Physics [JEE (Mains + Advanced)]

Notes

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typeset with LaTeX

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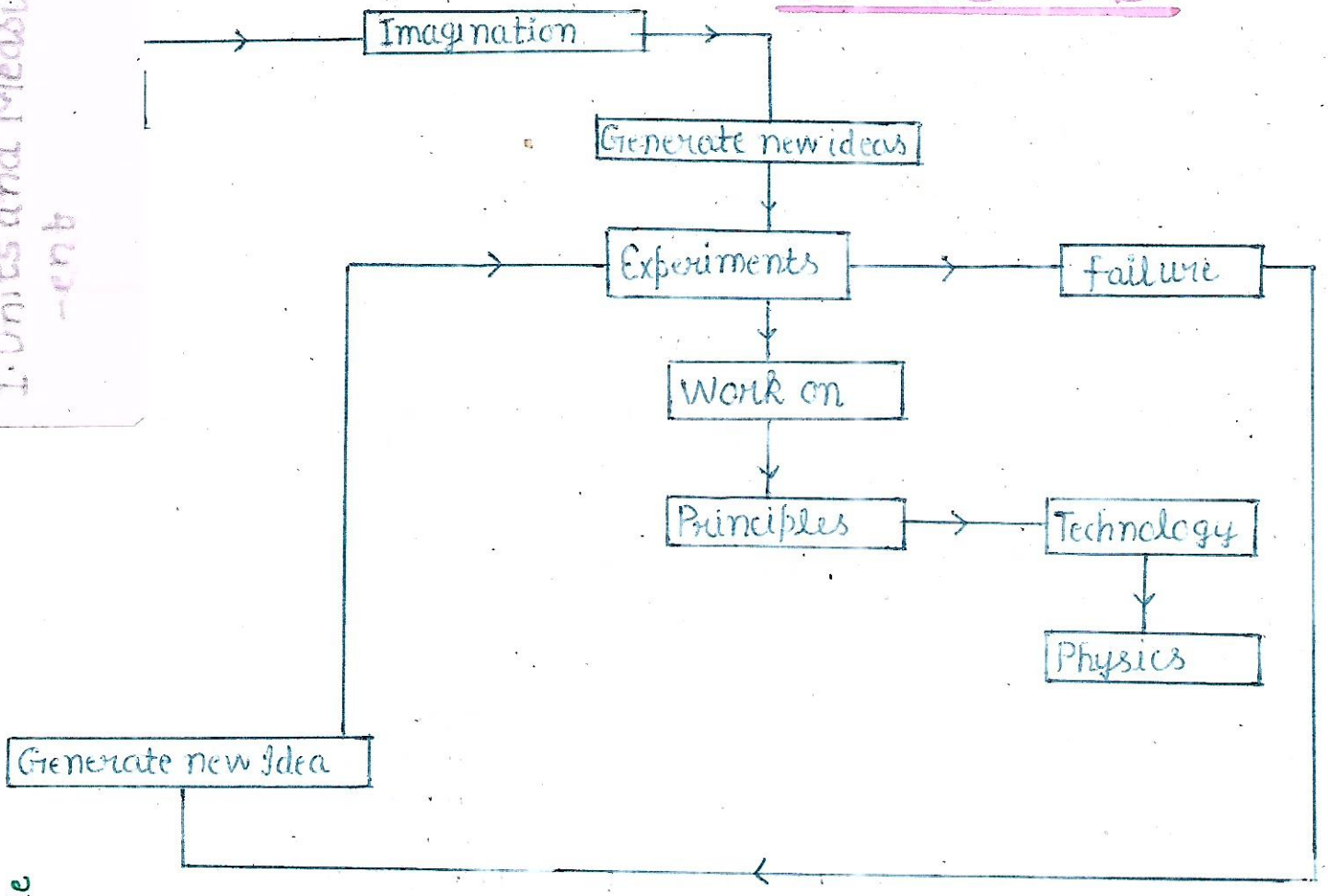
PHYSICS

PHYSICS



Physics is main branch of science which deals with nature and natural Phenomena · OR Physics is objective observation.

Matter
- Electron
- Proton
- Neutron

$E_T = E_K + E_P$

New inovations are always based upon old scientist's theory.

Energy is a scalar quantity.

Fundamental forces in nature
- Gravitation Force
- Weak Forces
- Nuclear Forces
- Electromagnetic Forces

1. Units and Measurement

1. Units-

* Physical Quantities - { Fundamental, Derived }
  - Scalar Quantity
  - Vector Quantity

The quantity that can be measured is known as physical Quantities.

(2)m → Unit

↓ Magnitude of Physical quantity

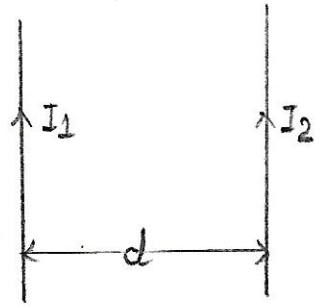
The quantity which are Independent and do not required the help of any other quantity for their defination are called fundamental quantities.

mass - m - Kg
Length - l - m
time - t - sec.
temp. - T - K
Current - i - A
quantity of matter - n - mole
luminous Intensity - cd

The quantity which can derive suitable multiplication or devision of different powers of fundamental quant. are called derived quantity.

We can't Add 2 different quantities.

2Kg + 2m = ???



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

DIMENSION-

- All the Physical quantities represented by derived units can be expressed in terms of some combination of 7 fundamental quantities.

The dimension of a Physical qnantity are the power (or exponents) to which the base quantities are raised to represent that derived quantity.

form of dimensional formula $= [M^a T^b L^c]$

• DIMENSION ANYLSIS AND ITS APPLICATION-

⇒ PRINCIPLE OF HOMOGENEITY OF DIMENSIONS-

It states that, in a correct eq^n, the dimension of each term added or substracted must be same.

$$v = u + at$$
$$S = ut + \frac{1}{2} at^2$$
$$v^2 = u^2 + 2as$$

• TO FIND THE RELATION AMONG PHYSICAL QUANTITIES-

$$F = Km^{x_1} a^{x_2}$$
$$F = K[ML^0T^0]^{x_1}[M^0LT^{-2}]^{x_2}$$
$$F = K[ML^0T^0]^{x_1}[M^0LT^{-2}]^{x_2}$$
$$x_1 = 1, x_2 = 1$$
$$F = Kma$$
$$K = 1 \text{ [dimension less constant]}$$

G_1 = dimensional Constant

$$F = G_1 \frac{m_1 m_2}{r^2}$$
$$[MLT^{-2}] = G_1 \frac{M^2}{L^2}$$
$$G_1 = \frac{[MLT^{-2}][L^2]}{[M^2]} = [M^{-1}L^2T^{-2}]$$

• DIMENSIONS OF SOME QUANTITIES-

1. $[M^0L^0T^{-1}]$ - frequency, Angular frequency, *Angular Velocity, *Velocity gradient *decay constant (λ)

2. $[ML^2T^{-2}]$ - work, Internal energy, Potential energy, Kinetic energy, torque (τ), moment of force

3. $[ML^{-1}T^{-2}]$ - Pressure, stress, Young's Modulas, Modulas of elasticity, *Energy density

4. $[M^1L^1T^{-1}]$ - Momentum, Impulse

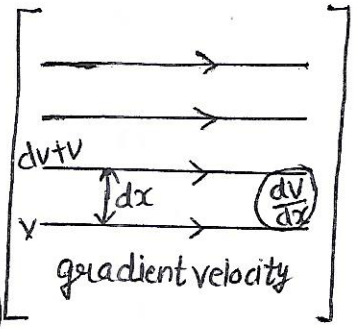
5. $[M^0L^1T^{-2}]$ - Acceleration, gravitational field, Intensity

6. $[M^1L^1T^{-2}]$ - Thurst, Force, Weight, *Energy gradient

7. $[M^1L^2T^{-1}]$ - Angular momentum, *Plank Constant

8. $[M^1L^0T^{-2}]$ - surface tension, surface energy (energy/unit Area)

9. $[M^0L^0T^0]$ - strain, Refractive Index, Relative density Angle, solid Angle, distance gradient, relative Permittivity and Relative Permeability



Pressure- Applied force upon area

Stress- Restoring force upon Area

10. $[M^0L^2T^{-2}]$ - Latent Heat, Gravitational Potential

11. $[ML^2T^{-2}\theta^{-1}]$ - Thermal Capacity, Gas constant (R), Valtzman constant, Entropy

$$K = \frac{R}{N_A}$$

12. $[M^0L^0T]$ - $\sqrt{\frac{l}{g}}$, *$\sqrt{\frac{m}{K}}$, $\sqrt{\frac{R}{g}}$ - Radius of earth, Acceleration due to gravity

- L/R, $\sqrt{LC}$, RC

13. $[ML^2T^1]$ - I^2Rt, $\frac{V^2}{R}t$, VIt, qV, LI^2, $\frac{q^2}{C}$, CV^2

$T = 2\pi\sqrt{\frac{m}{K}}$ - Inertial factor, K - spring factor

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

Question- If A/μ_0 has the dimension $[MLT^{-4}]$, What is A

A. square of electric flux
B. square of magnetic flux
✓ C. square of electric field
D. square of energy

$$\frac{A}{\mu_0} = [MLT^{-4}]$$

$$c^2 = \frac{1}{\mu_0 \epsilon_0}$$

$$A[c^2\epsilon_0] = [MLT^{-4}]$$

$$A[L^2T^{-2}] = [MLT^{-4}]$$

$$A = [ML^{-1}T^{-2}]$$

Question- In a direct impact, the loss of Kinetic Energy is given by

$$\Delta K = \frac{M_1 M_2}{2(M_1+M_2)} (V_1-V_2)^2 (1-K^2)$$

With usual notations (expect K). The quantity K will have dimensiona formula.

It is dimensionless.

Question- If velocity(V), force(F), time(T) are taken to be fundamental quantities and K is dimensional less constant of perportionality, find the dimension formula of mass.

* MEASUREMENT-

⊙ Accuracy- The closeness of measured value to the true value is known as accuracy of measurement.

Q÷ In the Relation $P = \frac{\alpha}{\beta} e^{-\frac{\alpha z}{k\theta}}$, P is Pressure, z is distance, K is the Boltzman constant and θ is temp. Find the dimension of θ.

$$P = \frac{\alpha}{\beta} \quad \text{——②} \qquad \frac{\alpha z}{k\theta} = [M^0 L^0 T^0] \quad \text{——①}$$

$$\frac{\alpha [L]}{[K][ML^2T^{-2}K^{-1}]} = [M^0 L^0 T^0]$$

$$\frac{\alpha [L]}{[ML^2T^{-2}]} = [M^0 L^0 T^0]$$

$$\alpha = [MLT^{-2}]$$

$$P = \frac{[MLT^{-2}]}{\beta} \qquad P = [ML^{-1}T^{-2}]$$

$$\beta = [L^2]$$

Q÷ To estimate g (from $g = 4\pi^2 \frac{L}{T^2}$) error in measurement of L is ±2% and error in measurement of T is 3%. Find the Percentage error?

$$g = 4\pi^2 \frac{L}{T^2} = \frac{L}{T \times T}$$

$$\frac{\Delta g}{g} \times 100 = \pm \left(\frac{\Delta L}{L} + \frac{\Delta T}{T} + \frac{\Delta T}{T} \right) \times 100$$

$$\frac{\Delta g}{g} \times 100 = \pm \left(\frac{\Delta L}{L} + \frac{2\Delta T}{T} \right) \times 100$$

$$= 2\% + 2(3\%)$$

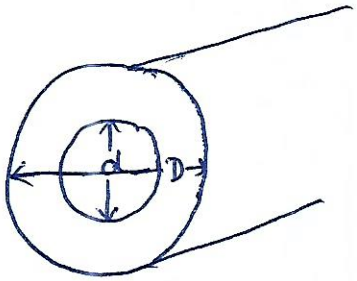
$$= 2\% + 6\%$$

$$= 8\%$$

Q÷ The external and Internal diameter of a hollow cylinder are measured to be (4.23 ± 0.01) cm and (3.89 ± 0.01) cm. The thickness of wall will be ÷

$$\Delta V = (4.23 - 3.89) \pm (0.01 + 0.01)$$

$$\Delta V = 0.34 \pm 0.02$$



$$\text{Thickness of a cylinder} = \frac{0.34 \pm 0.02}{2}$$

$$= (0.17 \pm 0.01)\text{ cm}$$

Q÷ A wire of length $l = 6 \pm 0.06$ cm and radius $= 0.5 \pm 0.005$ cm and mass $m = 0.3 \pm 0.003$ g. Find the max. Percentage error in density

$$\rho = \frac{m}{V} = \frac{m}{l \cdot A} = \frac{m}{l \cdot \pi r^2} = \frac{m}{l \cdot r^2}$$

$$\pm \left(\frac{\Delta l}{l} + 2\frac{\Delta r}{r} + \frac{\Delta m}{m} \right) = \frac{\Delta \rho}{\rho}$$

$$\pm \left(\frac{0.003}{0.3} + \frac{0.06}{6} + 2\left(\frac{0.005}{0.5} \right) \right) = \frac{\Delta \rho}{\rho}$$

$$\frac{\Delta \rho}{\rho} = 4\%$$

* Significant Figure –

(i) All non-zero digits are significants.

No. of significant figure

1) 42.3 – 3
2) 243.4 – 4
3) 24.123 – 5

(ii) A zero b/t two non-zero digit is significant.

1) 5.03 – 3
2) 5.604 – 4
3) 4.004 – 4

4) 23.41 – 4
5) 23.400 – 5
6) 23.420 – 5
7) 2.3 cm – 2
8) 0.023 m – 2
9) 2.3×10^{-2} – 2

- Think like a mechanical Instrument.
- 10^{-n} is non measurable in significant no.

(iii) Leading zeros or zero placed on left of the number are never significant.

e.g. 1) 0.543 – 3
2) 0.045 – 2
3) 0.006 – 1

(iv) In exponential notation, the numerical Portion gives the no of significant figure.

e.g. 1) 1.32×10^{-2} – 3
2) 1.32×10^{4} – 3

$$\begin{array}{r} 2.30 \\ \times\ 1.3 \\ \hline 2.9\ 9\ 0 \end{array}$$

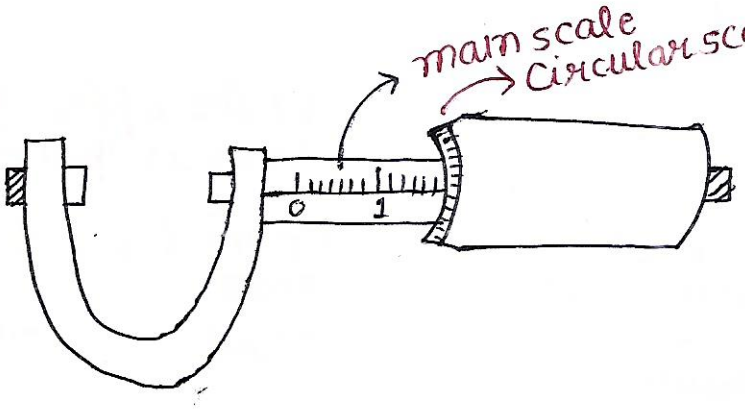
2.99 is significant figure

$$\begin{array}{r} 10.230 \\ +\ 15.23 \\ \hline 25.46 \end{array}$$

$$\begin{array}{r} 10.230 \\ +15.200 \\ \hline 25.430 \end{array}$$

$$\begin{array}{r} 10.230 \\ 10.23 \\ +10.2 \\ \hline 30.7 \end{array}$$

SCREW GUAGE (Micrometer)



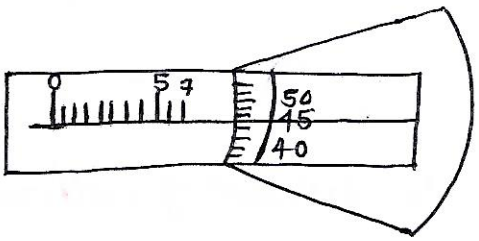
- One rotation = 1mm (Pitch)
- 1mm = 100 division of circular scale

$$\text{Least count} = \frac{1}{100} = 0.01\ \text{mm}$$

M.S.R (main scale Read)
= 5.3 mm
CSR = 45 (0.01)

$$\text{Reading} = \underset{\text{MSR}}{5.3\ \text{mm}} + \underset{\text{CSR}}{45(0.01)} = 5.75$$

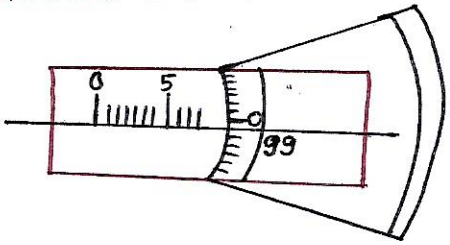
eg.

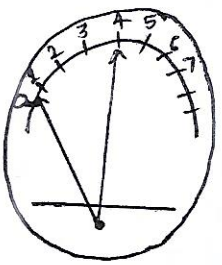


Redding = M.S.R + C.S.R
= 7 + 45 (0.01)
= 7.45 mm

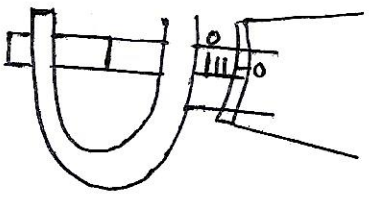
- Zero error -

⇒ Positive zero error -

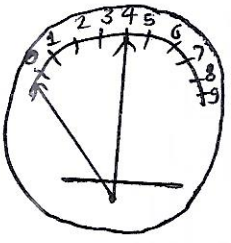




Reading = 4 Amp.
⇒ 4 − 0.5 = 3.5 Amp.



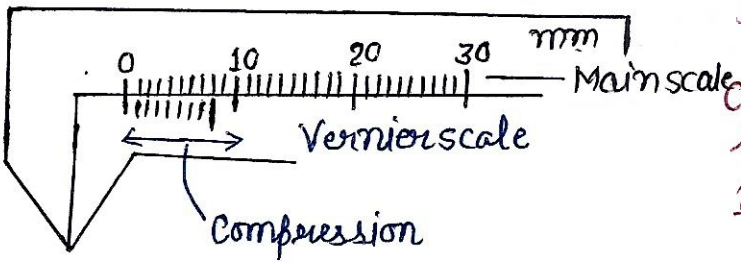
Reading = 0 + 0 = 0
= 0 + 1 (0.01)
= 0.01 mm



Radding = 4 Amp.
⇒ 4 + 0.5 = 4.5 Amp.

VERNIER CALLIPERS

It is used to measure accurate value upto 0·1 mm



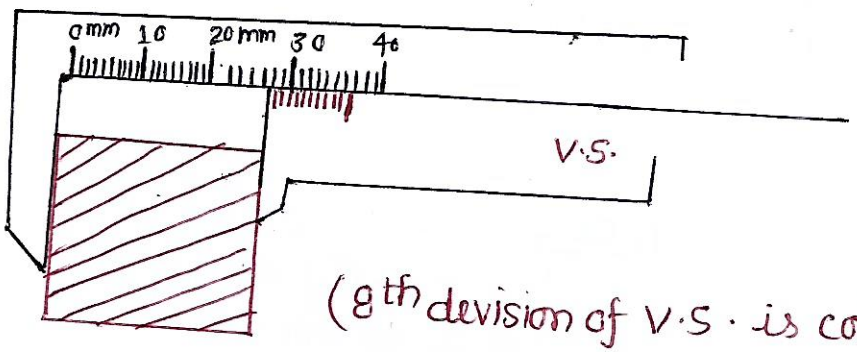
On the upper part (mm) scale is printed

On the lower part compressed scale

1 Part = 0·9 mm

$$\text{Least Count} = \frac{9}{10} = 0.9 \text{ mm}$$

$$\Rightarrow 1 \text{ mm} - 0.9 \text{ mm} = 0.1 \text{ mm}$$



M.S.R = 24 mm

V.S.R = 2(0·1)

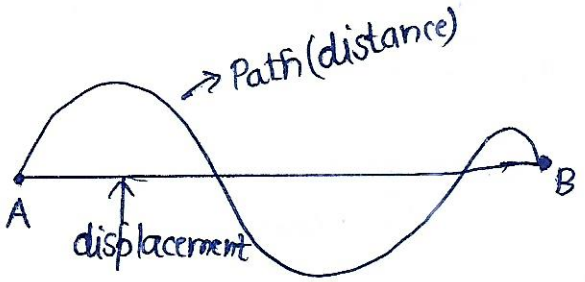
(8th devision of V.S. is consiging with main scale)

2. KINEMATICS

2. Kinematics

tion in 1-D-

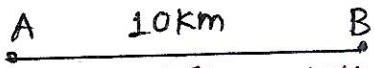
istance and displacement-



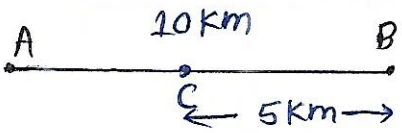
distance - scalar quantity
displacement - Vector quantity

Distance $\geq$ |displacement|

In straight line motion distance = |displacement|, when the object is not changing its direction of its motion.



Dist = Displace = 10Km



distance = 10+5 = 15 Km
displacement = 10-5 = 5Km

⇒ Speed and velocity-

Speed $\geq$ |velocity|

$\frac{\text{distance}}{t} \geq \left|\frac{\text{displacement}}{t}\right|$

$\frac{\text{distance}}{t} = \left|\frac{\text{displacement}}{t}\right|$ if the object moving into straight path

distance = |displacement|

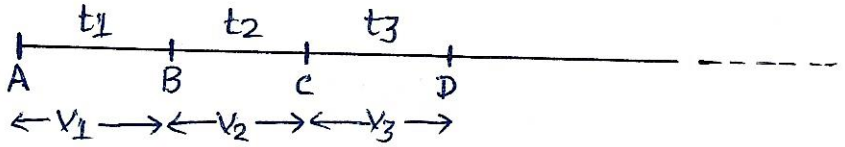
⇒ Avarage velocity-

$$\langle v \rangle = \frac{\text{Total disp.}}{\text{Total t}} = \frac{\Delta x}{\Delta t}$$

$$\text{Instantanious velocity} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

⇒ Time avarage speed -

When the particles moves with different velocity v_1, v_2, v_3 at different times t_1, t_2, t_3.



$$\langle V \rangle = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{v_1 t_1 + v_2 t_2 + \ldots + v_n t_n}{t_1 + t_2 \ldots + t_n}$$

⇒ distance Avarage speed -

When a particle describe d_1, d_2, d_3 with speeds v_1, v_2, v_3 and so on respectively.



$$t_1 = \frac{d_1}{v_1}$$

$$t_n = \frac{d_n}{v_n}$$

$$\langle V \rangle = \frac{d_1 + d_2 + d_3 + \ldots + d_n}{\frac{d_1}{v_1} + \frac{d_2}{v_2} + \ldots + \frac{d_n}{v_n}}$$

Ex-1- equal distance with equal speeds

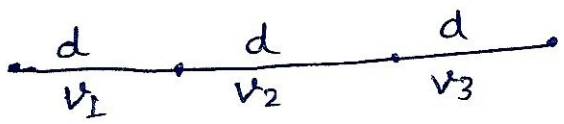
$$\langle V \rangle = \frac{v_1 + v_2 + \ldots v_n}{n}$$

⇒ When a particle move with speed upto the half time of its half time. It is moving with v_2. What is avarage speed?

$$\langle V \rangle = \frac{v_1 + v_2}{t}$$

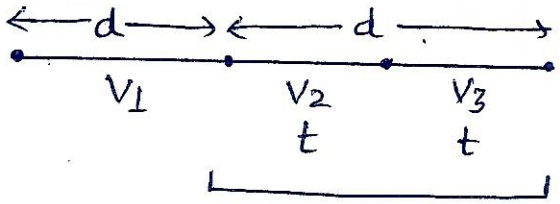
$$\left[\langle V \rangle = \frac{\frac{1}{v_1} + \frac{1}{v_2}}{2} \text{ for second case} \right]$$

Ex-2-



$$\frac{1}{V_{avg}} = \frac{\frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}}{3}$$

Ex-3-



$$V'_{avg} = \frac{v_2 + v_3}{2}$$

$$1/\langle V \rangle = \frac{\frac{1}{V'_{avg}} + \frac{1}{V_1}}{2}$$

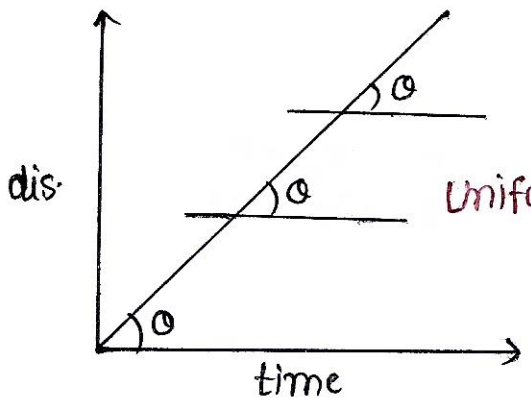
Graph

Slope devision | Area Multiplicatio

$m = \frac{\Delta y}{\Delta x} = \frac{\text{Physical quant on Y}}{\text{Phy. quant on X axis}}$

= derived Physical quant.

⇒ Position-time Graph-



Uniform Motion

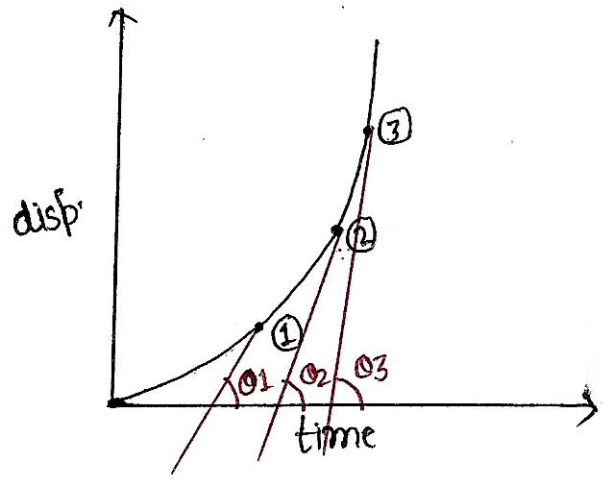
θ → Constant

m → Constant

$m = \frac{\Delta y}{\Delta x} = \frac{\text{disp.}}{\text{time}}$

m = velocity = Const.

⇒ Uniform Motion

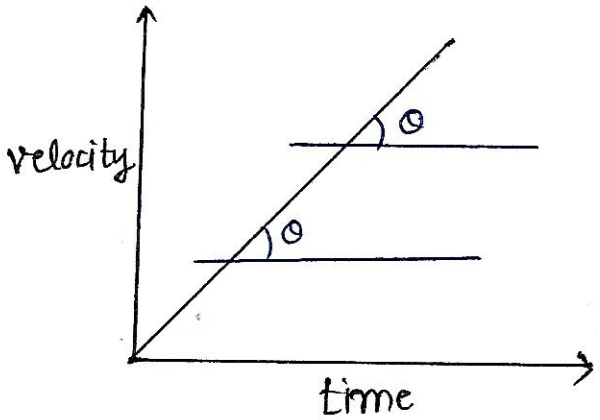


$\theta_3 > \theta_2 > \theta_1$

$v_3 > v_2 > v_1$

Non-uniform Motion with increasing speed.

⇒ Velocity-time Graph -

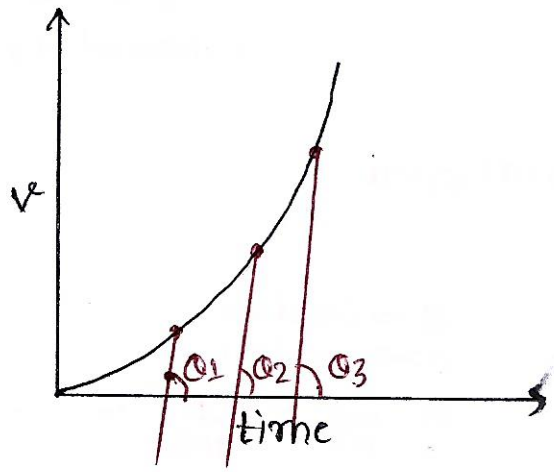


slope θ = Constant

$m = \frac{\Delta y}{\Delta x} = \frac{\Delta V}{\Delta t}$ = acceleration

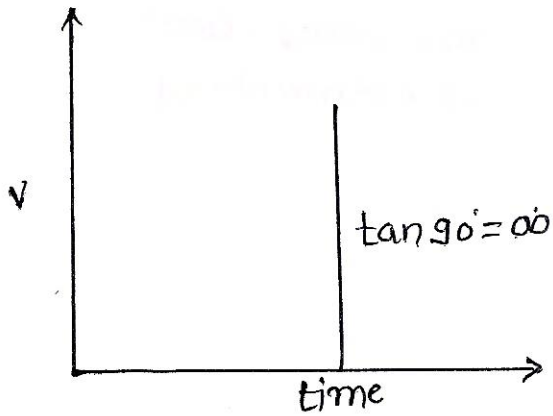
$m = a$ = constant

Uniform Accelerated Motion



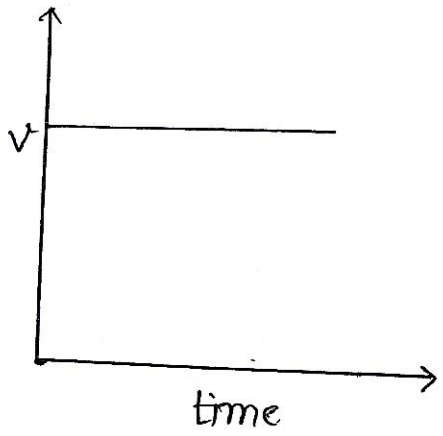
$\theta_3 > \theta_2 > \theta_1$

$a_3 > a_2 > a_1$

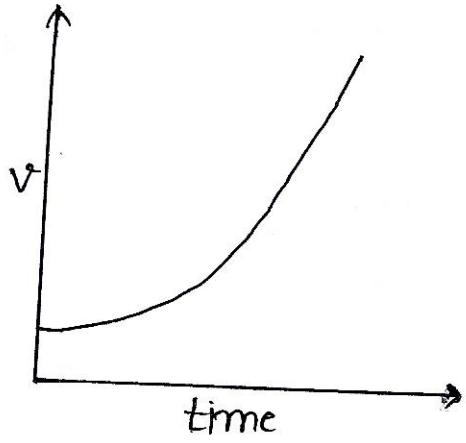


Not possible

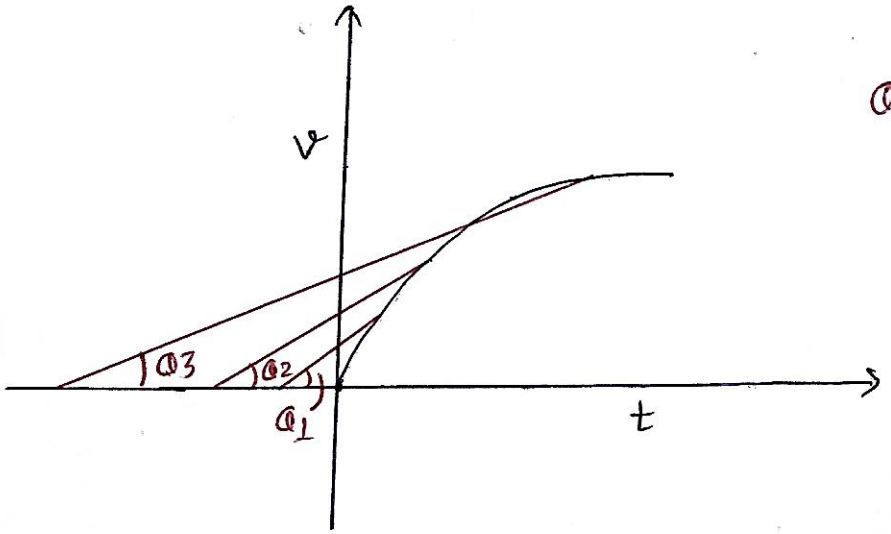
Infinite Acceleration



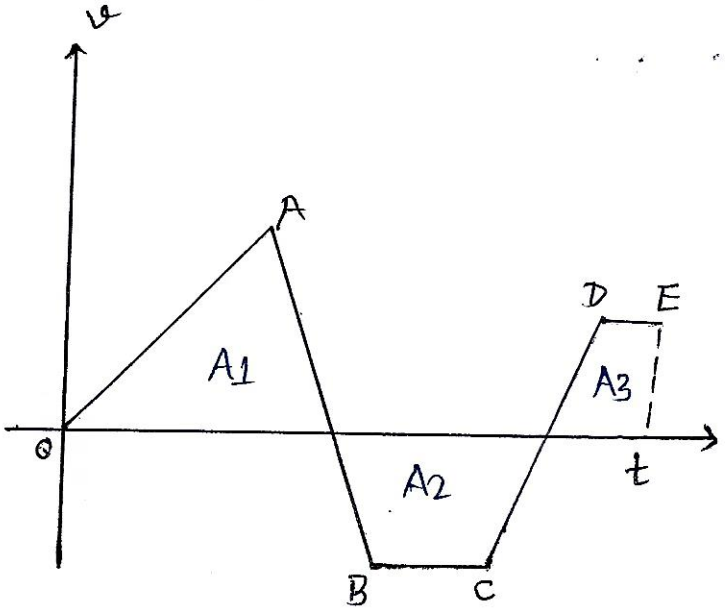
$a = 0$, slope $= 0$
Uniform Motion



$a \neq 0$
increasing Acceleration



$\theta_3 < \theta_2 < \theta_1$

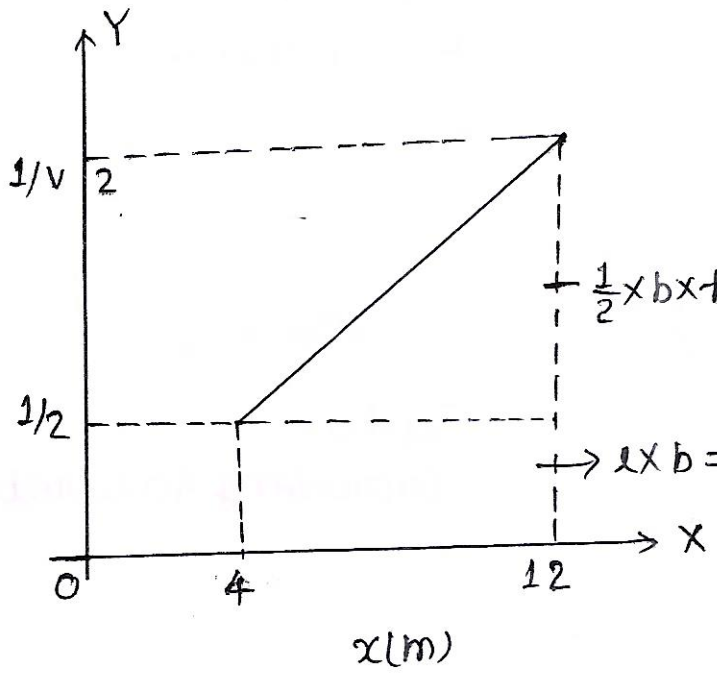


OA = Uniform Acceleration
AB = Uniform Retarted
BC = Uniform motion
CD = Uniform Accelerated
DE = Uniform motion

distance = $|A_1| + |A_2| + |A_3|$

displacement = $|A_1| + |A_3| - |A_2|$

Question-



Find the time taken By the Particle to move from $x=4$ to $x=12$ m

$\frac{1}{2} \times b \times h = \frac{1}{2} \times 8 \times \frac{3}{2} = \frac{24}{4} = 6$

$l \times b = \frac{8}{2} = 4$

$t = 6 + 4$

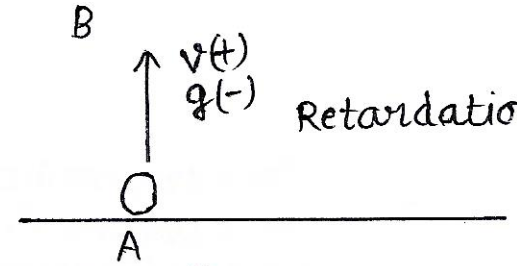
$t = 10$

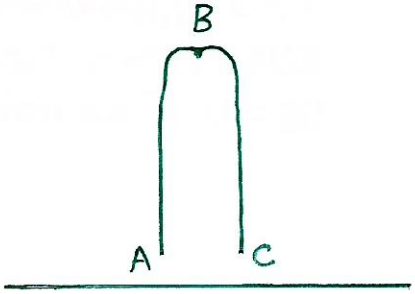
⊙ Motion under gravity -

Sign convention-

[Acceleration →
v(+), [a(+)]
v(-), a(-)]

[Retardation
v(+) a(-ve)
v(-) a(+ve)]

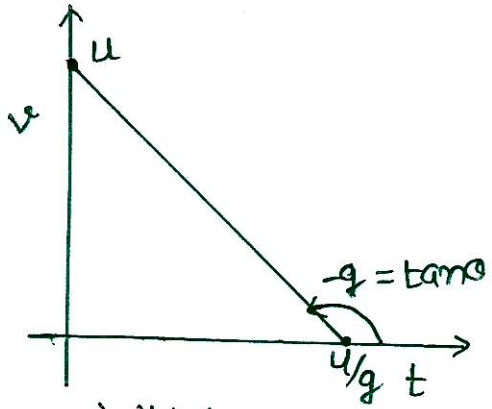




A to B → Retardation

B to C → Acceleration

Velocity time graph-



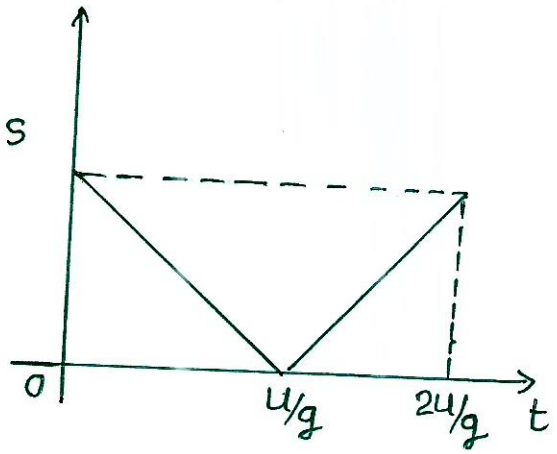
initial $v = u$

$a = -g$

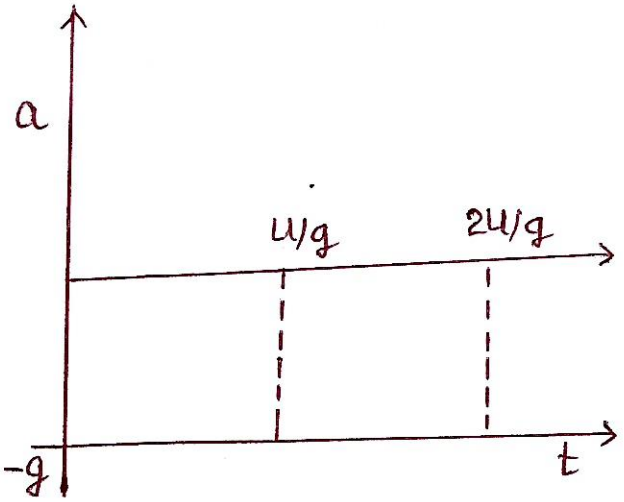
$v = u + at$

$v = +u - gt$

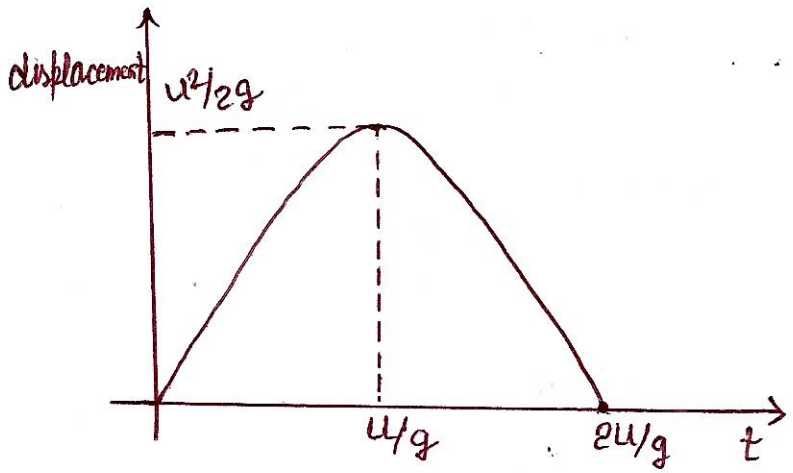
speed time graph-



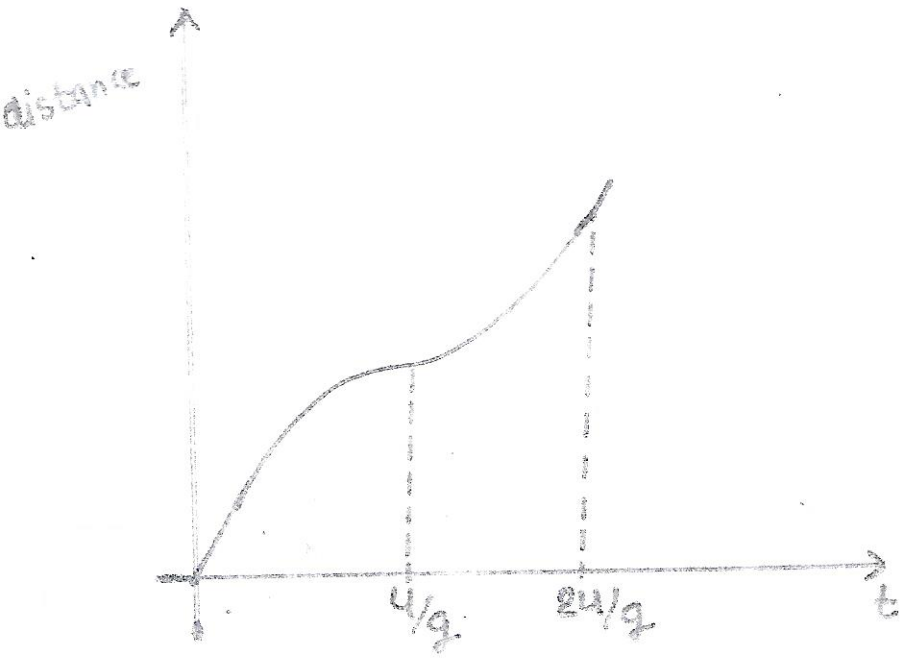
Acceleration time graph-



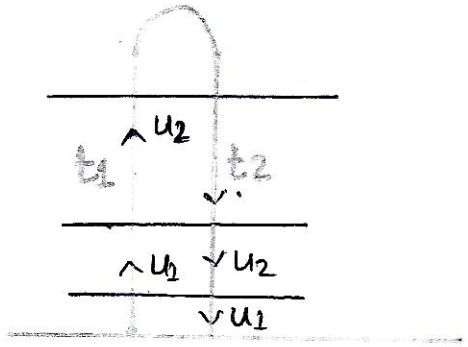
displacement-Time graph-



distance-time graph-

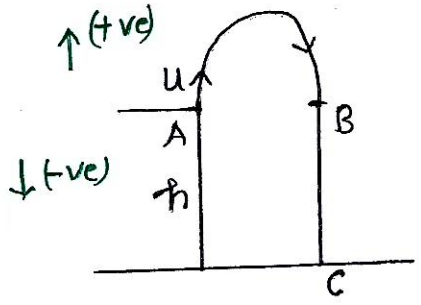


⊙



$t_1 = t_2$ (Air resistance neglected)
$t_1 < t_2$ (Air resistance consideration)

A body is Projected upward from certain height h with initial speed 'u'.



METHOD-I

A to B - $T_{AB} = \frac{2u}{g}$

B to C - initial speed = -u
$a = -g$
$s = -h$



$$s = ut + \frac{1}{2}at^2$$

$$-h = -ut - \frac{1}{2}gt^2$$

$$h = ut + \frac{1}{2}gt^2$$

Method [II] -

Let T_1 be the time for motion A to B ⟶ B to C

Initial speed = $+u$

$a = -g$

$-h = s$

$s = ut + \frac{1}{2}at^2$

$-h = ut - \frac{1}{2}gt^2$

$-2h = 2ut - gt^2$

$gt^2 = 2ut - 2h$

$gt^2 - 2ut - 2h = 0$

$t_1 = \frac{2u + \sqrt{4u^2 + 8gh}}{2g}$

* Relative motion in 1-D - Mathematically it is vector substraction.

Case 1.



Relative velocity of A with respect to B

$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$ (Vector substraction)

$= 10 - (+5)$

$= 5\ ms^{-1}$

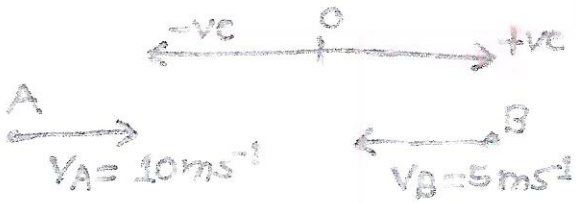
Relative velocity of B w.r.to A

$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

$= (+5) - (+10)$

$= -5$ m/s

Case 2.

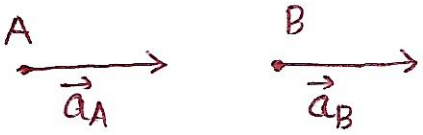


$$V_{relative} = \frac{S_{relative}}{t}$$

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$
$$= (+10) - (-5)$$
$$= +15\ ms^{-1}$$

$$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$$
$$= (-5) - (+10)$$
$$= -15\ ms^{-1}$$

* Relative Acceleration –

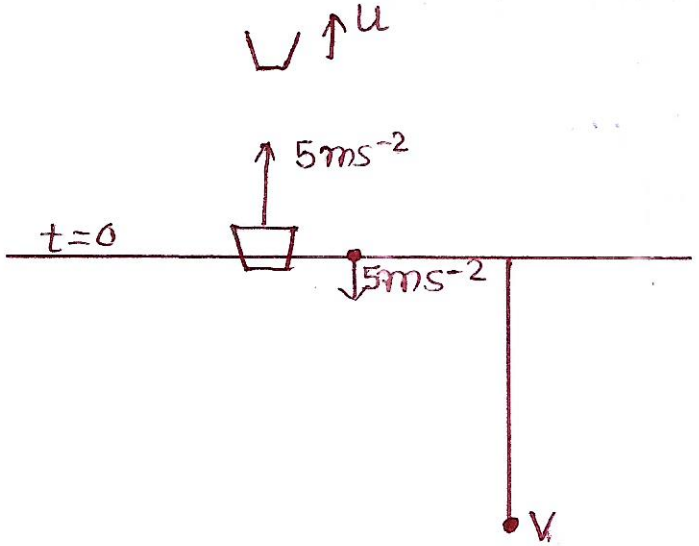


$$\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$$
$$\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$$

© Uniformly Accelerated Motion –

$$v = u + at \qquad v_{rel} = u_{rel} + a_{rel}t$$
$$s = ut + \frac{1}{2}at^2 \qquad s_{rel} = u_{rel}t + \frac{1}{2}a_{rel}t^2$$
$$v^2 = u^2 + 2as \qquad v_{rel}^2 = u_{rel}^2 + 2a_{rel}s_{rel}$$

Problem– A man in a balloon throws a stone downward with u speed of $5ms^{-1}$ with respect to balloon. The balloon is moving upward with acceleration $5ms^{-2}$. Find the velocity of the stone relative to man after 2 Sec?



$= u_{rel} + a_{rel} \cdot t$

$= 5 + 15 \times 2$

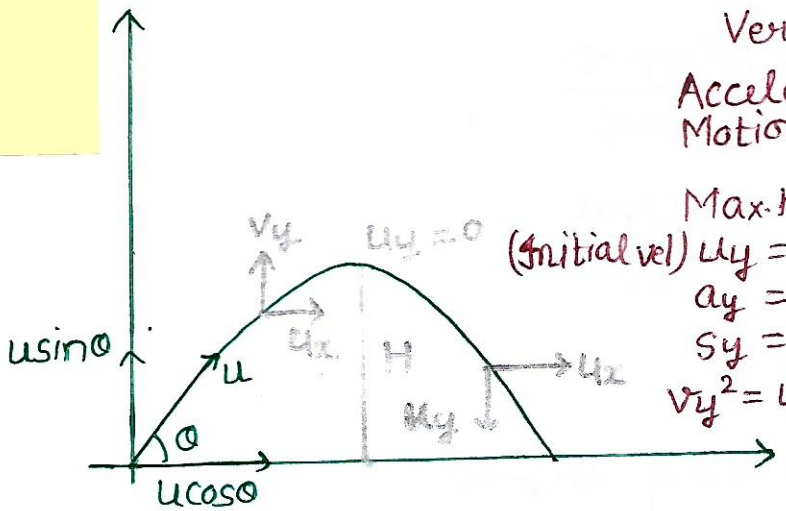
$= 35\ ms^{-1}$

$D = S \times t$

$D_{rel} = S_{rel} \times t$

Projectile Motion

ECTILE MOTION – 2 dimensional Motion –



$u_y = u\sin\theta$

$u_x = u\cos\theta$

Vertically Accelerated Motion

Max. H

(Initial vel) $u_y = u\sin\theta$

$a_y = -g$

$s_y = +H$

$v_y^2 = u_y^2 + 2a_y s_y$

$H_{max} = \frac{u^2}{2g}$

$H_{max} = \frac{u_y^2}{2g}$

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

Horizontally Uniform Motion

Time of flight

$= \frac{2u_y}{g}$

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

Range $\Rightarrow$ R

$R = u_x \times$ time of flight

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

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

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

Maximum Range –

$\theta = 45^\circ$

$\sin 2\theta = 1\ (max)$

$R_{max} = \frac{u^2}{g}$

- Change in momentum

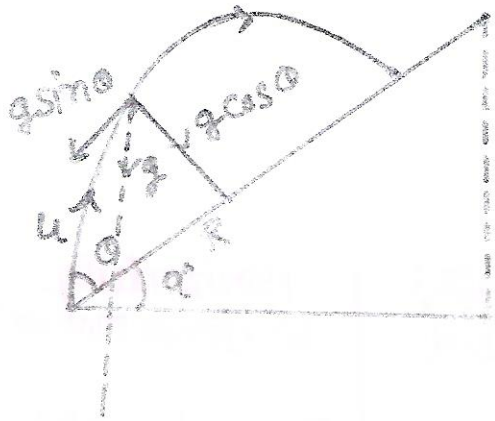
$P_i = P_x\hat{i} + P_y\hat{j} = mu_x\hat{i} + mu_y\hat{j}$

$P_f = P_x\hat{i} + P_y\hat{j} = mu_x\hat{i} - mu_y\hat{j}$

$\Delta P = P_f - P_i$

$= 2mu_y\hat{j}$

Projectile Motion over an Inclined Plane-



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

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

$R = ?$

Horizontal Motion (Calculation of Range R)

$$a = -g\sin\alpha$$

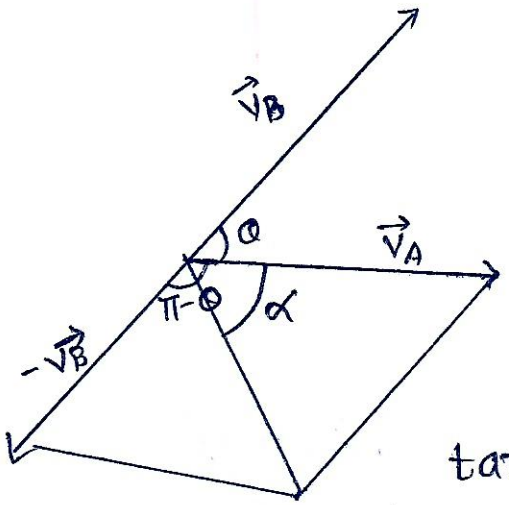
$$u = u\cos\theta$$

$$S_x = u_x t + \frac{1}{2} a_x t \quad \text{(flight)}$$

$$R = u\cos\theta \frac{2u\sin\theta}{g\cos\alpha} - \frac{1}{2} \cdot \frac{g\sin\alpha\, 4u^2\sin^2\theta}{g^2\cos^2\alpha}$$

↑ It will be (+ve) when it moves down to incline

* Relative Motion in 2D-



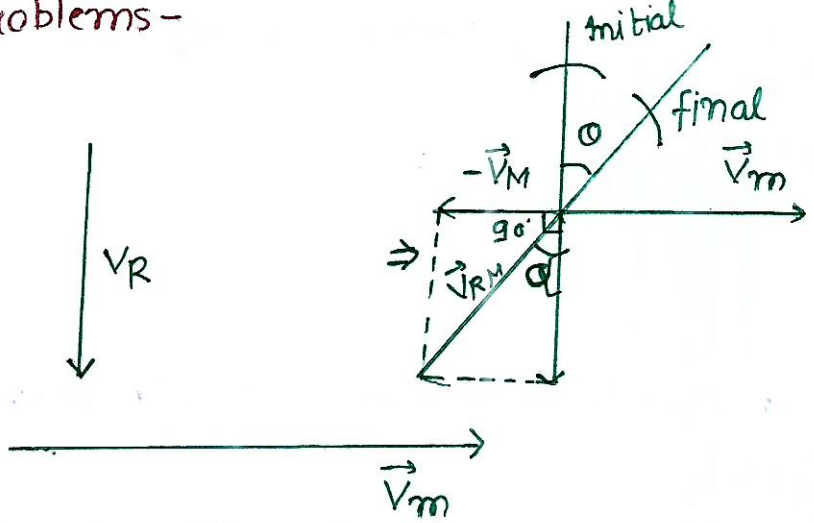
$$\vec{V}_{AB} = \vec{V}_A - (\vec{V}_B)$$
$$= \vec{V}_A + (-\vec{V}_B)$$

$$\vec{V}_{AB} = \sqrt{\vec{V}_A^2 + V_B^2 + 2V_A V_B \cos(\pi-\theta)}$$

$$V_{AB} = \sqrt{V_A^2 + V_B^2 + 2V_A V_B \cos\theta}$$

$$\tan\alpha = \frac{V_B \sin(\pi-\theta)}{V_A + V_B\cos(\pi-\theta)}$$

⊙ Boat, Rain etc. Problems -



Velocity of rain with respect to man

$$\vec{V}_{RM} = \vec{V}_R - \vec{V}_M$$

$$= \vec{V}_R + (-\vec{V}_M)$$

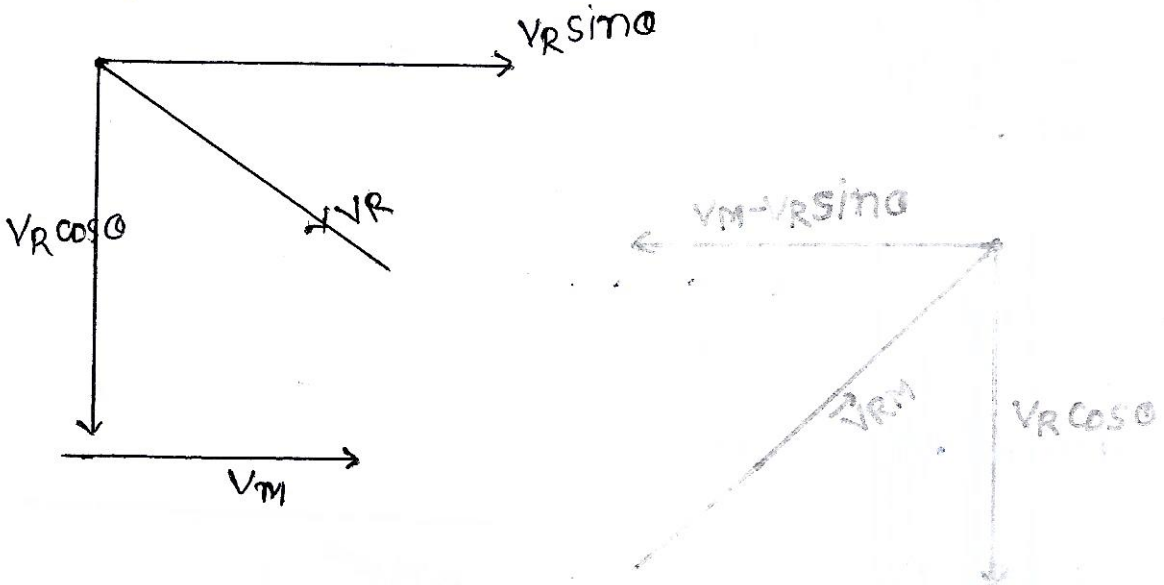
$$|\vec{V}_{RM}| = \sqrt{V_R^2 + V_M^2 - 2V_M V_R \cos 90^\circ}$$

$$|\vec{V}_{RM}| = \sqrt{V_R^2 + V_M^2}$$

Angle to which the umbrella is titted

$$\tan\alpha = \left|\frac{V_M}{V_R}\right|$$

Rain is falling at some Angle θ from vertically.



$$\vec{V}_{RM} = [(V_M - V_R \sin\theta)\hat{i} + V_R \cos\theta \hat{j}]$$

$$|\vec{V}_{RM}| = \sqrt{(V_M - V_R \sin\theta)^2 + (V_R \cos\theta)^2}$$

What will the velocity of man ⇒ vartically relative velocity of Rain.

$$V_M = V_R \sin\theta$$

$$\tan\alpha = \left(\frac{V_M - V_R\sin\theta}{V_R\cos\theta}\right)$$

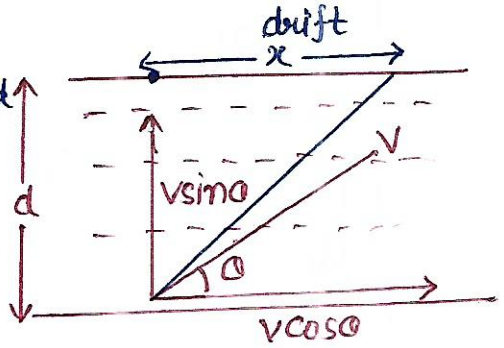
River, Rain and Boat Problems –

Case I – Boat travels at some angle θ with down stream.

$$\vec{V}_R = u\hat{i}$$

$$\vec{V}_{BW} = V$$

$$\vec{V}_{BW} = V\cos\theta\hat{i} + V\sin\theta\hat{j}$$



Horigontal componant of velocity w.r.to ground

$$V_H = V\cos\theta + V_R$$

$$V_H = V\cos\theta + u$$

Vertically componant of velocity of boat with respect to ground

$$V_V = V\sin\theta$$

$$\text{drift} = \frac{d}{V\sin\theta} \times (u + V\cos\theta)$$

For minimum time

$$t = \frac{d}{V\sin\theta}$$

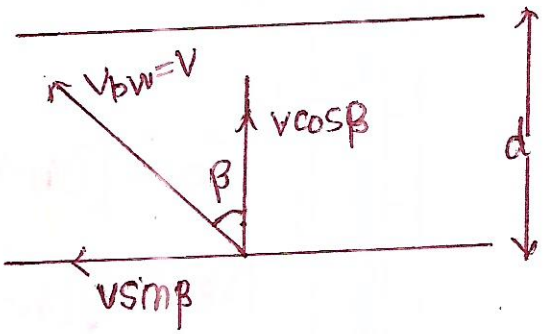
$$\sin\theta(\max^m) = 1$$

$$\theta = 90^\circ$$

$$t = \frac{d}{V}$$

$$\text{drift} = \frac{d}{V} V_R$$

Case II – When the drift is zero.



$$x(\text{drift}) = t(V_R - V\sin\beta)$$

$$V_R - V\sin\beta = 0$$

• CIRCULAR MOTION-

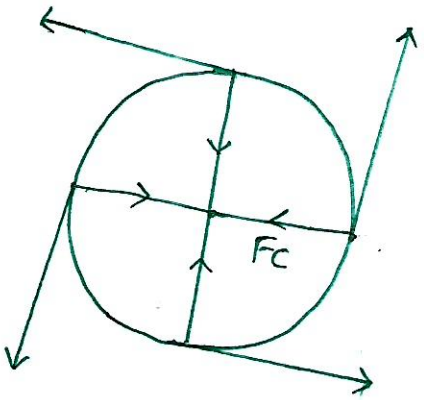
Circular Motion (Horizontal)

- Uniform Circular Motion
- Non-uniform Circular Motion

• Uniform Circular Motion is

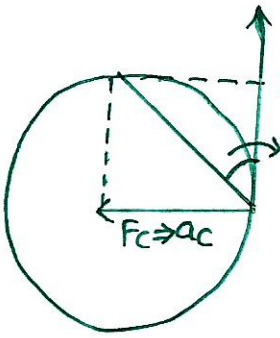
A. Uniform Motion
B. Uniform Acc. Motion
✓C. Non-Uniform Acc. Motion
D. None

because $|\vec{v}|$ = constant



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

$$|\vec{a}_c| = \frac{v^2}{r}$$

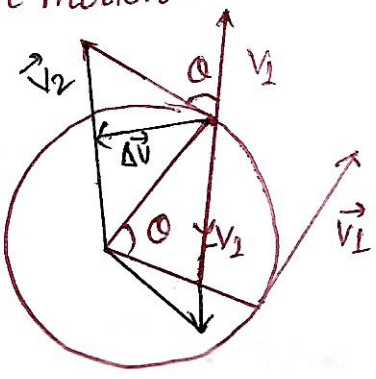


$$a_c = \frac{v^2}{r} \qquad a_R = \sqrt{a_c^2 + a_t^2}$$

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

$$\tan\alpha = \frac{a_c}{a_t}$$

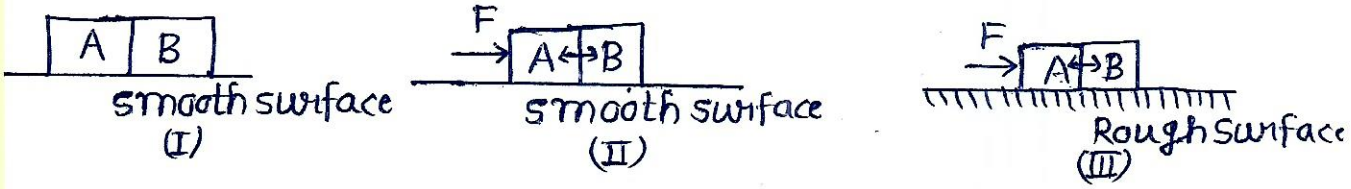
Calculation for change in velocity in uniform circular motion-

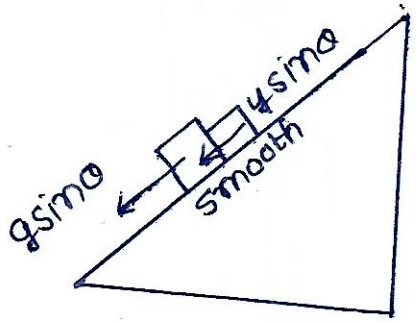


$$|\Delta\vec{V}| = \sqrt{2v^2 \times 2\sin^2\frac{\theta}{2}}$$

$$|\Delta\vec{V}| = 2v\sin\frac{\theta}{2}$$

4. Laws of Motion

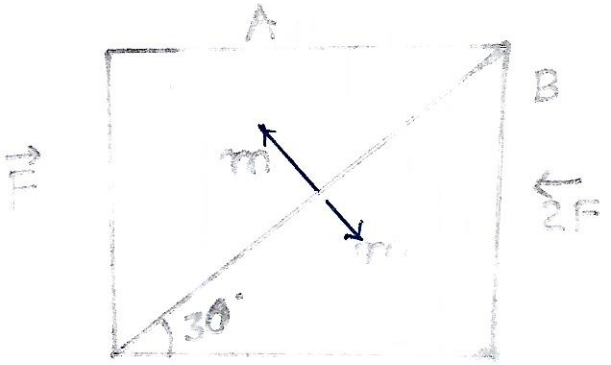




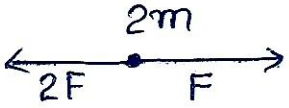
Problem-

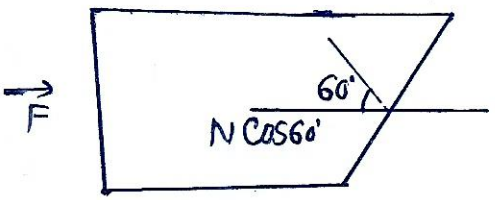
Find the normal Reaction b/w two blocks

$$a_c = \frac{F}{2m}$$



F·BD of AB





$$N\cos 60° - F = ma$$

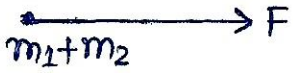
$$\frac{N}{2} - F = m \times \frac{F}{2m}$$

$$\frac{N}{2} = \frac{F}{2} + F$$

Problem -



· String is massless, tension in the string



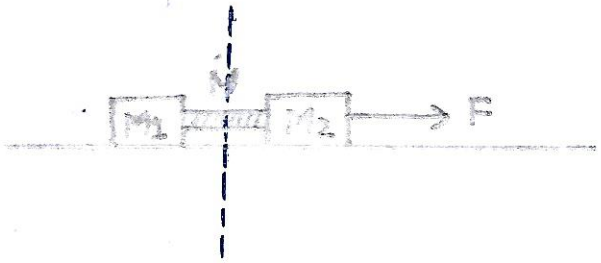
$$a = \frac{F}{m_1+m_2}$$



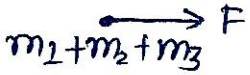
$$T = m_1 a$$

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

Problem -

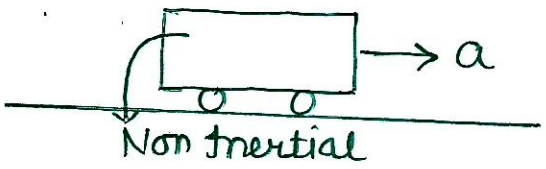


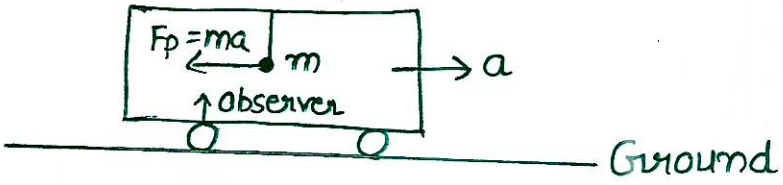
Find the tension in the middle of the string.



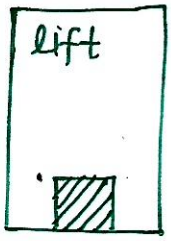
$$a_S = \frac{F}{m_1+m_2+m_3}$$

* Inertial and Non-frame Inertial -





- There are no Psudo force on Inertial frames.

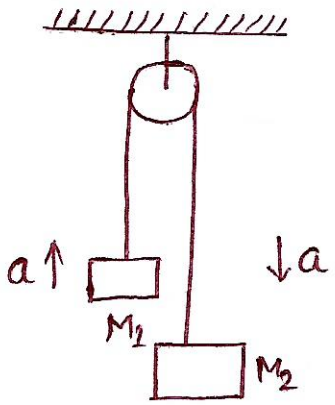


F.BD of Block w.r.to lift (Non-Inertial frame)

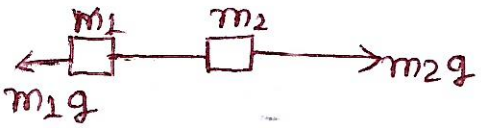


$N = ma + mg$

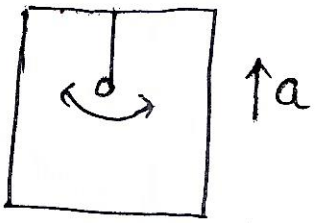
* Connected Motion and Constrain Relation-







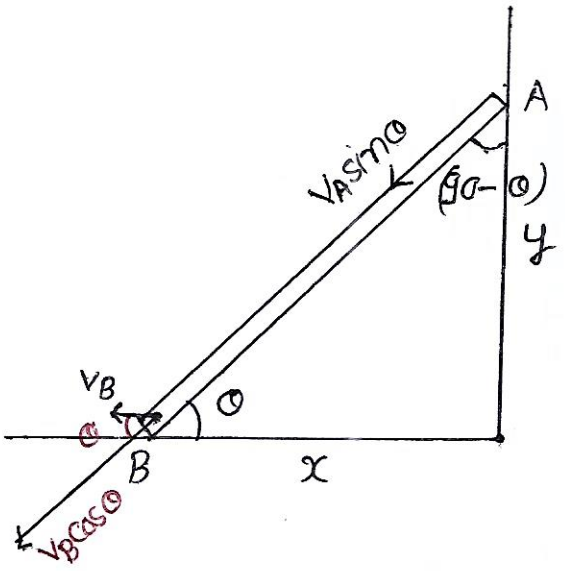
$$a = \frac{m_2 g - m_1 g}{m_1 + m_2} = \frac{(m_2 - m_1) g}{(m_1 + m_2)}$$



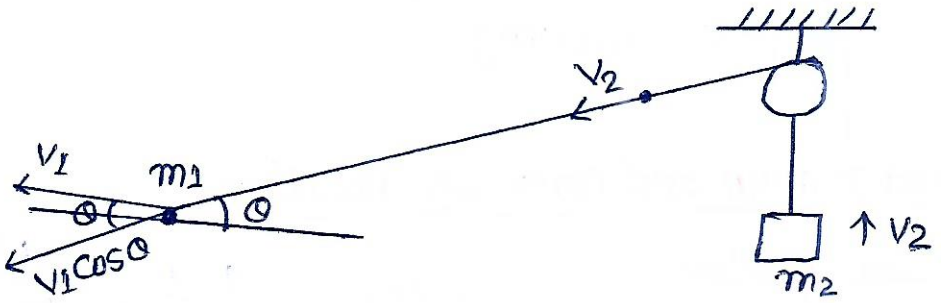
$$T = 2\pi \sqrt{\frac{l}{g + a}}$$

Velocity of end A

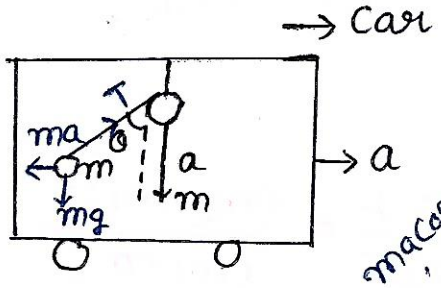
$v_A \sin\theta = v_B \cos\theta$



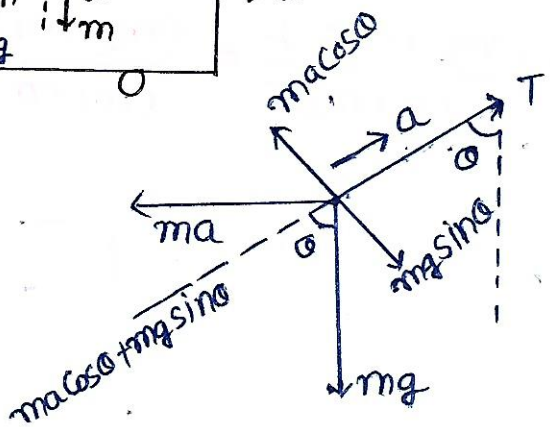
Problem-



$V_2 = V_1 \cos\theta$



Find the tension in the string ?



$ma\cos\theta = mg\sin\theta$

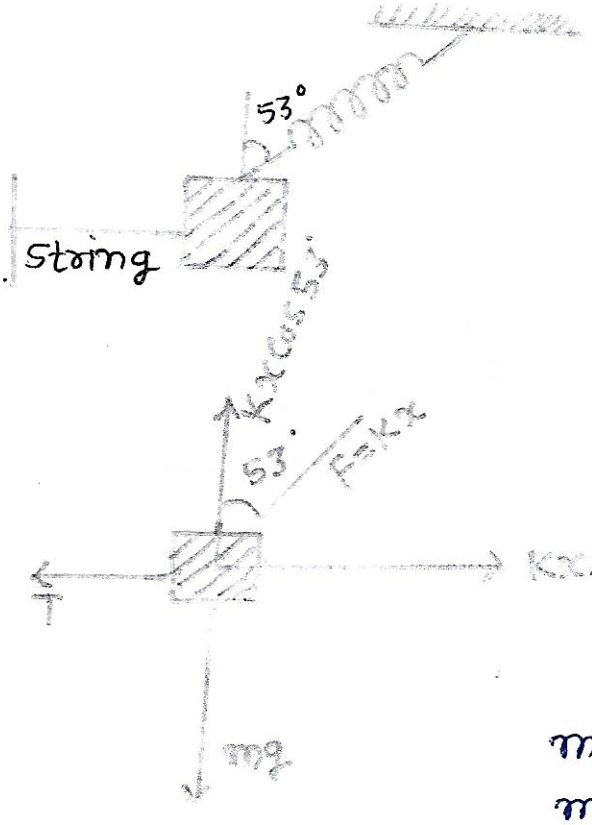
$\frac{a}{g} = \tan\theta$

$T - (ma\sin\theta + mg\cos\theta) = ma$

$$\sin\theta = \frac{a}{\sqrt{a^2+g^2}}, \quad \cos\theta = \frac{g}{\sqrt{a^2+g^2}}$$

Put these into question

QUESTION-

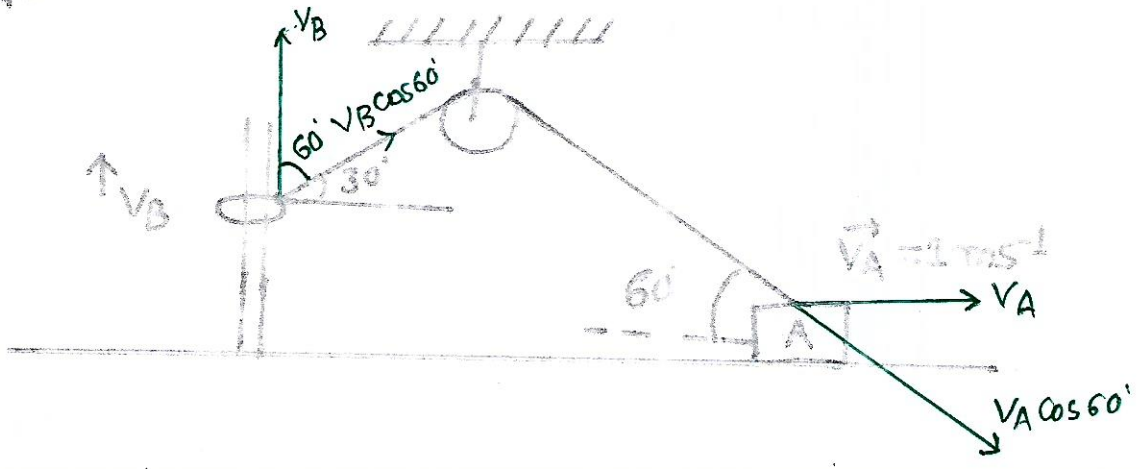


Find the acceleration of the block just after the string is cut.

$$T = Kx\sin53^\circ$$
$$mg = Kx\cos53^\circ$$
$$mg = Kx \times \frac{3}{5}$$
$$Kx = \frac{5mg}{3} \quad \text{——(1)}$$
$$ma_x = Kx\sin53^\circ$$
$$ma_x = \frac{5mg}{3} \times \sin53^\circ$$

$$\boxed{a = g\tan53^\circ}$$

QUESTION-

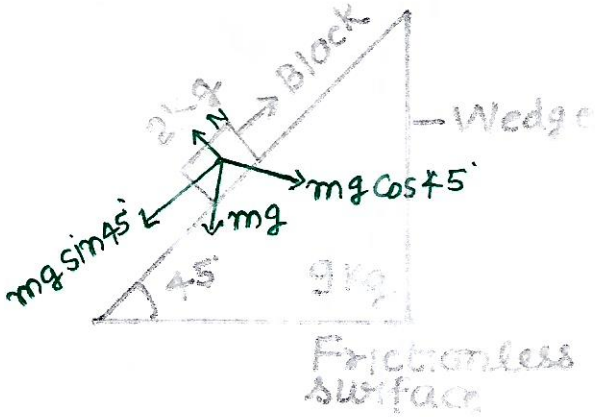


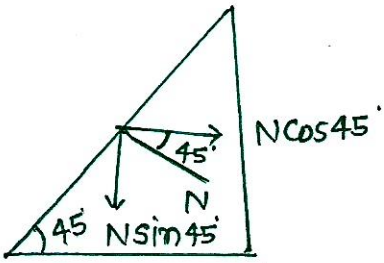


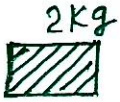
$V_B \cos 60^\circ = V_A \cos 60^\circ$

QUESTION-

Find the acceleration of the wedge?



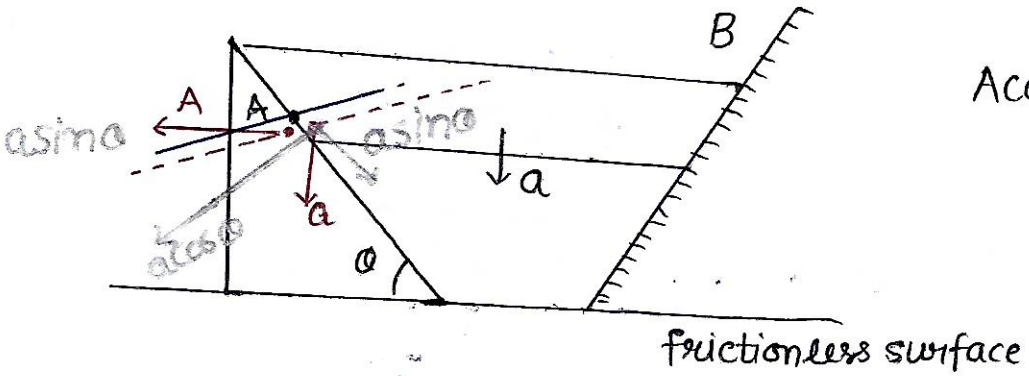




$N\cos 45^\circ = ma$

$N\cos 45^\circ = g \times A$

*Wedge Constrain-



Acceleration = ?

$a\cos\theta - A\sin\theta = 0$

$a\cos\theta = A\sin\theta$

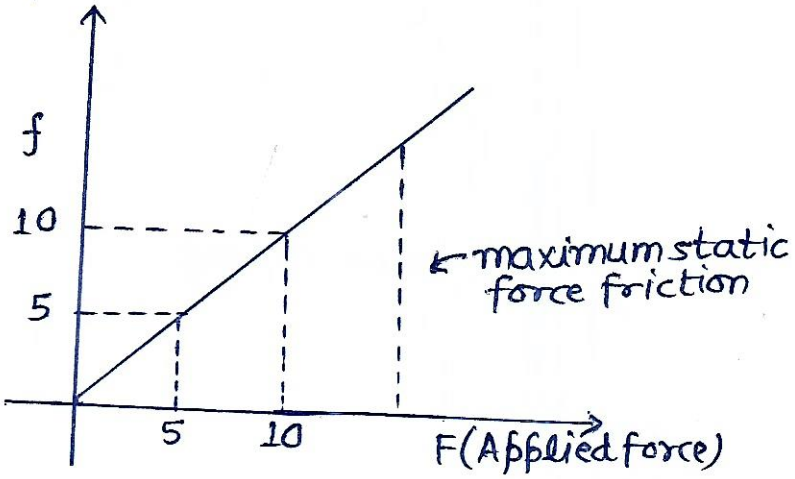
most important topic
[• Glider]

Friction Force-

Friction force always opposses Relative Motion-

- Static Friction (Self Adjeustable friction)
  - Limiting Friction
- Kinetic Friction

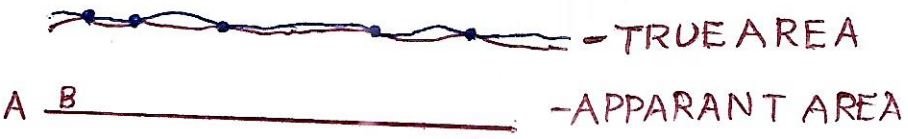
- There is no formula to calculate the static Friction. It is always equal to applied force.



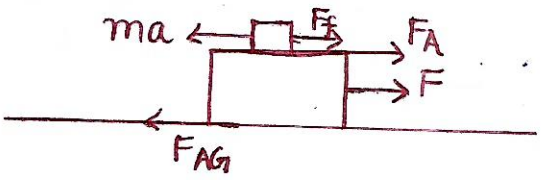
$f_l = \mu_S N$

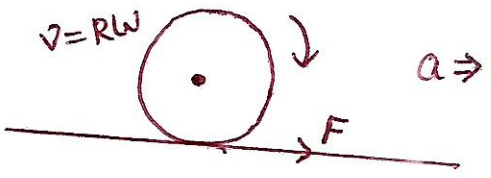
$f_K = \mu_K \cdot N$

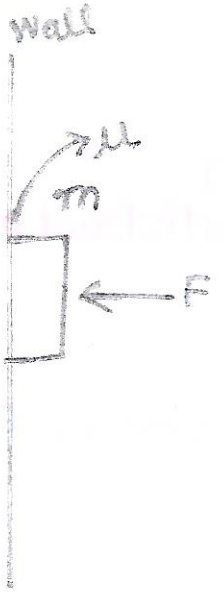
$\mu_S > \mu_K$



- Friction opposes ~~force~~ Relative motion.





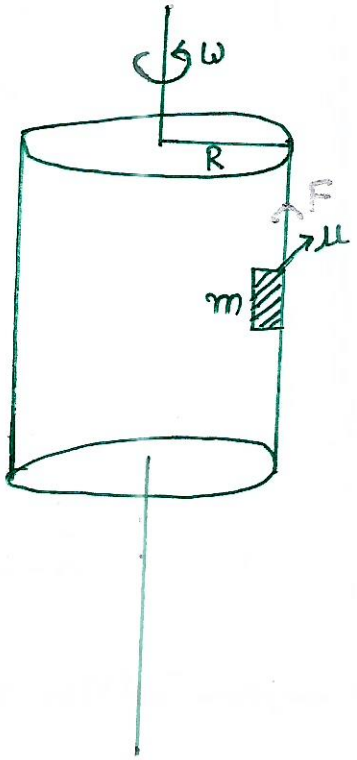


$f = \mu N$



$f = \mu F$

* Find the frictional force acting on the block?



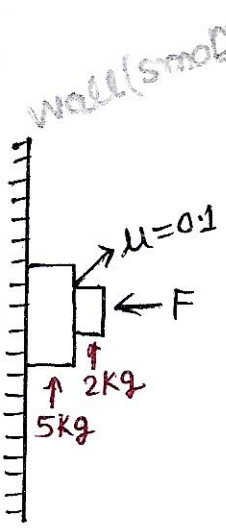
$F \geq mg$

$F = m\omega^2 R$

$f = \mu N$

$f = \mu m\omega^2 R$

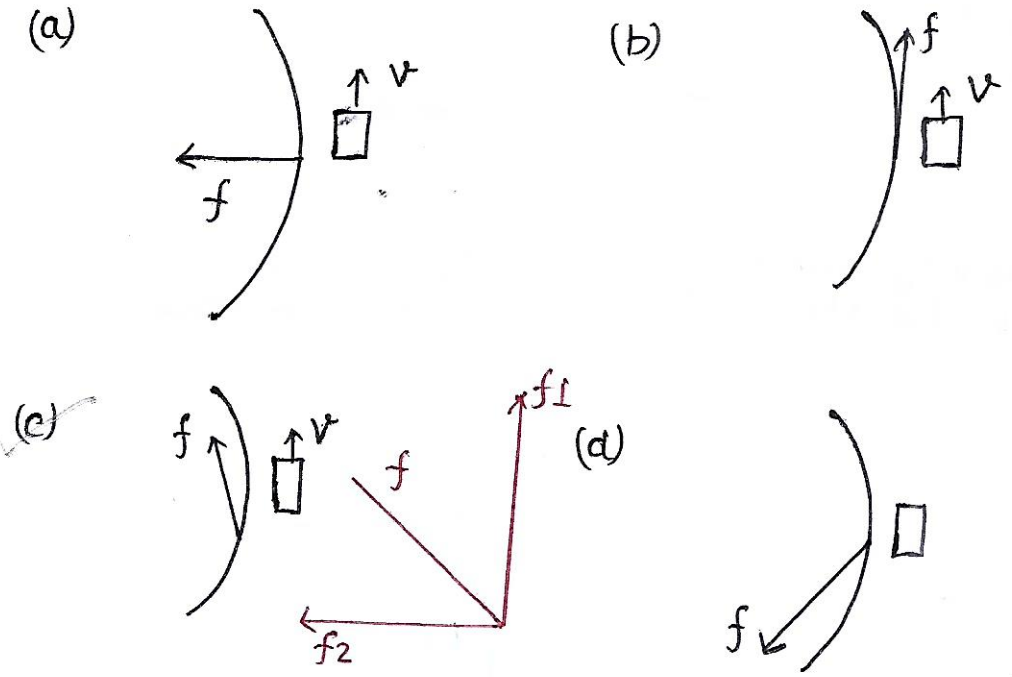
⇒



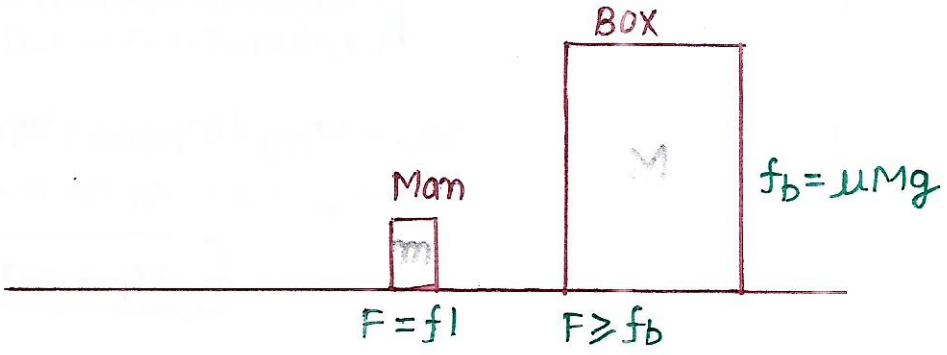
F = 1000N

1. The normal reaction force b/w the block is 1000N.
2. The frictional force b/w the blocks is zero
3. Both the block remain at rest.
4. All the statement.

Question- Correct one finding =??



Question- A man of mass 75 kg is Pushing a heavy box on a floor. The μ_k and μ_s b/w the floor and box is 0.20 and the co-officient of static friction b/w the man's shoes and the floor is 0.80. If the man pushes horizontally, what is the maximum mass of the box; he can move.



$F_l = \mu_s mg$

5. Work, energy and Power

*Work -

$W = \vec{F} \cdot \vec{S}$

$W = FS\cos\theta$

$W = \Delta K.E.$

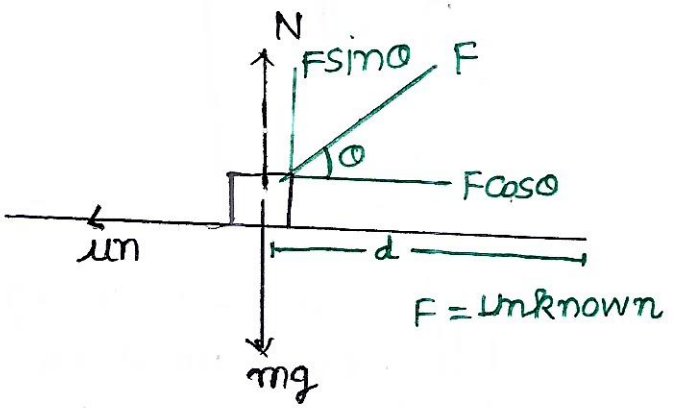
Question- The Block is moving with constant velocity. Find the work done by this applied Force during the displacement

$$\int dw = \int F\,dx$$

$F\cos\theta = \mu N$

$F\cos\theta = \mu(mg - F\sin\theta)$

$W = (F\cos\theta)\,d$



Work-Energy Theorem

- is applicable for all type of force
  [Conservation, Non-conservation
  Internal, External]

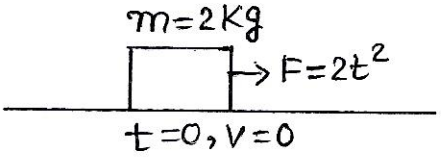
$W_N + W_{mg} + W_{F\sin\theta} + W_{F\cos\theta} + W_f = \Delta E_K$

$0 + 0 + 0 + W_F\cos\theta + W_f = 0$

$$\boxed{W_f = -W_F\cos\theta}$$

Question-

Find the work done in 2S?



$\int dw = \int F \cdot v \cdot dt$

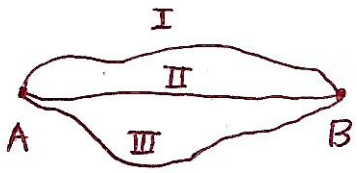
$$W = \int_0^2 2t^2 \times \frac{t^3}{3}\,dt$$

$$W = \frac{26}{9}$$

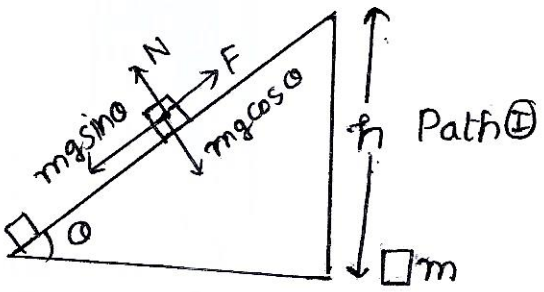
Conservative Forces –

e.g.
- Gravitational Force
- Electrostatic Force
- Elastic Force

Work done by conservative force is independent from the path.



$W_I = W_{II} = W_{III}$



$W_N = W_{mg\cos\theta} = 0$

$W_{II} = mg\sin\theta \times \frac{h}{\sin\theta} = mgh$

- The concept of Potential Energy is just applicable only for Conservative forces.

- Relation b/w Conservative Force and Potential Energy –

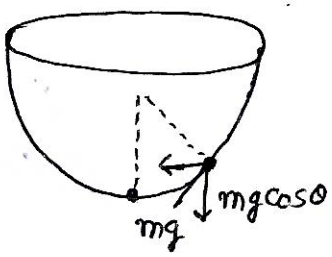
$$qE = -\frac{(dV)}{dr}\, q$$

$$F = -\frac{du}{dr}$$

$$du = -\int F\, dr$$

- Stable Equilibrium
- Unstable Equilibrium
- Neutral Equilibrium

• Stable Equilibrium -



In stable equilibrium
P.E. minimum

$U = -\vec{P} \cdot \vec{E}$

$\theta = 0°$ if $\theta = 180°$

$U = -PE$ $\quad U = -PE\cos\theta$

$U = PE$

STABLE -

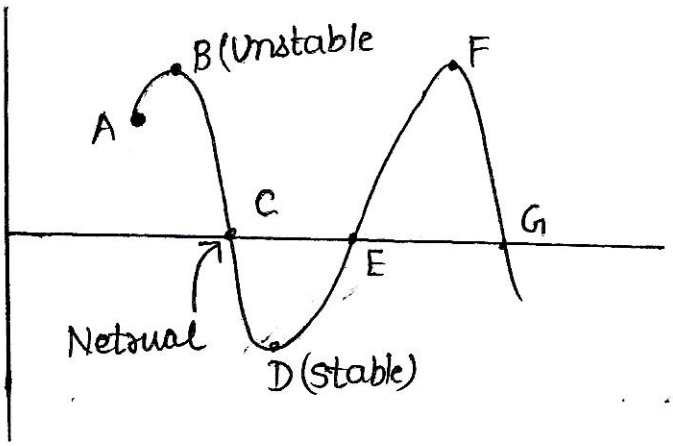
$F = 0, \frac{du}{dx} = 0, \frac{d^2u}{dx^2} > 0$ (+ve)

UNSTABLE -

$F = 0, \frac{du}{dx} = 0, \frac{d^2u}{dx^2} < 0$ (-ve)

NETRUAL -

$F = 0 \quad \frac{du}{dx} = 0, \frac{d^2u}{dx^2} = 0$



Problem- $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$, when a and b are constant, find the value of x for stable equilibrium

$$U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$$

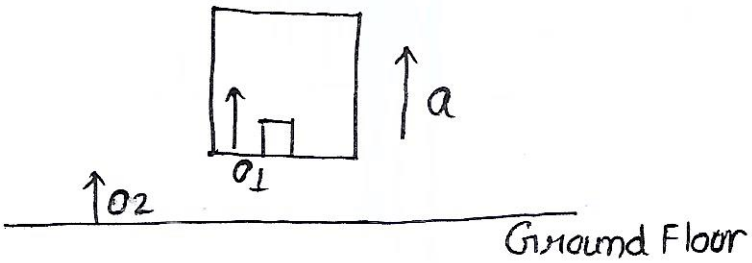
$$= \frac{-12a}{x^{13}} - \frac{6b}{x^7}$$

$$= -12ax^{-13} + 6bx^{-7}$$

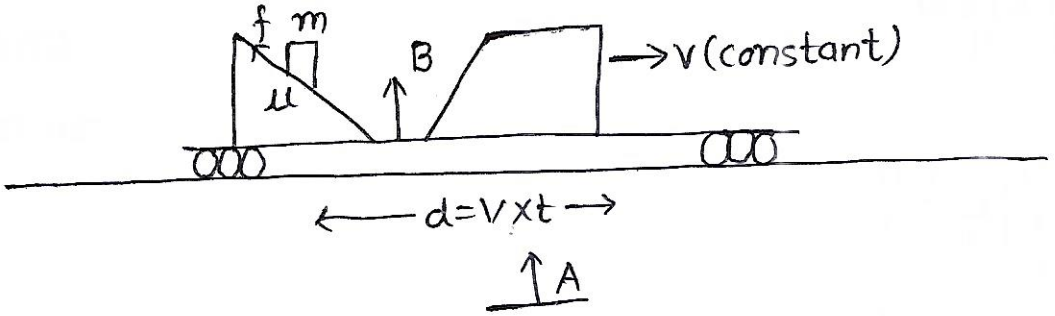
$F(x) = 0$

• Work done on frame of Reference-

According to observer O_1, Work done on the block is 0.



Problem-
find out the work done by friction in time t with respect to t, observer B and A



$W_f = f \cos\theta (vt)$

$f = \mu N$
$f = \mu mg \cos\theta$

Work Energy Theorem

Work done = $\Delta K.E.$

This theorem is applicable for work done by all type of forces.

$W_C + W_{NC} = \Delta K_E$

W_{NC} → Work done by non-conservative force

W_C → Work done by conservative force

$W_C = KE_f - KE_i$

$-(\Delta U) = KE_f - E_{ki}$

Conservation of Mechanical Energy

$M.E_i = M.E_f$

$K.E_i + P.E_i = K.E_f + P.E_f$

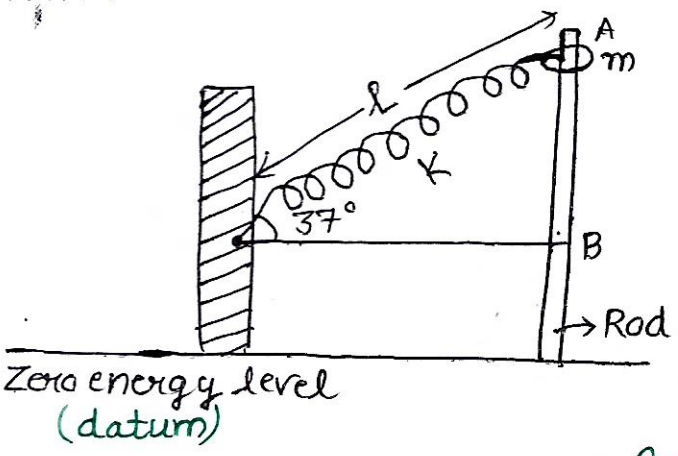
This theorem is applicable only in case of conservative force.

↓

$W_{NC} = 0$

$F_{NC} = 0$

Problem-



Natural length of spring = d
All surface are frictionless.
Find the velocity of Ring at Point B.

Conservation of Mechanical Energy

$ME_B = ME_A$

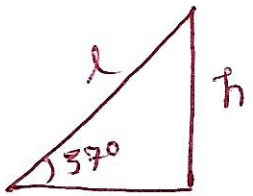
$KE_A + PE_A = KE_B + PE_B$

$0 + PE_A = \frac{1}{2} m V_B^2 + 0$

Potential Energy at A

G.P.E = mgh

Elastic P.E = $\frac{1}{2} K(l-d)^2$



d = Known

$h = d\sin\theta$

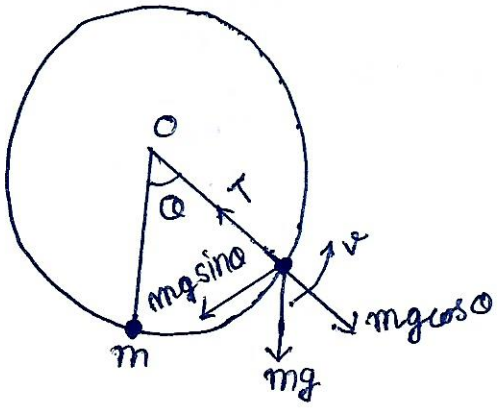
$l = d\cos\theta$

$H \neq d$

$\sin 37 = \frac{3}{5}$

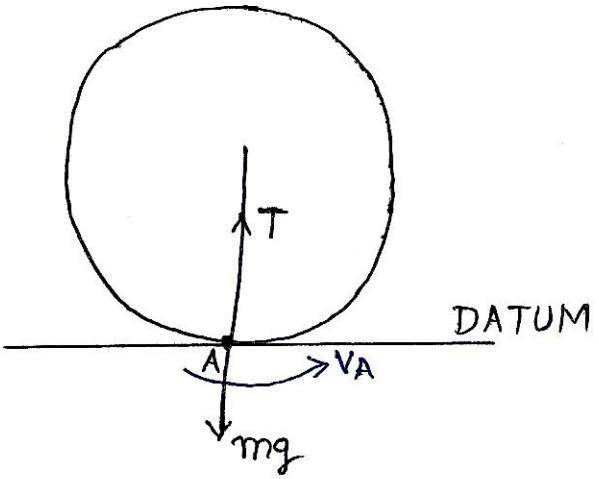
$\cos 37 = 4/5$

* Vertical Circular Motion-

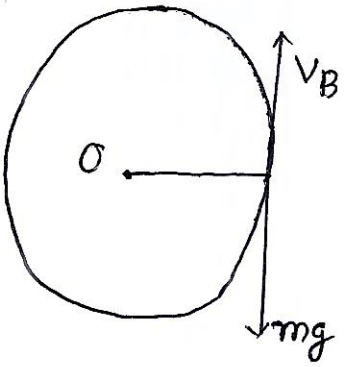


$T = mg\cos\theta + \frac{mv^2}{r}$

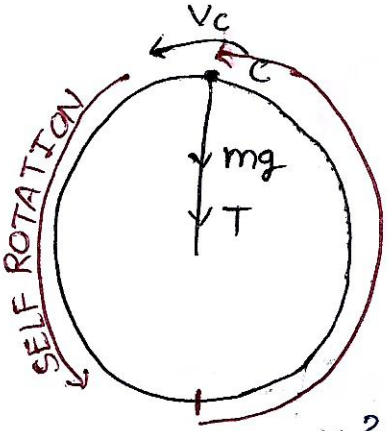
$T - mg\cos\theta = \frac{mv^2}{r}$



$$T_A = mg + \frac{mV_A^2}{r}$$



$$T_B = \frac{mV_B^2}{r}$$



$$T_C + mg = \frac{mV_C^2}{r}$$

For T_A and T_C –

$$ME_A = ME_B$$

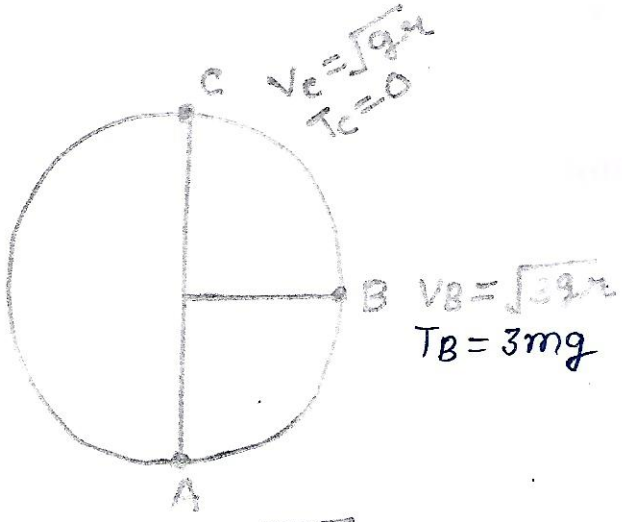
$$\frac{1}{2}mV_A^2 + 0 = \frac{1}{2}mV_C^2 + mg(2r)$$

For minimum velocity at Point A

$*T_C = 0$

$$\left(mg = \frac{mV_C^2}{r}\right)$$

$$V = \sqrt{5gr}$$

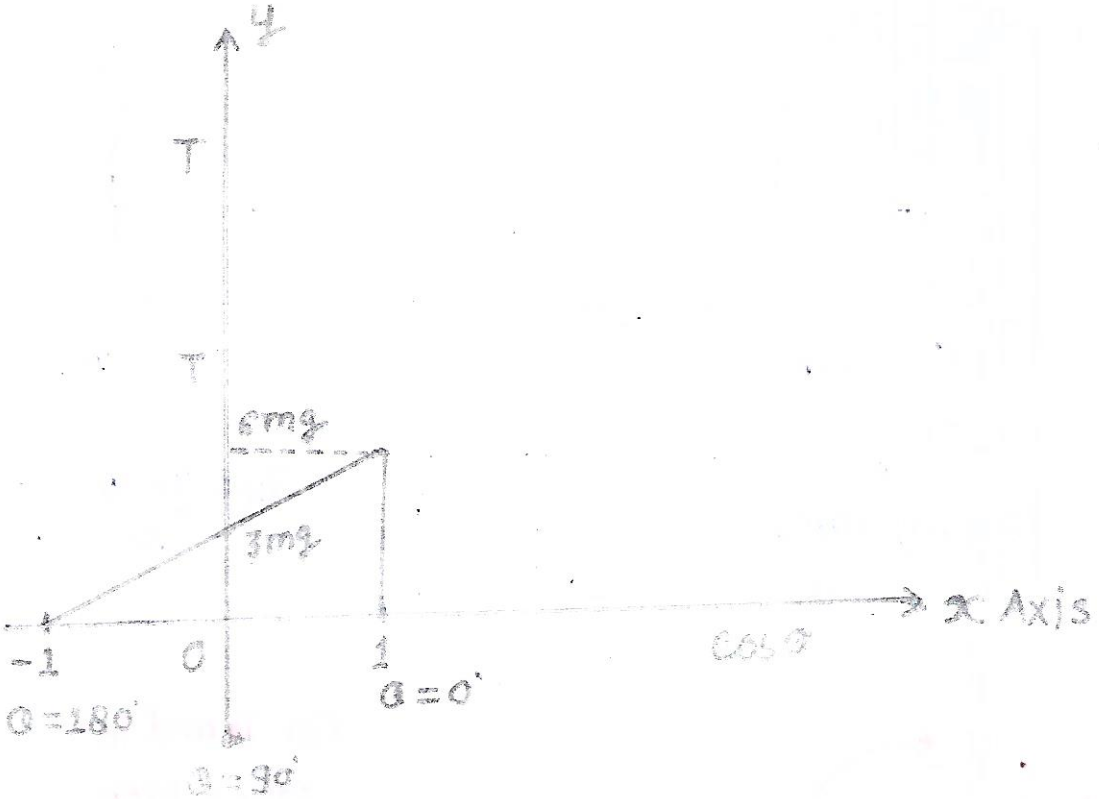


$$T_A = 6mg$$

$$T_A = mg + \frac{mV_A^2}{r}$$

$$T_A = mg + \frac{5mgr}{r} = 6mg$$

Draw the graph b/w T and cos θ in vertical Circular Motion:



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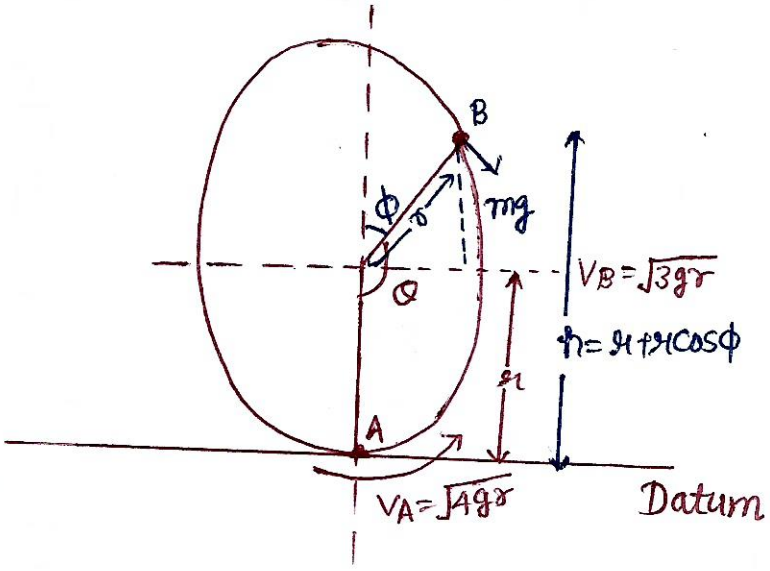
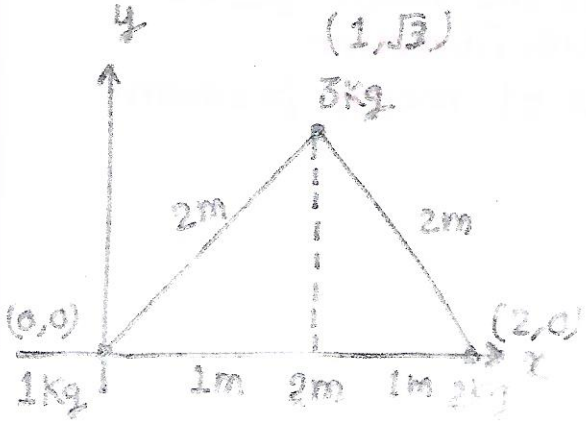


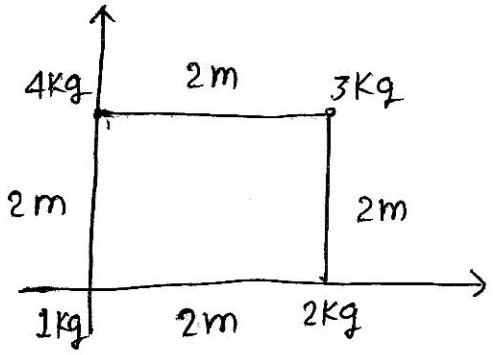
$$T + mg\cos\theta = \frac{mv^2}{r} \quad \text{——} (1)$$

of Mass-

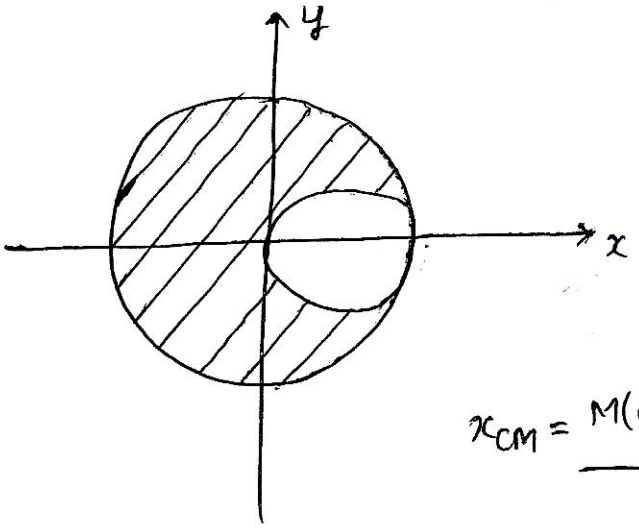


$x_{cm} = 1 \cdot 1$

$y_{cm} = \frac{\sqrt{3}}{2}$



(1, 1.4)



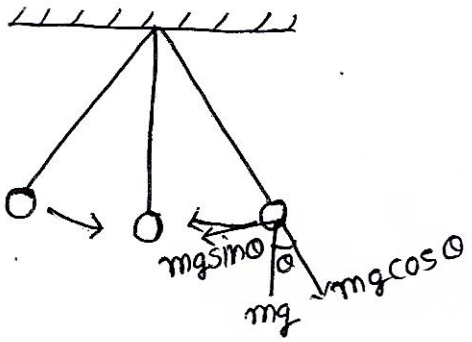
Mass = M
Radius = R

$$x_{CM} = \frac{M(0) + \left(-\frac{M}{4}\right)\left(\frac{R}{2}\right)}{M - \frac{M}{4}} = -\frac{R}{6}$$

Point is $\left(-\frac{R}{6}, 0\right)$

7. Simple Harmonic Motion

- Restoring Force (Oscillatory Motion)
  (1) It is always directed towards the mean position.
  (2) It always changes its direction (direction)
  (3) The restoring force is zero at mean position.



Restoring force $= -mg\sin\theta$

$$\boxed{SHM(F) = -Kx}$$

Equation of SHM –

$F = -Kx$ [Mean Position at (zero) 0]

$$ma = -Kx$$

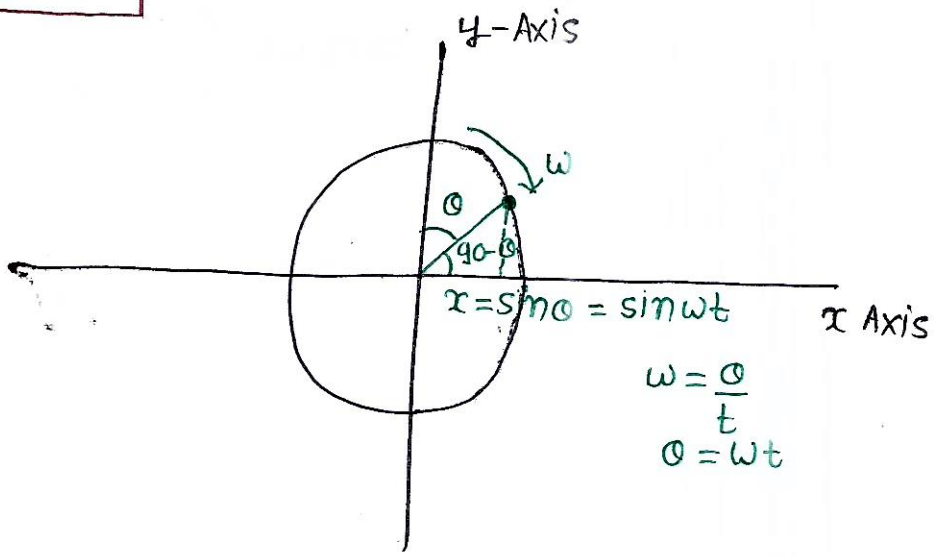
$$\boxed{\frac{md^2x}{dt^2} = \frac{-K}{m}x}$$

$$\omega^2 = \frac{K}{m}$$

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

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

- SHM



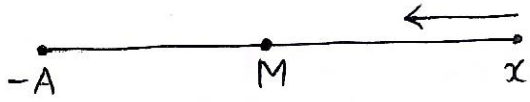
$V(t) = A\omega\cos\omega t$

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

$\boxed{a(t) = -\omega^2 x}$

- Phase difference-

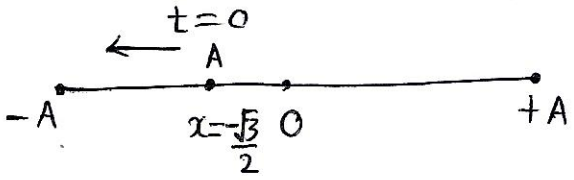
Two SHM are compared



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

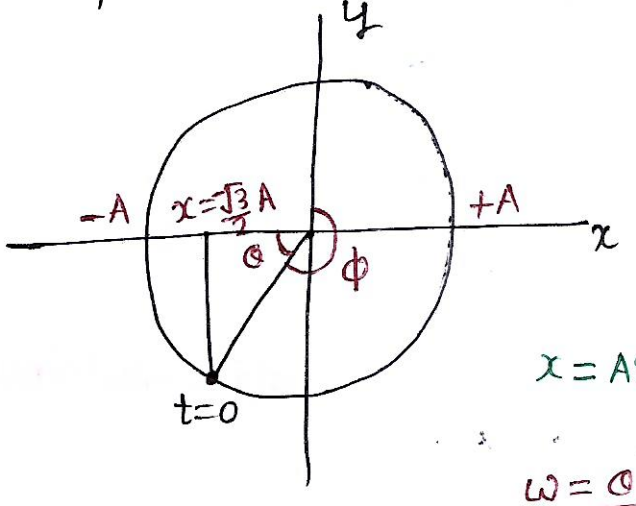
Problem-

A Particle stats from $x = -\frac{\sqrt{3}}{2}A$ and moves towards negative extreme.



(a) find the eqn of SHM

(b) find the time taken by Particle to go from directly from its initial Position to negative extreme.



$x = A\sin\left(\omega t + \frac{4\pi}{3}\right)$

$\omega = \frac{\theta}{t}$

$t = \frac{\pi/6}{\omega}$

$t = \frac{\pi/6}{2\pi/T}$

$t = T/12$ Sec.

Energy of SHM-

$$E_K = \frac{1}{2}mv^2$$

$$E_K = \frac{1}{2}mA^2\omega^2\cos^2\omega t \quad \text{——(1)}$$

$$E_K = \frac{1}{2}m\omega^2(A^2 - x^2) \quad \text{——(2)}$$

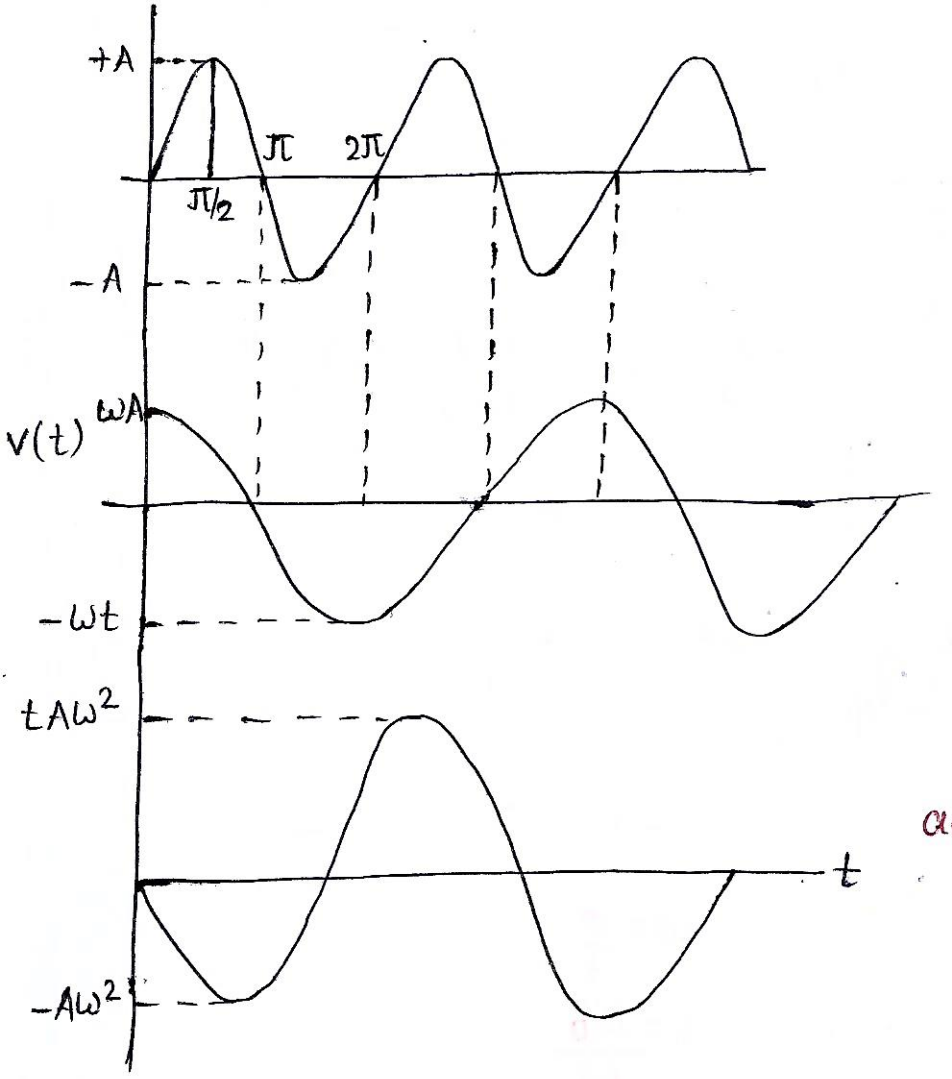
$$P_E = \frac{1}{2}kx^2 \quad \text{—— (3)}$$

$$P_E = \frac{1}{2}m\omega^2A^2\sin^2\omega t \quad \text{—— (4)}$$

total mechanical energy $= E_K + P_E$

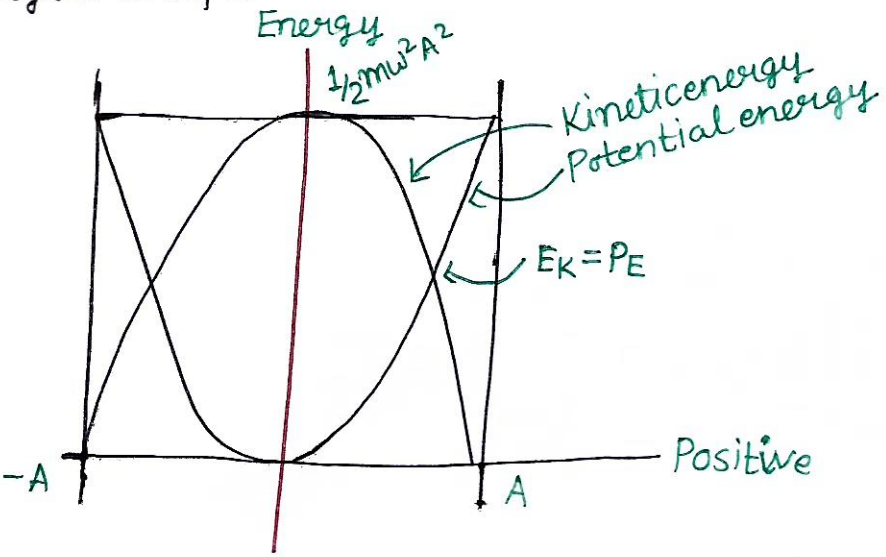
$$= \frac{1}{2}m\omega^2A^2$$

Graphes of SHM-



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

Energies Graph-



Velocity-Position Graph

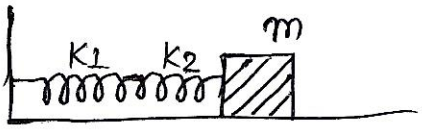
$$\frac{y^2}{(\omega A)^2} + \frac{x^2}{A^2} = 1$$

↖ Equation of ellipse

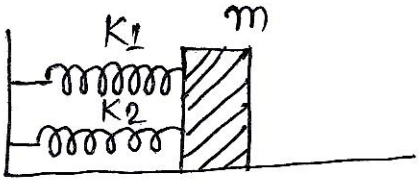
Time Period depends { Inertial Factor, Spring Factor }

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

Series Combination and Parellel Combination of spring-

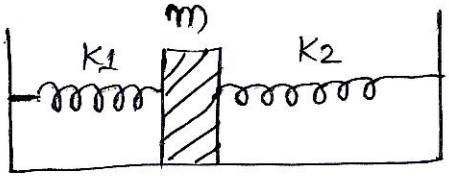


In series combination
$x \rightarrow$ diff, $F \rightarrow$ same



In Parellel combination
$F \rightarrow$ diff, $x \rightarrow$ same

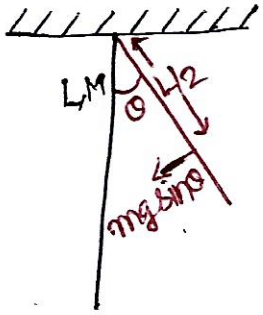
$$\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$$



In it
$x \rightarrow$ same $K_{eq} = K_1 + K_2$
$F \rightarrow$ diff

$$T = 2\pi\sqrt{\frac{m}{K_{eq}}}$$

Angular SHM-



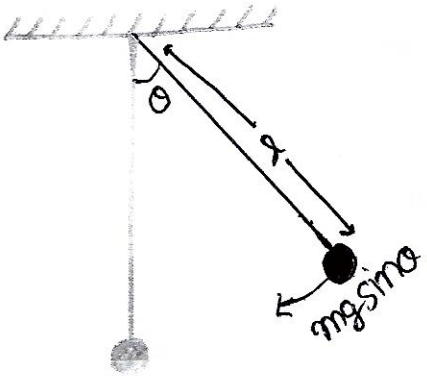
Restoring Torque

$$\tau = -mg\sin\theta\,\frac{L}{2} = -\frac{mgL}{2}\theta = -K\theta$$

$$I = \frac{mL^2}{3}$$

$$T = 2\pi\sqrt{\frac{I}{K}} = 2\pi\sqrt{\frac{\frac{1}{3}ML^2}{\frac{mgL}{2}}}$$

Simple Pendulum-



$$\tau = -mg\sin\theta\cdot l$$

$$\tau = -(mgl)\theta$$

$$\tau = -K\theta$$

$$\boxed{K = mgl}$$

$$I = ml^2$$

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

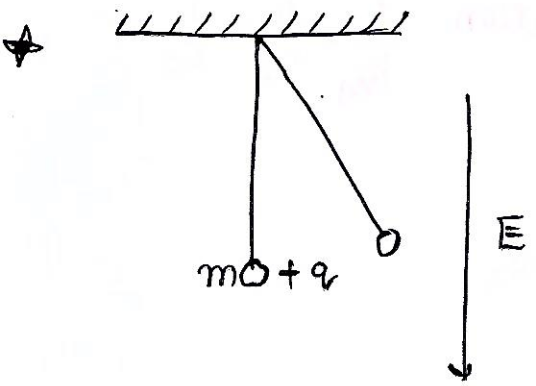
Second Pendulum-

$t = 2$ Sec.

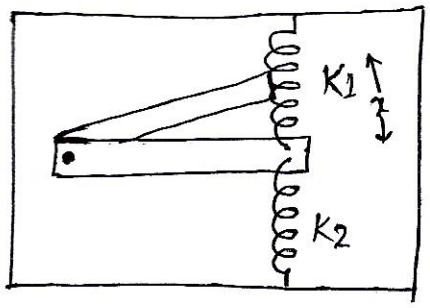
$l \approx 1$ m

$$T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow 2 = 2\pi\sqrt{\frac{l}{10}}$$

$$l \approx 1\ m$$



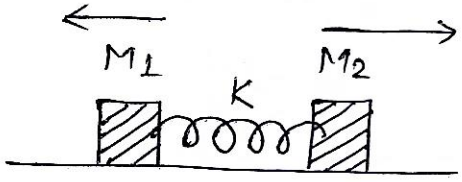
$$T = 2\pi\sqrt{\frac{l}{g + \frac{qE}{m}}}$$



$K_{ef} = K_1 + K_2$

$I = \frac{1}{3}ML^2$

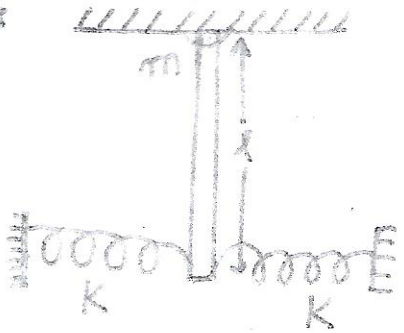
$T = 2\pi\sqrt{\frac{I}{K_{ef}}}$



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

$\frac{1}{\mu} = \frac{1}{m_1} + \frac{1}{m_2}$

↑ effective inertial mass



$T = \left(mg\sin\theta\frac{l}{2}\right) + 2Kx\,l\cdot\sin\theta$

$T = -\left(\frac{mgl}{2} + 2Kxl\right)\theta = -K\theta$

$\theta = \theta$

$$\boxed{K = \frac{mgl}{2} + 2Kx}$$

HEAT TRANSFER-

Thermal Expension-

$L = L_0(1+\alpha\Delta T)$

$L - L_0 = L_0\alpha\Delta T$

$\Delta L = L_0\alpha\Delta T$

$A = A_0(1+\beta\Delta T)$

$V = V_0(1+\gamma\Delta T)$

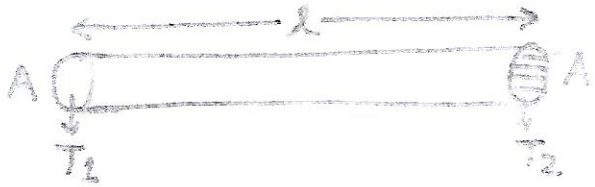
$T_0 = 2\pi\sqrt{\frac{l_0}{g}}$

$T = 2\pi\sqrt{\frac{l_0(1+\alpha\Delta T)}{g}}$

$\frac{T}{T_0} = \frac{\sqrt{l_0(1+\alpha\Delta T)}}{\sqrt{l_0}}$

$$\boxed{\frac{T}{T_0} = (1+\alpha\Delta T)^{1/2}}$$

Conduction of Heat--



$T_1 > T_2$

H → Rate of Heat flow

$H \propto \Delta T$

$H = \frac{\Delta T}{R}$ ← Thermal Resistance

$R = \frac{1}{K}\frac{l}{A}$

↳ Thermal Conductivity

$H = \frac{\Delta T}{\frac{1}{K}\cdot\frac{l}{A}}$

$H = \frac{KA(T_1 - T_2)}{l}$

Current Electricity

$V = iR$

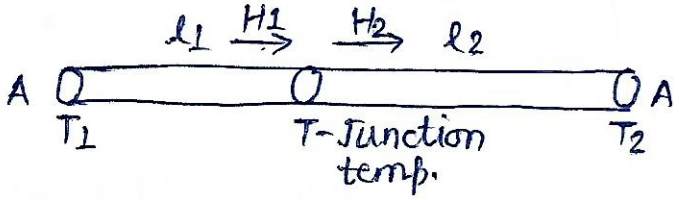
$i = \frac{V}{R}$

$\frac{dq}{dt} = \frac{\Delta V}{R}$

$R = \rho\frac{l}{A}$

$\frac{dQ}{dt} \propto \frac{dT}{dl}$ ← Temp. gradient

- Series Combination-



$H_1 = H_2$

$\frac{K_1 A(T_1 - T)}{l_1} = \frac{K_2 A(T - T_2)}{l_2}$

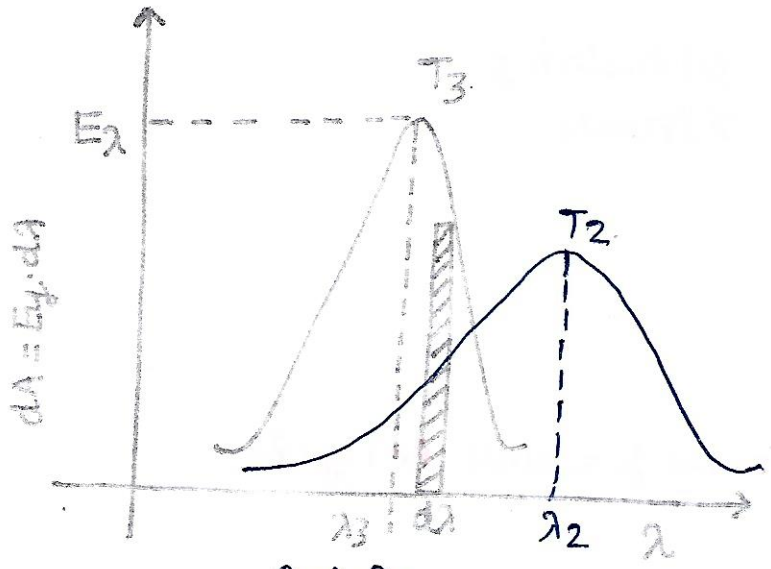
equivalent Thermal resistance

$R_{eq} = R_1 + R_2$

$\frac{1}{K_{eq}}\cdot\frac{l}{A} = \frac{1}{K_1}\cdot\frac{l_1}{A} + \frac{1}{K_2}\cdot\frac{l_2}{A}$

$$\boxed{\frac{1}{K_{eq}} = \frac{l_1}{K_1(l_1+l_2)} + \frac{l_2}{K_2(l_1+l_2)}}$$

* Radiation -



Total Energy realeased Per unit time emission Power

$$\int E_\lambda \, d\lambda$$

$\lambda_2 > \lambda_3$

$f_2 < f_3$

$T_2 < T_3$

VIBGYOR

$\lambda_V < \lambda_R$

$f_V > f_R$

Wein distance-displacement Theory -

$$\lambda \cdot T = b$$

↓

constant

✣ STEPHEN'S LAW -

The radiation energy emitted by Perfectly Black body

$$E \propto T^4$$

$$E = \sigma T^4$$

↓

Stephen constant

For other bodies (which are not black bodies)

$$E = e \sigma T^4$$

↓

emissivity

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

$$\boxed{\frac{Q}{t} = Ae\sigma T^4}$$

8. Wave Motion

- Velocity of a wave in a medium-
  - ⇒ Elasticity
  - ⇒ Inertia

- Velocity of wave in string-

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

μ = mass per unit length.

* Velocity of Longitudnal Wave-

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

E → co-officient of elasticity
ρ → density

- velocity of sound

$v_{sound} > v_{liquid} > v_{gases}$

* Velocity of sound in Metallic Rod-

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

Y → Young's Modulas

* Velocity of sound in liquid-

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

β → Bulk Modulas

* Velocity of sound in gas (or Air)-

- NEWTON'S FORMULA-

According to Newton the propagation of sound in Air is an isothermal process.

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

$$\beta = \frac{-\Delta P}{\Delta V/V} = P \text{ (Pressure)}$$

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

Laplas correction-

Propogation of sound in Air is an adiabatic Process.

$$V = \sqrt{\frac{\gamma P}{\rho}} \qquad \beta = \frac{-\Delta P}{\Delta V/V} = \gamma P$$

Effect of Temperature-

$$V = \sqrt{\frac{\gamma P}{\rho}} \qquad \rho = \frac{M}{V}$$

$$V = \sqrt{\frac{\gamma PV}{M}} \qquad PV = nRT \quad PV = RT$$

$$V = \sqrt{\frac{\gamma RT}{M}}$$

$$\boxed{V \propto T}$$

Effect the Pressure-

The speed of sound does not change on changing in pressure

Effect of Humidity-

Increase in humidity decreases density, hence speed of sound increases.

Mathematical Eq^n of wave -

$$y = A\sin(\omega t \pm Kx)$$

$y(x,t) = A\sin(\omega t + Kx) \rightarrow$ Negative part

$y(x,t) = A\sin(\omega t - Kx) \rightarrow$ Positive part

SHM-

$y = A\sin(\omega t)$ $\qquad y = A\sin(\omega t \pm \phi) = A\sin(\omega t \pm Kx)$



Phase difference

$$\frac{\phi}{2\pi} = \frac{\Delta x}{\lambda} \Rightarrow \phi = \frac{2\pi}{\lambda} \cdot x \Rightarrow \phi = Kx$$

- $y(x,t) = A\sin(\omega t - kx)$

$$k = \frac{2\pi}{\lambda}, \quad \omega = \frac{2\pi}{T}$$

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

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

⇒ Wave Velocity

$$v = \lambda f$$

$$v = \frac{\lambda}{2\pi} \times 2\pi f$$

$$v = \frac{1}{K} \cdot \omega$$

$$\boxed{v = \frac{\omega}{K}}$$

PROBLEM-

$$y(x,t) = 0.05\sin\left[\frac{\pi}{2}(10x - 4\alpha t) - \frac{\pi}{4}\right]$$

(a) λ, f and wave velocity

(b) The Particle velocity at $x = 0.5\,m$ and $t = 0.05$ sec.

(a) $y(x,t) = 0.05\sin\left[5\pi x - 20\pi t - \pi/4\right]$

$$y(x,t) = 0.05\sin\left[-(20\pi t - 5\pi x + \pi/4)\right]$$

$$y(x,t) = A\sin(\omega t - kx + \phi)$$

$\omega = 20\pi \rightarrow 2\pi f = 20\pi$

$k = 5\pi \qquad f = 10\pi$

$$\frac{2\pi}{\lambda} = 5\pi$$

$$\lambda = \frac{2\pi}{5\pi}$$

$$\boxed{\lambda = \frac{2}{5}}$$

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

$$v = \frac{20\pi}{5\pi}$$

$$\boxed{v = 4}\ ms^{-1}$$

(b) SHM

$y = A\sin\omega t$

$y' = A\omega\cos\omega t = dy/dt$

$y = A\sin(\omega t - kx)$

$\frac{\partial y}{\partial t} = A\cos(\omega t - kx)\cdot\frac{\partial}{\partial t}(\omega t - kx)$

$\frac{\partial y}{\partial t} = A\omega\cos(\omega t - kx)$ ——— (I)

↓

Velocity of particle

slope $\frac{\partial y}{\partial x} = -kA\cos(\omega t - kx)$ ——— (II)

(I)/(II)

$$\frac{\partial y/\partial t}{\partial y/\partial x} = \frac{+\omega A\cos(\omega t - kx)}{-kA\cos(\omega t - kx)}$$

$$\frac{\partial y/\partial t}{\partial y/\partial x} = -v \rightarrow \text{Wave velocity}$$

$$\frac{\sqrt{P}}{\text{slope}} = -v$$

$$\frac{\partial y}{\partial t} = 0.05 \times 20\pi \sin\cos\left(20\pi \times 0.05 - 5\pi \times \left(0 - \frac{\pi}{4}\right)\right)$$

$$= \pi\cos\left(\pi - \frac{5}{2}\pi - \frac{\pi}{4}\right)$$

- SUPERPOSITION OF WAVES
  - Interference ✓
  - Standing Wave ✓
  - Beat ✓
  - Complex Wave
  - Noise

$\Delta x = S_2P - S_1P$

* Interference-

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

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

↑ ϕ should be constant

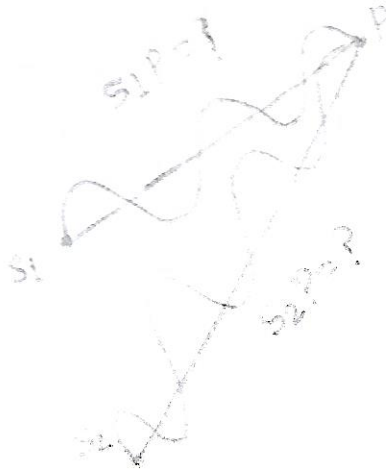
$y = y_1 + y_2$

$y = A_1\sin(\omega t - kx) + A_2\sin(\omega t - kx + \phi)$

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

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

Constructive Interference-



$$\Delta x = S_2P - S_1P$$

$$\Delta x = n\lambda \quad [n = 0, 1, 2 \ldots]$$

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

$$\boxed{\phi = 2\pi n}$$

Destructive Interference-

$$\Delta x = (2n-1)\frac{\lambda}{2} \qquad [n = 1, 2, 3]$$

Phase difference

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

$$\boxed{\phi = (2n-1)\pi} \quad [\because n = 1, 2, 3]$$

Interference-

$$A = A_2 - A_1$$

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

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

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

* Beats Formation-



Variable Amplitude

frequency of superposed wave $= \frac{f_1 + f_2}{2}$

* Standing Wave-

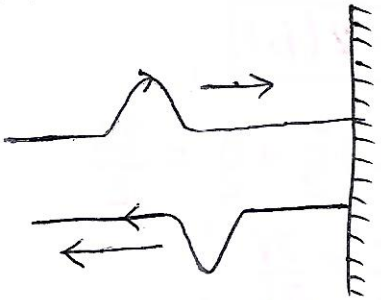
• Reflection of transverse wave from Rigid end-

$y_i = A\sin(\omega t - kx)$

$y_r = A\sin(\omega t + kx + \pi) = -A\sin(\omega t + kx)$

$y_i = A\sin(\omega t - kx)$ } for free End

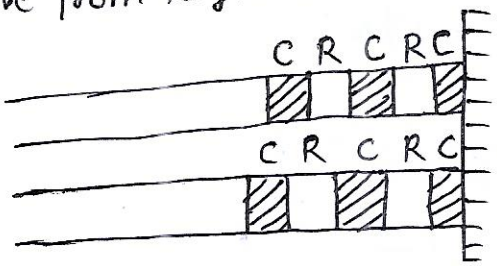
$y_r = A\sin(\omega t + kx)$ }



→ crust is reflected as trough

→ Trough is reflected as crust.

• Reflection of longitudnal Wave from Rigid End-



$y_i = A\sin(\omega t - kx)$

$y_r = A\sin(\omega t + kx)$

$y_i = A\sin(\omega t - kx)$ } for free End

$y_r = -A\sin(\omega t + kx)$ }

$y = y_i + y_r$

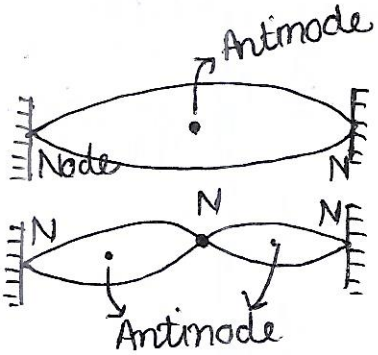
$y = A[\sin(\omega t - kx) - \sin(\omega t + kx)]$

$y = \underbrace{(-2A\sin kx)}_{\text{Variable Amplitude}} \cos\omega t$

Node $x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}$

distance b/w two nodes $= \frac{\lambda}{2}$

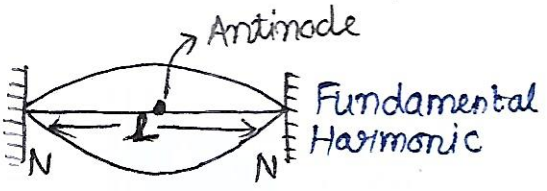
Antinodes $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$



• Standing Wave on string-

$L = \frac{\lambda}{2}$, $V = \lambda f$

$\lambda = 2L$, $f = \frac{V}{\lambda} \Rightarrow \frac{V}{2L} \Rightarrow f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

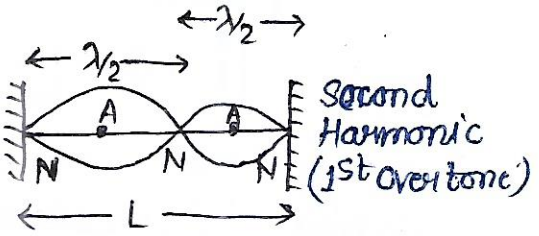


Fundamental Harmonic

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

$f = \frac{V}{L} = \frac{V}{\lambda} = \frac{1}{L}\sqrt{\frac{T}{\mu}}$

$\boxed{f_1 = 2(f_0)}$

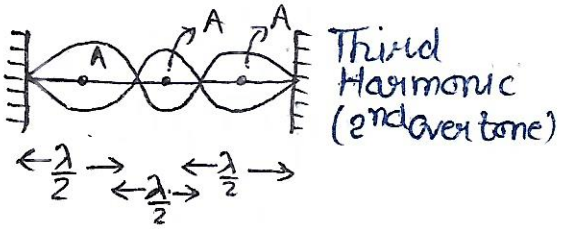


Second Harmonic (1st Overtone)

$L = \frac{\lambda}{2} + \frac{\lambda}{2} + \frac{\lambda}{2} = \frac{3\lambda}{2}$

$f = \frac{V}{\lambda} = \frac{3V}{3L}$

$f = 3\left(\frac{V}{2L}\right) \Rightarrow \boxed{f = 3f_0}$



Third Harmonic (2nd Overtone)

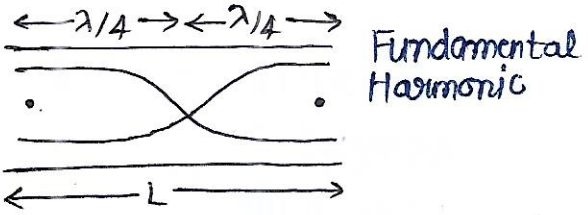
* Longitudnal Standing Wave-

• Open Organ Pipe-

$L = \frac{2\lambda}{4} = \frac{\lambda}{2}$

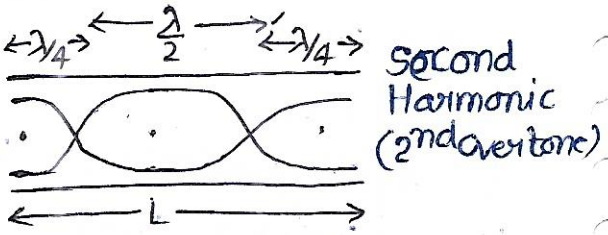
$V = \lambda f$

$\boxed{f_0 = \frac{V}{\lambda} = \frac{V}{2L}}$



Fundamental Harmonic

$L = 4\lambda/4$, $f = \frac{V}{L} \Rightarrow \boxed{f = 2(f_0)}$

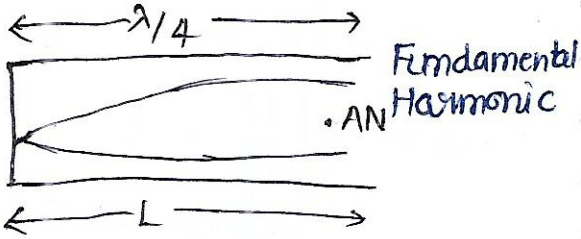


Second Harmonic (2nd Overtone)

• Close Organ Pipe-

$L = \frac{\lambda}{4}$, $V = \lambda f$

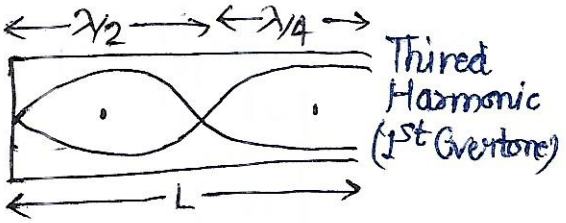
$f = \frac{V}{\lambda} \Rightarrow \boxed{f_0 = \frac{V}{4L}}$



Fundamental Harmonic

$L = \frac{3\lambda}{4}$, $f = \frac{V}{\lambda}$

$f = 3\left(\frac{V}{4L}\right) = 3f_0$



Third Harmonic (1st Overtone)

9. Electrostatics

1. Electrostatics (विद्युत आवेश)

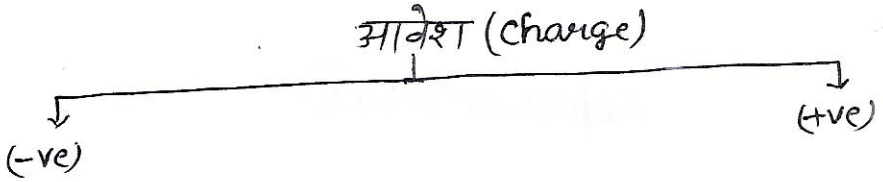
(स्थिरवैद्युतिकी) — स्थिर बल, स्थिर क्षेत्र, स्थिर विभव

- आवेश — सजातीय आवेश एक- दूसरे को प्रतिकर्षित करते हैं।
  विजातीय आवेश एक- दूसरे को आकर्षित करते हैं।

- सभी पदार्थ परमाणु तथा अणु से बने हैं।
- सभी वस्तुएँ विद्युत उदासीन होती हैं।

- कोई भी वस्तु e^- खोकर धनावेशित हो जाती है।
- कोई भी वस्तु e^- लेकर ऋणावेशित हो जाती है।
- कुछ पदार्थ अपने में से होकर विद्युत को प्रवाहित होने देते हैं; ऐसे पदार्थ चालक कहलाते हैं।
- कांच, प्लास्टिक, पार्सेलेन जैसी अधिकांश अधातु अपने में से विद्युत प्रवाह होने पर उच्च प्रतिरोध (High Resistance) लगाती हैं। इन्हें विद्युतरोधी कहते हैं।
- अर्द्धचालक, आवेशों की गति में अवरोध उत्पन्न करता है।

Wire from Electric Supply Plant
- ——— विद्युन्मय तार
- ——— उदासीन तार
- ——— भूसंपर्क तार



- आवेश की योज्यता—

$$q_T = q_1 + q_2 + q_3 + q_4 + \ldots + q_n$$

*charge is a scalar quantity.
*charge is always conserved.

$$\boxed{q = ne}$$

- आवेश का क्वांटमीकरण—

आवेश हमेशा धनात्मक व ऋणात्मक पूर्णांक होता है।

इलेक्ट्रॉन का आवेश $(-e) = -1.6 \times 10^{-19}$ C

प्रोटॉन का आवेश $(+e) = 1.6 \times 10^{-19}$ C

आवेश का मात्रक (SI) कूलॉम (C) है। इसका प्रतीक C है।

- एक कूलॉम वह आवेश है जो किसी तार में 1 Amp. धारा 1 sec. में प्रवाहित होती है।

$1C = 6 \times 10^{18} e^-$

$1 \mu C = 10^{-6} C$

$1 mC = 10^{-3} C$

- यदि किसी वस्तु में n_1 इलें० व n_2 प्रोट्रॉन हैं तो कुल आवेश = ?

$$q_T = n_2 \times e + n_1 \times (-e) = (n_2 - n_1) e$$

- कूलॉम नियम –

$$F = \frac{K |q_1 \cdot q_2|}{r^2}$$

$$K = 9 \times 10^9$$

$$K = \frac{1}{4\pi\epsilon_0}$$

$$F = \frac{1}{4\pi\epsilon_0} \frac{|q_1 \cdot q_2|}{r^2}$$

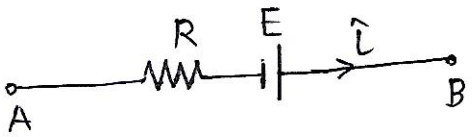
$$\epsilon_0 = 8.85 \times 10^{-12} \, C^2/N m^2$$

Force is a vector quantity.

$$F_{21} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r_{21}^2} \vec{r}_{21} = -F_{21}$$

* विद्युत क्षेत्र (Electric Field) – Represents to $\vec{E}$.

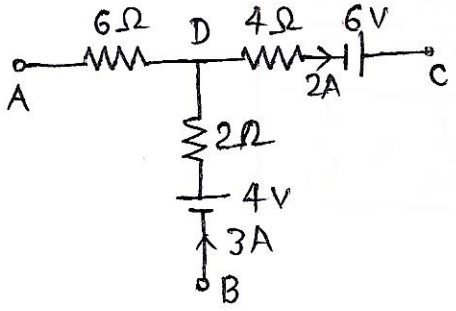
10. Current Electricity



$V_A - V_B = ?$

$V_A - iR + E = V_B$

$\boxed{V_A - V_B = iR - E}$

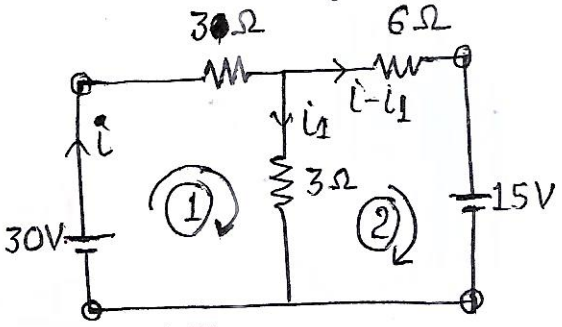


$V_A + 1\times6 + 6 - 4 = V_B$

$\boxed{V_A - V_B = -8}$

$V_D - 4\times2 + 6 = V_C$

$\boxed{V_D - V_C = 2\,V}$



Loop ① -

$30 - 3i - 3i_1 = 0$

Loop ② -

$+3i - 6(i - i_1) = 0$

Then by solving

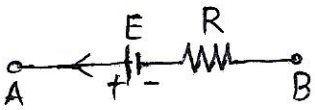
$i_1 = 5\,Amp$

$i_2 = 0\,Amp$

$i + i_1 = 10$

$\boxed{i = 5\,Amp}$

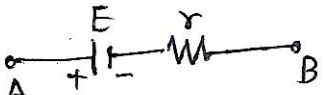
Ex-



$V_A - E + ir = V_B$

$V_A - V_B = E - ir$

$< E$



$V_A - (-E) - ir = V_B$

$V_A - V_B = E + ir$

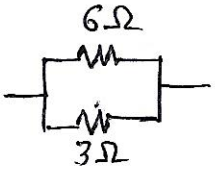
$> E$



$i = 0$

$V_A - E = V_B$

$V_A - V_B = E$

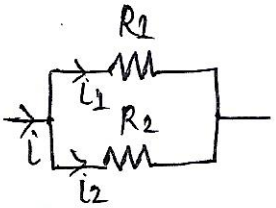


$$R = \frac{R_1 R_2}{R_1 + R_2}$$



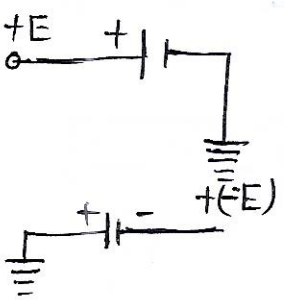
$V_A - E = V_B$

$\boxed{V_A - V_B = E}$

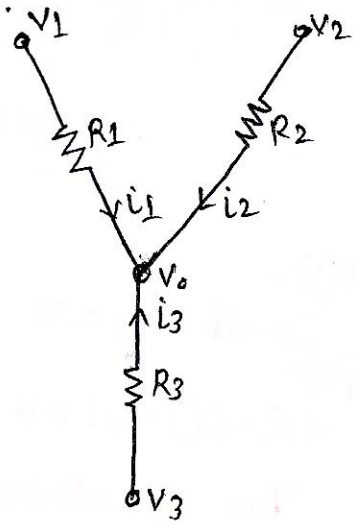


$$i_1 = \frac{iR_1}{R_1 + R_2}$$

$$i_2 = \frac{iR_2}{R_1 + R_2}$$



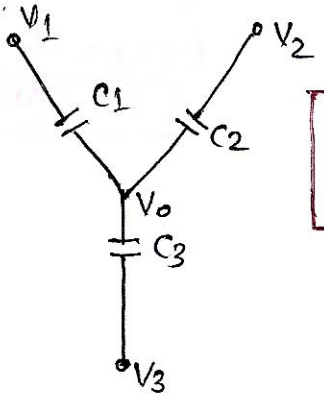
NODE METHOD -



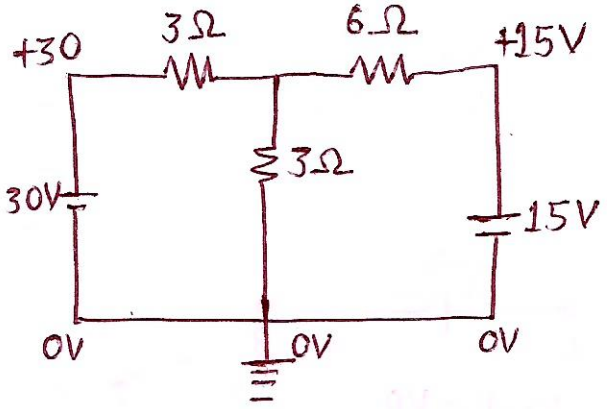
$$i_1 + i_2 + i_3 = 0$$

$$\frac{V_1 - V_o}{R_1} + \frac{V_2 - V_o}{R_2} + \frac{V_3 - V_o}{R_3} = 0$$

$$V_o = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$



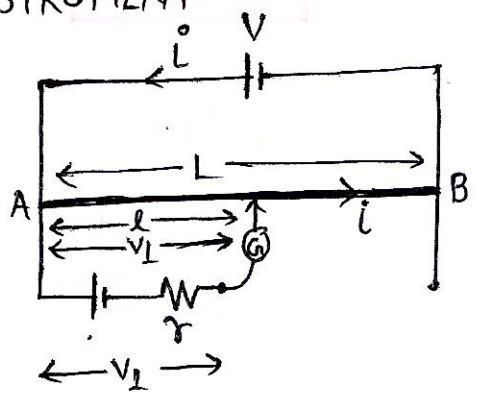
$$V_o = \frac{C_1 V_1 + C_2 V_2 + C_3 V_3}{C_1 + C_2 + C_3}$$



Then solve it

ELECTRICAL INSTRUMENT -

[1]



$$R_{AB} = \frac{\rho L}{A} \qquad i = \frac{V}{R_{AB}} = \frac{VA}{\rho L} = \frac{VA}{\rho L}$$

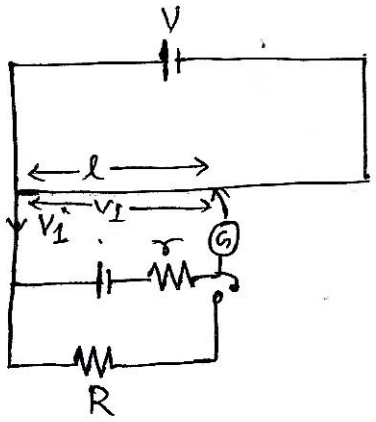
$$V_1 = iR_{AP}$$

$$V_1 = \frac{VA}{\rho L} \cdot \frac{\rho L}{A}$$

$$\boxed{\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}}$$

$$\boxed{E = \frac{l}{L} V}$$

[2]



When swich is open

$$E = \frac{l_0}{L} V \quad \text{—— (1)}$$

When switch is closed

$$i_1 = \frac{E}{R+r} \quad \text{—— (2)}$$

$$V_1 = \frac{l}{L} V$$

$$E - i_1 r = \frac{l}{L} V$$

$$E - \frac{E}{R+r} r = \frac{l}{L} V$$

$$E \frac{R}{R+r} = \frac{l}{L} V \quad \text{—— (3)}$$

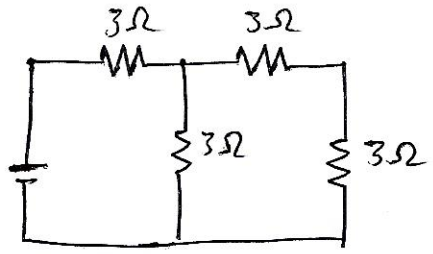
Then

$$\frac{E \frac{R}{R+r}}{E} = \frac{\frac{l}{L} V}{\frac{l_0}{L} V}$$

$$\frac{R+r}{R} = \frac{l_0}{l}$$

$$\boxed{r = R\left(\frac{l_0}{l} - 1\right)}$$

[3]



$$R_1 = \frac{\rho l_1}{A_1}$$

$$R_2 = \rho l_2 / A_2$$

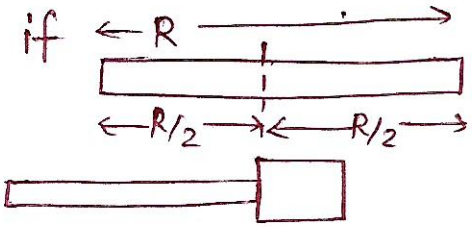
$$\frac{R_2}{R_1} = \frac{\rho l_1}{A_1} \times \frac{A_2}{\rho l_2}$$

$$\frac{R_2}{R_1} = \frac{A_2}{A_1} \times \frac{l_1}{l_2}$$

$$\boxed{\frac{R_2}{R_1} = \left(\frac{l_1}{l_2}\right)^2}$$ ✓

$$\boxed{\frac{R_2}{R_1} = \left(\frac{A_1}{A_2}\right)^2}$$

if

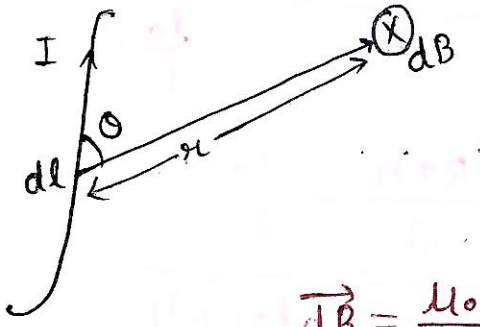


$$R = 4\left(\frac{R}{2}\right) + \frac{1}{4}\left(\frac{R}{2}\right)$$

$$R = 2R + \frac{R}{8}$$

$$R = \frac{17R}{8}$$

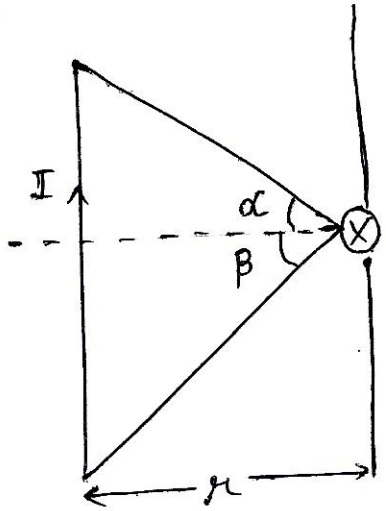
Magnetic Effect of Current-



$$\vec{dB} = \frac{\mu_0}{4\pi} \cdot \frac{I(\vec{dl} \times \vec{r})}{r^3}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\vec{dl} \times \vec{r}}{r^2}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2} \hat{n}$$



$$B = \frac{\mu_0 I}{4\pi r}(\sin\alpha + \sin\beta)$$

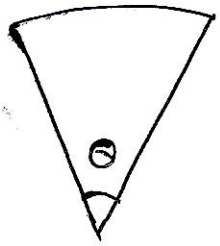
If $\alpha = \beta = 90^\circ$

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

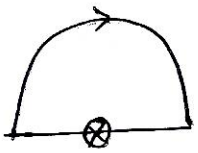
If $\alpha = 90^\circ$

$\beta = 0^\circ$

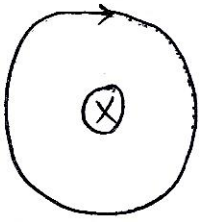
$$B = \frac{\mu_0 I}{4\pi r}$$

If 

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

If 

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

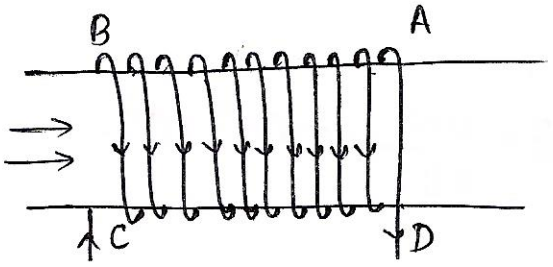
If 

$$B = \frac{\mu_0 I}{2r} \quad \because \theta = 2\pi$$

- Ampere's Law.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{in}$$

Magnetic Field Inside long Solenoid-



$$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{in}$$

$$\int_A^B \vec{B}\cdot\vec{dl} + \int_B^C \vec{B}\cdot\vec{dl} + \int_C^D \vec{B}\cdot\vec{dl} + \int_A^D \vec{B}\cdot\vec{dl} = \mu_0 N I$$

$$0 + 0 + Bl + 0 = \mu_0 N I$$

$$B = \frac{\mu_0 N I}{l}$$

$$n = \frac{N}{l}$$

$$\boxed{B = \mu_0 n I}$$

*Force acting on a current carrying wire placed in a uniform Magnetic Field-

$$d\vec{F} = I\,d\vec{l} \times \vec{B}$$

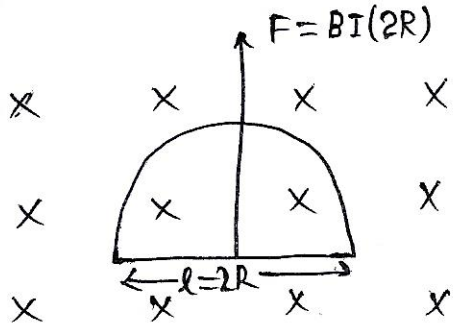
$$\vec{F} = \int d\vec{F}$$

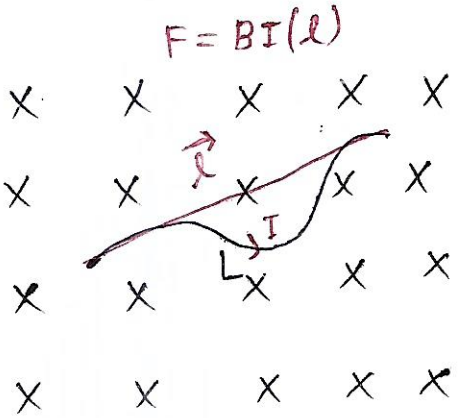
$$\vec{F} = I\int (d\vec{l} \times \vec{B})$$

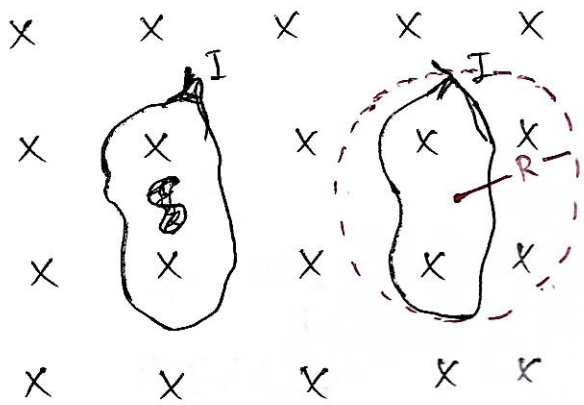
$$\vec{F} = I\int d\vec{l}\,(\vec{B})$$

$$\vec{F} = \vec{B}\,I \times \vec{l}$$

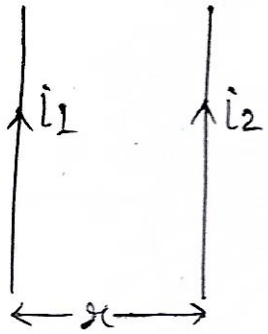
↓ Resultant length Vector





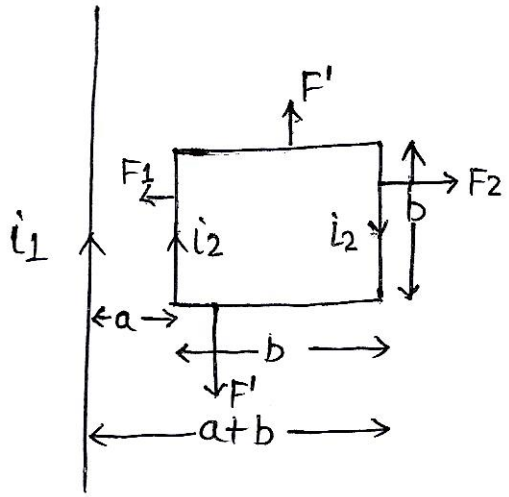


$$T = BIR$$



$$\frac{F}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}$$

Problem-

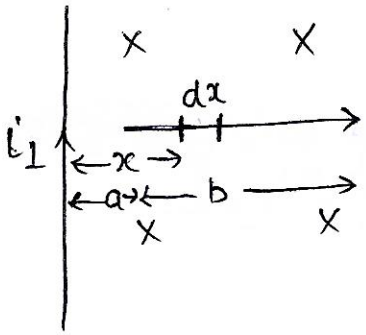


$$F_{net} = F_1 - F_2$$

$$\frac{F_1}{b} = \frac{\mu_0 i_1 i_2}{2\pi a}$$

$$F_1 = \frac{\mu_0 i_1 i_2}{2\pi a} b$$

$$F_2 = \frac{\mu_0 i_1 i_2}{2\pi (a+b)} b$$



$$B = \frac{\mu_0 i_1}{2\pi x}$$

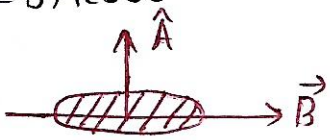
$$dF = i_2 dx\, B = i_2 \frac{\mu_0 i_1}{2\pi x} dx$$

$$\int_0^F dF = \frac{\mu_0 i_1 i_2}{2\pi} \int_a^{a+b} \frac{dx}{x}$$

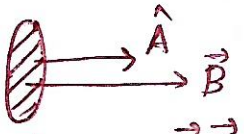
$$\boxed{F = \frac{\mu_0 i_1 i_2}{2\pi} \ln \frac{a+b}{a}}$$

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

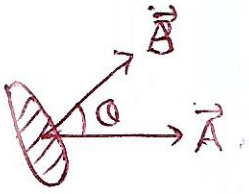
$= BA\cos\theta$



$\phi = 0$

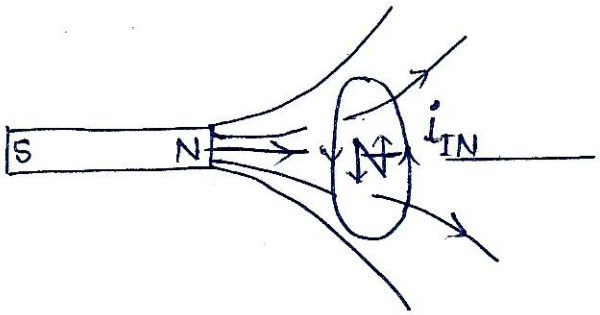


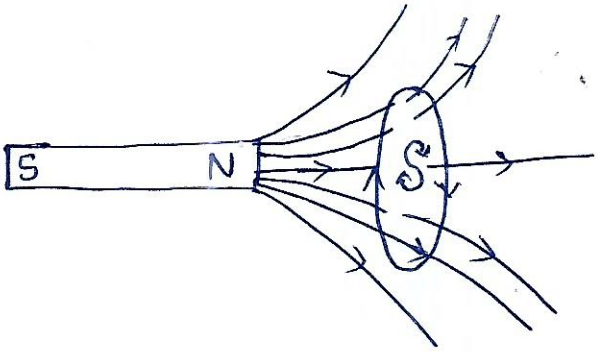
$\phi_{max} = \vec{B}\vec{A}$



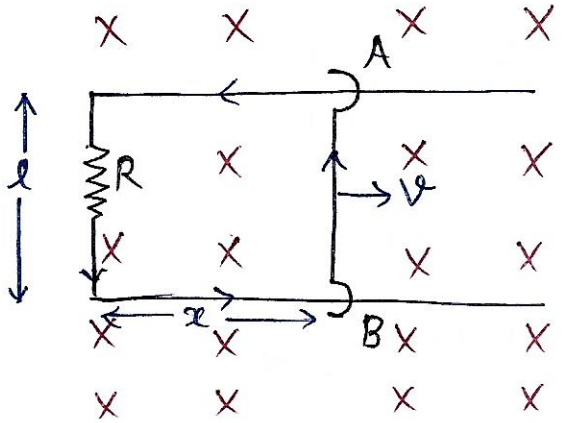
$\phi = BA\cos\theta$

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





Problem -



Find = ?

(i) Inducted Current

(ii) External force needed to move rod AB with uniform Velocity

(iii) Prove Lenz's Law

$\phi = BA$

$\phi = Blx$

$E = \frac{d\phi}{dt}$

$E = \cancel{d}Bl\frac{dx}{dt}$

$\boxed{E = Blv}$

$i = \frac{E}{R} = \frac{Blv}{R}$

$F_{mag} = Bil$

$= B\left(\frac{Blv}{R}\right)l$

$= \frac{B^2l^2v}{R}$

$\vec{F}_{net} = 0, \vec{a} = 0, v = c$

$\vec{F}_{net} + \vec{F}_{ext} = 0$

$\vec{F}_{ext} = -F_{net}$

$\boxed{\vec{F}_{ext} = -\frac{B^2l^2v}{R}}$

(iii) Energy will be conserved.

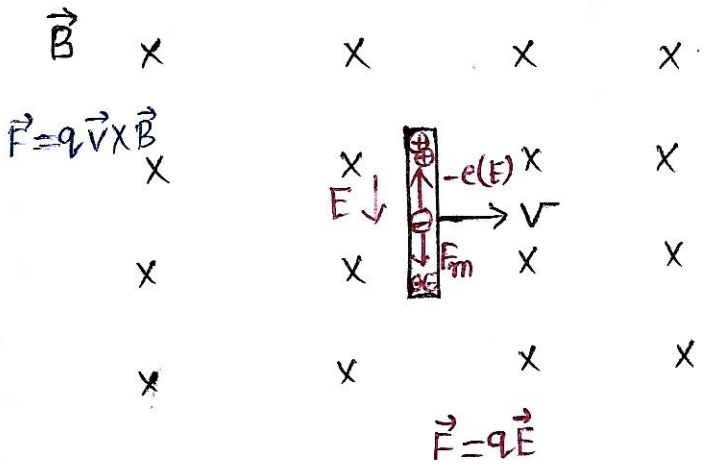
⊗ ↑ or ⊙ ↓

i = Anticlockwise

⊗ ↓ or ⊙ ↑

i = clockwise

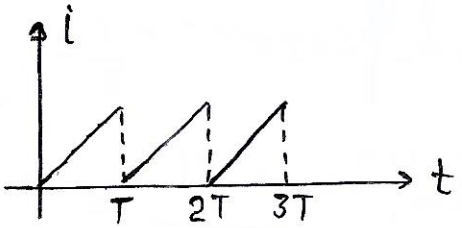
⇒Motional Emf-



Problem⇒ **13. Alternating Current**

$$I_{av} = \frac{\int I\,dt}{\int dt} = \frac{\text{Area Under I-t Curve}}{\text{Total time}}$$

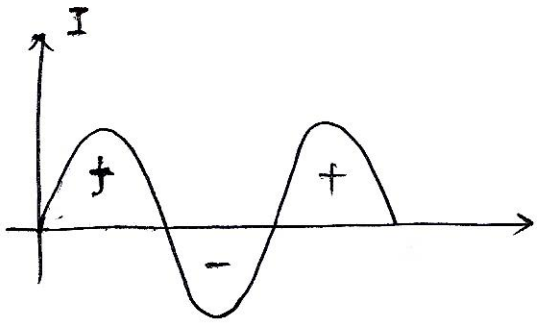
$$I_{av} = \frac{\frac{1}{2} T I}{T} = \frac{I}{2}$$



$$I_{av} = \frac{\int_0^T \frac{I}{T} t\,dt}{T} = \frac{I}{T^2}\int_0^T t\,dt$$

$$I_{av} = \frac{I}{T^2} \times \frac{T^2}{2}$$

$$\boxed{I_{av} = \frac{I}{2}}$$



$$\boxed{I = \frac{2I_0}{\pi}}$$

for triangular wave

$$\boxed{I_{rms} = \frac{I}{\sqrt{3}}}$$

$$H = \int dH$$

$$I^2_{rms} R T = \int i^2 R\,dt$$

$$I^2_{rms} = \frac{\int i^2 dt}{dt}$$

$$\boxed{I_{rms} = \sqrt{\frac{\int I^2 dt}{\int dt}}}$$

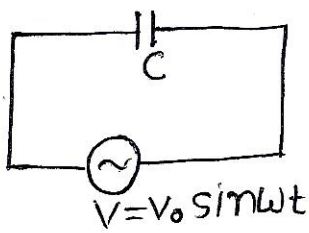
$$P_{av} = \langle VI \rangle = \langle V_0 I_0 \sin^2 \omega t \rangle$$

$$P_{av} = \frac{1}{2} V_0 I_0$$

$$P_{av} = \frac{V_0}{\sqrt{2}} \cdot \frac{I_0}{\sqrt{2}}$$

$$\boxed{P_{av} = V_{rms} \cdot I_{rms}}$$

* AC supply in Capacitor –



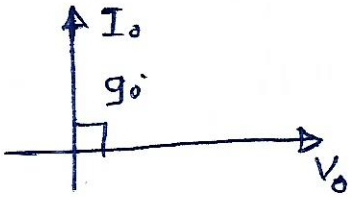
$$q = CV = CV_0 \sin\omega t$$

$$I = \frac{dq}{dt} = \omega V_0 C \sin\omega t$$

$$I = \frac{V_0}{(1/\omega C)} \sin(\omega t + \pi/2)$$

$$I = \frac{V_0}{X_C} \sin(\omega t + \pi/2)$$

$$\boxed{I = I_0 \sin(\omega t + \pi/2)}$$



$$P_{av} = \langle VI \rangle$$

$$P_{av} = \langle V_0 \sin\omega t \; I_0 \sin\omega t \rangle$$

$$P_{av} = \frac{1}{2} V_0 I_0 \langle \sin 2\omega t \rangle$$

$$\boxed{P_{av} = 0}$$

$V_C = IX_C$

$V_L = IX_L$

$V_R = IR$

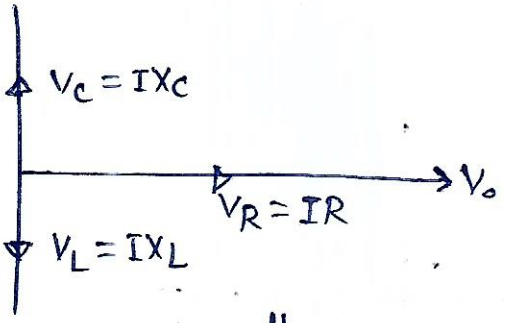
$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{(IR^2) + (IX_L - IX_C)^2} = IZ$$

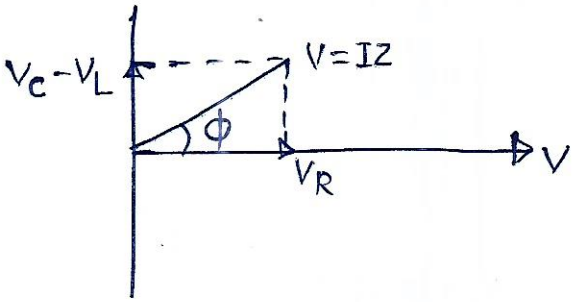
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$Z_{min} = R$

$I = I_{max} = \frac{V}{R}$



⇓ Let $V_C > V_L$



$V_o \sin\omega t = V$

$I = I_o \sin(\omega t \pm \phi)$

$[+\phi] \rightarrow$ When $X_C > X_L$

$[-\phi] \rightarrow$ When $X_C < X_L$

$[0] \rightarrow$ When $X_C = X_L$

$P_{av} = \langle VI \rangle$

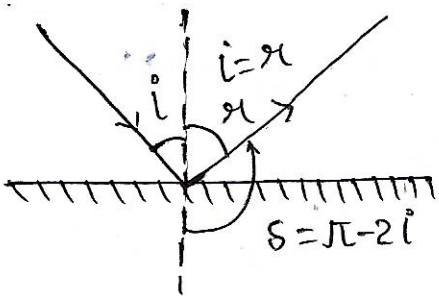
$P_{av} = \langle V_o \sin\omega t \rangle \langle I_o \sin(\omega t + \phi) \rangle$

$P_{av} = V_o I_o \langle \sin\omega t (\sin\omega t \cos\phi \pm \cos\omega \sin\phi) \rangle$

$P_{av} = V_o I_o \cdot \frac{1}{2} \cos\phi$

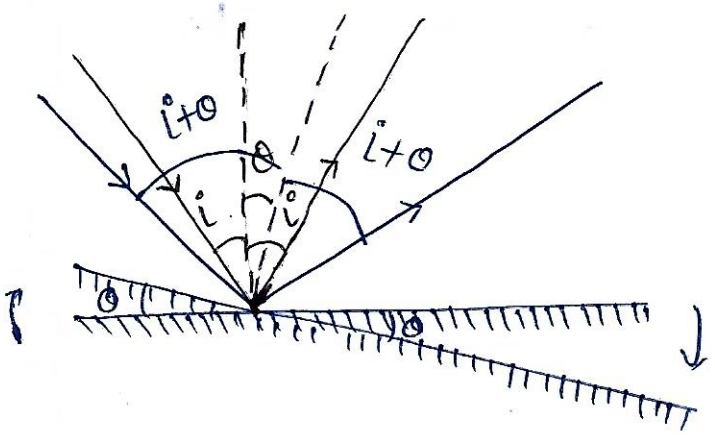
$$\boxed{P_{av} = V_{rms} I_{rms} \cos\phi}$$

14. Ray Optics



$$\boxed{\delta = \pi - 2i}$$

PROBLEM ⇓

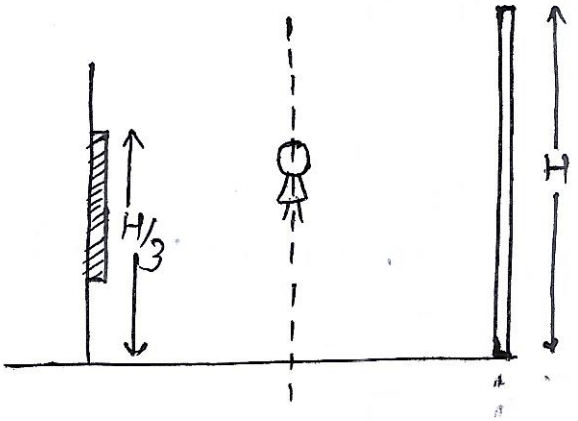


$\Rightarrow 2i + 2\theta$

For Mirror–

$$\frac{I}{f} = \frac{1}{v} + \frac{1}{u}$$

$$m = \frac{v}{u}$$



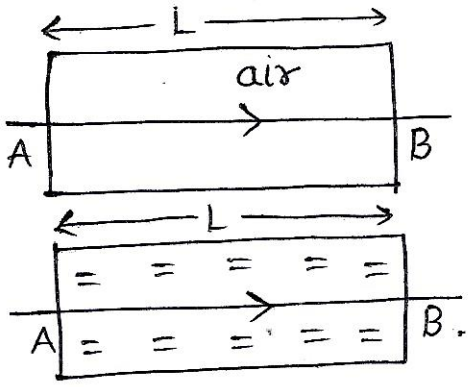
Refraction–

$$\mu = \text{ref-index} = \frac{\text{Velocity of light in vaccum}}{v \text{ of light in medium}}$$

$$\boxed{\mu = \frac{c}{v} \geq 1}$$

$$\left[v = \frac{c}{\mu} \right]$$

• Geometrical and Optical Path length -



$$t' = \frac{L}{v} = \frac{L}{c/\mu}$$

$$t' = \frac{\mu L}{c}$$

$$t' = \mu t$$

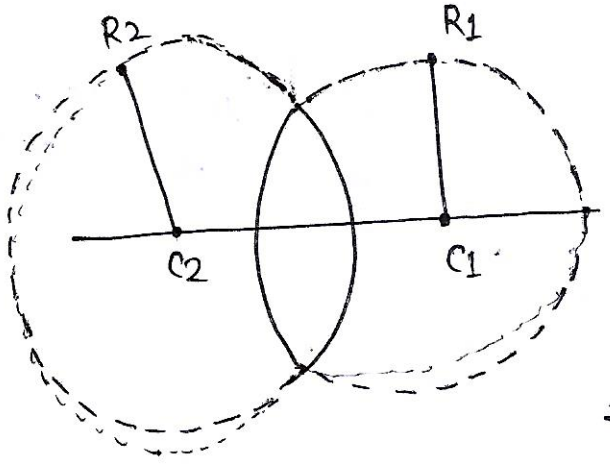
μL = Optical length

L = Geometrical length

Extra length $= \mu L - L$

$= (\mu - 1)L$

• Lens Maker Formula -

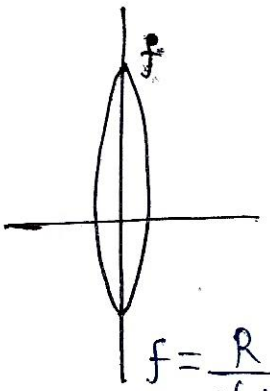


$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

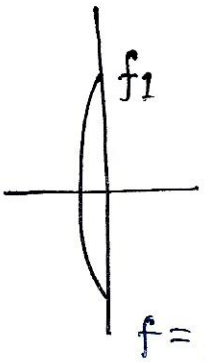
μ = Refractive index of lens material with respect to surrounding

- Biconvex lens.

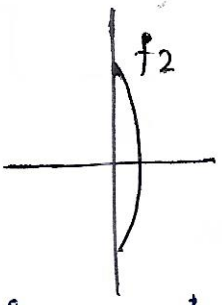
$$f = \frac{R}{2(\mu-1)}$$



$$f = \frac{R}{2(\mu-1)}$$



$$f = \frac{R}{(\mu-1)} = 2f$$

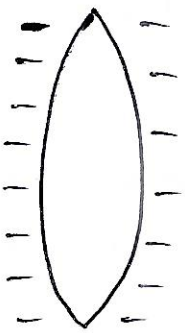


$$\frac{1}{f_2} = \frac{(\mu-1)}{R}$$

- Quailty of Image depends on Apartur.
- Lens in a Medium-

Lens in Air





$$\frac{1}{fa} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{fm} = \left(\frac{\mu_i}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{\frac{1}{fa}}{\frac{1}{fm}} = \frac{(\mu_1-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}{\left(\frac{\mu_i}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

Case I-

$$\left(\frac{\mu_i}{\mu_m} - 1\right) > 0$$

$$\Rightarrow \frac{\mu_i}{\mu_m} > 1$$

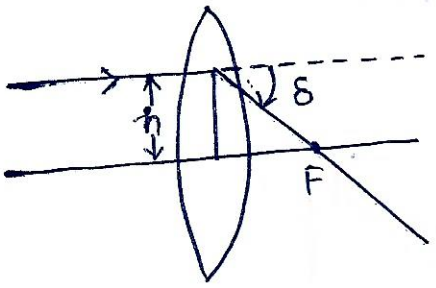
f_a = +ve

f_m = +ve

Converging ability = +ve

- Power of a Lens and Mirror -

1. Power of a Lens -



$$\tan\delta = \frac{h}{F} \quad [\because h = 1]$$

$$\tan\delta = \frac{1}{F}$$

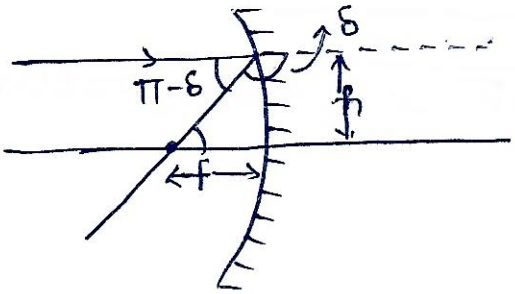
$$\boxed{\delta} = \frac{1}{F}$$

↓

Power

- Sign Convention of Power for Lens and Mirror
  1. Converging ability is (+ve)
  2. Diverging ability is (-ve)

2. Power of Mirror -



$$\tan(\pi - \delta) = \frac{h}{f_m}$$

$$\boxed{P = -\frac{1}{f_m}}$$

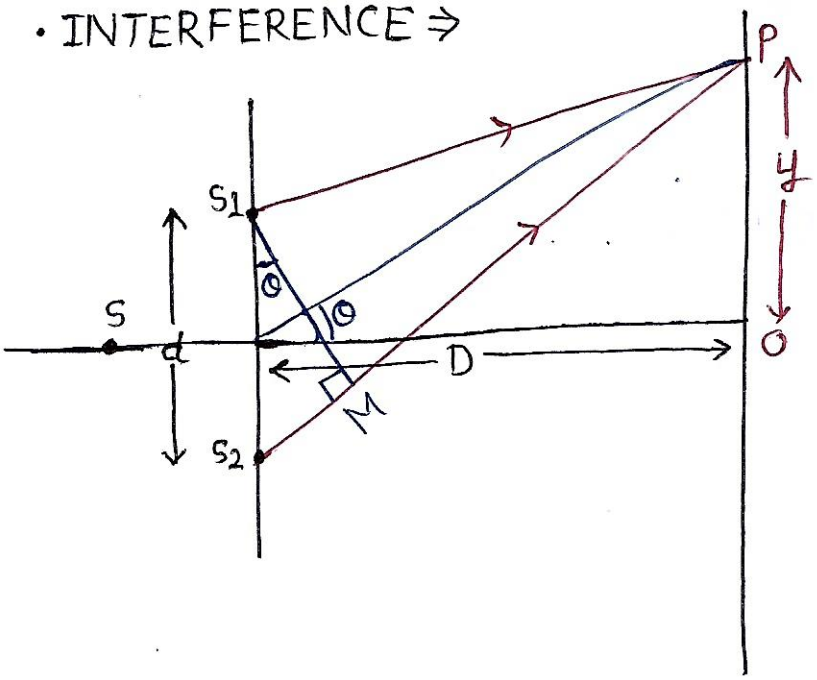
• Refraction at spherical surface-

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

μ_1 = Refractive index of medium
μ_2 = Refractive index of medium from which rays are coming

• Young's double slit Experiment-

• INTERFERENCE ⇒



S ⇒ Point source Placed symmetrically b/w S_1 and S_2.

Path difference $\Delta x = (SS_2 + S_2P) - (SS_1 + S_1P)$

$$\boxed{\Delta x = SS_1 = SS_2}$$

$$\boxed{\Delta x = S_2P - S_1P}$$ for symattrical Path

$$\sin\theta = \frac{S_2M}{S_1S_2} = \frac{S_1M}{d}$$

$S_1M = d\sin\theta$

$$\boxed{\Delta x = d\sin\theta}$$

Assumption for small Angle

$$\sin\theta \approx \tan\theta$$

For const. Interference

$$\Delta x = n\lambda \quad [\because n = 0, 1, 2, 3]$$

$$d\tan\theta = n\lambda$$

$$\frac{dy}{D} = n\lambda$$

↓

Path difference

Position of nth bright fringe

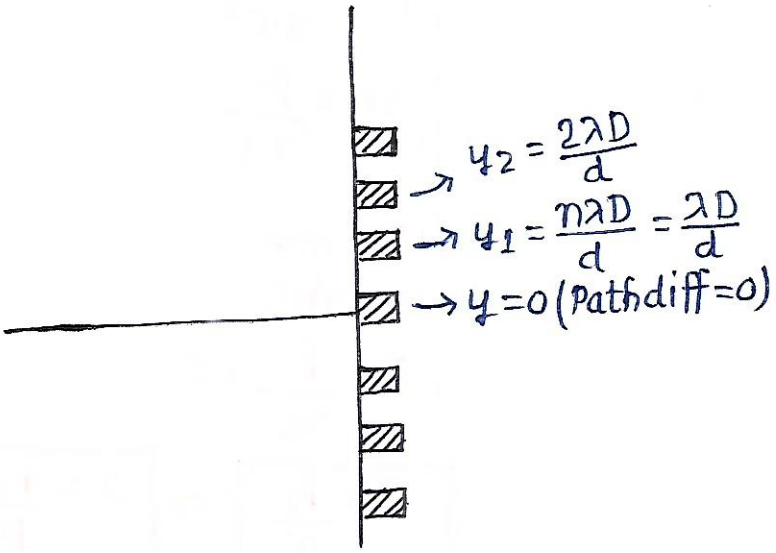
$$y = n\left(\frac{\lambda D}{d}\right)$$

For destructive Interference
(Dark fringe)

$$\Delta x = (2n-1)\frac{\lambda}{2} \quad [n = 1, 2, 3, 4]$$

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

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



Fringe Width (Linear fringe Width) -

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

Fringe Width in a medium -

$$\beta_w = \frac{\lambda_w D}{d}$$

$$\mu = \frac{\lambda_a}{\lambda_w}$$

$$\frac{\beta_w}{\beta_a} = \frac{\lambda_w}{\lambda_a}$$

$$\frac{\beta_w}{\beta_a} = \frac{1}{\mu}$$

$$\boxed{\beta_w = \frac{1}{\mu}\beta_a}$$

15. Modern Physics

- Dual Nature of Radiation and Matter -
  (Electron emission)

*Properties of Photon -

1. Rest mass of Photon always 0 (zero).
2. Speed of Photon (c)
3. Energy of each photon $E = h\nu$
4. $E = mc^2$, $E = h\nu$

$$mc^2 = h\nu$$

$$m = \frac{h\nu}{c^2}$$

$$m = \frac{h\frac{c}{\lambda}}{c^2}$$

$$m = \frac{h}{\lambda \cdot c}$$

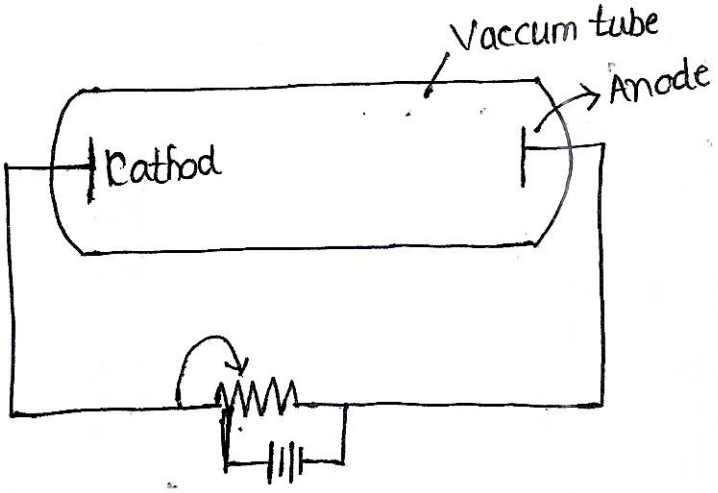
$$p = mv$$

$$p = mc$$

$$p = \frac{h}{\lambda c} \times c$$

$$\boxed{p = \frac{h}{\lambda}} \Rightarrow \boxed{\lambda = \frac{h}{p}}$$

* PHOTOELECTRIC EFFECT -



$h\nu = \phi + E_{kmax}$

$h\nu = \phi + eV_0$ ($V_0 \rightarrow$ stopping Potential)

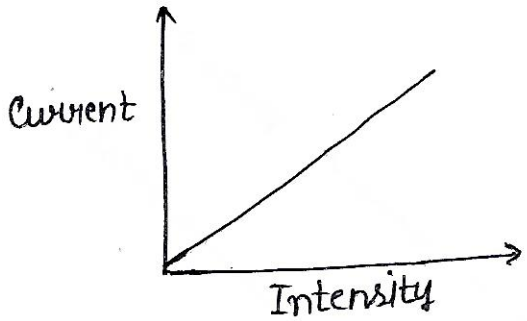
$$\text{Intensity} = \frac{\text{Energy}}{\text{time} \times \text{Area}}$$

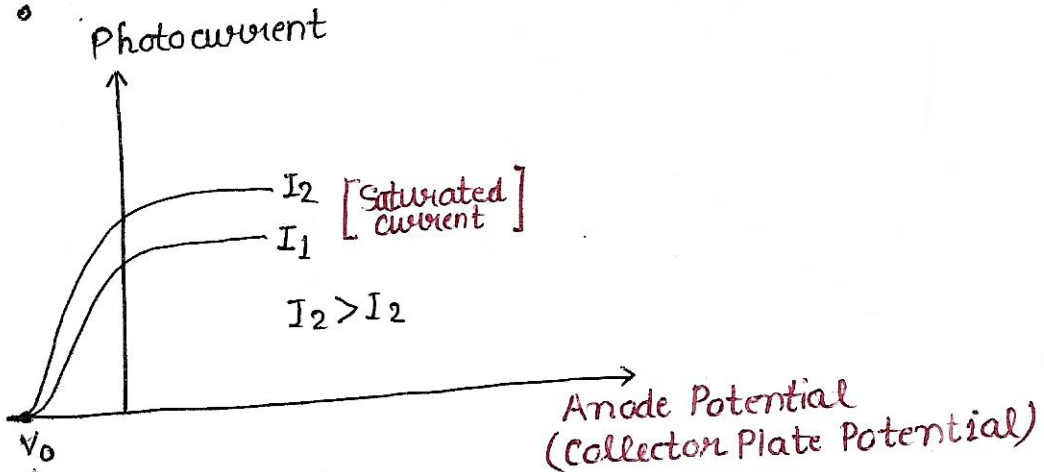
$$= \frac{nh\nu}{t \times \text{Area}}$$

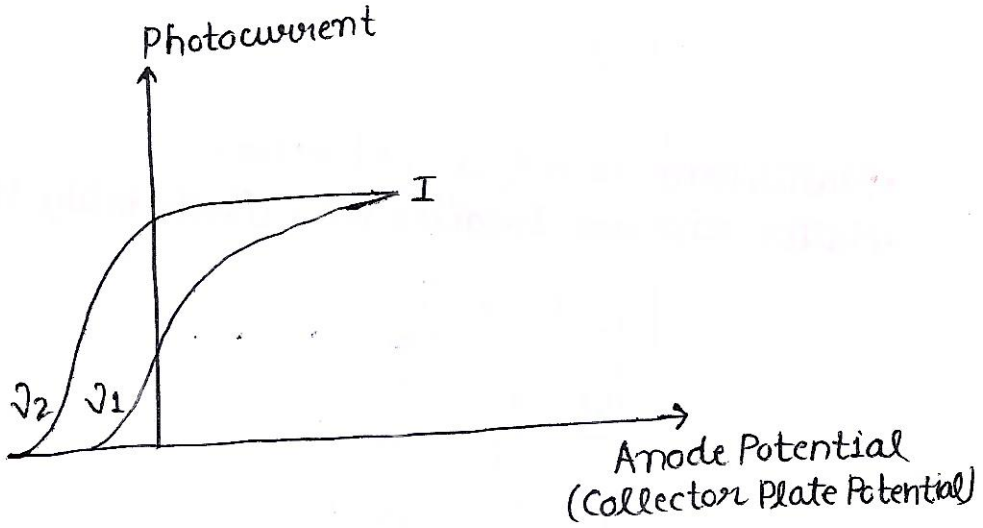
n = no. of Photon

ϕ = Work function

- Intensity and Photo Current Graph-







Graph b/w frequency(ν) and stopping Potential -

$V_0 \longrightarrow y$

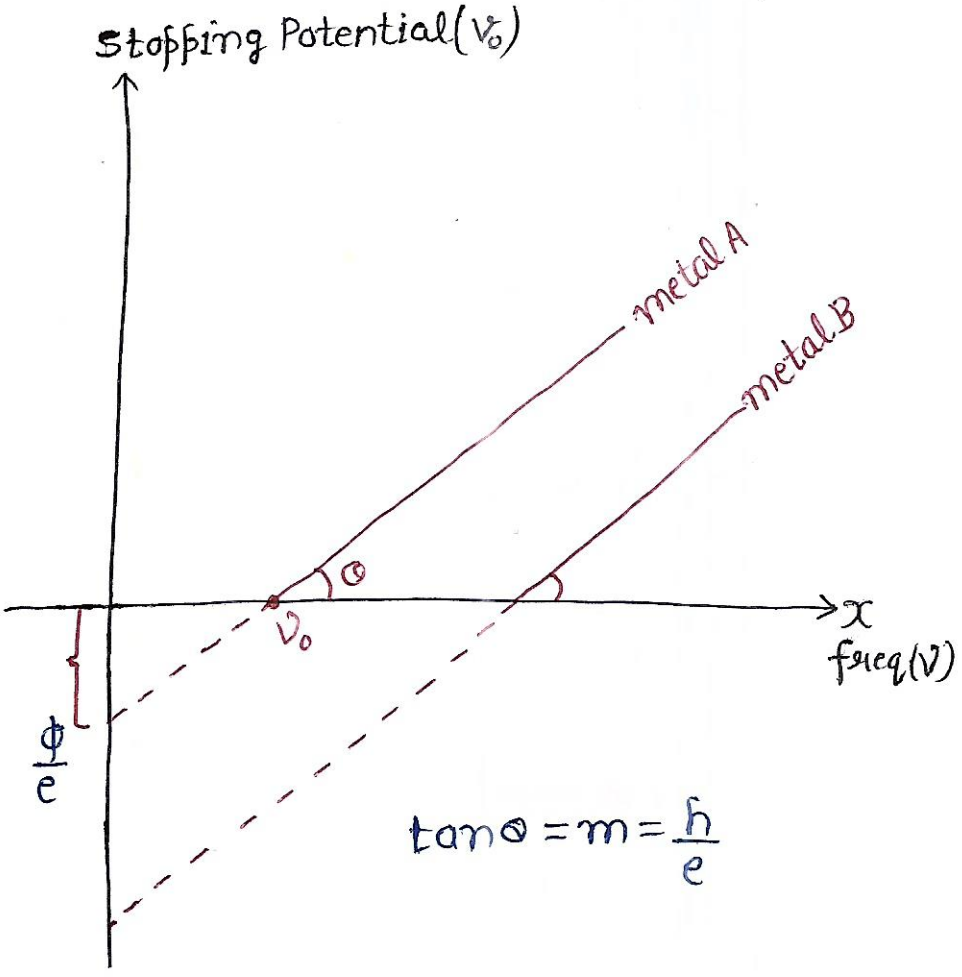
$\nu \longrightarrow x$

$$h\nu = \phi + eV_0$$

$$eV_0 = h\nu - \phi$$

$$V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$$

$$\boxed{y = mx + c}$$



De-Broglie Wave-length(matter wave) -

$$\lambda = \frac{h}{P}$$

- Matter wave is not a EM wave.
- Matter wave are localize wave (Probability Wave)

$$K.E = \frac{P^2}{2m}$$

$$E = \frac{P^2}{2m}$$

$$P = \sqrt{2mE}$$

$$\boxed{\lambda = \frac{h}{\sqrt{2mE}}}$$

(A) Charge Particle is acc. through Potential diff.

$E = qV$

$\lambda \propto \frac{1}{\sqrt{mq}}$ $\quad \lambda = \frac{h}{\sqrt{2mqV}}$

$\frac{\lambda_p}{\lambda_e} = \sqrt{\frac{m_e q_e}{m_p q_p}}$

(B) $\lambda = \frac{h}{\sqrt{2m \times \frac{3}{2} KT}} = \frac{h}{\sqrt{3mKT}}$

*Nucleous-

- size of nucleus-

$$R = R_0 A^{1/3}$$

$R_0 = 1.2$ fermi $= 1.2 \times 10^{-15}$ m

$V \propto A$

A = Mass no.
= Total no. of Nucleus (No. of P + No of N)

- density of nucleus is constant

$$\rho = \frac{m}{V} = \frac{M}{\frac{4}{3}\pi R_0^3 \cdot A}$$

$$\rho = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

$$\boxed{\rho = \frac{m}{\frac{4}{3}\pi R_0^3}}$$

- Binding Energy-

$${}_Z X^A$$

mass defect

$$\Delta m = [Z m_p + (A-Z) m_N - M]$$

M → Mass of nucleus

$$B.E = \Delta m c^2$$

$$B.E = \Delta m \, 931 \text{ MeV}$$

if $\Delta m \rightarrow$ amu

- Stability of a Nucleus $\propto \frac{B.E}{A}$

* Radioactivity –

(1) α - decay –

• heavy Nuclei

$$ {}^{A}_{Z}X \xrightarrow{\alpha\,({}^{4}_{2}He)} {}^{A-4}_{Z-2}X + {}^{4}_{2}He $$

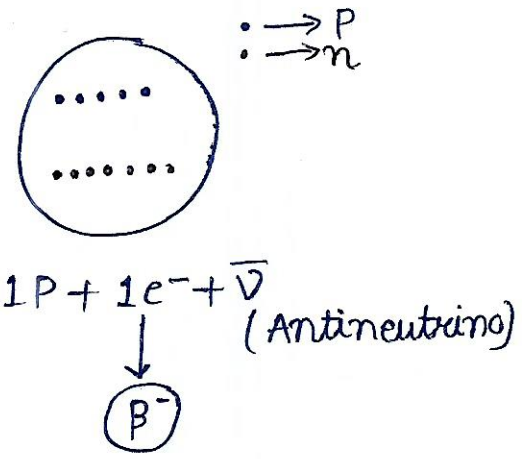
(2) β - decay –

• depends on n/Z

n = no. of Neutron

Z = no. of Proton

CASE I – $\frac{n}{Z} > 1 \Rightarrow n > Z$



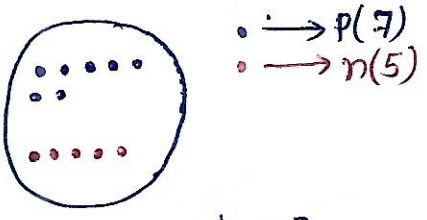
$$ 1n \longrightarrow 1P + 1e^{-} + \bar{\nu} \quad (\text{Antineutrino}) $$

$\downarrow$

β^{-}

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + \beta^{-} $$

CASE II – $\frac{n}{Z} < 1 \Rightarrow n < Z$



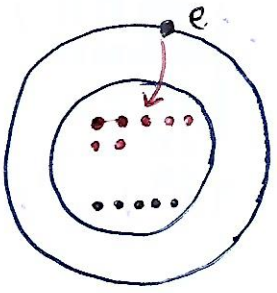
$$ 1P \longrightarrow 1n + 1e^{+} + \nu \quad (\text{neutrino}) $$

$\downarrow$

β^{+}

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + \beta^{+} $$

CASE III- K-Capture



$$1e^- + 1p^+ \longrightarrow 1n$$

$$\boxed{{}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y}$$

(3) γ-decay -

$${}_{27}Co$$

$$\downarrow \beta^-$$

$${}_{28}Ni \text{ (Excited State)}$$

$$\sim\downarrow$$

$${}_{28}Ni \text{ (Ground State)}$$

- Radioactivity is a first order reaction.

$$-\frac{dN}{dt} \propto N$$

$N_0 \rightarrow$ No. of nuclei at $t=0$

$N \rightarrow$ No. of nuclei at any instant time t.

$$\frac{dN}{dt} = -\lambda N$$

$\lambda \rightarrow$ Rate Constant

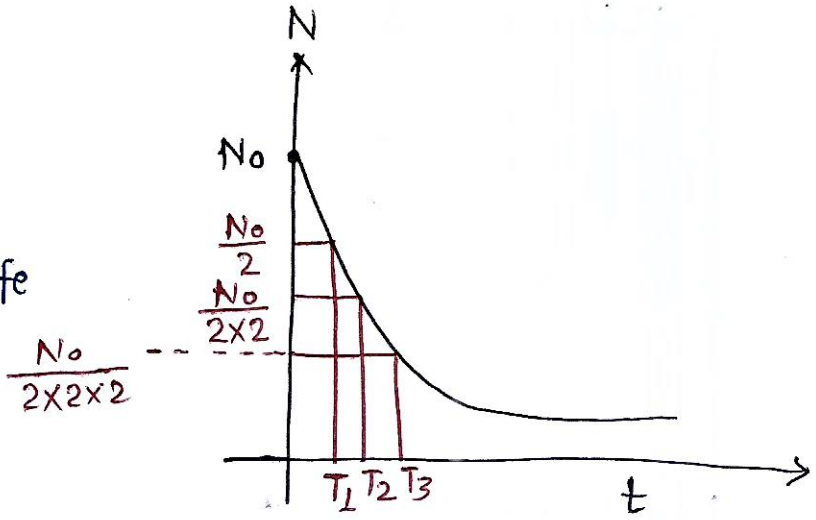
$$\int_{N_0}^{N} \frac{dN}{N} = \int_{0}^{t} -\lambda\, dt$$

$$\log\left(\frac{N}{N_0}\right) = -\lambda t$$

$$\boxed{N = N_0 e^{-\lambda t}}$$

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

$n \rightarrow$ no. of half life



$$T_{1/2} = \frac{0.693}{\lambda}$$

Mean life (Avarage) $= \frac{1}{\lambda}$

$$\tau = \frac{1}{\lambda}$$

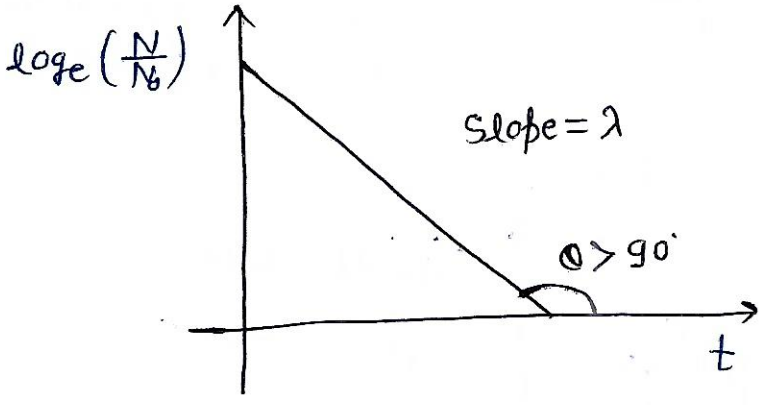
- Graph b/w $\log_e\left(\frac{N}{N_0}\right)$ and time t –

$$N = N_0 e^{-\lambda t}$$

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$\log_e\left(\frac{N}{N_0}\right) = -\lambda t$$

$$y = mx$$



The inverse of slope of $\log_e\left(\frac{N}{N_0}\right)$ vs time Graph give Mean life.

Problem-

A freshly Prepared Radioactive source of half life 2 hrs. emits Radiation of Intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely.

$$t^{1/2} = 6 \text{ hours}$$

$$\frac{N}{N_0} = \frac{1}{64}$$

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

Problem-

Two radioactive material X_1 and X_2 have decay constant 10λ and λ respectively. If initally they have same number of nuclei, then the ratio of the no of nuclei of X_1 to that of X_2 will be $1/e$ after time t. (find t=?)

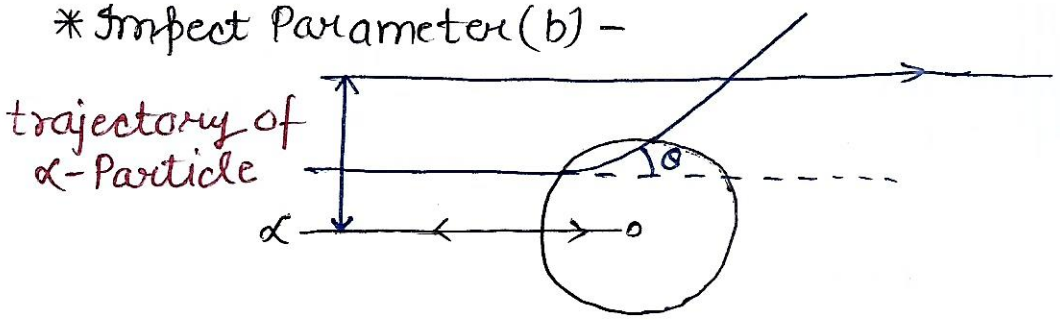
$$\frac{N(X_1)}{N(X_2)} = \frac{N_0 e^{-\lambda t}}{N_0 e^{-10\lambda t}} = \frac{1}{e} = e^{-9\lambda t} = e^{-1}$$

$$9\lambda t = 1$$

$$\boxed{t = \frac{1}{9\lambda}}$$

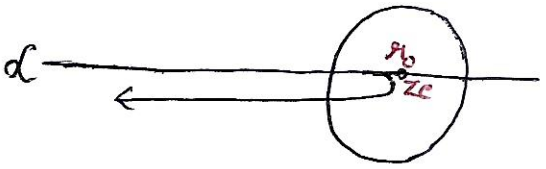
• Atom –

* Impact Parameter (b) –



* distance of closest Approach –

Conservation of Mechanical Energy



$$\frac{Kq_1q_2}{r}$$

$$ME_A = ME_B$$

$$KE = \frac{1}{4\pi\epsilon_0}\frac{(2e)(Ze)}{r_0}$$

$$(2e)(V_0) = \frac{1}{4\pi\epsilon_0}\frac{(2e)(Ze)}{r_0}$$

* Bohr Quantanization –

$$mvr = \frac{nh}{2\pi}$$

$$\lambda = \frac{h}{mv} \quad \text{——(1)}$$

Const. Interference

$$\Delta x = n\lambda$$

$$\Delta 2\pi r = n\lambda \quad \text{——(2)}$$

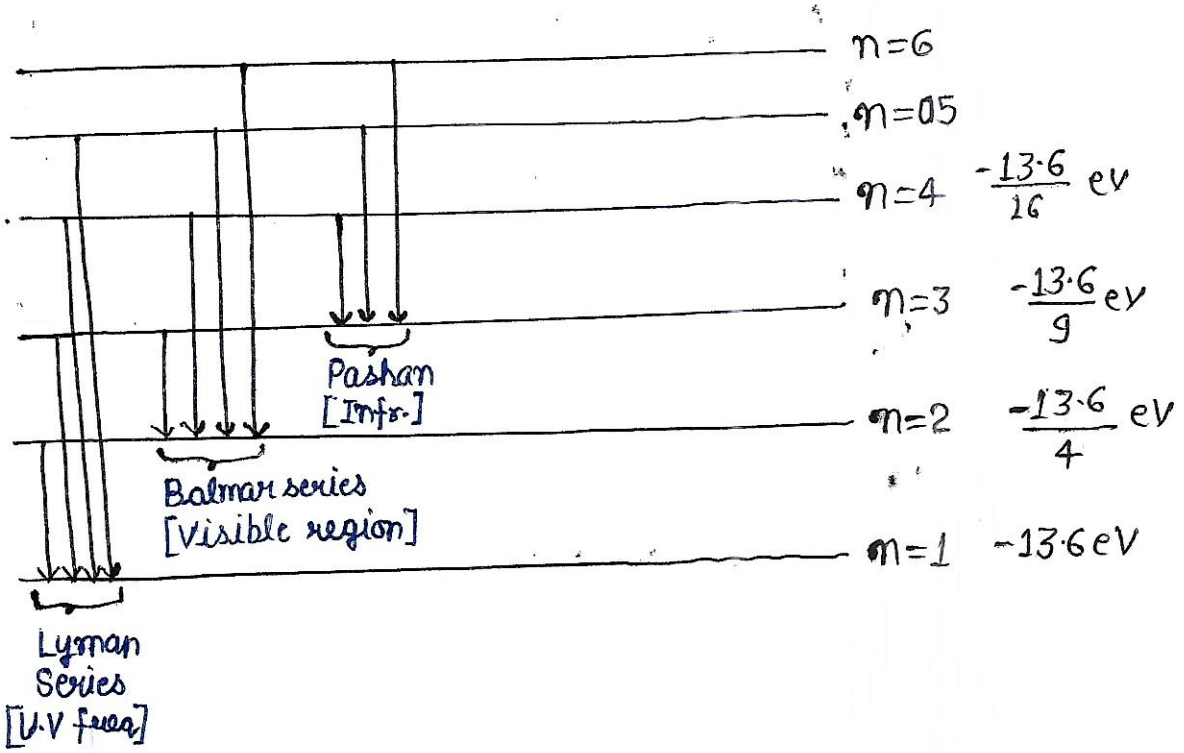
• Bohr quantanization is just applicable for Hydrogen like atoms.

- $v = \left(\frac{c}{137}\right)\left(\frac{Z}{n}\right)$
- $r = 0.537\text{Å}\left(\frac{n^2}{Z}\right)$
- $E = \frac{-13.6\,eV\,Z^2}{n^2}$
- $T = \frac{2\pi r}{v}$ $\quad T \propto \frac{\frac{n^2}{Z}}{\frac{Z}{n}}$

$$\boxed{T = \frac{n^3}{Z^2}}$$

Mechanical Energy = Potential Energy + Kinetic Energy

- SPECTRAL LINE OF H-ATOM-



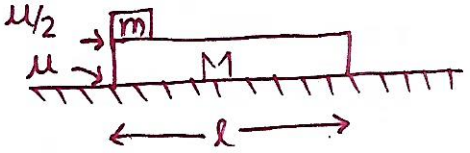
$\lambda_{UV} \Rightarrow ?$

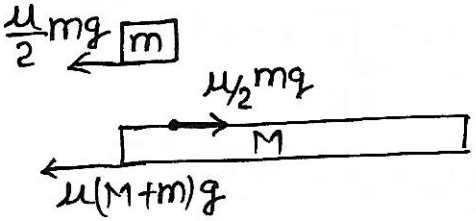
$\lambda_{UV} < 400\,nm$

- $KE_{max} = h\nu - \phi$

$KE_{max} = \frac{hc}{\lambda} - \phi$

Article 1.





$f_u = \frac{\mu}{2} mg$

$f_L = \mu(M+m)g$

$\underleftarrow{a_1} = \frac{\mu g}{2}$

$a_2 = \frac{\mu(M+m)g - \frac{\mu}{2}mg}{M} = \frac{\left(\mu M + \frac{\mu}{2}m\right)g}{M}$

$$\boxed{\underleftarrow{a_2} = \mu g\left(\frac{2M+m}{2M}\right)}$$

$$a_R = \mu g\left[\frac{2M+m}{2M} - \frac{1}{2}\right]$$

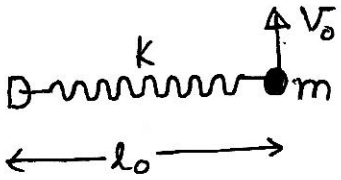
$$a_R = \frac{\mu g}{2}\left[\frac{2M+m-M}{M}\right] = \frac{\mu g}{2}\left[\frac{M+m}{2}\right]$$

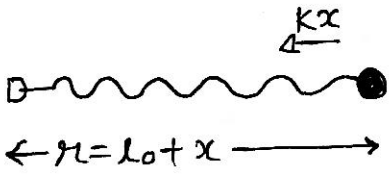
$$S_R = u_R t + \frac{1}{2} a_R t^2$$

$$\ell = \frac{1}{2}\frac{\mu g}{2}\left(\frac{M+m}{M}\right)t^2$$

$$\boxed{t = \sqrt{\frac{4\ell M}{\mu g(M+m)}}}$$

Article 2-





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

$$kx\,r = mv^2$$

$$kx(l_0 + x) = mv^2$$

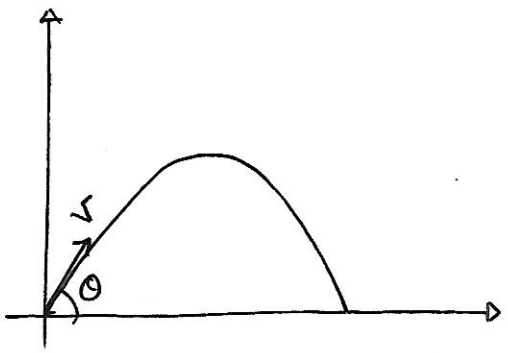
$$kx^2 + kx\,l_0 - mv^2 = 0$$

$$x = \frac{-kl_0 \pm \sqrt{k^2l_0^2 + 4mkv^2}}{2k}$$

$$x = \frac{-kl_0 + \sqrt{k^2l_0^2 + 4mkv^2}}{2k}$$

B. Work, energy and Power

Art 1 -



$$\vec{v}_t = v\cos\theta\,\hat{i} + (v\sin\theta - gt)\hat{j}$$

$$\vec{F} = mg(-\hat{j})$$

$$\Leftrightarrow P = \vec{F}\cdot\vec{v}$$

$$P = -mg(v\sin\theta - gt)$$

$$\boxed{P = mg(gt - v\sin\theta)}$$

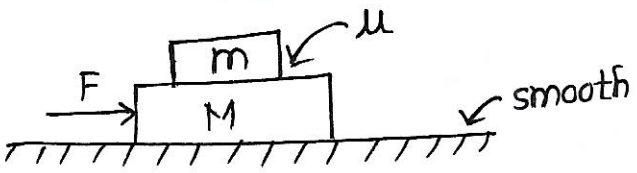
$$P_{av} = \frac{\int_0^T P\,dt}{\int_0^T dt}$$

$$P_{av} = \frac{\int_0^T mg(gt - v\sin\theta)\,dt}{\int_0^T dt}$$

$$P_{av} = \frac{mg\left[\frac{gt}{2} - v\sin\theta\right]_0^T}{T}$$

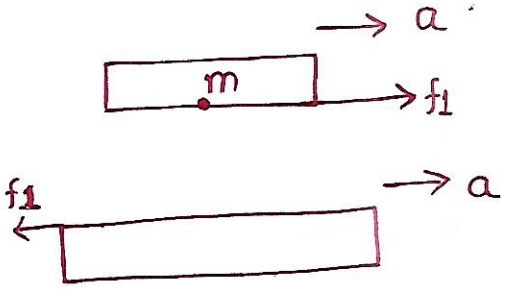
Art 2 -

$$a = \frac{f}{M+m}$$



$$F \leq \mu(M+m)g$$

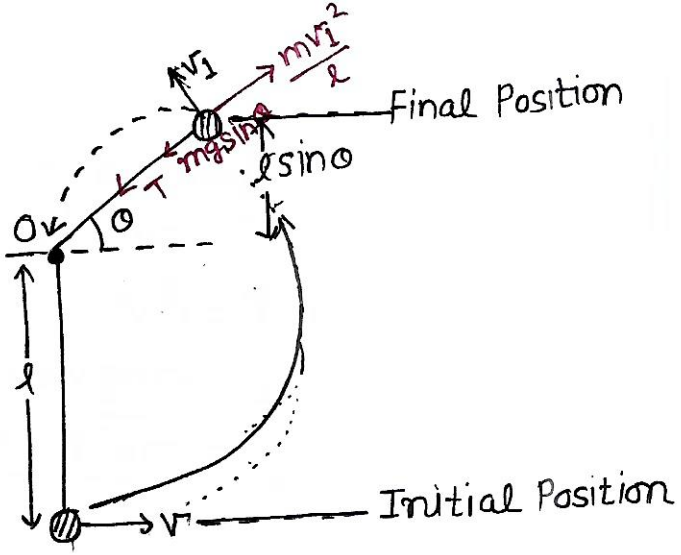
What is the work done by Friction force on small m & M?



$$W_{f_1} = f_1 \frac{1}{2} a t^2 = ma \frac{1}{2} a t^2 = \frac{1}{2} m a^2 t^2$$

$$W_f = -f_1 \frac{1}{2} a t^2$$

Part 3-



$$T = 0$$

$$mg\sin\theta = \frac{mv_1^2}{l}$$

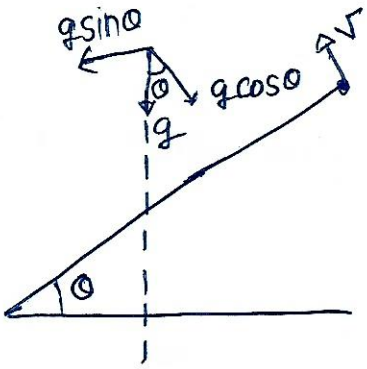
$$v_1 = \sqrt{gl\sin\theta} \quad \text{——(1)}$$

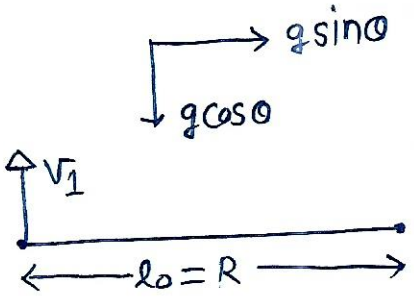
$$(K+V)_i = (K+V)_f$$

$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv_1^2 + mg(l + l\sin\theta)$$

$$v^2 = gl\sin\theta + 2gl + 2gl\sin\theta$$

$$v = \sqrt{gl(2+3\sin\theta)} \quad \text{——(2)}$$





$$T = \frac{2v_1}{g\cos\theta}$$

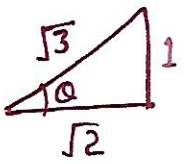
$$R = 0 + \frac{1}{2}g\sin\theta\, T^2$$

$$R = \frac{1}{2}g\sin\theta \times \frac{2v_1}{g\cos\theta} \times \frac{2v_1}{g\cos\theta}$$

$$l = \frac{R\sin\theta}{g\cos^2\theta} \times gl\sin\theta$$

$\cos^2\theta = 2\sin^2\theta$

$\tan\theta = 1/\sqrt{2}$

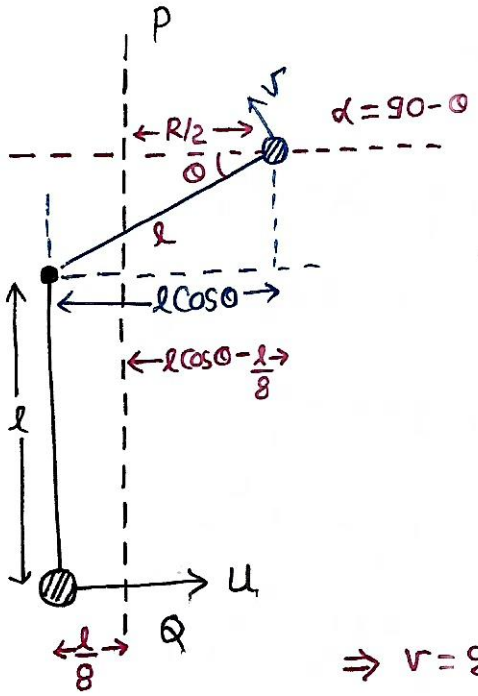


$\sin\theta = \frac{1}{\sqrt{3}}$

Then $v = \sqrt{gl\left(2+\frac{2}{\sqrt{3}}\right)}$

$v = \sqrt{gl\,(2+\sqrt{3})}$

Apt 4-



$\Rightarrow v = \sqrt{gl\sin\theta}$

$$l\cos\theta - \frac{l}{8} = \frac{R}{2} = \frac{1}{2}\frac{v^2 \cdot 2\sin\alpha\cos\alpha}{g}$$

$$l\cos\theta - \frac{l}{8} = \frac{gl\sin\theta}{g}\cos\theta\sin\theta$$

$$\cos\theta - \frac{1}{8} = \cos\theta(1-\cos^2\theta)$$

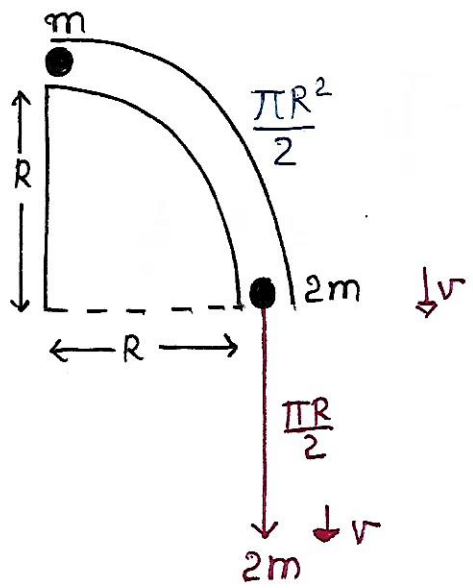
$$\cos\theta - \frac{1}{8} = \cos\theta - \cos^3\theta$$

$$\cos^3\theta = \frac{1}{8}$$

$$\cos\theta = \frac{1}{2}$$

$$\boxed{\theta = 60^\circ}$$

Art 5-



$$(K+V)_i = (K+V)_f$$

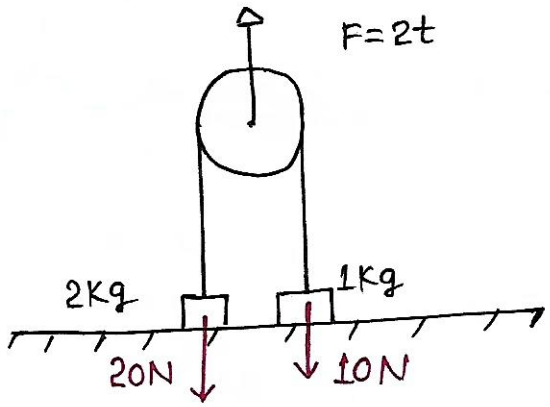
$$mgR = -2mg\frac{\pi R}{2} + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v^2$$

$$gR = g\pi R + \frac{3v^2}{2}$$

$$3v^2 = 2gR + 2g\pi R$$

$$\boxed{v = \sqrt{\frac{2gR(1+\pi)}{3}}}$$

Art 6-





$$t-10 = 1a \quad [10 \le t \le 20]$$

$$t-10 = \frac{dv}{dt}$$

$$\int_0^v dv = \int_{10}^{20} (t-10)\,dt$$

$$v = \left[\frac{t^2}{2} - 10t\right]_{10}^{20} = \left(\frac{400}{2} - 200\right) + 50$$

$$\boxed{v = 50 ms^{-1}}$$

$$\int_0^v dv = \int_{10}^{t} (t-10)\,dt$$

$$v = \left[\frac{t^2}{2} - 10t\right]_{10}^{t} = \frac{t^2}{2} - 100 - 10(t-10) = \frac{t^2}{2} - 50 - 10t + 100$$

$$\frac{ds}{dt} = \frac{t^2}{2} - 10t + 50$$

$$\int_0^S ds = \int_{10}^{20} \frac{t^2}{2} - 10.\int_{10}^{20} t + 50$$

$$\boxed{S = 166.66}$$

- Oblique Collision -



$$v_1 = \left(\frac{m_1 - em_2}{m_1 + m_2}\right) u_1 + \left(\frac{m_2 + em_2}{m_1 + m_2}\right) u_2$$

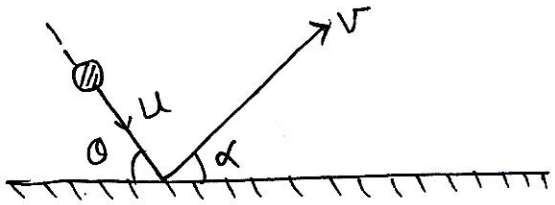
$$v_2 = \left(\frac{m_1 + em_1}{m_1 + m_2}\right) u_1 + \left(\frac{m_2 - em_1}{m_1 + m_2}\right) u_2$$

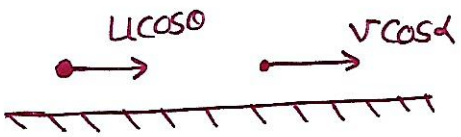
* Linear Momentum is conserved along the plane if $\mu = 0$

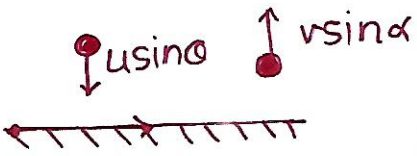
$$e = \frac{\text{Vel. of sepration}}{\text{Vel. of Approach}}$$

* For e i.e. velocity of sepration and velocity of approach should always be taken as ⊥ to the colliding plane.

Art 7-







$$e = \frac{v\sin\alpha}{u\sin\theta}$$

$$mu\cos\theta = mv\cos\alpha$$

$$v\cos\alpha = u\cos\theta \quad \text{—(1)}$$

$$v\sin\alpha = eu\sin\theta$$

$(1)^2 + (2)^2$

$$\boxed{v = u\sqrt{\cos^2\theta + e^2\sin^2\theta}}$$

$(2)/(1)$

$$\boxed{\tan\alpha = e\tan\theta}$$

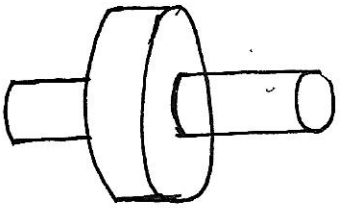
For Horizontal Angle-

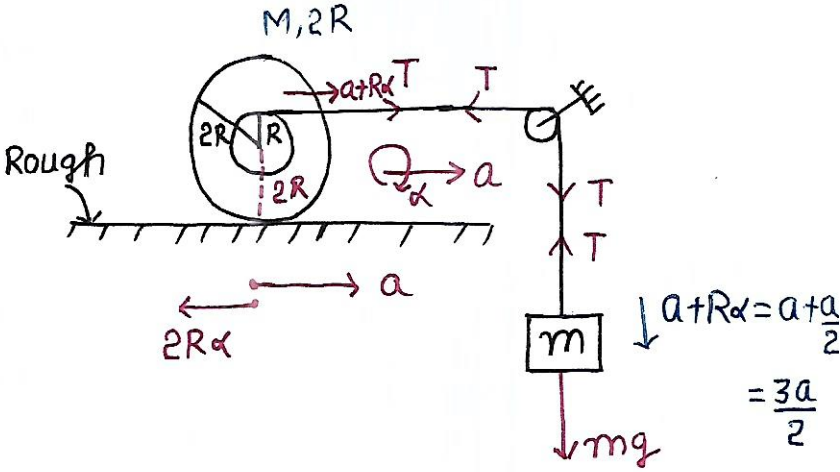
$$\boxed{v = u\sqrt{e^2\cos^2\theta + \sin^2\theta}}$$

$$\boxed{\tan\alpha = \frac{\tan\theta}{e}}$$

C. Angular Momentum

Art 1.-





$a = R \cdot 2\alpha$ ——— (1)

$T - f = Ma$ ——— (3)

$mg - T = m\frac{3a}{2}$ ——— (2)

$f2R + TR = I\alpha$

$(2f + T)R = \frac{1}{2}m(2R)^2 \times \frac{a}{2R}$

$2f + T = Ma$ ——— (4)

③ × 2

$2T - 2f = 2Ma$

$2f + T = Ma$

$3T = 3Ma$

$\boxed{T = Ma}$

$\Rightarrow \left[a = \frac{2mg}{3m + 2M}\right]$

Art 2--

- $N = F + mg$
- $\vec{F}_{net} = \frac{d\vec{p}}{dt}$

  if $\vec{F}_{net} = 0$, $d\vec{p} = 0$

  $\vec{p}$ = Constant

} Conservation of Linear Momentum

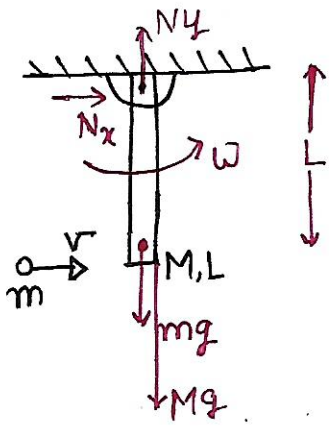
- $\vec{\tau}_{net} = \frac{d\vec{L}}{dt}$

  if $\vec{\tau}_{net} = 0$ $\quad d\vec{L} = 0$

  $\vec{L}$ = constant

} Conservation of Angular momentum

Art 3-



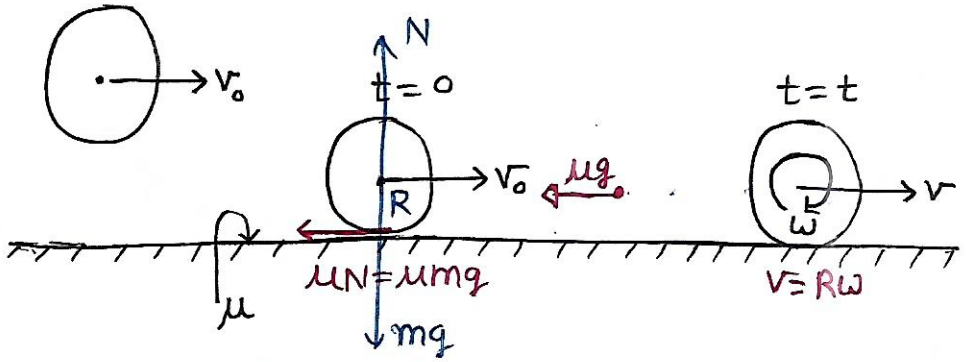
$L_i = L_f$

$mvL = I_0\omega$

$mvL = \left(\frac{1}{3}ML^2 + mL^2\right)\omega$

$$\omega = \frac{3mv}{(M+3m)L}$$

Art 4-



$v = u + at$

$v = v_0 - gt$ ——(1)

$(L_c)_i = (L_c)_f$

$\vec{mv_0R} = \vec{mvR} + \vec{I_0\omega}$

$mv_0R = mvR + \frac{1}{2}mR^2$

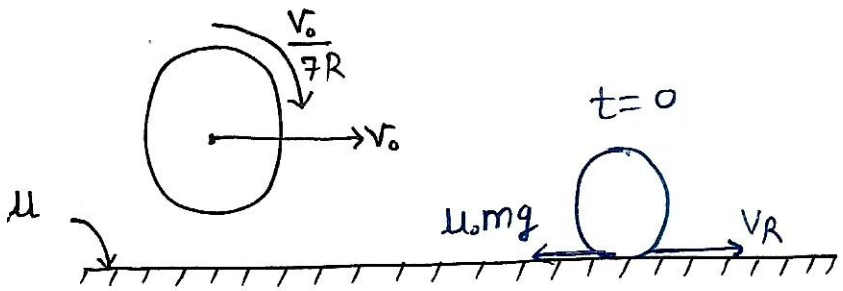
$$\frac{2v^\circ}{3} = v_0 - \mu g t$$

$$\boxed{t = \frac{v_0}{3\mu g}}$$

$$v_0 = \frac{3v}{2}$$

$$\boxed{v = \frac{2v_0}{3}}$$

Art 5-



$t = 0$

$$\omega = \frac{v_0}{7R}$$

$$v = v_0 - \mu g t \quad \text{—— (1)}$$

$$(mv_0 R) + I_0\omega_0 = mvR + I\omega$$

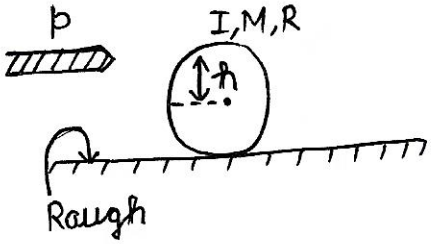
$$mv_0 R + \frac{1}{2}mR^2 \cdot \frac{v_0}{7R} = mvR + \frac{1}{2}mR^2\frac{v}{R}$$

$$v_0 + \frac{v_0}{14} = v + \frac{v}{2}$$

$$\frac{15v_0}{14} = \frac{3v}{2}$$

$$\boxed{v = \frac{5v_0}{7}}$$

Art 6-



$\boxed{I \doteq MR}$

Linear Impulse

$$p = mv - 0$$

$$p = mv \quad \text{—— (1)}$$

Angular Impulse

$$ph = I_0\omega$$

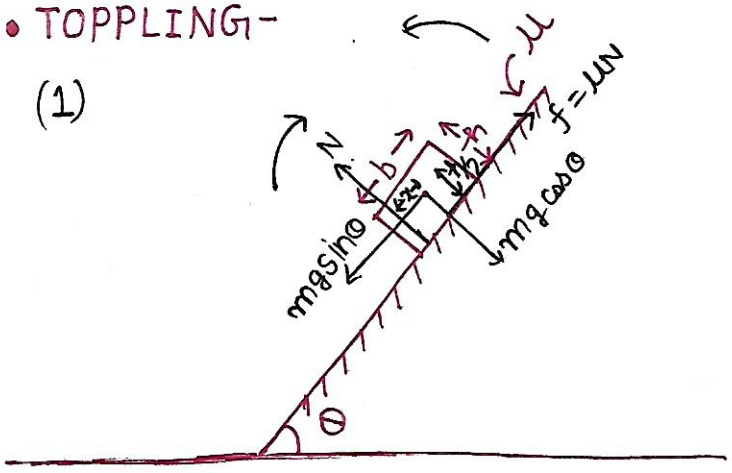
$$mvh = I_0\frac{v}{R}$$

$$h = \frac{I_o}{MR}$$

- $\frac{2}{5}R \Rightarrow$ S.S
- $\frac{2}{3}R \Rightarrow$ H.S
- $\frac{1}{2}R \Rightarrow$ Disc
- $R \Rightarrow$ Ring

- TOPPLING-

(1)



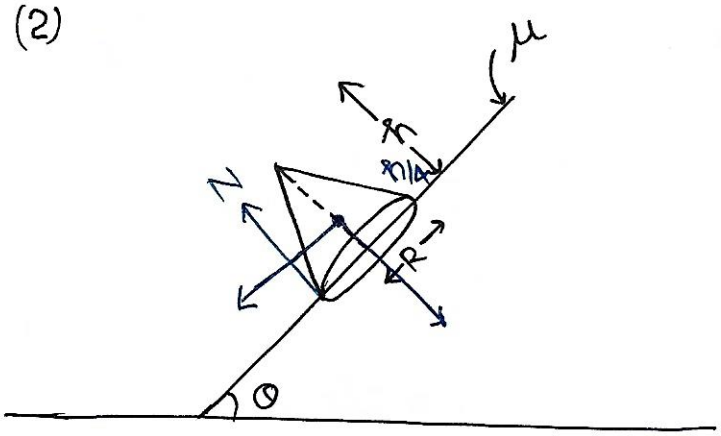
$$\Sigma \tau_o = 0$$

$$Nx = (\mu N)\frac{h}{2}$$

$$x = \frac{\mu h}{2} \leq \frac{b}{2}$$

$$\boxed{\mu \leq \frac{b}{h}}$$

(2)

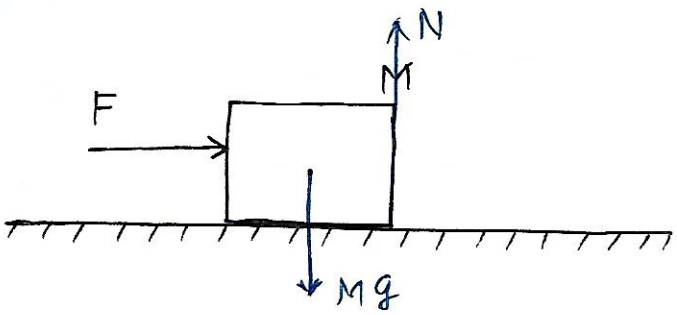


$$NR = \mu N \frac{h}{4}$$

$$\mu \leq \frac{4R}{h}$$

$$\boxed{\tan\theta \leq \mu \leq \frac{4R}{h}}$$

(3)

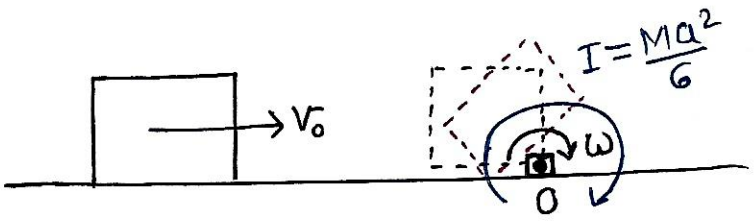


$$\Sigma \tau = 0$$

$$f(N) = mg\frac{h}{2}$$

$$\boxed{f = \frac{mg}{2}}$$

(4)



$$I_o = I_{cm} + m\left(\frac{a}{\sqrt{2}}\right)^2$$

$$I_o = \frac{Ma^2}{6} + \frac{Ma^2}{2}$$

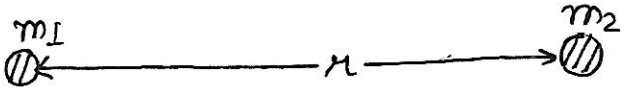
$$I_o = \frac{2}{3}Ma^2$$

$$mv_0\frac{a}{2} = I_o\omega$$

$$mv_0\frac{a}{2} = \frac{2}{3}ma^2\omega$$

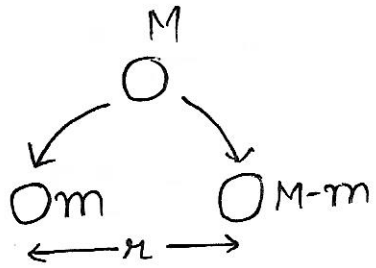
$$\boxed{\omega = \frac{3V_0}{4a}}$$

D. Gravitation + Mechanics of solids & Fluids



$$F = G\frac{m_1 m_2}{r^2}$$

* Point Masses only



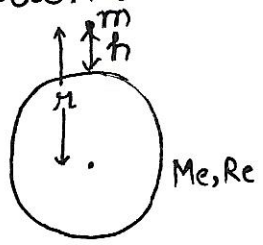
$$F = \frac{Gm(M-m)}{r^2}$$

$F = F_{max} = ?$

$m = M - m$

$$\frac{m}{M} = \frac{1}{2}$$

Acceleration due to gravity -



$$g = \frac{GMe}{r^2} = \frac{GMe}{(Re+h)^2} = \frac{GMe}{Re^2\left(1+\frac{h}{Re}\right)^2} = \frac{g_0}{\left(1+\frac{h}{Re}\right)^2}$$

$[\because r \geq Re]$

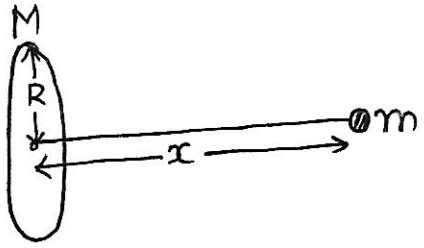
When $h \ll Re$

$$g = g_0\left(1+\frac{h}{2Re}\right)$$

$$g = \frac{g_0}{\left(1-\frac{h}{Re}\right)^2} \quad [\because Re \ll Re \geq r]$$

$$\underbrace{\text{Acceleration due to gravity}}_{\text{Earth}} = \underbrace{\text{Gravitational field}}_{\text{For any other mass}}$$

$$g = E = \frac{F}{m} = \frac{Gm}{r^2}$$



$$E = \frac{GMx}{(R^2+x^2)^{3/2}}$$

$$F = -mE$$

$$F = -\frac{GMmx}{(R^2+x^2)^{3/2}}$$

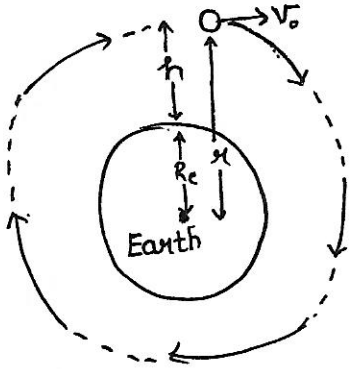
if $x \ll\ll R$

$$x^2 + R^2 = R^2$$

$$F = -\frac{GMmx}{R^3}$$

* Motion of setellite -

☆ Energy is always conserved.



$$E = -\frac{GMem}{2r}$$

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

$$K = \frac{1}{2}mv_0^2 = \frac{GMem}{2r}$$

$$U = -\frac{GMem}{r} = -2K$$

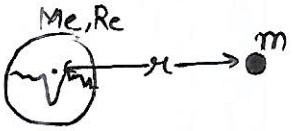
$$E = K + U$$

$$E = -K = \frac{U}{2}$$

$$\frac{GMem}{r^2} = \frac{mv_0^2}{r}$$

$$\boxed{v_0 = \sqrt{\frac{GMe}{r}}}$$

$$\boxed{T = \frac{2\pi r}{v_0} = 2\pi\sqrt{\frac{r^3}{GMe}}}$$



$$U = -\frac{GMem}{r}, \quad r \geq Re$$

When $r < Re$

$$U = -\frac{GMem}{2Re^3}(3Re^2 - r^2)$$

At $r = Re$

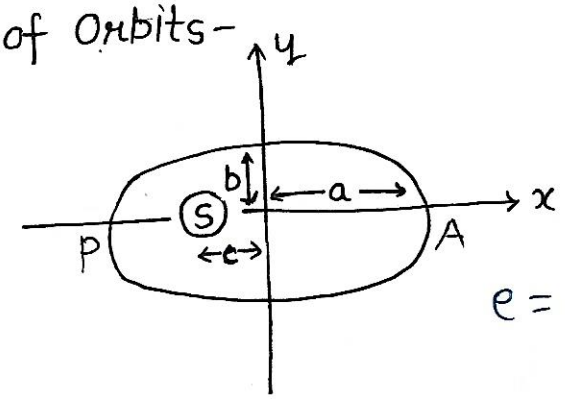
$$U = -\frac{GMem}{Re}$$

At $r = 0$ (centre)

$$U = -\frac{3}{2}\frac{GMem}{Re} = -1.5\,\frac{GMem}{Re}$$

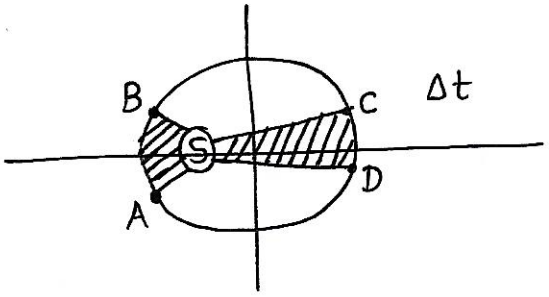
Kepler's Law-

✡ Law of Orbits-



$$e = \frac{c}{a}$$

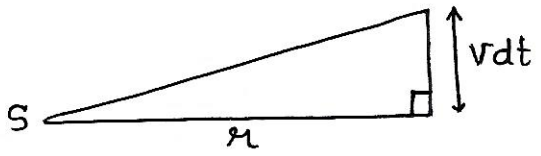
✡ Law of Area-



P → Perigue
A → Apogue

In Δt times

$$Ar[SAB] = Ar[SCD]$$



$$dA = \frac{1}{2} r v dt$$

$$\frac{dA}{dt} = \frac{1}{2} rv = c$$

$$\frac{dA}{dt} = \frac{mvr}{2m}$$

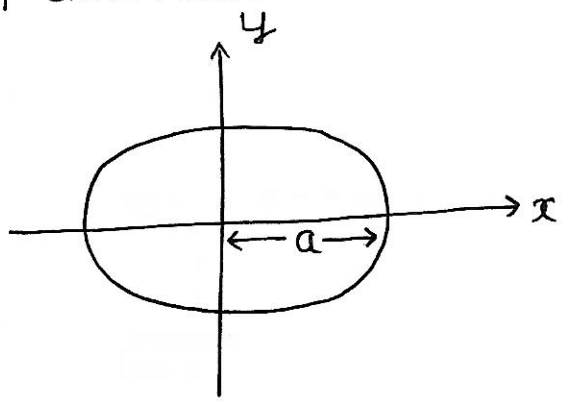
$$\frac{dA}{dt} = \frac{L}{2m} = c$$

$$L = c$$

$vr = c$

$$\boxed{v \propto \frac{1}{r}}$$

✡ Law of time Period-



$$T^2 \propto a^3$$

$$\frac{V_a}{V_p} = \frac{1-e}{1+e}$$

$$\boxed{\frac{V_p}{V_a} = \frac{1+e}{1-e}}$$

Elasticity

$$Y = \frac{F/A}{\Delta l/l} \qquad \eta = \frac{F/A}{\theta} \qquad B = \frac{-\Delta P}{\frac{\Delta V}{V}}$$

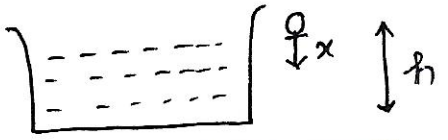
$$\boxed{\frac{9}{Y} = \frac{3}{\eta} + \frac{1}{B}}$$

Relation

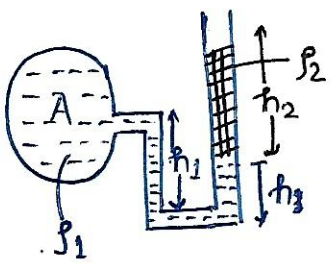
- $B_{Force} = B_{stress} \times Area$

✡ Fluids Statics -

- Pascal's Law-



$$\boxed{P = \rho g h}$$



$$P_A + \rho_1 g h_1 - \rho_2 g h_2 = P_0$$

E. Electricity and Magnetism

• ऊर्जा जो हल्की वस्तु को अपनी ओर आकर्षित करे, Electricity होती है।

Frictional Electricity → Electrified → charge

↓

Electrostatics
(r=0)

charge
(+ve) (-ve)

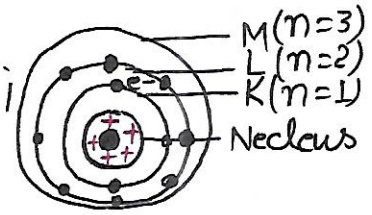
⇒Like charges deattract each other
⇒Different charges attaract each other.

• Modern e⁻ Theory -

Atom

Proton	Neutron	Electron
p	n	e
(+ve) charge	No charge	(-ve) charge
Radarford	chedwich	J.J. Thomson
$e^+ = 1.6 \times 10^{-19} C$	$q = 0$	$-e = -1.6 \times 10^{-19} C$
[in the Necleus]		Revolve in the Orbits
Basic Particles		Called K,L,M,N,O,P....

• किसी वस्तु के विद्युतीकरण के लिए e⁻ ही उत्तरदायी होते हैं।



• Conservation of Charge -

"आवेश न तो उत्पन्न हो सकता है और न ही नष्ट।"

charge is a scalar quantity

$$q = \pm(q_1 + q_2 + q_3 + q_4)$$

इलेक्ट्रान पर ठीक बराबर किन्तु विपरित आवेश होता है।

$q = \pm ne$

q = charge on the body

$e = 1.6 \times 10^{-19} C$

n = No. of e^-

$F = G\frac{m_1 m_2}{r^2}$

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

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

$m_n = 1.674 \times 10^{-27}$ kg

$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N m^2/C^2$

Linear charge density - $\lambda = \frac{q}{l}$

Surface charge desity - $\sigma = \frac{q}{A}$

Volume charge deniity $P = \frac{q}{V}$

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

$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$

$P = q \times 2l$

- वैद्युत द्विध्रुव के कारण किसी बिंदु पर वैद्युत क्षेत्र की तीव्रता-

(i) अक्षीय स्थिति-

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{2P}{r^3}$$

(ii) निरक्षीय स्थिति-

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{P}{r^3}$$

(iii) किसी भी स्थिति के लिए-

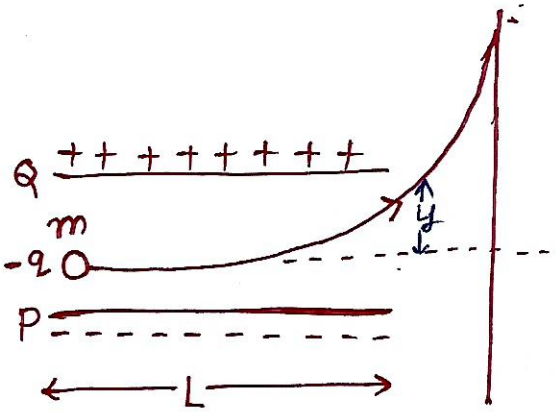
$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{P}{r^3} \sqrt{1+3\cos^2\theta}$$

$$\alpha = \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$$

- समरूप वैद्युत क्षेत्र में वैद्युत द्विध्रुव पर बल और बल आघूर्ण-

$$T = PE\sin\theta$$

$$F = q\Delta E$$



Prove-

$$y = \frac{qEL^2}{2mv_x^2}$$

समय = $\frac{\text{दूरी}}{\text{चाल}}$

$$t = \frac{L}{v_x}$$

$F = ma$

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

$F = -qE$

$a = \frac{-qE}{m}$

$$s = ut + \frac{1}{2}at^2$$

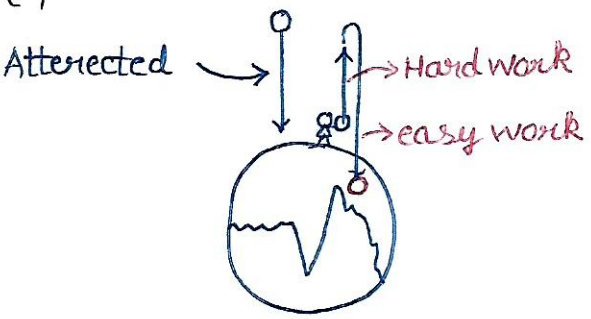
$$s = 0 + \frac{1}{2}\left[\frac{-qE}{m}\right]\left[\frac{L}{v_x}\right]^2$$

$$\boxed{s = \frac{qEL^2}{2mv_x^2}}$$

- escape velocity doesn't depend on Angle.

F. गुरुत्वाकर्षण (Gravitation)

- सभी वस्तुएं पृथ्वी की ओर आकर्षित होती हैं।
- सभी पिण्ड, चाहे वह किसी भी द्रव्यमान का हो, एकसमान त्वरण से पृथ्वी की ओर आकर्षित होता है।

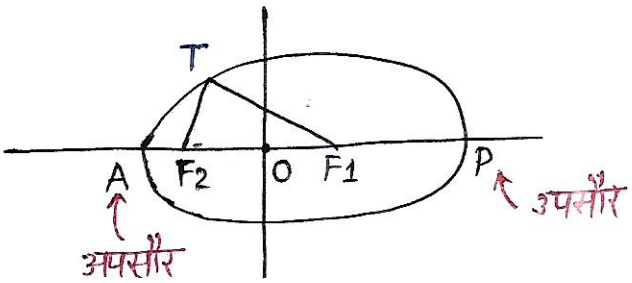


{ Escape velocity (पलायन वेग) doesn't depend on Angle ϕ.

- सभी पिण्ड सूर्य के परित वृत्तीय (Eliptical) गति करते हैं।

केप्लर के ग्रहों की गति के नियम-

1. कक्षाओं का नियम-
   सभी ग्रह दीर्घवृत्तीय कक्षाओं में गति करते हैं।



2. क्षेत्रफलों का नियम-
   - सूर्य के निकट ग्रहों की गति तीव्र होती है।
   - सूर्य से अधिक दूरी पर ग्रहों की गति मंद होती है।

3. आवर्त कालों का नियम-

$$T^2 \propto r^3$$

- अगर सूर्य के परित कोई ग्रह दीर्घवृत्तीय गति को छोड़कर वृत्तीय गति करे तो समय कम ही लगेगा।

$$\Delta A = \frac{1}{2}(r \times \Delta t)$$

$$v = \frac{p}{m}$$

$$\frac{\Delta A}{\Delta t} = \frac{1}{2}\left(r \times \frac{p}{m}\right)$$

गुरुत्वाकर्षण का सार्वत्रिक नियम-

$$a_m = \frac{V^2}{R_m} = \frac{4\pi^2 R_m}{T^2}$$

V = चन्द्रमा की चाल
T = आवर्तकाल

---

1. Introduction of Physics.

$$F \propto \frac{m_1 m_2}{r^2}$$

$$F = G\frac{m_1 m_2}{r^2}$$

DIMENSION-

Mass - [M]
Length - [L]
Time - [T]
Agnle - [θ]
current - [A]

$E = \frac{1}{2}mv^2$

$[E] = [M] \times \left[\frac{L}{T}\right]^2$ from समय = दूरी / चाल

$[E] = [ML^2T^{-2}]$

acceleration = velocity / time

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

$[L] = [LT^{-1}] + [LT^{-1}T^{-1}][T^2]$

$[L] = [L] + [L]$

$[L] = [L]$

$t = 2\pi\sqrt{\frac{m}{F/x}}$

$[T] = \sqrt{\frac{M}{[MLT^{-2}]/[L]}}$

$[T] = \sqrt{1/[T^{-2}]}$

$[T] = \sqrt{[T^2]}$

$[T] = [T]$

$F = ma$

$F = [M][L][T^{-2}]$

$F = [MLT^{-2}]$

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

$P = \frac{[MLT^{-2}]}{[L^2]}$

$P = [ML^{-1}T^{-2}]$

$A = \pi r^2$

$[A] = [L^2]$

$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$

$F = G\frac{m_1 m_2}{r^2}$

$[F] = \frac{[M^2]}{[L^2]}G$

$\frac{[MLT^{-2}][L^2]}{[M]^2} = G$

$G = [M^{-1}L^3T^{-2}]$

6. $[V^2] = \left[\frac{L}{T}\right]^2 = [L^2T^{-2}]$

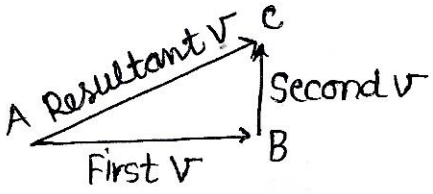
$[u^2] = \left[\frac{L}{T}\right]^2 = [L^2T^{-2}]$

$[2ax] = \frac{[L]}{[T^2]}[L] = [L^2T^{-2}]$

equation can be correct

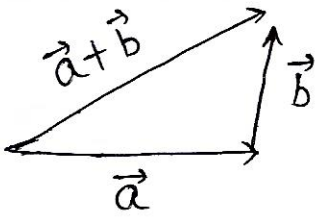
2. Physics and Measurement

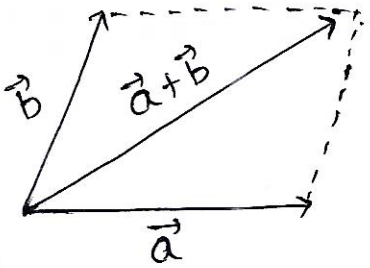
- Vector and Scalar Quantity-

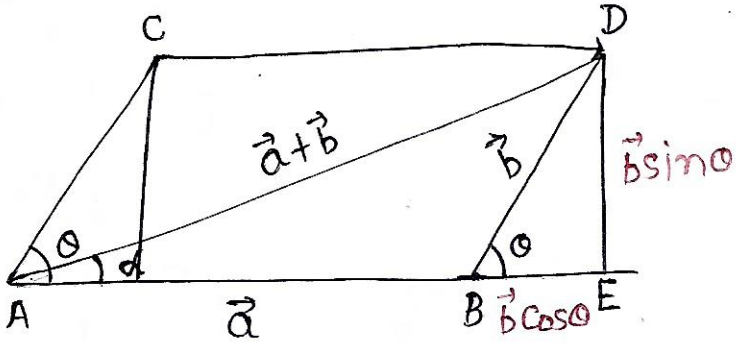


vector - two or more vector(same) quantities.
Magnitude and direction is same.

Addition of vector-







$$AD^2 = (AB+BE)^2 + DE^2$$

$$AD^2 = (a+b\cos\theta)^2 + (b\sin\theta)^2$$

$$AD^2 = (a^2 + b^2\cos^2\theta + 2ab\cos\theta) + b^2\sin^2\theta$$

$$AD = \sqrt{a^2+b^2+2ab\cos\theta}$$

$$\tan\alpha = \frac{DE}{AE} = \frac{b\sin\theta}{a+b\cos\theta}$$

Ex-2.1-

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

$$B = \sqrt{2A^2(1+\cos\theta)} = \sqrt{4A^2\cos^2\frac{\theta}{2}} \qquad \left[\because 1+\cos\theta = \cos^2\frac{\theta}{2}\right]$$

$$\boxed{B = 2A\cos\frac{\theta}{2}}$$

$$\tan\alpha = \frac{A\sin\theta}{A+A\cos\theta} = \frac{A\sin\frac{\theta}{2}\cos\frac{\theta}{2}}{A\left(1+\cos\frac{\theta}{2}\right)} = \frac{\cancel{A}\sin\frac{\theta}{2}\cancel{\cos\frac{\theta}{2}}}{\cancel{A}\cos^2\frac{\theta}{2}}$$

$$\tan\alpha = \tan\frac{\theta}{2}$$

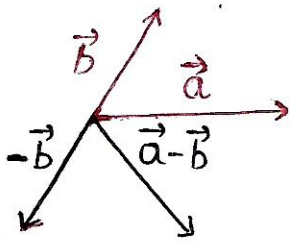
$$\alpha = \tan^{-1}\left(\tan\frac{\theta}{2}\right)$$

$$\boxed{\alpha = \frac{\theta}{2}}$$

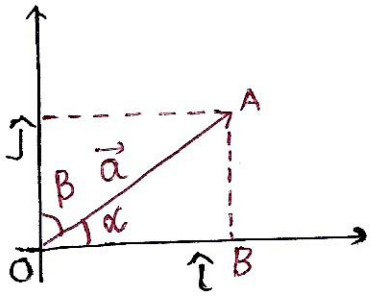
Multiplication of vectors -

$$\vec{a} = a\vec{u}$$
$$\vec{b} = k\vec{a}$$

Subtraction of vector -



Resolution of vectors -



$$\vec{a} = a\cos\alpha\,\hat{i} + a\cos\beta\,\hat{j} + a\cos\gamma\,\hat{k}$$

Addition of vectors -

$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$
$$\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$$
$$\vec{c} = c_x\hat{i} + c_y\hat{j} + c_z\hat{k}$$

$$\vec{a}+\vec{b}+\vec{c} = (a_x+b_x+c_x)\hat{i} + (a_y+b_y+c_y)\hat{j} + (a_z+b_z+c_z)\hat{k}$$

if Mutual Perpendicular vectors

Then

$$\sqrt{(a_x+b_x+c_x)^2 + (a_y+b_y+c_y)^2}$$

$$\tan\alpha = \frac{a_y+b_y+c_y}{a_x+b_x+c_x}$$

Example 2.2 -

sum of vectors -

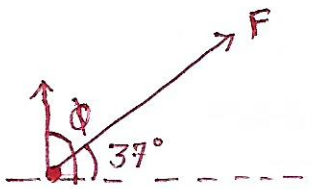
$$|\vec{A}+\vec{B}| = \sqrt{5^2+5^2+2\times5\times5\cos60^\circ}$$
$$= \sqrt{25+25+50\cos60^\circ}$$
$$= \sqrt{50+50\cos60^\circ}$$
$$= \sqrt{2(25+25\cos60^\circ)}$$
$$= (\sqrt{2})^2 5\cos30^\circ$$
$$= 2\times5\cos30^\circ$$
$$= 5\sqrt{3}\ \text{unit}$$

difference of vectors -

$$|\vec{A}-\vec{B}| = \sqrt{5^2+5^2+2\times5\times5\cos120^\circ}$$
$$= 5\ \text{unit}$$

Ex 2-3-

$F = 10.5\ N$



$F_1 = F\cos\theta$

$= 10.5(\cos 37^\circ)$

$= 10.5 \times \frac{4}{5}$

$= 8.40\ N$

Ex 2.4-

$W = \vec{F} \cdot \vec{r}$

$= F r \cos\theta$

$= (12)(2.0)\cos 180^\circ$

$= -24\ J$

Dot product of two vectors-

$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

$\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$

$\vec{a}\cdot\vec{b} = (a_x\hat{i} + a_y\hat{j} + a_z\hat{k})\cdot(b_x\hat{i} + b_y\hat{j} + b_z\hat{k})$

$= a_x b_x \hat{i}\hat{i} + a_x b_y \hat{i}\cdot\hat{j} + a_x b_z \hat{i}\hat{k}$

$+ a_y b_x \hat{j}\hat{i} + a_y b_y \hat{j}\cdot\hat{j} + a_y b_z \hat{j}\hat{k}$

$+ a_z b_x \hat{k}\hat{i} + a_z b_y \hat{k}\hat{j} + a_z b_z \hat{k}\hat{k}$

$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\hat{k} = 1$

$\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\hat{i} = 0$

$$\vec{a}\cdot\vec{b} = a_x b_x + a_y b_y + a_z b_z$$

Cross product-

$|\vec{a} \times \vec{b}| = ab\sin\theta\hat{n}$

- DIFFERENTIAL CALCULAS $\left[\frac{dy}{dx}\right]$

$$\frac{\Delta y}{\Delta x} = \tan\theta$$

$\frac{d}{dx}(\sec\theta) = \sec\theta\tan\theta$

$\frac{d}{dx}(\cos\theta) = -\operatorname{cosec}\theta\cot\theta$

$\frac{d}{dx}(\log x) = \frac{1}{x}$

$\frac{d}{dx}(e^x) = e^x$

$\frac{d}{dx}(x^n) = nx^{n-1}$

$\frac{d}{dx}(\sin\theta) = \cos\theta$

$\frac{d}{dx}(\cos\theta) = -\sin\theta$

$\frac{d}{dx}(\tan\theta) = \sec^2\theta$

$\frac{d}{dx}(\cot\theta) = -\operatorname{cosec}^2\theta$

Formulae-

(A) $\frac{d}{dx}(cy) = c\frac{dy}{dx}$

(B) $\frac{d}{dx}(u+v) = \frac{du}{dx} + \frac{dv}{dx}$

(C) $\frac{d}{dx}(u-v) = \frac{du}{dx} - \frac{dv}{dx}$

(D) $\frac{d}{dx}(u.v) = u\frac{dv}{dx} + v\frac{du}{dx}$

(E) $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$

(F) $\frac{dy}{dx} = \frac{\frac{dy}{du}}{\frac{dx}{du}}$

Ex 2.7-

$y = e^x \sin x$

$\frac{dy}{dx} = e^x \cos x + e^x \sin x$

$= e^x + y$

$= e^x(\cos x + \sin x)$

- INTEGRAL CALCULAS-

$\int \sin x = -\cos x$

$\int \cos x = \sin x$

$\int \sec^2 x = \tan x$

$\int \operatorname{cosec}^2 x = -\cot x$

$\int \sec x \tan x = \sec x$

$\int \operatorname{cosec} x \cot x = -\operatorname{cosec} x$

$\int x^n = \frac{x^{n+1}}{n+1}$

$\int \frac{1}{x} = \ln x$

$\int \frac{1}{x^2+a^2} = \frac{1}{a}\tan^{-1}\frac{x}{a}$

$\int \frac{1}{\sqrt{a^2-x^2}} = \sin^{-1}\frac{x}{a}$

(A) $\int cf(x) = c\int f(x)$

(B) $\int f(x)\,dx = F(x)$

(C) $\int [f(x)+g(x)]dx = \int f(x)dx + \int g(x)dx$

Ex 2.9-

$= \int_3^6 (2x^2+3x+5)dx$

$= \int 2x^2dx + \int 3x\,dx + \int 5\,dx$

$= \left[\frac{2x^3}{3} + \frac{3x^2}{2} + \frac{5x}{1}\right]_3^6$

$= \frac{2}{3}(216-27) + \frac{3}{2}[36-9] + 5[6-3]$

$= 126 + 40.5 + 15$

$= 181.5$

• SIGNIFICANT DIGITS -

Ex 2.10 -

Round off -

(A) 15462 ⇒3 = 15500

(B) 14.745 = 14.7

(C) 14.750 = 14.8

(D) 14.650 = 14.6

Ex 2.11 -

$$\frac{25.2 \times 1374}{33.3} = 1040.$$

Ex 2.12 -

$$\begin{array}{r} 24.36 \\ 0.0623 \\ 256.2 \\ \hline 280.6223 \end{array}$$

24.4 + 0.1 + 256.2 = 280.7

3. Rest and Motion (KINEMATICS) -

Rest → Position doesn't change with time

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2ax$ (s)

Free falling Bodies -

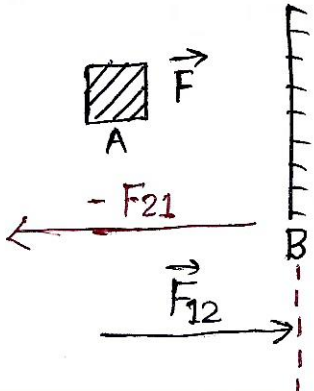
$v = u - gt$

$y = ut - \frac{1}{2}gt^2$

$v^2 = u^2 - 2gy$

4. The Forces

Newton's Third law of Motion -



Gravitational force-

$$F_G = \frac{G m_1 m_2}{r^2}$$

EM force-

$$F_E = \frac{1}{4\pi\varepsilon_0 K} \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\varepsilon_0 K} = 9 \times 10^9 \, N m^2 c^{-2}$$

5. NEWTON'S Laws of Motion-

- 1st Law-

$\vec{a} = 0$ if and only if $\vec{F} = 0$

- 2nd Law-

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

$$\vec{F} = m\frac{d\vec{v}}{dt}$$

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

- 3rd Law-

$$F_{12} = -F_{21}$$

6. Friction

$$f_k = \mu N$$

7. Circular Motion.

$$v = r\omega$$

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

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$a = r\alpha$$

Uniform Circular Motion

$$a = \omega^2 r$$

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

Non- uniform Circular Motion

$$a = \sqrt{\left(\frac{v^2}{r}\right)^2 + \left(\frac{dv}{dt}\right)^2}$$

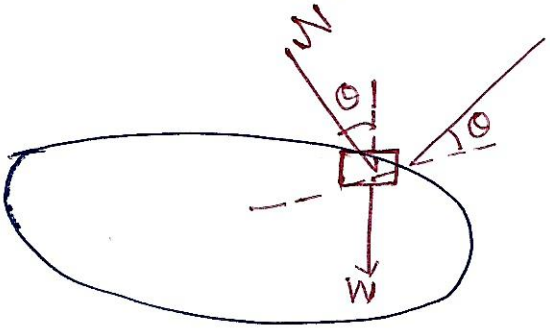
$$\alpha = \tan^{-1}\left[\frac{dv/dt}{v^2/r}\right]$$

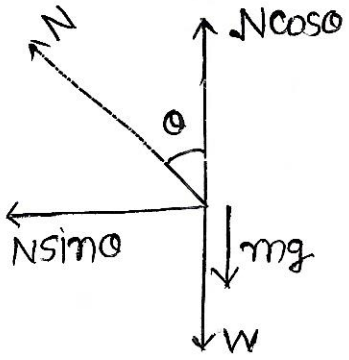
dynamics of circular motion

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

$$\frac{v^2}{r} = \frac{F}{m}$$

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





$$N\sin\theta = \frac{Mv^2}{r}$$

$$N\cos\theta = mg$$

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

Centrifugal force

$$f = m\omega^2 r$$

8. Work, energy and Power

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}m\vec{v}\cdot\vec{v}$$

$$W_{ext} = E_f - E_i$$

$$W = \int F\cos\theta\, dr$$

$$W = \int dK = K_2 - K_1$$

$$W = Fr\cos\theta$$

9. Centre of mass, Linear Momentum and Collision

- $\vec{R}_{CM} = \frac{1}{M}\sum_i m_i \vec{r}_i$

Center of mass of several Groups of Particle

$$x = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$y = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$

$$z = \frac{m_1 z_1 + m_2 z_2}{m_1 + m_2}$$

✡ Center of mass of continuous Bodies-

(A) Center of mass of uniform straight Rod

$$\left[\frac{L}{2}, 0, 0\right]$$

(B) Center of mass of a uniform semicircular wire

$$\left[0, \frac{2R}{\pi}\right]$$

(C) center of mass of uniform semicircular Plate

$$[0]$$

(D) Motion of center of mass.

$$v_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$a_{cm} = \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2}$$

10. Gravitation

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

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

Gravitational Potential Energy

$$U_f - U_i = -\int_i^f \vec{F}\cdot d\vec{r}$$

$$U_f - U_i = mgh$$

$$U(r) = -\frac{GM_1M_2}{r}$$

Gravitational Potential

$$V_B - V_A = \frac{U_B - U_A}{m}$$

$$V_B = \frac{U_B - U_A}{m}$$

• CALCULATION OF GRAVITATIONAL POTENTIAL

✡ Potential due to point mass

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

✡ Potential due to Uniform ring at a point on its Axis

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

✡ Potential due to a uniform Thin spherical Shell

⇒ outside

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

⇒ Inside

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

• Gravitational Field

$$E = \frac{GM}{r^2} \quad [\text{Point mass}]$$

$$E = \frac{GMr}{(a^2+r^2)^{3/2}} \quad [\text{Uniform Circular Ring}]$$

- $g = \frac{GM}{R^2}$

- Escape velocity

$$V = \sqrt{\frac{GMX2}{R}}$$

11. SHM

Simple Pendulum -

$$T = mgl\sin\theta$$

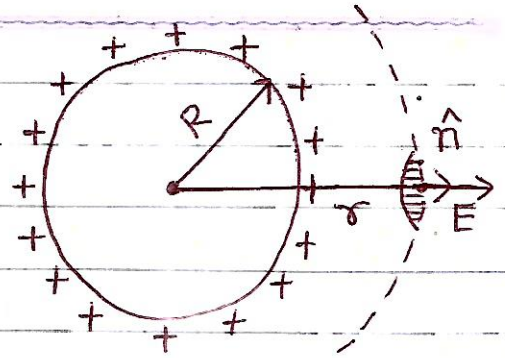
$$\alpha = -\omega^2\theta$$

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

@Abhishek

ELECTROSTATIC

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$$



(2) $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R^2}$ $[\because r = R]$

(3) $r < R$

$E = 0$

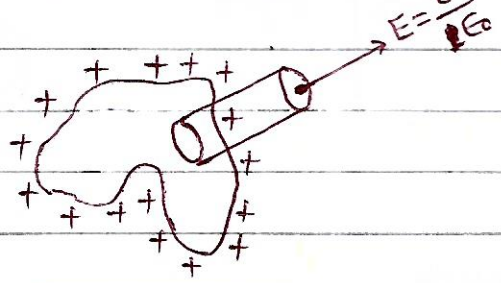
(1) $r > R$

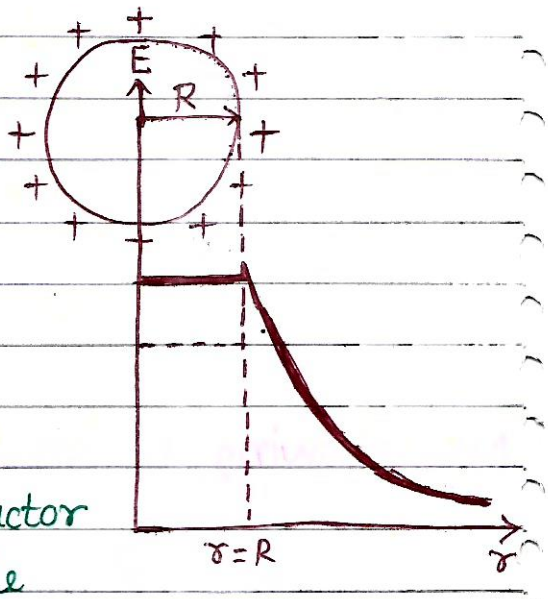
$$\oint \vec{E} \cdot d\vec{S} = \frac{q}{\epsilon_0}$$

$$\oint \vec{E} \cdot ds\cos 0 = \frac{q}{\epsilon_0}$$

* The Graph Between the electric field and distance r

If a charge is given to the conductor The whole charge resides on the outer surface of the conductor.

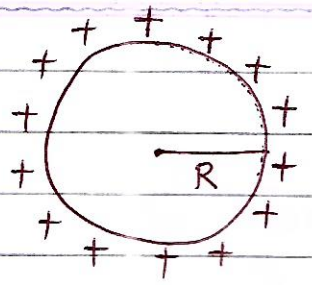




If the charge is given to the conductor and electrostatic Pressure x on the Body. It has the tendency of outward pulling.

$$P_E = \frac{\sigma^2}{2\epsilon_0}$$

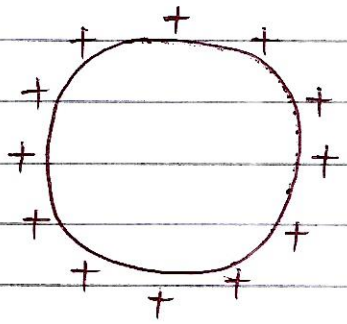
at is the stracting force on the cell?



$$F = \sigma \times 4\pi R^2$$

$$F = \frac{\sigma q_0^2}{8\pi R^2 \epsilon_0}$$

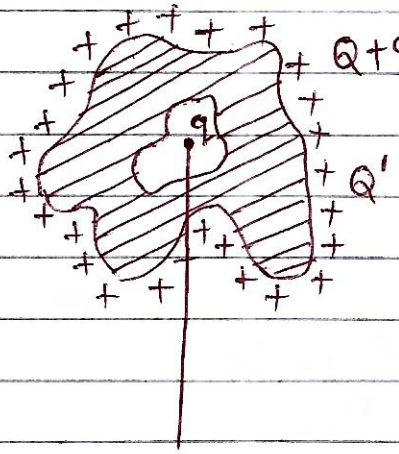
lid Conducting Sphere -



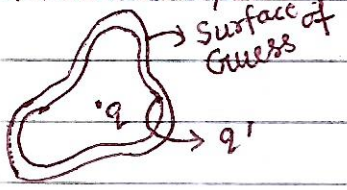
$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2} \qquad r > R$$

$$E = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{R^2} \qquad R < r$$

$$E = 0 \qquad R = r$$

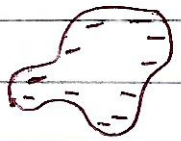


find the charge on the outer and Inner Surface?



$$\oint \vec{E}\cdot d\vec{S} = \frac{q+q'}{\epsilon_0}$$

w showing the inner figure



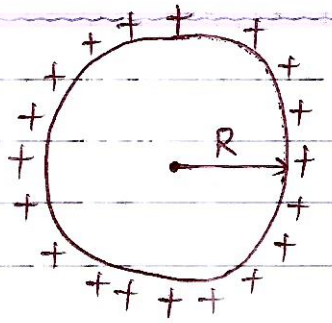
$$Q' - q = Q$$

Inside the conductor; Electric field $\vec{E} = 0$

$$q + q' = 0$$

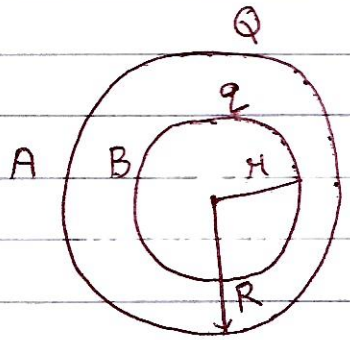
$$q' = -q$$

$r > R$; $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$



$R = r$; $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R}$

$r < R$; $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R}$



$$V_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R}$$

$$V_B = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r} + \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$$

$$V_B - V_A = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r} - \frac{1}{R}\right)$$

$$V_B > V_A$$

✡ The Potential of Inner shall is always greater than the outer potential.

[ELECTRIC CHARGE / ELECTRIC FIELD]

- वह ऊर्जा जो हल्की वस्तु आकर्षित करें।
  - friction is measure reason here.
    ↑ घर्षण विद्युत

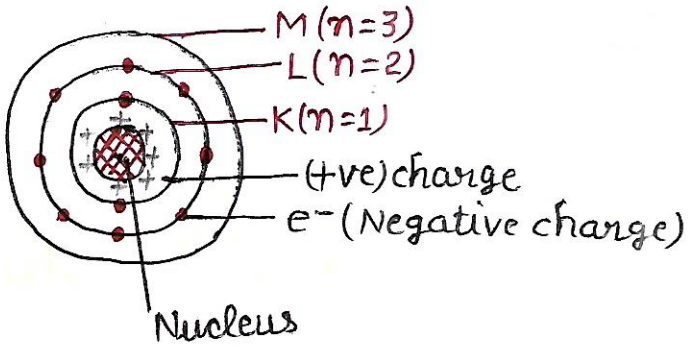
- आवेश ग्रहण किया तो वस्तु electrified हो जाती है।

(q) charge { Positive $(1.6 \times 10^{-19} C)$ / Negative $(-1.6 \times 10^{-19} C)$

आवेश { सजातीय (समान प्रकार) / विजातीय

- सजातीय आवेश प्रतिकर्षित करते हैं
- विजातीय आवेश एक दूसरे को आकर्षित करते हैं।

ELECTROSTATICS



इलेक्ट्रॉन की संख्या = प्रोटॉनो की संख्या

- किसी वस्तु के विद्युतीकरण के लिए e^- उत्तरदायी होते हैं।

☆ दो वस्तुओं में कौन धनावेशित व कौन ऋणावेशित होगा; यह e^- की Bond Energy पर निर्भर करता है।

conservation of Charge-

q { अविनाशी / अजन्म

$$q = \sum [q_1 + q_2 + q_3 \dots q_n]$$

$\Delta E = mc^2$

$c = 3 \times 10^8 \, ms^{-1}$

$e^{\ominus}$

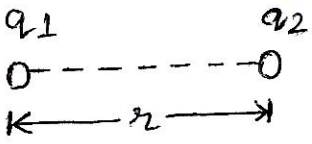
↑ सबसे कम आवेश वाला पदार्थ

$e = 1.6 \times 10^{-19} C$

$q = \pm ne$

↑ आवेश की कुल मात्रा

Columb's Law-



$F \propto q_1 q_2$

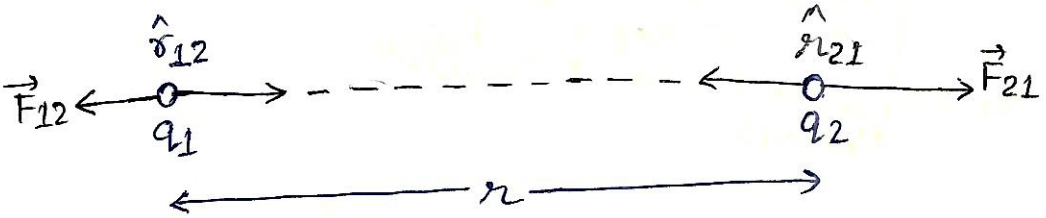
$F \propto \frac{1}{r^2}$

$F \propto \frac{q_1 q_2}{r^2}$

$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$

$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \, Nm^2 C^{-2}$

$|\vec{F}_{12}| = |\vec{F}_{21}| = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$



$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$

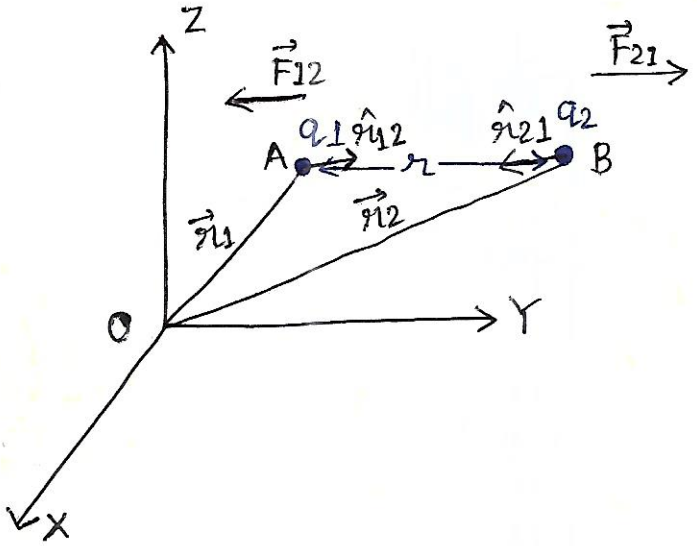
$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{21}$

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

$\hat{r}_{12} = -\hat{r}_{21}$

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{21}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}(r\cdot\hat{r}_{21})$$



$$r\cdot\hat{r}_{21} = \vec{r}_{21} = (BA)$$

$$\vec{OB} + \vec{BA} = \vec{OA}$$

$$r\cdot\hat{r}_{21} = \vec{r}_1 - \vec{r}_2$$

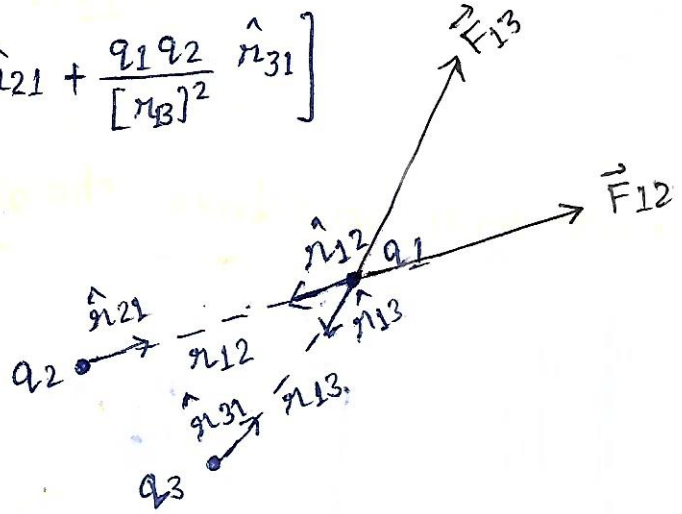
$$r = |\vec{r}_1 - \vec{r}_2|$$

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}_1-\vec{r}_2|^3}(\vec{r}_1-\vec{r}_2)$$

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}_2-\vec{r}_1|^3}(\vec{r}_2-\vec{r}_1)$$

अध्यारोपण का सिद्धान्त (Superposition Principle)-

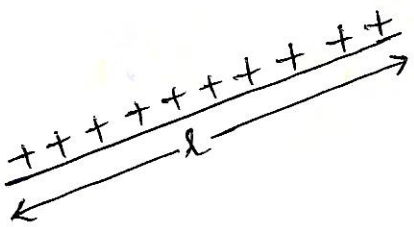
$$\vec{F}_1 = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_2}{[r_{12}]^2}\hat{r}_{21} + \frac{q_1 q_2}{[r_{13}]^2}\hat{r}_{31}\right]$$



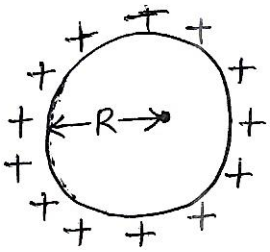
Force due to continuous charge-

1 D – Linear charge distribution
2 D – Surface charge distribution
3 D – Volume charge distribution

Linear charge Density-



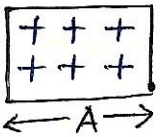
$$\lambda = \frac{q}{l} \ cm^{-1}$$



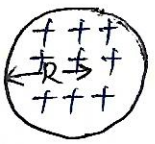
$$\lambda = \frac{q}{2\pi R} \ cm^{-1}$$

Surface charge density-

$$\sigma = \frac{q}{A} \ cm^{-2}$$



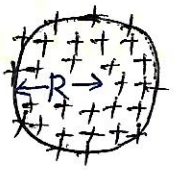
$$\sigma = \frac{q}{A^2} \ cm^{-2}$$



$$\sigma = \frac{q}{4\pi R^2} \ cm^{-2}$$

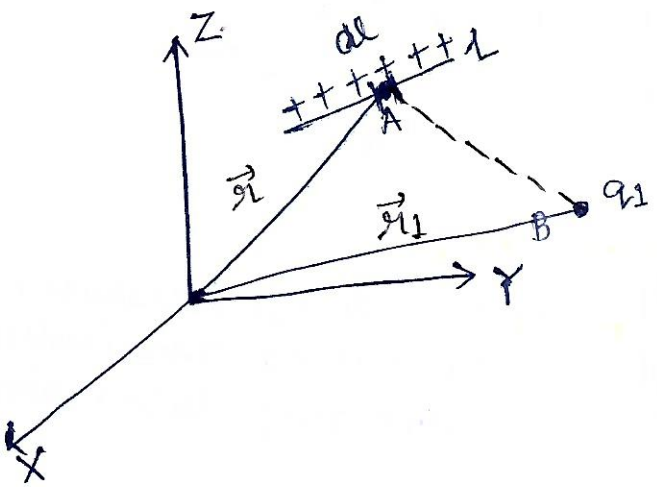
Volume charge Density-

$$\rho = \frac{q}{V} \ cm^{-3}$$



$$\rho = \frac{q}{\frac{4}{3}\pi R^3}$$

Electric Force due to continuous Linear charge-



$dq = \lambda dl \qquad \left[\because \lambda = \frac{q}{l} = \frac{dq}{dl}\right]$

$\vec{OA} = \vec{r}$
$\vec{OB} = \vec{r_1}$
$\vec{AB} = \vec{OB} - \vec{OA}$
$= \vec{r_1} - \vec{r}$

$$d\vec{F} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 dq}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

$$\vec{F} = \int_L \frac{1}{4\pi\epsilon_0} \frac{q_1 \lambda dl}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_L \frac{\lambda dl}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

अविरत पृष्ठीय आवेश के कारण बल

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_S \frac{\sigma dS}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

अविरत आयतनिक आवेश के कारण बल

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_V \frac{\rho dV}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

- **Comparison between F_E and F_G -**

SAME {
- हम निर्वात में रहते हैं।
- निर्वात में F_E व F_G क्रियाशील होते हैं।

✡ गुरुत्वाकर्षण बल केवल आकर्षणात्मक होता है।
✡ विद्युत बल गुरुत्वाकर्षण बल की तुलना में अधिक बड़ा होता है।

- **Electric Field and its Intensity -**

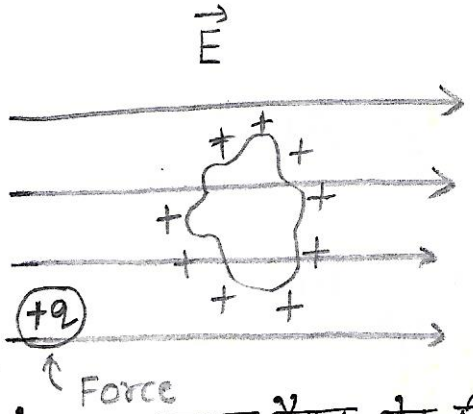
$$\vec{E} = \frac{\vec{F}}{q_0} \ N/C \qquad [MLT^{-3}A^{-1}]$$

- विद्युत क्षेत्र की दिशा वह होती है जो धन-परिक्षण आवेश पर लगने वाले बल की दिशा होती है।

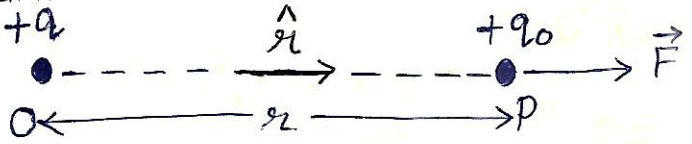
$$\vec{F} = q\vec{E}$$

- धनावेश पर बल की दिशा विद्युत क्षेत्र के अनुदिश व ऋणावेश पर विद्युत क्षेत्र के विपरित होती है।

Physical Significance-



⇒ बिंदु आवेश के द्वारा उत्पन्न वैद्युत क्षेत्र की तीव्रता-



$$\vec{F} = \frac{1}{4\pi\epsilon_0\epsilon_r} \cdot \frac{qq_0}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{E}}{q_0} = \frac{\frac{1}{4\pi\epsilon_0\epsilon_r}\frac{qq_0}{r^2}\hat{r}}{q_0}$$

$$\vec{E} = \frac{1}{4\pi\epsilon_0\epsilon_r}\frac{q}{r^2}\hat{r}$$

$$[\epsilon_r = 1]$$

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

$$\boxed{E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}}$$

$\vec{E} = \vec{E}_1 + \vec{E}_2 + \ldots + \vec{E}_n$

✡ Electric field lines-

- यदि विद्युत क्षेत्र में रखा कोई आवेश गति के लिए स्वतन्त्र हो, तो वह बल की दिशा में चलने लगेगा।

$dq = \lambda dl$ $\quad \left[\because \lambda = \frac{q}{l} = \frac{dq}{dl}\right]$

$\vec{OA} = \vec{r}$
$\vec{OB} = \vec{r_1}$
$\vec{AB} = \vec{OB} - \vec{OA}$
$= \vec{r_1} - \vec{r}$

$$d\vec{F} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 dq}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

$$\vec{F} = \int_L \frac{1}{4\pi\epsilon_0} \frac{q_1 \lambda dl}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_L \frac{\lambda dl}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

अविरत पृष्ठीय आवेश के कारण बल

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_S \frac{\sigma dS}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

अविरत आयतनिक आवेश के कारण बल

$$\vec{F} = \frac{1}{4\pi\epsilon_0} q_1 \int_V \frac{\rho dV}{|\vec{r_1} - \vec{r}|^3} |\vec{r_1} - \vec{r}|$$

- **Comparison between F_E and F_G -**

SAME {
- हम निवति में रहते हैं।
- निवति में F_E व F_G क्रियाशील होते हैं।

✡ गुरुत्वाकर्षण बल केवल आकर्षणात्मक होता है।
✡ विद्युत बल गुरुत्वाकर्षण बल की तुलना में अधिक बड़ा होता है।

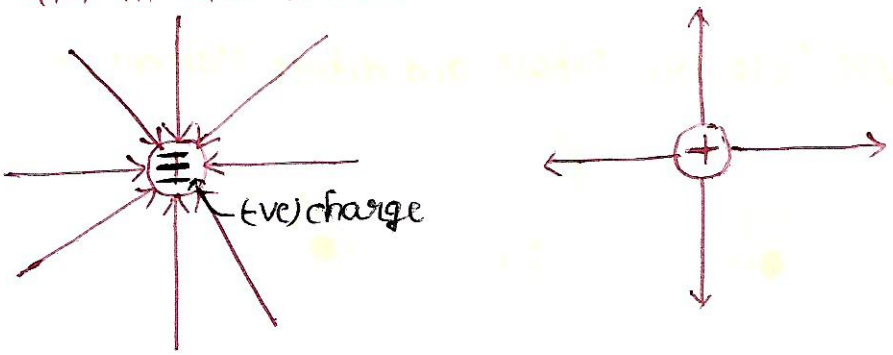
- **Electric Field and its Intensity -**

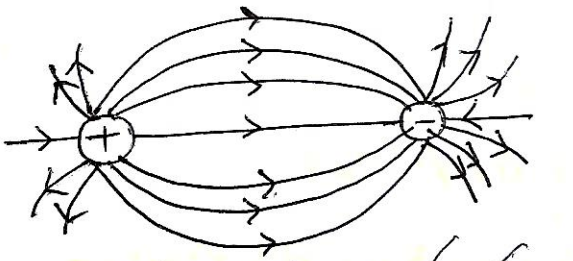
$$\vec{E} = \frac{\vec{F}}{q_0} \text{ N/C} \quad [MLT^{-3}A^{-1}]$$

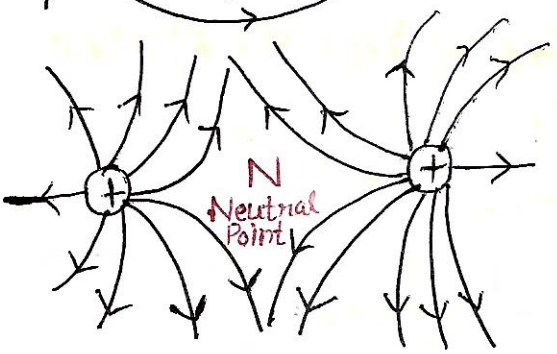
- विद्युत क्षेत्र की दिशा वह होती है जो धन-परिक्षण आवेश पर लगने वाले बल की दिशा होती है।

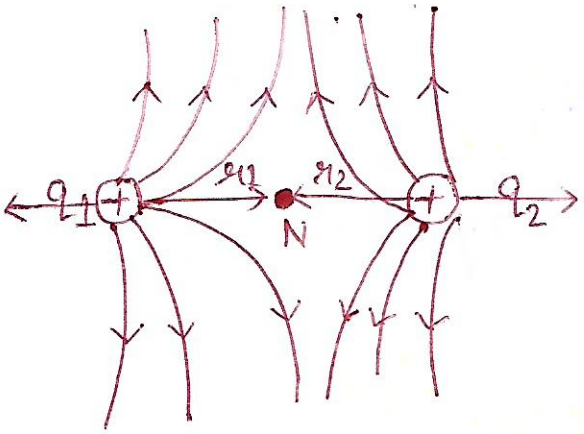
$$\vec{F} = q\vec{E}$$

• विद्युत बल रेखा के किसी भी बिंदु पर खींची गई स्पर्श रेखा उस बिंदु पर विद्युत क्षेत्र की दिशा प्रदर्शित करती है।









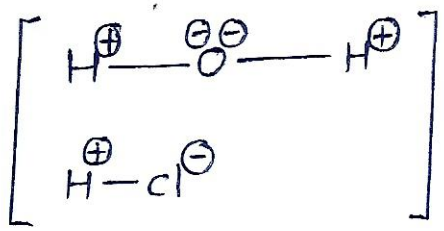
$$\frac{q_1}{r_1^2} = \frac{q_2}{r_2^2}$$

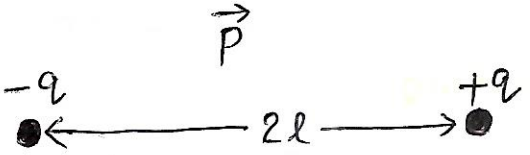
✡ वैद्युत बल रेखाओं की विशेषताएं-

- वैद्युत बल रेखाएं धनावेश से प्रारम्भ व ऋणावेश पर अन्त होती हैं।
- दो बल रेखाएं एक-दूसरे को नहीं काटती।

• समरूप क्षेत्र (Uniform field) पर खींची गई बल रेखाएँ परस्पर समान्तर होती है व समान दूरी पर होती है।

✱ वैद्युत द्विध्रुव तथा द्विध्रुव आघूर्ण (Electric Dipole and dipole Moment)-



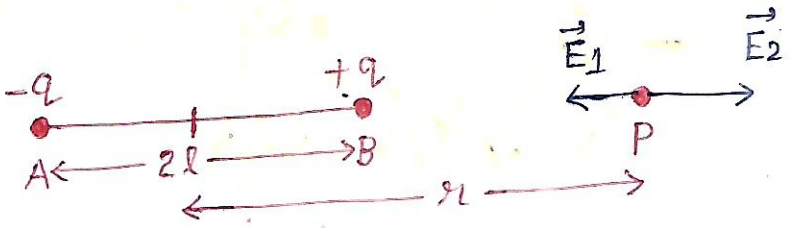


$P = q \times 2l$ C·m

वैद्युत द्विध्रुव की दिशा द्विध्रुव के अक्ष के अनुदिश ऋणावेश से धनावेश की ओर होती है।

✱ वैद्युत द्विध्रुव के कारण किसी बिंदु पर वैद्युत क्षेत्र की तीव्रता-

(1) अक्षीय व अनुदैर्ध्य स्थिति-



+q आवेश के कारण वैद्युत क्षेत्र की तीव्रता-

$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{q}{(r-l)^2}$$ ($\vec{BP}$ दिशा में)

-q आवेश के कारण

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{q}{(r+l)^2}$$ ($\vec{PA}$ दिशा में)

$$E = E_1 - E_2$$

$$E = \frac{1}{4\pi\epsilon_0}[q]\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]$$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{4rl}{(r^2-l^2)^2}\right]$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{2(2q)l\cdot r}{(r^2-l^2)^2}$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{2Pr}{(r^2-l^2)^2}$$

$l <<< r$

$$\boxed{E = \frac{1}{4\pi\epsilon_0}\frac{2P}{r^3}}$$

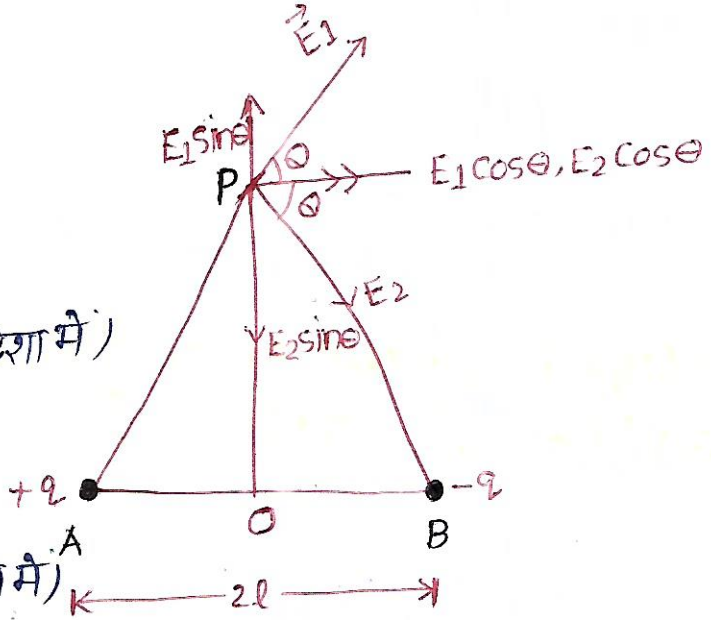
$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{P}}{r^3}}$$

(2) निरक्षीय स्थिति –

$P = q \times 2l$

$$E_1 = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r^2+l^2)^2} \quad (\vec{AP} \text{ दिशा में})$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r^2+l^2)^2} \quad (\vec{PB} \text{ दिशा में})$$



$$E = E_1\cos\theta + E_2\cos\theta$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2+l^2)^2}\cos\theta + \frac{1}{4\pi\epsilon_0}\frac{q}{r^2+l^2}\cos\theta$$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{(r^2+l^2)^2}\cdot\frac{l}{\sqrt{r^2+l^2}} + \frac{1}{(r^2+l^2)^2}\frac{l}{\sqrt{r^2+l^2}}\right]$$

$l <<< r$

$l^2 <<<<<<<<<< r$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{l}{r^3} + \frac{l}{r^3}\right]$$

$$E = \frac{2q}{4\pi\epsilon_0}\left[\frac{l}{r^3}\right]$$

$$E = \frac{l \times 2q}{4\pi\epsilon_0(r^3)}$$

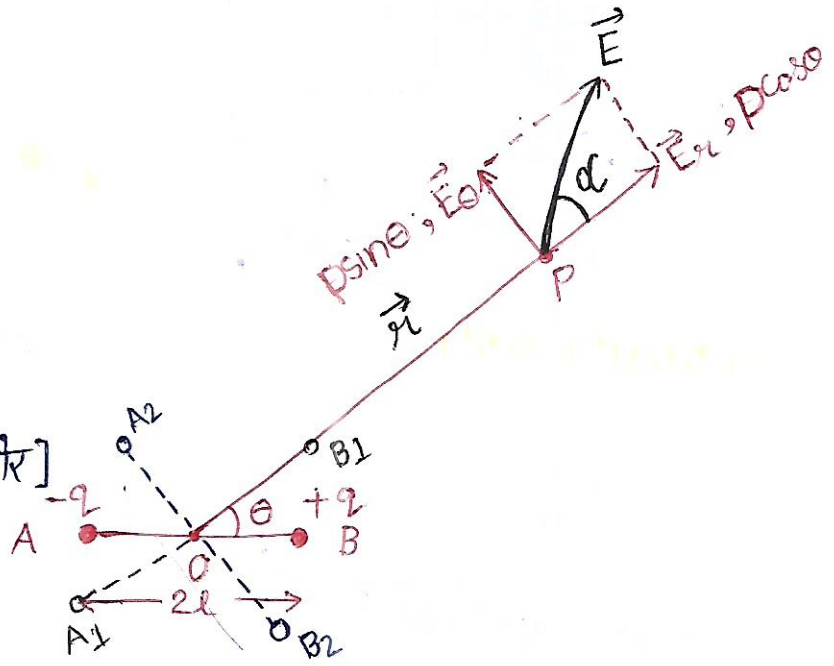
$$\boxed{E = \frac{1}{4\pi\epsilon_0}\cdot\frac{P}{r^3}}$$

$2E_{\text{अक्षीय}} = E_{\text{निरक्षीय}}$

$$E_{Axial} = \frac{E_{Non\text{-}Axial}}{2}$$

(3) किसी भी स्थिति में –

$\vec{P} = q \times 2l$



$$E_r = \frac{1}{4\pi\epsilon_0}\frac{2P\cos\theta}{r^3}$$ [O से P की ओर]

$$E_\theta = \frac{1}{4\pi\epsilon_0}\frac{P\sin\theta}{r^3}$$

$$\vec{E} = \sqrt{(E_r)^2 + (E_\theta)^2}$$

$$E = \sqrt{\left[\frac{1}{4\pi\epsilon_0}\cdot\frac{2P\cos\theta}{r^3}\right]^2 + \left[\frac{1}{4\pi\epsilon_0}\cdot\frac{P\sin\theta}{r^3}\right]^2}$$

$$E = \frac{1}{4\pi\epsilon_0}\cdot\frac{P}{r^3}\sqrt{(2\cos\theta)^2 + (\sin\theta)^2}$$

$$E = \frac{1}{4\pi\epsilon_0}\cdot\frac{P}{r^3}\sqrt{4\cos^2\theta + \sin^2\theta}$$

$$\boxed{E = \frac{1}{4\pi\epsilon_0}\cdot\frac{P}{r^3}\sqrt{1+3\cos^2\theta}}$$

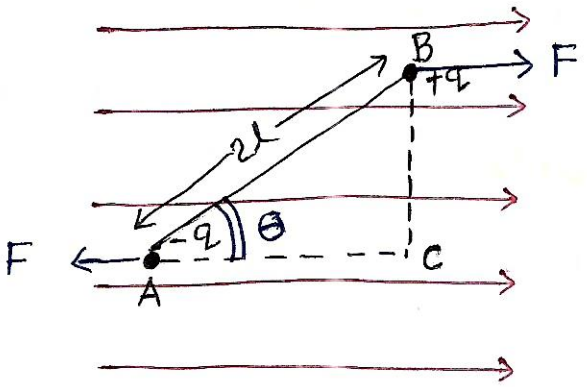
$$\tan\alpha = \frac{E_\theta}{E_r} = \frac{\frac{1}{4\pi\epsilon_0}\cdot\frac{P\sin\theta}{r^3}}{\frac{1}{4\pi\epsilon_0}\cdot\frac{2P\cos\theta}{r^3}}$$

$$\boxed{\alpha = \tan^{-1}\left[\frac{1}{2}\tan\theta\right]}$$

* समरूप वैद्युत क्षेत्र में वैद्युत द्विध्रुव पर बल व बल आघूर्ण -

$p = q \times 2l$

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



$\tau = F \times 2l \sin\theta$

$\tau = qE \times 2l \sin\theta$

$\tau = pE\sin\theta$

$\boxed{\vec{\tau} = \vec{p} \times \vec{E}}$

$\boxed{\tau_{max} = pE}$

$\Rightarrow \left[p = \frac{\tau_{max}}{E} \right]$

$E = 1\ NC^{-1}$

$p = \tau_{max}$

Formulae -

1. परमाणुओं की संख्या = $\frac{\text{पदार्थ का द्रव्यमान} \times \text{आवोगाद्रो सं०}}{\text{पदार्थ का भार}}$

2. स्थानान्तरित (परमाणु) के e^- की सं० = $\frac{\text{परमाणु की संख्या} \times \text{पदार्थ का परमाणु क्र०} \times \text{स्थानान्तरित } e^- (\%)}{\text{द्वरी}}$

INTRODUCTION TO PHYSICS-

- $F \propto \frac{m_1 m_2}{r^2}$

- Fundamental quantities

Length	m
Mass	Kg
Time	s
Electric current	A
Thermodynamics Temperature	K
Amont of substance	mol
Luminous Intensity	cd

- $E.K = \frac{1}{2}mv^2$
- $P = \frac{F}{A}$

$\mu(micro) = 10^{-6}$
$n(nano) = 10^{-9}$
$m(mili) = 10^{-3}$

- $F = ma$
- $F = m\frac{dv}{dt}$

REST AND MOTION (KINEMATICS)-

- $V_{av} = \frac{s}{t_2 - t_1}$
- $\vec{a}_{av} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1}$

- समय = $\frac{\text{दूरी}}{\text{चाल}}$
- $ut + \frac{1}{2}at^2 = s$
- $v = u + at$
- $v^2 = u^2 + 2as$

In Projectile motion $\begin{cases} u_x = u\cos\theta \\ u_y = u\sin\theta \end{cases}$

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

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

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

- $F = G\frac{m_1 m_2}{r^2}$
- $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

Circular Motion-

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

- $v = r\omega$
- $a = r\alpha$
- $a = \frac{F}{m} \Rightarrow \frac{v^2}{r} = \frac{F}{m}$

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

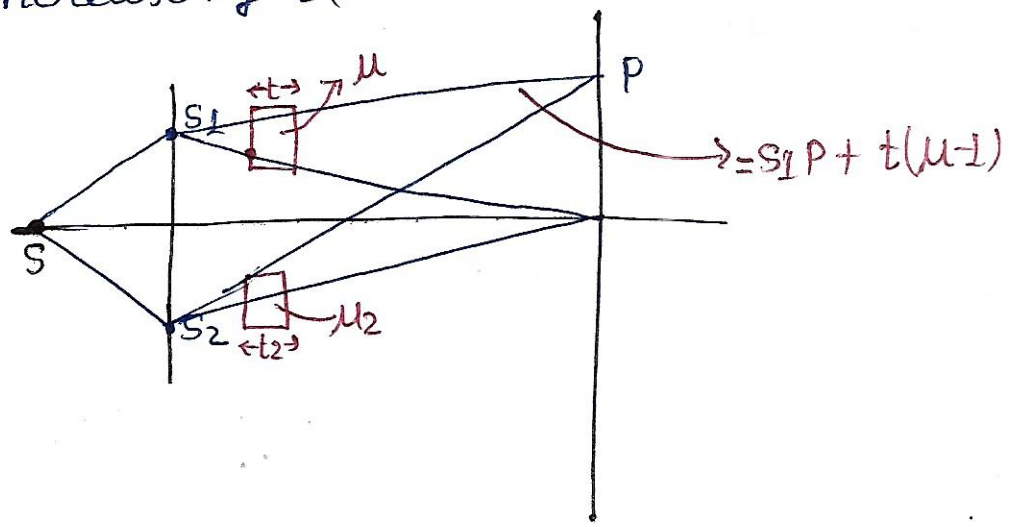
WORK AND ENERGY-

- $E.K = \frac{1}{2}mv^2$

→Ray Optics←

• Displacement of figure-

On Interducing of thickness glass, the optical path is S_1P will increase by $t(\mu-1)$



Path difference $\Delta x = S_2P - [S_1P + t(\mu-1)]$

$$\Delta x = (S_2P - S_1P) - t(\mu-1)$$

distance by which the central Bright fringe shifted

$$\Delta x = 0$$

$$(S_2P - S_1P) - t(\mu-1) = 0$$

$$\frac{yd}{D} = t(\mu-1)$$

$$\boxed{y = t(\mu-1)\frac{D}{d}} \quad \text{—(1)}$$

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

$$\frac{\beta}{\lambda} = \frac{D}{d} \quad \text{—(2)}$$

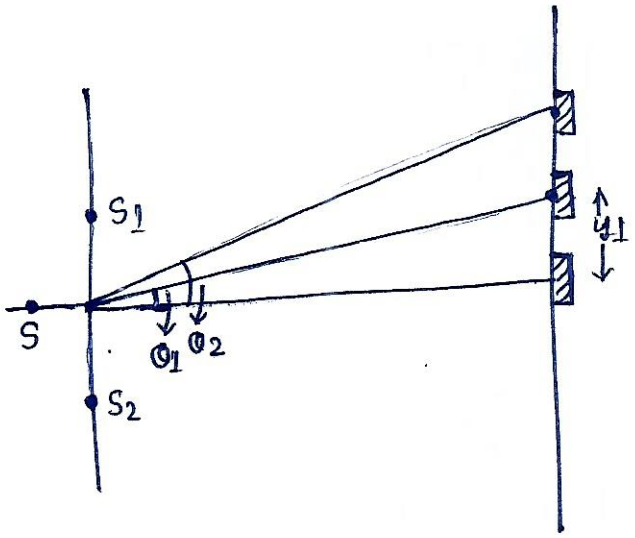
$$\boxed{y = t(\mu-1)\frac{\beta}{\lambda}}$$

- Angular Position and Angular Width of YDSE -

$$\theta_1 = \frac{y_1}{D}$$

$$\theta_1 = \frac{\lambda}{d}$$

$$\frac{y_1}{D} = \frac{\lambda}{d} \quad \left[\because y_1 = \frac{\lambda D}{d}\right]$$



Anglar Position of second Bright fringe

$$\theta_2 = \frac{2\lambda}{d}$$

$$d\theta = \theta_2 - \theta_1$$

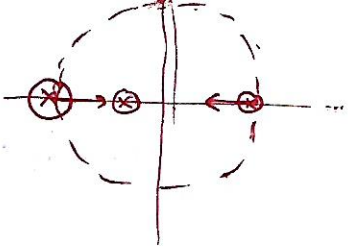
$$d\theta = \frac{2\lambda}{d} - \frac{\lambda}{d}$$

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

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

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

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



$\phi = ar^2 + b$

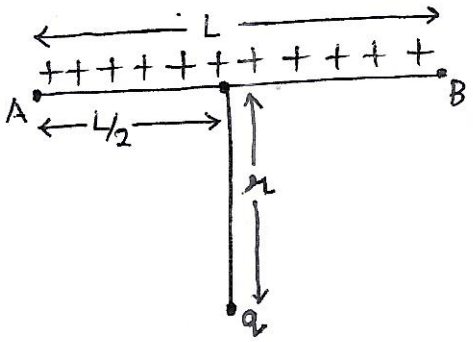
117. A charge Q is distributed over a line of length L. After Another Point charge q is Placed at a distance r from the centre of the line distribution. Then the force experienced by q is:

(a) $\dfrac{qQ}{4\pi\epsilon_0(r^2-L^2)}$

(b) $\dfrac{qQ}{4\pi\epsilon_0 r^2}$

(c) $\dfrac{qQ}{4\pi\epsilon_0\left(r^2+\left[\frac{L}{2}\right]^2\right)}$ ✓

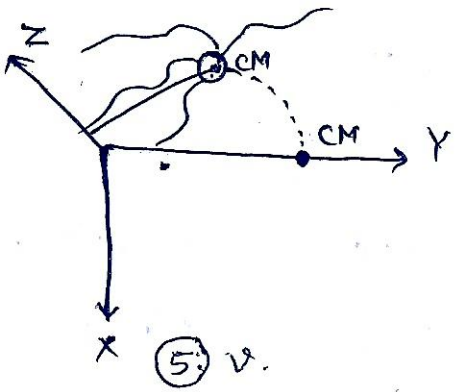
(d) $\dfrac{qQL}{4\pi\epsilon_0 r^2}$



$\vec{F} = ?$

$F = \dfrac{1}{4\pi\epsilon_0}\dfrac{qQ}{\left[r^2-\left(\frac{L}{2}\right)^2\right]}$

$$\boxed{F = \frac{qQ}{4\pi\epsilon_0\left[r^2-\left(\frac{L}{2}\right)^2\right]}}$$



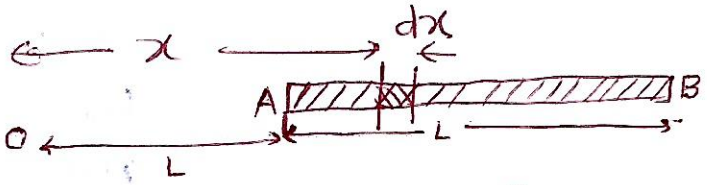
(5) v.

- Velocity = 0
- Will follow shame trajectory.

Permittivity of vaccum

A = electric current

$[\epsilon_0] = [M^{-1}L^{-3}T^4A^2]$



$E = \frac{Q}{4\pi\epsilon_0 x^2} = E = \frac{q}{4\pi\epsilon_0 (x)^2}$

$L \longrightarrow Q$

$1 \longrightarrow \frac{Q}{L}$

$dx \longrightarrow \frac{Q}{L}dx$

$= dq$

df $dE = k\frac{dq}{x^2}$

$$\int dE = \frac{kQ}{L}\int_{L}^{(L+L)} \frac{dx}{x^2}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\left[\ln x\right]_{L}^{2L}$$

$$= \frac{Q}{4\pi\epsilon_0 L}\ln 2$$

Chemistry

1. Atomic structure - 1 (14)
2. classification of Elements and Periodicity in Properties - (15)
3. Hydrogen - (15)
4. S-Block elements - (15)
5. P Block elements - (15)
6. The P Block elements - (15)
7. d and f Block elements - (16)
8. Coordination Compounds - (16)

} 15

9. Heat and Thermodynamics (17)
10. solution - (17)
11. Nuclear Chemistry - (14)

} 3

Enough to crack IIT-JEE
(35% of Question Paper)

{ Complete whole chemistry till 10th of May (32p/D) }

Mettalurgy, Chemical Bonding } (17) + (21)

45

Physics

1. Optics (14)
2. current Electricity (16)
3. Electrostatics (16)
4. Meignetism (17)
5. Electromagnetic Induction (18)
6. Modern Physics, A.C (18)
7. Miscellaneous (18)

} 24

8. Rotation (18)
9. Gravitation (19)

} 5

Enough to crack IIT-JEE
(60% of Question Paper)

{ complete whole Physics till 20th of May (1c/D) }

IIT-B student

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Mathematics

1. Relation & Functions - 1 (19)
2. Matrics - 2 (19)
3. Determinants - 1 (19)
4. Logerithms and Prof. - 1 (19)
5. Probability - 3 (20)
6. Circle - 3 (14)
7. Parabola - 1 (20)
8. Ellipse - 1 (20)
9. Hyperbola - 1 (20)
10. Vectors - 2 (20)
11. 3-D Geometry - 4 (20)
12. Differential - 1 (20)
13. Integration - 1 (20)

Enough to crack IIT-JEE
(14% of Question Paper)

1 - 14 [ ]
2 - 15 [ ]
3 - 16 [ ]
4 - 17 [ ]
5 - 18 [ ]
6 - 19 [ ]
7 - 20 [ ]
8 - 21 [ ]

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Physics

⇒ HC VERMA

⇒ Modern ABC

⇒ BANSAL -

- Rotational dynamics
- Circular Motion/W.E.P.
- C.O.M and Collision
- Gravitation
- Electrostatics
- Magnetic Effect of Current
- Modern Physics
- Geometrical Optics
- EMI and AC
- Current Electricity
- Capacitance
- EM Waves and Wave Optics

⇒ Aviral Classes -

- Modern Physics
- Nuclear Physics
- A.C.
- E.M.I
- optics
- Electrostatics
- Capacitance
- Current Electricity
- M.E.C. and Magnetism
- Gravitation

⇒ 37 year Arihant Book

chemistry

* Solution from Aviral Store
* Atomic structure for Aviral store
* BANSAL -
  - Surface chemistry
  - Solid States
  - Solution
  - Electrochemistry
  - d block and f Block
  - Hydrocarbon

* 32 years Arihant Solved Questions

Maths

- Quick Revision (SNAPSHOT)
- Quadratic Eq^n Aviral Book
- Sequence and Series Aviral Book
- Circle for Aviral Store
- Parabola
- Ellipse
- Hyperbola
- Vector
- Bansal -
  1. differential Eq^n
  2. Circle
  3. Vector and 3D
  4. Conic section
  5. Functions
- Crash Course in Mathematics
- 32 years IIT-JEE (Arihant)

REVISION CHART FOR JEE(Advanced)

Physics	Chemistry	Mathematics	Date
1. Elactrostatics } (7)	Atomic Structure } (5)+(6)	Vector } (1)	2
2. Elactrostatics	Bonding } (15)	Vector	3
3. Elactrostatics + Gravitation } (8)	Molecular structure	Vector	4
4. Current Electricity } (9)	S-P Block and their elements } (16)	Quardratic Eq^n } (2)	5
5. Current Electricity	General Organic Chemistry	Quadratic Eq^n	6
6. Magnetics } (10)	General Organic chemistry	Quadratic Eq^n	7
7. Magnetics	S-P Block and their elements } (17)	Quadratic Eq^n	8
8. Magnetics	S-P Block and their elements	differential } (3)	9
9. Magnetics	Solutions	differentiation	10
10. E.M.I } (11)	Solutions	differentiation	11
11. A.C + Rotation	Transition Elements and Co-or.Com } (18)	differentiation	12
12. Modern Physics } (12)+(13)	Transition Elements and Co-or.Com	Progression and Series } (4)	13
13. Modern Physics	Transition Elements and Co-or.Com	Progression and Series	14
14. Modern Physics	Transition Elements and Co-or.Com	Progression and Series	15
15. Modern Physics	In-organic chemistry } (19)	Progression and Series	16
16. Modern Physics	In-organic chemistry	Conic Section } (5)+(6)+	17
17. Modern Physics	In-organic chemistry	Conic Section	18
18. optics } (14)	In-organic chemistry	Conic Section	19
19. Optics	In-organic chemistry	Conic Section	20
20. Miscelleneous	In-organic chemistry	Conic Section	21
Total Questions - 20+5+5	Total Questions - 14	Total Questions - 14	