Please check the examination details below before entering your candidate information

Candidate Name	Class	Section

BLOOM Physics Olympiad (BPhO)

Question Paper 2024-25

Class 11

Total Questions **50 + 5** (Tie-Breaking Section)

Total Time Allotted : 60 minutes

Total Marks : 60

Instructions

1. There are **50 Multiple Choice Questions** in this booklet having 4 options out of which **ONLY ONE** is correct.
2. There are two sections in the Question Paper; Section A having 40 Questions carrying 1 Mark each & Section B having 10 Higher Difficulty Order Questions carrying 2 Marks each.
3. All questions are compulsory. There is **NO negative** marking for incorrect answers.
4. Total time allotted to complete the paper is 60 minutes.
5. Please fill in your details in the space provided on this page before attempting the paper.

OMR Sheet Instructions

1. Before starting the paper, fill in all the details in the OMR Sheet.
2. Additional 10 minutes will be provided to fill up the OMR sheet, before the start of the exam.
3. Use HB Pencil to darken the circle of the correct Option in OMR sheet. The correct way to darken the circle in OMR sheet is shown below.

4. Use black or blue ball point pen/HB pencil to fill the information in the OMR sheet. Partially filled OMR sheet will not be checked.
5. Return the OMR sheet to the invigilator after the exam.

CODE#210

P11

BLOOM CAP

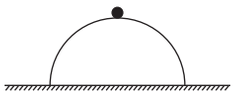
Founded by | arihant

Section A (1 Mark)

1. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine? (Take, $g = 10\ ms^{-2}$)

(a) 12.2 kW (b) 10 kW
(c) 8.1 kW (d) 14.3 kW

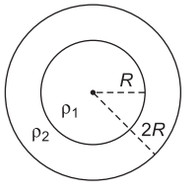
2. A hemisphere of radius R and of mass $4m$ is free to slide with its base on a smooth horizontal table.



A particle of mass m is placed on the top of the hemisphere. The angular velocity of the particle relative to hemisphere at an angular displacement θ when velocity of hemisphere become v is

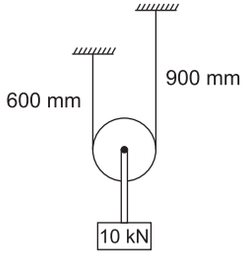
(a) $\frac{2v}{R\cos\theta}$ (b) $\frac{3v}{R\sin\theta}$
(c) $\frac{5v}{R\cos\theta}$ (d) $\frac{5v}{R\sin\theta}$

3. The density of the core of a planet is ρ_1 and that of the outer shell is ρ_2. The radii of the core and shell of the planet are R and $2R$, respectively. If the acceleration due to gravity at the surface of the planet is same as at a depth R, then the ratio of $\frac{\rho_1}{\rho_2}$ is



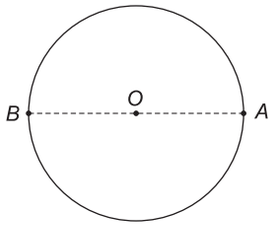
(a) $\frac{5}{3}$ (b) $\frac{7}{3}$ (c) $\frac{7}{5}$ (d) 3

4. A load of 10 kN is supported from a pulley, which in turn is supported by a rope of cross-sectional area $10^3\ mm^2$ and modulus of elasticity $10^3\ Nmm^{-2}$ as shown in the figure. Neglecting friction at the pulley, then downward deflection of the load (in mm) is



(a) 3.75 (b) 4.25 (c) 2.75 (d) 4.004

5. A particle is moving on a circular path of radius R with constant speed v. During moving the particle from point A to point B, (shown in figure)



(a) average speed is $2v$

(b) the magnitude of average velocity is $\frac{v}{\pi}$

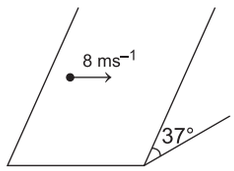
(c) the magnitude of average acceleration is $\frac{2v^2}{\pi R}$

(d) average velocity is zero

6. A man starts from rest with an acceleration $1\ ms^{-2}$ at $t = 0$. At $t = 3\sqrt{3}$ s, it appears to him that rain falls with the velocity $3\,ms^{-1}$ vertically downwards. The velocity of actual rainfall is

(a) $3\sqrt{3}\ ms^{-1}$ (b) $3\ ms^{-1}$
(c) $6\ ms^{-1}$ (d) $6\sqrt{3}\ ms^{-1}$

7. A particle is projected on smooth inclined plane in a direction perpendicular to line of greatest slope with speed $8\,ms^{-1}$. Its speed at $t = 1$ s is



(a) $5\ ms^{-1}$ (b) $8\ ms^{-1}$
(c) $6\ ms^{-1}$ (d) $10\ ms^{-1}$

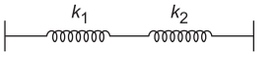
8. The mean free path for the collision of nitrogen molecules at NTP is 6.85×10^{-8} m. If the rms speed of nitrogen molecule at NTP is $4.53 \times 10^2\ ms^{-1}$.

The frequency of collision for nitrogen molecules at NTP will be

(a) $6.6 \times 10^9 \times \sqrt{\frac{2}{3}}(s^{-1})$ (b) $6.6 \times 10^9 \times \sqrt{\frac{3}{2}}(s^{-1})$

(c) $6.6 \times 10^9 \times \sqrt{\frac{3\pi}{8}}(s^{-1})$ (d) $6.6 \times 10^9 \times \sqrt{2}(s^{-1})$

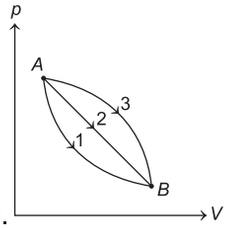
9. If the two springs with spring constants k_1 and k_2 are arranged as shown in figure, then the effective spring constant of two spring system will be



(a) $k_1 - k_2$ (b) $k_1 + k_2$

(c) $\frac{k_1 k_2}{k_1 - k_2}$ (d) $\frac{k_1 k_2}{k_1 + k_2}$

10. An ideal gas is taken from state A to state B as shown on p-V diagram by three different processes 1,2 and 3.
If Q = heat absorbed and
U = change in internal energy,
then choose the correct option.



(a) $Q_1 = Q_2 = Q_3$, $U_1 < U_2 < U_3$

(b) $Q_1 > Q_2 > Q_3$, $U_1 = U_2 = U_3$

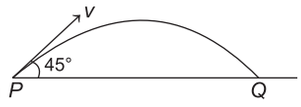
(c) $Q_1 < Q_2 < Q_3$, $U_1 = U_2 = U_3$

(d) $\frac{Q_1}{U_1} = \frac{Q_2}{U_2} = \frac{Q_3}{U_3}$

11. Force constants of two wires A and B of the same material are k and $2k$, respectively. If the two wires are stretched equally, then the ratio of work done in stretching $\left(\frac{W_A}{W_B}\right)$ is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{1}{4}$ (d) $\frac{2}{3}$

12. A projectile of mass m is fired with velocity v from a point P as shown in figure. Neglecting air resistance, the magnitude of the change in momentum between the points P and arriving at Q is



(a) zero (b) $\frac{mv}{\sqrt{2}}$

(c) $mv\sqrt{2}$ (d) $2mv$

13. When the tension on wire is 4 units, its length is l_1 and when the tension is 5 units, its length is l_2. Its natural length is

(a) $4l_1 - 3l_2$ (b) $5l_1 - 4l_2$

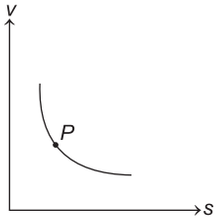
(c) $5l_2 - 4l_1$ (d) $\frac{l_1 + l_2}{2}$

14. In a system of measurement, the unit of length is 5 cm, unit of mass is 100 g and unit of time is 0.01 s. How many newton will the unit of force contains?

(a) 5×10^{-5} N (b) 5×10^{5} N

(c) 5 N (d) 15 N

15. A particle is moving on straight line whose velocity-displacement graph is shown in figure.
At point P of graph,
$v = \sqrt{3}\,\text{ms}^{-1}$ and slope is $-\sqrt{3}$.

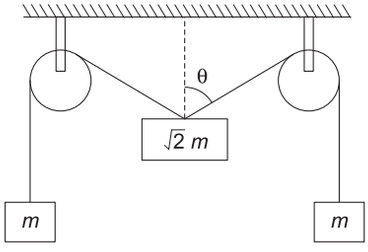


The magnitude of acceleration at point P is

(a) zero (b) $2\sqrt{3}\,\text{ms}^{-2}$

(c) 3ms^{-2} (d) 1ms^{-2}

16. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be



(a) 0° (b) 30° (c) 45° (d) 60°

17. A tank is designed to store 18 kg of N_2 (Nitrogen) gas at a pressure of 4.5 atm. If H_2 (Hydrogen) gas is filled in the tank at 3.5 atm, then amount of gas in the tank will be

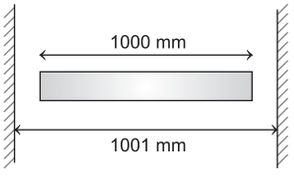
(a) 18 kg (b) 5 kg (c) 1 kg (d) 7 kg

18. The equation of a transverse wave is given by $y = 0.05\sin\pi(2t - 0.02x)$, where x and y are in metre and t is in second. The minimum distance of separation between two particles which are in phase and the wave velocity are, respectively

(a) 50 m, 50 ms^{-1} (b) 100 m, 50 ms^{-1}

(c) 50m, 100 ms^{-1} (d)100m, 100ms^{-1}

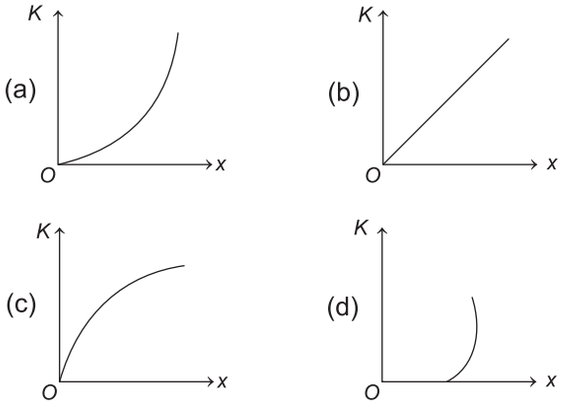
19. A rod of length 1000 mm and coefficient of linear expansion $\alpha = 10^{-4}\ ^\circ\text{C}^{-1}$ is placed symmetrically between fixed walls



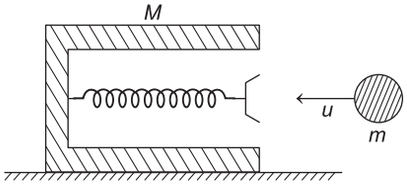
separated by 1001 mm. The Young's modulus of the rod is 10^{11} Nm^{-2}. If the temperature is increased by 20°C, then the stress developed in the rod is

(a) 10^{11} Pa (b) 10^{10} Pa
(c) 10^{9} Pa (d) 10^{8} Pa

20. A body moves from rest with a constant acceleration. Which one of the following graphs represents the variation of its kinetic K with the distance travelled x?

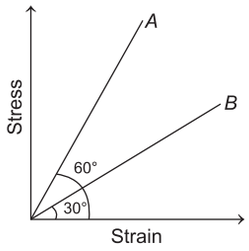


21. A ball of mass m is projected with a speed u into the barrel of a spring gun of mass M initially at rest on a frictionless surface. The mass m sticks in the barrel at the point of maximum compression in the spring. The fraction of the initial kinetic energy of the ball stored in the spring is?



(a) $\frac{m}{\sqrt{2}(m+M)}$ (b) $\frac{M}{\sqrt{2}(m+M)}$
(c) $\frac{m}{m+M}$ (d) $\frac{M}{m+M}$

22. The stress *versus* strain graphs for wires of two materials A and B are as shown in the figure. If Y_A and Y_B are the Young's modulii of the materials, then

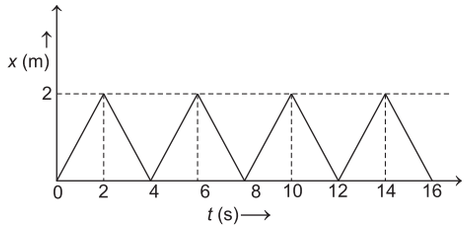


(a) $Y_B = 2Y_A$ (b) $Y_B = 3Y_A$
(c) $Y_A = 3Y_B$ (d) $Y_A = Y_B$

23. Water rises in a capillary tube to a height of 2.0 cm. In another capillary tube whose radius is one-third of it, how much the water will rise?

(a) 6 cm (b) 2 cm (c) 8 cm (d) 10 cm

24. The figure shows the position-time (x-t) graph of one-dimensional motion of a body of mass 0.4 kg. The magnitude of each impulse is



(a) 0.2 Ns (b) 0.4 Ns (c) 0.6 Ns (d) 0.8 Ns

25. A particle is moving in XY- plane whose X and Y-coordinates are $x = 3\sin 2\pi t$ and $y = 2\cos 2\pi t$, where x and y are in metre and t is in second.

(a) The path of the particle is elliptical.
(b) The path of the particle is circular.
(c) The path of the particle is parabolic.
(d) The path of the particle is straight line.

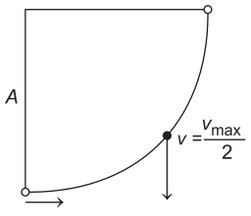
26. A block of mass 4 kg is placed on a rough horizontal plane. A time dependent horizontal force $F = kt^2$ acts on the block, where $k = 2\text{Ns}^{-2}$ and coefficient of friction $\mu = 0.8$. Force of friction between block and plane at $t = 2$s is

(a) 4 N (b) 8 N (c) 6 N (d) 35 N

27. A cylinder contains two types of gases A and B. Number of molecules of gas A in cylinder is N, each having a mass m. Number of molecules of gas B in cylinder is $2N$, each having a mass $2m$. The mean square of x-component of velocity of A is v_{Ax}^2 and mean square of x-component of velocity of B is v_{Bx}^2. The ratio of $v_{Ax} : v_{Bx}$ is

(a) 1 : 1 (b) 2 : 1 (c) 1: $\sqrt{2}$ (d) $\sqrt{2}$: 1

28. A particle starts with SHM from the mean position as shown in the figure. Its amplitude is A and its time period is T. At the time, when its speed is half of the maximum speed, its displacement is



(a) $\frac{2A}{\sqrt{3}}$ (b) $\frac{3A}{\sqrt{2}}$ (c) $\frac{\sqrt{2}A}{3}$ (d) $\frac{\sqrt{3}A}{2}$

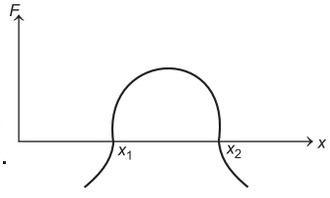
29. A sample of 10 g of oxygen is heated through 100°C at a constant pressure, then choose the correct option. (Take, $C_V = 5.03$ cal mol^{-1} - K^{-1} and $R = 1.98$ cal mol^{-1}K^{-1})

(a) Heat supplied is 62 cal
(b) Work done by gas is 219 cal
(c) Change in internal energy of gas is 157 cal
(d) No work is done by the gas

30. A particle of mass m_0 is transferred from the centre of the base of a uniform solid hemisphere of mass M and radius R to infinity. The work done in this process by the gravitational force exerted on the particle by the hemisphere, is

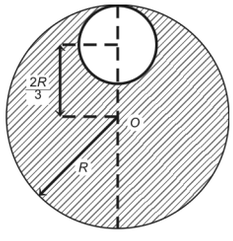
(a) $-\frac{5}{2}\cdot\frac{Gmm_0}{R}$ (b) $-\frac{Gmm_0}{2R}$
(c) $-\frac{3}{2}\cdot\frac{GMm_0}{R}$ (d) None of these

31. The force acting on a body moving along X-axis varies with the position of the particle as shown in the figure. The body is in stable equilibrium at



(a) $x = x_1$ (b) $x = x_2$
(c) Both x_1 and x_2 (d) Neither x_1 nor x_2

32. From a disc of radius R has mass $9m$, a hole of radius $\frac{R}{3}$ is removed from it as shown in the figure. What is the moment of inertia of the remaining part about an axis passing through centre O of the disc and perpendicular to the plane of the disc?

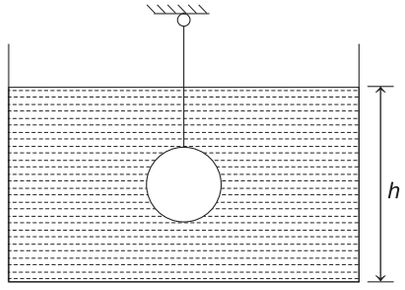


(a) $6mR^2$ (b) $4mR^2$
(c) $2mR^2$ (d) $3.5mR^2$

33. Velocity of a point on the equator of a rotating spherical planet is v. The angular velocity of the planet is such that the value of g at the equator is half of g at the pole. Determine the escape velocity for a polar particle on the planet as a function of v.

(a) $4v$ (b) $8\ v$
(c) $6\ v$ (d) $2\ v$

34. A metal sphere connected by a string is dipped in a liquid of density ρ as shown in figure. The pressure at the bottom of the vessel will be (p_0 = atmospheric pressure)



(a) $p = p_0 + \rho gh$ (b) $p > p_0 + \rho gh$
(c) $p < p_0 + \rho gh$ (d) p_0

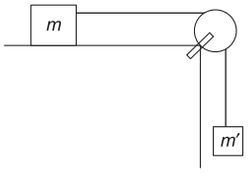
35. The distance covered by a particle in time t is given by $x = a + bt + ct^2 + dt^3$. The dimensions of a and d are

(a) [L] , [T^{-3}] (b) [L], [LT^{-3}]
(c) [L], [T^3] (d) None of these

36. A parachutist bails out and falls for 5 m when his parachute opens. The deceleration now produced is 1ms^{-2}. If he reaches at ground with zero velocity, at what height did the parachutist bails out?

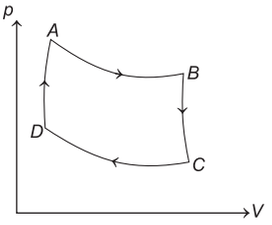
(a) 50 m (b) 45 m (c) 55 m (d) 100 m

37. In the figure given below, masses m and m' are tied with a thread passing over a pulley and m is on a frictionless horizontal surface. If acceleration due to gravity is g, the acceleration of m' in this arrangement will be



(a) g (b) $\frac{m'g}{(m+m')}$
(c) $\frac{mg}{m'}$ (d) $\frac{mg}{(m-m')}$

38. In the cyclic process $ABCDA$ shown in the figure, consider the following statements.



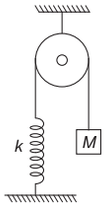
I. Area $ABCD$ = Work done on the gas
II. Area $ABCD$ = Net heat absorbed
III. Change in the internal energy in cycle = 0

Which of these are correct?

(a) Only I (b) Only II

(c) Both II and III (d) I, II and III

39. A mass $M = 5$ kg is attached to a spring as shown in the figure and held in position, so that the spring remains unstretched. The spring constant is $200\,\text{Nm}^{-1}$. The mass M is then released and begins to undergo small oscillations. The amplitude of oscillation is



(a) 0.5 m (b) 0.25 m

(c) 0.2 m (d) 0.1 m

40. A solid sphere, a hollow sphere and a disc, all having same mass and radius, are placed at the top of an incline and released. The friction coefficients between the objects and the incline are same and not sufficient to allow pure rolling. Least time will be taken in reaching the bottom by

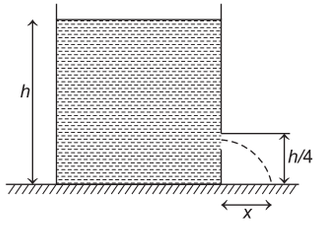
(a) the solid sphere (b) the hollow sphere

(c) the disc (d) All will take same time

Section B (2 Marks)

Directions Read the following case study and answer the questions 41 - 44 based on this case.

Water is filled to a height h in a fixed vertical cylinder placed on a horizontal surface. At time $t = 0$, a small hole is drilled at a height $\frac{h}{4}$ from the bottom of cylinder as shown in the figure. The cross-sectional area of hole is a and the cross-sectional area of cylinder is A and $A >> a$.



41. Let the value of horizontal distance of point where the water falls on horizontal surface from the bottom of cylinder be x as shown in the figure. Then, from time $t = 0$ till water comes out

(a) x decreases with time

(b) x increases with time

(c) x first increases and then decreases with time

(d) x first decreases and then increases with time

42. As long as water comes out of hole, the time taken by a water particle starting from the hole to reach the horizontal surface

(a) increases

(b) decreases

(c) remains constant

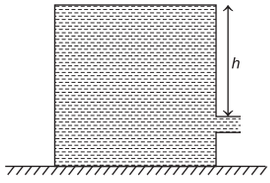
(d) increases and then decreases

43. The duration of time for which water flows out of hole is

(a) $\frac{A}{a}\sqrt{\frac{3h}{2g}}$ (b) $\frac{a}{A}\sqrt{\frac{3h}{2g}}$

(c) $\frac{A}{a}\sqrt{\frac{2h}{3g}}$ (d) $\frac{a}{A}\sqrt{\frac{h}{g}}$

44. In the figure shown, a light container is kept on a horizontal rough surface of coefficient of friction $\mu = \frac{Ah}{V}$. A very small hole of area A is made at a depth h. Water of volume V is filled in the container. The friction is not sufficient to keep the container at rest. The magnitude of acceleration of the container initially is



(a) $\frac{V}{Ah}g$ (b) g (c) $\frac{Ah}{V}g$ (d) zero

45. **Assertion (A)** Static friction acting on a body is always greater than the kinetic friction acting on this body.

Reason (R) Coefficient of static friction is more than the coefficient of kinetic friction.

In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

46. **Assertion (A)** A solid sphere cannot roll without slipping on smooth horizontal surface.

Reason (R) If the sphere is left free on smooth inclined surface, it cannot roll without slipping.

In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

47. **Statement I** Time period of a spring-block system is T. If length of spring is decreased, time period will decrease.
Statement II If length is decreased, then the block will have to travel less distance and it will take less time.
In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both Statement I and Statement II are incorrect.

(b) Statement I is correct and Statement II is incorrect.

(c) Statement I is incorrect and Statement II is correct.

(d) Both Statement I and Statement II are correct.

48. **Statement I** Escape velocity from surface of a planet is v. If a tunnel is made from the surface, then escape velocity from a point inside the tunnel must be greater than v.
Statement II Gravitational force is a conservative force.
In the light of the above statements, choose the most appropriate answer from the options given below.

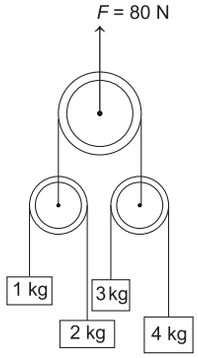
(a) Both Statement I and Statement II are incorrect

(b) Statement I is correct and Statement II is incorrect

(c) Statement I is incorrect and Statement II is correct

(d) Both Statement I and Statement II are correct

49. In the diagram shown in figure, all pulleys are smooth and massless and strings are light. Now, match the Column I with Column II and select the correct answer from the codes given below.



	Column I		Column II
A.	1 kg block	1.	will remain stationary
B.	2 kg block	2.	will move down
C.	3 kg block	3.	will move up
D.	4 kg block	4.	$5\ ms^{-2}$

Codes

A B C D	A B C D
(a) 1, 2, 3, 4	(b) 1, (2,3), 4 (1,3)
(c) 4, 3, 1, 2	(d) 3, 1, 2, (2,4)

50. Consider a planet of mass M and radius R. A satellite is launched from a height h ($<< R$) from its surface with a speed v. For different values of v,
Match the Column I with Column II and select the correct answer from the codes given below.

	Column I		Column II
A.	$v > \sqrt{\frac{2GM}{R}}$	1.	Ellipse
B.	$v = \sqrt{\frac{2GM}{R}}$	2.	Hyperbola
C.	$v < \sqrt{\frac{2GM}{R}}$	3.	Circle
D.	$v = \sqrt{\frac{GM}{R}}$	4.	Parabola

Codes

A B C D	A B C D
(a) 3, 4, 2, 1	(b) 2, 4, 1, 3
(c) 1, 3, 2, 4	(d) 4, 2, 1, 3

Tie-Breaking Section

Instructions

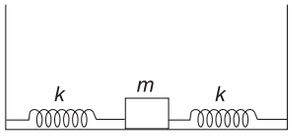
1. This section consists of 5 questions.
2. The score achieved in this section will not be included in the total marks.
3. If overall marks of two or more students are same, winner will be decided based on the score in this section.
4. Participation in this section is optional, and students may choose to attempt it or not.

1. Two particles, each of mass m are attached to a light rod of length d, one at its centre and the other at a free end. The rod is fixed at the other end and is rotated in a plane at an angular speed ω. Calculate the angular momentum of the particle at the end with respect to the particle at the centre.

(a) $\frac{1}{2}m\omega d^2$ (b) $\frac{1}{4}m\omega d^2$

(c) $\frac{1}{3}m\omega d^2$ (d) $\frac{2}{3}m\omega d^2$

2. A block of mass m is attached to two unstretched springs of spring constant k, each as shown in figure. The block is displaced towards right through a distance x and is released. The speed of the block as it passes through the mean position will be



(a) $x\sqrt{\frac{m}{2k}}$ (b) $x\sqrt{\frac{2k}{m}}$

(c) $x\sqrt{\frac{m}{k}}$ (d) $x\frac{2k}{m}$

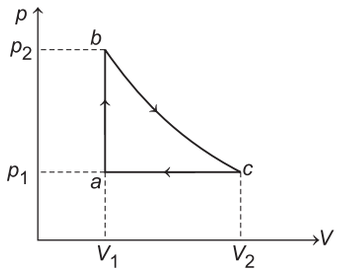
3. Balls A and B are released from rest from roof of a building at $t = 0$ and $t = 2$ s, respectively. The ball A strikes with ground and comes back with same speed. After sometime, both balls A and B meet with each other at a height of 55 m from the ground. If the height of building is $60n$ m, then the value of n is

(a) 5 (b) 6 (c) 3 (d) 9

4. The frequency of a sonometer wire is f. The frequency becomes $\frac{f}{2}$ when the mass producing the tension is completely immersed in water and on immersing the mass in a certain liquid, frequency becomes $\frac{f}{3}$. The relative density of the liquid is

(a) 1.32 (b) 1.03 (c) 1.41 (d) 1.18

5. Carbon monoxide is carried around a closed cycle $abca$ in which bc is an isothermal process as shown in the figure. The gas absorbs 7000 J of heat as its temperature increases from 300 K to 1000 K in going from a to b.



The quantity of heat rejected by the gas during the process ca is approximately

(a) 4200 J (b) 5000 J

(c) 9000 J (d) – 9800 J