VANDANA INTERNATIONAL SCHOOL
HALF-YEARLY EXAMINATION
SESSION 2024-25
CLASS: XI
SUBJECT: PHYSICS (042)
Set - B

TIME: 3 Hours **M.M. 70**

GENERAL INSTRUCTIONS:

Read the following instructions very carefully and follow them:

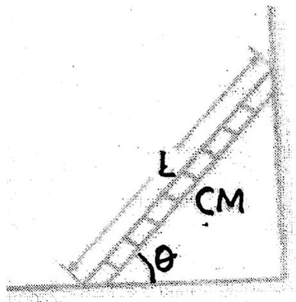
- **(i) This question paper contains 33 questions. All questions are compulsory.**
- **(ii) This question paper is divided into five sections – Section A, B, C, D and E.**
- **(iii) In Section A: Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.**
- **(iv) In Section B : Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.**
- **(v) In Section C : Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.**
- **(vi) In Section D : Question numbers 29 and 30 are case-study based questions. Each question carries 4 marks.**
- **(vii) In Section E : Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.**

SECTION A

1. A satellite of mass m is placed at a distance r from the centre of earth (mass M). The mechanical energy of the satellite is

(a) $\frac{GMm}{r}$ (b) $\frac{GMm}{r}$ (c) $\frac{GMm}{2r}$ (d) $-\frac{GMm}{2r}$

2. A ladder of length L leans against a wall at an angle of θ from the horizontal, as shown in the figure. What torque is applied about the ladder's centre of mass by the normal force F_N exerted by the ground on the ladder?



(a) F_N (L/2) (b) F_N. L cos θ

(c) F_N L sin θ (d) F_N (L/2) cos θ

3. A rod of length L has non-uniform linear mass density given by $p(x) = a + b\left(\frac{x}{L}\right)$, where a and b are constants and 0 ≤ x ≤ L. The value of x for the centre of mass of the rod is at

(a) $\frac{4}{3}\left(\frac{a+b}{2a+3b}\right) L$ (b) $\frac{3}{2}\left(\frac{2a+b}{3a+b}\right) L$

(c) $\frac{3}{2}\left(\frac{a+b}{2a+b}\right) L$ (d) $\frac{3}{4}\left(\frac{2a+b}{3a+b}\right) L$

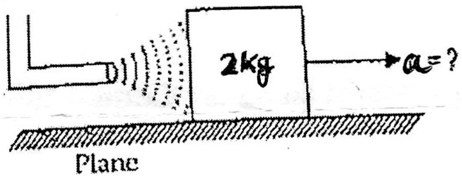
4. A mass m is supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on the cylinder, with what acceleration will the mass fall on release?
(a) $\frac{2g}{3}$ (b) $\frac{g}{2}$ (c) $\frac{5g}{6}$ (d) g

5. A block of mass 10 kg is moving in x – direction with a constant speed of 10 ms^{-1}, it is subjected to a retarding force, $F = -0.1\,x\,Jm^{-1}$, it is subjected to a regarding force, F = 0.1 $x\,Jm^{-1}$ during its travel from $x = 20$m to $x = 30$m. Its final kinetic energy will be
(a) 475 J (b) 450 J (c) 275 J (d) 250 J

6. A body of mass 3 kg under a constant force has displacement s metres in it, given by the relation $s = \frac{1}{3}t^2$, where t is in seconds. Work done by the force in 2 seconds is
(a) $\frac{19}{5}$ J (b) $\frac{5}{19}J$ (c) $\frac{3}{8}J$ (d) $\frac{8}{5}J$

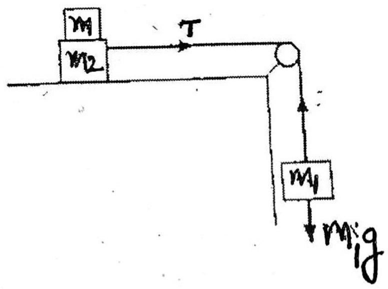
7. If the linear momentum is increased by 50%, then kinetic energy will increase by
(a) 50% (b) 100% (c) 125% (d) 25%

8. A block of metal weighing 2 kg is resting on a frictionless plane (as shown in the figure). It is struck

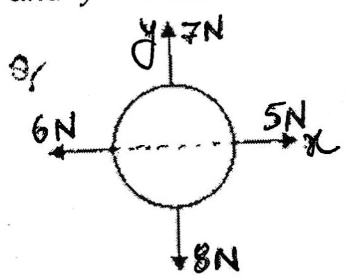


by a jet releasing water at a rate of 1 kgs^{-1} and at a speed of 10 ms^{-1}. Then, the initial acceleration of the block, in ms^{-2}, will be
(a) 3 (b) 6 (c) 5 (d) 4

9. Two masses $m_1 = 5$ kg and $m_2 = 10$ kg, connected by an inextensible string over a frictionless surface are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. The minimum weight m that should be ut on top of m_2 to stop the motion is
(a) 18.3 kg (b) 27.3 kg
(c) 43.3 kg (d) 10.3 kg



10. For a free body diagram shown in the figure, the four sources are applied in the 'x' and 'y' direction



What additional force must be applied and at what angle with positive $x - axis$ so that net acceleration of body is zero?

(a) $\sqrt{2}$ N, 45°
(b) $\sqrt{2}$ N, 135°
(c) $\frac{2}{\sqrt{3}}$ N, 30°
(d) $2\ N, 45°$

11. A particle is moving with a velocity $\vec{v} = K(y\,\hat{\imath} + x\,\hat{\jmath})$, where K is a constant. The general equation for its path is
(a) $y^2 + x + constant$
(b) y = x^2 + constant
(c) $y^2 = x^2 + \text{constant}$
(d) $xy = \text{constant}$

12. If the coefficient of static friction between the tyres and the road is 0.5, what is the shortest distance in which an automobile can be stopped when travelling at 72 km/hr.

(a) 50m **(b) 60m** **(c) 40.8m** (d) 80.16

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of the assertion
(b) If both assertion and reason are true but the reason is not the correct explanation of assertion
(c) If the assertion is true but the reason is false
(d) if both assertion and reason are false

13. **Assertion (A) :** During turning, a cyclist leans towards the centre of the curve; while a man sitting in the car leans outwards of the curve.
Reason (R): An acceleration is acting towards the centre of the curve.

14. **Assertion (A):** When a ball collides elastically with a floor, it rebounds with the same velocity as with it strikes.
Reason (R): Momentum of the earth + ball system remains constant.

15. **Assertion (A):** If the ice caps of the pole melt, the day length will shorten.
Reason (R): Ice flows towards the equator and decreases the moment of inertia of the earth and hence increases the earth's rotation frequency.

16. **Assertion (A):** A planet moves faster, when it is closer to the sun in its orbit and *vice-versa.*
Reason (R): Orbital velocity in orbit of planet is constant.

SECTION B

17. Derive an expression for the escape velocity of a satellite projected from the surface of the earth.

18. State and prove the law of conservation of angular momentum.

19. Draw the variation of potential energy and kinetic energy of a block attached to a spring, which obeys Hooke's law.

20. Obtain an expression for the angle which a cyclist will have to make with vertical while taking a circular turn. [For successful negotiation].

21. A projectile is fired with velocity u making an angle θ with the horizontal. Derive expression for :
(i) time of maximum height and
(ii) horizontal range

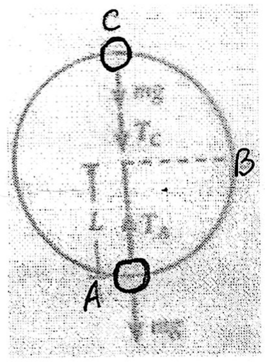
SECTION C

22. A body is projected such that its kinetic energy at the top is 3/4th of its initial kinetic energy. What is the initial angle of projection of the projectile with the horizontal?

23. In the expression $P = El^2\, m^{-5}\, G^{-2}$; E, m, l and G denote energy, mass angular momentum and gravitational constant, respectively. Show that P is a dimensionless quantity.

24. What do you mean by banking of a curved road? Determine the angle of banking so as to minimise the wear and tear of the tyres of a car negotiating a banked curve.

25. A bob of mass m is suspended by a light string of length L. it is imparted a horizontal velocity v_0 at the lowest point A such that it completes a semi-circular trajectory in the vertical plane with the string becoming slack only on reaching the topmost point, C. This is shown in below fig. Obtain an expression for (i) v_0 ; (ii) the speeds at points B and C ; (iii) the ratio of the kinetic energies (K_B / K_C) at B and C. Comment on the nature of the trajectory of the bob after it reaches the point C.



26. A rain drop of radius 2 mm falls from a height of 500 m above the ground. It falls with decreasing acceleration (due to the viscous resistance of the air) until at half its original height, it attains its maximum (terminal) speed and moves with uniform speed thereafter. What is the work done by the gravitational force on the drop in the first and second half of its journey? What is the work done by the resistive force in the entire journey if its speed on reaching the ground is 10 ms^{-1}?

27. Establish the relation between torque and angular acceleration. Hence define the moment of inertia.

28. Define orbital velocity. Derive an expression for the orbital velocity of a satellite revolving around a planet.

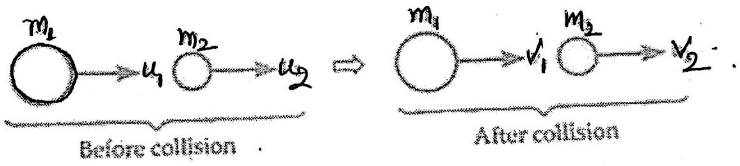
SECTION D (CASE BASED)

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

29. A collision is strong interaction that occurs for a very short time interval during which redistribution of momenta occurs ignoring the effect of other forces. In all collisions total linear momentum is conserved while the total kinetic energy

of the system is not necessarily conserved. If there is no loss of kinetic energy during a collision, it is called an elastic collision. Collisions between billiard balls, steel balls and marbles are nearly elastic. The collisions between atoms and subatomic particles are truly elastic. If there is loss of kinetic energy during a collision, it is called an inelastic collision. The impact and deformation during a collision may convert part of the initial kinetic energy into heat and sound. When two bodies stick together after a collision, the collision is perfectly inelastic.

Consider the head-on elastic collision between two bodies of masses m_1 and m_2.



The velocities of the two bodies after collision will be

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2} \cdot \mu_1 + \frac{2m_2}{m_1 + m_2} \cdot \mu_2$$

and

$$v_2 = \frac{2m_1}{m_1 + m_2} \cdot \mu_1 + \frac{m_2 - m_1}{m_1 + m_2} \cdot \mu_2$$

(i) A particle of mass m_1 moves with velocity v_1 and collides with another particle at rest of equal mass. The velocity of the second particle after the elastic collision is
(a) $2v_1$ (b) v_1
(c) $-v_1$ (d) 0

(ii) A body of mass 5 kg, moving with velocity 10 m/sec collides with another body of the mass 20 kg at rest and comes to rest. The velocity of the second body due to collision is
(a) 2.5 m/sec (b) 7.5 m/sec
(c) 5 m/sec (d) 10 m/sec

(iii) A body moving with a velocity v, breaks up into two equal parts. One of the parts retraces back with velocity v.
Then the velocity of the other part is
(a) v in forward direction
(b) $3v$ in forward direction
(c) v in backward direction
(d) $3v$ in backward direction

(iv) A spacecraft of mass M and moving with velocity v suddenly breaks in two pieces of same m. After the explosion one of the masses m becomes stationary.
What is the velocity of the other part of craft?
(a) $\frac{Mv}{M-m}$ (b) v
(c) $\frac{Mv}{m}$ (d) $\frac{M-m}{m}v$

30. Whenever a body moves or tends to move over the surface of another body, a force comes into play which acts parallel to the surface of contact and opposes the relative motion. This opposing force is called friction. Static friction f_s opposes the impending relative motion while the kinetic friction f_k

opposes the actual relative motion. State friction is a self-adjusting force. The maximum value of static friction (f_s^{max}) which comes into play when a body just starts moving over the surface of another body is called limiting friction. Two important constants which are characteristics of the pair of surfaces in contact are defined as follows :

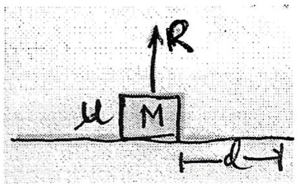
Coefficient of limiting friction, $\mu_s = \frac{f_s^{max}}{R}$

Coefficient of kinetic friction, $\mu_k = \frac{f_k}{R}$

As $f_k < f_s^{max}$ or $\mu_k R < \mu_s R \Rightarrow \mu_k < \mu_s$

where R is the normal reaction between the two surfaces in contact. Both static and kinetic friction are independent of the area of surfaces in contact.

(i) If reaction is R and coefficient of friction is μ, what is work done against friction in moving a body by distance d?



(a) $\frac{\mu Rd}{4}$ (b) $2\mu Rd$
(c) μRd (d) $\mu Rd/2$

(ii) A block of mass 50 kg just slides over a horizontal distance of 1 m. If coefficient of friction between their surfaces is 0.2, the work done by friction is
(a) 98 J (b) 56 J
(c) 72 J (d) 34 J

(iii) A cylinder of mass 10 kg is rolling on a place with an initial velocity of 10 m/s. If coefficient of friction between surface and cylinder is 0.5, then before stopping, the cylinder will cover a distance of
(a) 10 m (b) 5 m
(c) 7.5 m (d) 2.5 m

(iv) Two iron blocks of equal masses but with different surface areas slide down an inclined plane with friction coefficient μ. If the first block with surface area A experiences a frictional force f, then the second block with surface area 2A will experience a frictional force
(a) $f/2$ (b) f
(c) $2f$ (d) $4f$

SECTION E

31. (a) Obtain an expression for the centripetal force required to make a body of mass m, moving with a velocity v around a circular path of radius r.
(b) Find an expression for the velocity of the recoil of the gun.

Or (2+1+ 2)

(i) Why does a horse pull a cart harder during the first few steps of its motion?
(ii) Sudden motion of a blanket removes the dust particles from the blanket. Why?

(iii) A batsman deflects a ball by an angle of 45° without changing its initial speed which is equal to 54 km h^{-1}. What is the impulse imparted to the ball? Mass of the ball is 0.15 kg.

32. (a) Derive an expression for the acceleration due to gravity 'g' at a depth d (from the centre of the earth. What happens to 'g' at the centre of the earth?
(b) At what height above the earth's surface, is the value of 'g' the same as in a mine 80 km deep? **(3+2)**

Or

(a) State Kepler's laws of planetary motion.
(b) Suppose there existed a planet that went round the sun twice as fast as the earth. What will be its orbital size as compared to that of the earth.
(3+2)

33. Define rotational motion of a body. Derive the following equations of rotational motion under constant angular acceleration. **(2+2+1)**

(i) $\omega = \omega_0 + \alpha t$ (ii) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

(iii) $\omega^2 - \omega_0^2 = 2\alpha\theta$.

Or

(a) What is projectile motion?
(b) The maximum range of projectile is $2/\sqrt{3}$ times actual range. What is the angle of projection for the actual range?
(c) Two balls are thrown with the same initial velocity at angles α and $(90° - \alpha)$ with the horizontal. What will be the ratio of the maximum heights attained by them? When will this ratio be equal to 1?