
Physics Mega Revision
#4
Unit & Dimensions
Vectors
Kinematics 1D
Kinematics 2D
NLM
Friction
Circular Motion
Work Power Energy
Center of Mass
Superfast Revision
PDF in Description
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Complete Physics Mega Revision Timetable

15 Feb
Electrostatics
Current electricity
Capacitor
🎁 **Surprise Gift** 🎁

16 Feb
Calorimetry
Elasticity
Thermal Expansion
Heat Transfer
KTG
Thermodynamics
Fluid Mechanics

17 Feb
Magnetic effect of current
Magnetism and matter
Emi
AC

18 Feb
UD
Vector
Kinematics 1D
Kinematics 2D
NLM
Friction
Circular motion
Work power energy
COM
Rotation motion

19 Feb
Ray optics
Optical Instruments
Wave optics
EM Waves
Errors in measurement

20 Feb
Gravitation
SHM
Wave on string
Sound wave

21 Feb
Dual nature of radiation
X-rays
Nuclear physics
Radioactivity
Semi conductor
Communication system

Phase 2 Launching on 20 Feb

Faculty of the Series

Saransh Gupta Sir

eSaral Physics HoD

- **IIT Bombay**, CS
- **AIR-41** IIT-JEE
- **Air-71** AIEEE (JEE Main)
- **AIR-4** NSO
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eSaral Chemistry Faculty

- **IIT Bombay,** Metallurgy
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Master Planners & Faculties

N.K. Gupta Sir

eSaral Math Faculty & Master Planner

- **IIT Kanpur**, Mechanical
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Unit and Dimension

Superfast Revision

System of Units

	Length	Mass	Time
CGS	Centimetre	Gram	Second
FPS	Foot	Pound	Second
MKS	Metre	Kilogram	Second

Fundamental Quantities

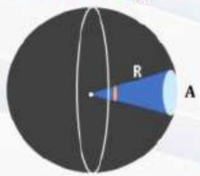
	SI unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd
Amount of Substance	mole	mol

Plane angle

$$\text{Plane Angle} = \frac{\text{Arc Length}}{\text{Radius}}$$

	SI unit	Symbol
Plane Angle	radian	rad
Solid Angle	Steradian	sr

Solid angle



$$\text{Solid Angle} = \frac{\text{Area}}{(\text{Radius})^2}$$

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Applications of Dimensions

1. Principle of Homogeneity

Only same type of physical quantities can be added or subtracted $x = A + B$ $\quad x = A - B$

$$[x] = [A] = [B]$$

2. Conversion of Units

1 m = 100 cm = 1000 mm

$n_1u_1 = n_2u_2 = n_3u_3$ $\quad nu = \text{constant}$

When unit become smaller, numerical value increase.

3. To derive relationship between physical quantities

Limits of Dimensions

1. The relation derived from this method gives no information about the dimensionless constants.
2. The dimensional quantity to be derived must be of multiplication type. We cannot derive relations if addition or subtractions are involved.
3. This method is not applicable when unknown variables are more than equations present.

Units and Dimension

A physical quantity is expressed as

n u

- n → Numerical Value
- u → Unit

Derived Quantities

Quantities which can be derived from fundamental quantities.

Dimensions

Quantity	Dimension Symbol
Length	L
Mass	M
Time	T
Temperature	θ, K
Electric Current	I, A
Amount of Substance	Mol
Luminous Intensity	cd

✓ Angles and trigonometric functions are dimensionless quantity

$[\theta] = [L^0]$ $\quad [\sin\theta] = M^0L^0T^0$

✓ All exponents are dimensionless.

✓ Logarithmic functions and it's arguments are dimensionless

$[a] = M^0L^0T^0$

$[\log a] = M^0L^0T^0$

★ Dimensionally correct equation may or may not be correct but dimensionally incorrect equation must be incorrect.

Units and Dimension

Small Angle Approximation

If θ is very small then

$\sin\theta \approx \theta$ $\cos\theta \approx 1 - \frac{\theta^2}{2}$

$\tan\theta \approx \theta$

θ must be in radian

Binomial Approximation

If $|x| << 1$

$(1+x)^n \approx 1 + nx$

2π radian $= 360°$

$1° = \frac{\pi}{180}$ rad.

Q) Time period of a simple pendulum depends on its length and acceleration due to gravity. Find an expression for time period.

Sol. $T \propto \ell^{a} g^{b}$

$T = K\ell^{a} g^{b}$

$[T] = [K\ell^{a} g^{b}]$

$T = L^{a}(LT^{-2})^{b}$

$L^{0}\,T^{-1} = L^{a+b}\,T^{-2b}$

$a + b = 0; -2b = 1$

$\therefore b = \frac{-1}{2} \quad a = \frac{1}{2}$

$T = K\,\ell^{\frac{1}{2}}\,g^{-\frac{1}{2}}$

$T = K\sqrt{\frac{\ell}{g}}$

Q) Can [momentum, mass, velocity] form a fundamental set ?

Sol. $p \propto m^a v^b$

$$M^1 L^1 T^{-1} = [M]^a \quad [L T^{-1}]^b$$

$$M^1 L^1 T^{-1} = M^a L^b T^{-b}$$

$a = 1 \quad b = 1$

Momentum can be expressed in terms of mass and velocity. Hence this set cannot form a fundamental set.

Vector

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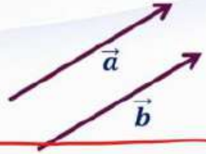
Vectors

Vector

$|\vec{A}|$ = Magnitude of $\vec{A}$

Two vectors are said to be equal if, and only if, they have same magnitude and the same direction.

$\vec{a} = \vec{b}$



$0^\circ \leq$ Angle between two vectors $\leq 180^\circ$

Parallel Vectors

Same direction and angle between vectors is 0°

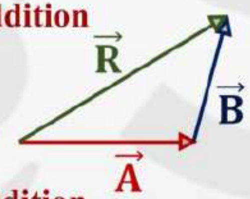
Anti-Parallel Vectors

Opposite direction and angle between vectors is 180°

Triangle rule of vector addition

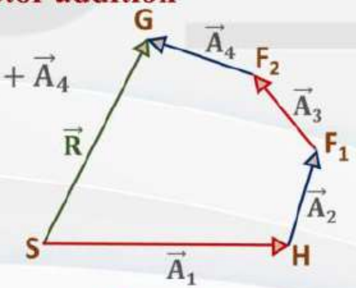
$\vec{A} + \vec{B} = \vec{R}$

$|\vec{R}| \neq |\vec{A}| + |\vec{B}|$



Polygon rule of vector addition

$\vec{R} = \vec{A}_1 + \vec{A}_2 + \vec{A}_3 + \vec{A}_4$



Multiplication of vector with real number

magnitude $|\lambda|\,|\vec{A}|$, direction remains the same.

Scalar Product (Dot Product) of two Vectors

$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}|\cos\theta$

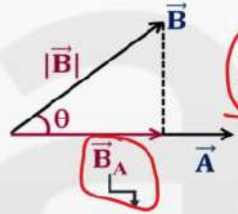
$\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$

$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$ $\qquad \vec{A} \cdot \vec{A} = |\vec{A}|^2$

$\hat{i} \cdot \hat{i} = 1 \quad \hat{j} \cdot \hat{j} = 1 \quad \hat{k} \cdot \hat{k} = 1$

$\hat{i} \cdot \hat{j} = 0 \quad \hat{i} \cdot \hat{k} = 0 \quad \hat{k} \cdot \hat{j} = 0$

To find angle between two vectors $\cos\theta = \frac{\vec{A} \cdot \vec{B}}{|\vec{A}||\vec{B}|}$

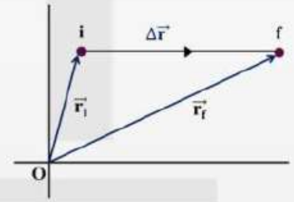


$\vec{B}_A = |\vec{B}| \frac{(\vec{A} \cdot \vec{B})}{|\vec{A}|\,|\vec{B}|} \hat{A}$

component of B along A

Displacement vector

$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$



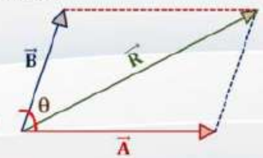
Parallelogram rule of vector addition

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

When $\theta = 0^\circ$ $\quad R_{max} = A + B$

When $\theta = 180^\circ$ $\quad R_{min} = |A - B|$

$R_{min} \leq |\vec{R}| \leq R_{max}$



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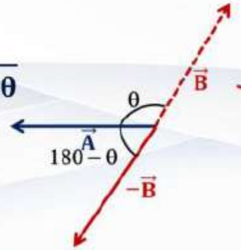
Subtraction of vectors

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

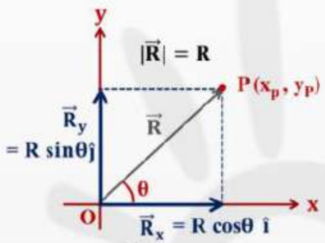
$|A - B| \le |\vec{A}-\vec{B}| \le A + B$



Zero vector $\vec{A} - \vec{A} = \vec{0}$

Resolution of a Vector into Components

Rectangular Components



$\vec{R} = \vec{R}_x + \vec{R}_y$

$\vec{R} = R\cos\theta\,\hat{i} + R\sin\theta\,\hat{j}$

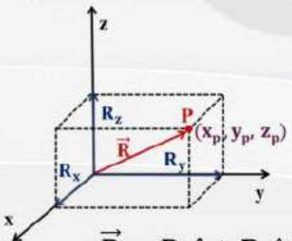
$|\vec{R}| = \sqrt{R_x^2 + R_y^2}$ $|\vec{R}| \ge 0$

$\hat{R} = \dfrac{\vec{R}}{|\vec{R}|} = \dfrac{R_x\hat{i} + R_y\hat{j}}{\sqrt{R_x^2 + R_y^2}}$

$\tan\theta = \dfrac{R_y}{R_x}$

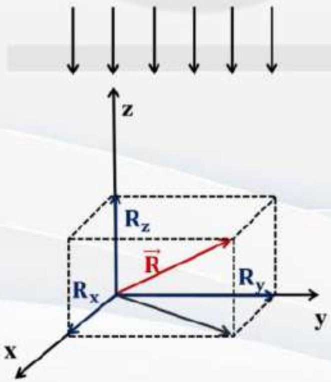
Position Vector $\overrightarrow{OP} = \vec{r} = x_p\hat{i} + y_p\hat{j}$

Resolution of vector in 3D



$\vec{R} = R_x\hat{i} + R_y\hat{j} + R_z\hat{k}$

$= |\vec{R}| = \sqrt{R_x^2 + R_y^2 + R_z^2}$



Projection of vector $\vec{R} = (R_x\hat{i} + R_y\hat{j} + R_z\hat{k})$

On xy plane will be $R_x\hat{i} + R_y\hat{j}$

& its length will be $\sqrt{R_x^2 + R_y^2}$

Projection on yz plane will be $R_y\hat{j} + R_z\hat{k}$

Projection on x axis will be $R_x\hat{i}$

Position Vector

$\vec{r} = x_p\hat{i} + y_p\hat{j} + z_p\hat{k}$

Unit vector

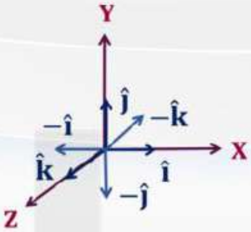
$\hat{A} = \dfrac{\vec{A}}{|\vec{A}|}$

- Magnitude = 1
- Purpose is to describe a direction in space

$|\hat{i}| = 1 = |-\hat{i}|$

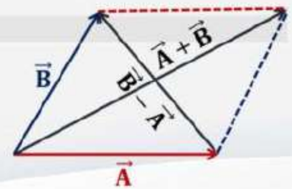
$|\hat{j}| = 1 = |-\hat{j}|$

$|\hat{k}| = 1 = |-\hat{k}|$



Key Points

When two vectors are joined tail to tail forming two adjacent sides of a ||gm, then one diagonal represent the sum and the other diagonal represent the difference.

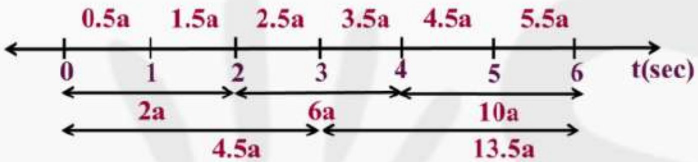


Kinematics 1D
Superfast Revision

$$s_{nth} = u + \frac{1}{2}a(2n-1)$$

$S_n - S_{n-1}$

Let acceleration be 'a'



A body starting from rest with uniform acceleration covers distance in ratio 1:3:5 in equal time interval.

Speed

- Average: $<\text{Speed}> = \frac{s}{\Delta t}$
- Instantaneous: $\text{Inst. Speed} = \frac{ds}{dt}$

s is distance

Velocity

- < > Average: $<\vec{v}> = \frac{\Delta \vec{r}}{\Delta t}$
- Instantaneous: $\vec{v}_{inst} = \frac{d\vec{r}}{dt}$

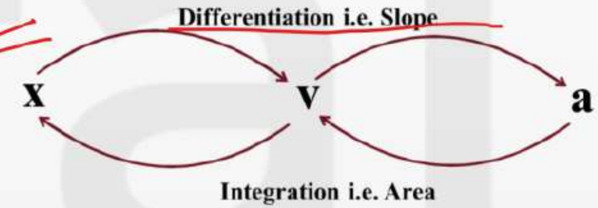
$\text{Inst. Speed} = |\vec{v}_{inst}|$

$\text{Avg. Speed} \geq |\text{Avg. } \vec{v}|$

Acceleration

- Average: $<\vec{a}> = \frac{\Delta \vec{v}}{\Delta t}$
- Instantaneous: $\vec{a} = \frac{d\vec{v}}{dt}$

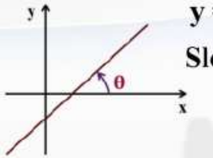
$$a = v\frac{dv}{dx}$$



If sign of a and v are same then speed is increasing and if sign are opposite then speed is decreasing

Kinematics1D

Slope



$y = (m)x + c$

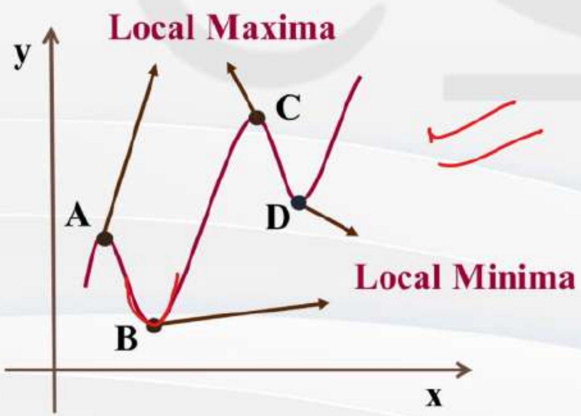
Slope $(m) = \tan\theta$

$0 < \theta < 90^\circ$ slope = +ve

$90^\circ < \theta < 180^\circ$ slope = −ve

$\theta = 0^\circ$ slope = 0

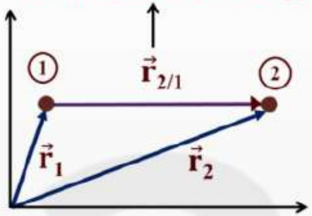
Local maxima and Local minima



	$\frac{dy}{dx}$	$\frac{d^2y}{dx^2}$
Local maxima	0	-ve
Local minima	0	+ve

Relative motion

Position of 2 w.r.t. 1 ($\vec{r}_{2/1}$)



$$\vec{r}_{2/1} = \vec{r}_2 - \vec{r}_1$$

$$\vec{v}_{2/1} = \vec{v}_2 - \vec{v}_1$$

$$\vec{a}_{2/1} = \vec{a}_2 - \vec{a}_1$$

For particle under constant acceleration

(1) $v = u + at$

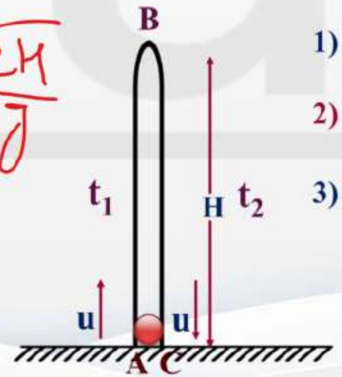
(2) $s = ut + \frac{1}{2}at^2$

(3) $v^2 = u^2 + 2as$

(4) $s = \left(\frac{v+u}{2}\right)t$

(5) $s = vt - \frac{1}{2}at^2$

Motion under gravity



1) Time of flight = $\frac{2u}{g}$

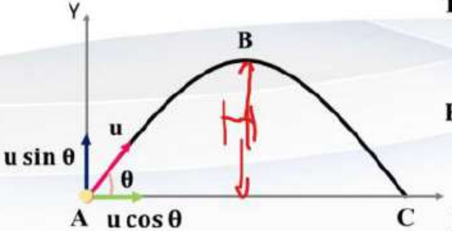
2) $H_{max} = \frac{u^2}{2g}$

3) $t_1 = t_2 = \sqrt{\frac{2H}{g}} = \frac{u}{g}$

Kinematics 2D

Superfast Revision

Projectile motion

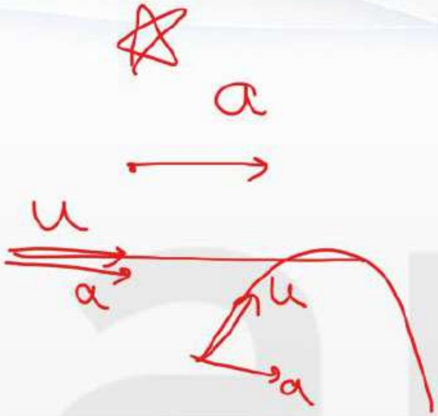


$$T = \frac{2u\sin\theta}{g} = \frac{2u_y}{g}$$

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

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

Kinematics 2D = 1D+1D



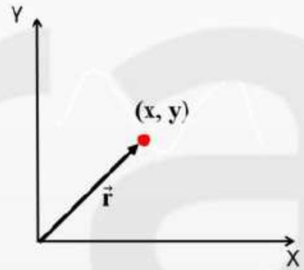
Path of particle having constant acceleration

Initial Velocity (u)	Path
u = 0	Straight Line
u ≠ 0, u and a collinear	Straight Line
u ≠ 0, u and a non-collinear	Parabolic

Range is same for the complimentary angles (θ and 90°- θ).

Range is maximum when θ is 45°

$$\frac{T_1}{T_2} = \tan\theta \qquad \frac{H_1}{H_2} = \tan 2\theta \qquad \frac{R_1}{R_2} = 1$$



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

$$\vec{v} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j}$$

$$\vec{a} = \frac{d^2x}{dt^2}\hat{i} + \frac{d^2y}{dt^2}\hat{j}$$

Relation between horizontal range and maximum height

$$H = \frac{R}{4}\tan\theta$$

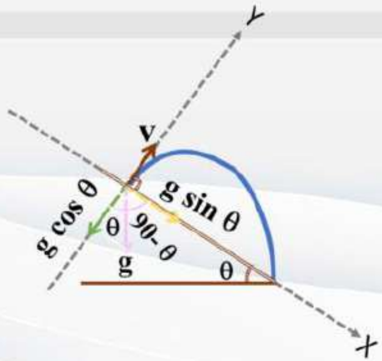
Equation of trajectory

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} = X\tan\theta\left(1 - \frac{X}{R}\right)$$

If a person can throw a ball to a maximum distance x then the maximum height to which he can throw the ball will be $\frac{X}{2}$

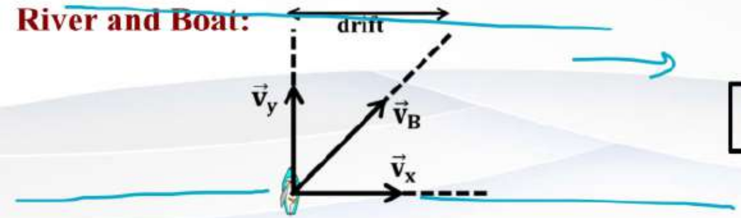
If two particles are projected in gravitational field then during the time at flight of both particles, trajectory of one particle w.r.t. other particle will be a straight line.

Projectile on inclined plane

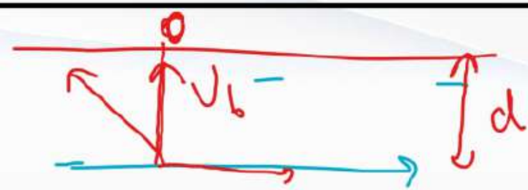


x	y
$u_x = 0$	$u_y = 0$
$a_x = g\sin\theta$	$a_x = -g\cos\theta$
$t = \frac{2v}{g\cos\theta}$	$s_y = 0$
$s_x = \frac{1}{2}\, g\sin\theta\left(\frac{2v}{g\cos\theta}\right)^2$	$0 = ut + \frac{1}{2}(g\cos\theta)t^2$
	$t = \frac{2v}{g\cos\theta}$

River and Boat:

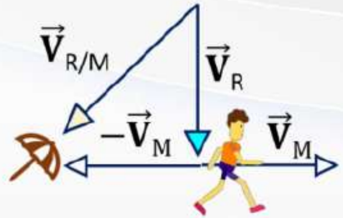


Kinematics 2D = 1D+1D



Rain Man situation:

1. Man observes rain in direction of velocity of rain w.r.t. man ($\vec{v}_{R/M}$).
2. Umbrella is held in direction opposite to the velocity of rain w.r.t. man ($-\vec{v}_{R/M}$). $= \vec{V}_R - \vec{V}_M$



$$\tan\theta < \frac{V_M}{V_R}$$

1. x component of $\vec{v}_B$ (i.e. along river flow) is responsible for drift.
2. y component of $\vec{v}_B$ (i.e. perpendicular river flow) is responsible for crossing the river.

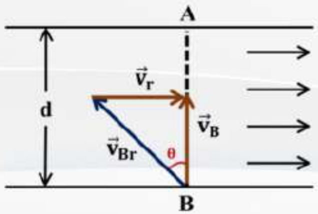
$$\vec{v}_B = \vec{v}_{B/r} + \vec{v}_r$$

For min. time	For min. distance
$V_{b/r}$ should be ⊥ to river flow	V_b should be ⊥ to river flow

For Shortest Path:

To reach at B, V_{Br} sin θ = V_r

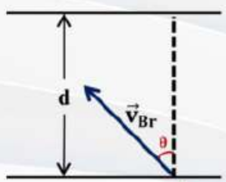
$$\sin\theta < \frac{V_r}{V_{Br}}$$



Time of Crossing:

If $V_r > V_{Br}$ then for minimum drifting

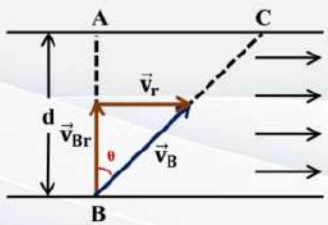
$$\sin\theta < \frac{V_{Br}}{V_r}$$



$$t = \frac{d}{V_{Br}\cos\theta}$$

For Minimum Time

$$t_{min} < \frac{d}{V_{Br}}$$



For minimum time

$V_{b/r}$ should be ⊥ to river flow

For minimum distance

V_b should be ⊥ to river flow

Lets Meditate !!

Newton's Laws of Motion

Superfast Revision

Newton's First Law of Motion (Law of Inertia)

Every body preserves its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by external forces impressed on it.

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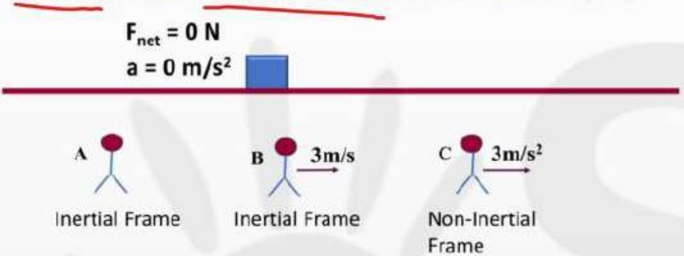
Newton's Laws of Motion

Inertial and Non-Inertial Reference Frame

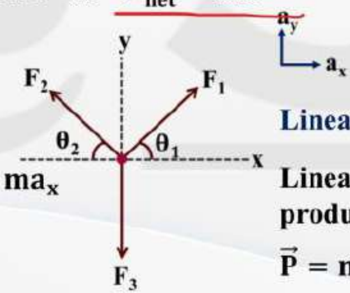


Newton's Second Law of Motion

In Inertial Frame, $\sum \vec{F} = m\vec{a}$ i.e $\vec{F}_{net} = m\vec{a}$

2nd Law for x-axis

$$\sum \vec{F}_x = m\vec{a}_x$$



$$\Rightarrow F_1\cos\theta_1 - F_2\cos\theta_2 = ma_x$$

2nd Law for y-axis

$$\sum \vec{F}_y = m\vec{a}_y$$

$$\Rightarrow F_1\sin\theta_1 + F_2\sin\theta_2 - F_3 = ma_y$$

Linear Momentum

Linear Momentum is the product of Mass and Velocity

$\vec{P} = m\vec{v}$ (kg m/s) or (N-s)

$$\vec{F}_{net} = \frac{d\vec{P}}{dt}$$

The rate of change of Linear Momentum of a body = net Force on a body.

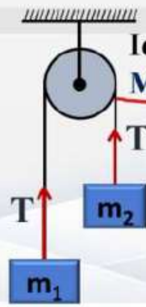
Normal Contact Force

- It is an electromagnetic type of force.
- It always acts along the common normal of the two surfaces in contact i.e. perpendicular to the surfaces.
- It is always directed towards the system.

Tension Force

- It is an electromagnetic type of force.
- This is a force applied by a string on an object or Force applied by one part of string on the remaining part of string.
- It acts along the string and away from the system on which it acts.

Tension in a massless string remains constant throughout the string if no tangential force acts along the string.



Ideal Pulley: Massless and Frictionless

Ideal String: Massless and Inextensible

Newton's Third Law of Motion

Every action has an equal and opposite reaction.

$\vec{F_1} = -\vec{F_2}$

Action and Reaction act on different bodies and not on the same body.

Action and Reaction forces are of same type.

Analysis of Translational Motion using NLM

In translational motion of a body, velocity of each point of the body is equal to velocity of every other point of the body.

In translation motion system can be treated as a particle.

Steps To Follow

(1) Define a System

(2) Define the Environment of the System

(3) Draw Free Body Diagram (FBD) of the system. Take only forces **on** the system (not By the system).

(4) Select appropriate axis and apply Newton's 2nd Law along each axis.

$\sum \vec{F} = m\vec{a}$ where $\sum \vec{F}$ is net force acting **on** the system along the chosen axis

Note: 'ma' is not a Force therefore, during the listing of forces in FBD in inertial frame, 'ma' should not be included.

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Newton's Laws of Motion

Translational Equilibrium

A system is said to be in Translational Equilibrium when net force on the system is zero.

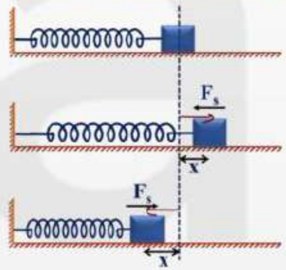
$$\sum \vec{F} = 0$$

Note: If magnitude of acceleration of each particle connected with a string is same then

$$a = \frac{\text{Net pulling force on string}}{\text{total mass}}$$

Spring Force:

NLP (Natural length position)

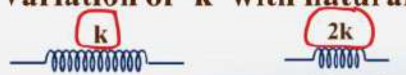


$\vec{F}_s = -K\vec{x}$

$|F_s| = K|x|$

Spring constant (or Force Constant of spring)

Variation of 'k' with natural length



natural length $= \ell$ | natural length $= \ell/2$

$k\ell =$ Constant | $k\ell = 2k\frac{\ell}{2}$

If both ends of a spring are attached with inertial mass then sudden change in length of spring is not possible.

Newton's Laws of Motion

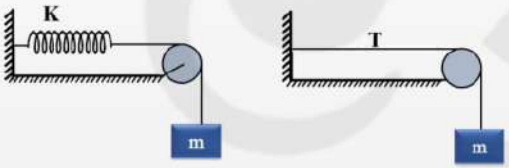
Reading of Weighing Machine

If an object is put on a weighing machine and 'N' is normal contact force b/w object & machine then reading of weighing machine will be given by

$$\text{Reading} = \frac{N}{g}$$

Key Point

If a spring is connected with a string then replace spring with string and find tension (T) in string and equate T with Kx to find elongation.



Reading of Spring Balance

$$\text{Reading of spring balance} = \frac{kx}{g}$$

Pseudo Force

- Second law of motion is not valid in non-inertial frame.
- To use Newton second law equation, one additional factor is added in F.B.D. of the system.
- This additional factor is called Pseudo Force.

Magnitude of Pseudo force is equal to 'ma'

'm' is mass of system

'a' is acceleration of non-inertial frame (in which analysis is done) w.r.t. inertial frame.

Pseudo force is applied in direction opposite to direction of 'a'

Pseudo force is not a force.

Constraint Motion

For a system,

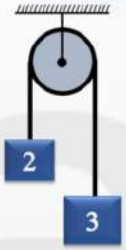
$\sum \vec{T}.\vec{x} = 0 \qquad \sum \vec{T}.\vec{v} = 0$

$\sum \vec{T}.\vec{a} = 0$

(if $\vec{a}$ are collinear with $\vec{v}$)

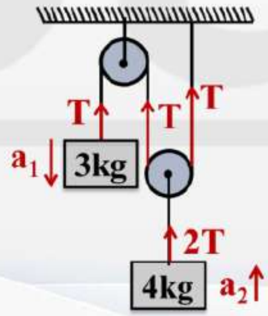
Keypoint

Constraint relation in string will also hold for string having mass provided it is inextensible.



Steps To Follow to Solve Problems Involving Constraint Motion

1. Take acceleration of each block in some direction.
2. Make FBD of each block and write Newton's 2nd law equation as per direction taken in step-I
3. Write constraint equations. Solve and get values of all accelerations. If acceleration comes positive – same direction as assumed in STEP-I and if acceleration comes negative then it is opposite to the direction assumed in STEP-I

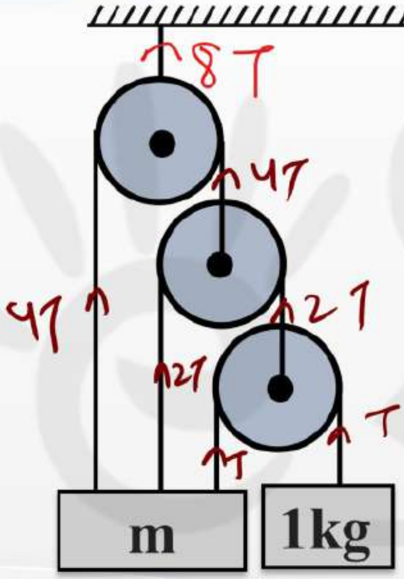


$T a_1(-1) + 2T a_2 = 0$

$3g - T = 3a_1$

$-2T + 4g = 4a_2$

Q) If the system is in equilibrium, find m.

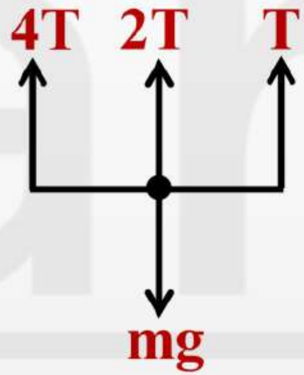


Sol.

(1 Kg)

$T = 1g$

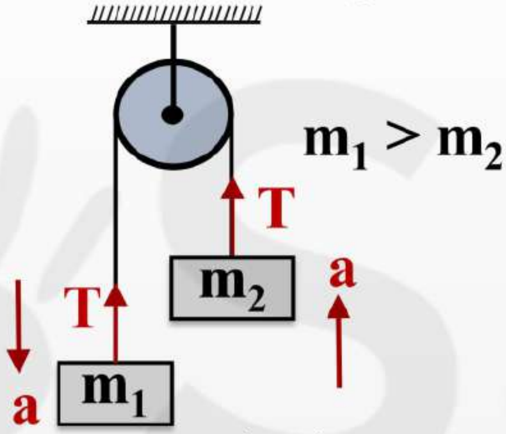
(m)



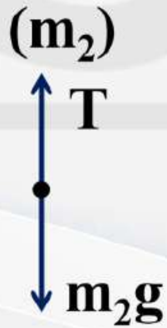
$7T = mg$

$m = 7\ kg$

Q) Find acceleration of m_1 and m_2 on releasing the system from rest.



Sol.



$$m_1g - T = m_1a \qquad T - m_2g = m_2a$$

Solving the two equations we get

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

$$T = \frac{2m_1m_2}{(m_1 + m_2)}g$$

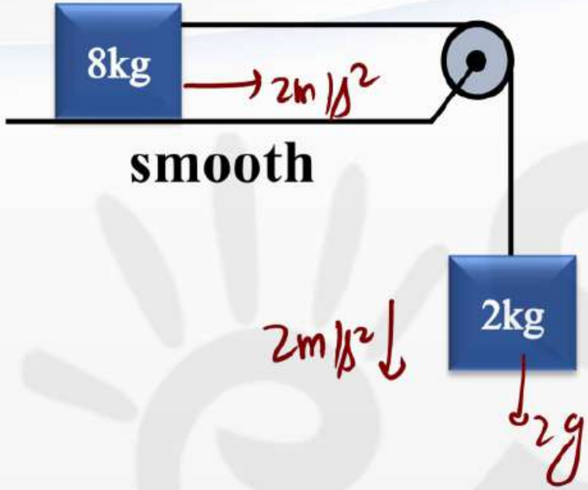
Note

If magnitude of acceleration of each particle connected with a string is same then

$$a = \frac{\text{Net pulling force on string}}{\text{total mass}}$$

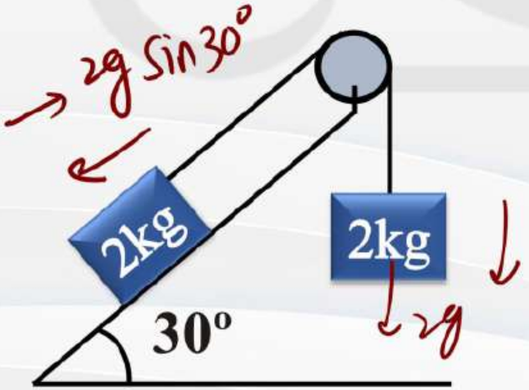
TRICK

$$a = \frac{\text{NET Pulling Force}}{\text{Total Mass}}$$



$$a = \frac{(2g - 0)}{(2 + 8)}$$

$= \sout{2 1 .r^1}$ 2m/s²



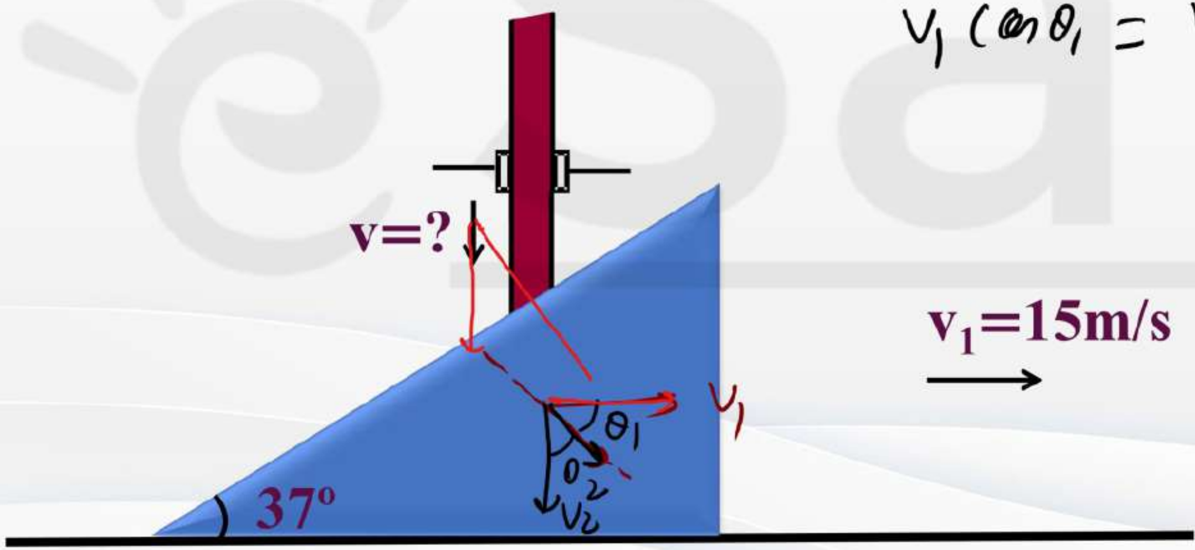
$$a = \frac{(2g - 2g\ \text{Sin}30^\circ)}{(2 + 2)}$$

$= \sout{2.5 1 .r^1}$

Wedge Constraint

Displacement, Velocity and Acceleration along common normal are equal.

$v_1 \cos\theta_1 = v_2 \cos\theta_2$



$v_1 = 15 m/s$

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Friction

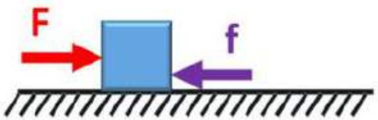
Friction does not oppose motion instead it opposes Relative Motion to the surface applying friction force.

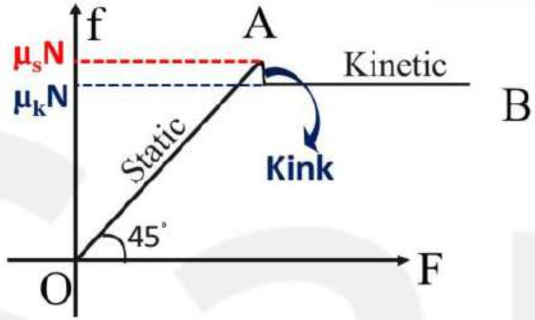
Friction acts along the surface in contact.

Static Friction

If there is a tendency of relative slipping (only tendency and not actual) between two surfaces in contact then the friction force acting between them is called Static Friction force.

It is a variable force whose value is equal to requirement to stop relative slipping till it reaches its limiting value known as Limiting Friction.





Laws of Static Friction

1) Maximum value of static friction (Limiting friction) is directly proportional to Normal force acting between the two surfaces in contact.

2) Static friction force acting between two surfaces in contact does not depend on area of contact.

$$(f_s)_{max} = \mu_s N$$ or $$f_s \le \mu_s N$$

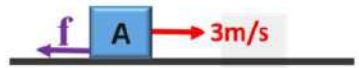
$(f_s)_{max}$ → Limiting friction

μ_s → coefficient of static friction

Kinetic Friction

Kinetic friction comes into picture when relative slipping occurs

It acts in direction opposite to relative velocity.



Laws of Kinetic Friction

1) Value of kinetic friction is directly proportional to Normal force acting between the two surfaces in contact

2) Kinetic friction force acting between two surfaces in contact does not depend on area of contact.

$$f_k = \mu_k N$$

f_k → Kinetic friction

μ_k → coefficient of kinetic friction

Generally $\mu_k < \mu_s$
(from experimental observation)

Value of μ_s and μ_k depends on nature of surfaces in contact.

Friction

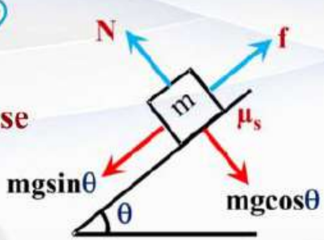
$$f_{min} = 0 \quad \le \quad f \quad \le \quad f_{max} = \mu N$$

$$R_{min} = N \quad \le \quad R \quad \le \quad R_{max.} = N\sqrt{1+\mu^2}$$

$$\tan\phi = 0 \quad \le \quad \tan\phi \quad \le \quad \tan\phi = \mu$$

$$\phi_{min.} = 0 \quad \le \quad \phi \quad \le \quad \phi_{max.} = \tan^{-1}(\mu)$$

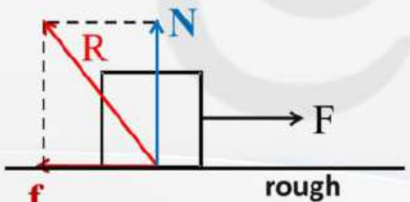
Angle of Response



At some angle of inclination θ the body starts sliding down the plane due to gravity. This angle of inclination is called angle of repose (θ).

$\theta = \tan^{-1}(\mu_s)$ is angle of repose.

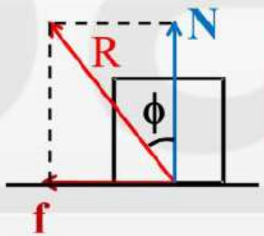
Net Contact Force:



Resultant of Normal and Friction force is the Net Contact Force.

$$R = \sqrt{N^2 + f^2}$$

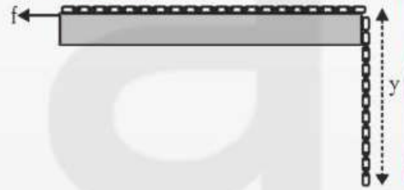
Angle of Friction



$$\tan\phi = \frac{f}{N}$$

The Angle of Friction (ϕ) is the angle between Net Contact Force and Normal Reaction

$\phi = 0$ for smooth surface



Weight of hanging part of the chain

$$= \frac{M}{L} yg$$

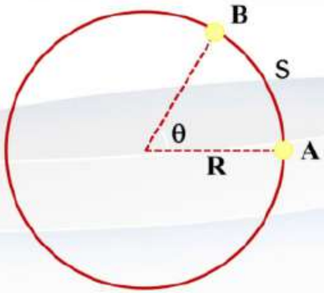
For equilibrium with maximum portion hanging, limiting friction = weight of hanging part of the chain

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

Lets Meditate !!

Circular Motion

Superfast Revision



Angle $\theta = \frac{S}{R} = \frac{arc\ length}{radius}$ radian

$S = R\theta$

Circular Motion

If α = constant, then

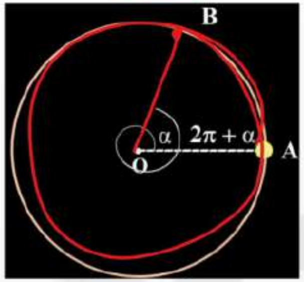
$\omega_f = \omega_i + \alpha t$

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

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

$\theta = \left(\frac{\omega_i + \omega_f}{2}\right) t$

$\theta = \omega_f t - \frac{1}{2}\alpha t^2$



Angular Displacement

$= 2\pi + \alpha$

Angular Velocity (ω)

Angular Velocity is defined as the rate of change of angular position w.r.t time.

Angular Velocity

- Average: $< \omega > = \frac{\Delta\theta}{\Delta t}$
- Instantaneous: $\omega = \frac{d\theta}{dt}$

SI unit is rad/s

Dimension is $[T^{-1}]$

1 RPM $= \frac{\pi}{30}$ rad/sec

$v = R\omega$

Angular Acceleration (α)

Angular Acceleration is defined as rate of change of angular velocity w.r.t. time.

Angular Acceleration

- Average: $< \alpha > = \frac{\Delta\omega}{\Delta t}$
- Instantaneous: $\alpha = \frac{d\omega}{dt}$

SI unit is rad/s^2

Dimension is $[T^{-2}]$

Time Period (T)

The time taken by an object to make one revolution is known as its Time Period

$T = \frac{2\pi}{\omega}$

Frequency (f)

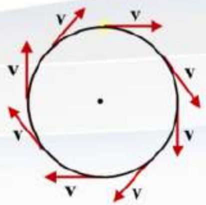
The number of revolutions made in one second is known as Frequency.

$f = \frac{1}{T} = \frac{\omega}{2\pi}$

Uniform Circular Motion

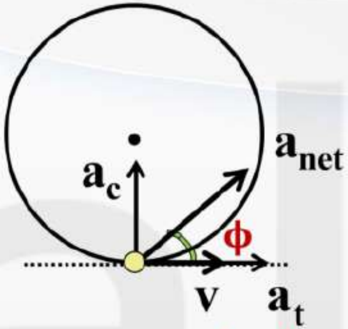
Circular Motion

Non–Uniform Circular Motion



If a particle is moving in a circle with constant speed then its motion is called Uniform Circular Motion (UCM).

If a particle is moving in a circle with variable speed then its motion is called Non-Uniform Circular Motion.

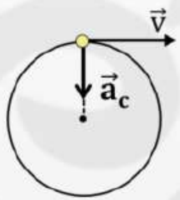


$|\vec{a}| = v\omega$

$|\vec{a}| = \frac{v^2}{R} \left(\because \omega = \frac{v}{R}\right)$

$|\vec{a}| = \omega^2 R$

$a_c = \frac{v^2}{R}$



$a_{net} = \sqrt{(a_c)^2 + (a_t)^2}$

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

$a_t = R\alpha$

This acceleration acts towards the centre, so it is called Centripetal Acceleration (a_c)

- Centripetal acceleration is perpendicular to the velocity and is responsible for changing the direction of the velocity.

- In U.C.M, $\vec{a}_c$ is not constant as its magnitude is constant but direction is changing.

Circular Motion

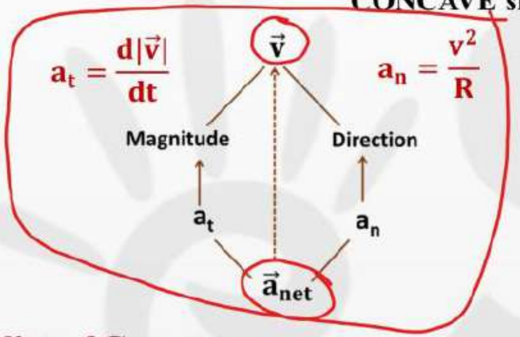
Curvilinear Motion

$$\vec{a}_{net} = \frac{d\vec{v}}{dt}$$

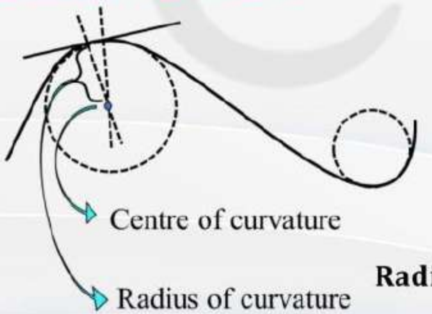
a_t is responsible for changing the magnitude of velocity i.e. speed of particle.

a_n is responsible for changing the direction of velocity. Its direction is towards the CONCAVE side.

$$a_t = \frac{d|\vec{v}|}{dt} \qquad a_n = \frac{v^2}{R}$$



Radius of Curvature



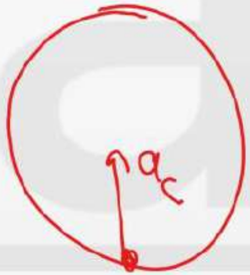
Radius of curvature $R = \frac{v^2}{a_n}$

Radius of curvature is property of curve & not of motion of particle.

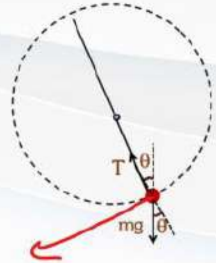
Dynamics of Circular Motion

The net resultant force providing the centripetal acceleration is called Centripetal Force.

$$\sum F_c = m\,a_c = \frac{mv^2}{R} = m\omega^2 R$$

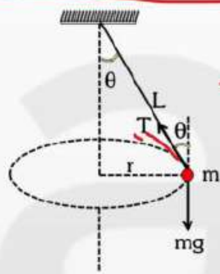


Vertical Circular Motion



$a_t = g\sin\theta$

Conical Pendulum



$v = \sqrt{rg\tan\theta}$

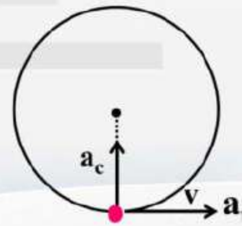
$$T = \frac{2\pi r}{v} = 2\pi\sqrt{\frac{L\cos\theta}{g}}$$

Dynamics of Non-UCM

Along radial

$$\sum F_C = ma_C = \frac{mv^2}{R} = m\omega^2 R$$

Along tangential $\sum F_t = ma_t$



$$F_{net} = \sqrt{\left(\sum F_C\right)^2 + \left(\sum F_t\right)^2}$$

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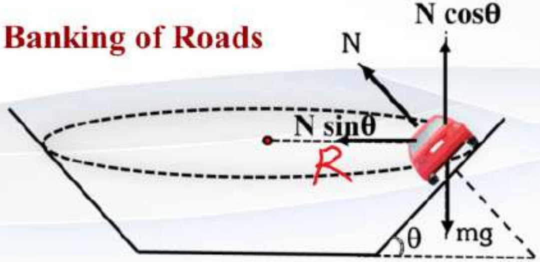
Circular Motion

Banking of Roads



No friction

$$\tan\theta = \frac{v^2}{Rg} \qquad V_0 = \sqrt{Rg\tan\theta}$$

Friction is present

$v < v_0$

For minimum speed, $f = \mu N$

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

$v > v_0$

For maximum speed, $f = \mu N$

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

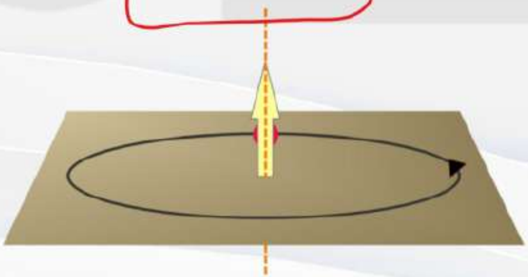
vehicle can successfully turn on a banked road in a circle of radius R for

$$v_{min} \le v \le v_{max}$$

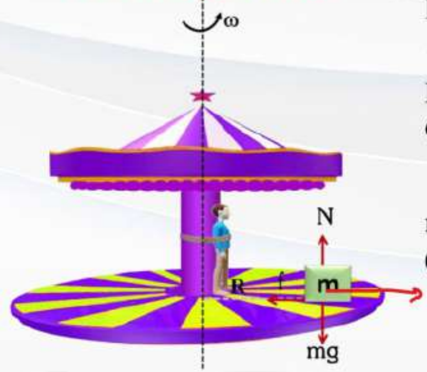
TRICK

Direction of ω

Right Hand Rule



Centrifugal Force



In ground frame

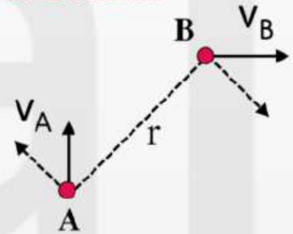
$f = m\omega^2 R$

Friction is the Centripetal Force.

In man's frame

$m\omega^2 R$ Pseudo Force (Centrifugal Force)

Angular Velocity in General



$$\omega = \frac{(v_\perp)_{rel}}{r}$$

$$= \frac{\text{relative velocity} \perp \text{ to line joining two particles}}{\text{separation between two particles}}$$

Lets Meditate !!

Work Power & Energy

Superfast Revision

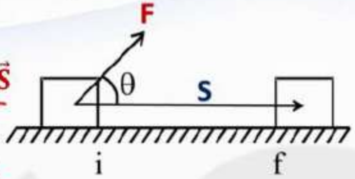
WPE

Work done by force $\vec{F}$ on an object is defined as

$$W_F = \int \vec{F}.d\vec{s}$$

$\vec{F}$ is the force on object $d\vec{s}$ is displacement of point of application of force ($\vec{F}$)

If $\vec{F}$ is constant, then $= \vec{F}.\vec{S}$



$W_F = \vec{F}.\vec{S} = FS\cos\theta$

θ is angle between $\vec{F}$ and $\vec{S}$

$0° < \theta < 90° \Rightarrow W_F = +ve$

$\theta = 90° \Rightarrow W_F = 0$

$\theta > 90° \Rightarrow W_F = -ve$

SI unit of work is Joule (J).
Cgs unit is erg.

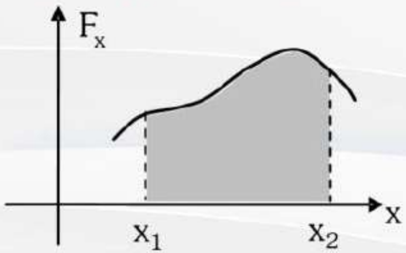
$1 \text{ erg} = 10^{-7} \text{ joule}$

Work is a scalar quantity.
It can be –ve , zero or +ve.

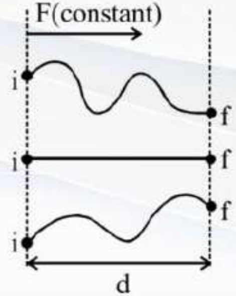
W_{Net}

- Get F_{net} and calculate its work to get W_{net} (for translation motion
- Get work from all the forces by applying $W = \int \vec{F}.d\vec{s}$ and add them to get net work

Work as Area Under Curve



$$W = \int F_x dx$$



$W_1 = W_2 = W_2 = Fd$

Work done by constant force depends only on initial and final position and not on the path taken

Work Done by Variable Force

If the force applying on a body is changing its direction or magnitude or both, the force is said to be variable.

$$W = \int \vec{F}.d\vec{r}$$

$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

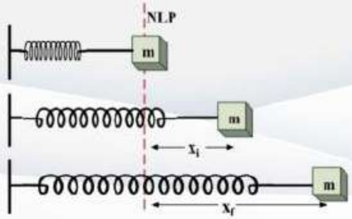
$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$$W = \int F_x dx + F_y dy + F_z dz$$

If particle goes from $(x_i\ y_i\ z_i)$ to $(x_f\ y_f\ z_f)$

$$W = \int_{x_i}^{x_f} F_x dx + \int_{y_i}^{y_f} F_y dy + \int_{z_i}^{z_f} F_z dz$$

Work Done by Spring Force



$$W_{sp} = \frac{1}{2}k(x_i^2 - x_f^2)$$

Where x_i and x_f are initial and final change in lengths from Natural Length of spring

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WPE

Work Energy Theorem

Work done by all the forces (external or internal) acting on a system is equal to the change in kinetic energy of the system.

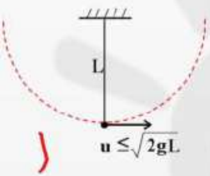
$W_{net} = \Delta KE = KE_f - KE_i$

KE of a particle $= \frac{1}{2}mv^2 = \frac{p^2}{2m}$

where p is momentum of particle

$W_{net} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

Vertical Circular Motion

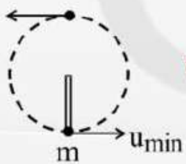


$u \le \sqrt{2gl}$

(circular motion but not complete)

$u \ge \sqrt{5gl}$

(complete vertical circular motion)



$u_{min} = \sqrt{4gL}$, for complete circle

Conservative Force

A Force is a Conservative Force when work done by it in any closed path (Loop) is zero.

$W_F = 0 \Rightarrow$ F is conservative

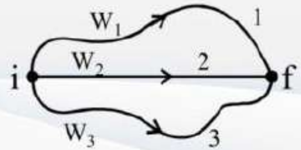
- Work energy theorem is valid in inertial frame.
- But we can use its equation in non-inertial frame by considering work of Psuedo Force.

Central Force

Force on an object whose magnitude only depends on the distance \`r\` of the object from a fixed point and is directed along the line joining object and the fixed point is referred as Central Force.

$$\vec{F} = f(r)\hat{r}$$

Work done by conservative force is independent of path. It depends only on initial & final position.



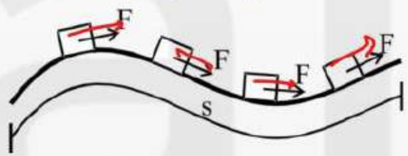
$W_1 = W_2 = W_3$ by F

Work Energy Theorem For System of Particle

$$(W_{net})_{sys} = (KE_f)_{sys} - (KE_i)_{sys}$$

- $(W_{net})_{sys} = \sum W_F$ on system
- W_F on system = $\sum W_F$ on each part of system
- KE of system = $\sum$ KE of each particle of system.

Work Done By Tangential Force



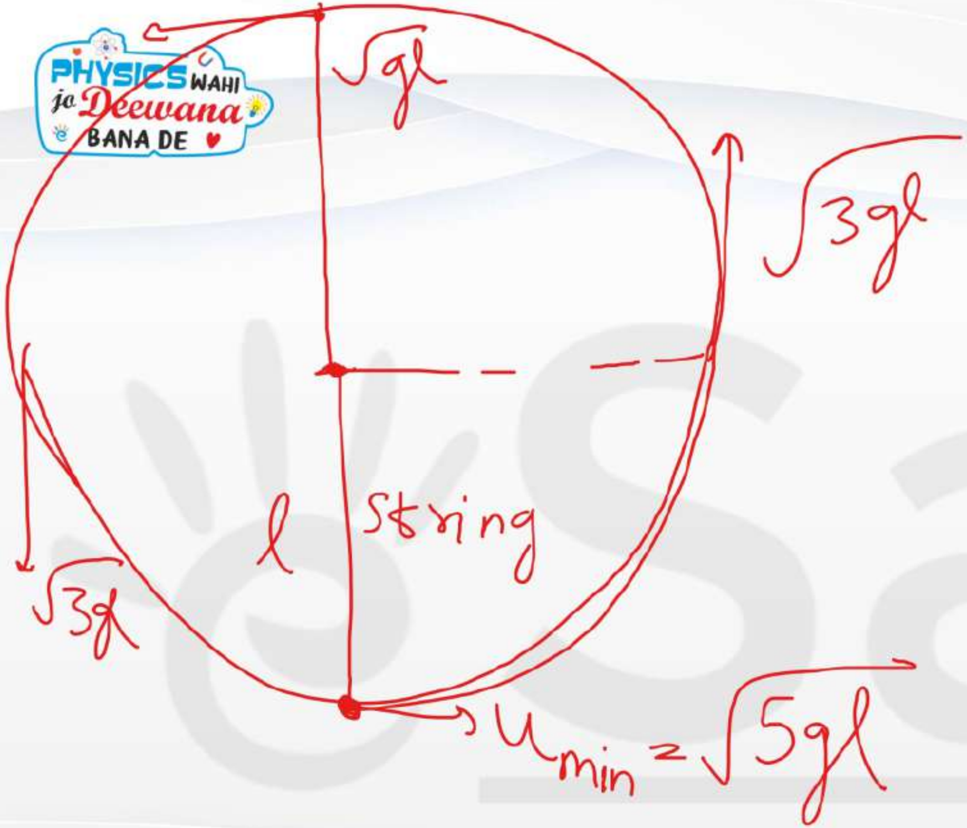
$W_F = \int \vec{F}.d\vec{s} = \int F\, ds\, \text{Cos}0^\circ$

If $\vec{F}$ is constant in magnitude

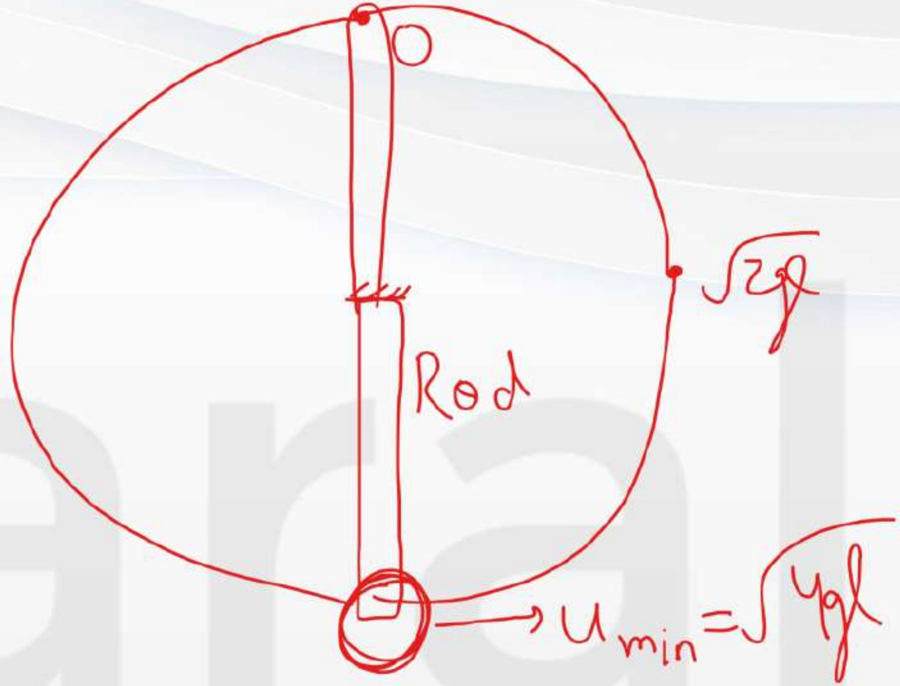
$W_F = F\int ds = Fs$ → Length of curve

- Constant Forces are conservative.
- Central forces are conservative.

Kinetic friction is an example of non-conservative force.

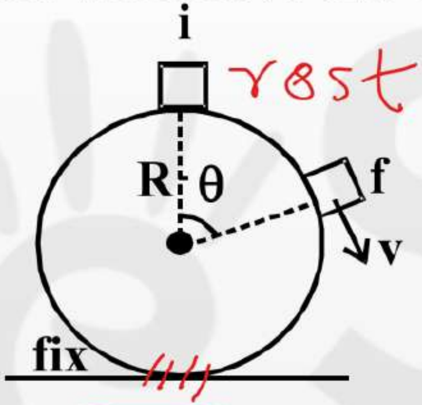


$\sqrt{gl}$
$\sqrt{3gl}$
$\sqrt{3gl}$
l
String
$u_{min} = \sqrt{5gl}$



O
$\sqrt{2gl}$
Rod
$u_{min} = \sqrt{4gl}$

Q) A block is released from rest from top of the fixed sphere. Find θ at which block will leave the contact with the sphere?



$$\cos\theta = \frac{2}{3}$$

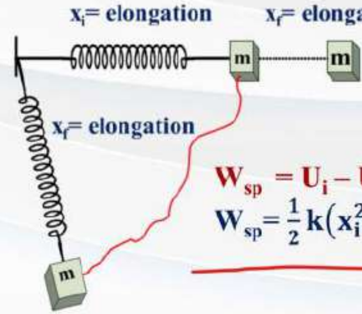
$$\theta = \cos^{-1}\left(\frac{2}{3}\right)$$

Potential Energy (U)

$\Delta U = -W_{int,C}$

$W_{int,C}$ is work done by internal conservative force

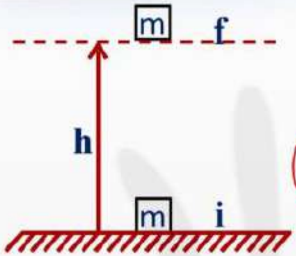
WPE



$W_{sp} = U_i - U_f$

$W_{sp} = \frac{1}{2}k(x_i^2 - x_f^2)$

Gravitational Potential Energy



$U_f = U_i + mgh$

If we take U at ground = 0 as reference value then

$U = mgh$

$W_g = -\Delta U = U_i - U_f$

$= mgh_i - mgh_f$

$= mg(h_i - h_f)$

$U = 3xy^2z$

$F = -\left[3y^2z\,\hat{i} + 3xz\,2y\,\hat{j} + 3xy^2\,\hat{k}\right]$

Force in terms of potential energy

$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

$\vec{F} = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right]$

Potential energy in terms of Force (conservative)

$$U_f - U_i = -\left(\int_{x_i}^{x_f} F_x dx + \int_{y_i}^{y_f} F_y dy + \int_{z_i}^{z_f} F_z dz\right)$$

Mechanical Energy & its Conservation

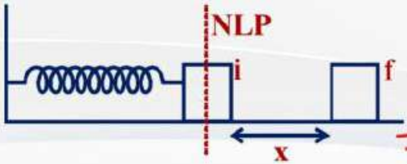
Mechanical Energy = Potential Energy + Kinetic energy

ME = U + KE

If $W_{ext} + W_{int,NC} = 0$

then ME = U + KE is conserved

Potential energy associated with Spring Force

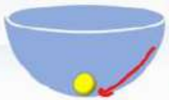


$U = \frac{1}{2}Kx^2$

A body is said to be in equilibrium when

$F_{net} = 0$

Stable Equilibrium



$\frac{dU}{dx} = 0$ and $\frac{d^2U}{dx^2} = +ve$ Stable Equilibrium

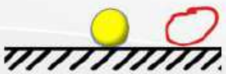
- It is an equilibrium where on slight displacement of particle from equilibrium position a force acts on particle which try to bring the particle back to equilibrium position.
- Such force is restoring and opposite to displacement.

Unstable Equilibrium

$\frac{dU}{dx} = 0$ and $\frac{d^2U}{dx^2} = -ve$ Unstable Equilibrium

- It is an equilibrium where on slight displacement of particle from equilibrium position a force acts on particle which tries to take the particle away from the equilibrium position.

Neutral Equilibrium



- It is an equilibrium where on slight displacement of particle from equilibrium position the particle remains in equilibrium position

$v = t^2$

$m\, 2t\, t^2$

$2mt^3$

Power

Power of a force is equal to rate of work done by that force.

$P = \frac{dW}{dt}$

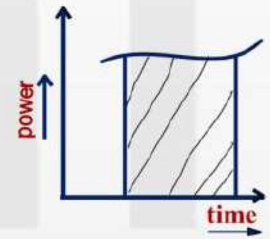
$P_{avg} = \langle P \rangle = \frac{\Delta W}{\Delta t}$

- S.I. unit of power is Watt (W)
- Other unit is Horse Power (HP)
- 1 HP = 746 W.

$P = \frac{dW}{dt}$ Slope of W-t graph gives instantaneous Power

$W = \int dW = \int P dt$

W is given by area under P-t graph



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

$= Fv$

$= m a v$

(1) $m\frac{dv}{dt}v$

(2) $mv\frac{dv}{ds}v$

Lets Meditate !!

Center of Mass

Superfast Revision

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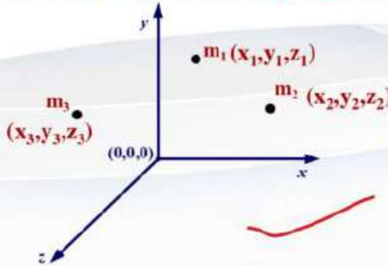
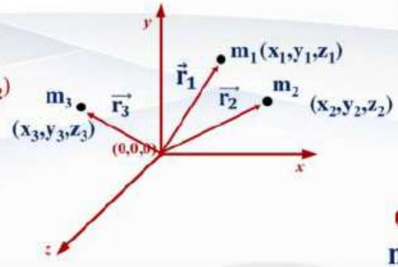
Center of Mass

Centre of mass of discrete point masses

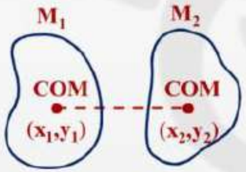




$$X_{cm} = \left(\frac{m_1x_1 + m_2x_2 + \ldots}{m_1 + m_2 + \ldots}\right) = \frac{\sum m_i x_i}{\sum m_i}$$

$$Y_{cm} = \left(\frac{m_1y_1 + m_2y_2 + \ldots}{m_1 + m_2 + \ldots}\right) = \frac{\sum m_i y_i}{\sum m_i}$$

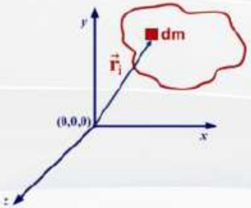
Com of several groups of particles



$$X_{CM} = \frac{M_1x_1 + M_2x_2}{M_1 + M_2}$$

$$Y_{CM} = \frac{M_1y_1 + M_2y_2}{M_1 + M_2}$$

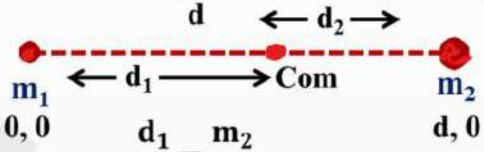
Com of continuous bodies



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

$$\vec{r}_{cm} = \frac{\sum m_i \vec{r}_i}{\sum m_i} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \cdots}{m_1 + m_2 + \cdots}$$

Locate COM of m_1 and m_2



$$\frac{d_1}{d_2} = \frac{m_2}{m_1}$$

Linear mass density (λ)

Mass per unit length is called linear mass density λ

$$\lambda = \frac{M}{L}$$

For uniform object, λ is same for every element

Surface mass density (σ)

Mass per unit area

For uniform objects $\sigma = \frac{M}{A}$

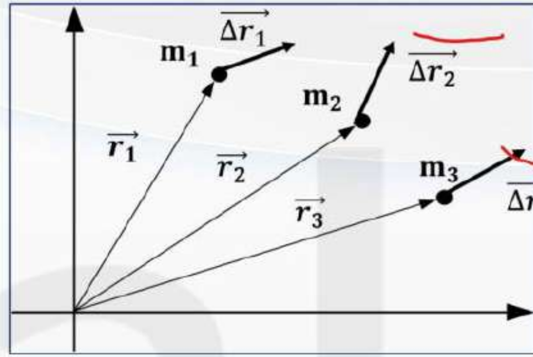
Volumetric mass density (ρ)

Mass per unit volume

If uniform then $\rho = \frac{M}{V}$

For uniform objects COM is at geometrical centre.

Displacement of COM due to displacement of particles of system



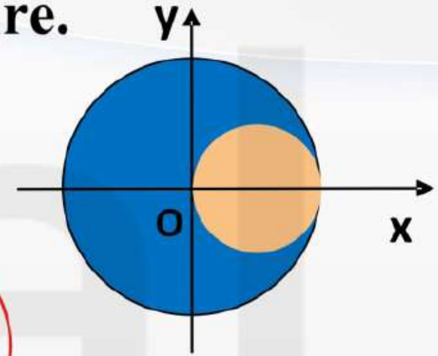
$$\Delta\vec{r}_{cm} = \frac{m_1\Delta\vec{r}_1 + m_2\Delta\vec{r}_2 + \ldots..}{m_1 + m_2 + \ldots..}$$

Velocity and Acceleration of COM

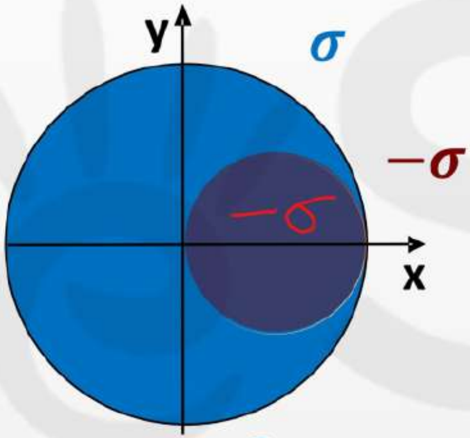
$$\vec{v}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2 + \ldots..}{m_1 + m_2 + \ldots..}$$

$$\vec{a}_{cm} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + \ldots..}{m_1 + m_2 + \ldots..}$$

Q) **Find COM of the following truncated disk made by removing disk of radius r/2 from the disk of radius r as shown in the figure.**



Sol.



$\sigma\pi r^2$ $\qquad$ $-\sigma\pi(r/2)^2$

$$-d = \frac{\sigma\pi r^2\,(0) + (-\sigma\pi\,(r/2)^2)(r/2)}{\sigma\pi r^2 + (-\sigma\pi\,(r/2)^2)} = -\frac{r}{6}$$

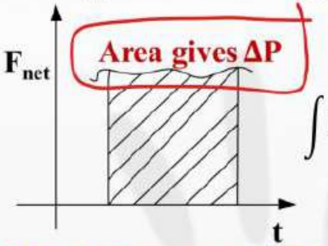
Center of Mass

Linear Momentum

Linear Momentum is the product of Mass and Velocity $\vec{P} = m\vec{v}$
SI Unit is (kg m/s) or (N-s)

For a particle.

$\vec{F}_{net} = \frac{d\vec{P}}{dt}$ $\quad < \vec{F}_{avg} > = \frac{\Delta \vec{P}}{\Delta t}$



$\int \vec{F}_{net}\, dt = \Delta \vec{P}$

Kinetic Energy of a particle

KE of particle $= \frac{P^2}{2m}$

Linear Momentum for system of particles

It is vector sum of L.M. of all the particles in system.

$\vec{P}_{sys.} = \sum \vec{P}_i = m_1\vec{v}_1 + m_2\vec{v}_2 + \ldots\ldots = M\vec{V}_{cm}$

M = Mass of System

$\vec{V}_{cm}$ = Velocity of COM of System

For calculation of linear momentum of a system we can assume whole mass to be concentrated at COM moving with $\vec{V}_{cm}$.

Kinetic Energy of System of particles

KE of system of particles is the algebraic summation of KE of all its constituent particles

$$KE = \sum \frac{1}{2} m_i v_i^2 \neq \frac{1}{2} M (V_{cm})^2$$

For calculation of Kinetic Energy of a system we CANNOT assume whole mass to be concentrated at COM moving with $\vec{V}_{cm}$.

Principle of conservation of L.M.

If net external force acting on a system is zero for a time interval then in that interval linear momentum of the system is conserved (i.e. remains constant)

Impulse-Momentum Theorem

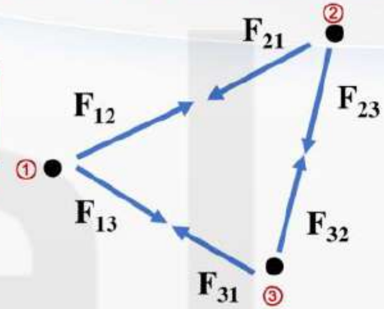
$$\vec{I}_{net} = \vec{P}_f - \vec{P}_i$$

Impulse is a vector quantity whose unit is same as that of momentum (kgm/s) or (N-s.)

(i) If linear momentum of a system is zero, then its KE may or may not be zero.
(ii) If KE of system is zero then its linear momentum must be zero.

Newton's Second Law for System of Particles

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



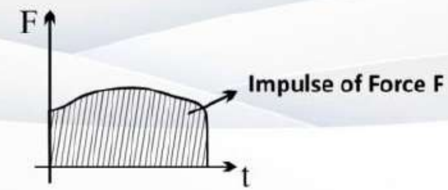
$M\vec{a}_{cm} = F_{1ext} + F_{1int}\ F_{2ext} + F_{2int} + \ldots\ldots$

Impulse : Impulse of a force for a time interval "t_1" to "t_2" is defined as

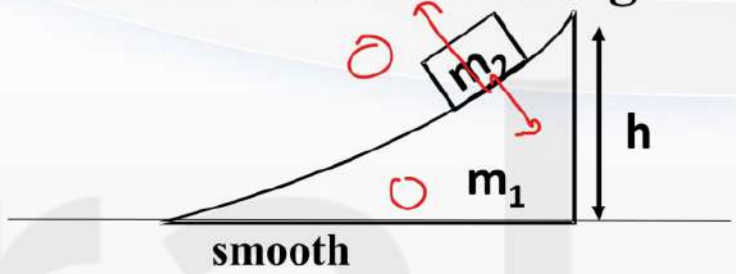
$$\vec{I} = \int_{t_1}^{t_2} \vec{F} dt$$

Area under F-t graph gives Impulse of Force F

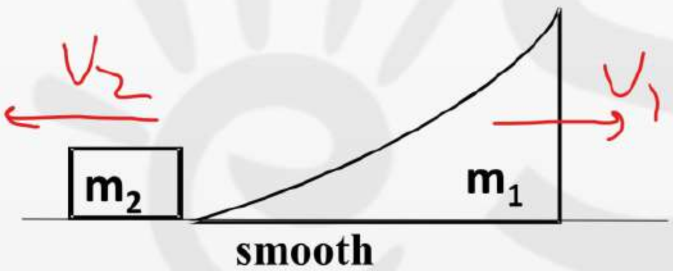
If $\vec{F}$ is constant, $\vec{I} = \vec{F}\,\Delta t$



Q) Find velocity of m_2 and m_1 when m_2 reaches the bottom after releasing from rest from height h.



Sol.



$$\sum (\vec{F}_{ext})_x = 0$$

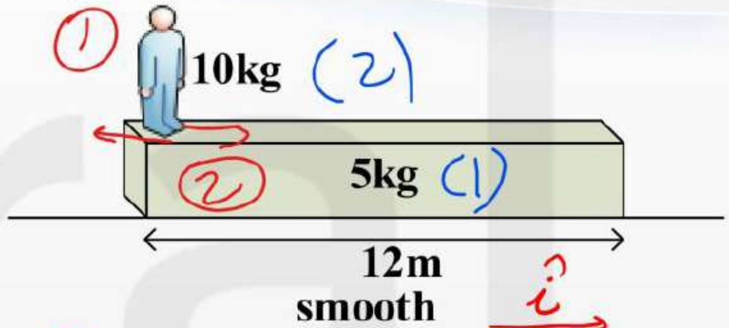
$$(P_i)_x = P(_f)_x$$

$$0 + 0 = m_2 v_2 - m_1 v_1$$

$$W_g + W_N = K_f - K_i$$

$$(m_2 gh) + 0 = \left(\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2\right) - (0 + 0)$$

Q) The man moves from one end to another on a plank kept on a smooth floor. If system was rest initially, how much has plank moved in the process?



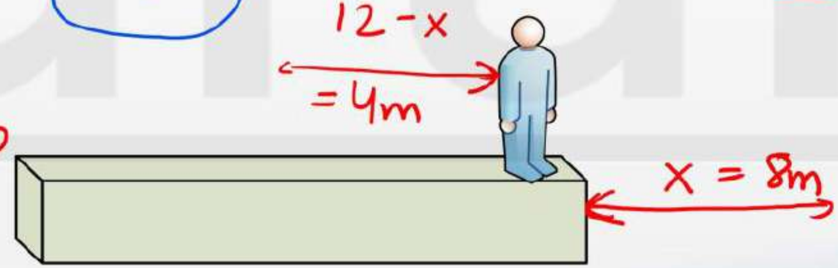
Sol.

$F_{ext} = 0$ $a_{cm} = 0$

$V_{cm} = 0 \Rightarrow \Delta x_{cm} = 0$

12m: 8m, 4m

$$\Delta x_{cm} = \frac{10(12-x)\hat{i} + 5(x)(-\hat{i})}{10+5} = 0$$



$$\Rightarrow x = \frac{2 \times 12}{(2+1)} = 8m$$

$$x = \frac{m_1 l}{m_1 + m_2}$$

Center of Mass

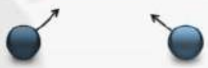
Impulsive Force

Force which acts for a very small time duration and whose magnitude is very large is called Impulsive Force.

In presence of impulsive forces, non-impulsive forces (like mg, spring force) can be neglected.

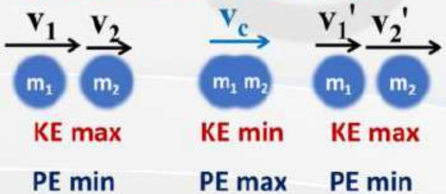
Collision

- **Head On Collision**: When during collision, velocities of both the objects are along the common normal of colliding objects
- **Oblique Collision**: If velocities of any of the colliding objects is not along the common normal



Elastic bodies are bodies which regain their original shape without any loss of energy.

Head-on Elastic Collision



(i) Total ME of system remains constant.

(ii) Initial KE & Final KE are equal but it is not constant throughout the process.

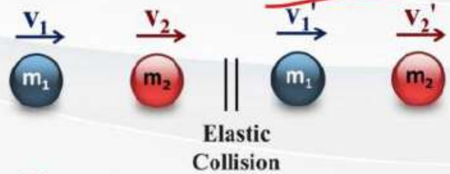
(iii) At the instant when velocities of both the bodies are same then PE is maximum & KE is minimum.

Coefficient of Restitution (e)

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

$$e = \frac{v_2' - v_1'}{v_1 - v_2} \qquad P_i = P_f$$

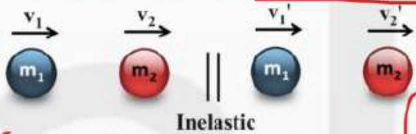
For elastic collision e = 1



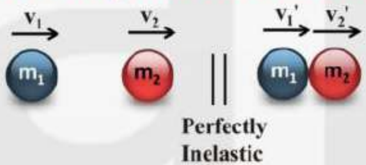
If $m_1 = m_2$

Velocities are interchanged.

Inelastic Collision $0 < e < 1$



Perfectly Inelastic Collision $e = 0$



Both bodies stick together and move with same velocity after collision

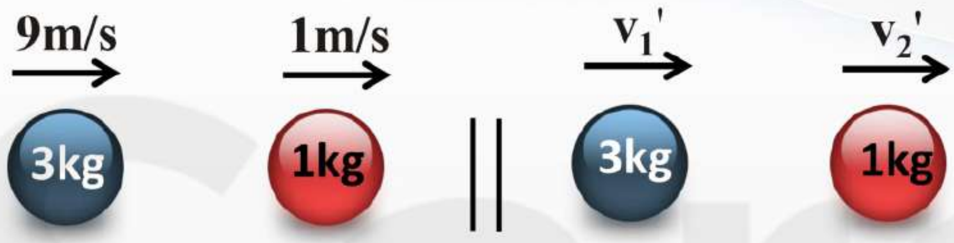
KE loss in collision

$$KE_{loss} = KE_i - KE_f$$

$$= \frac{1}{2}\mu v_{app.}^2 (1 - e^2)$$

$$\frac{m_1 m_2}{m_1 + m_2} = \mu \quad \text{(reduced mass)}$$

Q) Find v_1' and v_2'



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

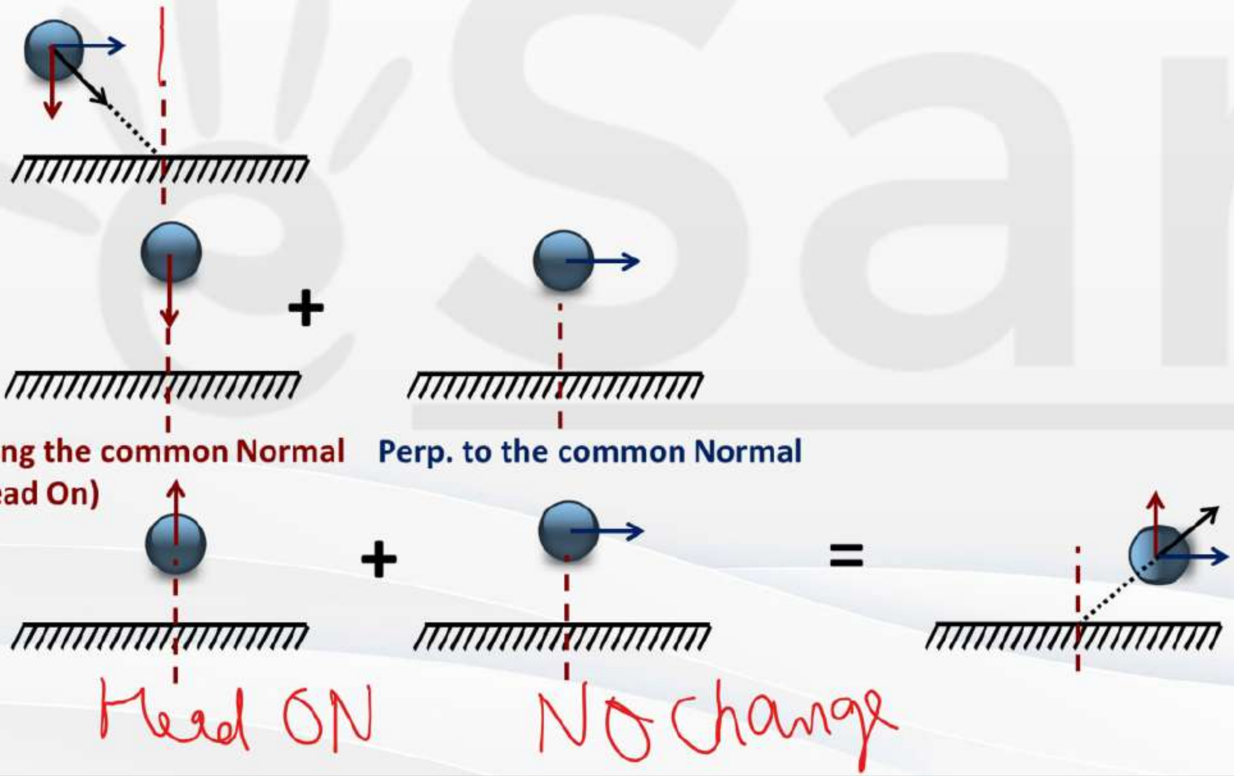
Sol. $P_i = P_f$

$$9 \times 3 + 1 \times 1 = 3v_1' + v_2' \quad \text{...(1)}$$

$$e = \frac{v_2' - v_1'}{v_1 - v_2} \Rightarrow \frac{1}{2} = \frac{v_2' - v_1'}{9 - 1} \quad \text{...(2)}$$

$$\Rightarrow v_1' = 6\,\text{m/s} \qquad v_2' = 10\,\text{m/s}$$

Oblique Collision



COM Frame

$\vec{P}_{sys} = M\vec{v}_{cm}$ $\quad \vec{P}_{sys/cm} = M\vec{v}_{cm/cm}$

$\vec{P}_{sys/cm} = 0$

In Centre of Mass frame, Linear Momentum of a System is Zero

Kinetic Energy of Two Particle System in CM Frame

In CM Frame

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

(reduced mass)

KE system

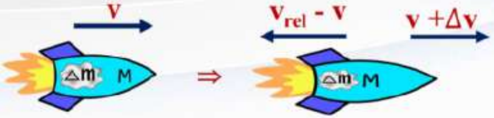
$$KE_{system} = \frac{1}{2}\mu (v_{rel})^2$$

$$KE_{sys} = KE_{sys/CM} + \frac{1}{2}(M)V_{cm}^2$$

total mass of system

Center of Mass

Variable Mass



$v_{rel.}$ is known as exhaust speed which is the speed of exhaust relative to the rocket

$$M(\Delta v) = \Delta m\, v_{rel}$$

$$F_{thrust} = M\frac{\Delta v}{\Delta t} = \frac{\Delta m}{\Delta t} v_{rel.}$$

Recoil of Gun

$$F_{thrust} = \frac{m_{bullet} v_{rel.}}{\Delta t}$$

$v_{rel.}$ is known as muzzle velocity i.e. velocity of bullet w.r.t gun.

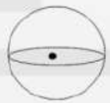
Center of Mass of some Shape

Disk

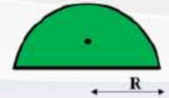
Ring

Solid Sphere

Hollow Sphere



Semi circular plate



$\frac{4R}{3\pi}$ = 1.33

Semi circular ring

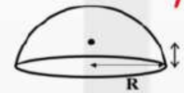
$\frac{2R}{\pi}$ = 2

TRICK

Solid hemisphere

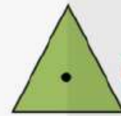
$\frac{3R}{8}$

Hollow hemisphere



$\frac{R}{2}$

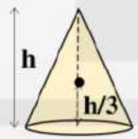
Triangle



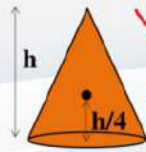
Centroid

Trick

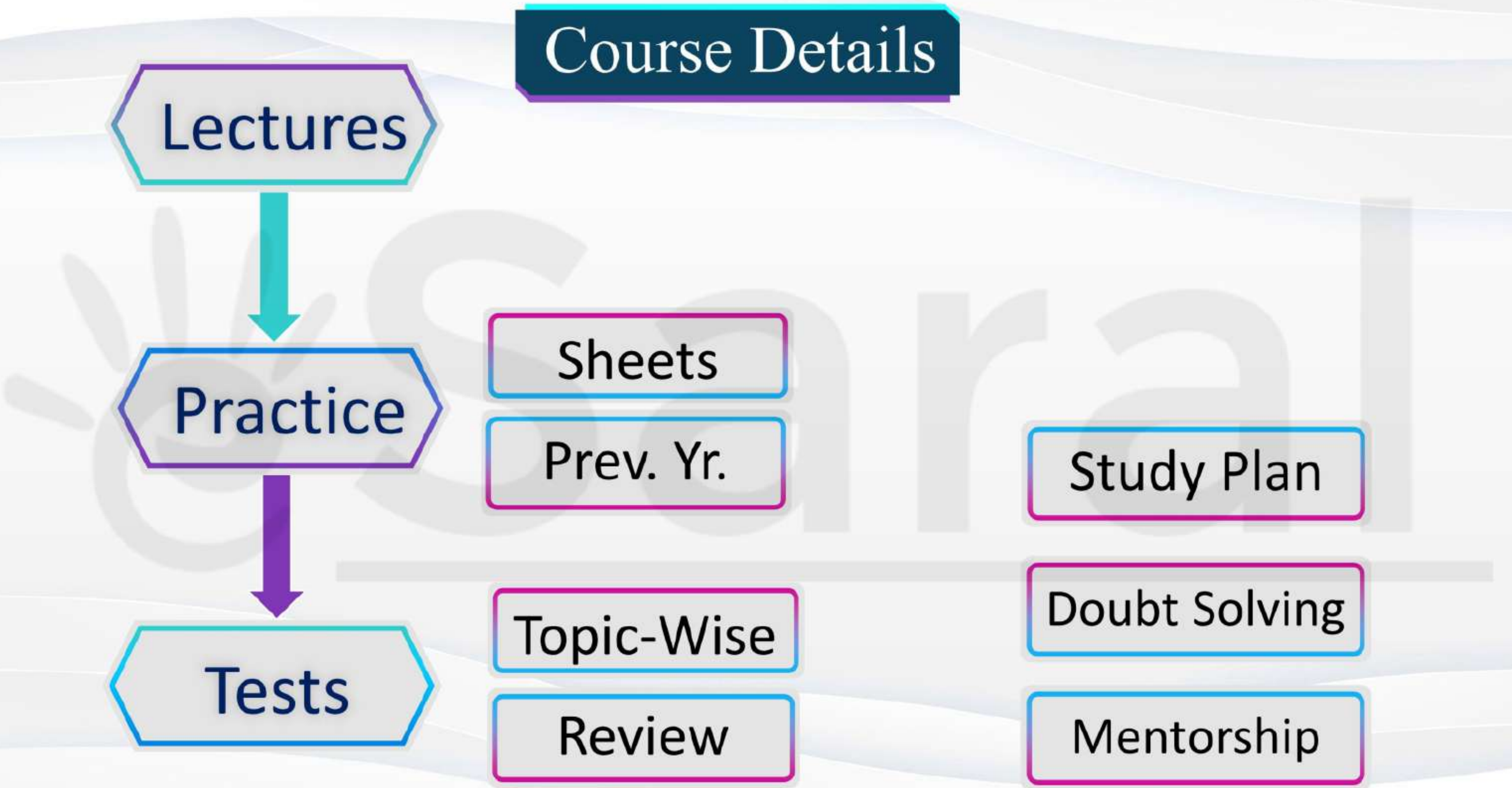
Hollow cone



Solid cone



Lets Meditate !!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Lectures
Practice
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Sheets
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Study Plan
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Mentorship


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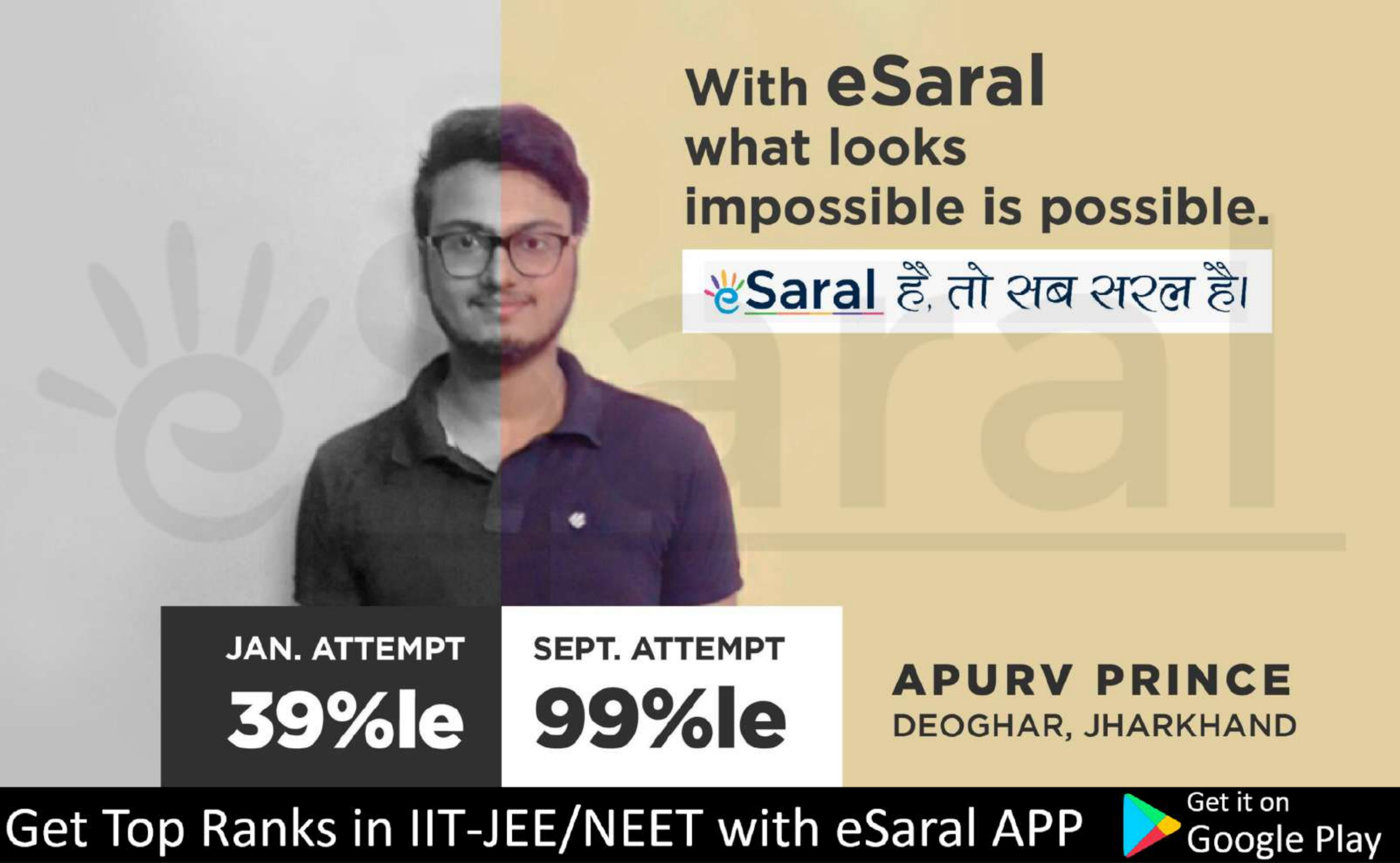
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Complete Physics Mega Revision Timetable

15 Feb
- Electrostatics
- Current electricity
- Capacitor
- 🎁 **Surprise Gift** 🎁

16 Feb
- Calorimetry
- Elasticity
- Thermal Expansion
- Heat Transfer
- KTG
- Thermodynamics
- Fluid Mechanics

17 Feb
- Magnetic effect of current
- Magnetism and matter
- Emi
- AC

18 Feb
- UD
- Vector
- Kinematics 1D
- Kinematics 2D
- NLM
- Friction
- Circular motion
- Work power energy
- COM
- Rotation motion

19 Feb
- Ray optics
- Optical Instruments
- Wave optics
- EM Waves
- Errors in measurement

20 Feb
- Gravitation
- SHM
- Wave on string
- Sound wave

21 Feb
- Dual nature of radiation
- X-rays
- Nuclear physics
- Radioactivity
- Semi conductor
- Communication system