Delhi Public School, Howrah

FINAL EXAMINATION (2024-2025)

Class-XI

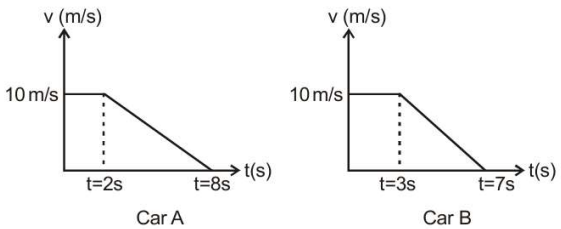
Care must be taken not to write anything on the question paper. All the questions must be attempted in the correct sequence.

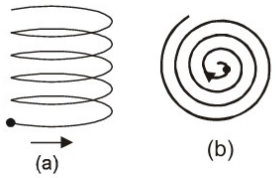
SUBJECT: PHYSICS (CODE- 042)

Time:-3 Hours **F.M.-70**

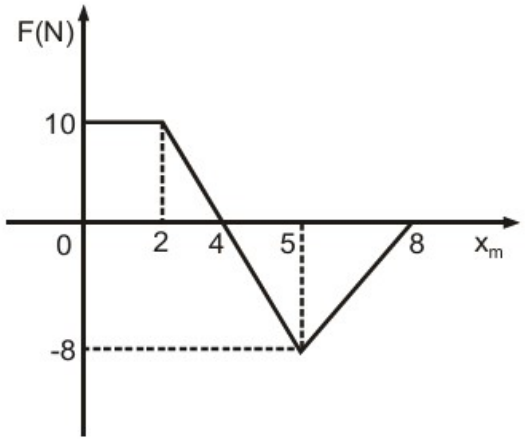
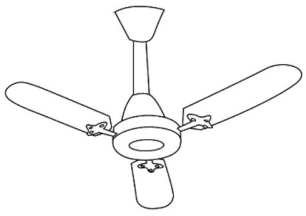
General Instructions:

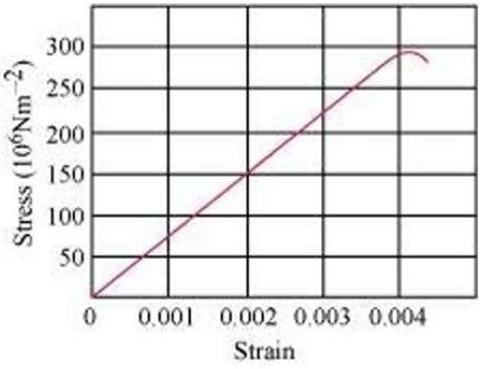
(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study based questions of four marks each and Section E contains three long answer questions of five marks each.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary.
i. $c = 3 \times 10^8$ m/s
ii. m_e = 9.1 x10-31 kg
iii. $e = 1.6 \times 10^{-19}$ C
iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
v. h = 6.63 x10^{-34} Js
vi. ε_0 = 8.854 x10^{-12} $C^2N^{-1}m^{-2}$
vii. Avogadro's number = 6.023 X 10^{23} per gram mole

	SECTION - A	
1.	A gas bubble from an explosion under water oscillates with a time period T proportional to $P^a d^b E^c$, where P is the pressure, d is the density and E is the total energy of the explosion. The values of a, b and c are: (a) a = 0, b = 1, c = 2 (b) a = 1, b = 2, c = 3 (c) a = 5/6, b = - 1/2, c = 1/3 (d) a = - 5/6, b = 1/2, c = 1/3	**1**
2.	Car A and car B move on a straight road and their velocity versus time graphs are as shown in figure. Comparing the motion of car A in between t = 0 to t = 8 sec and motion of car B in between t = 0 to t = 7 sec, choose the correct statement from the options that follows.  	**1**

	(a) Distance travelled by car A is less than distance travelled by car B. (b) Distance travelled by car A is greater than distance travelled by car B. (c) Average speed of both cars is equal. (d) Average speed of car A is less than average speed of car B.	
3.	A block is moving down a smooth inclined plane starting from rest at time t = 0. Let S_n be the distance travelled by the block in the interval t = n – 1 to t = n. The ratio $\frac{S_n}{S_{n+1}}$ is (a) $\frac{2n-1}{2n}$ (b) $\frac{2n-1}{2n+1}$ (c) $\frac{2n+1}{2n-1}$ (d) $\frac{2n}{2n-1}$	**1**
4.	A particle is going in a uniform helical and spiral path separately as shown in figure with constant speed. Choose the correct statement from the options given below.  (a) The velocity of the particle is constant in both cases. (b) The acceleration of the particle is constant in both cases. (c) The magnitude of acceleration is constant in (a) and decreasing in (b). (d) The magnitude of acceleration is decreasing continuously in both the cases.	**1**
5.	Water in a bucket is whirled in a vertical circle with a string attached to it. The water does not fall down even when the bucket is inverted at the top of its path. Hence, we conclude that in this position (a) $mg = mv^2/r$ (b) mg is greater than mv^2/r (c) mg is not greater than mv^2/r (d) Both (a) and (c)	**1**
6.	The displacement of a body in motion is given by x = a sin (ωt + θ). The time at which the displacement is maximum is (ω & θ are constants) (a) $\frac{\theta}{\omega}$ (b) $(\frac{\pi}{2\omega} - \frac{\theta}{\omega})$ (c) $\frac{\pi}{2\omega}$ (d) $(\frac{2\pi}{\omega} - \frac{\theta}{\omega})$	**1**
7.	A solid cylinder and a hollow cylinder, both of the same mass and same external diameter are released from the same height at the same time on an inclined plane. Both the cylinders roll down without slipping. Which one will reach the bottom first? (a) Both together (b) Hollow cylinder (c) Solid cylinder (d) Both together only when angle of inclination of plane is 45°	**1**
8.	Find the linear velocity, if $\vec{\omega} = 2\hat{k}$ and $\vec{r} = 2\hat{\imath} + 2\hat{\jmath}$. (a) $4\hat{\imath} + 4\hat{\jmath}$ (b) $4\hat{k} + 4\hat{\imath}$ (c) $4\hat{\jmath} - 4\hat{\imath}$ (d) $-4\hat{\imath} - 4\hat{\jmath}$	**1**
9.	Consider the earth to be a homogeneous sphere. Scientist A goes deep down in a mine while scientist B goes high up in a balloon. The gravitational field measured by: (a) A goes on decreasing and that by B goes on increasing (b) B goes on decreasing and that by A goes on increasing (c) Each remains unchanged (d) Each goes on decreasing	**1**

10.	When temperature of a gas is 20°C and pressure is changed from $p_1 = 1.01 \times 10^5$ Pa to $p_2 = 1.165 \times 10^5$ Pa then the volume changed by 10%. The bulk modulus in this case is: (a) 1.55×10^5 Pa (b) 0.115×10^5 Pa (c) 1.4×10^5 Pa (d) 1.01×10^5 Pa	**1**
11.	Two capillary tubes of radii r_1 and r_2 are dipped in water. If the corresponding rise of water are h_1 and h_2, the ratio of h_1/h_2 is: (a) r_1/r_2 (b) $r_1 - r_2$ (c) r_2/r_1 (d) $r_2 - r_1$	**1**
12.	Heat is flowing through two cylindrical rods of the same material. The diameters of the rods are in the ratio 1:2 and their lengths are in the ratio 2:1. If the temperature difference between their ends is the same, then the ratio of the amount of heat conducted through them per unit time will be: (a) 1:1 (b) 2:1 (c) 1:4 (d) 1:8	**1**
	For question numbers 13 to 16, two statements are given- one labeled as Assertion (A) and the other labeled as Reason (R). Select the correct answer to these questions from the codes (a), (b), (c), (d) and (e) as given below. **(a) Both A and R are true and R is the correct explanation of the 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 and R is true.** **(e) Both A and R are false.**	
13.	**Assertion (A)**: When a bottle of cold carbonated drink is opened, a slight fog forms around the opening. **Reason (R)**: Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapor.	**1**
14.	**Assertion (A):** When the range of a projectile is maximum, the time of flight is the largest. **Reason (R)**: Horizontal range is maximum when the angle of projection is 90°.	**1**
15.	**Assertion(A):** Dimension of energy density and pressure are same. **Reason(R):** Pressure and energy density have same units in SI system.	**1**
16.	**Assertion(A):** An air tight cage in which a bird is sitting is suspended from a spring balance. If the bird starts flying upwards with some acceleration, then the reading of the balance will increase. **Reason(R):** The spring balance measures the mass of a body.	**1**
	SECTION - B	
17.	(a) A particle moves a distance x in time t according to the equation $x = (t + 5)^{-1}$. Find the relation between the acceleration and velocity of the particle. (b) From the top of a tower, a stone is thrown up. It reaches the ground in t_1 second. A second stone thrown down with the same speed reaches the ground in t_2 second. A third stone released from rest reaches the ground in t_3 second. Find the relation between t_1, t_2 and t_3. **OR** Derive the following equation using velocity-time graph. $v^2 = u^2 - 2as$	**1+1** **2**
18.	(a) A particle is thrown with initial speed u at an angle θ with respect to the horizontal. Find the time after which velocity of the projectile becomes perpendicular to the initial velocity. (b) A large number of bullets are fired in all directions with the same speed v. What is the maximum area on the ground on which these bullets will spread?	**1+1**
19.	A man is sitting on the shore of a river. He is in the line of a 1.0 m long boat and is 5.5 m away from the center of the boat. He wishes to throw an apple into the boat. If he throws the apple with a speed of 10 m/s, find the minimum and maximum angles of projection for successful shot. Assume that the point of projection and the edge of the boat are in the same horizontal level.	**2**

20.	(a) A 5.0 kg block moves in a straight line on a horizontal frictionless surface under the influence of a force that varies with position as shown in figure.  How much work is done by the force as the block moves from the origin to x=8 m? (b) A particle of mass m moves on a straight line with its velocity varying with the distance travelled according to the equation v = a$\sqrt{x}$, where a is a constant. Find the total work done by all the forces during a displacement from x = 0 to x = d.	**1+1**
21.	(a) Escape velocity of a body from earth is about 11km/sec. Assuming the mass and radius of the earth to be about 81 and 4 times the mass and radius of the moon, calculate the escape velocity from the surface of the moon in km/sec. (b) A communication earth satellite which takes 24 hours to complete one circular orbit eventually has to be replaced by another satellite which has twice the mass of the first. If the new satellite is supposed to have an orbital period of 24 hours, what is the ratio of radius of the new orbit to the radius of the original orbit?	**1+1**
	SECTION - C	
22.	The knowledge of Reynold's number(R) tells, whether the flow of a liquid through a pipe will be streamlined or not. **By the method of dimensions**, find the expression for Reynold number(R), if it depends upon the velocity(v) of flow of the liquid, density(ρ) of the liquid, coefficient of viscosity of the liquid and diameter of the pipe(D). Given that Reynold number(R) varies directly as the diameter of the pipe(D).	**3**
23.	(a) Explain the following statements: i. It is easier to open or close a door when force is applied at maximum distance from the hinge and normal to the plane of the door. ii. Spin angular velocity of a star is greatly enhanced when it collapses under gravitational pull and becomes a neutron star. (b) A ceiling fan has a diameter (of the circle through the outer edges of the three blades) of 120 cm and rpm 1500 at full speed. Consider a particle of mass 1 g sticking at the outer end of a blade. How much force does it experience when the fan runs at full speed? 	**1+1+1**

24.	(a) Derive the expression for gravitational potential energy of a particle at a point due to the gravitational forces of the earth. (b) Find the gravitational potential energy of a system of four particles of identical mass 'm' placed at the vertices of a square of side L.	**2+1**
25.	(a) An elastic wire is cut to half its original length. How would it affect the maximum load that the wire can support? (b) The figure below shows the stress-strain curve for a given material. What are i. Young's modulus and ii. approximate yield strength for this material?  	**1+2**
26.	(a) On 18 June 2023, ***Titan***, a submersible operated by the American tourism and expeditions company **Ocean Gate**, imploded during an expedition to view the wreck of the *Titanic* in the North Atlantic Ocean off the coast of Newfoundland, Canada. Investigation suggested that the hull had been imploded to a depth rating of 3,000 m after demonstrating signs of cyclic fatigue. Find the pressure on the submersible due to which it imploded under the ocean. [g = 9.8 m/sec^2] (b) Derive Bernoulli's equation with proper explanation and diagram.	**1+2**
27.	(a) Find the temperature at which Kelvin and Fahrenheit scale coincide. (b) Global warming is an issue that threatens the very foundation of our existence. Rising temperatures are melting the polar ice caps. Earth receives 1400 W/m^2 solar power. If all the solar energy is falling on a block of ice of mass 280 gm and area 0.2 m^2 then calculate the time in which the whole ice will melt. Given that latent heat of fusion of ice = 3.3 x 10^5 J/kg.	**1+2**
28.	Suppose an ideal gas goes isothermally (at temperature T) from its initial state (P_1, V_1) to the final state (P_2, V_2). Derive the expression for the work done in the process.	**3**
	SECTION – D	
29.	**Read the following passage and answer the questions based on that.** Kinetic energy depends upon the frame of reference and is always positive. A bullet fired from a gun has very high kinetic energy and so, it can easily penetrate any object. This is because of the large amount of velocity possessed by the bullet. Although the mass of the bullet is less, its high-speed renders the high amount of kinetic energy.  	
i.	A bullet of mass 50 g is moving with a velocity of 500 ms^{-1}. It penetrates 10 cm into a still target and comes to rest. The initial kinetic energy possessed by the bullet is: (a) 6250 joule (b) 7000 joule (c) 6500 joule (d) 7250 joule	**1**

ii.	Based on the values in the above question, the average retarding force offered by the target will be: (a) 60250 N (b) 62500 N (c) 60000 N (d) 70000 N	**1**
iii.	A bullet of mass 10 g moving with a velocity of 100 m/s hits a wooden log and penetrates it up to a thickness of 5 cm. The resistive force of the log is: (a) 200 N (b) 500 N (c) 1000 N (d) 600 N	**1**
iv.	A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest, assuming that it faces constant resistance to motion? (a) 0.5 cm (b) 10 cm (c) 5 cm (d) 1 cm **OR** A bullet of mass 10 g is fired horizontally with a velocity 1000 ms^{-1} from a rifle situated at a height 50 m above the ground. If the bullet reaches the ground with a velocity 500 m/s, the work done against air resistance (magnitude) in the trajectory of the bullet in Joule (g = 10 m/s^2) is: (a) 5005 J (b) 3755 J (c) 3750 J (d) 17.5 J	**1** **1**
30.	**Read the following passage and answer the questions based on that.** According to this law, for any system in thermal equilibrium, the total energy is equally distributed among its various degree of freedom. And each degree of freedom is associated with energy 1/2 K_BT. (where K_B = 1.3 x 10^{-23} J/K, T= absolute temperature of the system). At a given temperature T; all ideal gas molecules no matter what their mass has the same average translational kinetic energy; namely, 3/2 K_BT. While measuring the temperature of a gas, we are also measuring the average translational kinetic energy of its molecules. At the same temperature, gases with different degrees of freedom (e.g. He and H_2) will have different average energy or internal energy namely f/2 K_BT (f is different for different gases).	
i.	Relation between pressure P and average kinetic energy E per unit volume of a gas is: (a) P = 2E/3 (b) P = E/3 (c) P = 3E/2 (d) P = 3E	**1**
ii.	At a temperature of 0 Kelvin, which of the following will be zero for a gas? (a) Kinetic energy (b) Potential energy (c) Vibrational energy (d) Density	**1**
iii.	The root mean square velocity of a gas molecule of mass m at a given temperature is proportional to: (a) m (b) m_0 (c) $\sqrt{m}$ (d) $m^{-1/2}$	**1**
iv.	An ant is walking on a horizontal surface. The number of degrees of freedom of the ant will be: (a) 1 (b) 2 (c) 3 (d) 6 **OR** The number of degrees of freedom for a diatomic gas molecule is: (assume that the inter-atomic distance is fixed) (a) 2 (b) 3 (c) 5 (d) 6	**1** **1**
	SECTION - E	
31.	The **Double Asteroid Redirection Test (DART)** was a NASA space mission aimed at testing a method of planetary defence against near-Earth objects (NEOs). Launched on 24 November 2021, the DART spacecraft successfully collided with the target asteroid Dimorphos diverting its trajectory. 	**1+2+2**

	(a) Explain how DART was able to divert Dimorphos. (b) If the mass of the DART spacecraft is 500 kg and it was moving at a speed of 6.6 km/sec then find the energy imparted by the spacecraft to the asteroid. (c) If after the collision the speed of Dimorphos reduces from 2.54 cm/s to 1.75 cm/s then find the mass of the asteroid. (Consider the mass of the spacecraft to be negligible) **OR** (a) Derive the expression for maximum velocity with which a car moving on a banked road can take the turn safely with proper diagram. (b) Establish with proper calculation the fact that the first and third laws of Newton are inbuilt in the second law.	**3+2**
32.	(a) Derive the equation of the kinetic and potential energy of a particle in Simple harmonic motion. (b) Show graphically the variation of kinetic, potential and total energy of the particle executing simple harmonic motion with respect to time over a period of time T choosing a suitable scaling. **OR** (a) Derive the expression for the time period of a simple pendulum using the concept of torque and angular acceleration. (b) Find the effective length of a second's pendulum. (c) The displacement of a particle in motion is represented by $y = \sin^3\omega t$. Verify with proper calculation if the particle is executing a simple harmonic motion or not.	**3+2** **2+1+2**
33.	(a) In the late 17th century, Sir Isaac Newton was working on his groundbreaking book, **"Principia Mathematica."** While studying the behavior of fluids, he began to think about the speed of sound. Newton derived an equation for the speed of sound. Derive the equation given by Newton to measure the speed of sound in air. (b) Experiments conducted by other scientists showed that the actual speed of sound in air was differing from the value deducted from Newton's equation by a long margin. In the late 18th century, Laplace re-examined Newton's work and realized that he had made an assumption that wasn't entirely accurate. Mention Laplace's correction and derive the correct equation to find the speed of sound in air. **OR** A transverse harmonic wave on a string is described by $$y(x,t) = 3.0\sin(36t + 0.018x + \frac{\pi}{4})$$ where x and y are in cm and t in s. The positive direction of x is from left to right. (a) Is this a travelling wave or a stationary wave? Justify your answer with proper reason. (b) What are the speed and direction of its propagation? (c) What are its amplitude and frequency? (d) What is the initial phase at the origin? (e) What is the least distance between two successive crests in the wave?	**2+3** **1+1+1+1+1**