Force and Laws of Motion

Multiple Choice Questions

1. Which of the following statement is not correct for an object moving along a straight path in an accelerated motion?
(a) Its speed keeps changing
(b) Its velocity always changes
(c) It always goes away from the earth
(d) A force is always acting on it

Ans. (c) It always goes away from the earth
Explanation: To move away from the earth, an object needs the acceleration which is more than acceleration due to gravity. Only moving on a straight path is not enough for an object to escape the gravitation of the earth.

2. According to the third law of motion, action and reaction
(a) always act on the same body
(b) always act on different bodies in opposite directions
(c) have same magnitude and directions
(d) act on either body at normal to each other

Ans. (b) always act on different bodies in opposite directions
Explanation: Action and reaction act on different bodies but in opposite directions. They have the same magnitude.

3. A goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal. This enables the goal keeper to
(a) exert larger force on the ball
(b) reduce the force exerted by the ball on hands
(c) increase the rate of change of momentum
(d) decrease the rate of change of momentum

Ans. (b) reduce the force exerted by the ball on hands
Explanation: Pulling the hand backwards allows enough time to reduce the momentum of the ball. This helps in reducing the force exerted by the ball on hands.

4. The inertia of an object tends to cause the object
(a) to increase its speed
(b) to decrease its speed
(c) to resist any change in its state of motion
(d) to decelerate due to friction

Ans. (c) to resist any change in its state of motion
Explanation: Inertia is the property because of which an object resists any change in its state of motion.

5. A passenger in a moving train tosses a coin which falls behind him. It means that motion of the train is

(a) accelerated
(b) uniform
(c) retarded
(d) along circular tracks

Ans. **(a)** accelerated
Explanation: Had the motions of the train been uniform, the coin would have fallen in his hand. Had the motion been retarded, the coin would have fallen ahead of him. So, the motion is accelerated.

6. An object of mass 2 kg is sliding with a constant velocity of 4 ms^{-1} on a frictionless horizontal table. The force required to keep the object moving with the same velocity is
(a) 32 N
(b) 0 N
(c) 2 N
(d) 8 N

Ans. **(b)** 0 N
Explanation: Since no friction is opposing the motion, hence no force is required to keep the object in uniform motion.

7. Rocket works on the principle of conservation of
(a) mass
(b) energy
(c) momentum
(d) velocity

Ans. **(c)** momentum

8. A water tanker filled up to 2/3 of its height is moving with a uniform speed. On sudden application of the brake, the water in the tank would
(a) move backward
(b) move forward
(c) be unaffected
(d) rise upwards

Ans. **(b)** move forward
Explanation: On sudden application of brake, the tanker would come to rest but water would remain in motion. Due to this, the water in the tank would move forward.

Force and Laws of Motion

Short Answer Questions

9. There are three solids made up of aluminium, steel and wood, of the same shape and same volume. Which of them would have highest inertia?

Ans. Steel- As the mass is a measure of inertia, the ball of same shape and size, having more mass than other balls will have highest inertia. Since steel has greatest density and greatest mass, therefore, it has highest inertia.

10. Two balls of the same size but of different materials, rubber and iron are kept on the smooth floor of a moving train. The brakes are applied suddenly to stop the train. Will the balls start rolling? If so, in which direction? Will they move with the same speed? Give reasons for your answer.

Ans. Yes. the balls will start rolling in the direction in which the train was moving. Due to the application of the brakes, the train comes to rest but due to inertia the balls try to remain in motion, therefore, they begin to roll. Since the masses of the balls are not the same, therefore, the inertial forces are not same on both the balls. Thus, the balls will move with different speeds.

11. Two identical bullets are fired one by a light rifle and another by a heavy rifle with the same force. Which rifle will hurt the shoulder more and why?

Ans. According to law of conservation of momentum; the momentum of bullet will be equal to the momentum of rifle. In case of light rifle; velocity will be more than the velocity of heavier rifle so that momentum (product of mass and velocity) for both shall be equal. Due to this, the lighter rifle will hurt the shoulder more.

12. A horse continues to apply a force in order to move a cart with a constant speed. Explain why?

Ans. When a cart is moving on the road, it has to encounter friction. To maintain a constant speed, some force need to be applied continuously to overcome the friction. Hence, the horse needs to continuously apply a force in order move the cart with a constant speed.

13. Suppose a ball of mass m is thrown vertically upward with an initial speed v, its speed decreases continuously till it becomes zero. Thereafter, the ball begins to fall downward and attains the speed v again before striking the ground. It implies that the magnitude of initial and final momentums of the ball are same. Yet, it is not an example of conservation of momentum. Explain why?

Ans. Law of conservation of momentum is applicable to isolated system (no external force is applied). In this case, the change in velocity is due to the gravitational force of earth.

14. Velocity versus time graph of a ball of mass 50 g rolling on a concrete floor is shown in Fig. 9.1. Calculate the acceleration and frictional force of the floor on the ball.

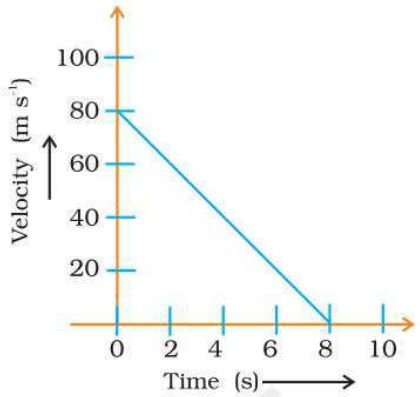

Fig. 9.1

Ans. Acceleration $= a = \frac{v-u}{t} = -\frac{80}{8} ms^{-2} = -10 ms^{-2}$

Force $= ma = \frac{50}{1000} \times 10 = 0.5N$

15. A truck of mass M is moved under a force F. If the truck is then loaded with an object equal to the mass of the truck and the driving force is halved, then how does the acceleration change?

Ans. Acceleration can be given as follow:

F = ma or $a = \frac{F}{m}$ or $a_1 = \frac{F}{M}$

When mass is doubled and force is halved;

$a_2 = \frac{F}{4M}$ or $\frac{a_2}{a_1} = \frac{F}{4M} \div \frac{F}{M} = \frac{1}{4}$

So, acceleration becomes one-fourth.

16. Two friends on roller-skates are standing 5 m apart facing each other. One of them throws a ball of 2 kg towards the other, who catches it, How will this activity affect the position of the two? Explain your answer.

Ans. Separation between them will increase. Initially the momentum of both of them are zero as they are at rest. In order to conserve the momentum, the one who throws the ball would move backward. The second will experience a net force after catching the ball and therefore will move backwards that is in the direction of the force.

17. Water sprinkler used for grass lawns begins to rotate as soon as the water is supplied. Explain the principle on which it works.

Ans. The working of the rotation of sprinkler is based on third law of motion. As the water comes out of the nozzle of the sprinkler, an equal and opposite reaction force comes into play. So, the sprinkler starts rotating.

Force and Laws of Motion

Long Answer Questions

18. Using second law of motion, derive the relation between force and acceleration. A bullet of 10 g strikes a sand-bag at a speed of 10^3 ms^{-1} and gets embedded after travelling 5 cm. Calculate
(i) the resistive force exerted by the sand on the bullet
(ii) the time taken by the bullet to come to rest.

Ans. (i) m = 10g $g = \frac{10}{1000} kg$

$u = 10^3 m/s$

$v = 0$

$s = \frac{5}{100} m$

$v^2 - u^2 = 2as$

$0 - (10^3)^2 = 2.a\frac{5}{100}$

$a = \frac{-1000 \times 1000}{2.5} \times 100$

$= -10^7 ms^{-2}$

$F = m.a = 10^5 N$

(ii) $v = u + at$

$0 = 10^3 - 10^7 t$

$10^7 t = 10^3$

$t = \frac{10^3}{10^7}$

$= 10^{-4} s$

19. Derive the unit of force using the second law of motion. A force of 5 N produces an acceleration of 8 ms^{-2} on a mass m_1 and an acceleration of 24 ms^{-2} on a mass m_2. What acceleration would the same force provide if both the masses are tied together?

Ans. F = m a = kg ms^{-2}
This unit is also called newton. Its symbol is N.

$m_1 = \frac{F}{a_1} = \frac{5}{8} kg,$

$m_2 = \frac{F}{a_2} = \frac{5}{24} kg,$

$$M = \left(\frac{5}{8} + \frac{5}{24}\right) kg = \left(\frac{5}{6}\right) kg$$

Acceleration produced in M,

$$a = \frac{F}{M} = \frac{5}{5/6} = 6ms^{-2}$$

20. What is momentum? Write its SI unit. Interpret force in terms of momentum. Represent the following graphically.

(a) momentum versus velocity when mass is fixed.

(b) momentum versus mass when velocity is constant

Ans. Momentum = mass × velocity

SI unit of momentum is kg ms^{-1}

Force = Rate of change in momentum