IIT JEE PHYSICS

2025-2026

Formula Sheet

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WARNING

Joint Entrance Examination

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UNIT-1

Physics and Measurement

- **The Gravitational force** $\boxed{F = \dfrac{GM_1M_2}{r^2}}$

  $G = 6.66 \times 10^{-11}\ Nm^2\ kg^{-2}$ (Universal constant of gravitation)

- **The Electromagnetic force** $\boxed{F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1q_2}{r^2}}$

  $\varepsilon_0 = 8.854 \times 10^{-12}\ C^2N^{-1}m^{-2}$ (absolute permittivity of free space)
  q_1q_2 = electric charges
  r = distance

- **Law of conservation of linear momentum** $\boxed{\vec{P_1} + \vec{P_2} = \text{constant}}$

  linear momentum of bodies

- **Law of conservation of Energy** $\boxed{E = mc^2}$

  speed of light
  mass

- **Law of conservation of angular momentum** $\boxed{I\omega = \text{constant}}$

  ω = angular velocity

- $\boxed{nu = \text{constant}}$ OR $\boxed{n_1u_1 = n_2u_2}$

NOTE

- A solar day is defined as the time that elapses between noons of two consecutive days and the mean solar day is the average of the solar days in one complete year.
- A second, or better called a mean solar second, is $\dfrac{1}{24 \times 60 \times 60}$ th OR $\dfrac{1}{86,400}$ th part of a mean solar day.

S.No.	Supplementary physical quantity	Unit	Symbol / abbreviation
1.	Plane angle	radian	rad
2.	Solid angle	steradian	sr

S.No.	Basic physical quantity	Unit	Symbol/abbreviation
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Temperature	kelvin	K
5.	Electric current	ampere	A
6.	Luminous intensity	candela	cd
7.	Quantity of matter	mole	mol

NOTE

1 a.m.u. = 1.66×10^{-27} kg
a.m.u. = atomic mass unit

1 fermi or femtometre (fm) = 10^{-15} m
1 angstrom (Å) = 10^{-10} m
1 micron or micrometre (μm) = 10^{-6} m

1 astronomical unit (AU) = 1.496×10^{11} m
1 light year = 9.46×10^{15} m
1 parallactic second (parsec) = 3.08×10^{16} m

1 shake = 10^{-8} s
1 solar day = 86,400 s
1 solar year = $365\frac{1}{4}$ solar days

➡ **The distance of moon from the earth**

$$S = \frac{c \times t}{2}$$

$c = 3 \times 10^{8}\ ms^{-1}$
= (velocity of Laser beam)

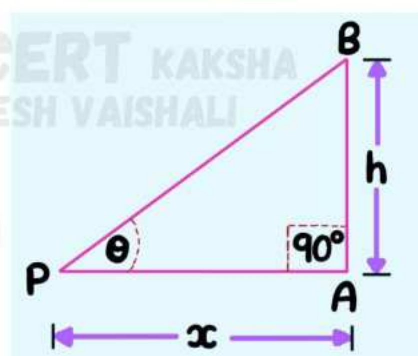
➡ **To find the thickness of a matter sheet**

$$d = \frac{c \times t}{2}$$

c = velocity of the signal

➡ **To find the height of a distant object by triangulation method**

$$h = x \tan\theta$$



➡ Determination of Radius of atom using Avagadro hypothesis

$$r = \left[\frac{VM}{2\pi Nm}\right]^{1/3}$$

V = Volume
M = Atomic weight
N = Avagadro no.

➡ Determination of Molecular size

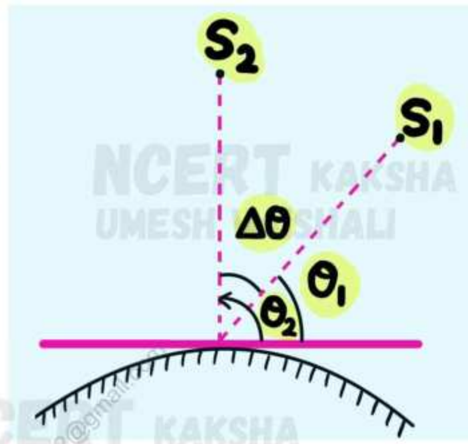
$$t = \frac{nV}{400A}\ cm$$

A = Area
t = thickness of the film

➡ Measurement of Large distances

$$\Delta\theta = \theta_2 - \theta_1$$

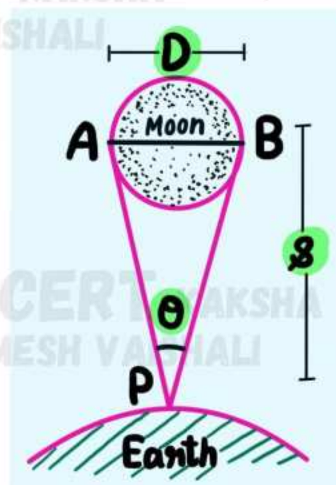
$\Delta\theta$ = Angular distance
$\theta_2 - \theta_1$ = Angle of elevation

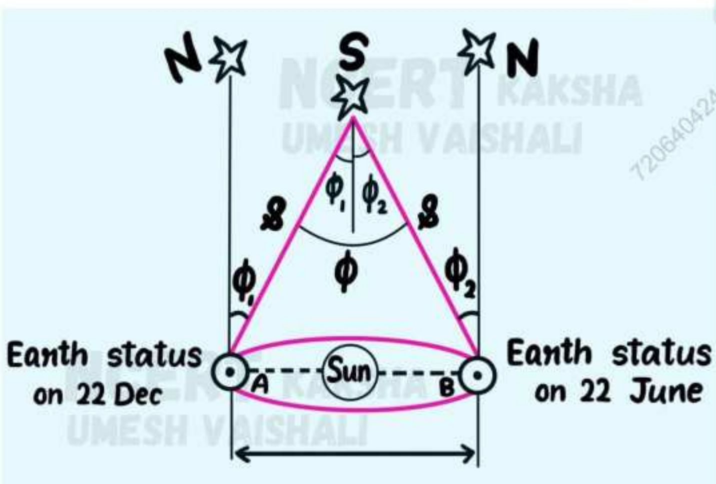


➡ Diameter of Moon

$$D = s\theta$$

s = radius
θ = angle





➡ Measurement of Distance of Astronomical objects by parallax method

$$S = \frac{b}{\phi}$$

ϕ = Parallax Angle
b = diameter of the Earth

➡ Measurement of Mass

$$m = \frac{F}{a}$$

F = Force
a = acceleration

➡ Inertial Mass

$$\frac{T_1^2}{T_2^2} = \frac{m_p + m_1}{m_p + m_2}$$

T_1, T_2 = Time Periods

➡ Gravitational Mass

$$\frac{W_1}{W_2} = \frac{m_1}{m_2}$$

W_1, W_2 = Weight

➡ Absolute Error $\Delta a_n = a_{mean} - a_n$

➡ Mean Absolute Error $\overline{\Delta a}_{mean} = \dfrac{|\Delta a_1| + |\Delta a_1| + \ldots\ldots + |\Delta a_n|}{n}$

OR $\overline{\Delta a} = \dfrac{1}{n} \sum_{i=1}^{i=n} |\Delta a_i|$

➡ Relative OR Fractional Error $\dfrac{\Delta a_{mean}}{a_{mean}}$

Δa_{mean} = Mean absolute Error

a_{mean} = Mean value

➡ Percentage Error $\delta a = \dfrac{\Delta a_{mean}}{a_{mean}} \times 100$

➡ Error in Addition and Subtraction $\Delta Z = \Delta x + \Delta y$

➡ Error in Multiplication and Divison $\left|\dfrac{\Delta Z}{Z}\right|_{max} = \dfrac{\Delta x}{x} + \dfrac{\Delta y}{y}$

➡ Error in power of a Measured Quantity $\dfrac{\Delta Z}{Z} = m \dfrac{\Delta x}{x}$

➡ Estimation of Maximum Error

$$\left|\frac{\Delta Y}{Y}\right|_{max} \times 100 = \left[3 \frac{\Delta a}{a} \times 100\right] + \left[\frac{\Delta b}{b} \times 100\right] + \left[2 \frac{\Delta c}{c} \times 100\right]$$

➡ Experimental % Error $\dfrac{\text{Real value} \sim \text{Experimental value}}{\text{Real value}} \times 100$

➡ Energy of Photon $E = h\nu$ ν = frequency of light

NOTE $1 AU = 1.496 \times 10^{11} m$

What you do today can Improve all your tomorrows

PHYSICAL QUANTITIES	FORMULAS	DIMENSION FORMULA	SI UNIT
Electric current (I)	Fundamental unit	$[M^0L^0T^0A]$	A (ampere)
Electric current density (j)	$\frac{\text{current}}{\text{area}}$	$[M^0L^{-2}T^0A]$	$A\,m^{-2}$
Electric charge (q)	current × time	$[M^0L^0T^0A]$	C (coulomb)
Electric potential (V)	$\frac{\text{work}}{\text{charge}}$	$[ML^2T^{-3}A^{-1}]$	V (volt)
Electric field intensity (E)	$\frac{\text{force}}{\text{charge}}$	$[MLT^{-3}A^{-1}]$	NC^{-1}
Permittivity of free space (ε_0)	$\frac{\text{charge} \times \text{charge}}{\text{force} \times \text{distance}^2}$	$[M^{-1}L^{-3}T^{-4}A^{-2}]$	C^2Nm^{-2}
Electric flux (ϕ_E)	electric field × area	$[ML^3T^{-3}A^{-1}]$	Nm^2C^{-1}
Electric capacitance (C)	$\frac{\text{charge}}{\text{potential difference}}$	$[M^{-1}L^{-2}T^4A^{-2}]$	F (farad)
Surface charge density (σ)	$\frac{\text{charge}}{\text{area}}$	$[M^0L^{-2}TA]$	$C\,m^{-2}$
Volume charge density (ρ)	$\frac{\text{charge}}{\text{volume}}$	$[M^0L^{-3}TA]$	$C\,m^{-3}$
Electric dipole moment (p_e)	charge × length	$[M^0LTA]$	C m
Electric resistance (R)	$\frac{\text{potential difference}}{\text{current}}$	$[ML^2T^{-3}A^{-2}]$	Ω (ohm)
Resistivity (ρ)	$\frac{\text{resistance} \times \text{area}}{\text{length}}$	$[ML^3T^{-3}A^{-2}]$	Ωm
Electric conductance (G)	$\frac{1}{\text{resistance}}$	$[M^{-1}L^{-2}T^3A^2]$	S(siemen) or Ω^{-1} (mho)
Conductivity (σ)	$\frac{1}{\text{resistivity}}$	$[M^{-1}L^{-3}T^3A^2]$	Sm^{-1} or $\Omega^{-1}m^{-1}$
Coefficient of self induction (L) or mutual induction (M)	$\frac{\text{e.m.f.} \times \text{time}}{\text{current}}$	$[ML^2T^{-2}A^{-2}]$	H (henry)
Inductive reactance (X_L)	ωL	$[ML^2T^{-2}A^{-2}]$	Ω

Capacitive reactance (X_C)	$\frac{1}{\omega C}$	$[ML^2T^{-3}A^{-2}]$	Ω
Power factor ($\cos\phi$)	Trigonometric ratio	Dimensionless	No unit
Resonant angular frequency (ω_0)	$\frac{1}{\sqrt{LC}}$	$[M^0L^0T^{-1}]$	Hz
Quality factor (Q)	$\frac{\omega_0 L}{R}$	$[M^0L^0T^0]$	No unit
Permeability of free space (μ_0)	$\frac{2\pi \times \text{force} \times \text{distance}}{\text{current}^2 \times \text{length}}$	$[MLT^{-2}A^{-2}]$	NA^{-2} or $Wb\,A^{-1}\,m^{-1}$
Magnetic pole strength (m)	$\frac{4\pi \times \text{force} \times \text{distance}^2}{\mu_0}$	$[M^0LT^0A]$	A m
Magnetic dipole moment (Pm)	pole strength $\times$ distance	$[M^0L^2T^0A]$	A m^2
Magnetic induction (B)	$\frac{\mu_0 \times \text{current}}{2\pi \times \text{distance}}$	$[ML^0T^{-2}A^{-1}]$	$Nm^{-1}A^{-1}$ or tesla (T)
Magnetic flux (ϕ_B)	B $\times$ area	$[ML^2T^{-2}A^{-1}]$	NmA^{-1} or weber (Wb)
Coefficient of self induction (L) or mutual induction (M)	$\frac{\text{magnetic flux}}{\text{current}}$	$[ML^2T^{-2}A^{-2}]$	H (henry)
Magnetic intensity (H)	$\frac{\text{magnetic induction}}{\mu_0}$	$[M^0L^{-1}T^0A]$	Am^{-1} or $Nm^{-2}\,T^{-1}$
Intensity of magnetisation (I)	$\frac{\text{magnetic moment}}{\text{volume}}$	$[M^0L^{-1}T^0A]$	Am^{-1} or $Nm^{-2}\,T^{-1}$
Coercivity	H (opposing)	$[M^0L^{-1}T^0A]$	Am^{-1} or $Nm^{-2}\,T^{-1}$
Retentivity	I (residual)	$[M^0L^{-1}T^0A]$	Am^{-1} or $Nm^{-2}\,T^{-1}$

UNIT-2

Kinematics

- **Average speed** $v_{av} = \frac{\Delta s}{\Delta t}$

- **Instantaneous speed** $v = \frac{ds}{dt}$

- **Average velocity** $\vec{v}_{av} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1}$ OR $\vec{v}_{av} = \frac{\overrightarrow{\Delta r}}{\Delta t}$

- **Instantaneous velocity** $\vec{v} = \frac{\overrightarrow{dr}}{dt}$

- **Average Acceleration** $\vec{a}_{av} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1}$

- **Instantaneous Acceleration** $\vec{a} = \frac{\overrightarrow{dv}}{dt}$

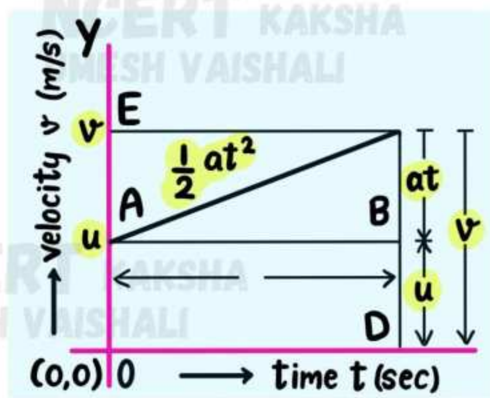
- **Equation of motion OR Equation of kinematics**

$v = u + at$ Velocity time Relation

$x = ut + \frac{1}{2}at^2$ Position time Relation

$v^2 = u^2 + 2ax$ Position velocity Relation

u = initial velocity
v = final velocity
t = time taken
a = acceleration
s = displacement



- **Freely falling bodies**

If $a = -g$: $v = u - gt$, $y = ut - \frac{1}{2}gt^2$, $v^2 = u^2 - 2gy$

If $a = g$: $v = u + gt$, $y = ut + \frac{1}{2}gt^2$, $v^2 = u^2 + 2gy$

Motion in a plane

If a_x is constant

$v_x = u_x + a_x t$ | $x = u_x t + \frac{1}{2} a_x t^2$ | $v_x^2 = u_x^2 + 2a_x x$

If a_y is constant

$v_y = u_y + a_y t$ | $y = u_y t + \frac{1}{2} a_y t^2$ | $v_y^2 = u_y^2 + 2a_y y$

Equal vectors

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

Opposite vectors

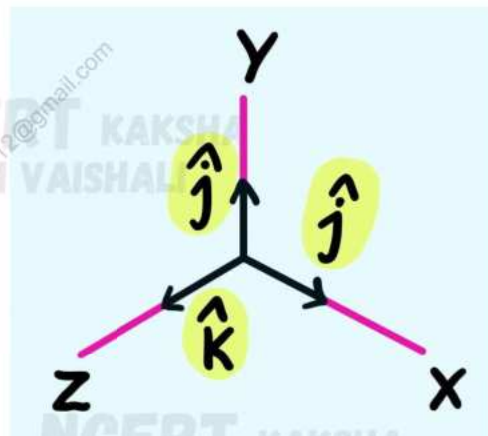
$\vec{A} = -\vec{D}$ | $\vec{B} = -\vec{D}$ | $\vec{C} = -\vec{D}$

Unit vector

$\vec{A} = A\hat{A}$

Orthogonal Unit vector

$|\hat{i}| = |\hat{j}| = |\hat{k}|$



Properties of zero vector

$\vec{A} + \vec{0} = \vec{A}$ | $n\vec{0} = \vec{0}$ | $0\vec{A} = \vec{0}$

Addition of two vectors

$\vec{R} = \vec{A} + \vec{B}$

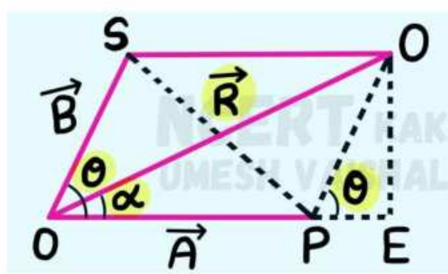
Method of triangle of vectors

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

Analytical Method

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

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



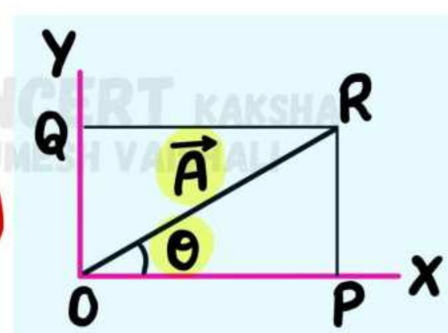
Subtraction of vectors

$\vec{R} = \vec{B} - \vec{A}$

Resolution of vector in a plane

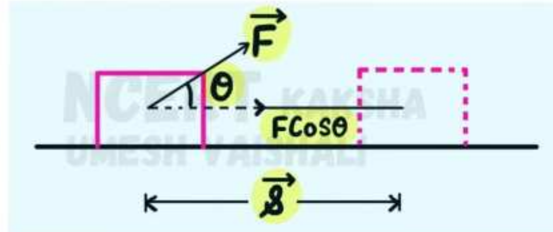
$$A = \sqrt{A_x^2 + A_y^2}$$

$$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$



- **Multiplication of a vector by Real number** $\boxed{\vec{R} = K\vec{A}}$
- **Scalar or dot product of two vectors** $\boxed{\vec{A} \cdot \vec{B} = AB\cos\theta}$

$\boxed{W = \vec{F} \cdot \vec{s}}$



$\boxed{P = \vec{F} \cdot \vec{v}}$ P = Power

$\boxed{\phi = \vec{B} \cdot \vec{A}}$ ϕ = Magnetic flux , $\vec{A}$ = Area , $\vec{B}$ = Magnetic field

$\boxed{i = \vec{j} \cdot \vec{A}}$ i = current , j = current density

- **Properties of scalar product**

★ **Commutative** $\boxed{\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}}$

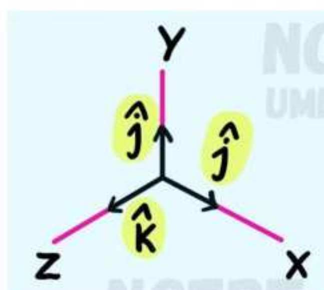
★ **Distributive** $\boxed{\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}}$

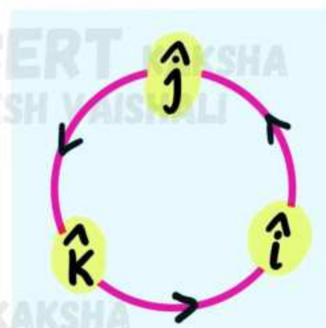
★ **Two mutually perpendicular vectors is zero** $\boxed{\vec{A} \cdot \vec{B} = 0}$

★ **Two parallel vectors is equal to product of their magnitude**

$\boxed{\theta = 0°}$ $\boxed{\vec{A} \cdot \vec{B} = AB}$

$\boxed{\theta = 180°}$ $\boxed{\vec{A} \cdot \vec{B} = -AB}$





★ **A vector with itself is equal to the square of the magnitude of the vector** $\boxed{\vec{A} \cdot \vec{A} = A^2}$

★ **Unit Orthogonal vectors** (i) $\boxed{\hat{i} \cdot \hat{j} = \hat{j} \cdot \hat{k} = \hat{k} \cdot \hat{i} = 0}$

(ii) $\boxed{\hat{i} \cdot \hat{i} = \hat{j} \cdot \hat{j} = \hat{k} \cdot \hat{k} = 1}$

★ **Two product is equal to the sum of the products of their corresponding x-, y-, z- components**

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

Vector of Cross product of two vector $\boxed{\vec{A} \times \vec{B} = AB \sin\theta \, \hat{n}}$

$\boxed{\vec{\tau} = \vec{r} \times \vec{F}}$ $\vec{\tau}$ = torque, $\vec{r}$ = Position vector

$\boxed{\vec{J} = \vec{r} \times \vec{p}}$ $\vec{J}$ = Angular momentum, $\vec{p}$ = Linear momentum

$\boxed{\vec{v} = \vec{\omega} \times \vec{r}}$ $\vec{v}$ = Linear velocity, $\vec{\omega}$ = Angular velocity

$\boxed{\vec{a} = \vec{\alpha} \times \vec{r}}$ $\vec{a}$ = Linear Acceleration, $\vec{\alpha}$ = Angular acceleration

Properties of vector product

★ **Not commutative** $\boxed{\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}}$

★ **Distributive** $\boxed{\vec{A} \times (\vec{B} + \vec{C}) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C}}$

★ **If any of the two vectors is multiplied by a scalar, then the vector product is also multiplied by the same scalar**

$$\boxed{(m\vec{A}) \times \vec{B} = \vec{A} \times (m\vec{B}) = mAB \sin\theta \, \hat{n}}$$

★ **The magnitude of the vector product of two mutually prependicular vectors is equal to the product of the magnitudes of the vector** $\boxed{\vec{A} \times \vec{B} = AB \sin 90^\circ \, \hat{n} = AB\,\hat{n}}$

OR $\boxed{|\vec{A} \times \vec{B}| = AB}$

★ **Two parallel vector is a null vector**

$$\boxed{\vec{A} \times \vec{B} = AB(\sin 0)\,\hat{n} = 0}$$

★ **Vector by itself is a null vector** $\boxed{\vec{A} \times \vec{A} = AA(\sin 0)\,\hat{n} = 0}$

★ **Unit Orthogonal vectors**

$$\boxed{\hat{i} \times \hat{j} = -\hat{j} \times \hat{i} = \hat{k}}$$

$$\boxed{\hat{j} \times \hat{k} = -k \times \hat{j} = \hat{i}}$$

$$\boxed{\hat{k} \times \hat{i} = -\hat{i} \times \hat{k} = \hat{j}}$$

$$\boxed{\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0}$$

★ Two vectors in terms of their x-, y-, x- components

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

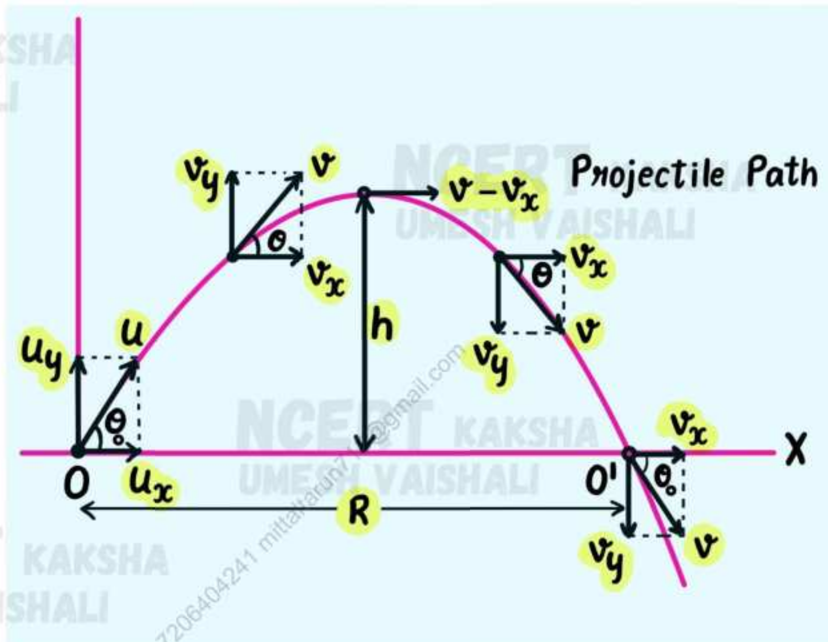
where, $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

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

➡ Projectile motion

$u_x = u\cos\theta \quad (a_x = 0)$

$u_y = u\sin\theta \quad (a_y = -g)$



➡ Time of flight

$$T = \frac{2u\sin\theta}{g}$$

➡ Range

$$R = \frac{u^2 \sin 2\theta}{g}$$

➡ Height

$$H = \frac{u^2 \sin^2\theta}{2g}$$

UNIT-3

Laws of Motion

- **Linear Momentum** $\boxed{\vec{p} = M\vec{v}}$ OR $\boxed{M_1 v_1 = M_2 v_2}$ OR $\boxed{\frac{v_1}{v_2} = \frac{M_2}{M_1}}$

- **Newton's second Law of Motion** $\boxed{\vec{F} = K\frac{\vec{dp}}{dt}}$ OR $\boxed{\vec{F} = m\vec{a}}$

mass

acceleration

NOTE

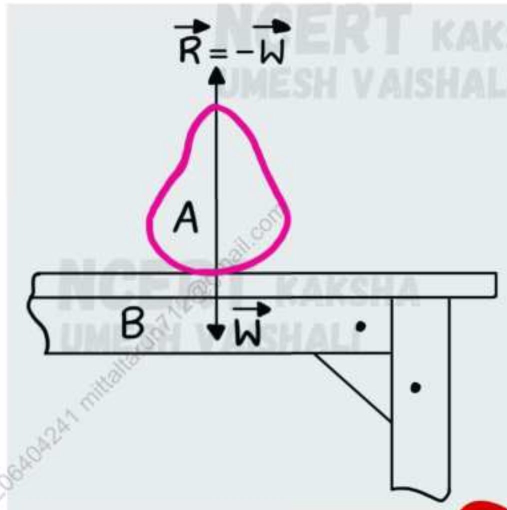
$\boxed{1 \text{ Newton} = 1 \text{ kg ms}^{-2}}$

$\boxed{1 \text{ dyne} = 1 \text{ kg cms}^{-2}}$

$\boxed{1 N = 10^5 \text{ dyne}}$

$\boxed{1 \text{ kg wt (or kgf)} = 9.8 N}$

$\boxed{1 \text{ kg (or gf)} = 980 \text{ dyne}}$



- **Impulse** $\boxed{\vec{I} = \vec{F}_{av}t = \vec{P}_2 - \vec{P}_1}$

- **Newton's third Law of Motion** $\boxed{\vec{F}_{AB} = -\vec{F}_{BA}}$

- **Principle of conservation of Linear Momentum**

$\boxed{\vec{P}_2 + \vec{P}_1 = \text{constant}}$

OR $\boxed{M_1\vec{u}_1 + M_2\vec{u}_2 = M_1\vec{v}_1 + M_2\vec{v}_2}$

u_1, u_2 = initial velocities
v_1, v_2 = final velocities

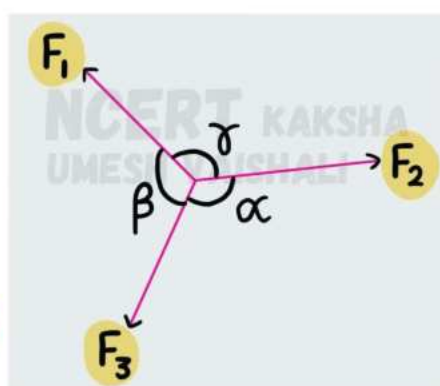
- **Equilibirium of concurrent forces**

$\boxed{\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0}$

OR $\boxed{\vec{F}_1 + \vec{F}_2 + \vec{F}_3 \ ..... + \vec{F}_n = 0}$

- **Lami's Theorem**

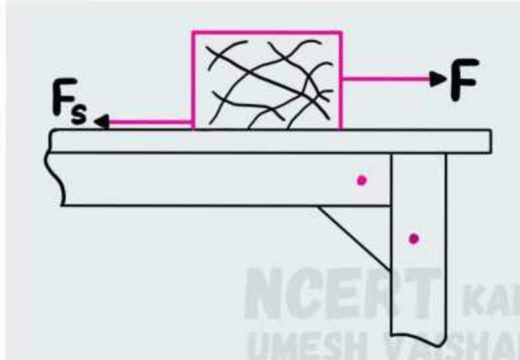
$$\boxed{\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_2}{\sin\gamma}}$$

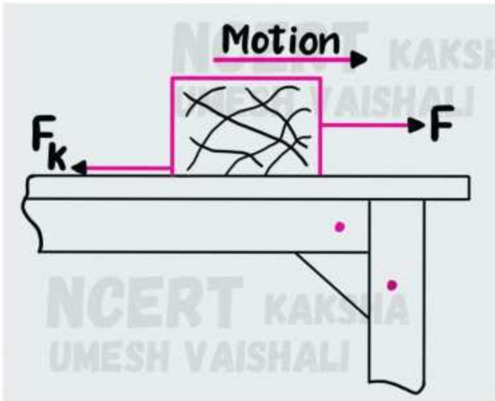


Static friction

$$(F_s)_{max} = \mu_s R$$

Cofficient of static friction





Kinetic friction

$$F_K = \mu_K R$$

Cofficient of kinetic friction

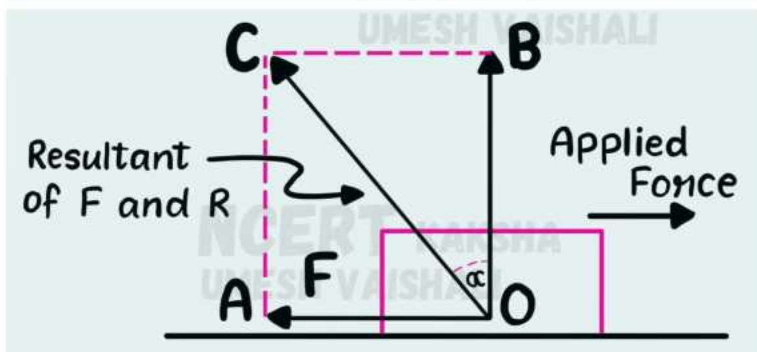
Limiting Static friction

$$\mu = \frac{F}{R} = \frac{\text{limiting friction}}{\text{normal reaction}}$$

$$\mu_K = \frac{F}{R} = \frac{\text{kinetic friction}}{\text{normal reaction}}$$

Angle of friction

$$\tan\alpha = \mu$$



NOTE

Angle of repose is equal to Angle of friction

Work, done against friction

- Along a horizontal surface $W = \mu_K Mgs$
- Along an inclined plane

(a) When the block is moved up the inclined plane

$$\boxed{W = Mg(\sin\theta + \mu_K \cos\theta)S}$$

(b) **When the block is moved down the inclined plane**

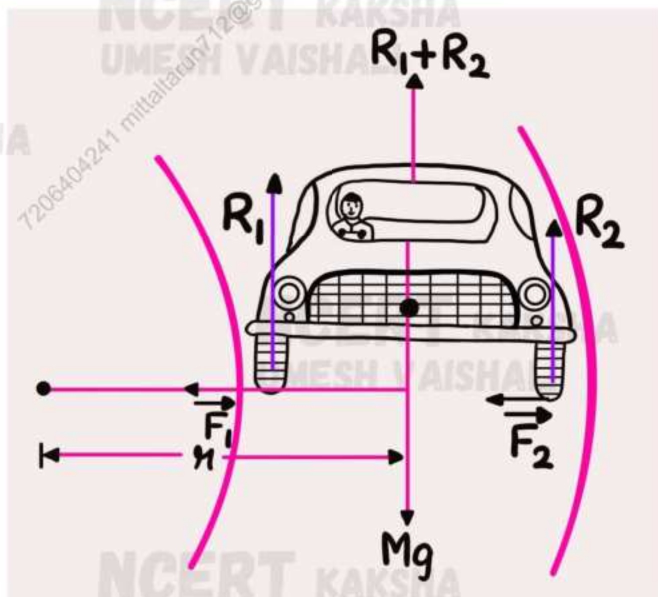
$$\boxed{W = Mg(\mu_K \cos\theta - \sin\theta)S}$$

- Centripetal force $\boxed{F = \frac{Mv^2}{r}}$
- Centripetal Acceleration $\boxed{a = \frac{v^2}{r}}$
- Centrifugal force OR Fictitious OR Pseudo force

$$\boxed{F = M\omega^2 r = 4\pi^2 M\nu^2 r}$$

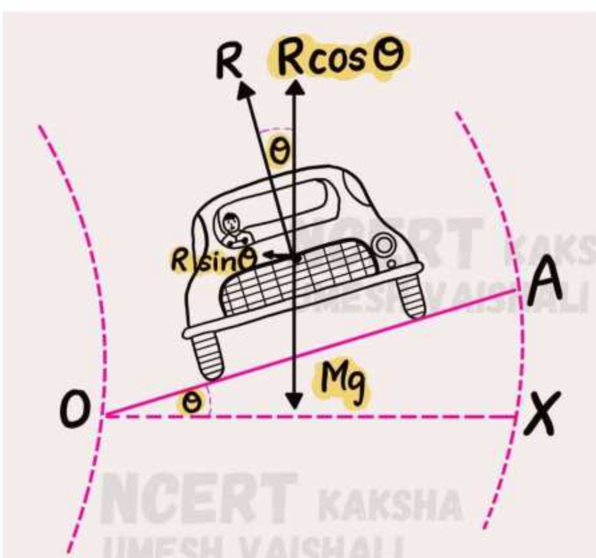
- A Vehicle taking a Circulation on level Road

$$\boxed{\mu = \frac{v^2}{rg}}$$



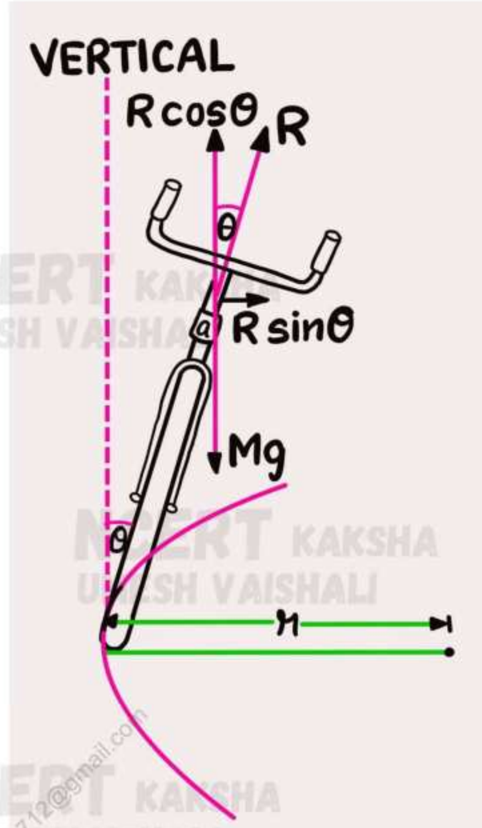
- Baking of tracks

$$\boxed{\tan\theta = \frac{v^2}{rg}}$$



Bending of a cyclist

$$\boxed{\theta = \tan^{-1} \frac{v^2}{rg}}$$



Motion in vertical circle

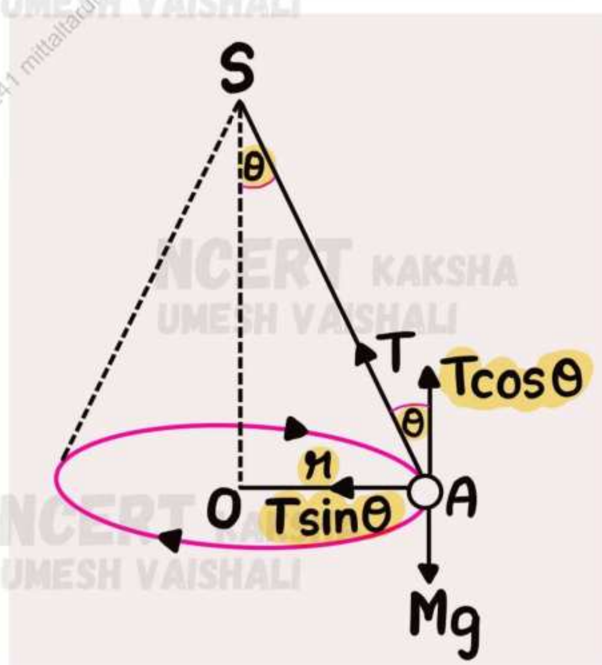
$$\boxed{v_2 = \sqrt{gr}}$$

★ **Minimum velocity at the lowest point**

$$\boxed{v_1 = \sqrt{5rg}} \text{ and } \boxed{T_1 = 6Mg}$$

Conical Pendulam

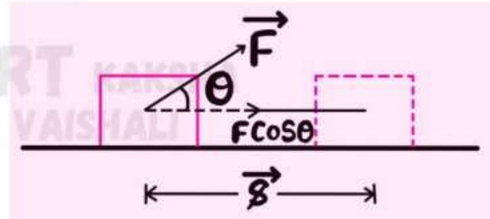
$$\boxed{t = 2\pi \sqrt{\frac{r}{g\tan\theta}}}$$



UNIT-4

Work Energy and Power

➡ **Work done by a constant force**

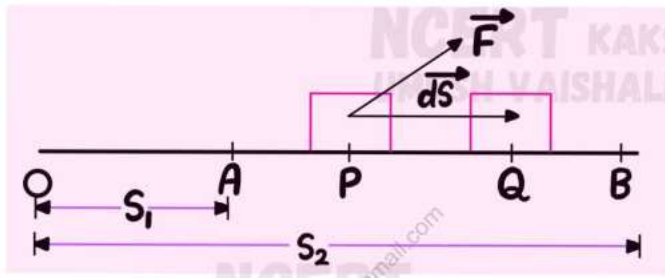


$\boxed{W = \vec{F} \cdot \vec{S} = FS\cos\theta}$

➡ **Work done by a variable force**

$$\boxed{W = \int_{x_1}^{x_2} F\,dx_r}$$

F = Force
S = displacement

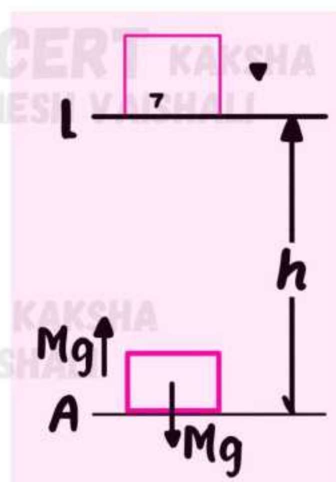


➡ **Power** $\boxed{P_{av} = \frac{\Delta W}{\Delta t}}$ $\boxed{P_{insta} = \vec{F} \cdot \vec{v}}$

3

➡ **Gravitational Potential Energy**

$\boxed{U = mgh}$ h = heigh



Important Values

1 Joule = 10^7 erg
1 Watt = 10^7 erg/sec
1 a.m.u = 1.66×10^{-27} Kg
1 a.m.u = 931 Mev
1eV = 1.6×10^{-19} Joule
1MeV = 1.6×10^{-13} Joule

NOTE

1 Joule = 1 Nm
1 erg = 1 dyne cm
1 J = 10^7 erg
1 kgm = 1 kgf × 1m = 9.8 J
1 g cm = 1 gf × 1 cm = 980 erg

Work Energy Theorem $\boxed{K_f - K_i = W}$ OR $\boxed{\Delta K = W}$

K_f = initial kinetic energy
K_i = last kinetic energy

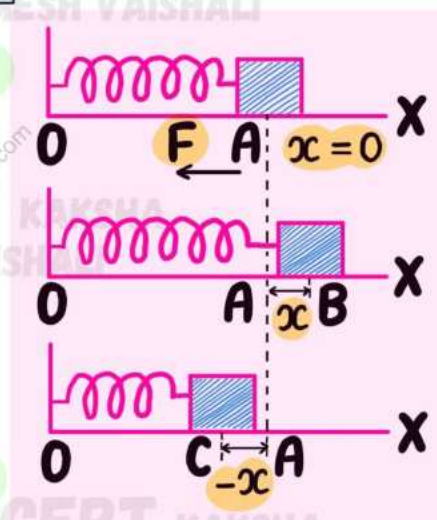
Conservative forces as Negative Gradient of Potential Energy

$$\boxed{\frac{dU}{dx} = -F} \quad \boxed{\frac{dU}{dx} = F'}$$

Potential Energy of an ideal spring

$$\boxed{U = \frac{1}{2} K x^2}$$

x = displacement



Mass - Energy Equivalence

$$\boxed{E = mc^2}$$

Elastic collision in one - dimensional space

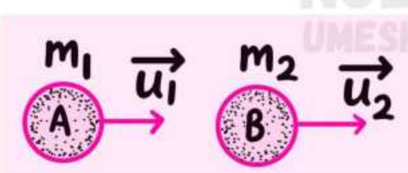
$$\boxed{u_1 - u_2 = v_2 - v_1 = -(v_1 - v_2)}$$

$$\boxed{v_1 = \left[\frac{m_1 - m_2}{m_2 + m_2}\right] u_1 + \left[\frac{2m_2}{m_1 + m_2}\right] u_2}$$

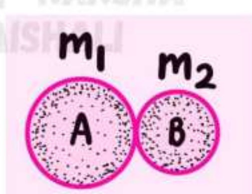
$$\boxed{v_2 = \left[\frac{2m_2}{m_1 + m_2}\right] u_1 + \left[\frac{m_1 - m_2}{m_2 + m_2}\right] u_2}$$

$u_1 - u_2$ = Relative velocity of approach

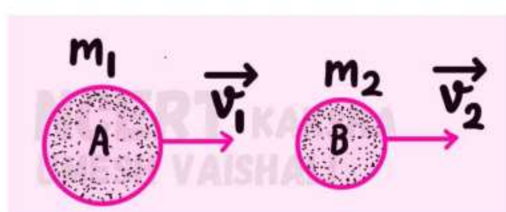
$v_1 - v_2$ = Relative velocity of separation



Before Collision [A]



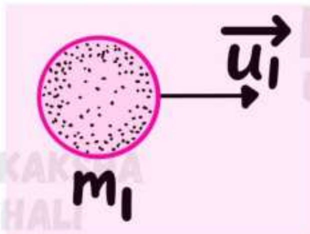
At the time of Collision [B]

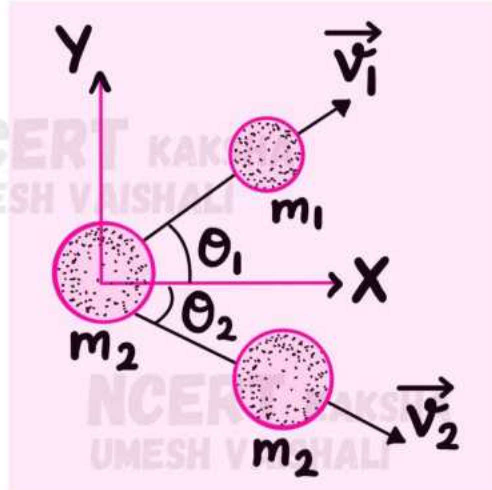


After Collision [C]

Elastic collision in two-dimensional space

$$m_1 u_1^2 = m_1 v_1^2 + m_2 v_2^2$$





NOTE

1 Watt = 1 Js^{-1}

1 KW = 10^3 W

1 horse power (h.p.) = 746 W

Perfectly inelastic collision

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

Kinetic Energy

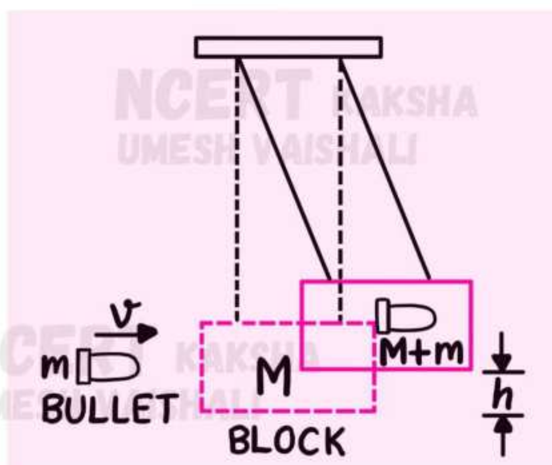
$$K = \frac{1}{2} m v^2 = \frac{p^2}{2m}$$

Inelastic collision in two dimensions

$$M_1 v_1 \sin\theta + M_2 v_2 \sin\phi = 0$$

Ballistic Pendulam

$$v = \frac{M + m}{m} \sqrt{2gh}$$



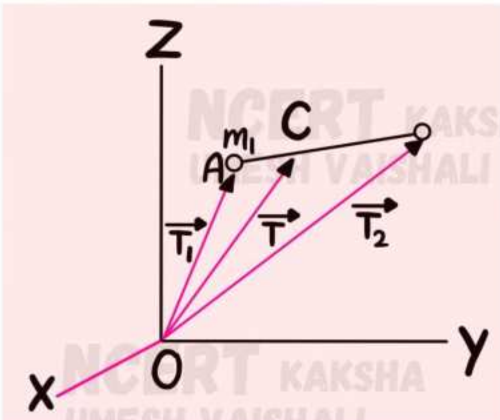
NOTE

- For a perfectly elastic collision, $v_2 - v_1 = u_1 - u_2$ and therefore $e = 1$.
- For an inelastic collision, $v_2 - v_1 < u_1 - u_2$ and therefore $0 < e < 1$.
- For a perfectly inelastic collision, $v_2 - v_1 = 0$ and therefore $e = 0$.

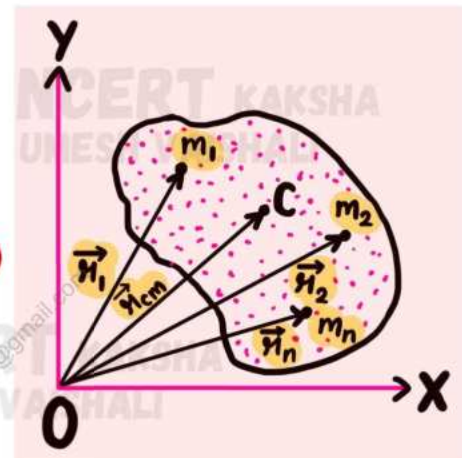
UNIT-5

Rotational Motion

Centre of Mass of a two-particle system



$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$



Centre of Mass of a system of a n-particle

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

Centre of Mass of a Rigid body

$$\vec{r}_{cm} = \frac{1}{M}\int \vec{r}\,dm$$

Motion of the centre of Mass

$$\vec{v}_{cm} = \frac{1}{M}(m_1\vec{v}_1 + m_2\vec{v}_2 + \ldots\ldots + m_n v_n)$$

$$M\vec{a}_{cm} = \vec{F}_{ext}$$

Momentum conservation and Centre-of-Mass Motion

$$\vec{P} = M\vec{v}_{cm}$$

$$\frac{dP}{dt} = \vec{F}_{ext}$$

Moment of Force OR Torque

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

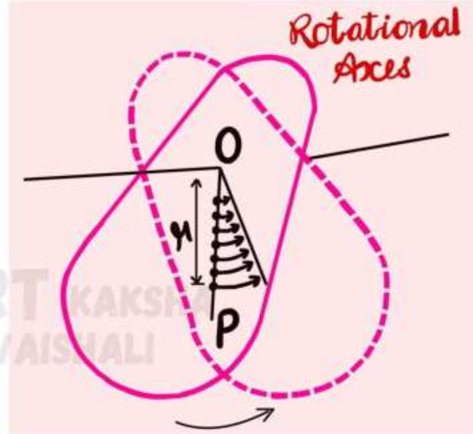
Acceleration of Centre-of-Mass

$$\vec{a}_{cm} = \frac{\vec{F}}{M}$$

Angular acceleration

$$\overline{\alpha} = \frac{\Delta\omega}{\Delta t}$$

- Relation between Angular acceleration and linear acceleration $\boxed{a = r \times \alpha}$

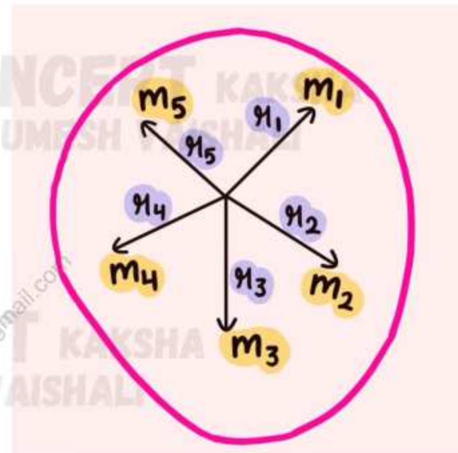


- Equations of Rotational Motion

$\boxed{\omega = \omega_0 + \alpha t}$ $\boxed{\theta = \omega_0 t + \frac{1}{2} \alpha t^2}$

$\boxed{\omega^2 = \omega_0^2 + 2\alpha\theta}$

- Moment of Inertia $\boxed{I = \Sigma m r^2}$



- Radius of gyration $\boxed{K = \sqrt{\frac{I}{M}}}$

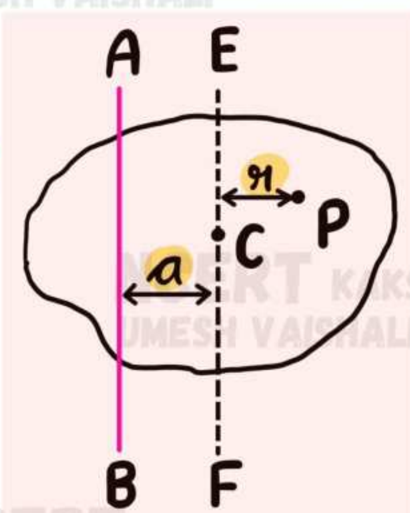
- Relation between Torque and angular acceleration $\boxed{\tau = I \times \alpha}$

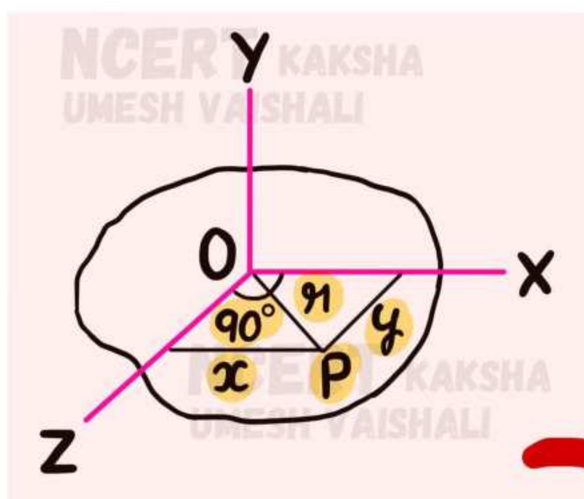
- Angular momentum $\boxed{J = I \times \omega}$

- Rate of change of momentum

$$\boxed{\frac{dJ}{dt} = \tau}$$

- Theorems of Parallel axis $\boxed{I = I_{cm} + Ma^2}$





- Theorems of Perpendicular axis $\boxed{I_z = I_y + I_x}$

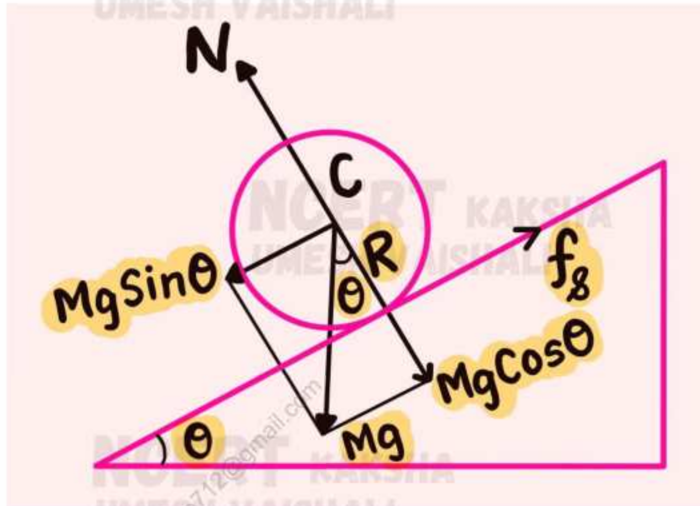
- Law of conservation of momentum $\boxed{J = \text{constant}}$

- kinetic Energy of rotation $\boxed{K = \frac{1}{2} I\omega^2}$

- Condition of rolling of a body without sliding over an inclined plane

$$\boxed{f_s = \frac{I a}{R^2}}$$

$$\boxed{a = \frac{g \sin\theta}{1 + \left(\frac{K^2}{R^2}\right)}}$$



- If the rolling body is a solid cyclinder

$$\boxed{a = \frac{2}{3} g \sin\theta} \quad \boxed{\mu_s = \frac{1}{3} \tan\theta}$$

- If the rolling body is a solid sphere

$$\boxed{a = \frac{5}{7} g \sin\theta} \quad \boxed{\mu_s = \frac{2}{7} \tan\theta}$$

- Total kinetic Energy of a body rolling without slipping

$$\boxed{K_{total} = K_{rot} + K_{trans}}$$

$$\boxed{K_{total} = \frac{1}{2} I\omega^2 + \frac{1}{2} Mv^2}$$

UNIT-6

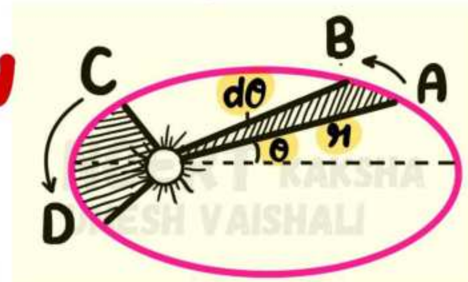
Gravitation

➡ Kepler's law of Planetary motion

★ **First law** ~ Law of orbits → Plants move in eliptical orbits

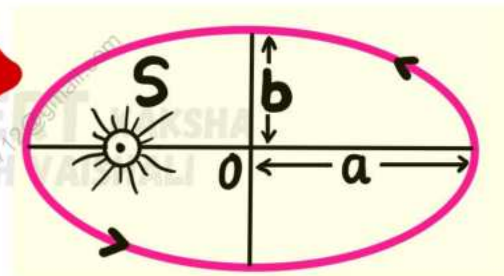
★ **Second law** ~

Law of Areal velocity → $\boxed{\frac{dA}{dt} = \frac{L}{2m}}$



★ **Third law** ~

Law of Periods → $\boxed{T^2 \propto a^3}$



➡ Gravitational force $\boxed{F = G\frac{m_1 m_2}{r^2}}$

➡ Intensity of Gravitational field $\boxed{I = \frac{F}{m}}$

➡ Relation between acceleration due to Earth's gravity g and Gravitational constant G

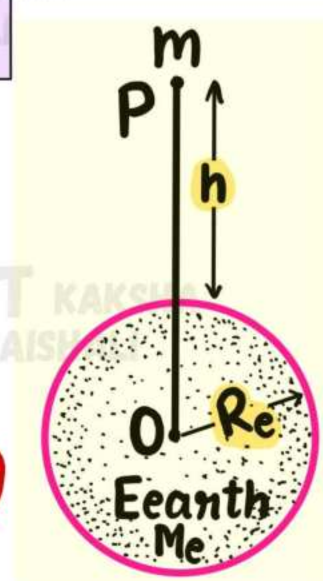
$$\boxed{g = \frac{GM_e}{R_e^2}}$$

➡ Computation of mass of Earth $\boxed{M_e = \frac{gR_e^2}{G}}$

➡ Density of Earth $\boxed{\rho = \frac{3g}{4\pi R_e G}}$

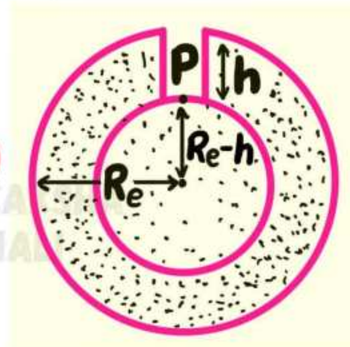
➡ Variation in acceleration due to gravity g in going above the surface of the Earth

$$\boxed{g' = \frac{g}{\left[1 + \frac{h}{R_e}\right]}}$$



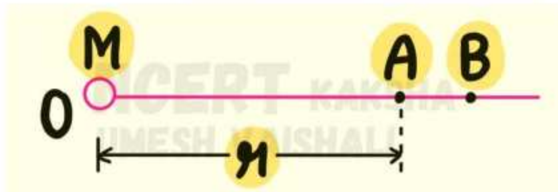
- **Variation in acceleration due to gravity g in going below the surface of the Earth**

$$g' = g\left[1 - \frac{h}{R_e}\right]$$



- **Expression for variation of g with Latitude** $g' = g - R_e\omega^2 \cos^2\lambda$

- **Gravitational Potential** $V = \frac{-W}{m}$



- **Gravitational Potential due to a Point - Mass**

$$V = \frac{-GM}{r}$$

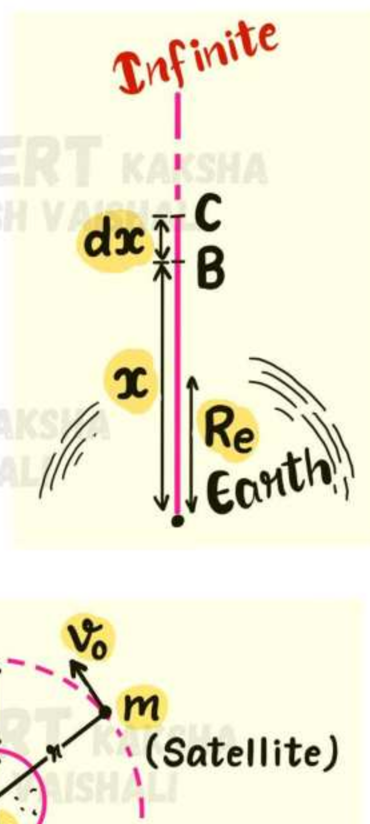
- **Gravitational Potential Energy**

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

- **Gravitational Potential Energy of a body on Earth's surface**

$$U = \frac{-GM_e m}{R_e} \quad \text{and} \quad U = \frac{-GM_e m}{r}$$

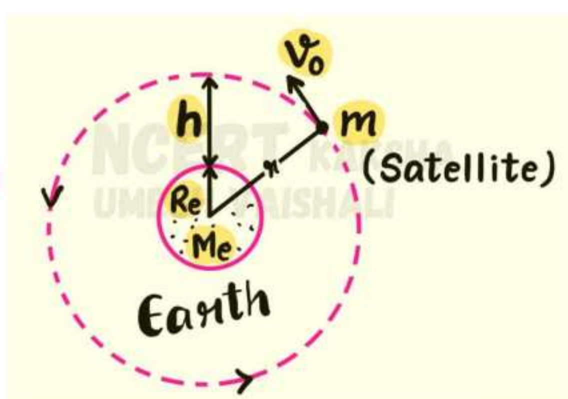
$$\because \; GM_e = gR_e^2$$



- **Orbital speed of Satellite**

$$v_o = \sqrt{\frac{GM_e}{R_e + h}}$$

$$v_o = R_e\sqrt{\frac{g}{R_e + h}}$$



- Period of Revolution of Satellite $T = \sqrt{\frac{3\pi}{G\rho}}$

- Total Energy of Satellite $E = -\frac{1}{2} \frac{GM_e m}{R_e}$

- Binding Energy of Satellite $\pm \frac{1}{2} \frac{GM_e m}{R_e} = +\frac{1}{2} mgR_e$

- Maximum height attained by a projectile

$$h = \frac{v^2 R_e}{2gR_e - v^2}$$

- Escape Energy $+\frac{GM_e m}{R_e}$

- Escape velocity $v_e = \sqrt{\frac{2GM_e}{R_e}}$ $v_e = \sqrt{2gR_e}$

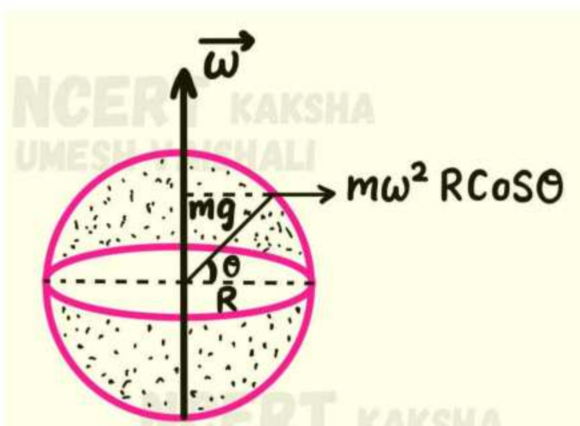
$\because GM_e = gR_e^2$

- Relation between orbital and Escape velocity

$$v_e = \sqrt{2}\, v_o$$

- Effect of earth rotation on Apparent weight

$$mg'_\theta = mg - m\omega^2 R \cos^2\theta$$

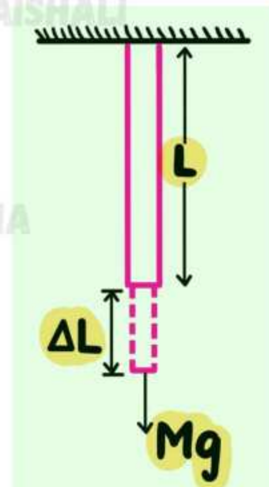


UNIT- 7

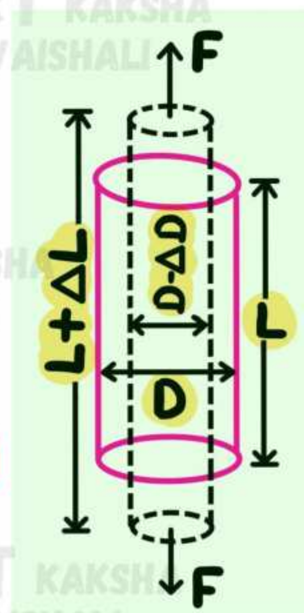
Properties of Solids and liquids

- $\boxed{\text{Stress} = \frac{F}{A}}$
- Hooke's Law $\boxed{E = \frac{\text{Stress}}{\text{Strain}}}$ E = Modulus of Elasticity
- Young's Modulus of Elasticity

$$\boxed{Y = \frac{MgL}{\pi r^2 \Delta L}}$$



- Longitudnal stress $\boxed{\frac{Mg}{\pi r^2}}$
- Longitudnal strain $\boxed{\frac{\Delta L}{L}}$
- Volume strain $\boxed{\frac{-\Delta V}{V}}$
- Lateral strain $\boxed{\frac{\Delta D}{D}}$
- Bulk Modulus of Elasticity $\boxed{B = \frac{-PV}{\Delta V}}$
- Compressibility $\boxed{\beta = \frac{1}{B} = \frac{-\Delta V}{PV}}$
- Modulus of Rigidity $\boxed{\eta = \frac{F}{A\theta}}$



- Poission's Ratio $\boxed{\sigma = \frac{\Delta D}{\Delta L}\,\frac{L}{D}}$ Diameter = D

If radius = r $\boxed{\sigma = \frac{\Delta r}{\Delta L}\,\frac{L}{r}}$

- Force Produced in Cooling wire stretched between two Rigid Supports $\boxed{F = YA\alpha\Delta t}$

- Surface Tension $\boxed{T = \frac{F}{\ell}}$

- Surface Energy $\boxed{U = \frac{S}{A}}$

- Work done in stretching a wire $\boxed{W = \frac{1}{2}\frac{YA}{L}x^2}$

- Elastic potential Energy $\boxed{u = \frac{1}{2} \times \text{stress} \times \text{strain}}$

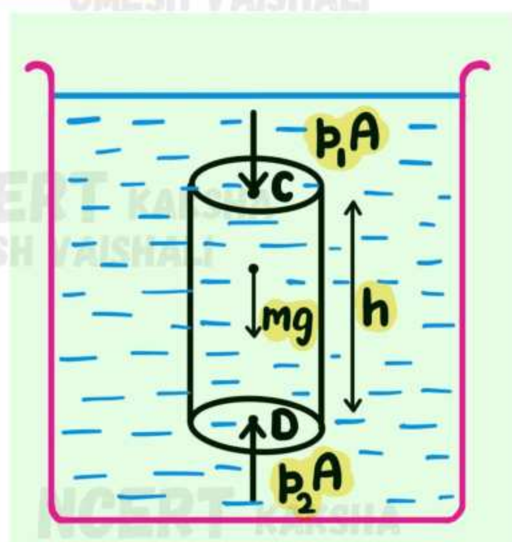
$$\boxed{u = \frac{1}{2} \times \text{Young's modulus of elasticity} \times (\text{strain})^2}$$

- Pressure $\boxed{P = \frac{F}{A}}$ $\boxed{P = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A} = \frac{dF}{dA}}$

- Pascal's Law $\boxed{F_1 = F_2} \Rightarrow \boxed{P_1 A = P_2 A} \Rightarrow \boxed{P_1 = P_2}$

- Effect of gravity on fluid Pressure

$\boxed{P = P_2 - P_1 = h\rho g}$



- Critical velocity of a liquid

$\boxed{v_c = R_e \eta^a \rho^b D^c}$

R_e = Reynold no.

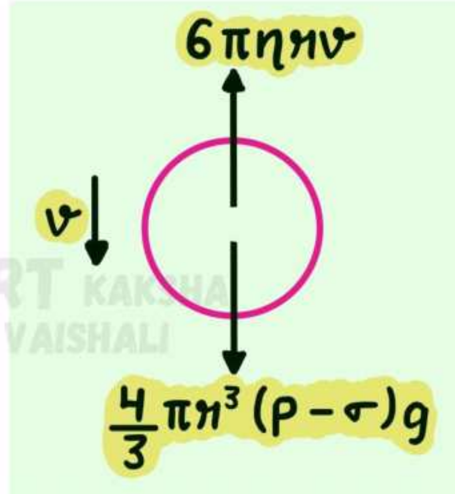
- Cofficient of Viscocity

$\boxed{F = \pm \eta A \frac{\Delta v_x}{\Delta z}}$

- Stoke's Law $\boxed{F = 6\pi\eta r v}$

Calculation of terminal velocity

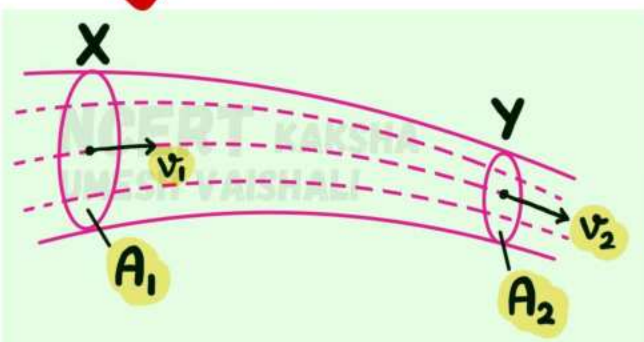
$$\boxed{v = \frac{2}{9}\,\frac{r^2(\rho-\sigma)g}{\eta}}$$

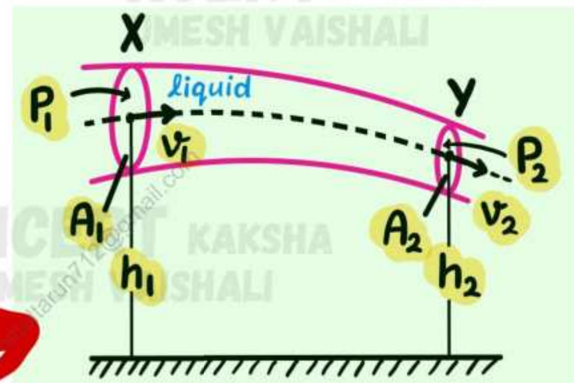


Equation of Continuous Flow of liquids

$$\boxed{A \times v = \text{constant}}$$

$$\boxed{A_1 \times v_1 = A_2 \times v_2}$$





Bernoulli's Theorem

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

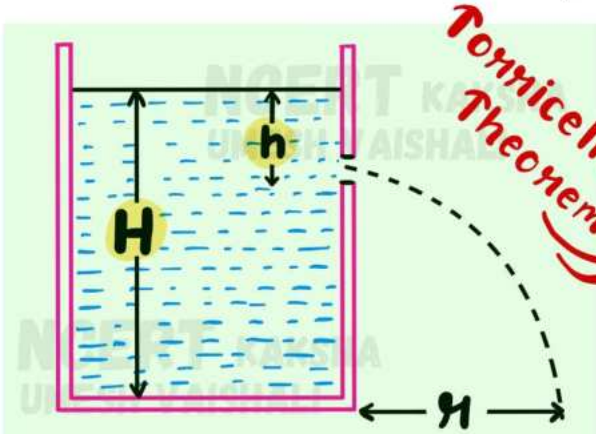
Divided by ρg

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

pressure head | velocity head | Gravitational head

Velocity of Efflux of liquid

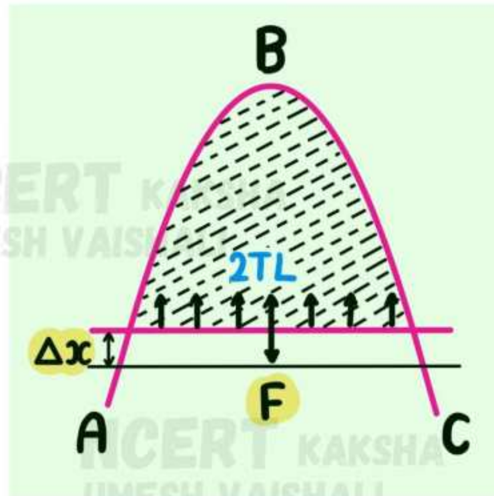
$$\boxed{v = \sqrt{2gh}}$$



Torricelli's Theorem

- **Work done in increasing the surface area of free surface of the liquid**

$$\boxed{W = T \times \Delta A}$$



- **Angle of contact**

$$\boxed{\cos\theta = \frac{T_{SA} - T_{SL}}{T_{LA}}}$$

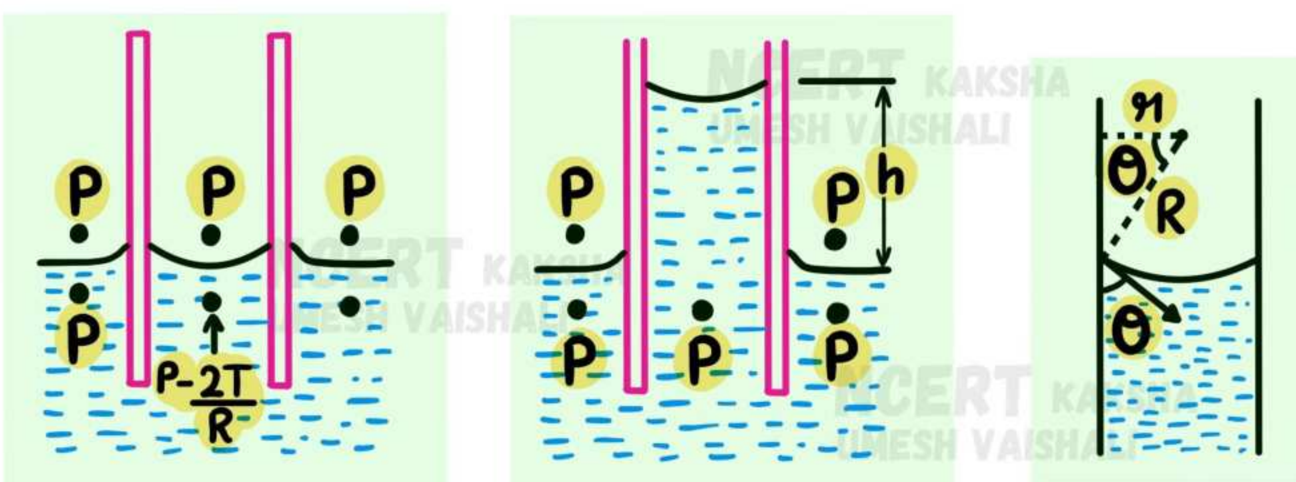
- **Excess of pressure inside a liquid drop** $\boxed{p = \frac{2T}{R}}$

- **Excess of pressure inside an air bubble in a liquid**

$$\boxed{p = \frac{2T}{R}}$$

- **Excess of pressure inside an air bubble of soap solution** $\boxed{p = \frac{4T}{R}}$

- **Capillarity** $\boxed{h\rho g = \frac{2T}{R}}$ $\boxed{h = \frac{2T\cos\theta}{r\rho g}}$



(a) (b) (c)

- Rising of liquid in a capillary tube of insufficient length $h'R' = hR = \frac{2T}{\rho g}$

- Derivation of the formula for the rise of liquid in a capillary tube $T = \frac{rh\rho g}{2\cos\theta}$

- Effect on rise of liquid in an inclined capillary Tube

$$h' = \frac{2T\cos\theta}{r\rho g\cos\alpha}$$

- Scale of Temperature $t_F = 32^\circ + \frac{9}{5}t_C$

- Ideal Gas equation $P = \frac{\mu R}{V}T$

- Absolute Temperature $T = t_C + 273.15$

- Cofficient of Linear Expansion $\alpha = \frac{\Delta L}{L \times \Delta t}$

- Cofficient of Superficial Expansion $\beta = \frac{\Delta A}{A \times \Delta t}$

- Cofficient of Volume Expansion $\gamma = \frac{\Delta V}{V \times \Delta t}$

- Relation between Cofficient of Superficial Expansion and Cofficient of Linear Expansion $\beta = 2\alpha$

- Relation between Cofficient of Volume Expansion and Cofficient of Linear Expansion $\gamma = 3\alpha$

- Relation between α, β and γ $\alpha : \beta : \gamma = 1 : 2 : 3$

- Apparent cofficient of expansion of a liquid

$$\boxed{\gamma_a = \frac{(\Delta V)_a}{V \times \Delta t}}$$

- Real cofficient of expansion of a liquid

$$\boxed{\gamma_r = \frac{(\Delta V)_r}{V \times \Delta t}}$$

- Relation between real and apparent expansion cofficient $\boxed{\gamma_r = \gamma_a + \gamma_g}$

- Variation of Density with Temperation of liquids

$$\boxed{d_t = d_0 (1 - \gamma_r t)}$$

- Thermal Capacity $\boxed{S = \frac{\Delta Q}{\Delta t}}$

- Specific Heat $\boxed{C = \frac{\Delta Q}{m \Delta t}}$

- Molar Specific Heat $\boxed{C = \frac{c}{\mu} = \frac{1}{\mu}\frac{\Delta Q}{\Delta t}}$

- Water Equivalent of Calorimeter $\boxed{W = m \times c}$

- Cofficient of Volume Expansion of gas $\boxed{\gamma_P = \frac{\Delta V}{V \Delta t} = \frac{1}{T}}$

- Cofficient of Pressure Expansion of gas

$$\boxed{\gamma_v = \frac{\Delta P}{P \Delta t} = \frac{1}{T}}$$

$$\boxed{\gamma_P = \gamma_v = \frac{1}{T}}$$

$0^\circ c$ $\gamma_v = 3.7 \times 10^{-3}\ K^{-1}$

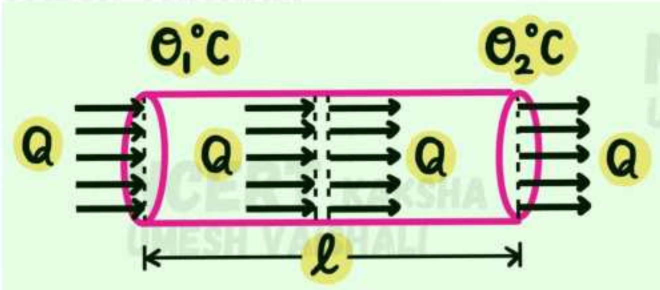
Room Temp. $\gamma_v = 3.3 \times 10^{-3}\ K^{-1}$

- Principle of Calorimetry $\boxed{m_1 c_1 (t_1 - t) = m_2 c_2 (t - t_2)}$

- Molar Specific Heats $\boxed{C_V = MC_V}$ and $\boxed{C_P = MC_P}$

➡ Latent Heat $\boxed{Q = mL}$ L = Latent Heat

➡ Cofficient of Thermal Conductivity $\boxed{Q = \frac{KA(\theta_1 - \theta_2)t}{\ell}}$



➡ Thermal Resistance $\boxed{R = \frac{\theta_1 - \theta_2}{H} = \frac{\ell}{KA}}$

➡ Stefan's Law $\boxed{E = \sigma T^4}$ σ = Stefan's constant

➡ Emissitivity $\boxed{e = \frac{Q}{A \times t}}$

➡ Kirchoff's Law $\boxed{\frac{e_\lambda}{a_\lambda} = E_\lambda}$

➡ Newton's law of Cooling $\boxed{\frac{T_1 - T_2}{t_2 - t_1} = K\left[\frac{T_1 + T_2}{2} - T_0\right]}$

➡ Wien's displacement Law

$\boxed{\lambda_m \times T = b}$

λ_m = Wavelength
b = constant $(2.9 \times 10^{-3}\ m\text{-}K)$

Important values

1 Pascal = 1 Newton/meter^2
1 atm = 1.013×10^5 Pa
1 Bar = 10^5 Pa
1 torr = 133 Pa

UNIT-8

Thermodynamics

1 Kilocalorie = 4.18×10^3 Joule

- **Equivalence of work and heat** $\boxed{W = JQ}$

  Q = Heat
  J = Conversion factor = 4.18 Joule / Calori
  (Mechanical equivalent of heat)

- **Work** $\boxed{dW = P \times dV}$ P = Pressure

- **First law of thermodynamics** $\boxed{Q = \Delta U + W}$

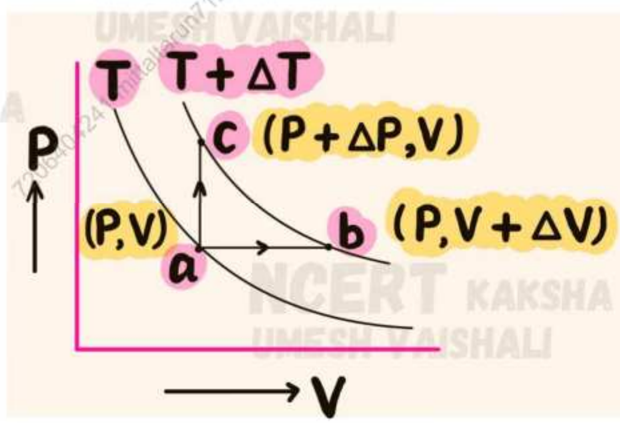
- **Specific Heat**

  $\boxed{Q = c \times m \times \Delta t}$

  c = specific heat

- **Mayer's Formula**

  $\boxed{C_P - C_V = R}$



- **Total kinetic Energy of an ideal gas**

  $$\boxed{U = N \times \frac{1}{2} fkt = \frac{1}{2} fRT}$$

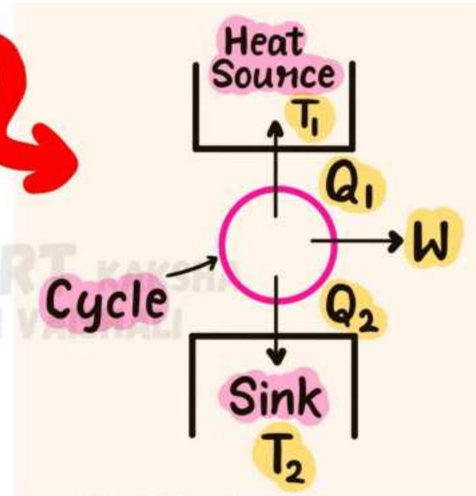
- **Evaluation of Molar specific Heats C_V and C_P of gass**

  $$\boxed{C_V = \frac{1}{2} fR}$$

  $$\boxed{C_P = \left[\frac{f}{2} + 1\right] R}$$

  $$\boxed{\gamma = 1 + \frac{2}{f}}$$

- **Heat Engine** $Q_1 - Q_2 = W$



- **Thermal Efficiency** $\eta = 1 - \frac{Q_2}{Q_1}$

- **Carnot's Ideal Heat Engine**

  Efficiency $e = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$

- **Cofficient of Performance**

$$K = \frac{T_2}{T_1 - T_2}$$

- **Isothermal Process**

$$PV = \text{constant}$$

- **Adiabatic process** $PV^\gamma = \text{constant}$

- **Adiabatic Relation between Temperature and Volume**

$$TV^{\gamma-1} = \text{constant} \qquad \frac{T^\gamma}{P^{\gamma-1}} = \text{constant}$$

- **Relation in isothermal and adiabatic curves**

$$\frac{\text{Slope of Adiabatic curve}}{\text{Slope of Isothermal curve}} = \gamma$$

- **Work done by an ideal gas in isothermal process**

$$W = 2.303\,\mu RT \log_{10}\left(\frac{V_f}{V_i}\right)$$

- **Work done by an ideal gas in Adiabatic process**

$$W = \frac{1}{\gamma-1}(P_i V_i - P_f V_f) \qquad W = \frac{\mu R}{\gamma-1}(T_i - T_f)$$

UNIT-9

Kinetic Theory of gases

- Boyel's law $PV = \text{constant}$ $P_1 V_1 = P_2 V_2$
- Charle's law $\frac{V}{T} = \text{constant}$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
- Equation of state for an ideal gas

$PV = \mu RT$ — For μ mole

$PV = RT$ — For 1 mole

$R = 8.31$ Joule/ Mole – K

- Ideal gas Equation in terms of K_B and n

$PV = nk_BT$ k_B = Boltzmann's constant

- Formula for the Pressure of an ideal gas

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

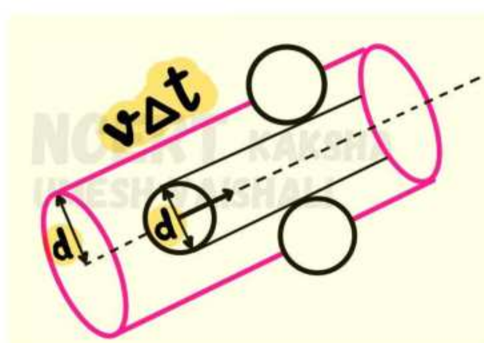
- Root – mean – square speed of gas molecule

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$ OR $$v_{rms} \propto \sqrt{T}$$

- Kinetic interpretation of Temperature $\frac{3}{2}k_BT$
- Mean Free Path

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

$$\lambda = \frac{k_BT}{\sqrt{2}\pi d^2 p}$$



N = Avagadro's Number $= 6.0221 \times 10^{23}$

- Atomic mass of an element $\boxed{m = \frac{M}{N}}$ M = atomic weight

- Number of Atoms in a given mass of an element

$$\boxed{n = \frac{N}{M} \times x}$$

x = Atomic number in grams

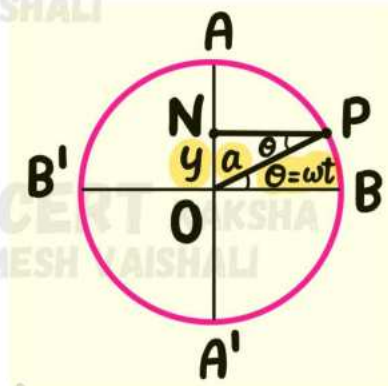
UNIT-10

Oscillations and Waves

- **Displacement Equation of S·H·M** $\boxed{y = a \sin\omega t}$

- **Periodic Time** $\boxed{T = \frac{2\pi}{\omega}}$ $\boxed{T = 2\pi\sqrt{\frac{m}{k}}}$

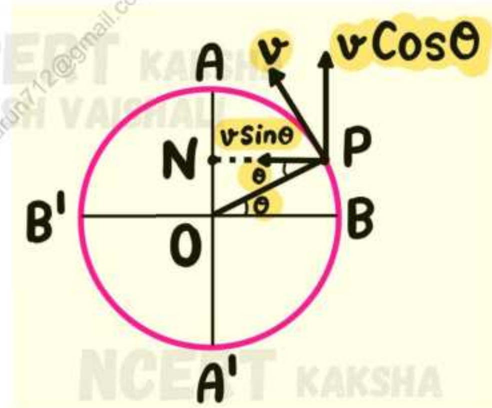
- **Frequency** $\boxed{n = \frac{1}{T} = \frac{\omega}{2\pi}}$ $\boxed{T = 2\pi\sqrt{\frac{k}{m}}}$

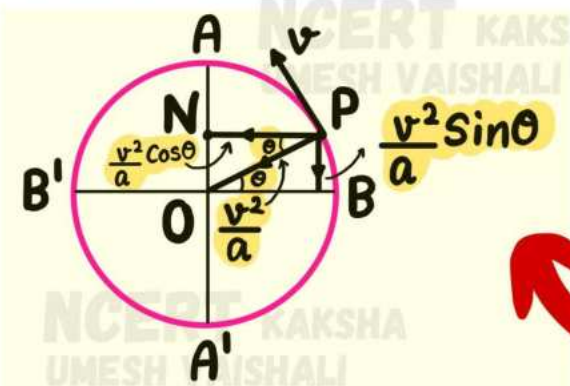


- **Phase** $\boxed{y = a \sin\omega t\,(\omega t + \phi)}$

- **Velocity in S·H·M**

$$\boxed{u = \omega\sqrt{a^2 - y^2}}$$





- **Acceleration in S·H·M**

$$\boxed{\alpha = -\omega^2 y}$$

- **Equation of Time - Displacement curve of S·H·M**

$$\boxed{y = a \sin\left[2\pi\frac{t}{T}\right]}$$

- **Periodic time formula for S·H·M, in terms of α and y**

$$\boxed{T = 2\pi\sqrt{\frac{y}{\alpha}}}$$

- **Frequency formula for S·H·M, in terms of α and y**

$$\boxed{n = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{\alpha}{y}}}$$

Displacement Equation of S·H·M in terms of Cos

$$x = a\cos(\omega t + \phi)$$

Equation for Time - velocity $$u = \frac{dy}{dt} = a\omega\cos\omega t$$

Equation for Time - Acceleration

$$\alpha = \frac{d^2y}{dt^2} = -a\omega^2\sin\omega t$$

Amplitude of S·H·M

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

$$\tan\theta = \frac{A_2\sin\delta}{A_1 + A_2\cos\delta}$$

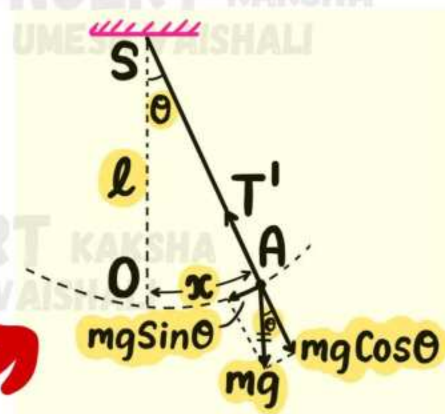
Potential Energy in S·H·M $$U = \frac{1}{2}m\omega^2y^2$$

Kinetic Energy in S·H·M $$K = \frac{1}{2}m\omega^2(a^2 - y^2)$$

Total Energy in S·H·M $$E = \frac{1}{2}m\omega^2a^2 = 2\pi^2mn^2a^2$$

Hook's law $$F = -kx$$

k = force constant OR spring constant

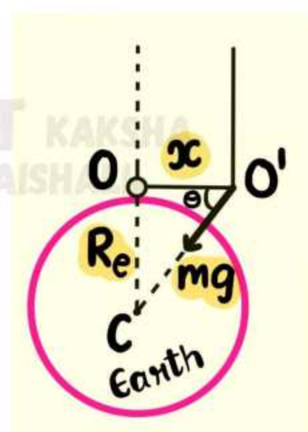


Time Period of Simple Pendulam

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

Second's Pendulam $$l = \frac{g}{\pi^2}$$

Time Period of a Simple Pendulam of infinite length $$T = 2\pi\sqrt{\frac{R_e}{g}}$$



Oscillations of a Hollow cylinder floating in a liquid

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

Oscillations of a liquid in a U-tube $T = 2\pi\sqrt{\frac{h}{g}}$

Differential Equation of S·H·M

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

for Linear

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

for Angular

Motion of body attached to a Horizontal light spring

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

Motion of a body attached to two horizontal springs

$$T = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$$

Vertical Oscillations of a body suspended by a light spring $T = 2\pi\sqrt{\frac{m}{K}}$

Motion of a body suspended by two light springs

$$T = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$$

Wave Speed $v = n\lambda$

n = frequency
λ = Wavelength

Speed of transverse wave motion $v = \sqrt{\frac{\text{stress}}{d}}$

Speed of longitudnal wave in solids $v = \sqrt{\frac{Y}{d}}$

- Speed of longitudnal wave in solids $v = \sqrt{\frac{B}{d}}$

I = moment of Inertia

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

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

- Newton's Formula $v = \sqrt{\frac{P}{d}}$

- Laplace's Correction $v = \sqrt{\frac{\gamma P}{d}}$

- Damping force $F = -bv$ $A = A_0 e^{-bt/2m}$

- Forced oscillations $A = \frac{F_0/m}{(\omega^2 - \omega_0^2)^2 + (b\omega/m)^2}$

- Effect of Pressure on the speed of longitudnal waves $\frac{P}{d} = \frac{RT}{M}$

- Effect of Temperature on the speed of longitudnal waves $v = \frac{\gamma RT}{M}$

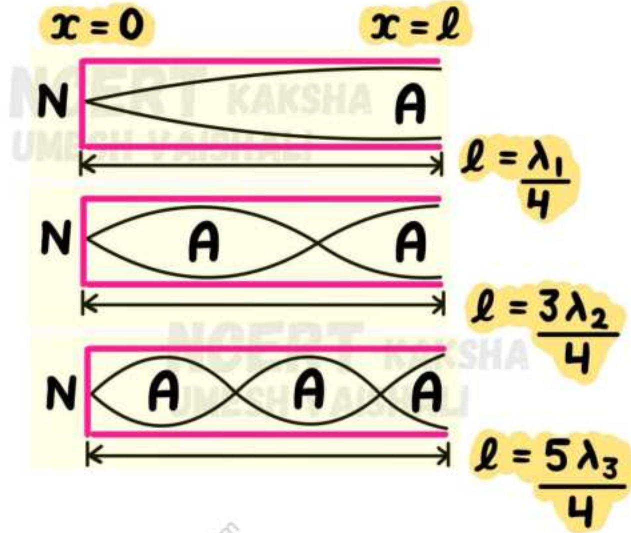
- Speed of Sound in different gases $\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$

- Relation between v and v_{rms} $v = \left(\sqrt{\frac{\gamma}{3}}\right) v_{rms}$

- Equation of Stationary wave

$$y = 2a \cos\frac{2\pi x}{\lambda} \sin\frac{2\pi t}{T} \qquad y = -2a \sin\frac{2\pi x}{\lambda} \cos\frac{2\pi t}{T}$$

Modes of Vibration of Air Column in closed organ pipe $\boxed{\lambda = \frac{4\gamma}{2m-1}}$



- First mode of Vibration

$$\boxed{n_1 = \frac{v}{4\ell}}$$

- Second mode of Vibration

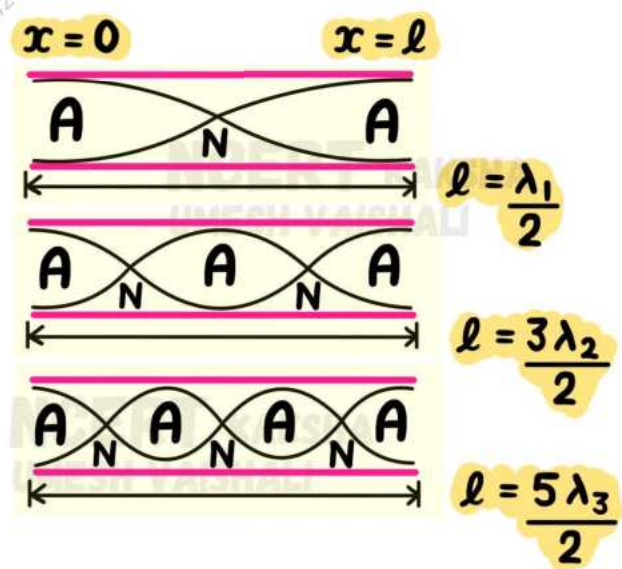
$$\boxed{n_2 = \frac{3v}{4\ell}}$$

- Third mode of Vibration

$$\boxed{n_3 = \frac{5v}{4\ell}}$$

Modes of Vibration of Air Column in open organ pipe

$$\boxed{\lambda = \frac{2\gamma}{m}}$$



- First mode of Vibration

$$\boxed{n_1 = \frac{v}{2\ell}}$$

- Second mode of Vibration

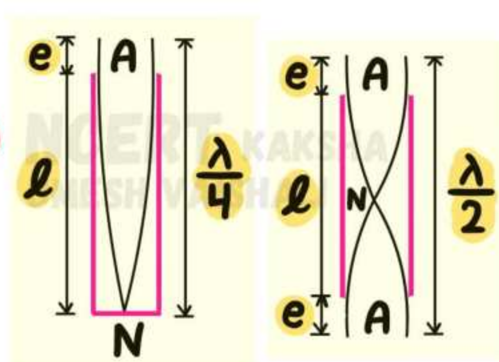
$$\boxed{n_2 = \frac{2v}{2\ell}}$$

- Third mode of Vibration

$$\boxed{n_3 = \frac{3v}{2\ell}}$$

End Correction

- For pen pipe $\boxed{n_1 = \frac{v}{4(\ell + e)}}$
- For closed pipe $\boxed{n_1 = \frac{v}{2(\ell + 2e)}}$



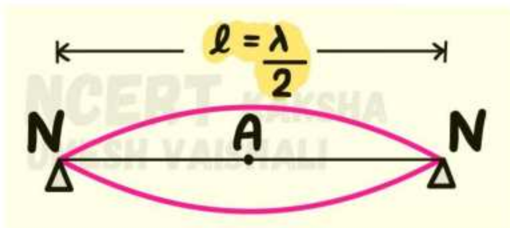
[A] [B]

➡ Speed of transverse wave in stretched wire

$$v = \sqrt{\frac{T}{m}} \quad \text{and} \quad v = \sqrt{\frac{T}{\pi r^2 d}}$$

➡ Vibrations of Stretched String

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



➡ Law of Transverse Vibrations of a Stretched String

- **Laws of length** $n \propto \frac{1}{l}$
- **Laws of Tension** $n \propto \sqrt{T}$
- **Laws of Mass** $n \propto \sqrt{\frac{1}{m}}$

➡ Modes of Vibrations

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

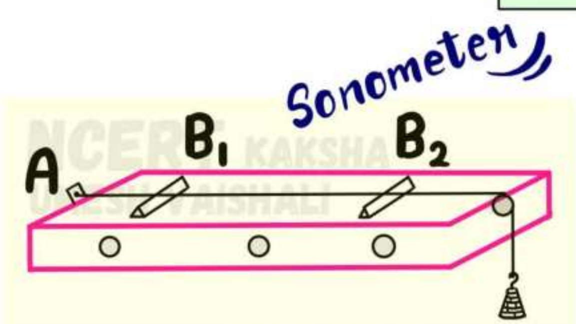
frequency

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}}$$

- **First mode of Vibration** $n_1 = \frac{v}{2l}$
- **Second mode of Vibration** $n_2 = \frac{2v}{2l}$
- **Third mode of Vibration** $n_3 = \frac{3v}{2l}$

➡ Sonometer frequency

$$n = \frac{1}{2l}\sqrt{\frac{Mg}{\pi r^2 d}}$$



Doppler Effect in sound

- **Sound source is moving and observer is stationary**

$$n' = n\left[\frac{v}{v - v_s}\right] \qquad n' = n\left[\frac{v}{v + v_s}\right]$$

- **Observer is moving and sound source is stationary**

$$n' = n\left[\frac{v - v_0}{v}\right]$$

Both, sound - source and observer are moving

- $$n' = n\left[\frac{v - v_0}{v - v_s}\right]$$

General State

$$n' = n\left[\frac{v - v_0 \cos\alpha}{v - v_s \cos\beta}\right]$$

Doppler's Shift

$$\Delta\lambda = \frac{v}{c}\lambda$$

UNIT- II

Electrostatics

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$m_e = 9.1 \times 10^{-31}$ Kg

$m_p = 1.67 \times 10^{-27}$ Kg

$m_n = 1.67 \times 10^{-27}$ Kg

Charges
- Positive (+)
- Negative (–)

like charges (+ , +) repel each other
unlike charges (+ , –) attract each other

➡ **Gravitational force** $\boxed{F = \dfrac{G m_1 m_2}{r^2}}$ $G = 6.67 \times 10^{-11}\ Nm^2 Kg^{-2}$

➡ **Additivity of charges** $\boxed{q_1 + q_2 + q_3 + \ldots\ldots q_n}$

n = integer (positive or Negative)
e = basic unit of charge = 1.6×10^{-19} c
$q_1, q_2, q_3 \ldots\ldots q_n$ = charge

➡ **Quantisation of charge** $\boxed{q = \pm ne}$

➡ $\boxed{q = i \times t}$ q = charge , i = Electric current , t = time

➡ **Coulomb's law** $\boxed{F = k \dfrac{|q_1 q_2|}{r^2}}$ $\boxed{F = \dfrac{1}{4\pi\varepsilon_0} \dfrac{|q_1 q_2|}{r^2}}$

$$\left[K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\text{-}m^2/c^2\right]$$

➡ $\boxed{K = \dfrac{\varepsilon}{\varepsilon_0}}$ ε_0 = Permittivity of free space = $8.854 \times 10^{-12}\ C^2 N^{-1} m^{-2}$,
ε = Permittivity of dielectric

➡ **Coulomb's law in vector form**

★ **Charge on proton** $e = 1.6 \times 10^{-19}$ c

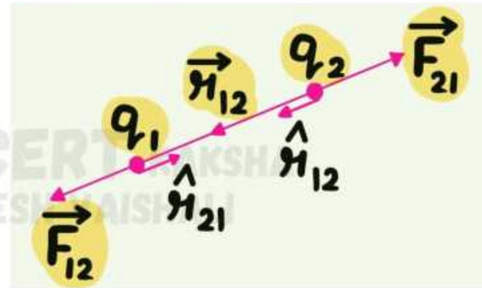
★ **Charge on electron** $e = -1.6 \times 10^{-19}$ c

$$\boxed{F_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21}}$$

$$\left[\hat{r}_{21} = \frac{\vec{r}_{21}}{r_{21}}\right] \quad \left[\vec{r}_{12} = \vec{r}_1 - \vec{r}_2 = -\vec{r}_{21}\right]$$

$$\boxed{F_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}}$$

$$\boxed{\vec{F}_{12} = -\vec{F}_{21}}$$



- **Force between multiple charges**

$$F_1 = \vec{F}_{12} + \vec{F}_{13} + \dots\dots \vec{F}_{1n}$$

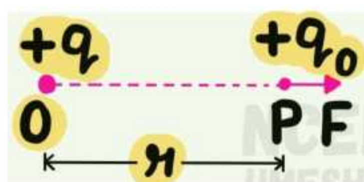
$$F_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + \frac{q_1 q_3}{r_{13}^2}\hat{r}_{13} + \dots\dots + \frac{q_1 q_n}{r_{1n}^2}\hat{r}_{1n}\right]$$

$$F_1 = \frac{q_1}{4\pi\varepsilon_0}\sum_{i=2}^{n}\frac{q_i}{r_{1i}^2}\hat{r}_{1i}$$

- **Electric field** $\boxed{\vec{E} = \frac{\vec{F}}{q_0}}$ q_0 = test charge

- **Electric field due to a point charge**

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}$$



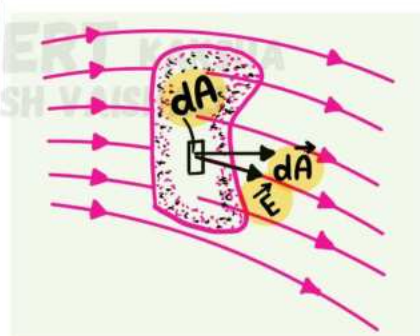
- **Force on a charged particle due to an electric field**

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

- **Electric flux** $\boxed{\phi_E = \int_A \vec{E}\cdot d\vec{A} = EA\cos\theta}$

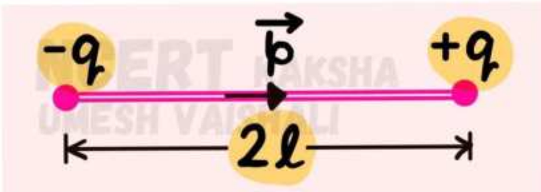
OR $\boxed{\Delta\phi = \vec{E}\cdot d\vec{A}}$

dA = area element
θ = angle between E and ΔS



Electric dipole moment

$$p = q \times 2l = 2ql$$



direction $(-q)$ to $(+q)$

$2l$ = distance between charges

Electric field due to an electric dipole

★ **At a point on the dipole axis**

$$\vec{E} = \frac{2\vec{p}}{4\pi\varepsilon_0 r^3}$$ (in $\hat{p}$ direction)

★ **At a point on equatorial plane**

$$\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$$ (in $-\hat{p}$ direction)

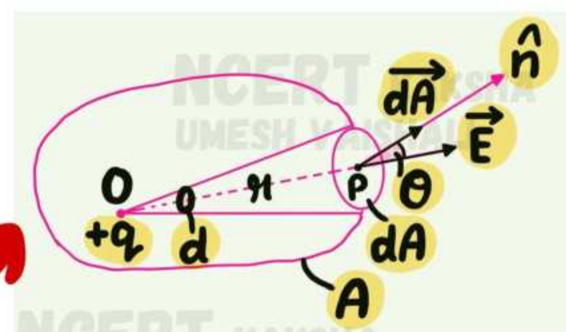
Dipole in a uniform external field

$$\vec{\tau} = \vec{p} \times \vec{E}$$ $$\tau = pE\sin\theta$$

τ = Torque

Gauss law

$$\phi_E = \oint \vec{E} \cdot \vec{dA} = \frac{q}{\varepsilon_0}$$



Applications of gauss law

★ **Field due to an infiniely long straight uniformly charged wire**

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

★ **Field due to a uniformly charged infinite plane sheet**

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$$

★ **Field due to a uniformly charged thin spherical shell**

(a) Outside the shell $\boxed{\vec{E} = \dfrac{q}{4\pi\varepsilon_0 r^2}\hat{r}}$ $(r \geq R)$

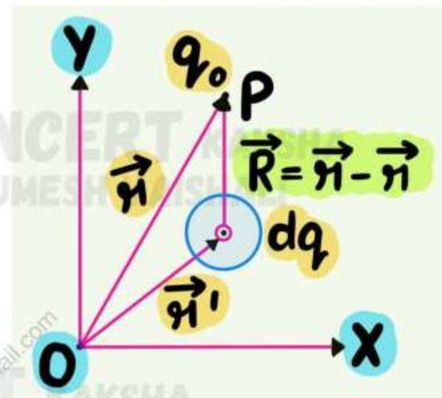
(b) inside the shell $\boxed{E = 0}$ $(r < R)$

➡ **Continuous charge density**

★ **Surface charge density** $\boxed{\sigma = \dfrac{\Delta Q}{\Delta S}}$

★ **Linear charge density** $\boxed{\lambda = \dfrac{\Delta Q}{\Delta \ell}}$

★ **Volume charge density** $\boxed{\rho = \dfrac{\Delta Q}{\Delta V}}$



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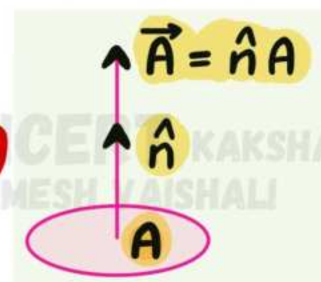
Coulomb's law agree with the Newton's third law.

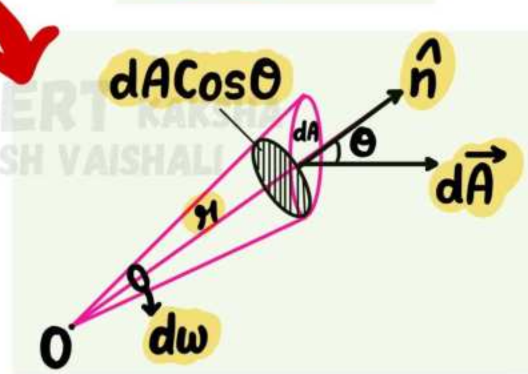
➡ **Area Vector** $\boxed{\hat{n} = \dfrac{\vec{A}}{A}}$ $\hat{n}$ = unit vector



➡ **Solid Angle** $\boxed{d\omega = \dfrac{dA}{r^2}}$

OR $\boxed{d\omega = \dfrac{dA\cos\theta}{r^2}}$

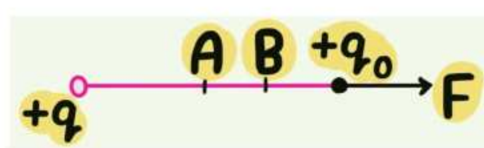
θ = Angle between $\hat{n}$ and $\vec{A}$



➡ **Electric Potential** $\boxed{V = \dfrac{W}{q_0}}$

W = Work
q_0 = positive test charge

➡ **Potential difference** $\boxed{V_A - V_B = \dfrac{W}{q_0}}$

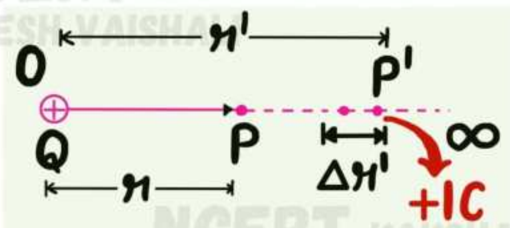


- **Work done in taking a charge between two points in an External field** $\boxed{W = q \times \Delta V}$

BOOSTER SHOT ~

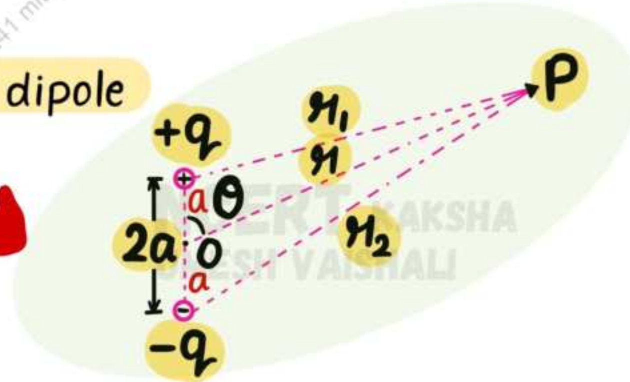
1 electron volt (eV) $= 1.6 \times 10^{-19}$ Joule
1 kiloelectron volt $= 10^{3}$ eV $= 1.6 \times 10^{-16}$ Joule
1 Millionelectron volt $= 10^{6}$ eV $= 1.6 \times 10^{-13}$ Joule
1 Billionelectron volt $= 10^{9}$ eV $= 1.6 \times 10^{-10}$ Joule

- **Potential due to point charge** $\boxed{V(r) = \dfrac{Q}{4\pi\varepsilon_0 r}}$



- **Potential due to an electric dipole**

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{p \cdot \hat{r}}{r^2}}$$



- **Potential due to a system of charges**

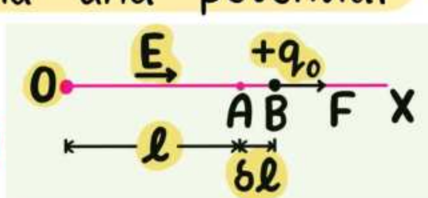
$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_{1p}} + \frac{q_2}{r_{2p}} + \dots\dots \frac{q_n}{r_{np}}\right]}$$

- **Potential Energy of a system of charges**

$$\boxed{U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}}$$

- **Relation between field and potential**

$$\boxed{\vec{E} = \frac{-\delta V}{\delta l}}$$



Potential Energy in an external field

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right]$$

★ Potential Energy of a single charge = $\boxed{qV(r)}$

★ Potential Energy of a system of two charges in an external field = $\boxed{q_1 V(r_1) + q_2 V(r_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}}$

★ Potential Energy of a dipole in an external field

$$q\left[V(r_1) - V(r_2)\right]$$

Electric field at the surface of a charged conductor

$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$

σ = surface charge density
$\hat{n}$ = unit vector normal to the surface in the outward direction

Work done in rotating Electric dipole

$$W = pE(\cos\theta_0 - \cos\theta)$$

(a) $\theta_0 = 0^\circ$ $\boxed{W = pE(1 - \cos\theta)}$

(b) $\theta = 90^\circ$ $\boxed{W = pE}$

(c) $\theta = 180^\circ$ $\boxed{W = 2pE}$

Potential Energy of electric dipole in an external field

$$U(\theta) = -pE\cos\theta = -\vec{p}\cdot\vec{E}$$

(a) $\theta_0 = 0^\circ$ $\boxed{U = -pE}$ (b) $\theta = 90^\circ$ $\boxed{U = 0}$ (c) $\theta = 180^\circ$ $\boxed{U = pE}$

➡ **Potential difference** $\boxed{V = Ed}$

➡ **Capacitor in series** $\boxed{\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3} + \cdots + \dfrac{1}{C_n}}$

➡ **Capacitor in parallel** $\boxed{C = C_1 + C_2 + C_3 + C_4}$

➡ **Energy stored in Capacitor**

$$\boxed{U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV}$$

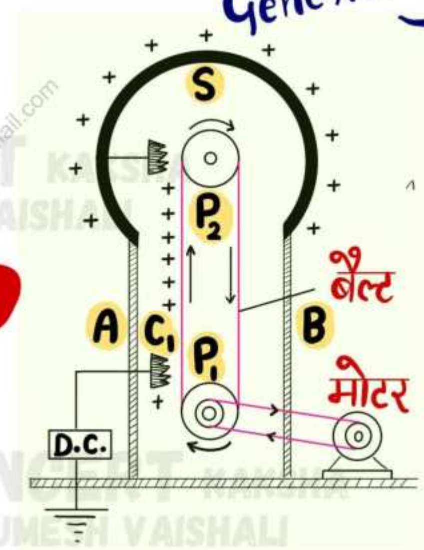
➡ **Energy density of electric field**

$$\boxed{u = \frac{1}{2}\varepsilon_0 E^2}$$

➡ **Van De Graff Generator**

$$\boxed{V(r) - V(R) = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{R}\right]}$$

Vande Graff Generator



➡ **Polarization (dipole moment per unit volume)**

$\boxed{\vec{P} = \chi_e \vec{E}}$ χ_e = electric susceptibility

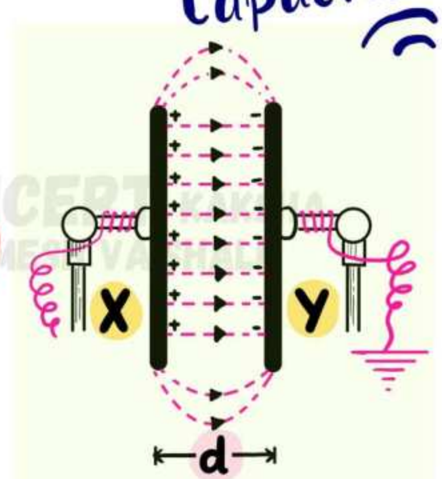
➡ **Capacitance** $\boxed{C = \dfrac{Q}{V}}$

➡ **The Parallel Plate Capacitor**

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

d = Separation between plates

Parallel - Plate Capacitor



- **Effect of dielectric on capacitance** $\boxed{K = \frac{C}{C_0}}$

  K = dielectric constant

- **Electric Displacement** $\boxed{\vec{D} = \varepsilon_0 \vec{E} + \vec{P}}$

- **Electric Suspectibility**

  $\boxed{\chi_e = \varepsilon_0 (K-1)}$ and $\boxed{\vec{D} = \varepsilon_0 K \vec{E}}$

- **Force between the plates of a charged parallel-plate capacitor** $\boxed{F = \frac{1}{2} qE}$

- **Energy Density** $\boxed{u = \frac{1}{2} \varepsilon_0 E^2}$

- **Energy stored in capacitor** $\boxed{U = \frac{1}{2} \varepsilon_0 E^2 Ad}$

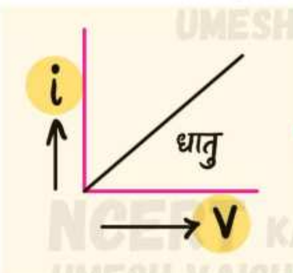
UNIT- 12

Current Electricity

➡ **Electric current** $\boxed{I = \frac{q}{t} = \frac{ne}{t}}$ $(\because q = ne)$

➡ **Ohm's law** $\boxed{V = RI}$

R = Resistance



BOOSTER SHOT

1 Ampere = 1 coloumb / sec

1 Ampere = 6.25×10^{18} e/sec

1 ohm = 1 Volt / Ampere

1 Megaohm = 10^{6} ohm (Ω)

1 microohm = 10^{-6} ohm

➡ **Electrical Resistance** $\boxed{R = \frac{V}{i}}$

➡ **Resistivity** OR **Specific Resistance** (ρ) $\boxed{\rho = R\frac{A}{l}}$ $\boxed{\rho = \frac{m}{ne^2\tau}}$

➡ **Specific conductance** OR **Conductivity** (σ)

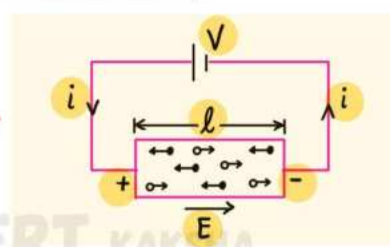
$\boxed{\sigma = \frac{1}{\rho}}$ $\boxed{\sigma = \frac{ne^2\tau}{m}}$ $\boxed{\sigma = e(\mu_e n_e + \mu_h n_h)}$

➡ **Relation between Specific Conductance and Current density (j)** $\boxed{\vec{j} = \sigma\vec{E}}$

➡ **Drift velocity on the basis of ohm's law** $\boxed{v_d = \left(\frac{eV}{ml}\right)\tau}$

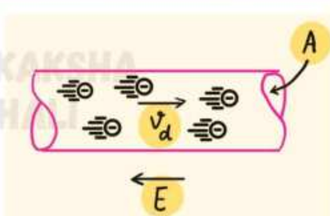
drift velocity

➡ **Mobility (μ)** $\boxed{\mu = \frac{v_d}{E} = \frac{e\tau}{m}}$



➡ **Relation between drift velocity of free electrons and electric current**

$\boxed{i = neAv_d}$



- **Current density** $\boxed{j = nev_d}$

- **Temperature dependence of Resistivity** $\boxed{\rho_T = \rho_0 [1 + \alpha(T - T_0)]}$

- **Dynamic Resistance** $= \boxed{\dfrac{\Delta V}{\Delta i}}$

- **Electric Energy** $\boxed{H = \dfrac{W}{4.2} = \dfrac{Vit}{4.2} = \dfrac{i^2Rt}{4.2} = \dfrac{V^2t}{4.2R} \text{ Calorie}}$

- **Electric Power** $\boxed{P = \dfrac{W}{t} = i^2R = \dfrac{V^2}{R}}$

BOOSTER SHOT

1 Watt = 1 Joule / sec

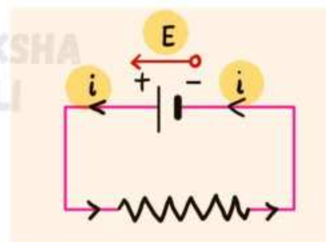
1 Kilowatt - hour = 3.6×10^6 Watt - sec = 3.6×10^6 Joule

- **Resistors in Series**

$$\boxed{R = R_1 + R_2 + R_3}$$

- **Resistors in parallel** $\boxed{\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}}$

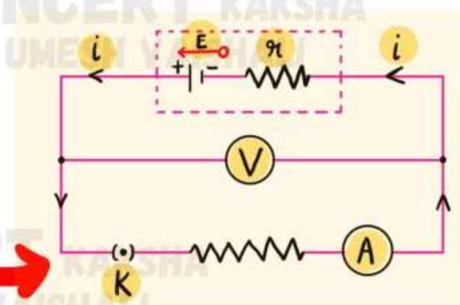
- **EMF of a cell** $\boxed{E = \dfrac{W}{q}}$



- **Terminal Potential difference** $\boxed{E = V_1 + V_2 + V_3 + \dots}$

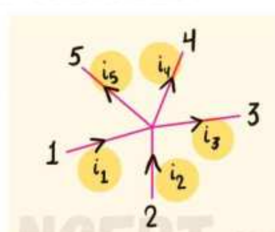
- **Relation among Terminal Potential difference, EMF and internel resistance of a cell**

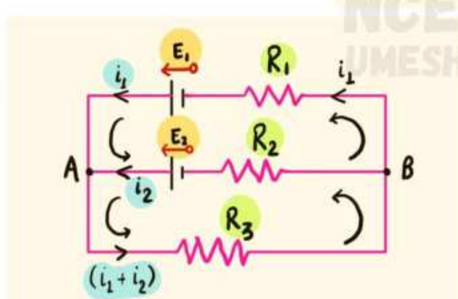
$\boxed{V = E - ir}$ $\boxed{r = R\left[\dfrac{E}{V} - 1\right]}$ $\boxed{i = \dfrac{E}{R + r}}$



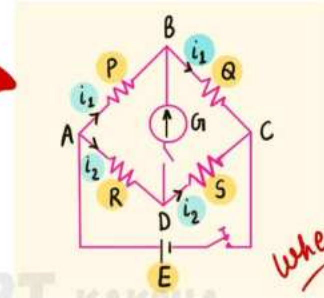
- **Kirchhoff's law**

1. First law or Junction Rule $\boxed{\Sigma i = 0}$
2. Second law or loop Rule $\boxed{\Sigma iR = \Sigma E}$





- **Wheatstone bridge** $\boxed{\dfrac{P}{Q} = \dfrac{R}{S}}$



Wheatstone Bridge

- **Meter bridge** $\boxed{S = R\left(\dfrac{100-l}{l}\right)}$

l = length
R = unknown Resistance
S = standard known Resistance

- **Potentiometer** $\boxed{\dfrac{E_1}{E_2} = \dfrac{l_1}{l_2}}$ $\boxed{V = E = \phi l}$ $\boxed{r = R\left[\dfrac{l_1}{l_2} - 1\right]}$

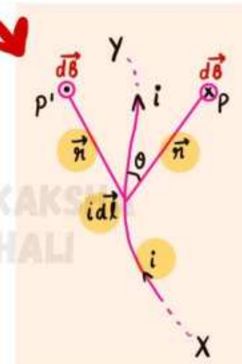
- **Electric Energy or dissipated Energy**

$$\boxed{W = Vq = Vit = \frac{V^2 t}{R} = i^2 RT}$$

UNIT- 13

Magnetic Effects of current and Magnetism

➡ Bio Savart law $\boxed{dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}}$ $\boxed{d\vec{B} = \frac{\mu_0}{4\pi}\frac{i(d\vec{l}\times\vec{r})}{r^3}}$



➡ Relation between μ_0 and ε_0 $\boxed{c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}}$

$\frac{\mu_0}{4\pi} = 10^{-7}$ N/Amp^2

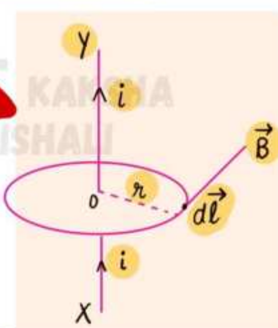
➡ Magnetic field along the axis of a current - carrying circular coil

$$\boxed{B = \frac{\mu_0 N i a^2}{2(a^2+x^2)^{3/2}}}$$

a = radius of loop
μ_0 = Permiability of free space
N = No. of rounds in coil
ε_0 = Permitivity of free space

➡ At centre of circular loop , $x = 0$ $\boxed{B = \frac{\mu_0 i}{2R}}$ $\boxed{B = \frac{\mu_0 N i}{2R}}$

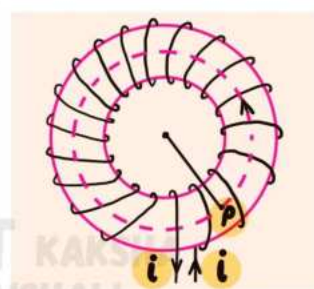
➡ Ampere's Circuital law $\boxed{\oint \vec{B}\cdot\vec{dl} = \mu_0 i}$



➡ Magnetic field due to an infinetly long straight current - carrying wire $\boxed{B = \frac{\mu_0 i}{2\pi r}}$

➡ Magnetic field inside a long solenoid $\boxed{B = \mu_0 n i_0}$

➡ Magnetic field due to a toroid (Endless) Solenoid $\boxed{B = \mu_0 n i}$

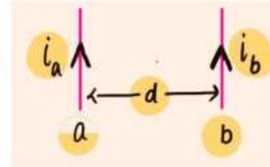


➡ Magnetic field outside the toroid $\boxed{B = 0}$

➡ Motion in combined electric and Magnetic field

$$\boxed{\vec{F} = q(\vec{E} + \vec{v}\times\vec{B}) = \vec{F}_B + \vec{F}_m}$$

Force between two parallel currents



$$\boxed{F_{ba} = \frac{\mu_0 i_a i_b L}{2\pi d}}$$

L = length of conductive wire

Torque on a current loop $\boxed{\tau = iABSin\theta}$

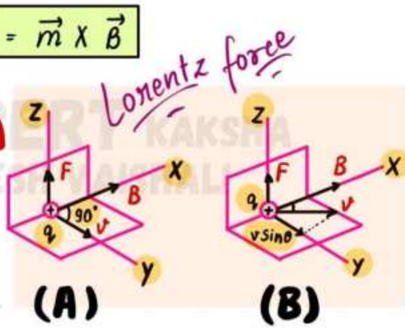
If loop N turns $\boxed{\tau = NiABSin\theta}$ A = Area of loop

If $\theta = 90^\circ$ $\boxed{\tau = NiAB}$ θ = Angle between field & Normal to the coil

If $\theta = 0^\circ$ $\boxed{\vec{\tau} = 0}$ i.e forces are collinear.

If $NiA = m$ (magnetic moment) $\boxed{\tau = mBSin\theta}$ OR $\boxed{\vec{\tau} = \vec{m} \times \vec{B}}$

Lorentz force $\boxed{F = qvB}$ $\boxed{F = qvBSin\theta}$



Motion of a charged Particle in a uniform Electric field

$$\boxed{y = \frac{qE}{2mv^2}x^2} \quad \boxed{y = \frac{qE\ell^2}{2mv^2}}$$

$$\boxed{y = \frac{qE\ell^2}{4K}} \quad \because K = \frac{1}{2}mv^2$$

1. Parallel to the field $\boxed{F = 0}$

2. Perpendicular to the field

Radius of circle $\boxed{r = \frac{mv}{qB}}$ $\boxed{r = \frac{\sqrt{2mk}}{qB}}$ $\because v = \sqrt{\frac{2K}{m}}$ $\boxed{r = \frac{1}{B}\sqrt{\frac{2mV}{q}}}$ $\because K = qB$

Time period $\boxed{T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}}$

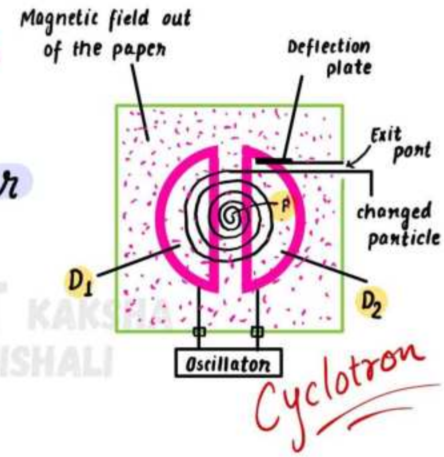
frequency $\boxed{\nu_0 = \frac{qB}{2\pi m}}$

Relative frequency $\boxed{\nu_0 = \frac{qB\sqrt{1 - \frac{v^2}{c^2}}}{2m_0}}$

3. Diagonal to the field

$$\boxed{P = v\cos\theta \times \frac{2\pi m}{qB}} \quad \boxed{r = \frac{mv\sin\theta}{qB}} \quad \boxed{T = \frac{2\pi m}{qB}}$$

Cyclotron $\boxed{K_{max} = \dfrac{q^2B^2R^2}{2m}}$



Force on a current carrying conductor

$\boxed{F = iBL\sin\theta}$

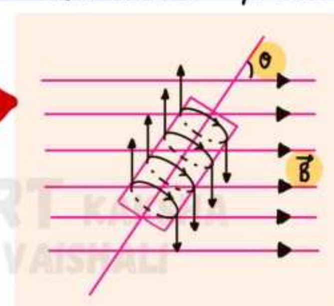
Magnetic field at the centre of a current carrying circular loop or coil

$\boxed{B = \dfrac{\mu_0 i}{2a}}$ $\boxed{B = \dfrac{\mu_0 N i}{2a}}$

Magnetic field due to a straight current carrying conductor to finite length $\boxed{B = \dfrac{\mu_0}{4\pi}\dfrac{i}{r}(\sin\phi_1 + \sin\phi_2)}$

Potential Energy of a Magnetic Dipole in an external field

$\boxed{U_\theta = -MB\cos\theta}$



Torque on a Bar Magnet

$\boxed{M = NiA}$ $\boxed{\tau = MB\sin\theta}$

Magnetic field Intensity due to Magnetic dipoles

(a) End on position $\boxed{B = \dfrac{\mu_0}{4\pi}\dfrac{2M}{r^3}}$

(b) Broad side on position $\boxed{B = \dfrac{\mu_0}{4\pi}\dfrac{M}{r^3}}$

Moving coil Galvanometer

Deflection formula $\boxed{\phi = \left(\dfrac{NAB}{K}\right) I}$ Current senstivity $= \boxed{\dfrac{\phi}{I}}$ Voltage sensitivity $= \boxed{\dfrac{\phi}{V}}$

Magnetic dipole moment of revolving electron

$\boxed{\vec{m} \text{ OR } \mu_e = \dfrac{-e}{2m_e}\vec{\ell}}$ $\left\{ \vec{\ell} \text{ OR } \vec{J} = \dfrac{nh}{2\pi} \text{ \& } n = 1 \text{ for min} \right\}$

Bohr Magneton $(\mu_e)_{min} = \dfrac{-eh}{4\pi m_e} = 9.27 \times 10^{-24}\ Am^2$

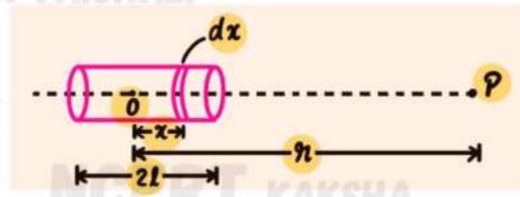
Magnetic field at centre of long solenoid

$$B = \frac{\mu_0 ni}{2}\left[\cos\theta_1 - \cos\theta_2\right]$$

Bar Magnet as equivalent solenoid

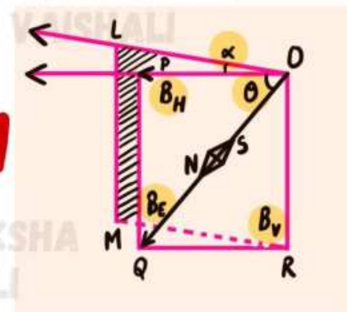
$$B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$$

m = magnetic moment



Horizontal component of Earth's Magnetic field (B_E)

$$B_E = \sqrt{B_H^2 + B_V^2} \qquad \theta = \tan^{-1}\left(\frac{B_V}{B_H}\right)$$



Intensity of Magnetisation $(\vec{M})$ OR $(\vec{I})$

$$\vec{M} = \frac{\vec{m}_{net}}{V}$$

Magnetic Intensity $(\vec{H})$ $\vec{H} = \dfrac{\vec{B}}{\mu_0} - \vec{M}$

Relative Magnetic Permeability (μ_r) $\mu_r = \dfrac{\mu}{\mu_0}$ $\mu_r = \dfrac{B}{B_0}$

flux density

Magnetic Susceptibility (χ_m) $\chi_m = \dfrac{\vec{M}}{\vec{H}}$ ➡ $\vec{B} = \mu_0 \vec{H}$

Relation between μ_r and χ_m $\mu_r = 1 + \chi_m$

- $\mu_r < 1$ Diamagnetic
- $\mu_r > 1$ Paramagnetic
- $\mu_r >> 1$ Ferromagnetic

Curie law $\chi = C\left(\dfrac{\mu_0}{T}\right)$ In Paramagnetic Phase $\chi = \dfrac{C}{T - T_c}$, $T > T_c$

Dipole in uniform magnetic field $B = \dfrac{4\pi^2 I}{MT^2}$

I = Moment of Inertia

Gauss law for magnetism for any closed surface

$$\phi_B = \oint \vec{B}\cdot\vec{dA} = 0$$

The Dipole Analogy

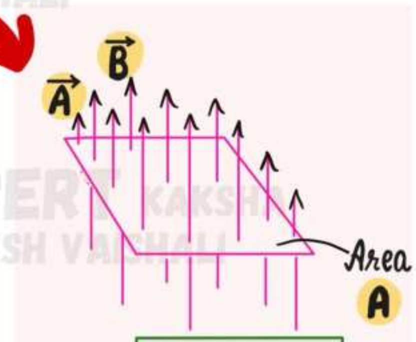
	Electrostatics	Magnetism
	$1/\varepsilon_0$	μ_0
Dipole Moment	p	m
Equatorial Field for a short dipole	$-p/4\pi\varepsilon_0 r^3$	$-\mu_0 m/4\pi r^3$
Axial Field for a short dipole	$2p/4\pi\varepsilon_0 r^3$	$\mu_0 2m/4\pi r^3$
External Field : torque	$p \times E$	$m \times B$
External Field : Energy	$-p\cdot E$	$-m\cdot B$

Magnetic Suspectibility Of Some Elements At 300 K

Diamagnetic substance	χ	Paramagnetic substance	χ
Bismuth	-1.66×10^{-5}	Aluminium	-2.3×10^{-5}
Copper	-9.8×10^{-6}	Calcium	-1.9×10^{-5}
Diamond	-2.2×10^{-5}	Chromium	-2.7×10^{-4}
Gold	-3.6×10^{-5}	Lithium	-2.1×10^{-5}
Lead	-1.7×10^{-5}	Magnesium	-1.2×10^{-5}
Mercury	-2.9×10^{-5}	Niobium	-2.6×10^{-5}
Nitrogen (STP)	-5.0×10^{-9}	Oxygen (STP)	-2.1×10^{-6}
Silver	-2.6×10^{-5}	Platinum	-2.9×10^{-4}
Silicon	-4.2×10^{-6}	Tungsten	-6.8×10^{-5}

Electromagnetic induction and Alternating current

- Magnetic Flux $\boxed{\phi_B = \vec{B}\cdot\vec{A} = BA\cos\theta}$

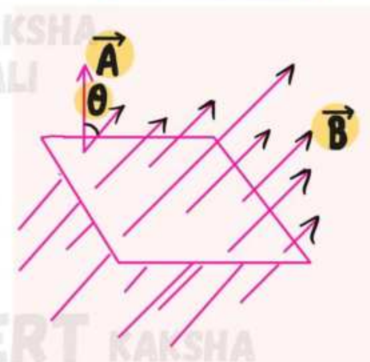


[A] $\boxed{\phi_B = BA}$

- Induced Current $\boxed{i = \frac{e}{r} = \frac{N}{R}\frac{d\phi_B}{dt}}$

$\boxed{\frac{d\phi_B}{dt} \propto \frac{di}{dt}}$ & $\boxed{N\phi_B \propto i}$

- Induced EMF $\boxed{e = \frac{-d\phi_B}{dt}}$ $\boxed{e = -N\frac{d\phi_B}{dt}}$



[B] $\boxed{\phi_B = BA\cos\theta}$

- Induced Charge $\boxed{q = \frac{N}{R}\, d\phi_B}$

- Induced EMF cross the ends of straight conductor

$\boxed{e = Bvl}$

- Self inductance $\boxed{L = \frac{N\phi_B}{i}}$ $\boxed{e = -L\frac{di}{dt}}$

- Self inductance of a plane coil $\boxed{L = \frac{\mu_0}{2}\pi N^2 r}$

- Self inductance of a long solenoid $\boxed{L = \frac{\mu N^2 A}{l}}$

- Energy stored in a coil $\boxed{U = \frac{1}{2}Li_0^2}$

OR

Energy required to build up the current i in coil

- Inductors In Series $\boxed{L = L_1 + L_2}$

- Inductors In Parallel $\boxed{\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}}$

- Mutual Inductance $\boxed{M = \frac{N_2\phi_2}{i_1}}$ $\boxed{M = \frac{-e_2}{\Delta i_1/\Delta t}}$

- Mutual Inductance of two coaxial Solenoids $M = \mu_r \mu_0 n_1 n_2 \pi r_1^2 l$

- Energy Consideration $P = \frac{B^2 l^2 v^2}{R}$ $\Delta Q = \frac{\Delta \phi_B}{R}$ P = Power

- Energy density in magnetic field $u = \frac{U}{V} = \frac{B^2}{2\mu_0}$

- Inductance when current flowing in both coil

$$e = -L_1 \frac{di_1}{dt} - M_{21} \frac{di_2}{dt}$$

OR

EMF = self inductance + Mutual inductance

- Alternating Voltage $e_0 = NBA\omega$

$e = e_m \sin \omega t$
$i = i_m \sin \omega t$
$v = v_m \sin \omega t$

i_m and v_m are maximum values of current and voltage respectively.

- Mean Value of Alternating Voltage $i_{mean} = \frac{2}{\pi} i_{max} = 0.637\, i_{max}$

- RMS (Root Mean Square) value of alternating current

$$i_{rms} = \sqrt{\overline{i^2}} = \frac{i_m}{\sqrt{2}} = 0.707\, i_m$$

- Periodic Time $T = \frac{2\pi}{\omega}$
- Frequency $f = \frac{1}{T} = \frac{\omega}{2\pi}$

- $P = i^2 R$ $\quad i_{virtual} = i_{rms} = \frac{i_m}{\sqrt{2}}$ $\quad V_{virtual} = V_{rms} = \frac{V_m}{\sqrt{2}}$

- Average of $\langle \sin^2 \omega t \rangle = \frac{1}{2}$

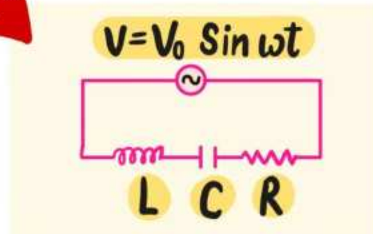
- Average value of Power over a cycle $\overline{P} = \frac{1}{2} i_m^2 R$ & $\overline{P} = (i_{rms})^2 R$

- The average value of a function f(t) over a period T

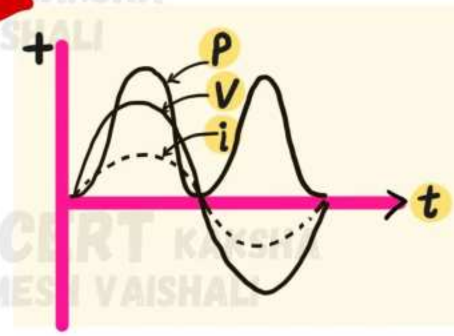
$$\langle f(t) \rangle = \frac{1}{T} \int_0^T f(t)\, dt$$

➡ Series L-C-R Resonance Circuit

$$\boxed{f = \frac{\omega}{2\pi} = \frac{1}{2\pi\sqrt{LC}}}$$



➡ Power in AC circuit



1. when circuit contains pure resistance only

$$\boxed{\bar{P} = V_{rms} \times i_{rms}}$$

2. when circuit contains L and R both

$$\boxed{\bar{P} = V_{rms} \times i_{rms} \times \cos\phi} \qquad \boxed{P = i^2_{rms} \cos\phi}$$

$$\boxed{\cos\phi = \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{R}{Z}} \qquad \boxed{P = \frac{v_m}{\sqrt{2}} \frac{i_m}{\sqrt{2}} \cos\phi}$$

➡ **Watless Current** $\boxed{\bar{P} = v_{rms} \times i_{rms} \times \cos 90^\circ = 0}$

➡ **Band Width** $\boxed{\Delta\omega = \omega_2 - \omega_1 = \frac{R}{L}}$

➡ **Quality Factor** $\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$

➡ **Transformer Efficiency** $\boxed{\eta = \frac{V_s \times i_s}{V_p \times i_p}}$ $\boxed{\bar{P} = (i_{rms})^2 \times R}$ $\boxed{\bar{P} = \frac{1}{2} i_0^2 R}$

$$\boxed{\frac{V_s}{V_p} = \frac{e_s}{e_p} = \frac{N_s}{N_p} = r} \qquad \boxed{\frac{i_p}{i_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p} = r}$$

➡ L-C oscillations

(i) $\boxed{\frac{d^2q}{dt^2} + \omega_0^2 q = 0}$ (ii) $\boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$

(iii) $\boxed{q = q_m \cos(\omega_0 t + \phi)}$ (iv) total energy of L-C circuit $\boxed{U_E = \frac{1}{2}\frac{q_m^2}{C}}$

UNIT- 15

Electromagnetic Waves

- **Displace Current**

$$i_d = \frac{\varepsilon_0 \, d\phi_e}{dt}$$

$$i = i_c + i_d$$

- **Max Wall Equations**

1. Gaus Law Of Electricity

$$\oint \vec{E}.\vec{dA} = \frac{q}{\varepsilon_0}$$

2. Gauss Law Of Magnetism

$$\oint \vec{B}.\vec{dA} = 0$$

3. Faraday's Law Of Electromagnetic induction

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

$$\oint \vec{E}.\vec{dl} = \frac{-d\phi_B}{dt}$$

4. Ampere's Maxwell circuital law

$$\oint \vec{B}.\vec{dl} = \mu_0 (i + i_d)$$

- **Energy Density Of Electromagnetic waves**

$$\bar{u} = \frac{1}{2} \varepsilon_0 E^2 + \frac{1}{2} \frac{B^2}{\mu_0}$$

$$u_e = \frac{1}{2} \varepsilon_0 E^2$$

$$u_m = \frac{1}{2} \frac{B^2}{\mu_0^2}$$

u_e = Electrical Energy Density
u_m = Magnetic Energy Density

- $$\frac{E}{B} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = C$$

$$B_0 = \frac{E_0}{C}$$

UNIT- 16

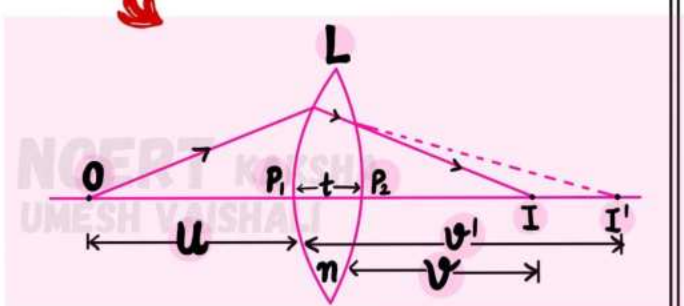
Optics

- **Focal length Of Spherical mirror** $\boxed{f = \frac{r}{2}}$ f = focal length, r = radius of curvature
- **Mirror Equation** $\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$ For both concave and convex mirror
- **linear Magnification for Mirror** $\boxed{m = \frac{h'}{h} = \frac{-v}{u}}$
- **Snell's law** $\boxed{\frac{\sin i}{\sin r} = {}^1n_2 \text{ OR } n_{21} = \frac{n_2}{n_1}}$ i = Angle Of Incident, r = Angle Of Reflection
- $\boxed{n_{12} = \frac{1}{n_{21}}}$ $\boxed{n_{32} = \frac{n_{31}}{n_{21}}}$
- **Relation Between Critical Angle And Refractive index**

$\boxed{n_{21} = \frac{1}{\sin c}}$ $\boxed{n_{ga} = \frac{1}{\sin c}}$ $\boxed{v = \frac{c}{n}}$ $\boxed{n_{gw} = \frac{n_{ga}}{n_{wa}}}$

1=rare medium 2=danser medium

- **Thin lens Formula** $\boxed{\frac{1}{v} - \frac{1}{u} = \frac{1}{f}}$



- **Magnification for lens**

$\boxed{m = \frac{y_2}{y_1} = \frac{v}{u}}$ +ve for lens

- **Power Of lens** $\boxed{P = \frac{1}{f}}$
- **Focal length Of Convex lens By Displacement method** $\boxed{f = \frac{a^2 - a^2}{4a}}$
- **For Combination Of lenses**

focal length $\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \ldots\ldots}$

Power $\boxed{P = P_1 + P_2 + P_3 + \ldots\ldots}$

Magnification $\boxed{m = m_1 . m_2 . m_3 \ldots\ldots}$

NOTE — sign Convention : According to cartesian sign convention

➡ Refraction at a spherical surface $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

➡ Deviation By A Thin Prism $\delta_m = (n-1)A$ & $D_m = n_{21} - A$

➡ Refractive Index Of The Prism

$$n = \frac{\sin\left[\frac{A+\delta m}{2}\right]}{\sin\frac{A}{2}}$$

➡ Rayleigh's Scattering law

$I \propto \frac{1}{\lambda^4}$

➡ Dispersive Power Of Prism $\omega = \frac{n_V - n_R}{n_y - 1}$

➡ Magnification Power Of Simple Microscope $m = \left(1 + \frac{D}{f}\right)$

➡ When image is at infinity, then angular magnification $m = \frac{\theta i}{\theta_0} = \frac{D}{F}$

where $\theta_0 = \frac{h}{D}$, $\theta_e = \frac{h}{f}$

➡ Magnification Power Of Compound microscope $m = m_0 m_e = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$

➡ Magnification Power Of Compound telescope

$m = \frac{\beta}{\alpha} = \frac{f_0}{f_e}$

β = Angle subtented at eye by image
α = Angle subtented at eye by object
f_0 = focal length of objective
f_e = focal length of eyepiece

➡ lens Maker Formula $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

➡ Refraction at spherical surface $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

If $\frac{n_2}{n_1} = n$ $\quad \frac{n}{v} - \frac{1}{u} = \frac{n-1}{R}$

➡ Principal foci of spherical surface

(a) first principal foci $f' = \frac{-R}{n-1}$

(b) second principal foci $f = \frac{nR}{n-1}$

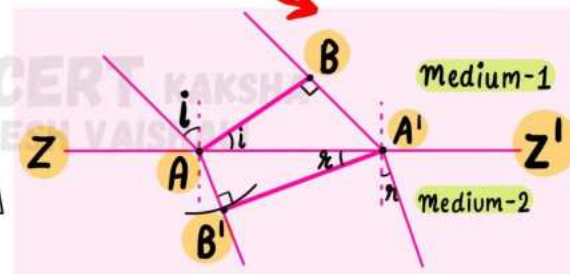
(c) $f = -nf'$

➡ Huygen's Principal Of Secondary Waves

$i = r$

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{Constant}$$

$$n_{21} = \frac{v_1}{v_2} = \frac{\text{velocity of light in first medium}}{\text{velocity of light in second medium}}$$



➡ $v = \dfrac{c}{n}$

n = refractive index
c = velocity of light

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = n_{21}$$

➡ Optical Path

$$c \times t = nd$$

➡ Doppler Effect

$$\frac{\Delta\nu}{\nu} = \frac{-\nu_{radical}}{c}$$

Change In Frequency

Velocity

➡ Refractive Index Of water relative to air

$$n = \frac{\lambda}{\lambda_w} \quad \text{OR} \quad \lambda_w = \frac{\lambda}{n}$$

➡ Interference

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

➡ Position Of Bright Fringes

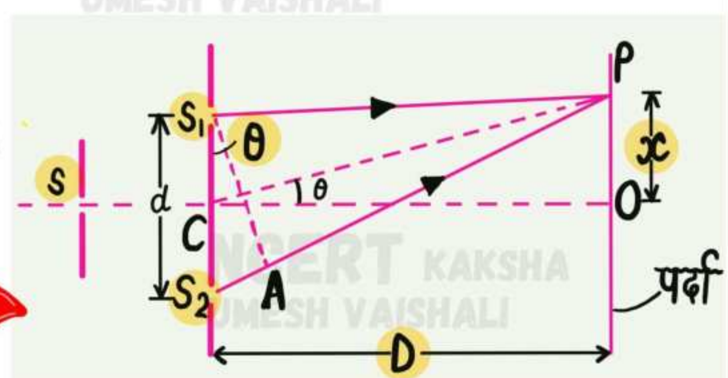
$$x = n\frac{D\lambda}{d}$$

➡ Position Of dark fringes

$$x = \left[n - \frac{1}{2}\right]\frac{D\lambda}{d}$$

➡ Displacement Of Fringe

$$x_0 = \frac{D}{d}(n-1)t$$



➡ Fringe Width

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

➡ Angular Fringe Width OR Angular Path Difference

$$\theta = \frac{\lambda}{d}$$

Thickness Of Plate $t = \frac{x_0 \lambda}{\omega(n-1)}$

Differaction Of light due to a single slit $e \sin\theta = (2m+1)\frac{\lambda}{2}$

$e \sin\theta = \pm m\lambda$

Angular width of central maximum $2\theta = \frac{2\lambda}{e}$

linear width of central maximum $2x = \frac{2\lambda}{e} \times f$

Resolving Power of telescope $1.22 \frac{\lambda}{d}$

Resolving Power of microscope $\frac{1.22\lambda}{2n \sin\alpha}$

Fresnel Distance $Z_f = \frac{e^2}{\lambda}$

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

Coherent and non-coherent additional of waves

$I \propto a^2$ I = intensity
a = amplitude

UNIT- 17

Dual nature of Matter and radiation

➡ **Maximum Kinetic Energy Of Photoelectrons**

$E_K = eV_0$ $\quad$ $E_K = K_{max} = eV_0$

➡ **Threshold Wavelength** $\lambda = \frac{c}{\nu_0}$ $\quad$ $\lambda = \frac{c}{\nu}$

ν_0 = Threshold Frequency

➡ **Einstein's Photoelectric Equation**

w = work function $\quad$ h = Plancks constant

$w = \phi = h\nu_0$ $\quad$ $K_{max} = h(\nu - \nu_0)$ $\quad$ $V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi_e}{e}$ $\quad$ $\frac{1}{2} mv^2_{max} = h(\nu - \nu_0)$

➡ **Energy Of Photon** $E = h\nu = \frac{hc}{\lambda}$

➡ **Momentum Of Photon** $P = mc = \frac{h}{\lambda}$ OR $\lambda = \frac{h}{P}$

➡ **Wave Nature Of Particle** $\lambda = \frac{h}{mv}$ $\quad$ $\lambda = \frac{h}{\sqrt{2mK}}$ $\quad$ $\lambda = \frac{h}{\sqrt{2meV}}$ $\quad$ $\lambda = \frac{12.27}{\sqrt{V}}$ Å

$h = 6.63 \times 10^{-34}$ Joule/sec.
$m = 9.31 \times 10^{-31}$ Kg

$e = 1.6 \times 10^{-19}$ c
$1 eV = 1.6 \times 10^{-19}$ Joule

$V_0 = \left[\frac{h}{e}\right]\nu - \left[\frac{h}{e}\right]\nu_0$

➡ **Bragg Equation** $\lambda = 2d \sin\theta$

➡ **Helsenberg's Uncertainty Principle** $\Delta x \cdot \Delta p \approx \hbar$ OR $\Delta x \cdot \Delta p \geq \hbar$

$\left[\hbar = \frac{h}{2\pi}\right]$

UNIT- 18

Atoms and Nuclei

- Electrostatic force of Repulsion b/w alpha particle and positively charged nucleas $F = \frac{1}{4\pi\varepsilon_0}\frac{(2e)(Ze)}{r^2}$

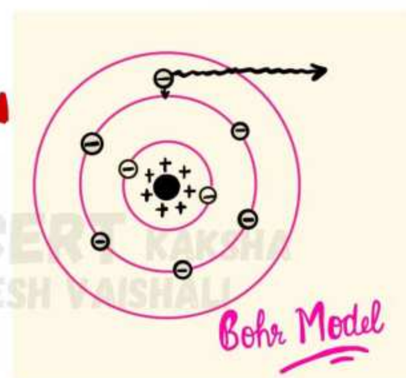
- Relation between orbit radius and electron velocity for hydrogen atom $r = \frac{e^2}{4\pi\varepsilon_0 mv^2}$

- Kinetic Energy for Hydrogen atom $K = \frac{e^2}{8\pi\varepsilon_0 r}$

- Potential Energy for Hydrogen atom $U = \frac{-e^2}{4\pi\varepsilon_0 r}$

- Total Energy $E = K + U$ $E = \frac{-e^2}{8\pi\varepsilon_0 r}$

- Bohr's atomic Model $l = mvr = \frac{nh}{2\pi}$ $h\nu = E_2 - E_1$



- Radius Of Stationary orbit $r = \frac{n^2h^2\varepsilon_0}{\pi m Ze^2}$

- Bohr Radius (n=1, z=1) $r_0 = \frac{h^2\varepsilon_0}{\pi me^2}$

- Velocity Of Electron in Stationary Orbits $v = \left[\frac{Ze^2}{2h\varepsilon_0}\right]\frac{1}{n}$

- Energy Of Electron in stationary orbits $E_n = -\left[\frac{mZ^2e^4}{8\varepsilon_0^2h^2}\right]\frac{1}{n^2} = -Z^2\,\frac{13.6}{n^2}\,eV$

- Ionisation Energy $E_n = \frac{-13.6}{n^2}\,eV$ $E_n = \frac{-Rhc}{n^2}\,eV$

- Wavelength in Emission And Absorption transitions

$\lambda = \frac{12375}{\Delta E}\,Å$ $R = \frac{me^4}{8\varepsilon_0^2h^3c}$

wave number $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ $R = 1.03 \times 10^7 m^{-1}$ = Rydberg Constant
n = quantum number

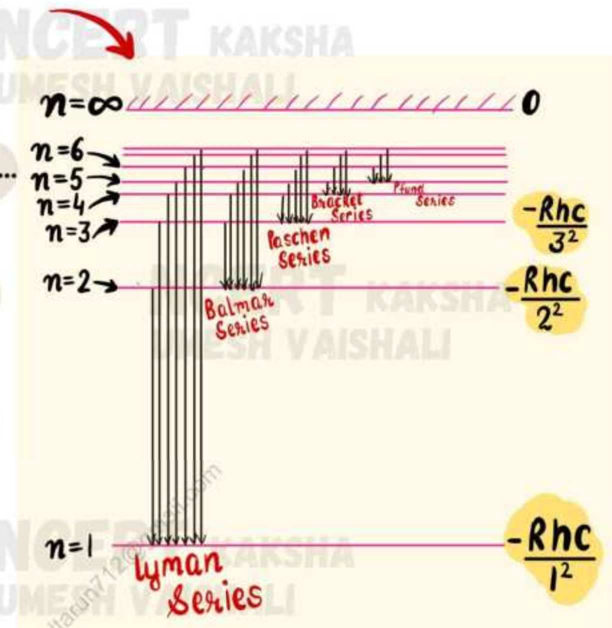
Lyman Series $\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right]$ $n_2 = 2, 3, 4....$

Balman Series $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$ $n_2 = 3, 4, 5..$

Paschen Series $\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$ $n_2 = 4, 5, 6....$

Bracket Series $\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$ $n_2 = 5, 6, 7....$

Pfund Series $\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n_2^2}\right]$ $n_2 = 6, 7, 8....$



➡ Frequency $\nu = RC\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

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

➡ Size Of nucleus $R = R_0 A^{1/3}$ $R_0 = 1.2 \times 10^{-15} m$
u = atomic mass unit

$1 amu = 1.66 \times 10^{-27} kg$ $1u \times c^2 = 931 meV$

➡ Mass Energy $E = mc^2$

➡ Nuclear Binding Energy $\Delta m = [Zm_p + (A-Z)m_n] - M$

➡ Binding Energy $E_b = \Delta Mc^2$ ΔM = mass defect

➡ Binding Energy per Nucleon $E_{bn} = \frac{E_b}{A}$

➡ Theory Of Relativity $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

➡ Rutherford and Soddy law $N = N_0 e^{-\lambda t}$

➡ Mass Energy Relation $\Delta E = \Delta mc^2$

➡ Half Life $T_{1/2} = \frac{\log_e 2}{\lambda} = \frac{0.6931}{\lambda}$

NOTE

1 fermi = 10^{-15} m

➡ **Average life** $\boxed{\tau = \frac{1}{\lambda}}$ $\boxed{T = 0.6931\,\tau}$

➡ **Rate of decay** $\boxed{R = -\frac{dN}{dt}}$ $\boxed{R = R_0 e^{-\lambda t}}$ $\boxed{\frac{\Delta N}{\Delta t} \propto N \Rightarrow \frac{dN}{dt} = -\lambda N}$

N = number of Nuclei
λ = Radioactive decay constant

➡ **α-decay** $\boxed{{}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}He}$

➡ **Destination Energy OR Q value for α-decay** $\boxed{Q = (m_X - m_Y - m_{He})c^2}$

➡ **β^- decay** $\boxed{n \rightarrow p + e^- + \bar{\nu}}$

➡ **β^+ decay** $\boxed{p \rightarrow n + e^+ + \nu}$

➡ **Activity of Radioactive Substance**

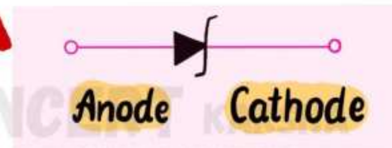
$\boxed{R = R_0 \left(\frac{1}{2}\right)^n}$ $\boxed{N = N_0 \left(\frac{1}{2}\right)^n}$

Electronic Devices

- $\boxed{\sigma = \frac{1}{\rho}}$ — σ = Electrical conductivity, ρ = Resistivity

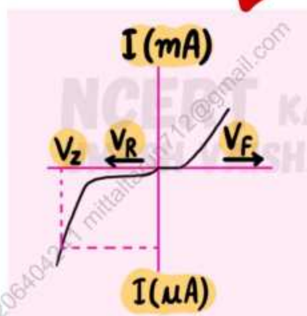
- Energy band gap for
  - Metals $E_g \simeq 0$
  - Semiconductor $E_g < 3ev$
  - Insulator $E_g > 3ev$

- $\boxed{i_E = i_B + i_C}$ — i_E = Emitter Current, i_B = Base Current, i_C = Collector current

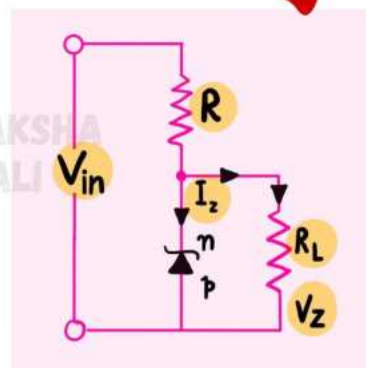


[A]

- Zener Diode $\boxed{R = \frac{V_{in} - V_z}{i_z + i_L}}$ $\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$



[B]



[C]

- Characterstics Of Transistor

Input Resistance $\boxed{R_1 = \left[\frac{\Delta V_{BE}}{\Delta i_B}\right]_{V_{CE}}}$

Output Resistance $\boxed{R_2 = \left[\frac{\Delta V_{CE}}{\Delta i_e}\right]_{i_B}}$

Current Gain In Common Emitter Configuration $\boxed{\beta = \left[\frac{\Delta i_e}{\Delta i_B}\right]_{V_{CE}}}$

- AC Current Gain $\boxed{\beta(ac) = \left[\frac{\Delta i_C}{\Delta i_B}\right]_{V_{CE}}}$

- AC Voltage Gain $\boxed{A_V = \frac{\Delta i_C}{\Delta i_B} \times \frac{R_{out}}{R_{in}}}$ — $\frac{R_{out}}{R_{in}}$ = Resistance Gain

- AC Power Gain = $\boxed{\beta^2 (ac) \times \text{Resistance}}$

- Collector -to- emitter voltage $\boxed{V_{CE} = V_{CC} - i_C R_L}$

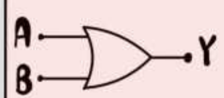
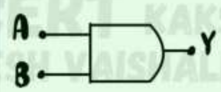
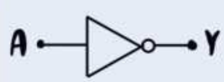
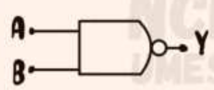
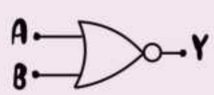
- Current transfer Ratio $\boxed{\alpha = \frac{i_C}{i_E}}$ $\boxed{\alpha = \frac{\beta}{1+\beta}}$

Current Amplifier factor $\boxed{\beta = \frac{i_e}{i_B}}$

$\boxed{n_e n_h = n_i^2}$

n_e = no. of electrons
n_h = no. of holes
n_i = Intrinsic carrier concentration

Table Summary of devices

Gate	Logic Symbol	Logic variables	Truth Table Input (A)	Truth Table Input (B)	Truth Table Output (Y)
OR		$A+B=Y$	0 0 1 1	0 1 0 1	0 1 1 1
AND		$A.B=Y$	0 0 1 1	0 1 0 1	0 0 0 1
NOT		$\bar{A}=Y$	0 1		1 0
NAND		$\overline{A.B}=Y$	0 0 1 1	0 1 0 1	1 1 1 0
NOR		$\overline{A+B}=Y$	0 0 1 1	0 1 0 1	1 0 0 0

- $\boxed{I = I_e + I_h}$ I_e = Current due to electrons, I_h = Current due to holes

- For intrinsic semi conductor $\boxed{n_e = n_h = n_i}$

- For n-type extrinsic semi conductor $\boxed{n_e \gg n_h}$

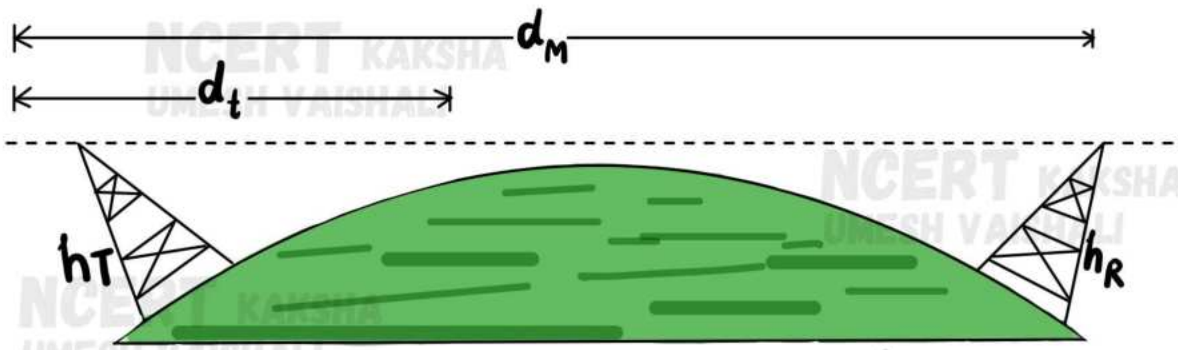
- For p-type extrinsic semi conductor $\boxed{n_e \ll n_h}$

- Dynamic Resistance $\boxed{r_d = \frac{\Delta V}{\Delta I}}$

UNTT- 20

Communication Systems

Transmission from tower of height h



$$\boxed{\text{the distance to the horizon } d_T = \sqrt{2Rh_T}}$$

$$\boxed{d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}}$$

Amplitude Modulation

The modulated signal

$$\boxed{c_m(t) = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos (\omega_c - \omega_m)\, t - \frac{\mu A_c}{2} \cos (\omega_c + \omega_m)}$$

Modulation index

$$\boxed{m_a = \frac{\text{Change in amplitude of carrier wave}}{\text{Amplitude of original carrier wave}} = \frac{KA_m}{A_c}}$$

where K= A factor which determines the maximum change in the amplitude for a given amplitude E_m of the modulating .

If **K= 1** then

$$\boxed{m_a = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} - A_{min}}}$$

If a carrier wave is modulated by several sine waves the total modulated index m_t is given by $\boxed{m_t = \sqrt{m_1^2 + m_2^2 + m_3^2 + \dots}}$

Side band frequencies

$(f_c + f_m)$ = Upper side band (USB) frequency

$(f_c - f_m)$ = lower side band (LSB) frequency

$$\boxed{\text{Band width} = (f_c + f_m) - (f_c - f_m) = 2f_m}$$

$$\boxed{\text{Power in AM waves}: P = \frac{V_{rms}^2}{R}}$$

(i) carrier power $\boxed{P_c = \dfrac{\left(\frac{A_c}{\sqrt{2}}\right)^2}{R} = \dfrac{A_c^2}{2R}}$

(ii) Total power of side bands $\boxed{P_{sb} = \dfrac{\left(\frac{m_a A_c}{2\sqrt{2}}\right)^2}{R} = \dfrac{\frac{m_a A_c}{2\sqrt{2}}}{2R} = \dfrac{m_a^2 A_c^2}{4l}}$

(iii) Total power of AM wave $\boxed{P_{Total} = P_c + P_{ab} = \dfrac{A_c^2}{2R}\left[1 + \dfrac{m_a^2}{2}\right]}$

(iv) $\dfrac{P_t}{P_c} = \left[1 + \dfrac{m_a^2}{2}\right]$ and $\dfrac{P_{sb}}{P_t} = \dfrac{m_a^2/2}{\left[1 + \frac{m_a^2}{2}\right]}$

(v) Maximum Power in the AM (without distortion) will occur when $m_a = 1$ i.e., $P_t = 1.5\ P = 3P_{ab}$

(vi) If I_c = Unmodulated current and I_t = total or modulated current

$$\Rightarrow \frac{P_t}{P_c} = \frac{I_t^2}{I_c^2} \Rightarrow \frac{I_t}{I_c} = \sqrt{\left[1 + \frac{m_a^2}{2}\right]}$$

➡ **Frequency Modulation** :-

- **Frequency deviation** $\boxed{\delta = (f_{max} - f_c) = f_c - f_{min} = K_f \cdot \dfrac{E_m}{2\pi}}$

- Carrier swing $\boxed{CS = 2 \times \Delta f}$
- Frequency modulation index (m_f)

$$\boxed{m_f = \frac{\delta}{f_m} = \frac{f_{max} - f_c}{f_m} = \frac{f_c - f_{min}}{f_m} = \frac{K_f\ E_m}{f_m}}$$

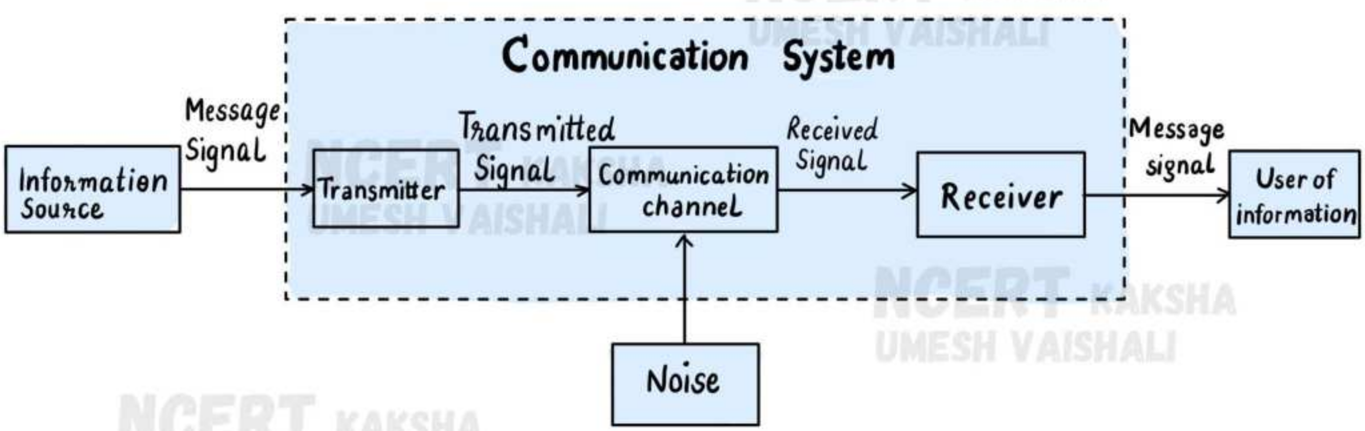
- Frequency spectrum = FM side band modulated signal consist of infinite number of side bands whose frequencies are $(f_c \pm f_m)$, $(f_c \pm 2f_m)$, $(f_c \pm 3f_m)$............

- $$\boxed{\text{Deviation ratio} = \frac{(\Delta f)_{max}}{(f_m)_{max}}}$$

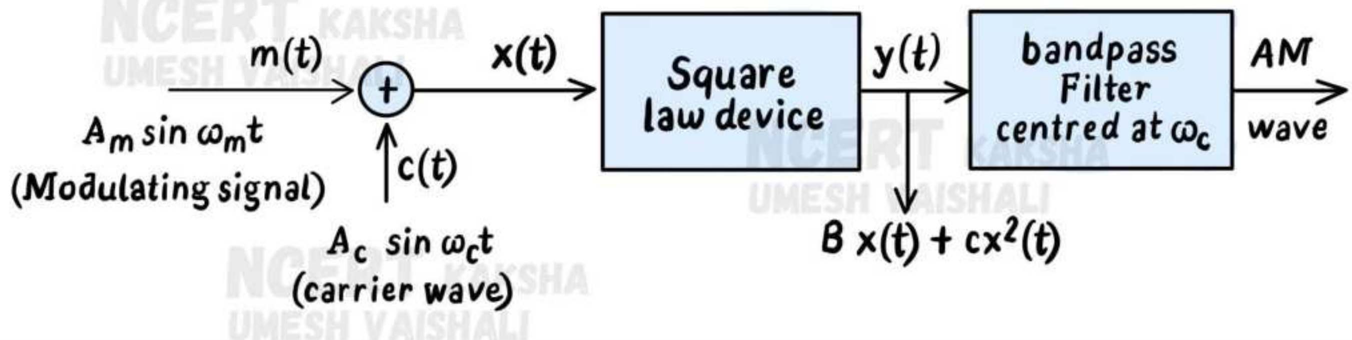
- Percent modulation $\boxed{m = \frac{(\Delta f)_{actual}}{(\Delta f)_{max}}}$

TOP Block Diagrams

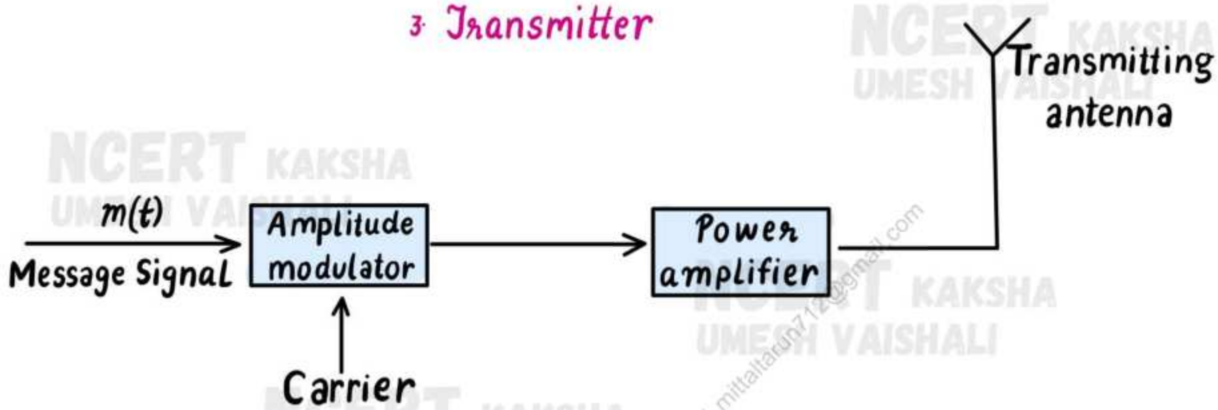
1. Generalized Communication system



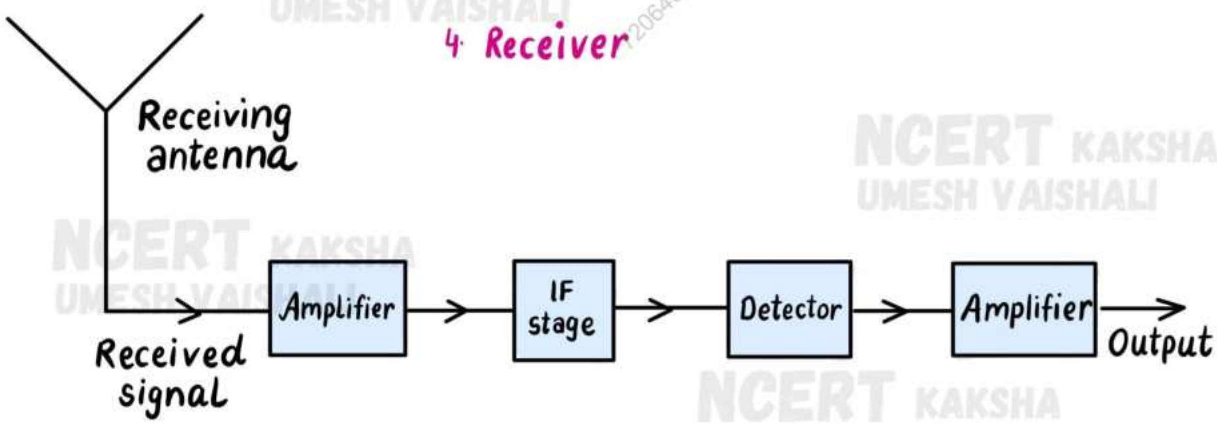
2. Simple Modulator for obtaining AM signal



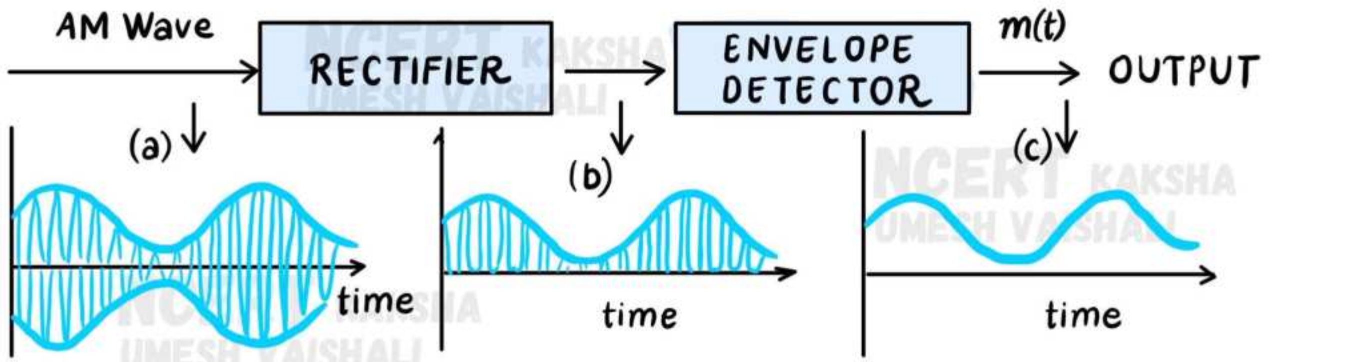
3. Transmitter



4. Receiver



5. Detection of an AM signal



AM input wave Rectified wave Output (without RF component)