NCERT Textual Exercise (Solved)

1. An object experiences a net zero external unbalanced force. Is it possible for the object to be travelling with a non-zero velocity? If yes, state the conditions that must be placed on the magnitude and direction of the velocity. If no, provide a reason.

Ans. Yes, when external unbalanced force on an object is zero, the object can be travelling with a non-zero velocity. The necssary conditions are:

(i) The object should already be moving with a uniform speed along a straight line.

(ii) There should be no change in magnitude of velcoty and also no change in the direction of motion

(iii) The resistance to motion due to air must be zero.

(iv) The resistance to motion due to friction between the object and the ground must be zero.

If any of the four conditons stated above is not met with, the answer will be 'No'. This is becuase external unbalanced force is needed for initiating the motion and also for any subsequent change (decrease/increase) in its velocity.

2. When a carpet is beaten with a stick, dust comes out of it. Explain.

Ans. When a carpet is beaten with a stick, it comes in motion. The dust particles in the carpet tend to remain at rest due to inertia with a stick, it comes in motion. The dust particles in the carpet tend to remain at rest due to inertia of rest. That is why these particles fall down.

3. Why is it advised to tie any luggage kept on the roof of a bus with a rope?

Ans. Any luggage kept on the roof of a bus should be tied with a rope. This is because when the bus starts suddenly, the luggage pieces may fall down due to inertia of rest. Similarly, when the moving bus stops suddenly, the luggage pieces may fall down due to inertia of motion.

4. A batsman hits a cricket ball which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows to a stop because

(a) the batsman did not hit the ball hard enough.

(b) velocity is proportional to the force exerted on the ball.

(c) there is a force on the ball opposing the motion.

(d) there is no unbalanced force on the ball, so the ball would want to come to rest.

Ans. (c) The cricket ball comes to rest after coverting a short distance, because there is a force on the ball, opposing the motion. This force is due

to resistance of air and also due to friction between the ball and the ground.

5. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 tonnes (*Hint*: 1 tonne = 1000 kg.)

Ans. Given, $u = 0$, $s = 400$ m, and $t = 20$ s

$m = 7$ metric tonne $= 7 \times 1000$ kg $= 7000$ kg

To find : a and F

Using $s = ut + \frac{1}{2}at^2$,

$$400 = 0 + \frac{1}{2}a \times (20)^2$$

or, $$a = \frac{400}{200} = 2 \text{ m/s}^2$$

$\therefore$ $F = ma = 7000 \times 2 =$ **14000 N**

6. A stone of 1 kg is thrown with a velocity of 20 m s^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice?

Ans. Given, $m = 1$ kg, $u = 20$ m/s; $v = 0$, $s = 50$ m,

To find : Force, F

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

$0 - (20)^2 = 2\,a \times 50 = 100\,a$

or $$a = \frac{-400}{100} = -4 \text{ m/s}^2$$

Thus, $F = ma = 1 \times (-4) =$ **– 4N**

7. A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000 N, then calculate:

(a) the net accelerating force;

(b) the acceleration of the train; and

(c) the force of wagon 1 on wagon 2.

Ans. Here, Mass of engine, $m_1 = 8000$ kg

Mass of 5 wagons, $m_2 = 5 \times 2000$ kg $= 10000$ kg

Force exerted by the engine, F = 40000 N;

friction force, $f = 5000$ N

(a) Net accelerating force = F – f = 40000 – 5000= **35000 N**

(b) The acceleration of the train = $a \frac{\text{net force}}{\text{total mass of engine and wagons}}$

$$= \frac{F - f}{m_1 + m_2} = \frac{35000}{18000} = 1.94 \text{ m/s}^2$$

(c) Force of wagon 1 on wagon 2 = mass of 4 wagons (behind wagon 1) × acceleration

= 4 × 2000 × 1.94 = **15520 N**

8. An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 m s^{-2}?

Ans. Given, m = 1500 kg, a = – 1.7 m s^{-2}

To find force, F

F = ma = 1500 × (–1.7) N = – **2550 N**

The negative sign indicates that the force is opposing the motion of the vehicle.

9. What is the momentum of an object of mass m, moving with a velocity v?

(a) $(mv)^2$ (b) mv^2

(c) mv^2 (d) mv

Ans. (d) Momentum = mass × velocity, i.e., momentum = $m \times v = mv$

10. Using a horizontal force of 200 N, we intend to move a wooden cabinet across a floor at a constant velocity. What is the friction at force that will be exerted on the cabinet?

Ans. Force applied, P = 200 N, let force of friction is F.

As the wooden cabinet is to move across the floor with a constant velocity, no force (f) is spent in accelerating the cabinet, i.e., f = P – F = 0

or, F = P **200 N**

11. Two objects, each of mass 1.5 kg, are moving in the same straight line but in opposite directions. The velocity of each object is 2.5 m s^{-1} before the collision during which they stick together. What will be the velocity of the combined object after collision?

Ans. Given, $m_1 = m_2$ = 1.5 kg, u_1 = 2.5 m s^{-1}, u_2 = – 2.5 m s^{-1}

If v is velocity of the combined object after collision, then applying the principle of conservation of momentum, we get

$(m_1 + m_2)\, v = m_1u_1 + m_2u_2$

or, $(1.5 + 1.5)\ V = 1.5\ (2.5) + 1.5\ (-2.5) = 0$

or, $v = 0$. The velocity of the combined object after collision will be zero i.e., it will be at rest.

12. According to the third law of motion, when we push on an object, the object pushes back on us with an equal and opposite force. If the object is a massive truck parked along the roadside, it will probably not move. A student justifies this by answering that the two opposite and equal forces cancel each other. Comment on this logic and explain why the truck does not move.

Ans. When we push a massive truck parked along the roadside, it does not move. The justification given by the student that the two oppoosite and equal force cancel each other is totally wrong. This is because forces of action and reaction never act on one body. There is no question of their cancellation. The truck does not move because the push applied is far less than the force of friction between the truck and the road.

13. A hockey ball of mass 200 g travelling at 10 m s^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 m s^{-1}. Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Ans. Given, $m = 200\text{g} = \frac{200}{1000}\text{kg} = \frac{1}{5}\ \text{kg}$

Initial velocity, $u = 10\ \text{m s}^{-1}$

Final velocity, $v = -5\ \text{m s}^{-1}$, [negative sign is used because the ball returns along the original path.]

Change of momentum = Final momentum – Initial momentum

$$mv = mu = \frac{1}{5}(-5) - \frac{1}{5}(10) = -3\ \text{kg m/s}$$

14. A bullet of mass 10 g travelling horizontally with a velocity of 150 m s^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

Ans. Given, $m = 10\ \text{g} = \frac{10}{1000}\ \text{kg} = 10^{-2}\ \text{kg}$

Initial velolcity, $u = 150$ m/s, final velocity, $v = 0$, time taken, $t = 0.03$ s

distance of penetration, s and force applied, F.

To find:

Acceleration, $a = \frac{v-u}{t} = \frac{0-150}{0.03} = -5\times10^3$ m/s^2

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

$0 - (150)^2 = 2 \times (-5 \times 10^3) \times s$

or, $s = \frac{-150\times150}{-10\times10^3} =$ **2.25 m**

As, $F = ma = 10^{-2}\times(-5 \times 10^3) = -50$ N

Therefore, the bullet will penetrate 2.25 m into the block and the force exerted by the block on the bullet will be 50 N.

15. An object of mass 1 kg travelling in a straight line with a velocity of 10 m s^{-1} collides with, and sticks to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object.

Ans. Given, $m_1 = 1$ kg, $u_1 = 10$ m/s; $m_2 = 5$kg, $u_2 = 0$

Before impact, total momentum = $m_1u_1 + m_2u_2$

or, $p_1 = 1 \times 10 + 5 \times 0 =$ **10 kg m/s**

Just after impact, total lmomentum remains the same, *i.e.*,

$p_2 = p_1 =$ **10 kg m/s**

If v is velocity of the combined object, then from $p_2 = (m_1 + m_2)v$,

$\Rightarrow \quad v = \frac{p_2}{m_1 + m_2} = \frac{10}{(1+5)} =$ **1.67 m/s.**

16. An object of mass 100 kg is accelerated uniformly from a velocity of 5 m s^{-1} to 8 m s^{-1} in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Ans. Given :$m = 100$ kg, $u = 5$ m/s, $v = 8$ m/s, $t = 6$ s

Initial momentum of object, $p_1 = mu = 100 \times 5 = 500$ kg m/s

final momentum of object, $p_2 = mv = 100 \times 8 = 800$ kg m/s

Force exerted, $F = \frac{\text{Change in momentum}}{\text{time taken}} = \frac{p_2 - p_1}{t} = \frac{800-500}{6} = 50$ N

17. Akhtar, Kiran and Rahul were riding in a motorcar that was moving with a high velocity on an expressway when an insect hit the windshield and got stuck on the windscreen. Akhtar and Kiran started pondering over the situation. Kiran suggested that the insect suffered a greater change in momentum as compared to the change in momentum of the motorcar

(because the change in the velocity of the insect was much more than that of the motorcar). Akhtar said that since the motorcar was moving with a larger velocity, it exerted a larger force on the insect. And as a result the insect died. Rahul while putting an entirely new explanation said that both the motorcar and the insect experienced the same force and a change in their momentum. Comment on these suggestions.

Ans. The suggestion made by Kiran that insect suffered a greater change in momentum as compared to the change in momentum of the motro car is wrong. The suggestion by Akhtar that motor car exerted a larger force on the insect because of large veloccity of motor car is also wrong. The explanation put forward by Rahul is correct. On collision of insect with motor car, both experience the same force as action and reaction are always equal and opposite. Further, changes in their momenta are also the same. Only the signs of changes in momenta are opposite, i.e., change in momenta of the two occur in opposite directions, though magnitude of change in momentum of each is the same.

18. How much momentum will a dumb-bell of mass 10 kg transfer to the floor if it falls from a height of 80 cm? Take its downward acceleration to be 10 m s^{-2}.

Ans. Given: $m = 10$ kg, $s = 80$ cm $= 0.8$ m, $a = 10$ ms^{-2} and

$u = 0$,

Let final velocity is u and momentum is P.

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

$v^2 - 0 = 2 \times 10 \times 0.8 = 16$

or, $v = \sqrt{16} = 4$ m/s

Momentum transferred, $p = mv$

$= 10 \times 4 = 40$ kg m/s