INDIAN SCHOOL SOHAR
TERM II EXAMINATION (2022-23)
SUBJECT: PHYSICS (042)

Class: XI **Time: 3 hours**
Date: 26/02/2023 **Maximum Marks: 70**

General Instructions:

1. There are 35 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. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.
6. You may use the following values of physical constants wherever necessary

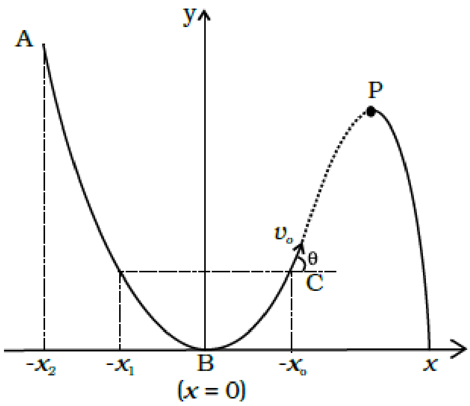
Avogadro's number = 6.02×10^{23} per gram mole
Boltzmann constant = 1.38×10^{-23} JK^{-1}
molar gas constant $R = 8.31\, JK^{-1}mol^{-1}$
Gravitational Constant $G = 6.67\times 10^{-11}\, Nm^2kg^{-2}$

Section A

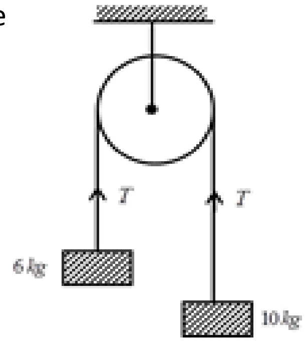
1. Planck's constant has the same SI units as that of angular momentum. The dimensions of Planck's constant is
   (a) ML^2T^{-1} (b) ML^2T^{-2}
   (c) ML^1T^{-1} (d) ML^2T^1
2. The displacement of a particle is given by $x = t^2 - 4$ where x is in metres and t in seconds. The velocity of the particle at 4 seconds is
   (a) $4\, ms^{-1}$ (b) $8\, ms^{-1}$
   (c) $12\, ms^{-1}$ (d) $0\, ms^{-1}$

3. A particle slides down a frictionless parabolic ($y = x^2$) track (A – B – C) starting from rest at point A. Point B is at the vertex of parabola and point C is at a height less than that of point A. After C, the particle moves freely in air as a projectile. If the particle reaches highest point at P, then

   (a) KE at P = KE at B
   (b) height at P = height at A
   (c) total energy at P = total energy at A
   (d) time of travel from A to B = time of travel from B to P.



4. A light string passes over a frictionless pulley. To one of its ends a mass of 6 kg is attached. To its other end a mass of 10 kg is attached. The tension in the thread will be



(a) 24.5 N (b) 73.5 N
(c) 2.4 N (d) 7.4 N

5. The work done by the force $\vec{F} = 2\hat{\imath} - 3\hat{\jmath} + 2\hat{k}$ in moving a particle from (3,4,5) to (1,2,3) is

(a) 0 (b) 3
(c) -4 (d) -2

6. A Merry-go-round, made of a ring-like platform of radius R and mass M, is revolving with angular speed ω. A person of mass M is standing on it. At one instant, the person jumps off the round, radially away from the centre of the round (as seen from the round). The speed of the round afterwards is

(a) 2ω (b) ω
(c) $\omega/2$ (d) 0

7. In our solar system, the inter-planetary region has chunks of matter (much smaller in size compared to planets) called asteroids. They

(a) will not move around the sun since they have very small masses compared to the sun.
(b) will move in an irregular way because of their small masses and will drift away into outer space.
(c) will move around the sun in closed orbits but not obey Kepler's laws.
(d) will move in orbits like planets and obey Kepler's laws.

8. According to Hooke's law of elasticity, if stress is increased, the ratio of stress to strain

(a) increase (b) decreases
(c) becomes zero (d) remains constant

9. An ideal fluid flows through a pipe of circular cross-section made of two sections with diameters 2.5 cm and 3.75 cm. The ratio of the velocities in the two pipes is

(a) 9:4 (b) 3: 2
(c) $\sqrt{3} : \sqrt{2}$ (d) $\sqrt{2} : \sqrt{3}$

10. A body radiates 5 W at a temperature of 400 K. If the temperature is increased to 1200 K, then it radiates energy at the rate of

(a) 200 W (b) 81 W
(c) 405 W (d) 310 W

11. Internal energy of a gas during isothermal expansion

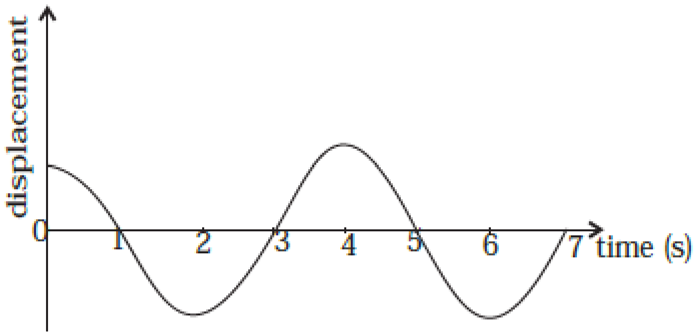
(a) increase (b) decreases
(c) becomes zero (d) remains constant

12. If the surface tension of water is 0.06 Nm^{-1}, then the capillary rise in a tube of diameter 1 mm is ($\theta = 0^0$)

(a)	1.22 cm	(b)	2.44 cm
(c)	3.12 cm	(d)	6.24 cm

13. Average kinetic energy of molecules is
    (a) directly proportional to the square root of temperature.
    (b) directly proportional to absolute temperature.
    (c) independent of absolute temperature.
    (d) inversely proportional to absolute temperature

14. Displacement vs. time curve for a particle executing S.H.M. is shown in Fig. Choose the correct statement.



(a) Phase of the oscillator is the same at t = 0 s and t = 2 s.
(b) Phase of the oscillator is the same at t = 2 s and t = 6 s.
(c) Phase of the oscillator is the same at t = 1 s and t = 7 s.
(d) Phase of the oscillator is the same at t = 3 s and t = 5 s.

15. A string of 7m length has a mass of 0.035 kg. If the tension in the string is 60.5 N, then the speed of the wave is

(a)	77 m/s	(b)	102 m/s
(c)	110 m/s	(d)	165 m/s

16. **Assertion**: A body can have acceleration even if its velocity is zero at a given instant of time.
Reason: A body is momentarily at rest when it reverses its direction of motion.
(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) The Assertion is correct but Reason is incorrect.
(d) Both the Assertion and Reason are incorrect.

17. **Assertion**: A body becomes massless at the centre of earth.
Reason: This follows from $g_d = g(1 + \frac{d}{R})$ where d is the depth.
(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) The Assertion is correct but Reason is incorrect.
(d) Both the Assertion and Reason are incorrect.

18. **Assertion**: in a stationary wave the amplitude is different for different particles.
Reason: In a stationary wave, no transfer of energy takes place.
(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

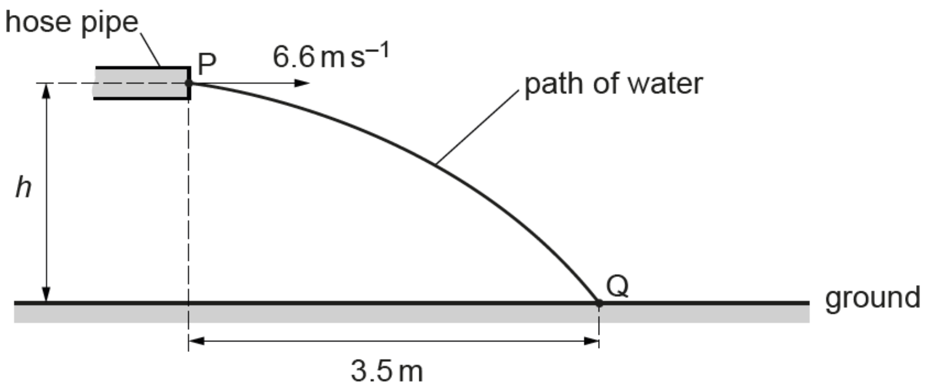
(c) The Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

Section B

19. The displacement of a progressive wave is represented by $y = Asin(\omega t - kx)$, where x is distance and t is time. Name the quantities ω *and* k and write the dimensional formula for them.

20. Water leaves the end of a hose pipe at point P with a horizontal velocity of 6.6 m s^{-1}, as shown in figure.



Point P is at height h above the ground. The water hits the ground at point Q. The horizontal distance from P to Q is 3.5 m. Air resistance is negligible. Assume that the water between P and Q consists of non-interacting droplets of water and that the only force acting on each droplet is its weight.

(a) Explain, briefly, why the horizontal component of the velocity of a droplet of water remains constant as it moves from P to Q.

(b) Show that the time taken for a droplet of water to move from P to Q is 0.53 s.

21. Define the term torque or moment of force. Give its unit. When will the torque be maximum?

22. 'The body weighs more at the poles than at the equator'. Justify with proper equations.

23. A rigid bar of mass 15 kg is supported symmetrically by three wires each 2.0 m long. Those at each end are of copper and the middle one is of iron. Determine the ratios of their diameters if each is to have the same tension. ($Y_{Iron} = 2 \times 10^{11} Nm^{-2}$ and $Y_{Copper} = 1 \times 10^{11} Nm^{-2}$)

24. State first law of thermodynamics. How does the internal energy of an ideal gas differ from that of a real gas?

OR

Gases have two specific heat capacities, but the solids and liquids have only one. Why?

25. Derive expressions for the kinetic and potential energies of a simple harmonic oscillator. Hence show that the total energy is conserved.

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 centimetres and t is in seconds. The positive direction of x is from left to right.

i. Is this a travelling wave or stationary wave.

ii. What is its frequency?

iii. What is the initial phase at the origin?

iv. What is the least distance between two successive crests?

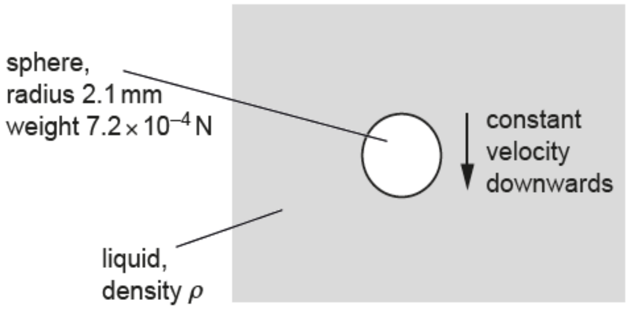
Section C

26. (a) Describe the conditions required for two waves to be able to form a stationary wave.

(b) A stationary wave on a string has nodes and antinodes. The distance between a node and an adjacent antinode is 6.0 cm.

i. State what is meant by a node.
ii. Calculate the wavelength of the two waves forming the stationary wave.
iii. State the phase difference between the particles at two adjacent antinodes of the stationary wave.

27. A sphere of radius 2.1 mm falls with terminal (constant) velocity through a liquid, as shown in Fig.



Three forces act on the moving sphere. The weight of the sphere is $W = 7.2 \times 10^{-4} N$ and the upthrust acting on it is $U = 4.8 \times 10^{-4} N$. The viscous force $\boldsymbol{F_V}$ acting on the sphere is given by $\boldsymbol{F_V} = \boldsymbol{krv}$ where r is the radius of the sphere, v is its velocity and k is a constant. The value of k in SI units is 17.

(a) Determine the *SI* base units of k.
(b) Use the value of the upthrust acting on the sphere to calculate the density ρ of the liquid.
(c) (i) On the sphere in figure., draw three arrows to show the directions of the weight **W**, the upthrust **U** and the viscous force $\boldsymbol{F_V}$. Label these arrows **W**, **U** and $\boldsymbol{F_V}$ respectively.
(ii) Determine the magnitude of the terminal (constant) velocity of the sphere.

28. (a) State what is meant by the latent heat of fusion (melting) of a substance.

(b) Ice cubes of total mass 70 g, and at 0 °C, are put into a drink of lemonade of mass 300 g. All the ice melts as 23 500 J of thermal energy transfers from the lemonade to the ice. The final temperature of the drink is 0 °C.

(i) Calculate the specific latent heat of fusion for ice.
(ii) The melting ice floats on top of the lemonade. Explain the process by which the lemonade at the bottom of the drink becomes cold.

29. The position of a particle is given by $\vec{r} = 3t\,\hat{\imath} + 2t^2\,\hat{\jmath} + 5\,\hat{k}$ where t is in seconds and the coefficients have the proper units for **r** to be in metres.

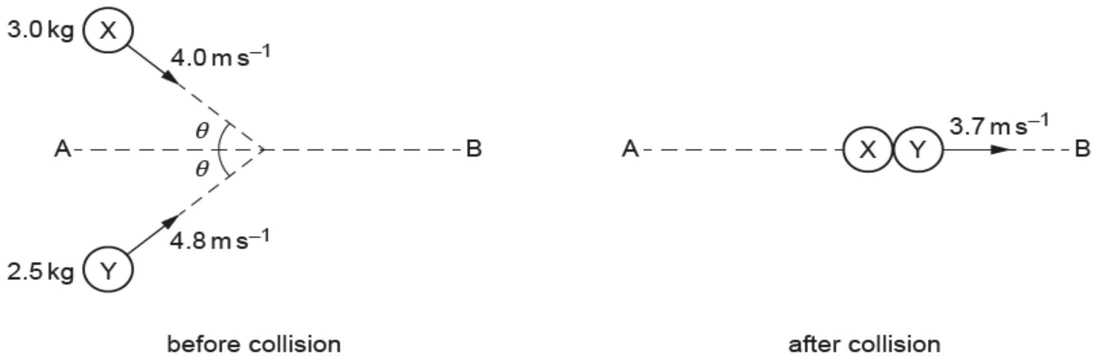
(i) Find v(t) and a(t) of the particle.
(ii) Find the magnitude and direction of v(t) at t = 1.0 s.

OR

Discuss the projectile motion and derive an expression for its trajectory to prove that it is parabolic.

30. (a) State the principle of conservation of momentum.

(b) Two balls, X and Y, move along a horizontal frictionless surface, as shown from above in figure.



Ball X has a mass of 3.0 kg and a velocity of 4.0 m s^{-1} in a direction at angle θ to a line AB.
Ball Y has a mass of 2.5 kg and a velocity of 4.8 m s^{-1} in a direction at angle θ to the line AB.
The balls collide and stick together. After colliding, the balls have a velocity of 3.7 m s^{-1} along the line AB on the horizontal surface, as shown in figure.

(i) By considering the components of the momenta along the line AB, calculate θ. (Given $cos^{-1}(0.8479) = 32^0$)

(ii) By calculation of kinetic energies, state and explain whether the collision of the balls is inelastic or perfectly elastic.

Section D

31. (a) Define instantaneous velocity. Give its SI unit.

(b) A constant driving force of 2400 N acts on a car of mass 1200 kg. The car accelerates from rest in a straight line along a horizontal road. Assume that the resistive forces acting on the car are negligible.

(i) Calculate the acceleration of the car.

(ii) sketch a graph showing the variation with time t of the velocity v of the car for the first 20 seconds of its motion.

(iii) A car moving with a speed of 50 km/h can be stopped by brakes after at least 6m. What will be the minimum stopping distance, if the same car is moving at a speed of 100 km/h.

OR

(a) What do you mean by uniformly accelerated motion? Give one example.

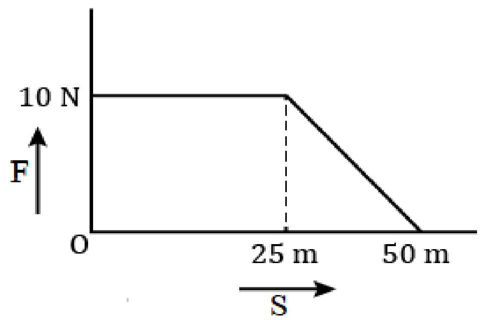
(b) Derive all kinematics equations for uniformly accelerated motion from velocity-time graph.

(c) In uniform circular motion, what is constant; speed or acceleration? Explain with a diagram?

32. (i) What is meant by positive and negative and zero work? Give one example of each.

(ii) An elastic spring of spring constant k is compressed by an amount x. Show that its potential energy is $\frac{1}{2}kx^2$.

(iii) A body of mass 5 Kg is acted upon by a variable force. The force varies with the distance covered by the body as shown in figure. What is the speed of the body when the body has covered 25 m? Assume that the body starts from rest.



OR

(i) What are the factors on which the moment of inertia of a body depends?

(ii) Prove that the rate of change of angular momentum (l) is torque (τ), $\frac{d\vec{l}}{dt} = \vec{\tau}$

(iii) a point mass (m = 0.2 Kg) is rotating in a horizontal circle of radius 10 cm with a frequency of $\frac{5}{\pi}$ revolutions/second. Calculate the angular momentum and kinetic energy of the particle.

33. (i) State and prove Bernoulli's principle.

(ii) A plane is in level flight at constant speed and each of its two wings has an area of 25 m^2. If the speed of the air is 180 km/h over the lower wing and 234 km/h over the upper wing surface, determine the plane's mass. (Take air density to be 1 kg m^{-3}).

OR

a) State the Pascal's law for transmission of fluid pressure.

b) Draw a schematic diagram illustrating the principle behind the hydraulic lift. Explain the working of it. What does the term mechanical advantage suggest?

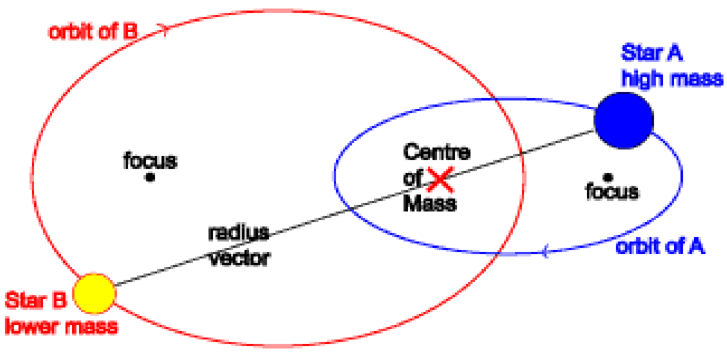
c) In a car lift compressed air exerts a force on a small piston having a radius of 5.0 cm. This pressure is transmitted to a second piston of radius 15 cm. If the mass of the car is 1350 kg what is the pressure necessary to accomplish this task?

Section E

34. Case study: *Binary (double) stars*.

Binary stars are of immense importance to astronomers as they allow the masses of stars to be determined. A binary system is simply one in which two stars orbit around a common centre of mass, that is they are gravitationally bound to each other. Actually, most stars are in binary systems.

The orbital periods and distances of binaries vary enormously. Some systems are so close that the surfaces of the stars are practically touching each other and can exchange material. Others may be separated by a few thousand Astronomical Units and have orbital periods of hundreds of years.



Orbits of Stars in a Binary System

1. Which of these is the best description of the orbital motion of a binary star system?
   (a) The less massive star orbits around the more massive one.
   (b) Both stars orbit around a common centre of mass.
   (c) The dimmer star orbits around the brighter one.
   (d) Each star orbits around the other.

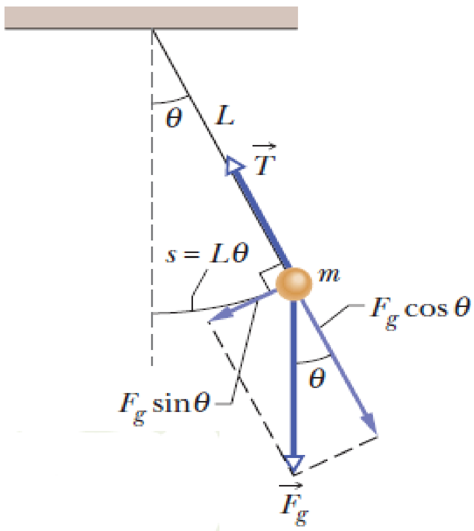
2. To study the double stars system, why is it so important to describe the motion of binary stars about the centre of mass?
3. In a certain binary-star system, each star has the same mass as our Sun ($M_s = 2 \times 10^{30}\ kg$), and they revolve about their center of mass. The distance between them is the same as the distance between Earth and the Sun ($r = 1.5 \times 10^{11}\ m$). Calculate the gravitational pull between them.

OR

Two stars each of one solar mass ($M_s = 2 \times 10^{30}\ kg$) are approaching each other for a head on collision. When they are at distance of $10^9\ km$, their speeds are negligible. What is the speed with which they collide? The radius of each star is10^4 km. Assume the stars to remain undistorted until they collide.

35. **Case study**: ***Simple Pendulum***.

A simple pendulum consists of a particle of mass m (called the bob of the pendulum) suspended from one end of an inextensible, massless string of length L that is fixed at the other end, as in figure. The bob is free to swing back and forth in the plane of the page, to the left and right of a vertical line through the pendulum's pivot point. We resolve $\vec{F_g}$ into a radial component $F_g cos\theta$ and a component $F_g sin\theta$ that is tangent to the path taken by the bob. This tangential component produces a restoring torque about the pendulum's pivot.



1. Why does the component $F_g cos\theta$ not produce any torque?
2. Why should the angular amplitude θ_m of the motion (the maximum angle of swing) be small?
3. Show that the period of the pendulum is $T = 2\pi\sqrt{\frac{I}{mgL}}$, where I is the moment of inertia of the pendulum.

OR

Find the length of the 'seconds' pendulum on the surface of the moon. The gravity on the moon is about $\frac{1}{6}$ times the gravity of the earth.

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