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11

HALF-YEARLY EXAMINATION – JANUARY 2025

PART – III

இயற்பியல் / PHYSICS

(English Version)

Time Allowed : 3.00 Hours] [Maximum Marks : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

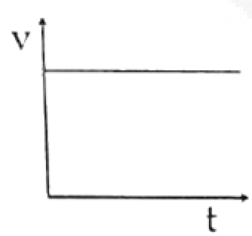
(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

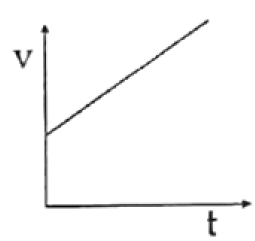
PART – I

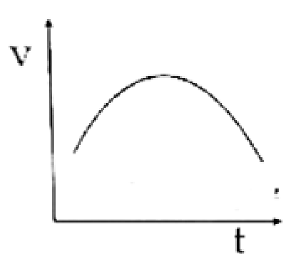
Note : (i) Answer **all** the questions. **15x1=15**

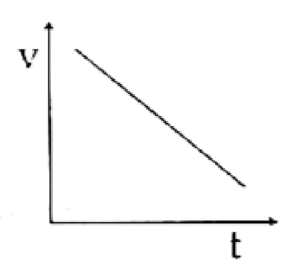
(ii) Choose the most appropriate answer from the given **four** alternatives and write the option code and the corresponding answer.

1. If the error in the measurement of radius of a sphere is 2%, then the error in the determination of its volume will be :
   (a) 8 % (b) 2 % (c) 4 % (d) 6 %
2. A stone of mass 0.5 kg tied to a string executes uniform circular motion in a circle of radius 2 m with a speed of 4 ms^{-1}. The magnitude of tension acting on the stone will be :
   (a) 3 N (b) 10 N (c) 0.5 N (d) 4 N
3. If a particle executes uniform circular motion in the xy plane in clockwise direction, then the angular velocity is in:
   (a) + y direction (b) + z direction
   (c) – z direction (d) – x direction
4. The velocity – time (v-t) graph representing motion of particle moving with uniform velocity is :

(a) 

(b) 

(c) 

(d) 

5. A rigid body rotates with an angular momentum L. If its kinetic energy is halved, then angular momentum becomes:

(a) 2L (b) L (c) $\frac{L}{\sqrt{2}}$ (d) $\frac{L}{2}$

6. The energy consumed in electrical units when a 60 W fan is used for 8 hours daily one month (30 days) is nearly:

(a) 14 units (b) 18 units (c) 16 units (d) 20 units

7. In a vertical circular motion, the minimum speed at the lowest point required by the mass to complete circular motion is (Radius of the circular path is r) :

(a) $\sqrt{2gr}$ (b) 2gr (c) $\sqrt{5gr}$ (d) 5gr

8. The wettability of a surface by a liquid depends primary on :

(a) viscosity (b) surface tension

(c) density (d) angle of contact between surface and the liquid

9. An object of mass 10 kg is hanging from a spring scale which is attached to the roof of a lift. If the lift is in free fall, the reading in the spring scale is :

(a) 98 N (b) zero (c) 49 N (d) 9.8 N

10. All natural processes occur such that entropy should:

(a) always increase (b) always decrease

(c) first increase and then decrease (d) does not change

11. The graph between volume of a given mass of gas and temperature when its pressure remains constant is :

(a) an ellipse (b) a circle (c) a straight line (d) a parabola

12. When a damped harmonic oscillator completes 100 oscillations, its amplitude is reduced to $\frac{1}{3}$ of its initial value. What will be its amplitude when it completes 200 oscillations?

(a) $\frac{1}{5}$ (b) $\frac{2}{3}$ (c) $\frac{1}{6}$ (d) $\frac{1}{9}$

13. Which of the following is an example of non-linear triatomic molecule?

(a) Water (b) Hydrogen (c) Helium (d) Nitrogen

14. If S_P and S_V denote the specific heats of nitrogen gas per unit mass at constant pressure and constant volume respectively, then :

(a) $S_P - S_V = 28 R$ (b) $S_P - S_V = R/28$

(c) $S_P - S_V = R/14$ (d) $S_P - S_V = R$

15. The first three frequencies of harmonics of a closed organ pipe will be in the ratio :

(a) 1 : 2 : 3 (b) 1 : 3 : 5 (c) 1 : 4 : 9 (d) 2 : 4 : 6

PART – II

Note : Answer **any six** questions. Question No. **24** is **compulsory.** 6x2=12

16. What are fundamental quantities? Give an example.
17. The position vector and angular velocity vector of a particle executing uniform circular motion at an instant are $2\hat{\imath}$ and $4\hat{k}$ respectively. Find its linear velocity at that instant.
18. When walking on ice one should take short steps. Why?
19. What is radius of gyration?
20. State Newton's Universal Law of Gravitation.
21. Explain red shift and blue shift in Doppler effect.
22. What is P-V diagram?
23. List the factors affecting the mean free path.
24. A metal cube of side 0.20 m is subjected to a shearing force of 4000 N. The top surface is displaced through 0.50 cm with respect to the bottom. Calculate the shear modulus of elasticity of the metal.

PART – III

Note : Answer **any six** questions. Question No. **33** is **compulsory.** 6x3=18

25. Write about dimensional variables and dimensionless variables with an example.
26. A train was moving at the rate of 54 kmh^{-1} when brakes were applied. It came to rest within a distance of 225 m. Calculate the retardation produced in the train.
27. Compare elastic and inelastic collisions.
28. Derive an expression for kinetic energy of a rigid body in rotational motion.
29. Suppose we go 200 km above and below the surface of the Earth, what are the g values at these two points? In which case, is the value of g small?
30. Write any three applications of Surface Tension.
31. Why does heat flow from a hot object to cold object?
32. Write any six postulates of kinetic theory of gases.
33. Calculate the amplitude, angular frequency, frequency, time period and initial phase of the simple harmonic oscillation for the given equation $y = 0.3 \sin (40\pi t + 1.1)$.

PART – IV

Note : Answer **all** the questions. **5x5=25**

34. (a) Prove the law of conservation of linear momentum. Use it to find the recoil velocity of a gun when a bullet is fired from it.

(OR)

(b) What is meant by angular harmonic oscillation? Derive an expression for the time period of angular harmonic oscillation.

35. (a) (i) What are the applications of dimensional analysis?

(ii) Express 76 cm of mercury pressure in terms of Nm^{-2} using the method of dimensions.

(OR)

(b) (i) Obtain a relation between momentum and kinetic energy.

(ii) Two objects of masses 2 kg and 4 kg are moving with same momentum of 20 $kgms^{-1}$.

(A) Will they have same kinetic energy?

(B) Will they have same speed?

36. (a) Derive the linear kinematic equations of motion for constant accelerated motion.

(OR)

(b) Explain the types of equilibrium with suitable examples.

37. (a) What is thermal expansion? Explain the three types of thermal expansion and obtain the relation between them.

(OR)

(b) What are stationary waves? Explain the formation of stationary waves.

38. (a) Derive an expression for Orbital Velocity and Time Period of the satellite.

(OR)

(b) Derive Poiseuille's formula for the volume of a liquid flowing per second through a pipe under stream lined flow.

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HIGHER SECONDARY FIRST YEAR HALF-YEARLY EXAMINATION – JANUARY 2025

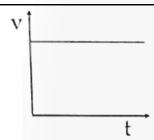
PHYSICS KEY ANSWER

Note:

1. Answers written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and write the option code and the corresponding answer.
3. For answers in Part-II, Part-III and Part-IV like reasoning, explanation, narration, description and listing of points, students may write in their own words but without changing the concepts and without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining correct steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

PART – I

Answer all the questions. **15x1=15**

Q. No.	Option	Answer	Q. No.	Option	Answer
1	(d)	6%	9	(b)	zero
2	(d)	4N	10	(a)	always increase
3	(c)	– z direction	11	(c)	a straight line
4	(a)		12	(d)	$\frac{1}{9}$
5	(c)	$\frac{L}{\sqrt{2}}$	13	(a)	Water
6	(a)	14 units	14	(b)	$S_P - S_V = R/28$
7	(c)	$\sqrt{5gr}$	15	(b)	1 : 3 : 5
8	(d)	angle of contact between surface and the liquid			

PART – II

Answer **any six** questions. Question number **18** is compulsory. 6x2=12

16	**Fundamental or base quantities:** Quantities which **cannot be** expressed in terms of **any other physical quantities.** **Examples:** Length, mass, time, electric current, temperature, luminous intensity and amount of substance.	2
17	v = rw ; = $2\hat{i} \times 4\hat{k}$; **v = 8**$\hat{j}$	2

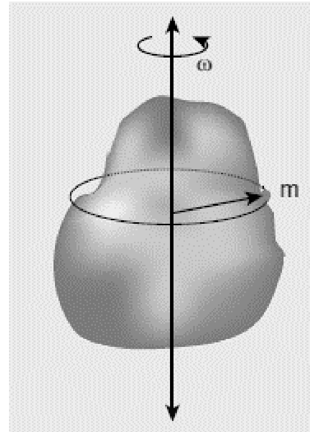
18	**Walking on ice one should take short steps:** To **avoid slipping**, take smaller steps. Because these steps causes more normal force and there by **more friction**	2
19	**Radius of gyration:** The radius of gyration of an object is **the perpendicular distance from the axis of rotation to an equivalent point mass**, which would have the same mass as well as the same moment of inertia of the object.	2
20	**Newton's Universal law of gravitation.** The strength of **this force of attraction** was found to be **directly proportional to the product of their masses and is inversely proportional to the square of the distance between them.**	2
21	**Red shirt and blue shift in Doppler Effect.** The **spectral lines of the star are found to shift towards red end of the** spectrum **(called as red shift)** then the **star is receding away from the Earth.** Similarly, if the spectral lines of the star are found to shift towards the blue end of the spectrum **(called as blue shift)** then the star is approaching Earth	2
22	**PV diagram:** PV diagram is a **graph between pressure P and volume V of the system**. The P-V diagram is **used to calculate the amount of work done by the gas during expansion** or on the gas during compression.	2
23	**Factors affecting the mean free path.** 1) Brownian motion **increases with increasing temperature**. 2) Brownian motion **decreases with bigger particle size**, high viscosity and density of the liquid (or) gas.	2
24	L = 0.20m, F=4000N, x=0.50cm ; =0.005m and Area A = L^2 = 0.04 m^2 Therefore, $\eta_R = \left(\frac{F}{A}\right) x \left(\frac{L}{x}\right)$; = $\left(\frac{4000}{0.04}\right) x \left(\frac{0.20}{0.005}\right)$; η_R= **4 x 10^6 Nm^{-2}**	2

PART – II

Answer **any six** questions. Question number **28** is compulsory. 6x3=18

<table>
<tr><td>25</td><td>
<u>Dimensional variables</u>
Physical quantities, which possess <u>dimensions and have variable</u> values are called dimensional variables. <u>Examples are length, velocity, and acceleration etc.</u>

<u>Dimensionless variables</u>
Physical quantities which have no dimensions, but have variable values are called dimensionless variables. Examples are specific gravity, strain, refractive index etc.
</td><td>3</td></tr>
<tr><td>26</td><td>
The final velocity of the particle v = 0
The initial velocity of the particle $u = 54 \times \frac{5}{18}\ ms^{-1} = 15\ ms^{-1}$; s = 225 m
Retardation is always against the velocity of the particle.
$v^2 = u^2 - 2aS$; $0 = (15)^2 - 2a(225)$; $450a = 225$
$a = \frac{225}{450}\ ms^{-2}$; $=0.5\ ms^{-2}$; Retardation = =0.5 ms⁻²
</td><td>3</td></tr>
<tr><td>27</td><td>
<table>
<tr><th>Elastic Collision</th><th>Inelastic Collision</th></tr>
<tr><td>Total momentum is conserved</td><td>Total momentum is conserved</td></tr>
<tr><td>Total kinetic energy is conserved</td><td>Total kinetic energy is not conserved</td></tr>
<tr><td>Forces involved are conservative forces</td><td>Forces involved are non-conservative Forces</td></tr>
<tr><td>Mechanical energy is not dissipated</td><td>Mechanical energy is dissipated into heat, light, sound etc.</td></tr>
</table>
</td><td>Any 3 (3)</td></tr>
<tr><td>28</td><td>
<u>Expression for kinetic energy in rotation:</u>
Let us consider a rigid body rotating with angular velocity ω about an axis as shown in Figure. Every particle of the body will have the same angular velocity ω and different tangential velocities v based on its positions from the axis of rotation.
Let us choose a particle of mass mi situated at distance ri from the axis of rotation. It has a tangential velocity v_i given by the relation, $v_i = r_i\,\omega$. The kinetic energy KE_i of the particle is,
$KE_i = ½\, m_i\, v_i^2$
Writing the expression with the angular velocity,
$KE_i = \frac{1}{2} m_i (r_i \omega)^2$; $= \frac{1}{2}(m_i r_i^2)\omega^2$
</td><td>3</td></tr>
</table>

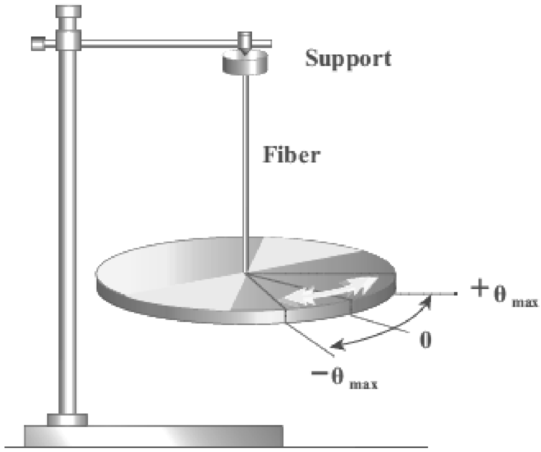
	For the kinetic energy of the whole body, which is made up of large number of such particles, the equation is written with summation as $KE = \frac{1}{2}(\Sigma m_i r_i^2)\omega^2$ Where, the term $\Sigma m_i r_i^2$ is the moment of inertia I of the whole body. $I = \Sigma m_i r_i^2$ Hence, the expression for KE of the rigid body in rotational motion is, $KE = \frac{1}{2} I\omega^2$  This is analogous to the expression for kinetic energy in translational motion $KE = \frac{1}{2} MV^2$	
29	$g_{height} = g\left[1 - \frac{2h}{R}\right]$; $g_{depth} = g\left[1 - \frac{d}{R}\right]$ $g_{height} = g\left[1 - \frac{2 \times 200}{6400}\right]$; $= g\left[\frac{64-4}{64}\right]$; $= g\left[\frac{60}{64}\right]$; $\mathbf{g_{height} = 0.94g}$ $g_{depth} = g\left[1 - \frac{200}{6400}\right]$; $= g\left[\frac{64-2}{64}\right]$; $= g\left[\frac{62}{64}\right]$; $\mathbf{g_{depth} = 0.968g}$	3
30	**<u>Applications of surface tension:</u>** 1) **Oil pouring on the water** reduces surface tension. So that the **floating mosquitos' eggs drown and killed.** 2) Finely adjusted surface tension of the liquid makes droplets of desired size, which **helps in desktop printing, automobile painting and decorative items.** 3) **Specks of dirt are removed** from the cloth when itis washed in detergents added hot water, which has low surface tension. 4) **A fabric can be made waterproof, by adding suitable waterproof material (wax) to the fabric.** This increases the angle of contact due to surface tension.	Any 3 (3)
31	**<u>Heat flow from a hot object to cold object:</u>** Because **<u>entropy increases</u>** when heat flows from hot object to cold object. **(OR)** The atoms in the hot object have higher kinetic energy than those of the cold object. Thus to maintain thermal equilibrium, the atoms of **<u>higher kinetic energy tries to move and collide with the atoms of low kinetic energy</u>**. Thus heat transfers from a hot object to a cold object.	3

32	**Postulates of kinetic theory of gases.** 1) All the molecules of a gas **are identical, elastic spheres**. 2) The molecules of **different gases are different.** 3) The number of molecules in a gas is **very large and the average** separation **between them is larger than size of the gas molecules.** 4) The molecules of a gas are in **a state of continuous random motion.** 5) The molecules collide with one another and also with the walls of the container. 6) These **collisions are perfectly elastic so that there is no loss of kinetic energy during collisions.** 7) Between two successive collisions, **a molecule moves with uniform velocity.** 8) The molecules do not exert any force of attraction or repulsion on each other except during collision. **The molecules do not possess any potential energy and the energy is wholly kinetic.** 9) The collisions are instantaneous. The time spent by a molecule in each collision is very small compared to the time elapsed between two consecutive collisions. 10) These **molecules obey Newton's laws of motion even though they move randomly.**	Any 6 (3)
33	y = A sin $(\omega t + \varphi_0)$(or) y = A cos $(\omega t + \varphi_0)$ Amplitude is A = 0.3 unit Angular frequency $\omega = 40\pi$ rad s^{-1} Frequency $f = \frac{\omega}{2\pi}$; $= \frac{40\pi}{2\pi}$; f = 20 Hz Time period $T = \frac{1}{f}$; $= \frac{1}{20}$; T = 0.05 s Initial phase φ_0 = 1.1 rad	3

PART – IV

Answer **all** the questions. 5x5=25

34. (a)	The force on each particle (Newton's second law) can be written as $\vec{F}_{12} = \frac{d\vec{p}_1}{dt}$ and $\vec{F}_{21} = \frac{d\vec{p}_2}{dt}$ Here $\vec{p}_1$ is the momentum of particle 1which changes due to the force $\vec{F}_{12}$ exertedby particle 2. Further $\vec{p}_2$ is the momentum of particle 2. These changes due to $\vec{F}_{21}$ exerted by particle 1. $\frac{d\vec{p}_1}{dt} = -\frac{d\vec{p}_2}{dt}$; $\frac{d\vec{p}_1}{dt} + \frac{d\vec{p}_2}{dt} = 0$; $\frac{d}{dt}(\vec{p}_1 + \vec{p}_2) = 0$ It implies that $\vec{p}_1 + \vec{p}_2$ = constant vector (always). $\vec{p}_1 + \vec{p}_2$ is the total linear momentum of the two particles ($\vec{p}_{tot} = \vec{p}_1 + \vec{p}_2$). It is also called as total linear momentum of the system. Here, the two particles constitute the system. If there are no external forces acting on the system, then the total linear momentum of the system ($\vec{p}_{tot}$) is always a constant vector. **Examples:** Consider the **firing of a gun.** Here the system is Gun+bullet. Initially the gun and bullet are at rest, hence the total linear momentum of the system is zero. Let $\vec{p}_1$ be the momentum of the bullet and $\vec{p}_2$ the momentum of the gun before firing. Since initially both are at rest, $\vec{p}_1 = 0$, $\vec{p}_2 = 0$. Total momentum before firing the gun is zero, $\vec{p}_1 + \vec{p}_2 = 0$. According to the law of conservation of linear momentum, total linear momentum has to be zero after the firing also. When the gun is fired, a force is exerted by the gun on the bullet in forward direction. Now the momentum of the bullet changes from $\vec{p}_1$ to $\vec{p}_1'$. To conserve the total linear momentum of the system, the momentum of the gun must also change from $\vec{p}_2$ to $\vec{p}_2'$. Due to the conservation of linear momentum, $\vec{p}_1' + \vec{p}_2' = 0$. It implies that $\vec{p}_1' = -\vec{p}_2'$, the momentum of the gun is exactly equal, but in the opposite direction to the momentum of the bullet. This is the reason after firing, the gun suddenly moves backward with the momentum ($-\vec{p}_2$). It is called 'recoil momentum'. This is an example of conservation of total linear momentum.	5

34. (b)	**When a body is allowed to rotate freely about a given axis then the oscillation** is known as the angular oscillation. The point at which the resultant **torque acting on the body is taken to be zero is called mean position.** If the body is displaced from the mean position, then the resultant torque acts such that it is **proportional to the angular displacement and this torque has a tendency to bring the body towards the mean position.** Let $\vec{\theta}$ be the angular displacement of the body and the resultant torque $\vec{\tau}$ acting on the body is  $\vec{\tau} \, \alpha \, \vec{\theta}$ ------------ 1 $\vec{\tau} = -k\vec{\theta}$ ------------ 2 k is the restoring torsion constant, which is torque per unit angular displacement. If *I* is the moment of inertia of the body and $\vec{\alpha}$ is the angular acceleration then $\vec{\tau} = I\vec{\alpha} = -k\vec{\theta}$. But $\vec{\alpha} = \frac{d^2\vec{\theta}}{dt^2}$ and therefore, $\vec{\alpha} = \frac{d^2\vec{\theta}}{dt^2} = \frac{k}{I}\vec{\theta}$ ------------ 3 This differential equation resembles simple harmonic differential equation. So, comparing equation with simple harmonic motion given in equation, we have $\omega = \sqrt{\frac{k}{I}}$ rad s^{-1} ---------- 4 The frequency of the angular harmonic motion is $f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{I}}$ Hz ....5 and the time period of the oscillation is $T = \frac{1}{f} = 2\pi\sqrt{\frac{I}{k}}$ second.	5

35 (a)	**Applications of Dimensional Analysis**: 1. Convert a physical quantity from **one system of units to another**. 2. **Check the dimensional correctness** of a given physical equation. 3. Establish **relations among various physical quantities.**	2
	In cgs system 76 cm of mercury pressure = 76 × 13.6 × 980 dyne cm^{-2} The dimensional formula of pressure P is $[ML^{-1}T^{-2}]$ $P_1[M_1^a L_1^b T_1^c] = P_2[M_2^a L_2^b T_2^c]$; $P_2 = P_1\left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$ M_1 = 1g, M_2 = 1kg; L_1 = 1 cm, L_2 = 1m; T_1 = 1 s, T_2 = 1s As a =1, b= -1, and c = -2 Then $P_2 = 76 \times 13.6 \times 980 \left[\frac{1g}{1kg}\right]^1 \left[\frac{1cm}{1m}\right]^{-1} \left[\frac{1s}{1s}\right]^{-2}$ $= 76 \times 13.6 \times 980 \left[\frac{10^{-3}kg}{1kg}\right]^1 \left[\frac{10^{-2}m}{1m}\right]^{-1} \left[\frac{1s}{1s}\right]^{-2}$ = 76 × 13.6 × 980 × $[10^{-3}]$ × 10^2 ;**P_2 = 1.01 × 10^5 Nm^{-2}**	3
35 (b)	**Relation between momentum and kinetic energy:** i) Consider an object of mass m moving with a velocity $\vec{v}$. Then its linear momentum is $\vec{p} = m\vec{v}$ and its kinetic energy, KE = ½ mv^2 KE = ½ mv^2; = ½ $m(\vec{v}.\vec{v})$ --------(1) ii) Multiplying both the numerator and denominator of equation (1) by mass, m KE = $\frac{1}{2}\frac{m^2(\vec{v}.\vec{v})}{m}$; $= \frac{1}{2}\frac{(m\vec{v}).(m\vec{v})}{m}$ $[\vec{p} = m\vec{v}]$; $= \frac{1}{2}\frac{(\vec{p}).(\vec{p})}{m}$ $= \frac{\vec{p}^2}{2m}$; KE = $\frac{p^2}{2m}$ iii) Where $\|\vec{p}\|$ is the magnitude of the momentum. The magnitude of the linear momentumcan be obtained by $\|\vec{p}\|$ = p = $\sqrt{2m(KE)}$ iv) Note that if kinetic energy and mass are given, only the magnitude of the momentum can be calculated but not the direction of momentum. It is because the kinetic energy and mass are scalars.	3
	(a) The kinetic energy of the mass is given by KE = $\frac{P^2}{2m}$ For the object of mass 2kg, kinetic energy is $KE_1 = \frac{(20)^2}{2x2} = \frac{400}{4}$ = 100J For the object of mass 4kg, kinetic energy is $KE_2 = \frac{(20)^2}{2x4} = \frac{400}{8}$ = 50J the kinetic energy of **both masses is not the same.** The kinetic energy of the **heavier object has lesser kinetic energy than smaller mass.** (b) As the momentum, p = mv, the two objects **will not have same speed**	2

36 (a)	**Kinematic equations of motion :** **Velocity – time relation:** a = $\frac{dv}{dt}$ (or) dv = a dt $\int_u^v dv = \int_0^t a\,dt$ v = u + at **Displacement – time relation:** v = $\frac{ds}{dt}$ (or) ds = v dt $\int_0^s ds = u\int_0^t dt$ + a $\int_0^t tdt$ s = ut + $\frac{1}{2}$ at^2 **Velocity – Displacement relation:** a = $\frac{dv}{dt} = \frac{dv}{ds}\frac{ds}{dt} = \frac{dv}{ds}v$ $\int_u^v v\,dv = a\int_0^s ds$ v^2 = u^2 + 2as s = $\frac{(u+v)t}{2}$ **(if only Four equations of motion are written – 2 Marks)**	5
36 (b)	**Translational equilibrium:** 1) Linear momentum is constant 2) Net force is zero *Example : A book resting on a table* **Rotational equilibrium:** 1) Angular momentum is constant 2) Net torque is zero *Example : A body moves in a circular path with constant velocity.* **Static equilibrium:** 1) Linear momentum and angular momentum are zero 2) Net force and net torque are zero *Example : A wall – hanging, hanging on the wall* **Dynamic equilibrium:** 1) Linear momentum and angular momentum are constant 2) Net force and net torque are zero *Example : A ball descends down in a fluid with its terminal velocity*	5

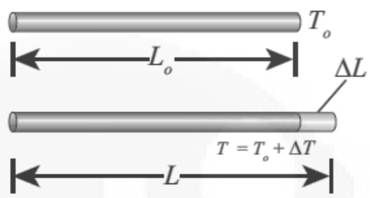
	Stable equilibrium: 1) Linear momentum and angular momentum are zero 2) The **body tries to come back to equilibrium if slightly disturbed** and released 3) The center of mass of the **body shifts slightly higher if disturbed** from equilibrium 4) Potential energy of the **body is minimum and it increases** if disturbed *Example : a table on the floor* **Unstable equilibrium:** 1) Linear momentum and angular momentum are zero 2) **The body cannot come back to equilibrium if slightly disturbed** and released 3) The **center of mass of the body shifts slightly lower if disturbed** from equilibrium 4) Potential energy of the body is **not minimum and it decreases** if Disturbed *Example : A pencil standing on its tip.* **Neutral equilibrium:** 1) Linear momentum and angular momentum are zero 2) The **body remains at the same equilibrium if slightly disturbed** and released 3) The **center of mass of the body does not shift higher** or lower if disturbed from equilibrium 4) **Potential energy remains same even if disturbed** *Example : a dice rolling on a game board*	
37 (a)	**Thermal expansion.** 1) Thermal expansion is the tendency of matter to change in shape, area, and volume due to a change in temperature. 2) All three states of matter (solid, liquid and gas) expand when heated. **When a solid is heated, its atoms vibrate with higher amplitude about their fixed points**. The relative change in the size of solids is small. **Railway tracks are given small gaps so that in the summer, the tracks expand and do not buckle**. Railroad tracks and bridges have expansion joints to allow them to expand and contract freely with temperature changes. **3)** **Liquids**, have less intermolecular forces than solids and hence they expand more than solids. This is the **principle behind the mercury thermometers.**	5

4) In the case of **gas molecules, the intermolecular forces are almost negligible and hence they expand much more than solids**. For example, in **hot air balloons when gas particles get heated, they expand and take up more space.**

5) The **increase in dimension of a body due to the increase in its temperature is called thermal expansion.**

6) The expansion in length is called **linear expansion**. Similarly, the expansion in area is termed as **area expansion** and the expansion in volume is termed as **volume expansion**.

Linear Expansion:

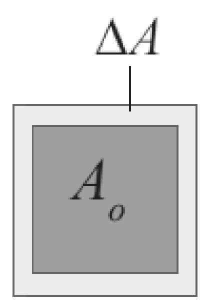


In solids, for a small change in temperature ΔT, the fractional change in length $\left(\frac{\Delta L}{L}\right)$ is directly proportional to ΔT. $\frac{\Delta L}{L} = \alpha_L \Delta T$

Therefore, $\alpha_L = \frac{\Delta L}{L\,\Delta T}$; Where, αL = coefficient of linear expansion.
ΔL = Change in length; L = Original length;
ΔT = Change in temperature.

Area Expansion:

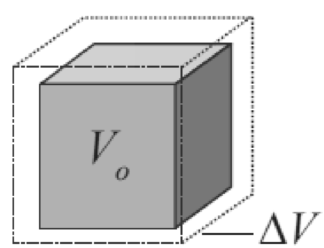
For a small change in temperature ΔT the fractional change in area $\left(\frac{\Delta A}{A}\right)$ of a substance is directly proportional to ΔT and it can be written as $\frac{\Delta A}{A} = \alpha_A \Delta T$



Therefore, $\alpha_A = \frac{\Delta A}{A\,\Delta T}$; Where, αA = coefficient of area expansion.
ΔA = Change in area; A = Original area;
ΔT = Change in temperature

Volume Expansion:

For a small change in temperature ΔT the fractional change in volume $\left(\frac{\Delta V}{V}\right)$ of a substance is directly proportional to ΔT.



$\frac{\Delta V}{V} = \alpha_V \Delta T$, Therefore, $\alpha_V = \frac{\Delta V}{V\,\Delta T}$

Where, αV = coefficient of volume expansion;
ΔV = Change in volume; V = Original volume; ΔT = Change in temperature. Unit of coefficient of linear, area and volumetric expansion of solids is C^{-1} or K^{-1}

37 (b)

Stationary waves

When the wave hits the rigid boundary it bounces back to the original medium and can interfere with the original waves. A pattern is formed, which are known as standing waves or stationary waves.

Consider two harmonic progressive waves (formed by strings) that have the same amplitude and same velocity but move in opposite directions. Then the displacement of the first wave (incident wave) is

$$\mathbf{y_1 = A \sin (kx - \omega t)} \text{ (waves move toward right) } \text{-----------------} 1$$

and the displacement of the second wave (reflected wave) is

$$\mathbf{y_2 = A \sin (kx + \omega t)} \text{ (waves move toward left) } \text{--------------} 2$$

both will interfere with each other by the principle of superposition, the net displacement is $\mathbf{y = y_1 + y_2}$ ------------------3

Substituting equation (1) and equation (2) in equation (3), we get

$$y = A \sin (kx - \omega t) + A \sin(kx + \omega t) \text{ --------------} 4$$

Using trigonometric identity, we rewrite equation (4) as

$$y (x, t) = 2A \cos(\omega t) \sin(kx) \text{ ----------- } 5$$

This represents a stationary wave or standing wave, which means that this **wave does not move either forward or backward, whereas progressive or travelling waves will move forward or backward.**

Further, the displacement of the particle in equation (5) can be written in more compact form, $y(x, t) = A' \cos(\omega t)$ where, $A' = 2A \sin(kx)$, implying that the particular element of the string executes simple harmonic motion with amplitude equals to A'.

The maximum of this amplitude occurs at positions for which

$$\sin(kx) = 1 \Rightarrow kx = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \ldots \, m\pi$$

where m takes half integer or half integral values. The position of maximum amplitude is known as antinodes.

5

38 (a)	**Orbital Velocity** Satellite of **mass M to move in a circular orbit, centripetal force must be acting on the satellite.** This centripetal force is provided by the Earth's gravitational force. $\frac{MV^2}{(R_E+h)} = \frac{GMM_E}{(R_E+h)^2}$ $V^2 = \frac{GM_E}{(R_E+h)}$; $V = \sqrt{\frac{GM_E}{(R_E+h)}}$ As h increases, the speed of the satellite decreases **Time period of the satellite:** The distance covered by the satellite during one rotation in its orbit is equal to 2π (R_E +h) and time taken for it is the time period, T. Then $\frac{\text{Distance travelled}}{\text{Time taken}} = \frac{2\pi\,(RE+h)}{T}$ From equation, $\sqrt{\frac{GM_E}{(R_E+h)}} = \frac{2\pi\,(RE+h)}{T}$ -------------- 1 $T = \frac{2\pi}{\sqrt{GM_E}}(R_E+h)^{\frac{3}{2}}$ ----------------- 2 Squaring both sides of the equation (2), we get $T^2 = \frac{4\pi^2}{GM_E}(R_E+h)^3$ $\frac{4\pi^2}{GM_E}$ = Constant say c, $T^2 = c\,(R_E+h)^3$ -------------- 3 Equation (3) implies that a satellite orbiting the **Earth has the same relation between time and distance as that of Kepler's law of planetary motion.** For a satellite orbiting near the surface of the Earth, h is negligible compared to the radius of the Earth R_E . Then, $T^2 = \frac{4\pi^2}{GM_E}R_E^3$; $T^2 = \frac{4\pi^2}{\frac{GM_E}{R_E^2}}$ $T^2 = \frac{4\pi^2}{g}R_E$ Since $\frac{GM_E}{R_E^2} = g$; $T = 2\pi\sqrt{\frac{R_E}{g}}$	2 3

38 (b)	**Poiseuille's formula:** Consider a liquid flowing steadily through a horizontal capillary tube. Let $v = \left(\frac{V}{t}\right)$ be the volume of the liquid flowing out per second through a **capillary tube. It depends on (1) coefficient of viscosity (η) of the liquid, (2) radius of the tube (r), and (3) the pressure gradient** $\left(\frac{P}{l}\right)$. Then, $v \,\alpha\, \eta^a r^b \left(\frac{P}{l}\right)^c$; $v = k\eta^a r^b \left(\frac{P}{l}\right)^c$ where, k is a dimensionless constant. Therefore, $[v] = \frac{\text{Volume}}{\text{time}} = [L^3T^{-1}]$, $\left[\frac{dP}{dx}\right] = \frac{\text{Pressure}}{\text{distance}} = [ML^{-2}T^{-2}]$, $[\eta] = [ML^{-1}T^{-1}]$ and $[r] = [L]$ Substituting in equation, So, equating the powers of M, L, and T on both sides, we get **a + c = 0, −a + b −2c =3, and −a −2c = −1** We have three unknowns *a*, *b*, and *c*. We have three equations, on solving, we get a = −1, b = 4, and c = 1 Therefore, equation becomes, $v = k\eta^{-1} r^4 \left(\frac{P}{l}\right)^1$ Experimentally, the value of *k* is shown to be $\frac{\pi}{8}$, we have $v = \frac{\pi r^4 P}{8\eta l}$	5