1. Newton's first law of motion states that every particle continues to be in a state of rest and if already in motion, it will continue in motion with uniform velocity unless a resultant force acts on it.
2. The momentum is defined as the product of the mass of the object and the velocity.
3. Impulse of a force is defined as the product of the force and the time with which it acts.
4. Newton's second law of motion states that the time rate of change of momentum is directly proportional to the applied resultant force and the momentum change takes place in the direction of the force.
5. Newton's third law states that to every action there is an equal and opposite reaction.
6. The law of conservation of linear momentum states that during collisions in which the colliding objects and the product bodies are not acted upon by an externally applied force, the sum of linear momentum before collision is equal to the sum of linear momentum after the collision.
7. The collision of two or more bodies can be classified into either elastic or inelastic. The law of conservation of momentum is conserved in both classes of collision.
8. Whenever two bodies are in contact with each other, there is always a resistance to motion experienced by the surfaces of the two bodies. This resistance to motion is referred to as force of friction, or simply, friction. Friction occurs for solid, liquid and gases. Basically, two kinds of friction exist between two solid surfaces. They are: static and sliding (kinetic).

Self-Assessment Questions (SAQs) for Chapter4

4.1. A body A of mass 1.5kg, travelling along the positive x-axis with speed 4.5m/s, collides with another body B of mass 3.2kg which, initially, is at rest. Because of the collision, A is deflected and

moves with a speed 2.1m/s in a direction which is at angle 30° below the x-axis. B is set in motion at an angle θ above the x-axis. Calculate the velocity of B after the collision.

4.2. A man of mass 80kg stands next to a stationary ball of mass 4kg on a frictionless surface. He kicks the ball forward along the surface with a speed 15m/s. Calculate the man's recoil speed.

4.3. A hose directs a horizontal jet of water, moving with a velocity of 20m/s, on to a vertical wall. The cross-sectional area of the jet is $5 \times 10^{-4}\text{m}^2$. If the density of water is 1000kgm^{-3}, calculate the force on a wall assuming the water is brought to rest there.

4.4. A ball A of mass 0.1kg, moving with a velocity of 6m/s, collides head-on with a ball B of mass 0.2kg at rest. Calculate their common velocity if both balls move off together. If A had rebounded with a velocity of 2m/s in the opposite direction after collision, what would be the new velocity of B?

4.5. In the system shown in Figure 4.8, a force 80N accelerates the 5kg body to the right. Find the acceleration of the motion if the coefficient of kinetic friction is 0.44.

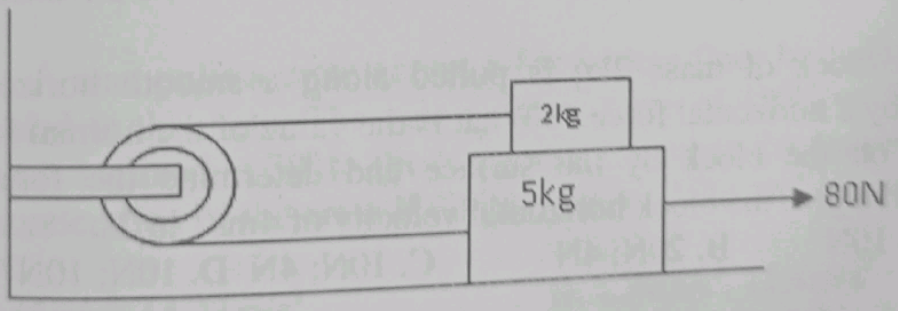


Figure 4.8: SAQ 4.5

4.6. A block of mass 20kg is at rest on a rough horizontal ground. The coefficient of friction between the block and the ground is 0.3. A horizontal force F is applied steadily to the block according to the law: $F = t^2 - t + 4$, F is innewtons and t is the time in seconds. Calculate the time it takes the block to start moving. What is the speed of the block when $t = 4.0$s?

4.7. A constant force acts on a 2.0kg object and reduces its velocity from 7.0m/s to 3.0m/s in a time of 3.0s. What is the magnitude of the force?

4.8. An 8000kg engine pulls a 40 000kg train along a level track and gives it an acceleration $1.20m/s^2$. What acceleration would the engine give to a 16 000kg train?

4.9. A 300g mass hangs at the end of a string. A second-string hang from the bottom of that mass and supports a 900g mass. (a) Find the tension in each string when the masses are accelerating upward at $0.700m/s^2$. (b) Find the tension in each string when the masses are accelerating downward at $0.700m/s^2$.

4.10. A horizontal force of 200N is required to cause a 15kg block to slide up a 20° incline with an acceleration of $25cm/s^2$. Find (a) the friction force on the block and (b) the coefficient of friction.

4.11. A lawn tennis ball of mass m and speed v strikes a wall perpendicularly and rebounds with undiminished speed. If the time of collision is t, what is the average force exerted by the ball on the wall?

A. mv/t B. $mv/2t$ C. $2mv/t$ D. $4mv/t$

4.12. A block of mass 2kg is pulled along a smooth horizontal surface by a horizontal force P. What is the value of the normal force exerted on the block by the surface and determine the force P required to give the block horizontal velocity of $4ms^{-1}$ in 2s.

A. 20N; 10N B. 20N; 4N C. 10N; 4N D. 10N; 10N

4.13. A block of mass m_1 = 2kg on a smooth horizontal surface which is pulled by a string which is attached to another block m_2 = lkg hanging over a pulley, as shown in Figure 4.9. The acceleration of the system and the tension in the string are given as:

A. $2.2ms^{-2}$; 60N B. $3.3ms^{-2}$; 6N

C. $4ms^{-2}$ 6.5N D. $3.3ms^{-2}$; 6.7N

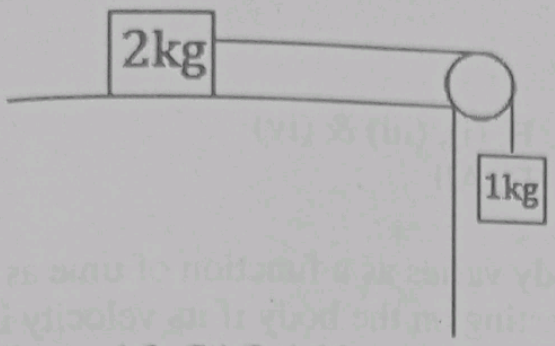


Figure 4.9: SAQ 4.13

4.14. Three forces act on a particle that moves with unchanging velocity $\mathbf{v}= (3m/s)\mathbf{i}- (4m/s)\mathbf{j}$. Two of the forces are $\mathbf{F}_1 = (2N)\mathbf{i} + (3N)\mathbf{j}+(-2N)\mathbf{k}$ and $\mathbf{F}_2 = (-5N)\mathbf{i} + (8N)\mathbf{j} +(-2N)\mathbf{k}$. What is the third force?

A. $(3N)\mathbf{i} +(-11N)\mathbf{j} + (4N)\mathbf{k}$
B. $(-11N)\mathbf{i} + (3N)\mathbf{j} +(4N)\mathbf{k}$
C. $(4N)\mathbf{i} + (3N)\mathbf{j}+(-11N)\mathbf{k}$
D. $(3N)\mathbf{i} +(4N)\mathbf{j}+ (-11N)\mathbf{k}$

4.15. A car that weighs 1.3×10^4N was initially moving at a speed of 40km/h when the brakes were applied. The car was brought to a stop in 15m. If the force that stops the car is constant, find the magnitude of that force and the time required to bring the car to a stop.

A. 5.33×10^3N, 1.35s
B. 5.33×10^3N, 2.7s
C. 5.45×10^3N, 1.35s
D. 5.45×10^3N, 2.7s

4.16. A man pulls a crate across a frictionless floor by pulling on a rope tied to the crate. The man exerts a force of 450N on the rope which is inclined at 38° to the horizontal. Calculate the magnitude of the acceleration of the crate if (i) its mass is 310kg and (ii) weight is 310N.

A. $1.45m/s^2$, $14.23m/s^2$
B. $1.14m/s^2$, $11.4m/s^2$
C. $1.45m/s^2$, $1.45m/s^2$
D. $14.23m/s^2$, $14.23m/s^2$

4.17. Which of the following is/are true of friction?
(i) Limiting friction is proportional to normal reaction
(ii) Dynamic friction is greater that static friction
(iii) Friction and the horizontally applied force are not equal when acceleration $\neq 0$

(iv) Friction opposes motion
A. (i), (ii) & (iv) B. (i), (iii) & (iv)
C. (i), (ii) and (iv) D. All

4.18. The mass of a certain body varies as a function of time as $m(t) = m_o e^{-0.5t}$. Find the force, inN, acting on the body if its velocity is $v(t) = 2\mathbf{i}$m/s. $\mathbf{i}$ is a unit vector in the x-direction.
A. $\mathbf{i}(2-t)m_o e^{-0.5t}$ B. $2\mathbf{i}m_o e^{-0.5t}$
C. $-0.5\mathbf{i}m_o e^{-0.5t}$ D. $\mathbf{i}(t-2)m_o e^{-0.5t}$

4.19. A tennis ball has a mass of 0.06kg. The impact with a wall changes its velocity from 25m/s towards the wall to 35m/s away from the wall. Determine the impulse the wall exerts on the tennis ball.
A. 2.16Ns B. 21.6Ns C. 3.6Ns D. 0.36Ns

4.20. A man kicks a stationary ball of mass 200g, giving it a speed of 100cm/s. What impulse is imparted to the ball?
A. 0.2kgm/s B. 20kgm/s C. 2kgm/s D. 200kgm/s

4.21. Two forces act at a single point as shown in Figure 4.10.What is the magnitude of the resulting force?
A. 15N B. 22N C. 27N D. 30N

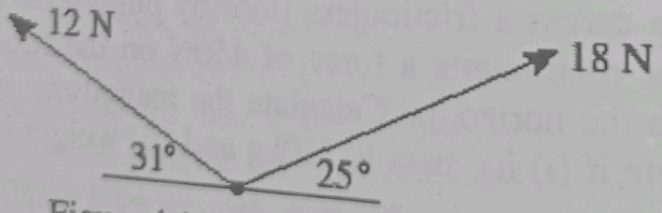


Figure 4.10: Activity 4.21

4.22. A force of 45N is applied at an angle of 35° above the horizontal to pull a 21kg crate across a floor as shown in Figure 4.11. What is the normal force on the crate? Take $g = 9.8\text{m/s}^2$.
A. 26N B.170N C. 180N D. 210N

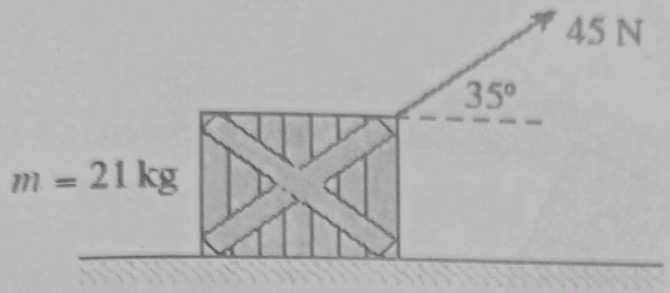


Figure 4.11: Activity 4.22

4.23. A frictionless pulley is set up with two hanging masses as shown in Figure 4.12. Calculate the tension in the rope. Take $g = 9.8 m/s^2$.

A. 8.5N B. 24N C. 26N D. 32N

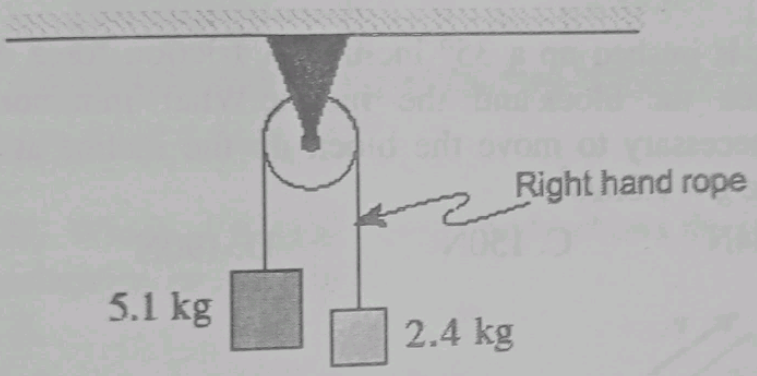


Figure 4.12: Activity 4.23

4.24. Two masses are connected by a rope and pulley on a frictionless inclined plane as shown in Figure 4.13.When the system is released, what is the initial acceleration of the 21 kg mass? Take $g = 9.8 m/s^2$.

	MAGNITUDE OF THE ACCELERATION	DIRECTION THE MASS WILL TRAVEL
A.	$0.26\ m/s^2$	up the incline
B.	$0.26\ m/s^2$	down the incline
C.	$0.48\ m/s^2$	up the incline
D.	$0.48\ m/s^2$	down the incline

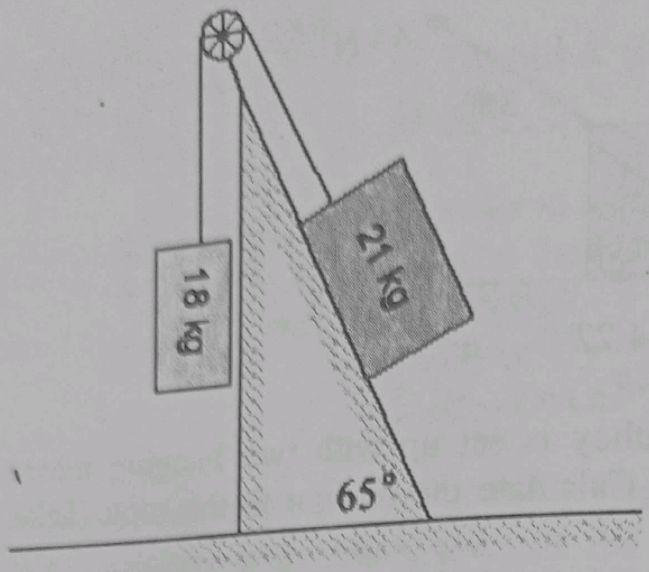


Figure 4.13: Activity 4.10

4.25. A 15kg block is pushed up a 35° incline. A friction force of 110N exists between the block and the incline.What minimum force F, would be necessary to move the block up the incline at a constant speed? Take $g = 9.8 m/s^2$.

A. 26N B. 84N C. 150N D. 190N

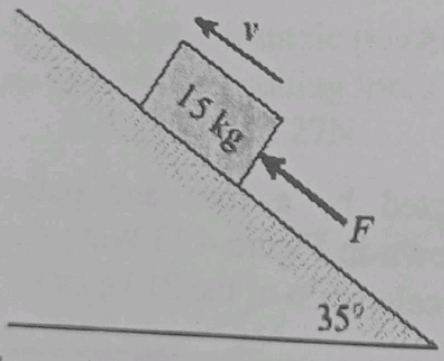


Figure 4.14: Activity 4.25

4.26. An 800kg dragster is being decelerated by a parachute at $2.5 m/s^2$ as shown in Figure 4.15.What is the tension in the cord at this moment?

A. 0 N B. 2.0×10^3 N C. 5.9×10^3 N D. 7.9×10^3 N

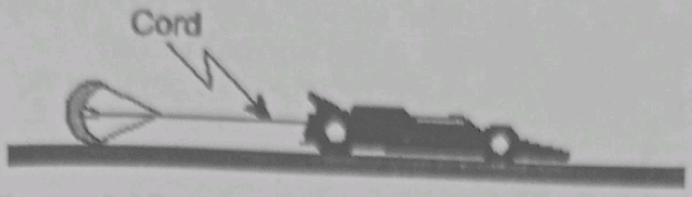


Figure 4.15: Activity 4.26

4.27. The system of blocks on a frictionless surface in Figure 4.16 is accelerating at 2.0 m/s^2.What is the tension in the cord at X?

A. 2.0 N B. 6.0 N C. 8.0 N D. 16 N

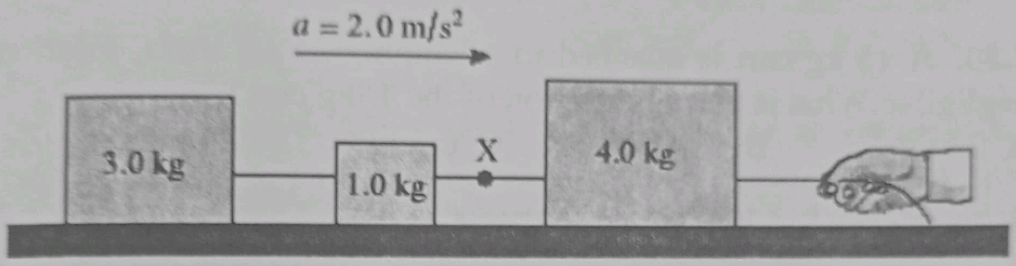
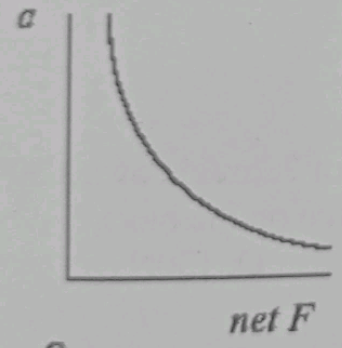


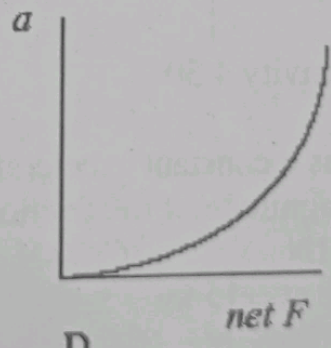
Figure 4.16: Activity 4.27

4.28. Which of the following graphs shows the relationship between acceleration and net force?

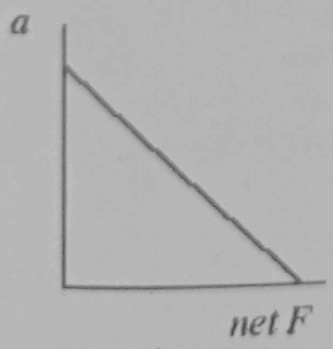
A.



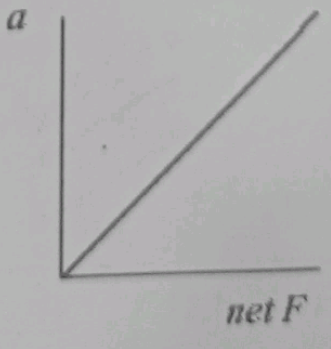
B.



C.



D.



4.29. A 15 kg block on a horizontal surface has a 100 N force acting on it as shown in Figure 4.17.What is the normal force?

A. 47N B. 100N C. 147N D. 247N

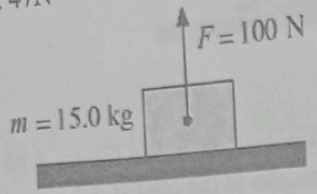


Figure 4.17: Activity 4.29

4.30. A 15 kg cart is attached to a hanging 25 kg mass. Friction is negligible.What is the acceleration of the 15kg cart?

A. 2.5m/s^2 B. 6.1m/s^2 C. 6.5m/s^2 D. 16m/s^2

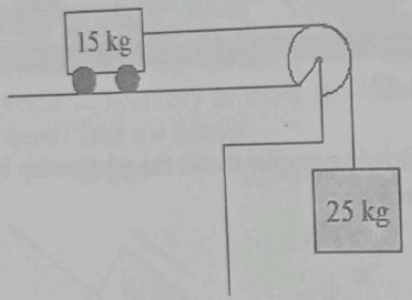


Figure 4.18: Activity 4.30

4.31. A 15kg block has a constant acceleration of 2.2m/s^2 down a 30° incline.What is the magnitude of the friction force on the block?

A. 33N B. 41N C. 74N D. 130N

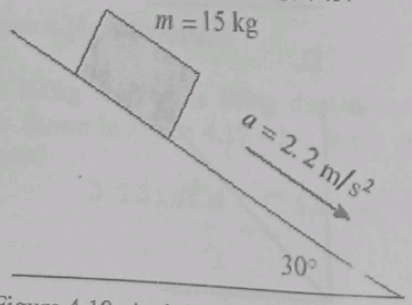


Figure 4.19: Activity 4.31

4.32. An 80kg man stands on a spring scale while accelerating upwards in an elevator. If the scale indicates that his "weight" is 980N, what is the magnitude of the acceleration of the elevator in meters per second squared?

A. 2.5 B. 10 C. 12.3 0.08

4.33. State the law of conservation of linear momentum.

4.34. A high diver of mass 74.0kg jumps off a board 9.00m above the water. If his downward motion is stopped 2.50s after he enters the water, what average upward force did the water exert on him?

A. 1.12N B. 0.332kN C. 0.393kN D. 0.725kN

4.35. A 2.50-kg mass is observed to accelerate at 16.0m/s^2 in a direction 39.0° north of east.The force F_2 acting on the mass has a magnitude of 25.2N and is directed north. Determine the magnitude and direction of the force F_1 acting on the mass.

A. 31.1N east B. 32.3N east C. 32.3N west D. 25.2Neast

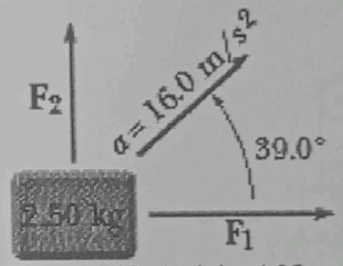


Figure 4.20: Activity 4.35

4.36. The system shown in Figure 4.21 has an acceleration of magnitude 2.00 m/s^2.Assume the coefficients of kinetic friction between block and incline are the same for both inclines. Find (a) the coefficient of kinetic friction and (b) the tension in the string.

A. (a) 0.0563;(b) 34.9N B. (a) 0.141; (b) 41.6N
C. (a) 0.146; (b) 28.8N D. (a) 0.366; (b) 28.8N

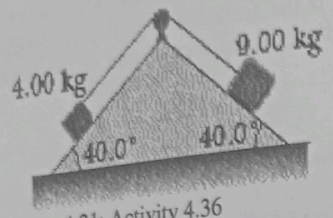


Figure 4.21: Activity 4.36

4.37. State the Newton's laws of motion.

4.38. An 18 kg cart is connected to a 12 kg hanging block as in Figure 4.22. (Ignore friction). a) Draw and label a free body diagram for the 18kg cart.
b) What is the tension in the cord connecting the two carts?

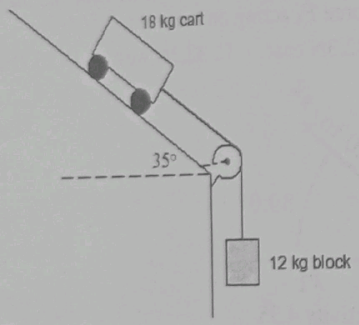


Figure 4.22: Activity 4.38

4.39. Two masses are connected by a light string over a frictionless massless pulley. There is a coefficient of friction of 0.27 between mass m_1 and the horizontal surface. (a) Draw and label a free body diagram showing the forces acting on mass m_1.
(b) What is the acceleration of mass m_2?

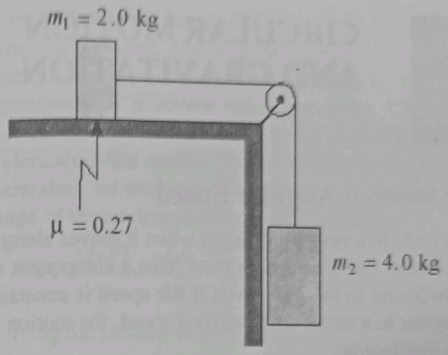


Figure 4.23: Activity 4.39

4.40. A 35N force applied at 21° to the horizontal is used to pull a mass as shown in Figure 4.24.The coefficient of friction between the floor and the mass is 0.15.
(a) Draw and label a free body diagram showing the forces acting on the mass.
(b) What is the acceleration of the mass?

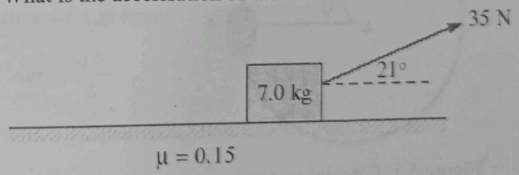


Figure 4.24: Activity 4.24

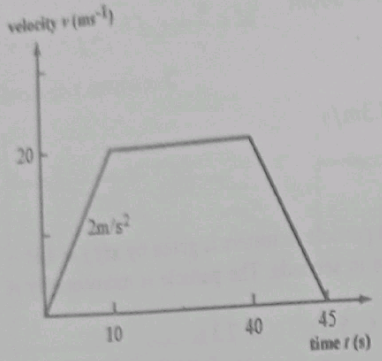


Figure 3.24: Activity 3.59

Total displacement $= \frac{1}{2}(30 + 45) \times 20 \text{ m} = 750 \text{ m}.$

3.60. In projectile motion, the
A. Acceleration is parallel to the velocity.
B. Acceleration is perpendicular to the velocity.
C. Acceleration is vertical while the velocity can be in any direction.
D. Acceleration reaches its minimum value at the top of the trajectory.

Solution

The correct option is C.

Summary of Chapter 3

In chapter 3, you have learnt that:

1. Mechanics, a branch of physics, is usually divided into two parts: kinematics and dynamics.
2. Speed can be defined as the rate of change of distance with time. There are two ways in which the speed of a particle is defined: average speed and instantaneous speed.

3. Velocity is defined as the rate of change of displacement with time.
4. Acceleration is defined as the time rate of change of velocity. It is a vector quantity.
5. All bodies at a location fall with the same downward acceleration, regardless of their size or weight.
6. A projectile motion is two-dimensional, and we can treat the x- and y-coordinates separately. The x-component of acceleration due to gravity g is zero since g is acting vertically downward; the y-component is constant and equal to $-g$.

Self-Assessment Questions (SAQs) for Chapter3

3.1. A stone of mass 2kg is thrown vertically upward with a speed of 20m/s. Calculate the maximum height reached.

3.2. A baseball is thrown vertically upward with an initial speed of 20m/s. Calculate how fast it was travelling on its way down when caught 5.0 m above where it was thrown.

3.3. Calculate the average speed of a car travelling from rest and covering 1200m in one minute.

3.4. A car accelerates uniformly at 3m/s^2 covering 70m in 5s. Calculate the initial and final velocities.

3.5. A ball is thrown straight downward with non-zero initial speed from a height of 50m. Calculate the initial speed if it takes the ball 2s to strike the ground. With what speed will it strike the ground?

3.6. A cliff is 20m above the ground. A boy rolls a ball off the edge with unknown initial velocity and it strikes the ground 3m horizontally away. Calculate (a) the ball's initial velocity, (b) its time of flight, and (c) the magnitude and the direction of its velocity when it strikes the ground.

3.7. A train moving with a velocity of 10m/s accelerates uniformly at $1m/s^2$ until it reaches a velocity of 15m/s. Calculate (i) the time taken, (ii) the distance travelled during the acceleration, (iii) the velocity reached 100 m from the place where the acceleration began.

3.8. A car is accelerating uniformly as it passes two points *A* and *B*whichare 30m apart. The time taken between the two points is 4.0s, and the car's speed at point *A* is 5.0m/s. Find the car's acceleration and its speed at point *B*.

3.9. A wooden box slides down an incline plane with uniform acceleration. It starts from rest and attains a speed of 10m/s in 3.0s. Find (a) the acceleration and (b) the distance moved in the first 6.0s.

3.10. A projectile is launched with 30.0m/s at an angle of 60.0° with the horizontal. (a) Find the position of the projectile, and the magnitude and direction of its velocity at $t = 2.0$ s (b) Find the time when the ball reaches the highest point. (c) Find the horizontal range.

3.11. An elementary particle with initial velocity of 1.50×10^5m/s enters a region where it is electrically accelerated, with its velocity reaching 5.70×10^6m/s. Calculate its constant acceleration after travelling for 1.0cm.

3.12. A car moving with constant acceleration covered the distance between two points *X* and *Y*,100.0m apart in 1.0s. Its speed as it passes the second point was 50.0m/s. What was the speed at the first point and what was the acceleration?

3.13. The speed of a car travelling due west is uniformly reduced from $20.0ms^{-1}$ to $10.0ms^{-1}$ in 80.0m. What is the magnitude of the deceleration and how much time has elapsed during this deceleration?

3.14. A man throws a ball vertically upwar . with an initial speed of 60.0m/s. What is the maximum height reached by the ball and how long does it take to return to the point it was thrown?

3.15. A projectile is launched with an initial velocity of 60m/s at an angle 60° to the vertical. What is the magnitude of its displacement after 5s?

3.16. A missile was to be launched at an angle 15° to the horizontal at an initial velocity v_o to hit a target 300m away. Calculate v_o and the maximum height *H*.

3.17. An object of mass 50g is projected at angle 60° to the horizontal with an initial speed of 20m/s. Calculate the horizontal range and the time taken to reach maximum height.

3.18. A footballer lobs a football at an angle of 30° to the horizontal with an initial speed of $20ms^{-1}$. What are the greatest height attained and the time of flight?

3.19. A car moving at a speed of 30m/s decelerates at a constant rate of $2.0m/s^2$. How far does it go before stopping?

3.20. A car moving at 20m/s slows uniformly to a speed of 5m/s in a time of 10s. Determine the distance travelled in the fifth second.

3.21. What is the total displacement of a trip in which a person travels 10 km[N] and then 24 km[E]?

3.22. A baseball pitcher is warming up as he travels to a game by plane. The plane is flying at 400 km/h[W] relative to the ground. The pitcher throws a ball at 150 km/h relative to the airplane. What is the ball's velocity relative to the ground, if the pitcher throws the ball towards
(a) the front of the plane?
(b) the rear of the plane?

3.23. A jet plane travelling horizontally at 1200 km/h relative to the ground fires a rocket forwards at 1100 km/h relative to itself. What is the velocity of the rocket relative to the ground?

3.24. A boat is travelling upstream at 5 km/h[N] relative to the shore. If there is a current of 7 km/h[S], what is the boat's velocity relative to the water?

3.25. A swimmer jumps into a river and swims straight for the other side at 1.5 km/h[N] relative to the water. There is a current in the river of 2.0 km/h[W]. What is the swimmer's velocity relative to the shore?

3.26. A plane has a velocity of 300 km/h relative to the air. If the pilot points the plane straight north, when there is a wind of 80 km/h blowing towards the west, what will the resultant velocity of the plane be?

3.27. The position of a particle is given as $s = (3t^3 + 5t^2 + 6t - 20)m$. Calculate the average velocity between 2s and 3s. Calcuate, also, the velocity at 2s.