SECTION-A

1. The distances traversed during equal interval of time, by a body falling freely from rest, stand to one another in the ratio : 1

(a) 1:2:3:4.....
(b) 1:3:5:7.....
(c) 2:4:6:8.....
(d) 1:5:9:13......

2. The position co-ordinates of a particle moving in a three-dimensional co-ordinate system given by : 1

x = a sin wt, y = a cos wt and z = a wt

The magnitude of velocity of the particle is :

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

3. In which of the following processes, heat is neither absorbed nor released by a system? 1

(a) Isothermal
(b) Adiabatic
(c) Isochoric
(d) Isobaric

4. The time period of a simple pendulum is 'a' second, when its length is increased to four-times, then its time-period becomes (in second) : 1

(a) a
(b) $\sqrt{2}$a
(c) 2a
(d) 4a

5. A wave on a string is described by the equation -

y(x, t) = 0.005 sin (6.28 x – 314t), where all quantities are in SI units. The speed of the wave propagation is : 1

(a) 50 m/s
(b) 0.02 m/s
(c) 200 m/s
(d) 3×10^8 m/s

10. Eight spherical rain drops of equal size are falling vertically through air with a terminal velocity of 0.20 m/s. What should be the velocity of these drops were to combine to form one large spherical drop? 1

(a) 0.40 m/s (b) 0.80 m/s

(c) 1.6 m/s (d) 2.4 m/s

11. Two liquids P and Q of equal amounts are heated on identical stoves in identical conditions for equal intervals of time. After heating, temperature of P is found to be less than that of Q. Choose the correct alternative : 1

(a) Latent heat of P is less than that of Q

(b) Latent heat of P is more than that of Q

(c) Specific heat capacity of P is less than that of Q

(d) Specific heat capacity of P is more than that of Q

12. At the highest point of a projectile thrown at angle θ with the ground, the angle between its velocity and acceleration is : 1

(a) 0° (b) 45°

(c) 90° (d) 180°

Question number 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given – One labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below :

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

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

(c) Assertion (A) is true and Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

6. Out of the following pairs, which one does not have identical dimensions? 1

(a) Impulse and momentum

(b) Work and torque

(c) Angular momentum and Planck's constant

(d) Moment of inertia and moment of force

7. A gun fires n bullets per second. If mass of each of the bullets fired by the gun is m and the speed of each bullet fired by the gun is v, the average force of the recoil is : 1

(a) $\frac{mv}{n}$ (b) $\frac{mn}{v}$

(c) mvn   (d) $\frac{nv}{m}$

8. When a body moves with constant speed in circular motion, then : 1

(a) no force acts on the body

(b) acceleration will be zero

(c) work done will be zero

(d) its velocity remains content

9. A particle of mass m is moving in a circle of radius r having angular momentum L, then the centripetal force will be : 1

(a) $\frac{L^2}{m^2r^2}$ (b) $\frac{L^2}{mr^2}$

(c) Lmr^2 (d) $\frac{L^2}{mr^3}$

13. Assertion (A): A stone is dropped from the window of a train running at a constant velocity of 72 km/h, the net force on the stone just after it is dropped to acts 1N vertically downwards.

Reason (R): The stone moves under gravity only just after it is dropped from the train. 1

14. Assertion (A): A projectile (cracker), following the usual parabolic trajectory, explodes into fragments midway in air. The common centre of mass of all the fragments continues along the same parabolic trajectory as it would have followed if there were no explosion. 1

Reason (R): The forces leading to the explosion are external forces.

15. Assertion (A): Modulus of rigidity is zero for a perfectly rigid body.

Reason (R): There is large change in the shape of a perfectly rigid body when any tangential force is applied. 1

16. Assertion (A) : Earth is continuously pulling moon towards its centre, but moon does hot fall to earth.

Reason (R) : Attraction of the sun on moon is greater them that of earth in moon. 1

SECTION-B

17. Find the dimensions of the quantity x from the expression :

$T = 2\pi\sqrt{\frac{m\ell^2}{5xY}}$, where T is time period of a bar of length ℓ, mass m and Y is young's modulus of the bar of the material. 2

18. The bob of a pendulum is released from a horizontal position. If the length of the pendulum is 1.6 m. What is the speed with which the bob arrives at the lowermost point, given that it dissipated 2% of its initial energy against air resistance? (Take $g = 10\ m/s^2$) 2

19. A body is dropped from rest from a height of 160 m and simultaneously, another body is dropped form rest from a point 120 m above the ground. What is the difference between heights after they have fallen for 5s? Consider that the body on reaching ground remains there. ($g = 10\ m/s^2$) 2

OR

A ball is dropped from the top of a tower of height h metres. If it takes T second to reach the grand. How much distance will it fall in T/4 seconds from start?

20. Derive an expression for the acceleration due to gravity of earth at a depth 'd' below the surface of the earth. 2

21. $\hat{i}$ and $\hat{j}$ are unit vectors along x and y-axis respectively. What is the magnitude and direction of the $(\hat{i}+\hat{j})$ and $(\sqrt{3}\,\hat{i}-\hat{j})$? 2

SECTION-C

22. The displacement x of a particle oscillating in simple harmonic motion from the origin varies with time as $x(t) = A\cos(wt + \phi)$, where A, w and ϕ are constants.

    (a) Find the expression for velocity and acceleration in the simple harmonic motion.

    (b) Write their phase differnce with the displacement.

23. (a) What is the analogue of mass in rotational motion? Define it. 3

    (b) Derive the expression for kinetic energy of a body rotating about a fixed axis.

24. A ball is dropped from the roof of a tower of height h. The distance covered by it in first three seconds is equal to the distance travelled by it in the last second of the journey. Find the height 'h' of the tower. ($g = 10\ m/s^2$) 3

25. A projectile is thrown with initial velocity of $(\hat{i}+3\hat{j})$ m/s, where $\hat{i}$ is a unit vector along positive x-axis (horizontal) and $\hat{j}$ is unit vector along positive y-axis (vertical). Show that equation of its path is $y = 3x - 5x^2$ (take $g = 10\ m/s^2$). 3

OR

A projectile is thrown from a height h above the ground with velocity u parallel to the ground. Find the expression for :

(a) equation of path of the projectile

(b) time of flight of the projectile

26. (a) State Stefan's law.

(b) If the temperature of a black body is increased then, to which side shorter / longer wavelength, corresponding to which energy emitted is maximum, will shift?

(c) Light from the moon is found to have a maximum intensity near the wavelength 14.5 μm, find the estimated temperature of the moon. (Wein's constant $= 2.9 \times 10^{-3}$ mK). 3

27. (a) A block is attached to a spring (treated as light and massless) and resting on smooth horizontal surface. The other end of the spring is attached to a rigid wall. A graph is plotted between the force (Fs, on y-axis) and the displacement to the block (x, on x-axis) from the equilibrium position. Which quantity is determined by the slope of this graph? Write its SI units.

(b) A spring is cut into two unequal parts. Will the spring constant of each part increase/decrease/remain same? Justify your answer.

(c) The potential energy of a spring, when stretched through a distance x is U. What would be the work done in stretching it further through the same distance? 3

28. (a) Define gravitational potential. Write its SI unit.

(b) Three point masses each of mass 'm' are placed on vertices of an equilateral triangle of side 'ℓ'. Find the gravitational potential at the centroid of the triangle. 3

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SECTION-D

Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

29. During the summer months, the heat from the sun can increase the temperature of objects on the surface of the earth. When you touch a metal surface lift outside under the sun, it feels much hotter than a plastic surface, even if both were exposed to the same amount of sunlight. This difference in temperature is due to the different thermal conductivities of the materials. There are three modes of heat transfer-conduction, convection and radiation. In a room warm air tends to rise due to convection, and this process creates a circulation of air. The heat from a hot cup of coffee escapes into the surroundings air via radiation. The heat current flowing through a bar of length L, area of cross-section A and temperature difference between the two ends ΔT is :

$H = KA\frac{\Delta T}{L}$, where K is thermal conductivity of the materiel. 4

(i) Which one of the following materials is a good conductor of heat?

(a) copper (b) body fat

(c) water (d) air

(ii) The method of heat transfer from the sun to the earth is :

(a) conduction (b) convection

(c) radiation (d) conduction & radiation

(iii) The process by which heat energy is transferred through vacuum is called :

(a) conduction (b) convection

(c) radiation (d) heat is not transferred through vacuum

(iv) In steady state :

(a) no heat flows through any cross section of the rod

(b) heat flowing into the element is more than the heat flowing out of it

(c) heat flowing into the element is less than the heat flowing out of it

(d) heat flowing into the element is equal the heat flowing out of it

OR

SI unit of thermal conductivity is :

(a) $J\,m^{-1}K^{-1}$ (b) $W\,m^{-1}K^{-1}$

(c) $J\,m\,K^{-1}$ (d) $W\,m\,K^{-1}$

30. Properties of gases are easier to understand than of solids and liquids. This is mainly because in a gas, molecules are far from each other and their mutual interactions are negligible except when two molecules are collide.

Gas molecules enclosed within a container are in a state of continuous random motion colliding against each other and with the walls of a container. In an ideal gas each molecule of a gas behave as an independent particle and momentum as well as kinetic energy.

Although moleculor speeds in a gas may have all possible values ranging from a small to a very high value for purpose of finding the pressure exerted by a gas or average energy of a gas molecule we may presume that all molecules are moving with a constant rms speed V. The rms speed of the molecules of a gas is defined as the square root of the mean of the squares of the speeds of all the molecules in a gas, and written as.

$$V_{rms} = \left[\frac{V_1^2 + V_2^2 + V_3^2 + \ldots.. + V_n^2}{n}\right]^{\frac{1}{2}}$$

On the basis of kinetic theory of a gas it is found that

$$V_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M_o}} = \sqrt{\frac{3K_BT}{M}}$$

where symbols have their usual meanings.

(i) A real gas may be behave as ideal gas :

(a) at low pressure and low temperature

(b) at high pressure and low temperature

(c) at low pressure and high temperature

(d) at low pressure and high temperature

(ii) The ratio of rms speeds of helium and nitrogen gas molecules is :

(a) $\sqrt{7}:1$

(b) 1:2

(c) $1:\sqrt{7}$

(d) $\sqrt{7}:2$

(iii) The pressure exerted by gas molecules is due to :

(a) in elastic collisions between molecules only

(b) elastic collisions between molecules only

(c) elastic collisions between molecules and walls of the container

(d) in elastic collisions between molecules and walls of the container

(iv) The translational kinetic energy of a gas molecules for 1 mol of gas is equal to :

(a) $\frac{3}{2}RT$

(b) $\frac{RT}{2}$

(c) $\frac{3K_BT}{2}$

(d) $\frac{2}{3}K_BT$

OR

(iv) A sample of gas at 0°C. To what temperature it must be raised in order to double the rms speed of the molecule.

(a) 270°C

(b) 719°C

(c) 1090°C

(d) 100°C

SECTION-E

1. (a) What do you mean by terminal velocity? Derive expression for it for spherical body is falling in a viscous medium.

(b) A rain drop is falling with terminal velocity v in a viscous medium. If the radius of the drop is doubled and the coefficient of viscosity is halved then what will be its terminal velocity? 5

OR

(a) Derive the expression for excess of pressure inside a liquid drop.

(b) Water flows through a horizontal pipe of radius 1 cm at a speed of 2 m/s. What should be the diameter of its nozzle of the water is to come out at a speed of 32 m/s?

2. (a) Discuss briefly the normal modes of vibration in a closed organ pipe.

(b) A pipe 30.0 cm long is open at both ends. Which harmonic mode of the pipe resonates with a 3.3 kHz source? Will the resonance with the same source be observed if one end of the pipe is closed? Speed of sound in air is 330 m/s. 5

OR

(a) What is meant by beats? Explain mathematical method of formation of beats and show that the beat frequency is equal to the difference in frequencies of sound waves.

(b) Write two applications of beats.

(i) A circular track of radius r is banked at an angle of θ. If the coefficient of friction between the wheels of a car and the road is μ, find :

(a) maximum permissible speed to avoid slipping

(b) optimum speed of the car to avoid wear and tear on its tyres.

(ii) Static friction is a self adjusting force. Explain. 5

OR

(a) State impulse-momentum theorem.

(b) A batsman hits back a ball straight in the direction of the bowler without changing its initial speed of 20 m/s. If the mass of the ball and bat are 150 g and 3 kg respectively. Find the magnitude of the impulse imparted to the ball.

(c) If the speed of a car is doubled, how much distance will it cover before stopping under the same retarding force if it has covered earlier a distance 'S'?