + I_L$$

9) Half wave rectifier




$$f_{i/p} = f_{o/p}$$

10) Full wave rectifier




$$f_{o/p} = 2f_{i/p}$$

11) In a transistor (CE - Configuration)

$$I_E = I_C + I_B$$

$$\alpha = \frac{I_C}{I_E}; \quad \beta = \frac{I_C}{I_B}$$

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

12) Transistor as an amplifier (CE - Configuration)

$$\beta_{dc} = \frac{I_C}{I_B}$$

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE} = \text{Constant}}$$

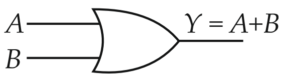
$$g_m = \frac{\Delta I_C}{\Delta V_{BE}} \Rightarrow g_m = \frac{\beta_{ac}}{R_{i/p}}$$

$$A_V = \frac{\Delta V_{o/p}}{\Delta V_{i/p}} \Rightarrow A_V = \beta \frac{R_{o/p}}{R_{i/p}}$$

$$A_V = g_m R_{o/p}$$

$$\text{Power gain} = \beta^2 \frac{R_{o/p}}{R_{i/p}}$$

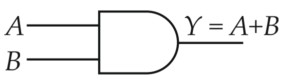
**13)** *OR* gate




| *A* | *B* | *Y* |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

- o/p is high if atleast one i/p is high
- o/p is low when all i/p are low

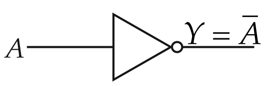
**14)** *AND* gate




| *A* | *B* | *Y* |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

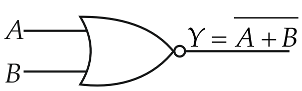
- o/p is high when all i/p are high
- o/p is low if atleast one o/p is low

**15)** *NOT* gate




| *A* | *Y* |
|---|---|
| 0 | 1 |
| 1 | 0 |

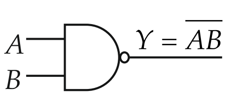
**16)** *NOR* gate




| *A* | *B* | *Y* |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

- o/p is high when all i/p are low
- o/p is low if atleast one i/p is high

**17)** *NAND* gate

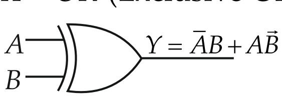



| *A* | *B* | *Y* |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

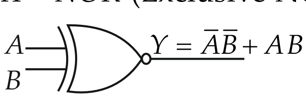
**18)** *NAND, NOR* gates are known as universal gates.

**19)** Special gates:

*X – OR* (Exclusive OR gate)




*X – NOR* (Exclusive NOR gate)




**20)** Boolean algebra:

1 – High voltage signal

0 – Low voltage signal

*A, B* – Imputs $\Rightarrow$ Can take value 0 (or) 1.

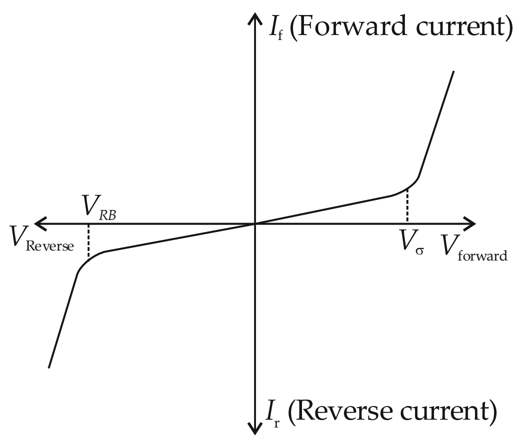
- $1 \times 1 = 1$ $\quad 0 + 0 = 0$
  $1 \times 0 = 0$ $\quad 0 + 1 = 1$
  $0 \times 0 = 0$ $\quad 1 + 1 = 1$
- A × A = A  If A = 1
  A + A = A  $\bar{A} = 0$
  1 + A = 1  If A = 0
  0 × A = 0
  0 + A = A  $\bar{A} = 1$
- De-morgan's law

$$\overline{(A+B)} = \bar{A}\,.\,\bar{B}$$

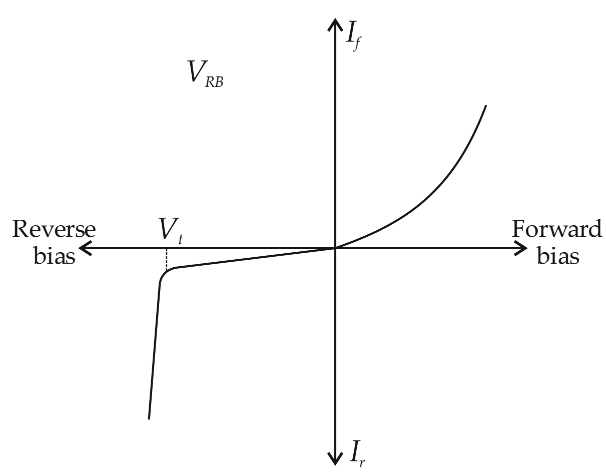
$$\overline{AB} = \bar{A} + \bar{B}$$

## GRAPHS

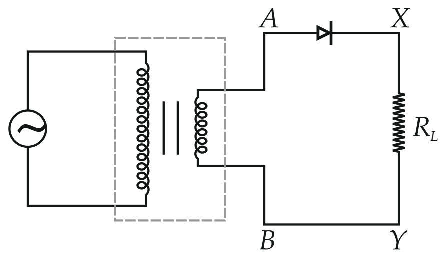
**1)** *p–n* junction diode:

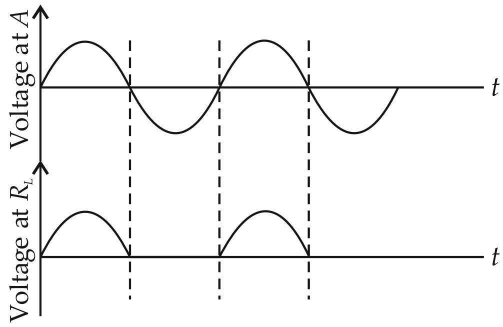



**2)** Zener diode:

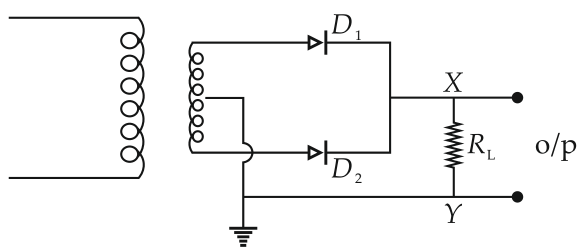


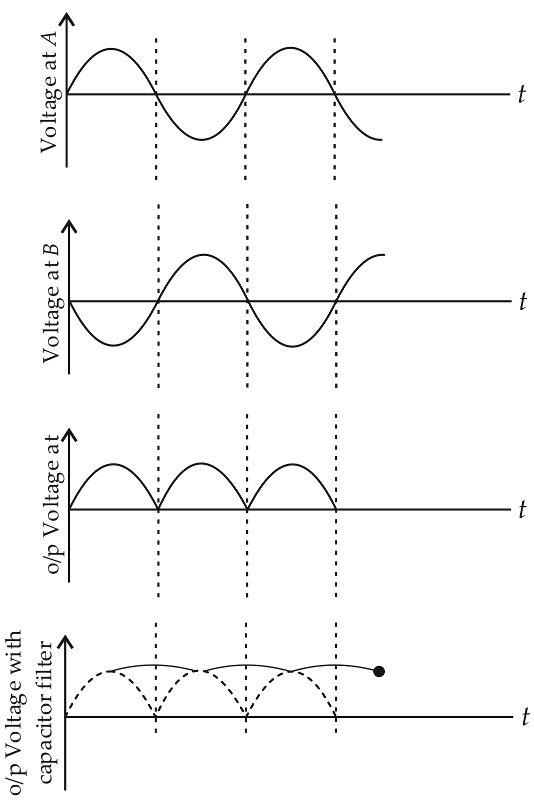
**3)** Half Wave Rectifier:



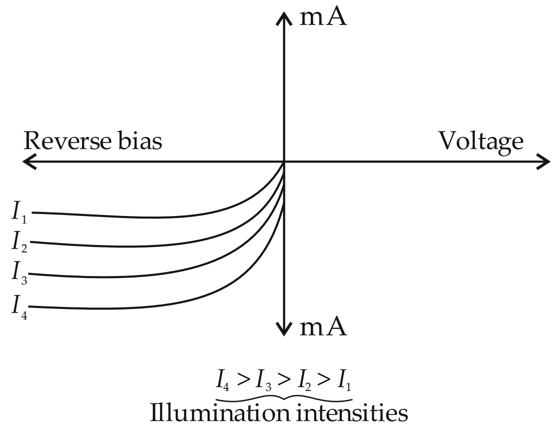




**4)** Full Wave Rectifier:

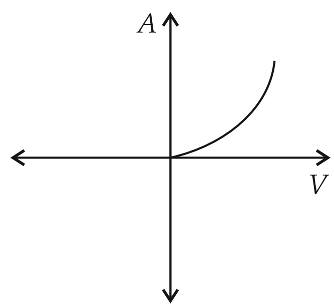


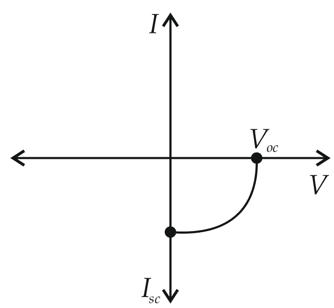

**5)** Photo Cell:




**6)** LED (Light Emitting Diode):



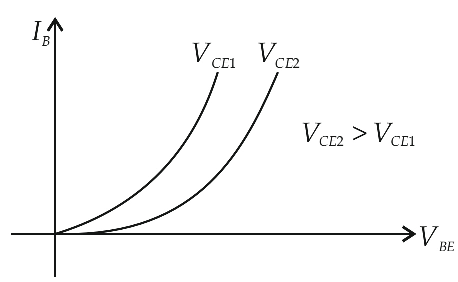

**7)** Solar Cell:



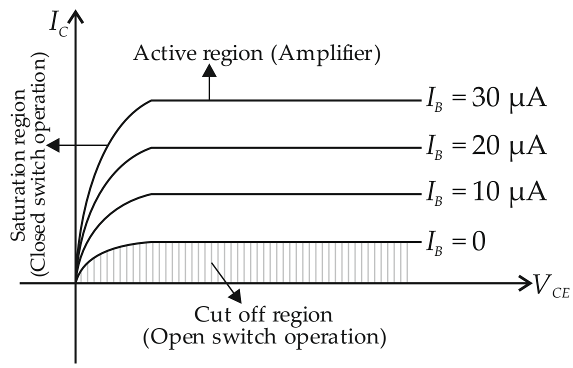

$V_{oc}$ – Open circuit voltage

$I_{sc}$ – Short circuit current

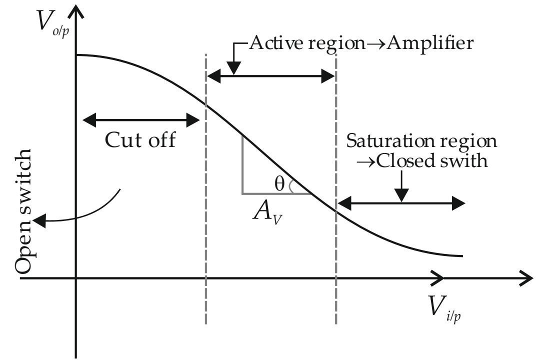
**8)** *i/p* characteristics of transistor (CE configuration):

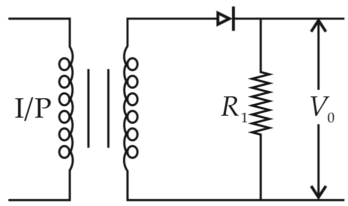
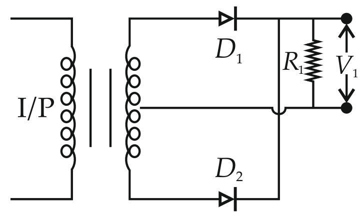
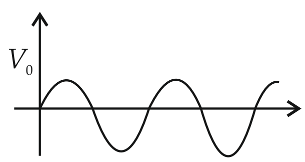
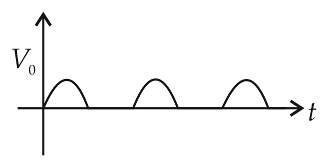
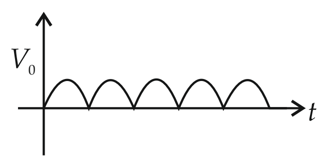


**9)** *o/p* characteristics of transistor (CE configuraion):




**10)** Transfer characteristics of transistor:




| Sr. No. | Items | Half Wave Rectifier | Full Wave Rectifier |
|---|---|---|---|
| 1. | Circuit |  |  |
| 2. | Input voltage  |  |  |
| 3. | The value of $I_{rms}$ of input alternating current $I = I_0 \sin \omega t$ | $I_0 / 2$ | $I_0 / \sqrt{2}$ |
| 4. | Output direct current | $I_0 / \pi$ | $2I_0 / \pi$ |
| 5. | Ripple factor | 1.21 | 0.48 |
| 6. | Maximum 'η' | 0.406 or 40.6% | 0.812 or 81.2% |