

**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. All the sections are compulsory.
- (3) Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 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

**SECTION A**

Multiple Choice Questions. Write the correct option along with the word or statement (1x16=16)

- |    |  |
|----|--|
| 1) | Which of the following is dimensionless<br>(a) force/acceleration                      (b) velocity/acceleration<br>(c) volume/area                                (d) energy/work   |
| 2) | The displacement-time graph of moving particle is shown below<br>The instantaneous velocity of the particle is negative at the point<br>(a) A<br>(b) B<br>(c) D<br>(d) E   |
|    |  |
| 3) | Two balls are dropped from a height $h$ and $3h$ respectively from the earth's surface. The ratio of time of these balls to reach the earth is<br>(a) $1:\sqrt{3}$ (b) $\sqrt{3}:1$ (c) $3:1$ (d) $1:3$  |
| 4) | Then horizontal range of projection is $4\sqrt{3}$ times of its maximum height. The angle of projection of the projectile will be<br>(a) $40^\circ$ (b) $90^\circ$ (c) $30^\circ$ (d) $45^\circ$   |
| 5) | The pair of the quantities having the same dimensions is<br>(a) displacement, velocity                      (b) time, frequency<br>(c) wavelength, focal length                      (d) force, acceleration   |
| 6) | A ball is thrown vertically upward. Ignoring the air resistance, which one of the following plots represents the velocity-time plot for the period ball remains in air?<br><div style="display: flex; justify-content: space-around; align-items: flex-end; margin-top: 10px;"> <div style="text-align: center;"> <p>(a)</p> </div> <div style="text-align: center;"> <p>(b)</p> </div> <div style="text-align: center;"> <p>(c)</p> </div> <div style="text-align: center;"> <p>(d)</p> </div> </div> |
| 7) | An ice cube is kept on an inclined plane of angle $30^\circ$ . Coefficient of kinetic friction between block and inclined plane is $1/\sqrt{3}$ . What is the acceleration of the block?<br>(a) Zero                      (b) $2 \text{ m/s}^2$ (c) $1.5 \text{ m/s}^2$ (d) $5 \text{ m/s}^2$  |
| 8) | Which of the following statements is false for a particle moving in a circle with constant angular speed?  |

- (a) The velocity vector is tangent to the circle.  
 (b) The acceleration vector is tangent to the circle  
 (c) The acceleration vector points to the centre of the circle  
 (d) The velocity and acceleration vectors are perpendicular to each other.

9) A body is initially at rest. It undergoes one-dimensional motion with constant acceleration. The power delivered to it at time  $t$  is proportional to  
 (a)  $t^{1/2}$  (b)  $t$  (c)  $t^{3/2}$  (d)  $t^2$

10) On a banked road, which force is essential to provide the necessary centripetal force to a car to take a turn while driving at the optimum speed?  
 (a) Component of normal reaction (b) Component of frictional force  
 (c) Both (a) & (b) (d) None of these

11) A body is moving unidirectionally under the influence of a source of constant power. Its displacement in time  $t$  is proportional to  
 (a)  $t^{1/2}$  (b)  $t$  (c)  $t^{3/2}$  (d)  $t^2$

12) Every action has an equal and opposite reaction, which suggests that  
 (a) action and reaction always act on different bodies.  
 (b) the forces of action and reaction cancel each other.  
 (c) the forces of action and reaction cannot cancel each other.  
 (d) Both (a) and (c)

**Question numbers 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.**

- (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).  
 (b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).  
 (c) Assertion (A) is true, but Reason (R) is false.  
 (d) Assertion (A) is false and Reason (R) is also false.

13) Assertion(A): A body can have acceleration even if its velocity is zero at that instant of time.  
 Reason (R): The body will be momentarily at rest when it reverses its direction of motion.

14) Assertion: Area under velocity-time graph give displacement.  
 Reason: Area under acceleration-time graph give velocity.

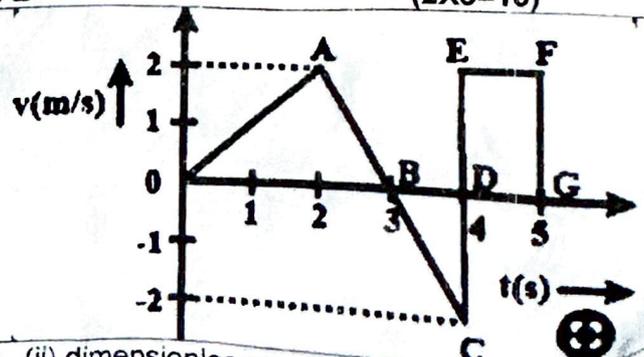
15) Assertion(A): Force and acceleration cannot be added.  
 Reason (R): Only the quantities having same dimensions can be added.

16) Assertion: No work is done if the displacement is zero  
 Reason: Work done by the force is defined to be the product of component of the force in the the direction of the displacement and the magnitude of displacement.

**SECTION B**

(2X5=10)

Q17 The velocity-time graph of a particle moving along a straight line is shown in the figure gives below. Calculate the distance and displacement of the particle in 5 second.



Q18 State two examples of each (i) dimensional constant (ii) dimensionless variable.  
 OR

Find the dimensions of a and b from the equation  $F = a\sqrt{x} + bt^2$  where, F is force, x is distance and t is time.

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- Q19 The velocity of a particle is given by the equation  $v = 2t^2 + 5$  cm/s. Find
- the change in velocity of the particle during the time interval between  $t_1=2s$  and  $t_2 =4s$ .
  - The average acceleration during the same interval.
  - Instantaneous velocity and acceleration at  $t = 4s$ .

Q20 An insect is trapped in a circular groove of radius 12cm moves along the groove steadily and completes 7 revolutions in 100s. What is the angular speed and linear speed of the motion? What is the value of acceleration here?

- Q21 Write the number of significant figures in each of the following
- (i) 36.42      (ii)  $1.67 \times 10^{-27}$  kg      (iii) 3400      (iv)  $0.007m^2$       (4,3,2,1)

**SECTION C** **(3X7=21)**

Q22 What is meant by banking of the roads and why is it needed? Obtain an expression for maximum speed  $v_{max}$  with which a vehicle can safely negotiate a curved road banked at angle  $\theta$ . The coefficient of friction between the wheels and the road is  $\mu_s$ .

Q23 A particle starts from origin at  $t=0$  with a velocity  $5i$  m/s moves in x-y plane under action of a force which produces constant acceleration of  $(3i+2j)$  m/s<sup>2</sup>.

- what is the y coordinate of the particle at the instant its x coordinate is 84m.
- what is the speed of the particle at this time.

Q24 Assuming that the mass m of the largest stone that can be moved by a flowing river depends on velocity v, density of water  $\rho$  and on acceleration due to gravity g. Show that m varies with sixth power of the velocity of flow. (use dimensional analysis)

Q25 A food packet is released from a helicopter which is rising steadily at 2m/s.

- After 2 s what is the velocity of the packet?
- How far is it below the helicopter? Take  $g = 9.8m/s^2$ .

**OR**

A parachutist bails out from an aeroplane and after dropping through a distance of 40 m, he opens the parachute and decelerates at  $2 m/s^2$ . If he reaches the ground with a speed of 2m/s, how long is he in the air? At what height did he bail out from the plane? Take  $g = 9.8m/s^2$ .

Q26 Find the angle between force  $F = (3i + 4j - 5k)$  unit and displacement  $d = (5i + 4j + 3k)$  unit. Also find the projection of F on d.

Q27 State and derive the work -energy theorem for a variable force.

**OR**

- Draw a plot of spring force versus displacement and hence derive an expression for the potential energy of an elastic stretch of spring.
- Draw the graphs to show the variation of P.E. with extension of the spring.

Q28 Derive the three equations of motion by graphical method.

**SECTION D** **(4X2=08)**

Q29 Work energy theorem states that – change in kinetic energy of a body is equal to the work done by the net force. In deriving the theorem, it is assumed that force is effective only in changing the KE. When the force and displacement are in same direction, KE increases and work done is positive. When the force and displacement are in opposite direction, KE decreases and work done is negative. When the body is in uniform motion, KE does not change and work done by centripetal force is zero.

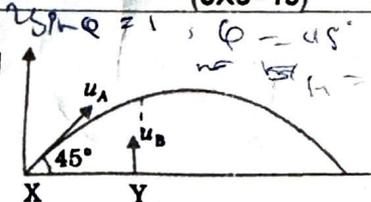
- One body of mass 8kg and another of mass 2 kg are moving with equal kinetic energy. What is the ratio of their respective momenta?
- If momentum of a body decreases by 20%, how will its kinetic energy change?
- Can there be a situation where  $(E - V)$  is less than zero?  
 (E is total energy and V is potential energy)
- A body of mass 10 kg initially at rest acquires a velocity of 10m/s. What is the work done?

- Q30** According to Newton's second law of motion  $F = ma$ , where  $F$  is the force required to produce an acceleration  $a$  in a body of mass  $m$ . If  $a=0$  then  $F=0$ , i.e. no external force is required to move a body uniformly along a straight line. If force acts on a body for  $t$  seconds, the effect of the force is given by impulse =  $F\Delta t$  = change in linear momentum of the body.
- (i) A cricket ball of mass 150g is moving with a velocity of 12m/s and is hit by a bat so that the ball is turned back with a velocity of 20m/s. If the duration of contact between the ball and the bat is 0.01 sec. The impulse of the force is
    - (a) 7.4Ns
    - (b) 1.2Ns
    - (c) 4.8Ns
    - (d) 4.7Ns
  - (ii) Average force exerted by the bat is
    - (a) 480N
    - (b) 120N
    - (c) 1200N
    - (d) 840N
  - (iii) The retardation of the ball is
    - (a) 1600 m/s<sup>2</sup>
    - (b) 320 m/s<sup>2</sup>
    - (c) 3200 m/s<sup>2</sup>
    - (d) 160 m/s<sup>2</sup>
  - (iv) An impulsive force of 100N acts on a body for 1s. What is the change in its linear momentum?
    - (a) 100 Ns
    - (b) 10 Ns
    - (c) 1000 Ns
    - (d) 1Ns

**SECTION E**

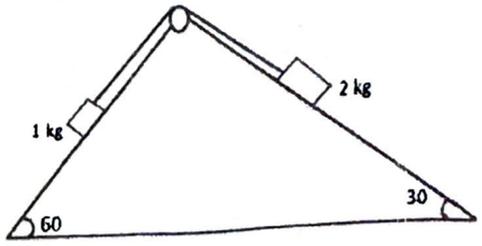
(3X5=15)

- Q31**
- (a) Obtain the condition for the maximum horizontal range.
  - (b) Two bodies A and B are projected simultaneously from points X and Y as shown in fig. with velocities  $u_A$  and  $u_B$  respectively. Find the ratio of velocities for both the bodies to collide
- OR**
- (a) A body is projected with a speed  $u$  at an angle to the horizontal to have maximum range. What is its velocity at the highest point?
  - (b) A bullet fired at an angle of 30° with the horizontal hits the ground 3km away. By adjusting the angle of projection, can one hope to hit the target 5km away?



- Q32**
- (a) Prove that when a particle suffers an oblique elastic (2D) collision with another particle of equal mass and initially at rest, the two particles would move in mutually perpendicular direction after collision.
  - (b) A ball moving with a speed of 9m/s strikes an identical stationary ball such that after the collision the direction of each ball makes an angle of 30° with the original line of motion. Find the speed of the two balls after the collision and state whether the kinetic energy is conserved or not?
- OR**
- (a) Show that when two bodies of equal masses suffer one dimensional elastic collision, their velocities get exchanged after collision.
  - (b) A 10kg ball and 20kg ball approach each other with velocity 20m/s and 10m/s respectively. What are their velocities after collision if the collision is perfectly elastic?

- Q33**
- (a) Two blocks of mass 1 kg and 2kg are connected by an inextensible string which passes over a frictionless pulley as shown in the figure. Calculate the tension and acceleration of these blocks.
  - (b) Prove with the help of the diagram that pulling is easier than pushing for the situation when force is applied at an angle.



**OR**

- (a) What is the acceleration of the block and trolley system shown in the figure, if the coefficient of kinetic friction between the trolley and the surface is 0.04? What is the tension in the string? (Take  $g = 10 \text{ m/s}^2$ ). Neglect the mass of the string.
- (b) Prove the law conservation of momentum?

