APEEJAY SCHOOL PITAMPURA

UNIT TEST II CLASS XIth PHYSICS

Time allowed : 3 hours

Maximum marks : 60

GENERAL INSTRUCTIONS

1. Use of calculator is not allowed
2. All questions are compulsory.
3. Question no. 1 to 7 carries one mark each.
4. Question no. 8 to 15 carries 2 marks each.
5. Question no. 16 and 24 carries 3 marks each.
6. Question number 25, 26 are long answer type question. It carries 5 marks.

PART A

1. State the number of significant figures in the following :
   a) $0.0006032\ m^2$
   b) 2.64×10^{24} kg
2. Position of an object is given by $\mathbf{r}(t) = (2\,\mathbf{i} + 3t^3\,\mathbf{j} + 4t^2\,\mathbf{k})$ m. can we use the equations of uniformly accelerated motion in this case.
3. Write Newton's second law of motion in mathematical form. Can you apply the second law of motion and law of inertia in a frame of reference attached to an Airplane during its take off.
4. Calculate the work done when a force $\mathbf{F} = (3\,\mathbf{i} - 4\,\mathbf{j} + 5\,\mathbf{k})$ units acts on an object and the displacement vector of the object is given by $\mathbf{r} = (2\,\mathbf{i} + 3\,\mathbf{j} + 4\,\mathbf{k})$ units.
5. When you lift a box from the floor and put it on an almirah the potential energy of the box increases, but there is no increase in its kinetic energy. Is it a violation of conservation of energy?
6. An egg is released from the roof of the building and falls on the ground. As the egg falls what happens to the momentum of the system "egg plus earth".
7. What is the moment of inertia of a ring about a tangential axis that is perpendicular to the plane of the ring?

PART B

8. When the planet Jupiter is at a distance of 824.7 million kilometers from the Earth, its angular diameter is measured to be 35.72" of arc. Calculate the diameter of the Jupiter.

OR

(a) If the n^{th} division of main scale coincides with the $(n+1)^{th}$ division of vernier scale, find the least count of the vernier. Given one main scale division is equal to 'a' units.

(b) If the linear scale of screw gauge moves 5 mm when we give 5 complete rotations and there are 100 divisions on the circular scale, find its least count.

9. (a) Which fundamental force of nature is responsible for the common forces in mechanics like friction, tension and viscous drag?
   (b) If the protons repel each other, why in nature we have multi protons nuclei like calcium, lead and uranium?
10. (a) An ant is moving on the plane ground (2 Dimensions). Yet to study the velocity and displacement of the ant, only one coordinate is enough. Why?
    (b) Under what conditions is average velocity of a particle equal to its instantaneous velocity?
11. An object is moving in a circle of radius **r** with angular speed ω . using the plane polar coordinates, derive the expression for the centripetal acceleration in vector form. What is the vector sum of the centripetal acceleration vector over one complete cycle.
12. The blades of a windmill sweep out a circle of area A. (a) If the wind flows at a speed v perpendicular to the circle, what is the mass of the air passing through it in time t? (b) What is the kinetic energy of the air? (c) Assume that the windmill converts 100 % of the wind's energy into electrical energy, and that A = 30 m^2, v = 10 ms^{-1} and the density of air is 1.0 kg m^{-3}. What is the electrical power produced?
13. A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is 1 m s^{-1}. What is the trajectory of the bob if the string is cut when the bob is (a) At one of its extreme positions, (b) At its mean position. Give reasons for your answer.
14. When a large star becomes a **supernova**, its core may be compressed so tightly that it becomes a neutron star, with a radius of about 10 km. Time period of rotation of a neutron star is 1 sec, (a) what is the speed of a particle on the star's equator and (b) what is the magnitude of the particle's centripetal acceleration at the equator?
15. Two bodies a solid cylinder and a ring roll down the same inclined plane without slipping. They start from rest. The radii of the two bodies are identical. Calculate the final velocities of the two objects when they reach the ground?

PART C

16. A rain drop of radius 2 mm falls from a height of 500 m above the ground. It falls with decreasing acceleration (due to 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 m s^{-1}? (given : Density of water = 1000 kgm^{-3}).
17. Two parallel rail tracks run north to south. Train A moves towards north with a speed of 15 ms^{-1}, and train B moves towards south with a speed of 25 m s^{-1}. What is the (a) velocity of B with respect to A? (b) Velocity of ground with respect to B? and (c) velocity of a monkey running on the roof of the train A against its motion (with a velocity of 5 m s^{-1} with respect to the train A) as observed by a man standing on the ground ?

18. Figure 1. gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B, C and D?

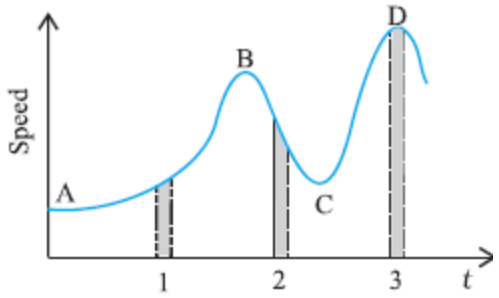

Fig. 1

19. A block of mass m_1= 3kg on a frictionless plane inclined at an angle θ = 30° is connected by a cord over a massless, frictionless pulley to a second block of mass m_2 =2 kg What are (a) the magnitude of the acceleration of each block, (b) the direction of the acceleration of the hanging block, and (c) the tension in the cord?

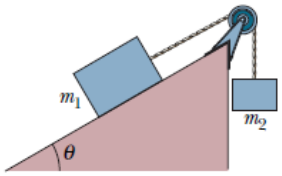

Fig.2

20. Explain why?
    (a) A horse cannot pull a cart and run in empty space
    (b) It is easier to pull a lawn mower than to push it.
    (c) Find the net force acting on:
    (i) A raindrop falling with constant speed. (ii) A cork floating in water.

OR

Give proper reasons for the following :

(a) The distance travelled by an object is proportional to the time. Is any external force acting on it?

(b) Sand is thrown on the tracks covered with snow. Why?

(c) Two boys having the same mass are standing on the ice skates at some distance apart on a frictionless surface. A rope is fastened around the body of a boy, the other end of which is in the hand of the second boy. What would happen if second boy pulls the rope?

21. (a) For an object in the free fall from the height H, prove that the total mechanical energy at all points on the path is conserved (neglect the air resistance).

(b) Comets move around the sun in highly elliptical orbits. The gravitational force on the comet due to the sun is not normal to the comet's velocity in general. Yet the work done by the gravitational force over every complete orbit of the comet is zero.Why ?

22. (a) If the ice at the poles melts and flows towards the equator because of global warming, how will it effect the duration of day and night?
(b) The density of rod AB continuously increases from A to B. Is it easier to set it in rotation by clamping it at A and applying perpendicular force at B or by clamping it at B and applying the perpendicular force at A.
(c) In the HCl molecule, the separation between the nuclei of the two atoms is about 1.27 Å. Find the approximate location of the center of mass of the molecule, given that a chlorine atom is about 35.5 times as massive as a hydrogen atom and nearly all the mass of an atom is concentrated in its nucleus.

23 . When an object rotates in a circular orbit, it experiences an inward force called **centripetal force**. It is found that the centripetal force is proportional to the mass of the object m, radius of the orbit r and its velocity v. Using the method of dimensional analysis find the expression for the centripetal force in terms of m, v and r.

24. (a) An elevator can carry a maximum load of 1800 kg (elevator + passengers) is moving up with a constant speed of 2 m s^{-1}. The frictional force opposing the motion is 4000 N. Determine the minimum power delivered by the motor to the elevator in watt as well as in horse power.
(b) Find the angle between force **F** = (3 **i** + 4 **j** + 5 **k**) unit and displacement **d** = (5 **i** + 4 **j** + 3 **k**) unit. Also find the projection of **F** on **d**.

PART D

25. A projectile is fired with velocity u from the ground making an angle θ with the horizontal direction. If T and R is the time of flight and range of the projectile.
   a) Derive an expression for R and T in terms of θ and u.
   b) For what values of θ, the range is maximum
   c) A bullet fired at an angle of 30° with the horizontal hits the ground 3.0 km away. By adjusting its angle of projection, can one hope to hit a target 5.0 km away? Assume the muzzle speed to be fixed, and neglect air resistance.

OR

(a) If you want maximum thrill and adventure on a circular ride in an adventure park, It is advisable to sit far away from the center of the circle. Why?

(a) An astronaut is rotated in a horizontal centrifuge of radius 5.0 m.

   (i) What is the astronaut's linear speed if the centripetal acceleration has a magnitude of 2.0g?
   (ii) How many revolutions per minute are required to produce this acceleration?

(b) Calculate the dot product of instantaneous velocity and position vector of a particle moving in a uniform circular motion?

26. Using the technique of integral calculus, derive an expression for the moment of inertia of a solid sphere of radius **R** and mass **M** rotating around an axis passing through its center.
    a) State Parallel axis theorem in rotation
    b) Find the moment of inertia of a disc about an axis normal to its plane and passing through a point on its edge.

OR

Write the vector expression for the angular momentum of a particle of mass m, moving with velocity **v** having position vector **r** from the origin.

a) Using the expression of the angular momentum, prove that the torque acting on the particle is the time derivative of angular momentum and if the torque on the particle is zero, its angular momentum remains conserved.

b) If you want to rotate faster, it is advisable to fold the arms. Why?

c) The rotational inertia of a collapsing spinning star drops to 1/3 of its initial value. What is the ratio of the new rotational kinetic energy to the initial rotational kinetic energy?