विद्या सर्वार्थि साधिका

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ANNUAL EXAMINATION
Class: XI

Subject: Physics (042) MM: 70
Date : 12-03-2024 Time: 3 Hours

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. Section A contains sixteen questions - twelve MCQ and four Assertion-Reasoning based - 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.
4. 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.
5. Use of calculators is not allowed.
6. You may use the following values of physical constants wherever necessary.
   The values of some physical constants:
   $G = 6.6 \times 10^{-11}\ Nm^2kg^{-2}$ $g = 10\ ms^{-2}$

SECTION A

1. Which of the following is a base quantity? (1)
   (A) Speed (B) Acceleration (C) Length (D) Force

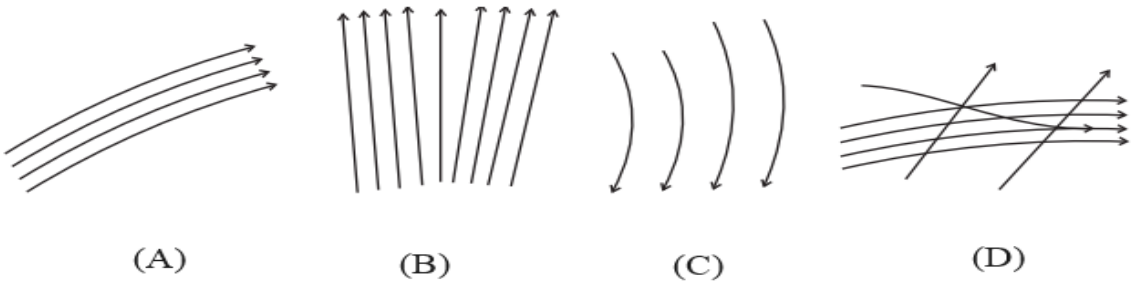
2. What is the result of the calculation 8.76 + 2.1 with the correct number of significant figures? (1)
   (A) 10.86 (B) 10.9 (C) 11 (D) 11.0

3. A 7 kg object is subjected to two forces (in Newton) $F_1 = (20\,\hat{\imath} + 30\,\hat{\jmath})$ N and $F_2 = (8\,\hat{\imath} - 2\,\hat{\jmath}\,)$ N. The magnitude of resulting acceleration in ms^{-2} will be _____. (1)
   (A) $5\sqrt{2}$ (B) $4\sqrt{2}$ (C) $3\sqrt{2}$ (D) $2\sqrt{2}$

4. When a long spring is stretched by 2 cm, its potential energy is 0.1 J. If the spring is stretched by 10 cm, its potential energy would be _____. (1)
   (A) 5 J (B) 1 J (C) 2.5 J (D) 0.5 J

5. A constant torque acting on a uniform circular wheel changes its angular momentum from L to 4 L in 4 seconds. The magnitude of this torque is _____. (1)
   (A) 3 L/4 (B) 4 L (C) L (D) 12 L

6. Which of the following diagrams does not represent a streamline flow? (1)



7. A bimetallic strip is made of aluminium and steel ($\alpha_{Al} > \alpha_{steel}$). On heating, the strip will _____. (1)

(A) remain straight (B) will bend with steel on concave side
(C) get twisted (D) will bend with aluminium on concave side

8. When steam is converted into water, internal energy of the system _____. (1)

(A) increases (B) decreases (C) remains constant (D) becomes zero

9. In the equation, PV = RT, the V refers to the volume of: (1)

(A) 1 g of a gas (B) 1 mole of a gas (C) 1 kg of gas (D) any amount of gas

10. Which of the following relationships between the acceleration '*a*' and the displacement '*x*' of a particle involve simple harmonic motion? (1)

(A) $a = 0.7x$ (B) $a = -200x^2$ (C) $a = -10x$ (D) $a = 100x^3$

11. Two sitar strings A and B playing the note 'Dha' are slightly out of tune and produce beats of frequency 5 Hz. The tension of the string B is slightly increased and the beat frequency is found to decrease to 3 Hz. What is the original frequency of B if the frequency of A is 427 Hz? (1)

(A) 422 Hz (B) 425 Hz (C) 430 Hz (D) 432 Hz

12. A travelling wave is represented by the equation $y = 0.2 \sin\left(\frac{2\pi}{10}x - \frac{2\pi}{0.002}t\right)$ cm, where *x* and *t* have units cm and s respectively. What is the speed of the wave? (1)

(A) 25 m/s (B) 50 m/s (C) 100 m/s (D) 5000 m/s

For question numbers 13 to 16, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as 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 and R is also true.

13. A: The displacement of an object in motion can be greater than the distance travelled. (1)
R: Displacement is a vector quantity that considers the change in position whereas distance is a scalar quantity that represents the total path travelled.

14. A: The rate of change of total momentum of a many particles system is proportional to the sum of the internal forces of the system. (1)
R: Internal forces can change the kinetic energy but not the momentum of the system.

15. A: Steel is more elastic than rubber. (1)
R: Under given deforming force, steel is deformed less than rubber.

16. A: Mean free path of gas molecules varies inversely as number density of the gas. (1)
R: Mean free path of gas molecules is defined as the average distance travelled by a molecule between two successive collisions.

SECTION B

17. Obtain the time period (T) of a simple pendulum using dimensional analysis. (2)

18. A car starts from rest and accelerates uniformly at 4 m/s² for a distance of 50 meters. Calculate the time taken to travel the 50 m and the final velocity of the car. (2)

19. What would be the acceleration due to gravity on a planet whose density and radius are $\frac{1}{3}\rho_E$ and $\frac{1}{4}R_E$ respectively? (ρ_E and R_E are the density and radius of the Earth respectively) (2)

OR

State and prove Kepler's II law of motion

20. A spring attached with a mass m oscillates simple harmonically with angular frequency ω and amplitude a. Write the expression for its maximum potential energy and maximum kinetic energy. At what distance from the mean position its potential energy be equal to the kinetic energy? (2)

21. Write the equation of a stationary wave. Give the positions of nodes and antinodes in a stationary wave. (2)

SECTION C

22. A body starts accelerating uniformly with an acceleration 'a' from a velocity 'u' and travels in a straight line. Prove that it covers a length of $u + \frac{a}{2}(2n-1)$ in the nth second of motion. (3)

23. Two equal masses, one moving with velocity 'u' and other stationary, collide. Assuming the collision is elastic collision, derive the velocity of the masses after collision. (3)

24. (a) State Pascal's law. (3)
(b) In a car lift compressed air exerts a force F_1 on a small piston having a radius of 5.0 cm. This pressure is transmitted to a second piston of radius 15 cm where the car is placed. If the mass of the car to be lifted is 1350 kg, calculate F_1. What is the pressure necessary to accomplish this task?

25. Show that in thermal expansion, the coefficient of area expansion α_A, of a rectangular sheet of the solid is twice its linear expansivity, α_l. (3)

OR

Draw a typical stress vs strain graph. Mark on the graph the (a) yield point, (b) proportional limit, (c) fracture point and (d) permanent set.

26. (a) State law of equipartition of energy. (3)
(b) Apply this law to predict the molar specific heats C_V and C_P of (i) monoatomic and (ii) diatomic gases. Assume the diatomic molecule as a rigid rotator.

27. An object is thrown with a velocity 40 m/s at 30º with horizontal. Find (a) the maximum height reached by the object, (b) the velocity at the maximum height and (c) the maximum horizontal distance travelled. (3)

28. Use the formula $v = \sqrt{\frac{\gamma P}{\rho}}$ to explain why the speed of sound in air (a) is independent of pressure, (b) increases with temperature, (c) increases with humidity. (3)

SECTION D

Question no 29 and 30 are case based questions. Read the paragraph and answer the questions given below.

29. A person standing in an elevator feels heavier when the elevator is accelerating upward and lighter when it is accelerating downward. When the elevator is accelerating upward, the net force acting on the person is the difference between the normal force and the force of gravity. The net force is greater in the upward direction. Therefore, the person feels heavier. When the elevator is accelerating downward, the net force is weaker. Therefore, the person feels lighter.

A man of mass 70 kg stands on a weighing scale in a lift which is moving. What would be the readings on the scale in case (i) & (ii)?

(i) downwards with a uniform acceleration of 5 m s^{-2}. (1)
(ii) upwards with a uniform acceleration of 5 m s^{-2}. (1)

(iii) What would be the reading if the lift mechanism failed and it hurtled down freely under gravity? Explain (2)

OR

(iii) A 10 kg mass is placed on a horizontal table. Another 5 kg mass is placed over the 10 kg mass. Find the reactionary force acting on (a) 10 kg mass and (b) 5 kg mass.

30. Moment of inertia of a body about a given axis is the rotational inertia of the body about that axis. It is represented by $I = MK^2$, where M is mass of body and *K* is radius of gyration of the body about that axis. it is a scalar quantity, which is measured in kg m^2.
When a body rotates about a given axis and the axis of rotation also moves, then total K.E of body = K.E of translation + kinetic energy of rotation.

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Based on the above information, answer the following:

(i) The moment of inertia of a body depends on _____. (1)
(A) mass of the body (B) shape and size of the body
(C) axis of rotation of the body (D) All the above

(ii) A 40 kg flywheel in the form of a uniform circular disc of diameter 1 m is making 120 rpm. The moment of inertia about a transverse axis through its centre is _____. (1)
(A) 20 kg m^2 (B) 5 kg m^2 (C) 10 kg m^2 (D) 25 kg m^2

(iii) For the above case, the kinetic energy of rotation of the flywheel is _____. (1)
(A) 250 J (B) 280.5 J (C) 394.8 J (D) 290.4 J

(iv) The moment of inertia of the circular ring about an axis perpendicular to its plane passing through its centre is _____. (1)
(A) $\frac{1}{2}MR^2$ (B) MR^2 (C) $\frac{3}{4}MR^2$ (D) $\frac{1}{4}MR^2$

OR

(iv) The radius of gyration of a cylindrical rod of mass m and length L about an axis of rotation perpendicular to its length and passing through its centre is _____.
(A) $\frac{2}{3}L$ (B) $\frac{L}{2\sqrt{3}}$ (C) $\frac{1}{\sqrt{3}}L$ (D) $\frac{L}{\sqrt{2}}$

SECTION E

31. (a) Prove that the path of a projectile is a parabola. (5)
(b) Show that range of projection of a projectile for two angles of a projection α and β is same where α + β = 90º.

OR

(a) State parallelogram law of vector addition. Show that the magnitude of resultant of two vectors A and B inclined at an angle θ is $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$.
(b) Prove that the vectors $(\hat{\imath} + 2\hat{\jmath} + 3\hat{k})$ and $(2\,\hat{\imath} - \hat{\jmath})$ are perpendicular to each other.

32. Obtain an expression for the escape velocity of an object of mass *m* from the surface of a planet of mass *M* and radius *R*. For planet earth, escape velocity is known to have a value of 11.2 km/s. How fast will an object be moving at infinity, if it is launched with a speed of 22.4 km/s from the surface of the earth? (5)

OR

Derive the expressions for the acceleration due to gravity on earth (i) at an altitude 'h' and (ii) at a depth 'd'. Assume that the earth as a uniform sphere and of uniform density.

33. State and prove Bernoulli's theorem. What are the assumptions made while deriving this theorem? (5)

OR

State first law of thermodynamics. Using first law of thermodynamics, show that $C_p - C_v = R$.