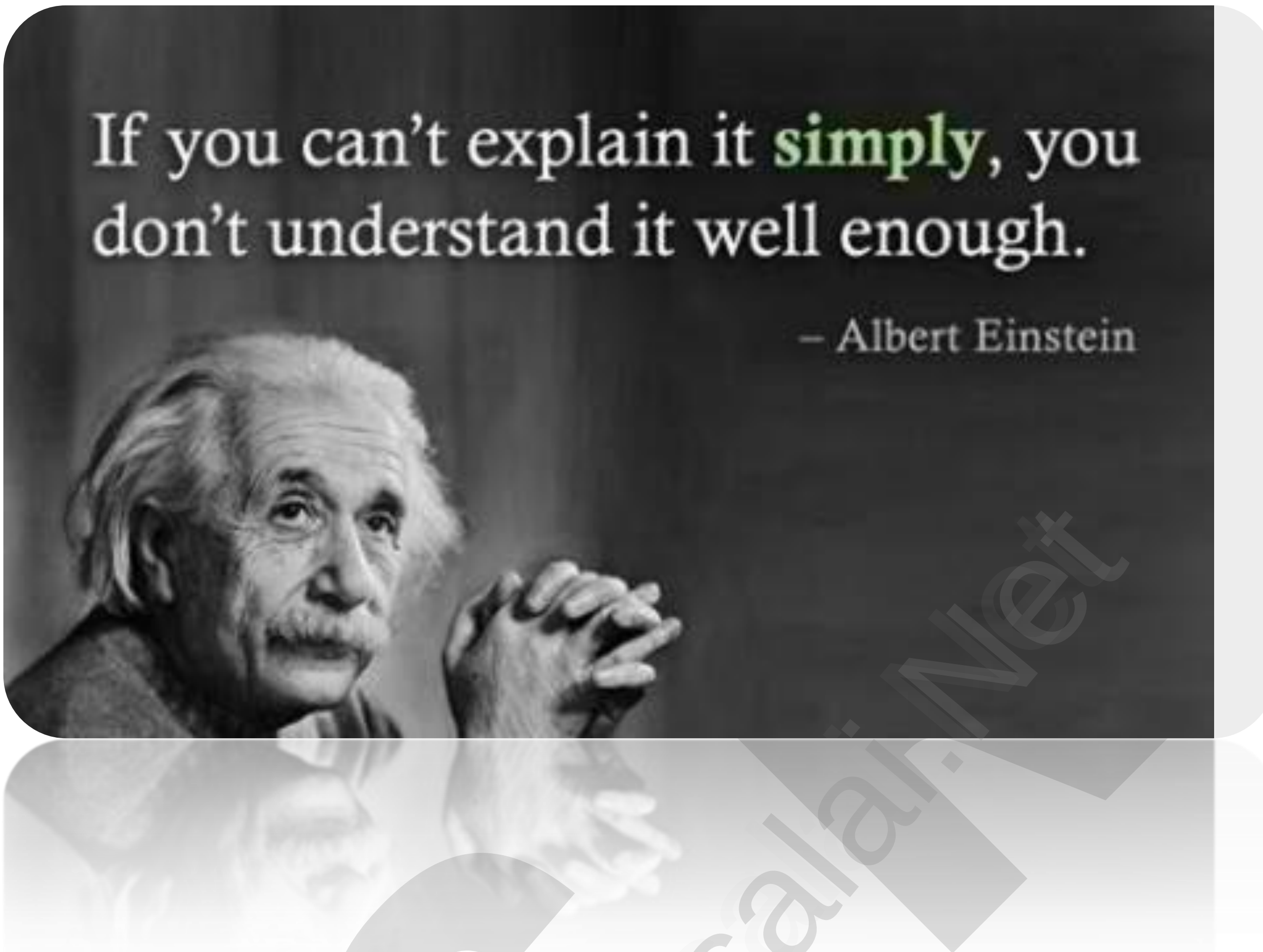

NAME

STD **SEC** **EXAM NO**

SCHOOL

ACKNOWLEDGEMENT

- **First of all, I am grate full to DHIVYA THAMBATHIGAL for guiding me in each and every phase of my life**
- **I wish to express my sincere thanks to Mr. T.A.S. KRISHNAN, our honorable secretary and our other committee members of my school for their constant encouragement.**
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LAKSHMI NARASIMHAN .G

CONTENTS

01. NATURE OF PHYSICAL WORLD & MEASUREMENTS

FIVE MARKS

1. If the value of universal Gravitational constant in SI is 6.6×10^{-11} Nm^2Kg^{-2}, then find its value in CGS system

G in SI system	$G_1 = M_1^a\ L_1^b\ T_1^C$ ______ (1)			
	$G_1 = 6.6 \times 10^{-11}\ N\,m^2\,kg^{-2}$			
G in Cgs system	$G_2 = M_2^a\ L_2^b\ T_2^C$ ______ (2)			
Dimensional Formula of G o	$M^{-1} L^3 T^{-2}$	a	b	C
		-1	3	-2
(2) = (1)	$G_1 [\ M_1^a\ L_1^b\ T_1^C\ ] = G_2[\ M_2^a\ L_2^b\ T_2^C\ ]$			
	$\frac{G_2}{G_1} = \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^C$			
Substituting	$G_{cgs} = 6.6\ X\ 10^{-8}\ dyne\ cm^2 g^{-2}$			

2. Convert 76cm of mercury pressure into Nm^{-2} using the method of dimensions.

P in cgs system	$P_1 = M_1^a\ L_1^b\ T_1^C$ ______ (1)			
	$P_1 = h\rho g = 76 \times 13.6 \times 980$ dyne cm^{-2}			
P in SI system	$P_2 = M_2^a\ L_2^b\ T_2^C$ ______(2)			
Dimensional Formula of P	$M L^{-1} T^{-2}$	A	B	C
		1	-1	-2
$\frac{(2)}{(1)}$	$\frac{P_2}{P_1} = \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^C$			
	$\boxed{P_2 = 1.01\ x\ 10^5\ Pa}$			

3. Obtain an expression for the time period T of a simple pendulum. The time period T depend upon (i) mass of the bob (ii) length of the pendulum (iii) acceleration due to gravity

Time period	$T = 2\pi\ M^a l^b g^c\ ---(1)$		
Sub in (1)	$T = K\ M^a\ L^{b+c}\ T^{-2c}$		
Equating powers		LHS	RHS
	M	1	a

	L	1	$b + c$
	T	-2	$-b$
LHS = RHS	$a = 0$ $b + c = 0$ $-2C = 1$		
On solving	$a = 0$	$b = \frac{1}{2}$	$c = -\frac{1}{2}$
Time period	$T = 2\pi\sqrt{\frac{l}{g}}$		

4. The Force acting on a body moving in a circular path depends on mass of the body (m), velocity (v), and radius (r) of the circular path. Obtain the expression for the force experienced by dimensional analysis method

Force	$F = K\, M^a V^b r^c \quad - - - (1)$		
Sub in (1)	$MLT^{-2} = K\, M^a\, L^{b+c}\, T^{-b}$		
Equating powers		LHS	RHS
	M	1	a
	L	1	$b + c$
	T	-2	$-b$
LHS = RHS	$a = 1$ $b + c = 1$ $-b = -2$		
On solving	$a = 1$	$b = 2$	$c = -1$
Sub in (1)	$F = K\, M^1 V^2 r^{-1}$		
Force	$F = \frac{MV^2}{R}$		

5. Define error. Explain in detail the various types of error.

Error	Uncertainty in a measurement is called random errors.	
Systematic error	Reproducible inaccuracies consistently in the same direction Occurs due to a problem that persists throughout the experiment	
	Type	Instrumental

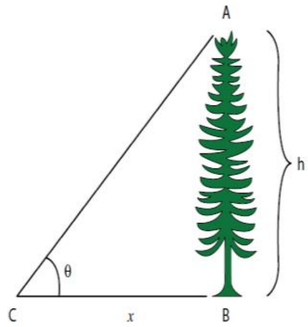
		Imperfect technique Personal errors External causes Least count
Random Error	➢ Arises due to random and unpredictable conditions like pressure, temperature, voltage supply etc. ➢ Also due to person reasons ➢ Large no. of readings are made and arithmetic mean is taken to minimize the error	
Gross Error	➢ Due to the carelessness of an observer Examples 1. Reading an instrument without setting it properly. 2. Recording wrong observations 3. Using wrong values in the calculations ➢ These can be minimized only when the observer is mentally alert	

THREE MARKS

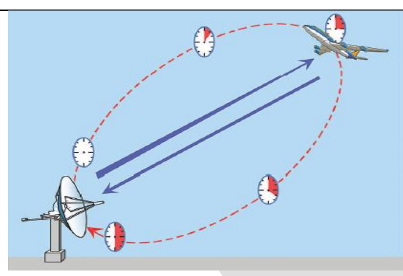
1. Write down the uses of Dimensional Analysis.
   - Convert of physical quantity from one system of units to another.
   - Check the dimensional correctness of a given equation
   - Establish relations among various physical quantities

2. What are the Limitations of Dimensional Analysis?
   - No information about the dimensionless constant
   - Cannot decide whether scalar or vector
   - Not suitable for log, trigonometric and exponential equations
   - Can't apply for more than three physical quantities

3. Write a note on triangulation method for the height of an accessible object

Diagram	
Description	➢ Let AB = h → height of the tree / tower ➢ C → observation point (BC = x) ACB = θ (angle of elevation)
From right angled triangle	$\tan\theta = \frac{h}{x}$ $\boxed{h = x\tan\theta}$

4. RADAR METHOD

RADAR	Radio Detection and Ranging
Diagram	
Formula	Speed = distance travelled / time taken $\boxed{d = \frac{v\,x\,t}{2}}$

5. Error in product of two quantities

Description	ΔA & ΔB → absolute errors in A and B
Measured Value of A	A $\pm \Delta A$
Measured Value of B	B $\pm \Delta B$
Product	Z = AB ------- (1)
Dividing by (1)	$\frac{\Delta Z}{Z} = \pm\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$
Conclusion	Maximum possible error = sum of individual fractional error

6. Error in product or division of two quantities

Description	ΔA & ΔB → absolute errors in A and B

Measured Value of A	$A \pm \Delta A$
Measured Value of B	$B \pm \Delta B$
Product	Z = A/B ------- (1)
Calculated value of Z	$Z \pm \Delta Z$
Dividing by (1)	$\frac{\Delta Z}{Z} = \pm\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$
Conclusion	Maximum possible error = sum of individual fractional error

7. Rules for counting Significant figures

Rule	Example	Sig fig
All Non zero digits are significant	1342	4
All Zero between non zeros are significant	2008	4
No. of significant digits doesn't depend on unit system	1.53cm, 0.0153m	3

8. Rules for rounding off

<table>
<tr><th colspan="3">Rule</th><th>Example</th></tr>
<tr><td colspan="2">Dropping digit</td><td>Preceding digit</td><td></td></tr>
<tr><td colspan="2">Less than 5</td><td>No change</td><td>7.32 → 7.3</td></tr>
<tr><td colspan="2">Greater than 5</td><td>Increased by 1</td><td>11.89 -> 11.9</td></tr>
<tr><td rowspan="3">= 5</td><td>Followed by non zero</td><td>Raised by 1</td><td>7.352 -> 7.4</td></tr>
<tr><td rowspan="2">Followed by zeros</td><td>No change (even)</td><td>3.45 -> 3.4</td></tr>
<tr><td>Raised by 1 (odd)</td><td>3.35 -> 3.4</td></tr>
</table>

TWO MARKS

1. Write down the difference between fundamental quantity and derived quantity

Fundamental	Derived
Cannot express in any other physical quantities	Can be expressed using fundamental quantities
Length, mass	Area, volume

2. What are the advantages of SI unit system?

advantages	Rational system
	Coherent system
	metric system

3. Verify by dimensional method. V = U + at

Substituting	$LT^{-1} = LT^{-1} + LT^{-2}\,T$ $LT^{-1} = LT^{-1} + LT^{-1}$

4. Check the correctness of the equation $\frac{1}{2}\,mv^2 = mgh$ using dimensions

	$ML^2T^{-2} = M\,L\,T^{-2}\,L$ $ML^2T^{-2} = ML^2T^{-2}$

5. Why is the cylinder used in defining kilogram made up of platinum – iridium alloy?

This is because platinum iridium alloy is least affected by environment and time.

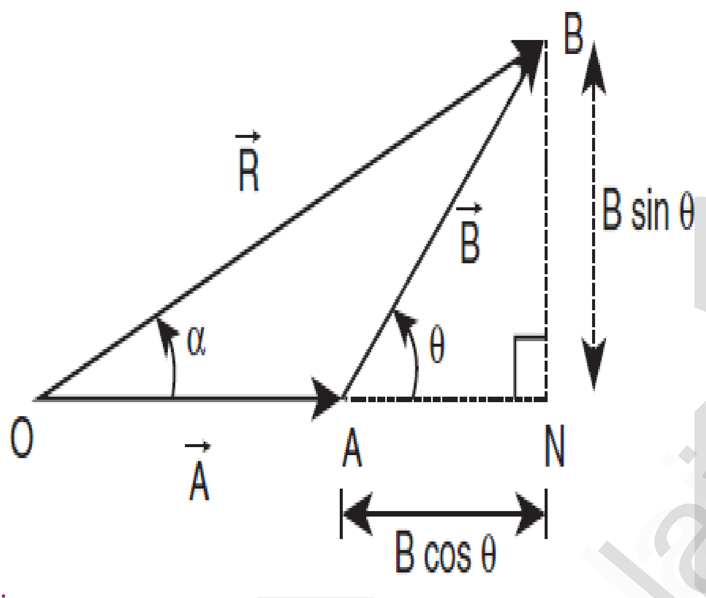
6. State Principle of homogeneity

The principle of homogeneity of dimensions states that the dimensions of all terms in a physical expression should be same.

02. KINEMATICS

FIVE MARKS

1. Triangle law of vector addition

Theorem	$\vec{A}$ and $\vec{B}$ vector → two adjacent sides of triangle in order $\vec{R}$ → closing side in reverse order
Diagram	
Magnitude of R	$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$
Direction of R	$\alpha = \tan^{-1}\left(\frac{B\sin\theta}{A + B\cos\theta}\right)$

2. Properties of Scalar and Vector properties

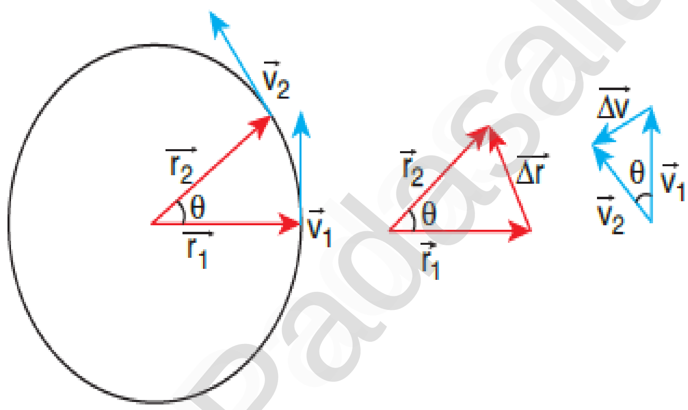
	Scalar	Vector
Resultant	Always Scalar	Always Vector
Commutative	Obey	Doesn't obey
Distributive	Obey	Doesn't obey
Max Magnitude	Parallel ($\Theta = 0^0$)	Perpendicular ($\theta = 90^0$)
Min Magnitude	Anti parallel ($\theta = 180^0$)	Parallel ($\Theta = 0^0$)
Orthogonal ($\theta = 90^0$)	Zero (cos 90 = 0)	Maximum magnitude
Self Product	$\hat{\imath}.\hat{\imath} = \hat{\jmath}.\hat{\jmath} = \hat{k}.\hat{k} = 1$	$\hat{\imath}\, x\, \hat{\imath} = \hat{\jmath}\, x\, \hat{\jmath} = \hat{k}\, x\, \hat{k} = 0$

3. Derive equations of motion using calculus method

Condition	➢ For Straight line ➢ Uniform accelerated motion

Equations of motion	$a = \frac{dV}{dt}$ $\int_U^V dV = a\int_0^t dt$ $V - U = at$ $\boxed{V = U + at}$	$ds = v\,dt$ $\int_0^s ds = U\int_0^t dt + a\int_0^t dt$ $\boxed{s = ut + \frac{1}{2}at^2}$
	$a = \frac{dV}{dt} \times \frac{ds}{ds}$ $a\int_0^s ds = \int_U^V V\,dV$ $\boxed{V^2 - U^2 = 2aS}$	$V = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 - u^2 = 2as$

4 Centripetal acceleration

Definition	In a circular motion , even though the velocity is tangential at every point in the circle, the acceleration is acting towards the centre of the circle
Diagram	
Uniform circular motion	$\frac{\Delta r}{r} = -\frac{\Delta v}{v} = \theta$
Divide by t on both sides	$a = \frac{\Delta v}{\Delta t} = -\frac{v}{r}\left(\frac{\Delta r}{\Delta t}\right)$
Centripetal acceleration	$a = -\frac{v^2}{r} = -\omega^2 r$

<u>THREE MARKS</u>

1. Equations of motion under gravity

Free fall	Body moving towards earth under the force of gravity		
For free falling	u = 0	a = g	s = h

On substituting	$v = u + at$	$V = gt$
	$s = ut + \frac{1}{2}at^2$	$h = \frac{1}{2}gt^2$
	$2as = v^2 - u^2$	$v^2 = 2gh$

2. Discuss the different types of motion

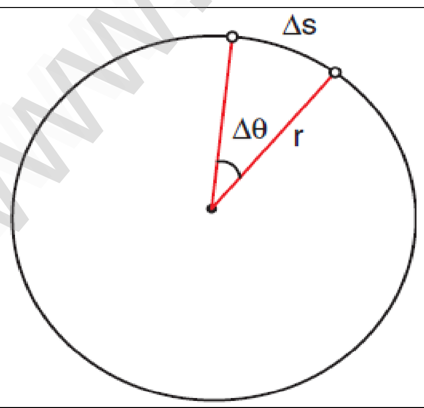
Linear	Moving in a straight line	Free falling object
Circular	Object traversing in a circular path	Satellite motion
Rotational	Moving about an axis	Spinning of earth
Vibratory	To and fro movement	Swing motion

3. Compare the kinematic equations for linear motion and angular motion

Linear motion	Angular motion
$v = u + at$	$\omega = \omega_0 + \propto t$
$s = ut + \frac{1}{2}at^2$	$\theta = \omega_0 t + \frac{1}{2} \propto t^2$
$v^2 - u^2 = 2as$	$\omega^2 - {\omega_0}^2 = 2 \propto \theta$
$s = \frac{(v+u)\,t}{2}$	$\theta = \frac{(\omega + \omega_0)\,t}{2}$

.

4. Relation between linear velocity and angular velocity

Diagram	
Arc length	$\Delta s = r\,\Delta\theta$
Divide by t	$\frac{\Delta s}{\Delta t} = r\,\frac{\Delta \theta}{\Delta t}$
Linear velocity	$v = r\omega$
Vector form	$\vec{v} = \vec{\omega}\, X\, \vec{r}$

TWO MARKS

1. Distinguish between Scalar and Vector

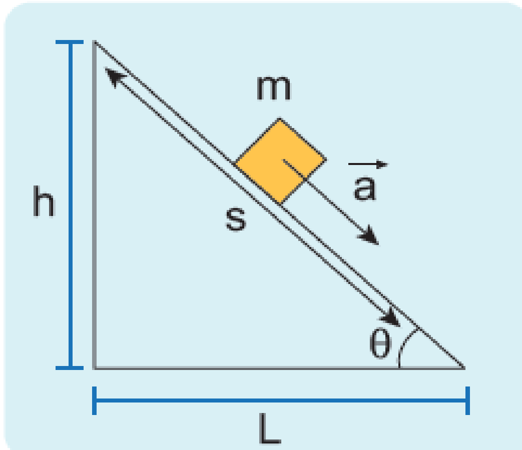
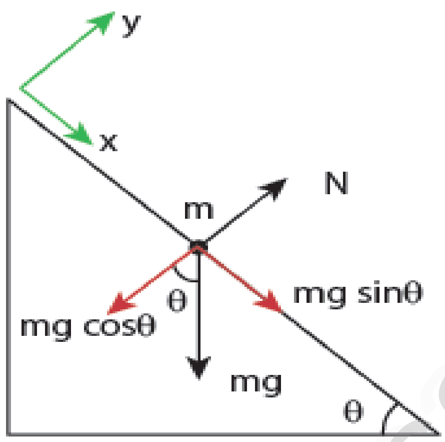
Scalar	Vector
Described only by magnitude	Described by magnitude and direction
Distance, mass, Energy	Force, Velocity

2. Distinguish between distance and displacement

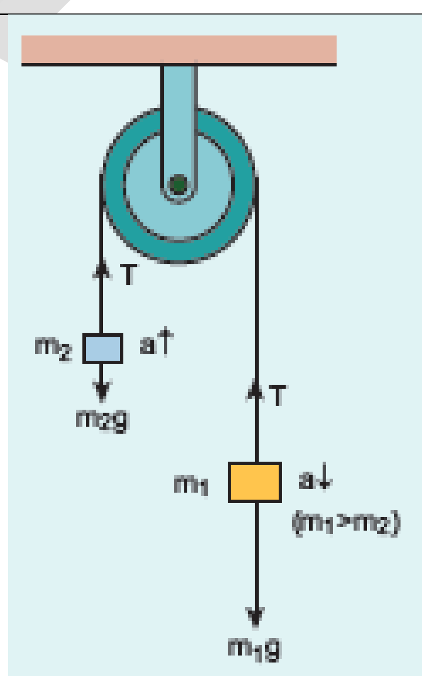
Distance	Displacement
Actual length travelled	Shortest distance between initial and final point
Scalar	Vector

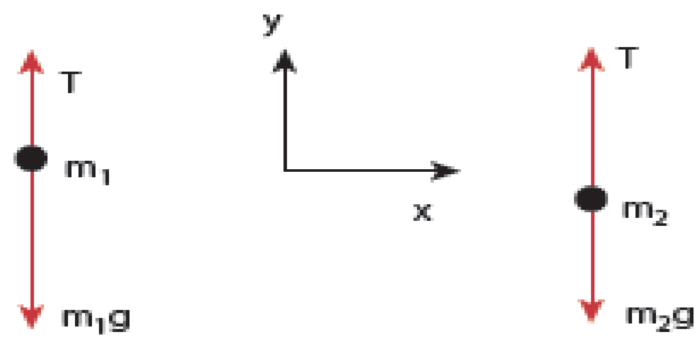
3. LAWS OF MOTION

01 Derive an expression for acceleration of the particle moving in an inclined plane and the velocity with which it reaches the bottom.

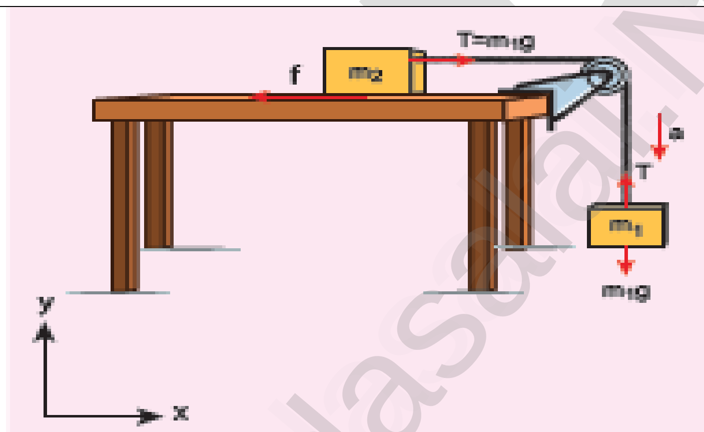
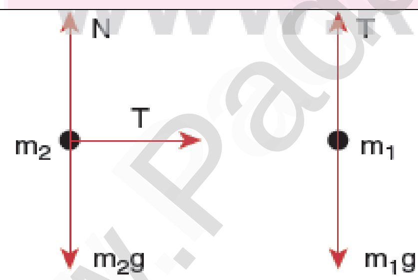
Diagram	
Free body Diagram	
Along y axis	$-mg\cos\theta\ \hat{j} + N\hat{j} = 0$ $N = mg\cos\theta$
Along x axis	$mg\sin\theta\ \hat{i} = ma\ \hat{i}$ $ma = mg\sin\theta$
Acceleration	$a = g\sin\theta$
Velocity	$v = \sqrt{2sg\sin\theta}$

02. Motion of vertically connected bodies

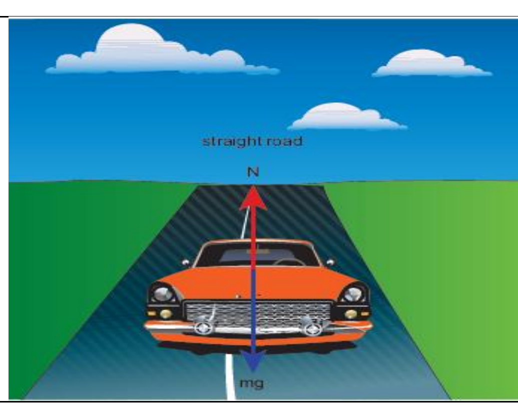
Diagram	

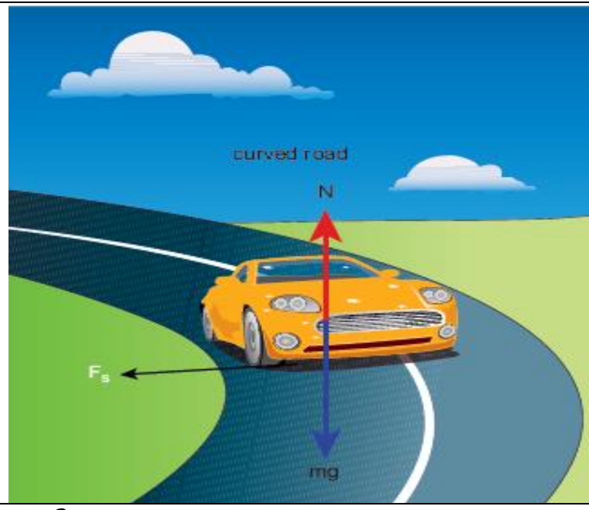
Free body Diagram	
Equation for m_1	$T - m_2 g = m_2 a$—(1)
Equation for m_2	$m_1 g - T = m_1 a$—(2)
Acceleration	$a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$
Tension	$T = \left(\frac{2 m_1 m_2}{m_1 + m_2}\right) g$

03. Motion of horizontally connected bodies

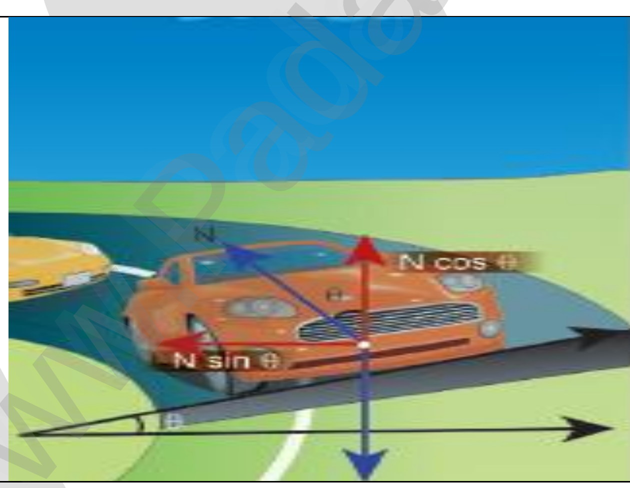
Diagram		
Free body diagram		
Comparing components	$N = m_2 g$—(2)	$T - m_1 g = -m_1 a$—(1)
	$T = m_2 a - -(3)$	
Acceleration	$a = \frac{m_1 g}{m_1 + m_2}$	
Tension	$T = \frac{m_1 m_2 g}{m_1 + m_2}$	

04. Explain the motion of the vehicle on a leveled circular road

Straight Road	

Levelled circular road	
Safe turn	$\frac{MV^2}{R} \leq \mu_s mg$
Maximum safe speed	$v \leq \sqrt{\mu_s rg}$
Skidding	$\frac{MV^2}{R} > \mu_s mg$
Co efficient friction	$\mu_s < \frac{V^2}{rg}$

05. Banking of tracks

Definition	To avoid skidding, the outer edge of the road is slightly raised compared to inner edge is called banking of roads.
Diagram	
Equating Forces	$N \cos\theta = mg - -(1)$
	$N \sin\ \theta = \frac{mV^2}{r} - -(2)$
$(2)/(1) =$	$\tan\theta = \frac{V^2}{rg}$
Safe speed	$v = \sqrt{rg \tan\theta}$

THREE MARKS

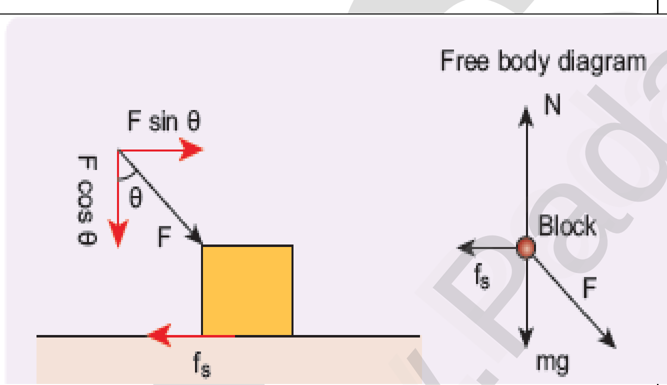
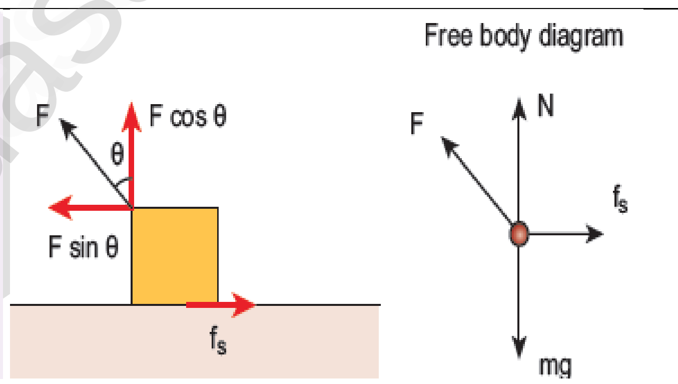
1 What are the types of friction and mention the method of reducing friction?

Types of friction	Reducing method
Static friction	Polishing the surface
Kinetic friction	Using lubricants
Rolling friction	Usage of ball bearings

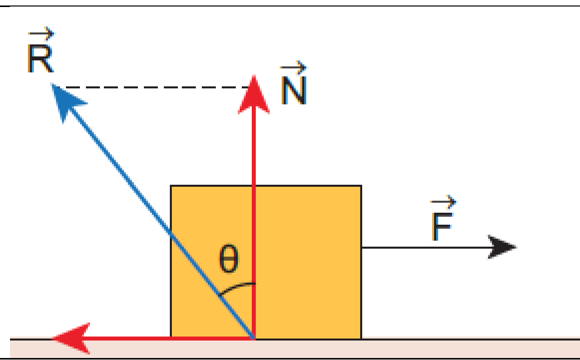
02. Differentiate between static and kinetic friction

	Static	Kinetic
Definition	Opposes the start of motion	Opposes relative motion
Contact surface	Independent	Independent
Mag. Applied force	Dependent	Independent
Magnitude	Zero to $\mu_s N$	Equal to $\mu_k N$

03. Is it easier to push or pull an object explain

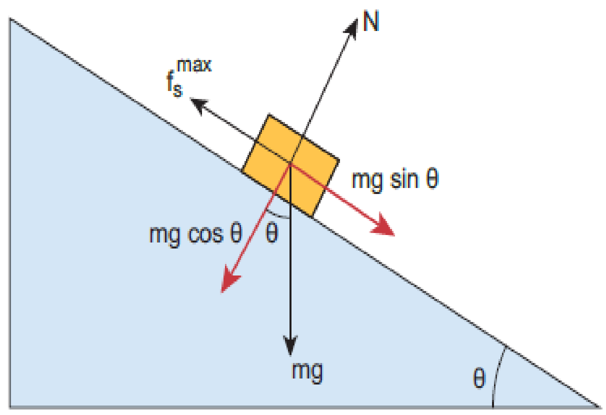
➢ Easy to pull	
Push	Pull
	
$f_s^{max} = \mu_s (N_{Push} = mg + F\cos\theta)$	$f_s^{max} = \mu_s (N_{Pull} = mg - F\cos\theta)$

04. angle of friction

Diagram	
Resultant Force	$R = \sqrt{(f_s^{max})^2 + N^2}$
From the fig.	$\tan\theta = \frac{f_s^{max}}{N}$ — (1)
From Definition	$\mu_s = \frac{f_s^{max}}{N}$ — − (2)

(1) = (2)	$\mu_s = tan\,\theta$

05. Angle of repose

Diagram	
Normal force	$N = mg\,cos\,\theta - - - (1)$
Static friction	$f_s = \mu_s N = mg\,sin\,\theta - - - (2)$
$\frac{2}{1}$	$\frac{f_s}{N} = tan\,\theta$
Conclusion	Angle of repose is same as angle of friction

06. Salient features of centripetal and centrifugal forces

	Centripetal	Centrifugal
Nature	Real force	Pseudo
Frame of reference	Both inertial and non inertial	Only in non inertial frame
Direction	Towards the axis of rotation	Away from the axis of rotation
Origin	Interaction between objects	Inertia

TWO MARKS

01 State Lami's theorem

<u>Condition</u> ➢ 3 concurrent F ➢ Coplanar forces ➢ in equilibrium	*magnitude of each Force ∝ sine of the angle between other two forces*

02. Define impulse

Very large force acting for a very short time

Vector quantity

$\boxed{J = F.t}$

Unit : Ns

03. What are the applications of angle of repose?

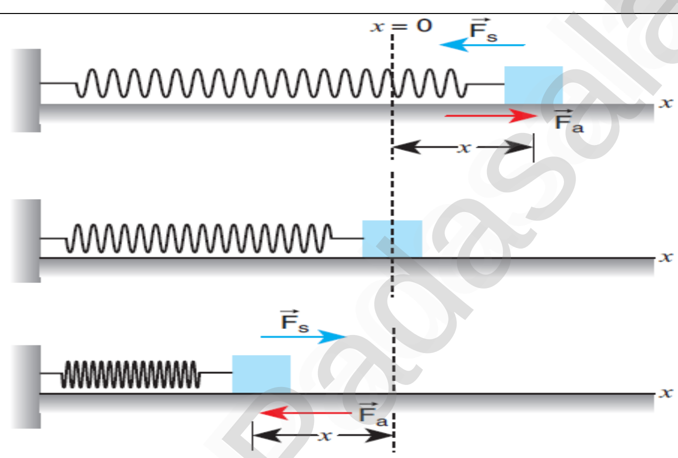
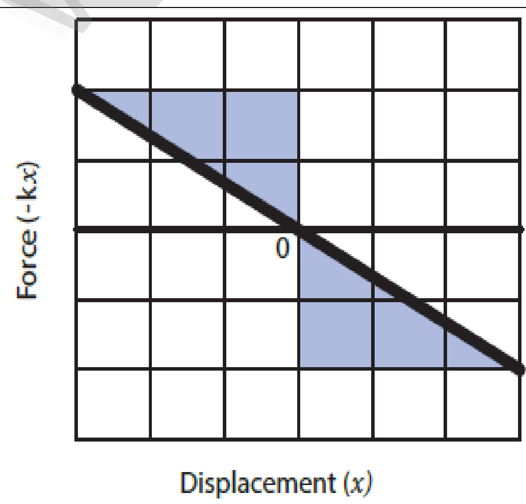
Antilons	➢ Antilons make sand traps in such a way that when an insect enter the edge of the trap, it starts to slide towards the bottom where the antilon hide itself. ➢ Angle of inclination = angle of repose.

04. WORK ENERGY POWER

01. Work Kinetic energy theorem

Work	$W = F\,s - - - (1)$
Newton's law	$F = ma - - - - (2)$
Equations of motion	$a = \dfrac{V^2 - U^2}{2s} - - - (3)$
(2) in (3)	$F = ma = m\left(\dfrac{V^2 - U^2}{2s}\right) - - - (4)$
(4) in (1)	$W = \frac{1}{2}MV^2 - \frac{1}{2}MU^2$ $\boxed{W = \Delta KE}$
Theorem	The work done by the force on the body changes its kinetic energy

02. Elastic potential energy

Diagram	
Force	$F = Kx$
Potential energy	$U = \int_0^x \vec{F}\,.\,\vec{dr}$
	$U = \frac{1}{2}K\,x^2$
Graph	
Conclusion	➢ Shaded Area = elastic potential energy

03. Arrive at an expression for elastic collision in 1D & discuss various cases

Description	Consider		
	Mass	Initial velocity	Final velocity
	m_1	u_1	v_1
	m_2	u_2	v_2
LOCO P	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ --- (1) $m_1 (u_1 - v_1) = m_2 (v_2 - u_2)$ ----(2)		
LOCO KE	$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2V_2^2$ $m_1 (u_1^2 - v_1^2) = m_2 (v_2^2 - U_2^2)$------(3)		
$(3)/(2)$	$\boxed{u_1 + v_1 = v_2 + u_2}$------(4)		
Final Velocity v_1	$v_1 = \left(\frac{2m_2U_2}{m_1+m_2}\right) + \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 - - - (5)$		
Final Velocity v_2	$v_2 = \left(\frac{2m_1U_1}{m_1+m_2}\right) + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2 - - - (6)$		

04. Expression for loss of kinetic energy in perfect inelastic collision

KE before collision	$KE_1 = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$
KE after collision	$KE_2 = \frac{1}{2}(m_1 + m_2)v^2$
Loss of KE	$\Delta Q = KE_2 - KE_1$ $\Delta Q = \frac{1}{2}(m_1 + m_2)v^2 - (\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2)$
On simplifying	$\Delta Q = \frac{1}{2}\frac{m_1m_2}{(m_1+m_2)}(u_1 - u_2)^2$

THREE MARKS

01

Differentiate between potential and kinetic energies

Potential Energy	Kinetic energy
Energy possessed by virtue of position	Energy possessed by virtue of motion
$PE = mgh$	$KE = \frac{1}{2}mv^2$
Scalar	Scalar

02 Relation between momentum and kinetic energy

Kinetic energy	$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\,(V.V)$
Multiply and divide by m	$KE = \frac{1}{2}\frac{(mV)(mV)}{m}$
	$KE = \frac{p^2}{2m}$
Magnitude of p	$p = \sqrt{2m\,(KE)}$

03 Comparison of conservative and non conservative forces

	Conservative Force	Non Conservative Force
Work done	Independent of path	Dependent on path
	Round trip is zero	Round trip is non zero
	Completely recoverable	Completely irrecoverable
Total Energy	Remains constant	Dissipated as heat
	$F = -\frac{dU}{dx}$ (negative gradient of PE)	No such relation exists
Examples	Gravitational Force, Magnetic force	Frictional Force, Viscous Force

04 Relation between power and velocity

Work done	$= \int dW = \int \frac{dW}{dt}\,dt - - - -(1)$
substituting $\frac{\vec{dr}}{dt} = \vec{V}$	$= \int(\vec{F}.\vec{V})dt - - -(2)$
Comparing (1) and (2)	$\int \frac{dW}{dt}\,dt = \int(\vec{F}.\vec{V})dt$
Conclusion	$P = \vec{F}.\vec{V}$

05 Define collision and distinguish the types of collision

Collision	If the path of the object is influenced by the other object is called collision.	
	Elastic collision	Inelastic collision
Total momentum	Conserved	Conserved
Total Kinetic Energy	Conserved	Not conserved
Involved Forces	Conservative Force	Non conservative Force

Mechanical Energy	Not dissipated	Dissipated as heat , light, sound

TWO MARKS

101 Define work

- Work is said to be done when the force applied on a body displaces it.
- Scalar quantity
- Unit: joule

$$w = F\, ds \cos\theta$$

201 Define Energy

- Energy is defined as the ability to do work.
- Scalar quantity
- Unit: joule

401 Power

- Rate of work done is called power.
- Scalar quantity
- unit : watt

$$P = \frac{w}{t}$$

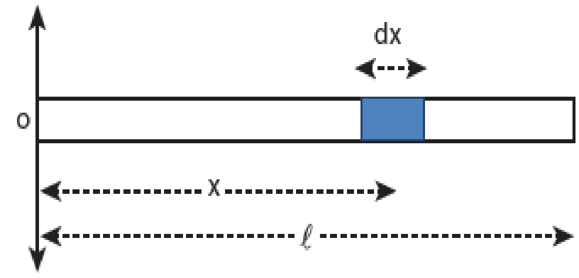
506 Define co efficient of restitution

It is defined as the ratio of velocity of separation after collision to the velocity of approach before collision

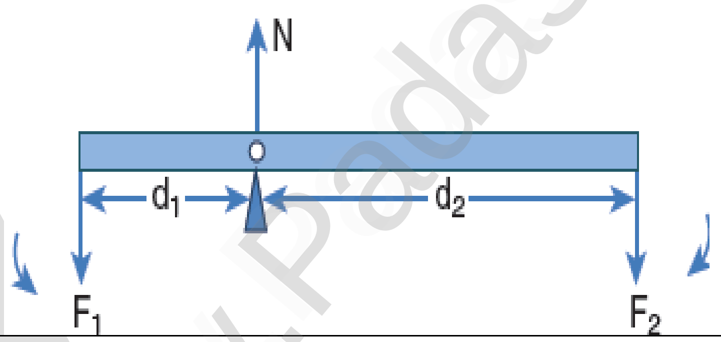
$$e = \frac{velocity\ of\ seperation\ (after\ collision)}{velocity\ of\ approach\ (before\ collision)}$$

05. SYSTEM OF PARTICLES & ROTATIONAL DYNAMICS

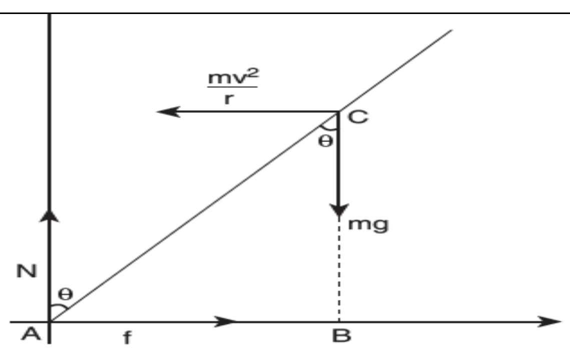
01 Locate the centre of mass of a uniform rod of mass M and length l.

Diagram	
The mass of small element	$dm = \frac{M}{L}\,dx$ ----(1)
Centre of mass	$X_{cm} = \frac{\int xdm}{\int dm}$ ----(2)
(2) in (1)	$X_{cm} = \frac{1}{L}\int_0^L xdx$
On integrating	$= \frac{1}{L}\left[\frac{x^2}{2}\right]_0^L = \frac{L}{2}$
Centre of mass lies at the geometrical centre itself	

02 Explain the concept of principle of moments

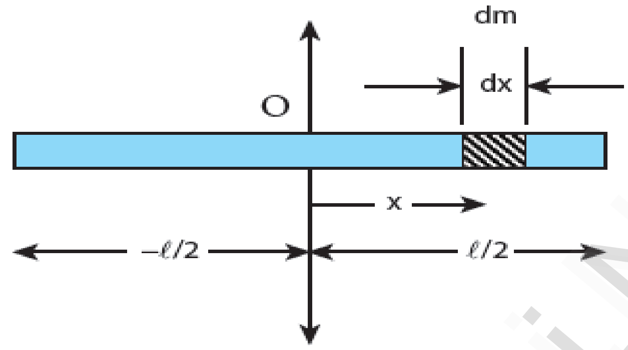
Diagram	
Condition	➢ rotational and translation equilibrium ➢ Net Force & Net torque = Zero
For net F = 0	$N = F_1 + F_2$
For net $\tau = 0$	$d_1F_1 = d_2F_2$ (represents principle of moments)
	$\frac{F_1}{F_2} = \frac{d_2}{d_1}$

03 Bending of a cyclist in curves

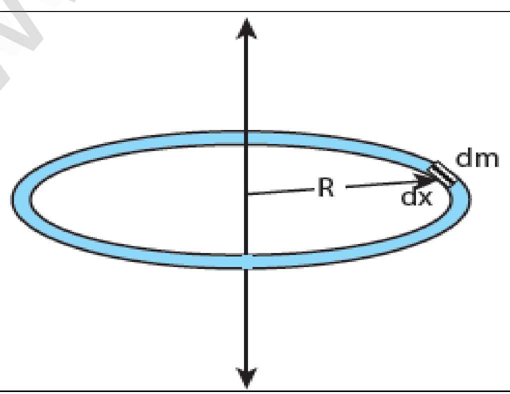
FBD	

At equilibrium	$Net\ force\ and\ Net\ torque\ =\ zero$ $\frac{Mv^2}{r}(BC)\ -\ Mg(AB) = 0$
Bending angle	$Mg(AC\ sin\ \theta)\ =\ \frac{Mv^2}{r}\ (AC\ cos\ \theta)$ $\boxed{tan\ \theta\ =\ \frac{v^2}{rg}}$

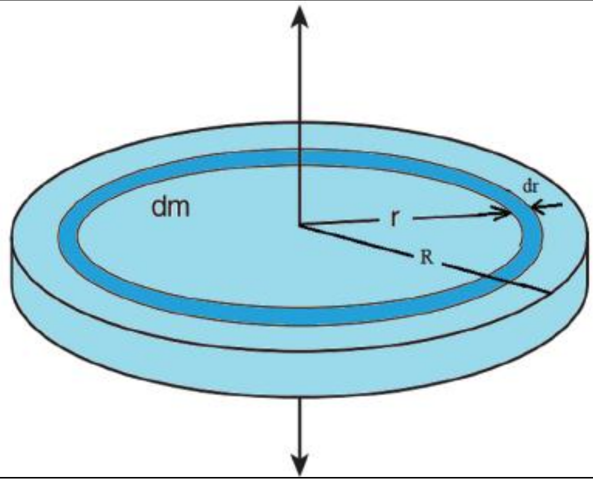
04 Moment of inertia of a uniform rod

Diagram	
MI of a rod	$dI\ =\ (\lambda dx)x^2$
	$I = \frac{M}{l}\int_{\frac{-l}{2}}^{\frac{l}{2}} x^2 dx$
	$I = \frac{M}{l}\left[\frac{x^3}{3}\right]_{\frac{-l}{2}}^{\frac{l}{2}}$
	$I = \frac{1}{12}ml^2$

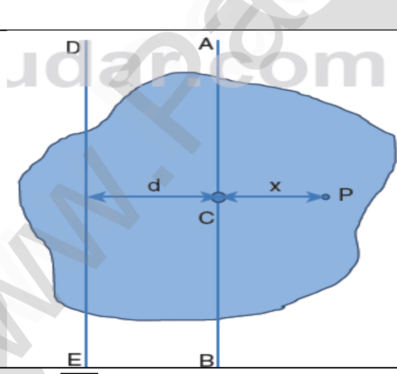
05 Moment of inertia of a uniform ring

Diagram	
The moment of inertia	$dI = dm\ R^2\ \ --(1)$
(2) in (1)	$I = \int\left(\frac{M}{2\pi R}\ dx\right)R^2$ $I = \frac{MR}{2\pi}\int_0^{2\pi R} dx$
On integrating	$I = M\ R^2$

06 Moment of inertia of a uniform Disc

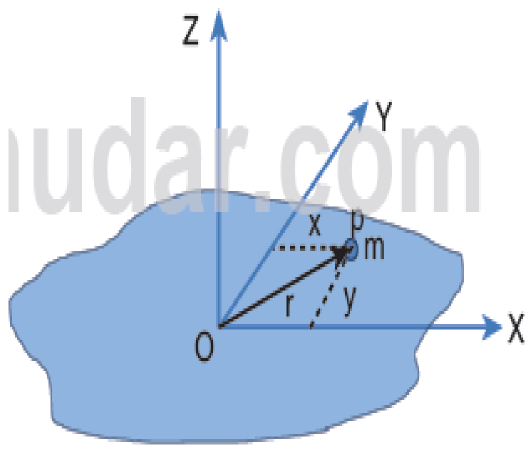
Diagram	
The moment of inertia	$dI = dm\, r^2$
(2) in (1)	$I = \int_0^R \left(\frac{2M}{R^2}\, r\, dr \right) r^2$ $I = \frac{2M}{R^2} \int_0^R r^3 dr$
On integrating	$I = \frac{1}{2} MR^2$

07 Parallel axis theorem

Theorem	MI about any axis = MI about axis passing though centre of gravity + (mass x (distance between axis)^2) $\boxed{I = I_c + Md^2}$
Diagram	
Moment of inertia	$I = \sum m(x+d)^2$
On expanding	$I = \sum mx^2 + \sum md^2 + 2d \sum mx$
MI about any parallel axis	$I = I_c + Md^2$

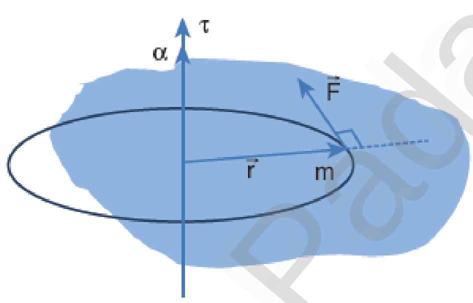
08 Perpendicular axis theorem

Theorem	MI of plane laminar of perpendicular axis = sum of MI about two perpendicular axis $\boxed{I_z = I_x + I_y}$

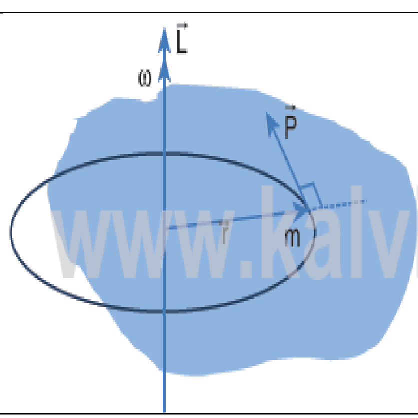
Diagram	
MI about x axis	$I_x = \sum my^2$
MI about y axis	$I_y = \sum mx^2$
MI about z axis	$I_z = \sum mr^2 — (1)$
From fig.	$r^2 = x^2 + y^2 — (2)$
Sub (2) in (1)	$I_z = I_x + I_y$

THREE MARKS

01 Relation between torque and angular acceleration

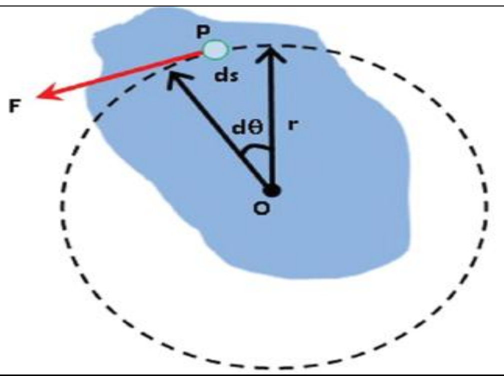
Diagram	
Derivation	$\tau = rFsin90 = rF$
	$\tau = rma$
	$\tau = mar^2$
	$\vec{\tau} = \left(\sum m_i r_i^2\right)\vec{\alpha}$
	$\vec{\tau} = I\vec{\alpha}$

02 Establish a relation between Angular momentum and Angular velocity

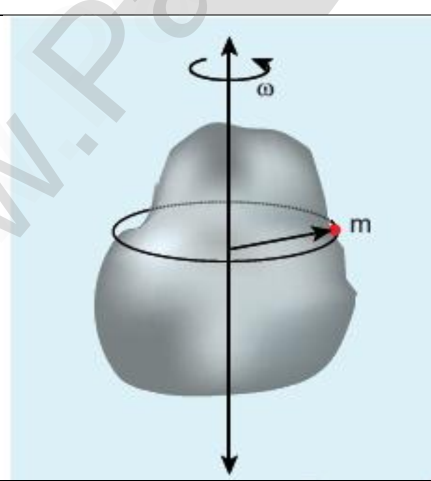
Diagram	

Derivation	$L = rp\ sin\theta$	
	$L = mvr$	
	$L = mr^2\omega$	
	$L = I\omega$	
	$\boxed{\vec{L} = I\vec{\omega}}$	

03 Work done by the torque

Diagram	
Work done	$dw = F.ds - - - (1)$
Displacement	$ds = r\ d\theta - - - (2)$
Sub (2) in (1)	$dw = F\ r\ d\theta$
WD by the torque	$dw = \tau\ d\theta$

04 Kinetic energy in rotation

Diagram	
Kinetic energy of the particle	$KE = \frac{1}{2}\ m_i v_i^2$
	$KE = \frac{1}{2}\ m_i\ (r_i\omega)^2$
	$KE = \frac{1}{2}\ (\sum m_i r_i^2\ )\omega^2$
Kinetic energy of the rigid body	$KE = \frac{1}{2}\ I\omega^2$

01 TWO MARKS

Torque

The moment of the external applied force about a point or axis of rotation.

$$\boxed{\tau = rF\, sin\theta}$$

02 Couple

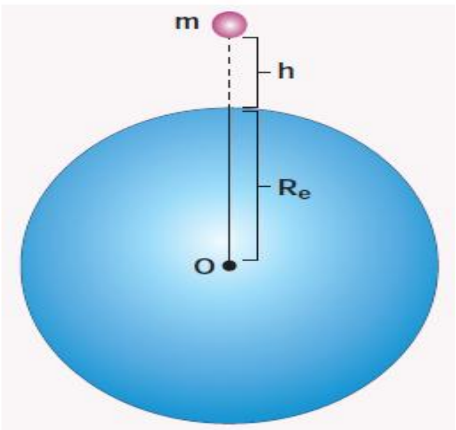
- Two forces of equal magnitude and opposite direction
- Separated by a perpendicular distance
- Whose line of action don't intersect produces a turning effect

03 Law of conservation of angular momentum

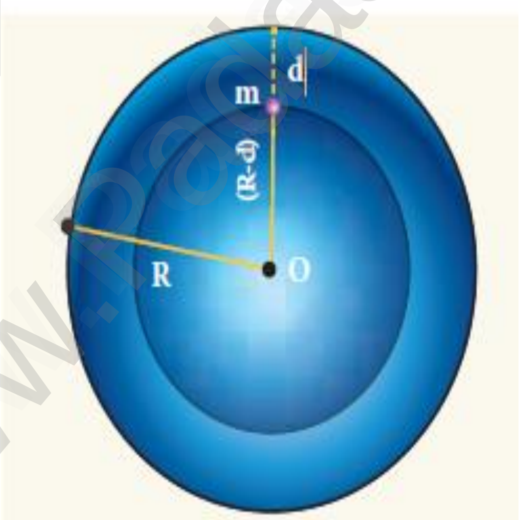
- No external torque
- Total angular momentum
- a constant

06. GRAVITATION

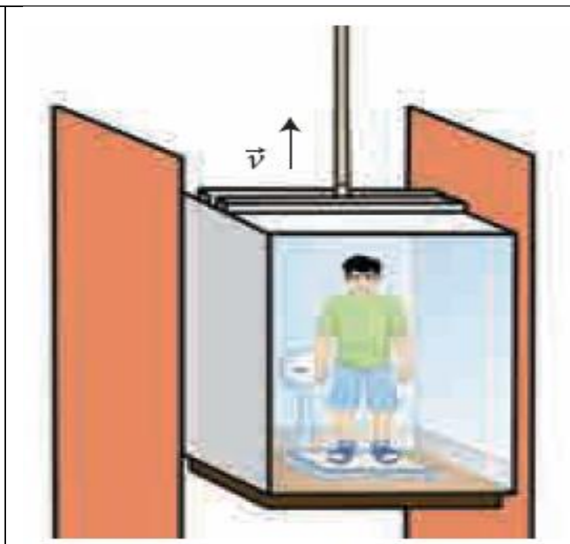
01 Variation g with altitude

Diagram	
g at the surface	$g = \frac{GM}{R^2}$
g at height h	$g_h = \frac{GM}{(R+h)^2} = \frac{GM}{R^2}(1 + \frac{h}{R})^{-2}$
g at height h	$g_h = g\,(1 - \frac{2h}{R})$
Conclusion	As h increases , g decreases

02. Variation of g with depth

Diagram	
g at the surface of the earth	$g = \frac{G\rho 4\pi}{3}(R)\ ---(1)$
g at depth	$g_d = \frac{G\rho 4\pi}{3}(R-d)\ ---(2)$
$(2)/(1)$	$\frac{g_d}{g} = \frac{R-d}{R} = 1 - \frac{d}{R}$
g at depth "d"	$g_d = g\,(1 - \frac{d}{R})$
Conclusion	As depth increases g decreases

03. Apparent weight in elevator

Diagram			
Acc	Vector eqn	Scalar eqn	Weight comparison
$a = 0$	$-mg\,\hat{j} + N\,\hat{j} = 0$	$N = mg$	Apparent weight = actual weight
$\hat{a} = a\hat{j}$	$-mg\,\hat{j} + N\,\hat{j} = ma\,\hat{j}$	$N = m(g + a)$	Apparent weight > Actual weight
$\hat{a} = -a\hat{j}$	$-mg\,\hat{j} + N\,\hat{j} = -ma\,\hat{j}$	$N = m(g - a)$	Apparent weight < Actual weight
$a = g$		$N = m(g - g)$	Weightlessness

04 Define escape velocity and derive an expression for it.

Definition	Escape speed is the minimum speed required by the object to escape from gravitational field
Total initial energy	$E_i = \frac{1}{2} MV_i^2 - \frac{GMm}{R}$
Total Final energy	$E_f = \frac{1}{2} MV_f^2 - \frac{GMm}{(R + h)}$
LOCO E	$\frac{1}{2} mV_i^2 - \frac{GMm}{R} = \frac{1}{2} mV_f^2 - \frac{GMm}{(R + h)}$
Escape speed	$V = \sqrt{2gR}$

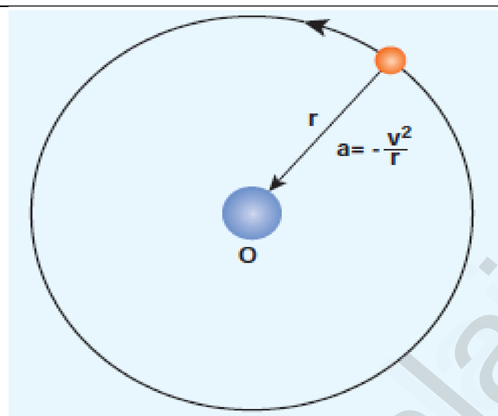
05 Derive orbital velocity

Definition	The velocity with which the satellite orbits around the planets at the specific height
Gravitational force	$F = \frac{GMm}{R^2} --- (1)$

Centripetal force	$F = \frac{mV^2}{(R+h)} ---(2)$
(1) = (2)	$F = \frac{GMm}{(R+h)^2} = \frac{mV^2}{(R+h)}$
orbital velocity	$V = \sqrt{\frac{GM}{(R+h)}}$

THREE MARKS

01 Derivation of Newton's inverse square law.

Diagram		
Centripetal acceleration	$a = -\frac{v^2}{r} ---(1)$	
Velocity	$v = \frac{2\pi r}{T} ---(2)$	
(2) in (1)	$a = -\frac{4\pi^2 r}{T^2}$	
From Newton's II law	$F = ma = \frac{4\pi^2 mr}{T^2} ---(3)$	
From Kepler's III law	$\frac{r^3}{T^2} = K\ (constant\ ) ---(4)$	
(4) in (3)	$F = \frac{4\pi^2 mK}{r^2}$	
Newton's law	$F = -\frac{GMm}{r^2}$	$4\pi^2 k = Gm$

02 Derive an expression for time period of a satellite

Definition	Time taken by the satellite to complete one revolution
Speed	$V = \frac{2\pi(R+h) --(1)}{T}$
Orbital velocity	$V = \sqrt{\frac{GM}{(R+h)}} --(2)$

Equating (1) & (2)	$T = \frac{2\pi \ (R+h)^{\frac{3}{2}}}{\sqrt{GM}}$
SOBS	$T^2 = \frac{4\pi^2 R^3}{GM}$
Time Period	$T = 2\pi \sqrt{\frac{R}{g}}$

03 Derive an expression for an energy of an orbiting satellite

Definition	The total energy of the satellite is the sum of the kinetic energy and gravitational potential energy
Potential energy	$U = -\frac{GMm}{(R+h)}$
Kinetic energy	$KE = \frac{GMm}{2(R+h)}$
Total energy	$E = \frac{GMm}{2(R+h)} - \frac{GMm}{(R+h)}$ $\boxed{E = -\frac{GMm}{2(R+h)}}$
Significance	Negative sign denotes satellite is bound with the earth which can't escape

04 Geostationary satellites

- Satellites orbiting the earth have different time periods corresponding to different orbital radii.
- As they appear to be stationary when seen from the earth and hence they are called so.
- They are used for the purpose of telecommunication

05 Polar satellites

- The satellite placed at a distance of 500 to 800 Km
- They orbit from north pole to south pole, hence called polar satellites
- The time period is 100 minutes.

06 Important features of gravitational force

- As the distance increases, the strength of the force decreases
- It constitute an action – reaction pair

- Torque experienced by the earth due to the sun is zero

Two Marks

1 Universal law of Gravitation

Strength of force	directly proportional	product of the masses
	inversely proportional	square of the distance
Expression	$F = \frac{GM_1M_2}{r^2}$	

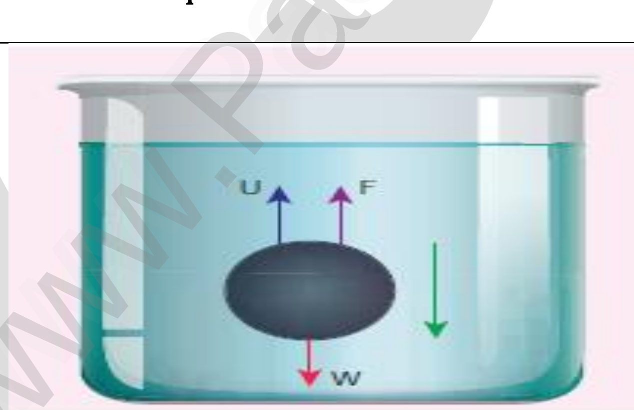
07. Properties of Matter

Five Marks

01 Write down the expression for the elastic potential energy of a stretched wire.

Statement	when a body is stretched ➢ work is done against the restoring force ➢ work done is stored as elastic energy
On substituting	$W = \int_0^l \frac{YAl}{L} dl$
On integrating	$W = \frac{YA}{L} \quad x \quad \left[\frac{l^2}{2}\right]_0^L$
Elastic Potential Energy	$U = \frac{1}{2} F l$
Energy density	is defined as energy per unit volume
	$U = \frac{1}{2}$ X $stress$ X $strain$

02 Define Terminal velocity. Derive an expression for terminal velocity

Terminal velocity	➢ the maximum constant velocity acquired by a body falling through a viscous liquid		
Diagram			
Forces	Force	Equation	Direction
	Gravitational force	$F_g = \frac{4\pi}{3} r^3 \rho g$	Downward
	Up thrust	$U = \frac{4\pi}{3} r^3 \sigma g$	Upward
	Viscous force	$F = 6\pi\eta r v$	Upward
Net force	$F_g - U = F$ $\frac{4\pi}{3} r^3 (\rho - \sigma) g = 6\pi\eta r v$		Downward
Terminal velocity	$V = \frac{2r^2(\rho - \sigma)g}{9\eta}$		On simplification

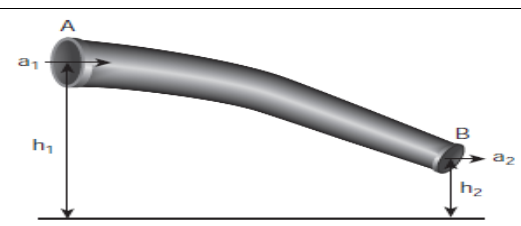
.03 Stokes law

Description	$F = 6\pi\, \eta^x r^y v^z ----(1)$		
Dimension formula	$F = MLT^{-2}$	$\eta = ML^{-1}T^{-1}$	
	$r = L$	$v = LT^{-1}$	
Sub in (1)	$MLT^{-2} = K\, M^x\, L^{-x+y+z} T^{-x-z}$		
LHS = RHS	$X = 1 --- (2)$ $-X + Y + Z = 1 --- (3)$ $-X - Z = -2 --- (4)$		
On solving	X = 1	Y = 1	Z =1
Stokes law	$F = 6\pi\eta r v$		Substituting in (1)

04 Poisuellies equation

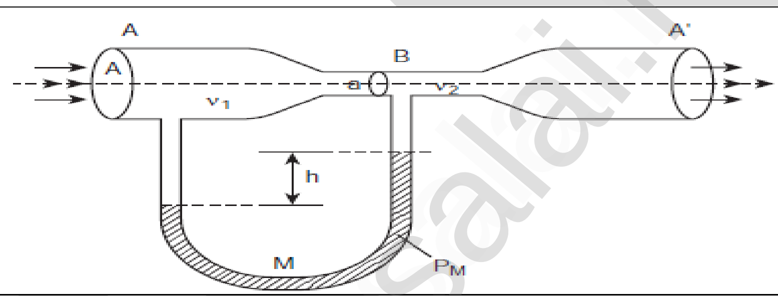
Description	$V = \frac{\pi}{8}\eta^a r^b \left(\frac{P}{l}\right)^c --- (1)$		
Dimension formula	$V = L^3T^{-1}$	$\eta = ML^{-1}T^{-1}$	
	$r = L$	$\frac{P}{l} = M\, L^{-2}T^{-2}$	
Sub in (1)	$L^3T^{-1} = M^{a+b}\, L^{a+b-2c}\, T^{-a-2c}$		
LHS = RHS	$a + b = 0$ $a + b - 2c = 3$ $-a - 2c = -1$		
On solving	a = -1	b = 4	c = 1
Poisuellies equation	$V = \frac{\pi\, r^4 P}{8\eta l}$		Substituting in (1)

05 Bernoulli's Theorem

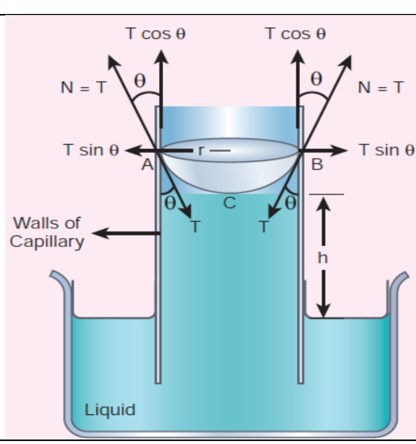
Conditions	Incompressible , Non viscous liquid and Streamline flow
Theorem	$\frac{Pressure\ energy + kinetic\ energy + potential\ energy}{unit\ mass} = constant$
Diagram	

		At A	At B
Energy per unit mass	Pressure energy	$\frac{P_A}{\rho}$	$\frac{P_B}{\rho}$
	Potential energy	gh_a	gh_b
	Kinetic energy	$\frac{{v_a}^2}{2}$	$\frac{{v_b}^2}{2}$
	Total energy	$\frac{P_A}{\rho} + gh_a + \frac{{v_a}^2}{2}$	$\frac{P_b}{\rho} + gh_b + \frac{{v_b}^2}{2}$
Bernoulli's theorem	$\frac{P}{\rho g} + h + \frac{v^2}{2g} = constant$		

06 Venturimeter

Use	Used to measure the rate of flow of incompressible liquid.
Principle	Bernoulli's theorem
Diagram	
continuity eqn	$v_2 = \frac{Av_1}{a}$ — (1)
(1) in (2)	$P_1 + \rho \frac{{v_1}^2}{2} = P_2 + \frac{\rho}{2}\left(\frac{Av_1}{a}\right)^2$
Pressure difference	$\Delta P = \rho \frac{{v_1}^2}{2}\left(\frac{A^2 - a^2}{a^2}\right)$
Speed of fluid at A	$v_1 = \sqrt{\frac{2\Delta P a^2}{\rho(A^2 - a^2)}}$
Volume of fluid out per second at A	$V = Av_1 = A\sqrt{\frac{2\Delta P a^2}{\rho(A^2 - a^2)}}$

07 Surface tension by capillary rise method

Diagram	

Resolving ST	Horizontal component	$T \sin\theta$
	Vertical component	$T \cos\theta$
Total upward force	$2\pi rT\cos\theta$ — (1)	
	$V = \pi r^2 h + \frac{1}{3}\pi r^3$	
Weight of liquid column	$W = \pi r^2 \left(h + \frac{r}{3}\right)\rho g$ — (2)	
Net force	$2\pi rT\cos\theta = \pi r^2 h + \frac{1}{3}\pi r^3$	
Surface tension	$\boxed{T = \frac{hr\rho g}{2\cos\theta}}$	

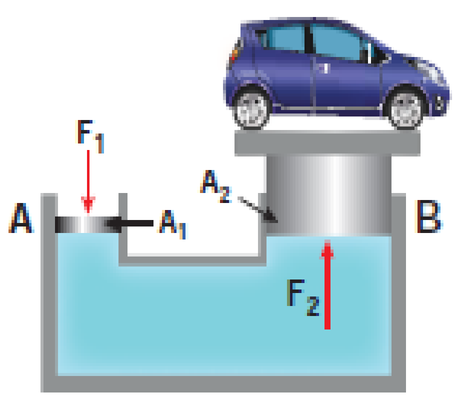
Three marks

01 Explain the different types of modulli

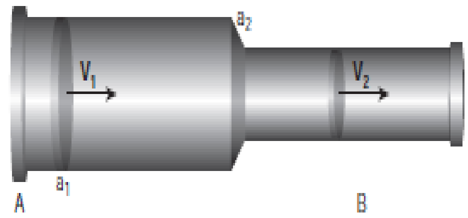
Based on the strain produced the modulli can be classified as

Young's modulus	$Y = \frac{Tensile\ stress}{Tensile\ strain}$	$Y = \frac{\sigma_t}{\epsilon_t}$
Bulk modulus	$K = \frac{Normal\ stress\ or\ Pressure}{Volume\ strain}$	$K = \frac{\Delta PV}{\Delta V}$
Rigidity modulus	$\eta_R = \frac{shearing\ stress}{shearing\ strain}$	$\eta_R = \frac{F}{A\theta}$

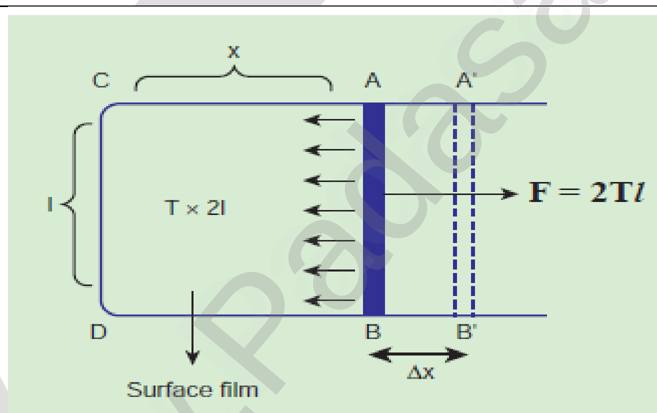
02 Explain the principle, construction and working of hydraulic lift

Principle	Pascal's law
Uses	To lift heavy load with small force
Diagram	
Derivations	$F_2 = P\ X\ A_2 = \frac{F_1}{A_1}\ X\ A_2$ $\boxed{F_2 = \frac{A_2}{A_1}\ X\ F_1}$

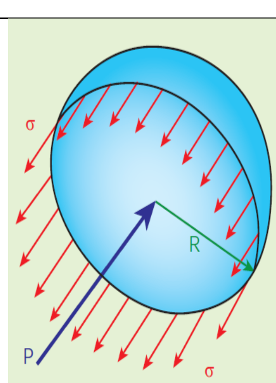
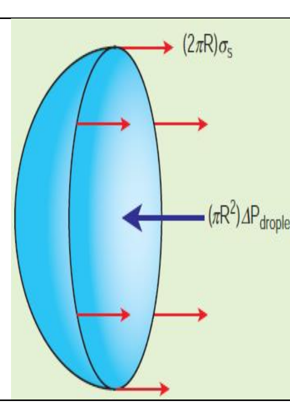
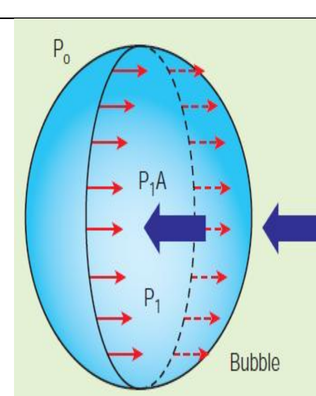
03 Continuity equation

Diagram		
Mass of the liquid entering at A	$m_1 = (a_1 v_1 \Delta t)\rho$	
Mass of the liquid leaving at B	$m_2 = (a_2 v_2 \Delta t)\rho$	
LOCO M	$(a_1 v_1 \Delta t)\rho = (a_2 v_2 \Delta t)\rho$ $a_1 v_1 = a_2 v_2 = av = constant$	
Conclusion	Area	Velocity
	Less	More
	More	Less

04 Relation between surface energy and surface Tension

Diagram	
Work done	$= (2Tl)(\Delta x)$
Increase in area	$= 2l\Delta x$
$surface\ energy$	$= \dfrac{work\ done}{increase\ in\ area} = \dfrac{(2Tl)(\Delta x)}{2l\Delta x} = T$

05 Excess pressure inside air bubble , liquid drop and soap bubble

	air bubble	liquid drop	soap bubble
Diagram			

Force Due to S. T	$F_T = 2\pi RT$	$F_T = 2\pi RT$	$F_T = 4\pi RT$
Force Due to outside pressure	$F_{P1} = P_1\pi R^2$	$F_{P1} = P_1\pi R^2$	$F_{P1} = P_1\pi R^2$
Force Due to inside pressure	$F_{P2} = P_2\pi R^2$	$F_{P2} = P_2\pi R^2$	$F_{P2} = P_2\pi R^2$
At Equilibrium	$(P_2 - P_1)\pi R^2 = 2\pi RT$	$(P_2 - P_1)\pi R^2 = 2\pi RT$	$(P_2 - P_1)\pi R^2 = 4\pi RT$
Excess pressure	$\Delta P = \frac{2T}{R}$	$\Delta P = \frac{2T}{R}$	$\Delta P = \frac{4T}{R}$

Two marks

01 Hooke's law

- For small deformation
- Within the elastic limit
- Stress and strain are proportional to each other

02 Poisson's ratio

The ratio of lateral strain to longitudinal strain

$$poisson\ ratio = \frac{lateral\ strain}{longitudinal\ strain}$$

03 Which is more elastic steel or rubber?

- Steel is more elastic.
- Steel produces less strain when force is applied.
- Hence young's modulus and elastic nature is more.

04 Why gas bubbles rise up in soda water?

- Density of g as sphere $<$ density of soda liquid
- Gas sphere attains terminal velocity in upward direction.
- That is why gas bubbles rise up in soda water.

.

05 What are the applications of viscosity?

- used as lubricants for heavy machinery

- Used as brake oil in hydraulic brakes
- Blood circulation through arteries and veins depends on the viscosity
- to determine the charge of an electron.

06 Water bugs and water striders walk on the surface of water.

- The water molecules are pulled inwards.
- The surface water surface acts like springy stretched membrane
- This balances the weight of water bugs and enables them to walk.

07 What are the factors affecting surface Tension?

- Presence of impurity
- Presence of dissolved substance
- Electrification
- Temperature

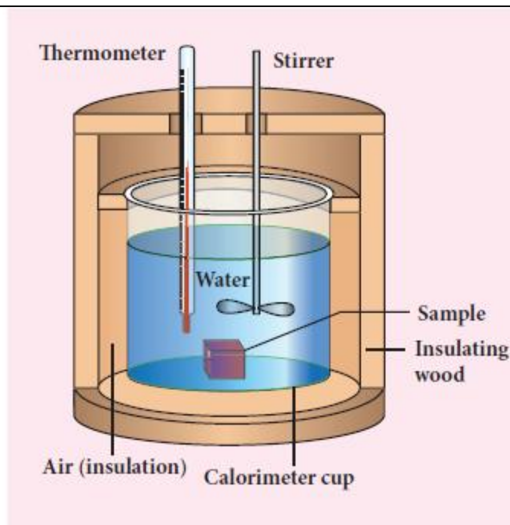
08 What are the practical applications of capillarity?

- Oil rises in the cotton within an earthen lamp.
- Sap rises from the roots of a plant
- Absorption of ink by a blotting paper
- Cotton dresses have fine pores which acts as capillaries for sweat.

08. Thermal properties and Thermodynamics

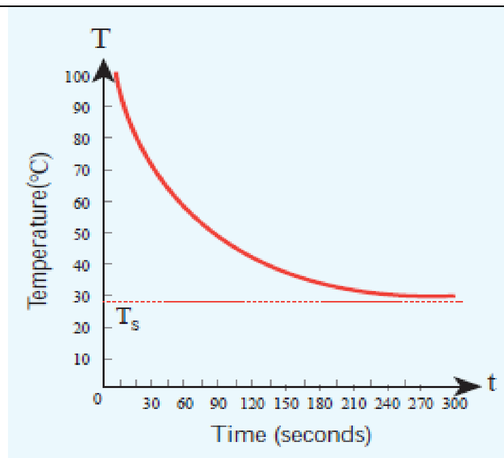
Five marks

01 Calorimetry

Calorimetry	Measurement of the amount of heat released or absorbed
Diagram	
Heat gained	$Q_{gain} = m_2 s_2 (T_f - T_2)$
Heat lost	$Q_{lost} = m_1 s_1 (T_f - T_1)$
$Q_{gain} = -Q_{lost}$	$m_2 s_2 (T_f - T_2) = -m_1 s_1 (T_f - T_1)$
Final temperature	$T_f = \frac{m_1 s_1 T_1 + m_2 s_2 T_2}{m_1 s_1 + m_2 s_2}$

02 Newton's law of cooling

Statement	The rate of heat loss is directly proportional to the temperature difference between that body and its surroundings.
Expression	$\frac{dQ}{dt} \propto -(T - T_s)$ -VE sign denotes temperature decreases
amount of heat lost is	$\frac{dQ}{dt} = \frac{msdT}{dt} —(1)$
Newton's law of cooling	$\frac{dQ}{dt} = -a(T - T_s) - -(2)$
Equating (1) & (2)	$-a(T - T_s) = \frac{msdT}{dt}$
Rearranging & integrating	$ln(T - T_s) = \frac{-at}{ms} + b_t$
Taking exponent	$T = T_s + b_2 e^{\frac{-at}{ms}}$

Graph	

03 Meyer's relation

Consider an ideal gas in a container	
Work done by the gas	$W = PdV$
From I law of thermodynamics	Q = dU + W
On Substituting	$\mu C_P dT = \mu C_V dT + PdV$ – (1)
From ideal gas equation	PV = μRT
On differentiating	PdV + VdP = μRdT PdV = μRdT (dP = 0) –(2)
Sub (2) in (1)	$\mu C_P dT = \mu C_V dT + \mu RdT$
Meyers relation	$C_p - C_V = R$

04 Derive an expression for work done in an isothermal process

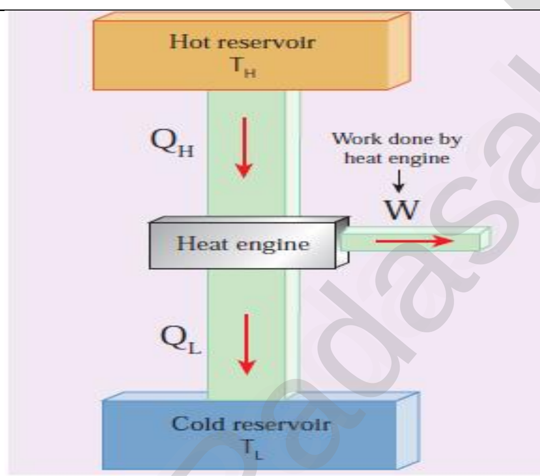
Isothermal process	➢ Temperature constant ➢ Pressure and Volume changes	
The work done by the gas	$W = \int_{V_i}^{V_f} PdV - - - (1)$	
Ideal gas equation	$P = \frac{\mu RT}{V} - - - (2)$	
(2) in (1)	$W = \mu RT \int_{V_i}^{V_f} \left(\frac{dV}{V}\right)$	
Work done by the gas	$W = \mu RT \ ln(\frac{V_f}{V_i})$	On integrating

05 Derive an expression for work done in an adiabatic process

adiabatic process	➢ No heat enters or leaves the system.

Ideal gas equation	$P = \frac{constant}{V^{\gamma}} - - - (1)$
The work done	$W = \int_{V_i}^{V_f} PdV - - - (2)$
(1) in (2)	$W = constant \int_{V_i}^{V_f} V^{-\gamma} dV$
On integrating	$W = \frac{constant}{1-\gamma} [\frac{1}{V_f^{\gamma-1}} - \frac{1}{V_i^{\gamma-1}}]$
Work done by the gas	$W_{adia} = \frac{\mu R}{\gamma - 1} [T_i - T_f]$

06 Refrigerator

Refrigerator	A refrigerator is a Carnot's engine working in the reverse order.
Diagram	
From I law of thermodynamics	$Q_L + W = Q_H - - - (1)$
Coefficient of performance	$\beta = \frac{Q_L}{W}$
	$\beta = \frac{Q_L}{Q_H - Q_L}$
	$\beta = \frac{T_L}{T_H - T_L}$

Two marks

01 Boyle's law

- At constant Temperature
- Pressure of the gas is inversely proportional to the volume

$P \ \alpha \ \frac{1}{V}$

02 Charles law

- At constant Pressure
- The volume of the gas is proportional to absolute temperature

$V \alpha T$

03 Latent heat capacity

- amount of heat energy required to change the state of a unit mass

$L = \frac{Q}{m}$

Unit : J Kg^{-1}

04 Prevost theory of heat exchange

- all bodies emit thermal radiation at all temperatures
- above absolute zero
- Irrespective of the nature of the surroundings.

05 Stefan Boltzmann law

Total amount of heat radiated per second per unit area of a black body is directly proportional to the fourth power of its absolute temperature

$E \alpha T^4$

06 Wien's displacement law

Wien's law states that, the wavelength of maximum intensity of emission of a black body radiation is inversely proportional to the absolute temperature of the black body.

$\lambda_m = \frac{b}{T}$

07 Zeroth law of thermodynamics

If two systems A and B are in thermal equilibrium with a third system C, the A and B are in thermal equilibrium with each other

08 Conditions for reversible process

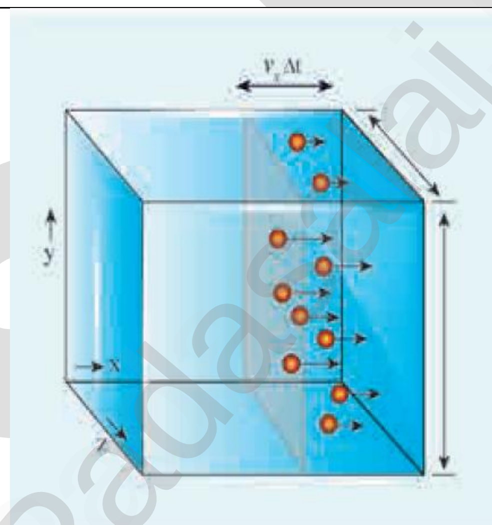
- Process rate should be extremely slow
- Should be in mechanical, thermal and chemical equilibrium at all the times
- No dissipative forces should be present

09. KINETIC THEORY OF GASSES

01 What are the postulates of kinetic theory of gases?

- All molecules are identical elastic spheres
- They are in continuous random motion
- Perfect elastic collision hence no kinetic energy loss
- They travel with uniform velocity
- Energy is wholly kinetic
- Collisions are instanteous
- They obey Newton's law

02 Derive an expression for pressure exerted by a gas

Diagram	
Change in momentum	$-2mv_x$
By LOCO P	$2mv_x$
Average no of molecules hitting the walls	$\frac{n}{2}Av_x\Delta t$
Total momentum transferred	$\frac{n}{2}Av_x\Delta t\ X\ 2mv_x$
From Newton's law	$nmAv_x^2$
Pressure	nmv_x^2

03 Law of equipartition of energy

Average kinetic energy in X , Y and Z direction	$\frac{1}{2}\ m\overline{v^2}_x = \frac{1}{2}\ m\overline{v^2}_y = \frac{1}{2}\ m\overline{v^2}_z = \frac{1}{2}\ kT$
Law of equipartition of energy	The average kinetic energy of system at a temperature T is uniformly distributed to all degrees of freedom

	Molecule		f	Average KE
Average Kinetic Energy	Mono atomic		3	$\frac{3}{2}\,kT$
	Diatomic	Normal T	5	$\frac{5}{2}\,kT$
		High T	7	$\frac{7}{2}\,kT$
	Tri atomic	Normal T	5	$\frac{5}{2}\,kT$
		High T	7	$\frac{7}{2}\,kT$
		Non linear	6	$3\,kT$

Two marks

01 Moon has no atmosphere. Why?

- Escape speed of moon <<< root mean square velocity of gasses
- Due to this all gasses escape from the surface of the moon

02 No Hydrogen in Earth's atmosphere. Why?

- Root mean square speed of hydrogen >>> Root mean square speed of nitrogen
- So hydrogen escapes easily from the surface of the earth.

03 Degrees of freedom

The minimum number of independent co ordinates needed to specify the position and configuration of a thermo dynamical system in space

04 Mean Free path

The average distance travelled by the molecule between collision is called mean free path

05 Why the smell of hot sizzling food reaches several meters away than the smell of cold food?

- As the mean free path increases with increasing temperature.
- As temperature increases, average speed of each molecule will increase
- So it travels longer distances.

06 What is Brownian motion? what are the factors affecting Brownian motion

The random motion of pollen suspended in a liquid is called Brownian motion.

<u>Factor affecting Brownian motion</u>

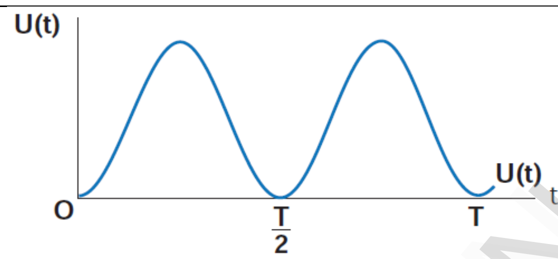
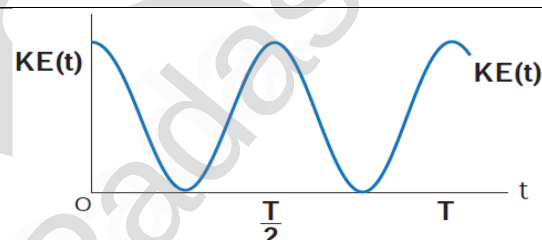
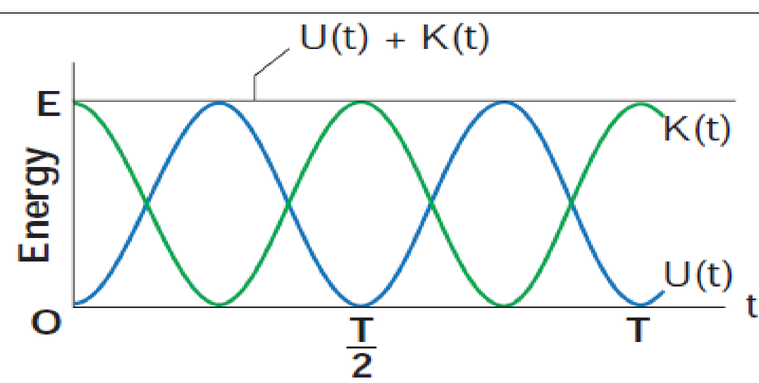
- Brownian motion increases with increasing temperature
- They decreases with bigger particle size, high viscosity and density of the liquid or gas

07 What is the reason for Brownian motion?

- According to kinetic theory, any particle suspended in a liquid or gas is continuously bombarded from all the directions so that the mean free path is almost negligible.
- This leads to the motion of the particles in a random manner.

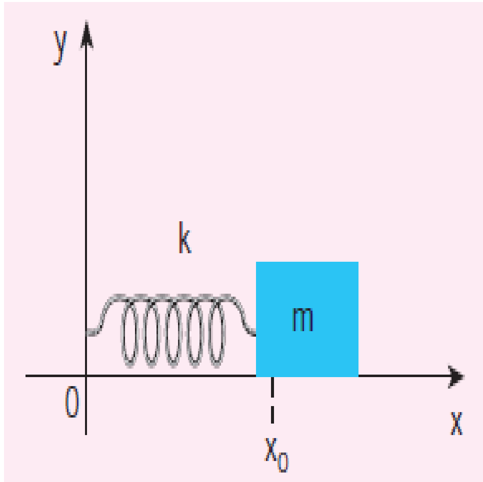
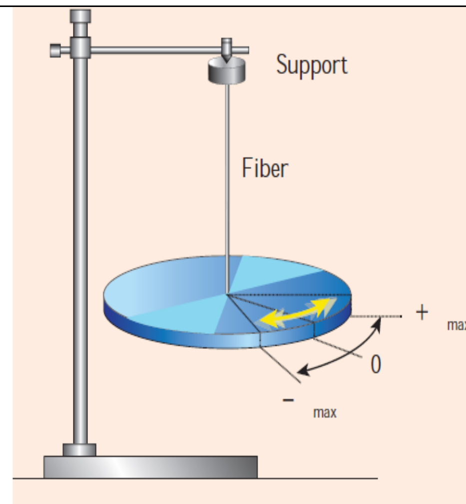
9. oscillations
FIVE MARKS

1 Discuss in detail the energy in simple harmonic motion

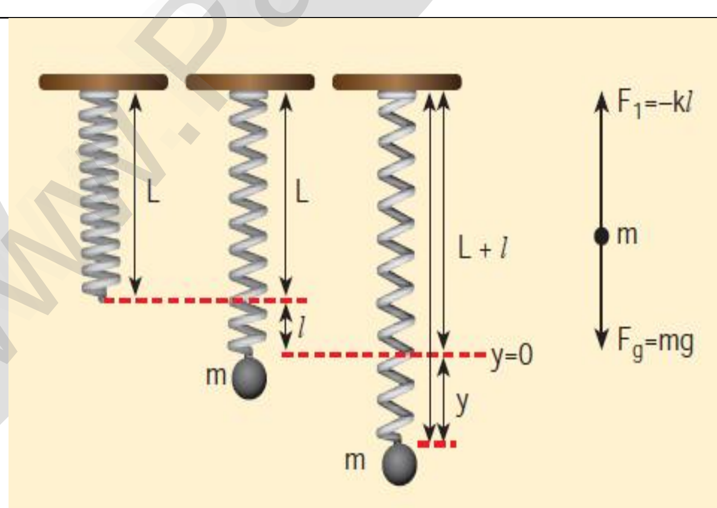
Potential Energy	Definition	The work done by the force F during a small displacement dx stores as potential energy
	Equation	$U = \int_0^x F\,dx = \int_0^x Kx\,dx$ $U = \frac{1}{2} Mw^2 x^2$
	Graph	
Kinetic Energy	Definition	Energy acquired by virtue of motion
	Equation	$KE = \frac{1}{2} MV^2$ $= \frac{1}{2} M\omega^2 (A^2 - x^2)$
	Graph	
Total Energy	Definition	Total Energy = Potential Energy + Kinetic Energy
	Equation	$E = \frac{1}{2} M\omega^2 x^2 + \frac{1}{2} M\omega^2 (A^2 - x^2)$ $E = \frac{1}{2} M\omega^2 A^2 = constant$
	Graph	

02 Derive an expression for time period and frequency of Linear / Harmonic oscillator

	Linear harmonic oscillator	Angular harmonic oscillator

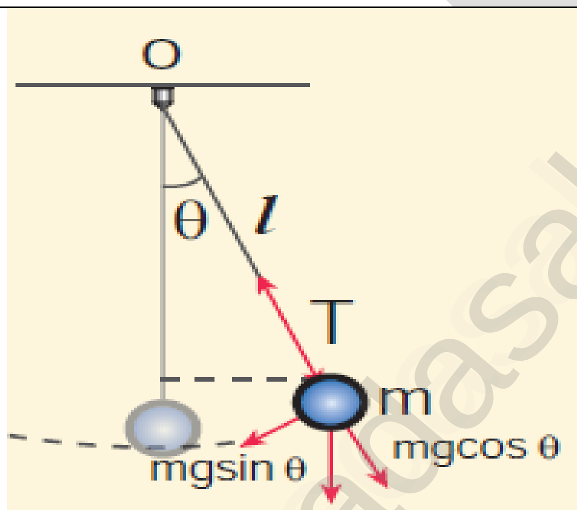
Diagram		
Applied F/ τ	$\vec{F} = m\vec{a} = -K\vec{y}$ $\boxed{\vec{a} = \frac{-K}{m}\ \vec{y} - -(1)}$	$\vec{\tau} = I\vec{\alpha} = -K\vec{\theta}$ $\boxed{\vec{\alpha} = \frac{-K}{I}\ \vec{\theta} - -(1)}$
Defn. of SHM	$\vec{a} = -\omega^2 y \ \ --(2)$	$\vec{\alpha} = -\omega^2\theta \ \ --(2)$
From (1) & (2)	$\omega = \sqrt{\frac{K}{m}}$	$\omega = \sqrt{\frac{K}{I}}$
Time period	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{K}}$	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{K}}$
Frequency	$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$	$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{K}{I}}$

03 Vertical oscillations of a spring

Diagram			
Forces	Force	Expression	Direction
	Gravitational	Mg	Downwards
	Restoring	-Kl	Upwards
@ Equilibrium	$F_1 = mg = Kl—(1)$ $\boxed{\frac{m}{K} = \frac{l}{g}}$		
Net force	$F = F_2 + mg$		

	$F = -Ky - Kl + mg$— (2)
(1) In (2)	$F = ma = -Ky$ $\vec{a} = \frac{-K}{m}\vec{y}$ - −(3)
Defn. of SHM	$\vec{a} = -\omega^2 y$
Angular frequency	$\omega = \sqrt{\frac{K}{m}}$
Time period	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{l}{g}}$

04 Derive an expression for oscillations of a simple pendulum.

Diagram	 		
Resolving	Gravitational force	Vertically downwards	
	Tension	Along the string	
acceleration	$a = g\ sin\theta = g\ \frac{s}{l}$		$sin\,\theta = \frac{s}{l}$
SHM definition	$\vec{a} = -\omega^2\ s$		
Angular velocity	$\omega = \sqrt{\frac{g}{l}}$		
Time period	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{l}{g}}$		

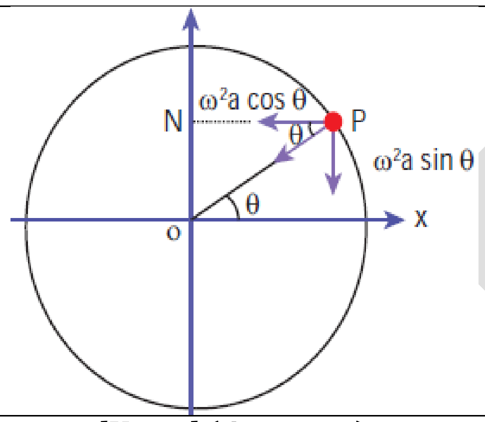
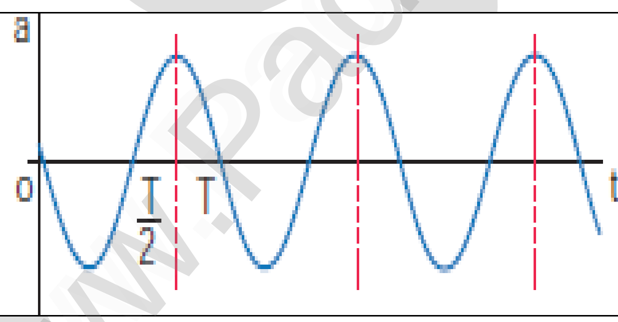
05 Types of oscillations with example

oscillation	Example
Free oscillation	➢ Vibration of tuning fork ➢ Vibration of stretched string
Damped	➢ EM oscillations in tank circuit

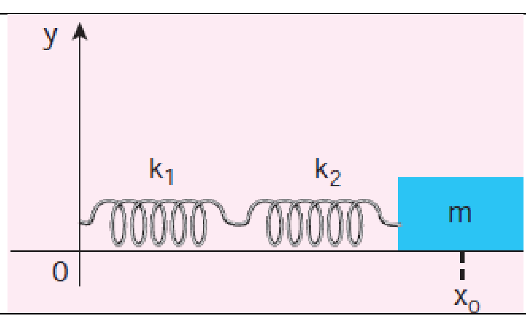
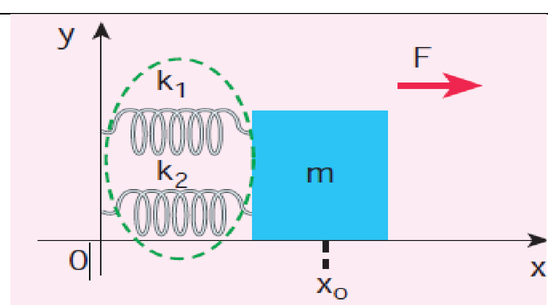
	➢ Dead beat galvanometer
Maintained	➢ tuning fork getting energy from a battery
Forced	➢ Sound board of stringed instruments
Resonance	➢ Breaking of glass due to sound

THREE MARKS

01 Discuss Acceleration in SHM

Definition	The rate of change of velocity is acceleration.
Diagram	
Derivations	$a_c = \frac{dV}{dt} = \frac{d\,(A\omega cos\omega t)}{dt}$ $a_c = -A\omega^2 sin\omega t$ $\boxed{a_c = -\,\omega^2 y}$
Graph	

02 Discuss the effective spring constants in series and parallel

	Series	Parallel
Diagram		
Net Disp / Force	$x = x_1 + x_2$	$F = F_1 + F_2$
On Subs	$\frac{F}{K_s} = \frac{F}{K_1} + \frac{F}{K_2}$	$K_P\, x = K_1 x + K_2 x$

k_{eff}	$\frac{1}{K_s} = \frac{1}{K_1} + \frac{1}{K_2}$	$K_P = K_1 + K_2$
" n " identical	$K_s = \frac{K}{n}$	$K_p = nK$
Conclusion	K_s less than any K	K_p greater than any K

TWO MARKS

1 Define oscillatory motion.

Definition	When an object or a particle moves back and forth repeatedly for some duration of time its motion is said to be oscillatory.
Example	heart beat, pendulum clock

2 What are periodic motions?

Definition	Any motion which repeats itself in a fixed time interval
Example	Hands in pendulum clock, swing of a cradle, the revolution of the Earth around the Sun, waxing and waning of Moon

3 What are non periodic motions?

Definition	Any motion which doesn't repeats itself in a fixed time interval
Example	Occurrence of Earth quake, eruption of volcano, etc.

4 Define Force constant

- Force constant is defined as the force per unit length.
- Unit : Nm^{-1}

5 Define Time period

- The time taken by a particle to complete one oscillation.
- Unit : s

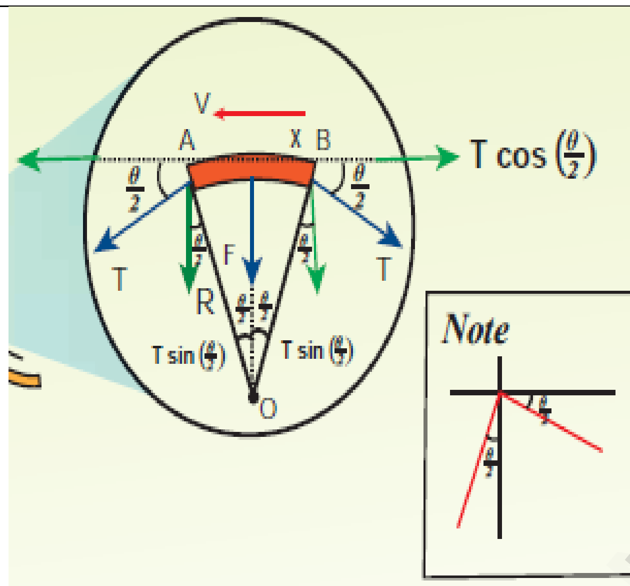
6 Define Frequency

- The number of oscillations produced by the particle per second is frequency.
- Unit : Hz

11. WAVES

FIVE MARKS

1 Derive an expression for velocity of transverse waves in a stretched string

Diagram			
Resolving T	Horizontal	$T\ Cos\theta$	Cancels each other
	Vertical	$Tsin\theta$	Added up
From Tensional force	$F = \frac{T\ dl}{R} — (1)$		
Centripetal force	$F = \frac{dm\ V^2}{R} = \frac{V^2 \mu dl}{R} - - - (2)$		
(1) = (2)	$\frac{T\ dl}{R} = \frac{V^2 \mu dl}{R}$		
Velocity of the string	$v = \sqrt{\frac{T}{\mu}}$		

2 Closed organ pipe

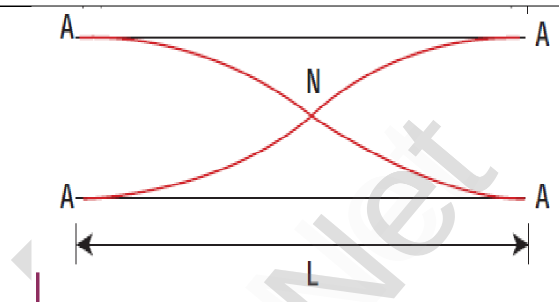
Description	One end is closed & another open Antinodes formed at open end Node is formed at closed end L is the length of the pipe				
Mode	nodes	Antinodes	Vibrating length $l = \frac{n\lambda}{4}$	Wavelength $\lambda = \frac{4l}{n}$	Frequency $f = \frac{V}{\lambda}$
Fundamental	1	1	$\frac{\lambda}{4}$	$4L$	$f_1 = \frac{V}{\lambda} = \frac{V}{4L}$
Second	2	2	$\frac{3\lambda}{4}$	$\frac{4L}{3}$	$f_2 = \frac{V}{\lambda} = \frac{3V}{4L}$

Third mode	3	3	$\frac{5\lambda}{4}$	$\frac{4L}{5}$	$f_3 = \frac{V}{\lambda} = \frac{5V}{4L}$
Frequency of n[th] harmonics	$f_n = (2n+1)f_1$				
$f_1 : f_2 : f_3 : f_4$	1 : 3 : 5 : 7				
Nature	Odd harmonics				

3 Open organ pipes

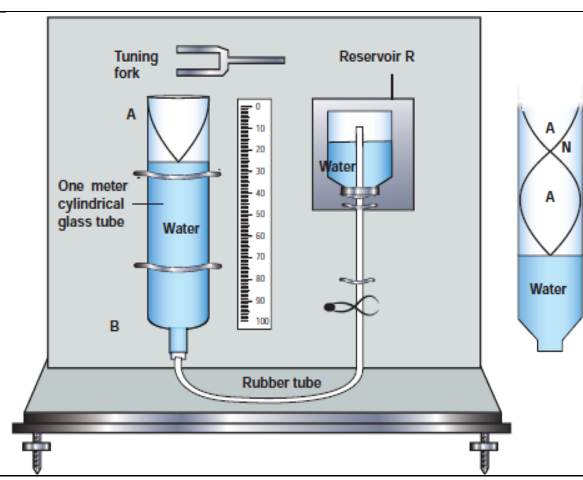
- Both the ends are open
- Anti nodes are formed at open ends
- Nodes are formed at mid point

L → length of the pipe



Mode	nodes	antinodes	Vibrating length $l = \frac{n\lambda}{2}$	Wavelength $\lambda = \frac{2l}{n}$	Frequency $f = \frac{V}{\lambda}$
Fundamental	1	2	$\frac{\lambda_1}{2}$	$2L$	$f_1 = \frac{V}{\lambda_1} = \frac{V}{2L}$
Second	2	3	λ_2	L	$f_2 = \frac{V}{\lambda_2} = \frac{V}{L}$
Third mode	3	4	$\frac{3\lambda_3}{2}$	$\frac{2L}{3}$	$f_3 = \frac{V}{\lambda_3} = \frac{3V}{2L}$
Frequency of n[th] harmonics			$f_n = (n)f_1$		
$f_1 : f_2 : f_3 : f_4$			1 : 2 : 3 : 4		
Natural harmonics					

4 Resonance air column

Diagram	
Working	➢ Vibrating tuning fork is brought nearer to open end ➢ Longitudinal waves are formed

	➢ At particular length frequency of air column resonates with frequency tuning fork
First resonance	➢ Occurs at L_1 ➢ $\frac{\lambda}{4} = L_1 + e$ — (1)
Second resonance	➢ Occurs at L_2 ➢ $\frac{3\lambda}{4} = L_2 + e$ — (2)
(2) – (1)	$\lambda = 2\Delta L$
The speed of sound	$v = f\lambda = 2f\Delta L$
End correction	$e = \frac{L_2 - 3L_1}{2}$

5 Newton's formula for speed of sound waves in air and Laplace correction

	Newton	Laplace
Assumption	Isothermal	Adiabatic
law	Boyle's law $PV = constant$	Poisson's law $PV^{\gamma} = constant$
Differentiating	$P = -V\frac{dP}{dV} = B$	$P\gamma = -V\frac{dP}{dV} = B$
Velocity of sound	$v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{P}{\rho}}$	$v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$
At NTP	$v = 280\ ms^{-1}$	$v = 331.3\ ms^{-1}$

THREE MARKS

1 Characteristics of wave motion

- ➢ Medium must possess inertia and elasticity
- ➢ Under go reflection, refraction, interference and diffraction
- ➢ Wave velocity is a constant
- ➢ Particle velocity ➔ maximum at mean position
  ➔ minimum at extremes

2 What are the characteristics of progressive waves?

- ➢ Particles vibrate about mean position with same amplitude

- Phase changes from 0 to 2π
- Particles will be at rest at extremes
- Same maximum velocity while passing through mean positions

3 Characteristics of stationary waves

- Wave doesn't move forward or backward i.e., remains stationary at a place
- Maximum amplitude is antinodes & minimum amplitude is nodes
- Distance between two consecutive nodes / antinodes is $\frac{\lambda}{2}$
- Distance between two neighboring nodes and antinodes is $\frac{\lambda}{4}$
- Energy transfer is zero

4 Laws of transverse vibration in stretched string

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

Law	Constant			
Length	T and ⍰	Frequency	Inversely proportional	Vibrating length
Tension	l and ⍰		Proportional	$\sqrt{Tension}$
mass	l and T		Inversely proportional	$\sqrt{mass\ per\ unit\ length}$

5 Explain the construction and working of stethoscope

Principle	Multiple reflection of sound	
Construction		
Chest Piece	Ear piece	Rubber tube
Small disc shaped diaphragm Very sound sensitive Amplifies the detected sound	Metal tubes Hear sounds from chest	Connects ear piece & chest piece
Working Heart beat sound reaches the ear piece by multiple reflections.		

TWO MARKS

1 State laws of reflection

- Angle of incidence = angle of reflection
- Incident wave, reflected wave, normal lie in the same plane

2 Define interference

- Two waves superimpose
- Forming as resultant wave
- Greater, lower or same amplitude

3 Beats

When two or more wave superimpose each other with slightly different frequencies, then a sound of periodically varying amplitude at a point is observed.

4 Define Intensity. Write its unit.

The sound power transmitted per unit area taken normal to the propagation of the sound wave.

5 Loudness

The degree of sensation of sound produced in the ear or the perception of sound by the listener.