SUBJECT : PHYSICS (SET-I)

Time : 3 Hrs. **M.M.: 70**

General Instructions :

i) All questions are compulsory.

ii) Q. no. 1 to 5 carry 1 mark each, Q. no. 6 to 10 carry 2 marks each, Q. no. 11-22 carry 3 marks each, Q. no. 23 is a value based question carrying 4 marks and Q. no. 24-26 carry 5 marks each.

iii) There is no overall choice, however, an internal choice is given in 1 question of 2 marks, 1 question of 3 marks and all questions of 5 marks.

iv) You may use the following constants :

$G = 6.6 \times 10^{-11}\ NM^2/Kg^2$

$M_e = 6 \times 10^{24}\ Kg$

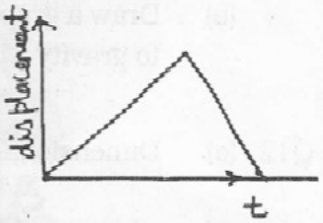
$R_e = 6.4 \times 10^6\ m$

Q1. Give the magnitude and direction of net force acting on a stone of mass 0.1 Kg after it is dropped from the window of a stationary train.

Q2. Find the angle which $\hat{i} + \hat{j}$ makes with the X-axis.

Q3. What is the angle between velocity and acceleration at any instant of an object in uniform circular motion?

Q4. The displacement-time graph for a body is shown. Plot the corresponding velocity-time graph.



Q5. A ball bounces to 80% its original height after hitting the ground. What fraction of its mechanical energy is lost?

Q6. A body weighs 600N on earth. How much will it weigh on the surface of a planet whose mass is 9 times the mass of earth, and radius 6 times the earth's radius?

OR

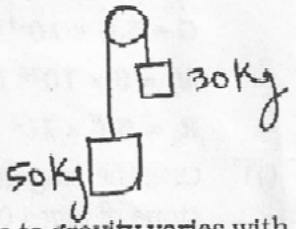
Determine the speed at which earth has to rotate so that weight of an object at equator becomes 3/5 of its original weight.

Q7. A body is thrown horizontally from the top of a tower. It strikes the ground after 3 sec. and its final velocity makes an angle of 45° with the horizontal. Find the initial speed of the object. ($g = 10\ m/s^2$)

Q8. While walking, a 30 Kg boy presses the ground with his back foot at an angle of 60° with the horizontal. Find (i) the force that helps him to move forward (ii) the force which the body exerts normally on the ground.

Q9. Derive the 3rd equation of motion.

Q10. Two blocks of masses 50 kg and 30 kg connected by a massless string pass over a pulley as shown: Find the acceleration of the masses and tension in the string.



Q11. (a) Prove that the acceleration due to gravity varies with depth below the earth's surface as $g' = g\left[1 - \frac{d}{R}\right]$ where d is the depth from the earth's surface.

(b) Draw a graph showing variation of acceleration due to gravity with distance from the centre of earth.

Q12. (a) Dimensionally, check the equation : $v = \frac{1}{l}\sqrt{\frac{T}{m}}$ where, v : velocity, l : length, T : Tension, m : mass

(b) Force and density are related as $F = \frac{\alpha}{\beta + \sqrt{d}}$. Find the dimensions of α and β.

Q13. (a) Derive a formula for centripetal acceleration.

(b) A body moves in a circle of radius 100 cm with a time period of 2 seconds. Find the acceleration of the body.

Q14. Derive an expression for the orbital velocity of a satellite. Using it, verify the Kepler's 3rd law.

Q15. A monkey of mass 40 kg climbs on a rope which can withstand a maximum tension of 500N. In which of the following cases, will the rope break :

the monkey (a) climbs up with an acceleration of 4 m/s^2 (b) climbs down with an acceleration of 4 m/s^2 (c) climbs up with a uniform speed of 4 m/s (d) falls down the rope nearly freely.

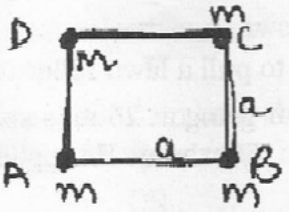
Q16. (a) Find the number of significant figures in 0.0230 cm.

(b) Calculate the percentage error in x, given by the formula : $x = \frac{4ab^2}{3\sqrt{c}}$ where the % errors in a, b and c are 4%, 2% and 6% resp.

Q17. What do you understand by gravitational field and gravitational potential? What is the significance of negative potential of earth?

OR

Calculate the net gravitational force acting on mass at vertex A.



Q18. (i) Find the value of x so that $\hat{A}$ is a unit vector :

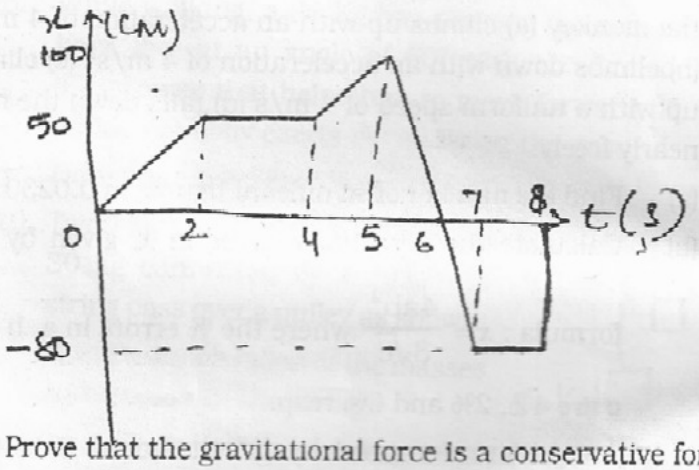
$$\hat{A} = x\,\hat{i} + 0.4\,\hat{j} + 0.2\,\hat{k}$$

(ii) Find the vector perpendicular to the given vectors :

$$\hat{A} = \hat{i} + \hat{j} + \hat{k} \text{ and } \hat{B} = \hat{i} - \hat{j} + \hat{k}$$

Q19. A stationary man holds his umbrella at 30° with vertical to keep the rain away. He now, starts running at 10 km/h and finds that the raindrops hit his umbrella vertically. Find the speed of raindrops (i) wrt the road (ii) wrt the moving man.

Q20. Following figure shows the position-time graph of an object. Find (i) the particle's speed at t = 1.5s. (ii) average velocity (iii) average speed.



Q21. Prove that the gravitational force is a conservative force.

Q22. Give reasons :

(a) When a man jumps from a boat to the shore, the boat slightly moves away from the shore.

(b) It is easy to catch a table tennis ball than a cricket ball, even when both are moving with the same velocity.

(c) It is easier to pull a lawn roller than to push it.

Q23. The driver of a car going at 25 m/s spots a child playing on the road about 150m away. He applies brakes and stops his car in 10s.

(a) Will the driver be able to save the child? What values are associated to the driver of the car?

(b) Plot the velocity time graph for the car.

Q24. State the parallelogram law of vectors. Derive the expression for the resultant of two vectors inclined at an

angle of θ with each other. Find the angle between two forces (A + B) and (A – B) such that their resultant is $\sqrt{3A^2 + B^2}$

OR

(a) Obtain the formula for the range and time of flight for a projectile projected at angle θ to the horizontal.

(b) A body of mass = 2 kg moves along X-axis such that its x coordinate varies with time as : $x = 5t^4 - 3t^3 + t$. What is the force acting on the object at $t = 1$ sec?

Q25. (a) What provides the necessary centripetal force to a vehicle moving on a levelled circular road? With the help of a neat diagram, explain it. Also obtain the expression for the maximum velocity with which, the vehicle can be moved without skidding on a levelled circular road.

(b) Why is banking of roads necessary. Explain using a well labelled diagram.

OR

(a) Calculate the minimum velocities at the lowest and the highest point in case of a vertical circle.

(b) The bridge over a canal is in the form of an arc of circle 20m. What is the maximum speed with which a car can cross the bridge without leaving contact with the ground at highest point?

Q26. Calculate the final velocities of two bodies after elastic collision in 1 dimension.

Discuss what happens when both the bodies are of equal masses, travelling with speeds u_1 and u_2.

OR

(a) Prove that mechanical energy is conserved when an object falls freely.

(b) Find the height (h') from ground when KE of the object becomes equal to the PE in terms of the height (h) from which the object falls.