CBSE NCERT Solutions for Class 9 Science Chapter 9

Back of Chapter Questions

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.

Solution:

Yes. It is possible for the object to be travelling with non-zero velocity. When a nonzero unbalanced force acts on an object, its velocity changes. Here change may be velocity magnitude or velocity direction or both magnitude and direction. Therefore, when zero external unbalanced force acts on a body, its magnitude and direction of velocity must be constant.

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

Solution:

When a carpet is beaten with a stick, carper comes to motion, but the dust particles in the carpet tend to remain at rest due to inertia. This appears like dust particles coming out of the carpet.

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

Solution:

When bus accelerates from rest, suddenly bus moves forward, but the luggage on the roof of the bus tend to remain at rest due to inertia. Hence, they might fall off the roof if not tied with rope.

Similarly, when the moving bus stops suddenly due to inertia, the luggage on the roof tend to continue to remain in motion. Thus, they might fall off the roof if not tied with rope.

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.

Solution: (C)

When the ball rolls on the ground, it comes to rest after covering short distance on the ground. Here friction is acting on the object opposite to the direction of motion. Due to the friction ball slows down continuously and stops after covering a short distance.

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).

Solution:

Given,

The mass of the truck, $m = 7$ tonnes $= 7000$ kg

The initial velocity of the truck, $u = 0$ ($\because$ the truck is starting from rest)

The distance covered by the truck, $S = 400$ m

Time taken, $t = 20$ s

Let the constant acceleration of the truck be a

From equations of motion,

$$S = ut + \frac{1}{2}at^2$$

$$\Rightarrow 400 = 0 \times t + \frac{1}{2} \times a \times 20^2$$

$$\Rightarrow a = \frac{400 \times 2}{20^2} = 2\ \text{m s}^{-2}$$

$\therefore$ From Newton's second law of motion, the force acting on the truck, $F = m \times a$

$\Rightarrow F = 7000 \times 2 = 14000$ N or 14 kN

$\therefore$ Acceleration the truck is $2\ \text{m s}^{-2}$ and the force acting on the truck is 14000 N or 14 kN.

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?

Solution:

Given,

The initial velocity of the stone, $u = 20\ \text{m s}^{-1}$

The final velocity of the stone, $v = 0$ ($\because$ stone is coming to rest after travelling 50 m)

Distance covered by the stone before coming to rest $S = 50$ m

Let the constant acceleration/retardation of the stone be a

From equations of motion,

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

$\Rightarrow 0^2 - 20^2 = 2 \times a \times 50$

$\Rightarrow a = -\dfrac{20^2}{2 \times 50}$

$\Rightarrow a = -4 \text{ m s}^{-2}$

From Newton's second law of motion,

Force of friction acting on the stone $F = m \times a$

$\Rightarrow F = 1 \times (-4) = -4 \text{ N}$

Therefore, friction force acting between the stone and the ice is -4 N

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 and (b) the acceleration of the train.

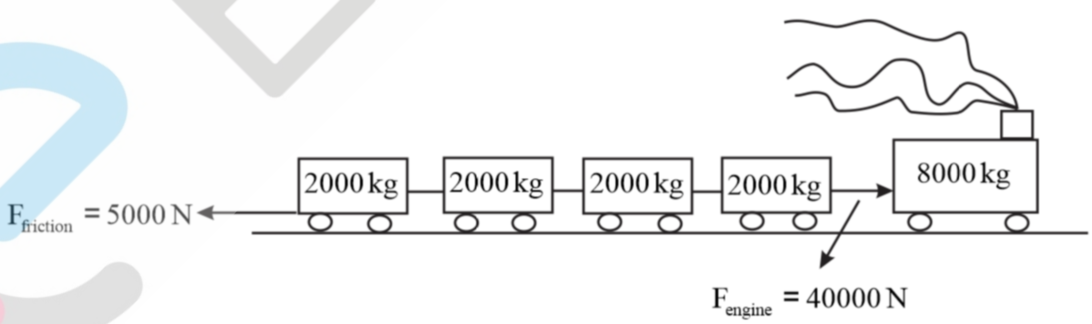
Solution:

Mass of the train $m = 2000 \times 5 = 10000$ kg

Force exerted by the engine $F_{engine} = 40000$ N

Force of friction on the train, $F_{friction} = 5000$ N

Let the acceleration of the train be a



(a) The net force acting on the train

F_{net} = force exerted by the engine − force of friction

$\Rightarrow F_{net} = 40000 - 5000 = 35000$ N

(b) From Newton's second law of motion, $F_{net} = m \times a$

$$\Rightarrow 35000 = 18000 \times a$$

$$\Rightarrow a = \frac{35000}{10000} = 3.5 \text{ m s}^{-2}$$

Therefore, the acceleration of the train is 3.5 m s^{-2} and the net accelerating force on the train is 35000 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}?

Solution:

Given,

the mass of the automobile $m = 1500$ kg

Negative acceleration or retardation of the automobile $a = -1.7 \text{ m s}^{-2}$

From Newton's second law of motion, $F = m \times a$

$\Rightarrow F = 1500 \times (-1.7) = -2550$ N

Therefore, the retarding force required between the road and the automobile is 2550 N.

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

(A) $(mv)^2$

(B) mv^2

(C) $\frac{1}{2}mv^2$

(D) mv

Solution: (D)

The momentum of an object of mass m moving with velocity v is defined as, $P = m \times v$

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 force that will be exerted on the cabinet?

Solution:

Given,

The horizontal force applied, $F_{applied} = 200$ N

Let the friction force required be $F_{friction}$

As the wooden cabin is to move with constant velocity, the net force acting on it is zero.

$\Rightarrow F_{applied} + F_{friction} = 0$

$\Rightarrow F_{friction} = -F_{applied} = -200\ \text{N}$

$\therefore$ Friction force exerted on the cabin is -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?

Solution:

Given

Masses of the two objects, $m_1 = m_2 = 1.5$ kg

The velocity of the first object $v_1 = 2.5$ m s^{-1}

The velocity of the second object $v_2 = -2.5$ m s^{-1} ($\because$ both the objects are moving in the opposite direction)

Let the velocity of the combined object after the collision be v

From the law of conservation of linear momentum,

The linear momentum before collision = The linear momentum after the collision

$m_1 \times v_1 + m_2 \times v_2 = m_1 \times v + m_2 \times v$

$$\Rightarrow v = \frac{m_1 \times v_1 + m_2 \times v_2}{m_1 + m_2}$$

$$\Rightarrow v = \frac{1.5 \times 2.5 - 1.5 \times 2.5}{1.5 + 1.5} = 0$$

$\therefore$ the velocity of the combined object after the collision is zero.

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.

Solution:

According to the third law of motion when we push an object, the object pushes us back with an equal and opposite force. These two forces are called as action-reaction pair. Action and reaction forces never act on the same object. Hence, they never cancel each other.

When we push a massive truck parked along the roadside, it will probably not move because applied force might not be strong enough to overcome the friction between the truck and the road. The justification given by the student is wrong.

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 magnitude of change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Solution:

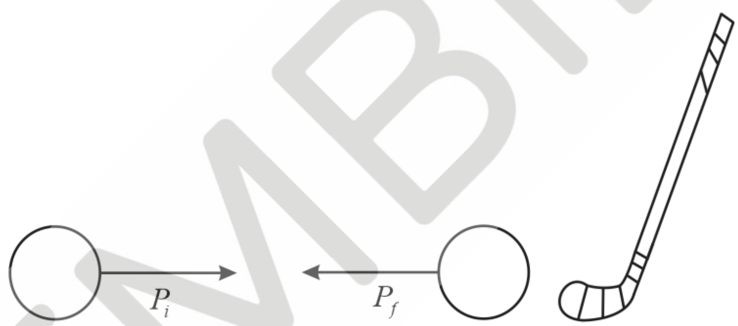
Given

The mass of the hockey ball, $m = 200\ g = 0.2\ kg$

The initial velocity of the hockey ball, $u = 10\ m\ s^{-1}$

The initial momentum of the hockey ball $P_i = 0.2 \times 10 = 2\ kg\ m\ s^{-1}$

The final velocity of the hockey ball, $v = -5\ m\ s^{-1}$



Final momentum of the hockey ball $P_f = 0.2 \times (-5) = -1\ kg\ m\ s^{-1}$

Change in the momentum $\Delta P = P_f - P_i = -1 - 2 = -3\ kg\ m\ s^{-1}$

$\therefore$ the magnitude of change in momentum is $3\ kg\ m\ s^{-1}$

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.

Solution:

Given

The mass of the bullet $m = 10\ g = 0.01\ kg$

The initial velocity of the bullet $u = 150\ m\ s^{-1}$

The final velocity of the bullet $v = 0$

Time taken for the bullet to come to rest $t = 0.03\ s$

Assuming the wooden block offers constant retardation during the penetration.

Let S be the distance the bullet covered before it comes to rest and a be the acceleration of it.

From the equation of motion,

$v = u + at$

$\Rightarrow a = \frac{v - u}{t}$

$\Rightarrow a = \frac{0 - 150}{0.03} = -5000 \text{ m s}^{-2}$

And the retardation force exerted by the wooden block $F = ma$

$\Rightarrow F = 0.01 \times (-5000) = -50 \text{ N}$

Again, from equations of motion,

$v^2 - u^2 = 2aS$

$\Rightarrow S = \frac{v^2 - u^2}{2a}$

$\Rightarrow S = \frac{0^2 - 150^2}{2(-5000)} = 2.25 \text{ m}$

Hence the magnitude of the force exerted by the wooden block is 50 N and the distance of penetration is 2.25 m

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.

Solution:

Given,

The mass of the object $m = 1$ Kg

The initial velocity of the object $u = 10 \text{ m s}^{-1}$

Mass of the wooden block $M = 5$ kg

The initial velocity of the wooden block is 0

Total momentum before impact, $P_i = m \times u + M \times 0 = 1 \times 10 = 10 \text{ kg m s}^{-1}$

Let the final common velocity be v

From the principle of conservation of the linear momentum, The linear momentum before the impact = the linear momentum after the impact

$\therefore$Total final momentum after impact $P_f = 10\ \mathrm{kg\ m\ s^{-1}}$

Also, from the principle of conservation of the linear momentum,

$\mathrm{m} \times \mathrm{u} + \mathrm{M} \times 0 = (\mathrm{m} + \mathrm{M}) \times \mathrm{v}$

$\Rightarrow \mathrm{v} = \dfrac{\mathrm{m} \times \mathrm{u}}{\mathrm{m} + \mathrm{M}} = \dfrac{1 \times 10}{1 + 5} = 1.67\ \mathrm{m\ s^{-1}}$

$= (1 + 5) \times 1.67 = 10\ \mathrm{kg\ m\ s^{-1}}$

Hence linear momentum before and after the impact is $10\ \mathrm{kg\ m\ s^{-1}}$ and the velocity of the combines object is $1.67\ \mathrm{m\ s^{-1}}$

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

Solution:

Given,

The mass of the object $\mathrm{m} = 100\ \mathrm{kg}$

The initial velocity of the object $\mathrm{u} = 5\ \mathrm{m\ s^{-1}}$

Initial momentum $P_i = \mathrm{m} \times \mathrm{u} = 100 \times 5 = 500\ \mathrm{kg\ m\ s^{-1}}$

The final velocity of the object $\mathrm{v} = 8\ \mathrm{m\ s^{-1}}$

Final momentum $P_f = \mathrm{m} \times \mathrm{v} = 100 \times 8 = 800\ \mathrm{kg\ m\ s^{-1}}$

Time taken $\mathrm{t} = 6\ \mathrm{s}$

From Newton's second law of motion, $F = \frac{\Delta P}{\Delta t} = \frac{P_f - P_i}{t} = \frac{800 - 500}{6}$

$\Rightarrow F = 50\ \mathrm{N}$

$\therefore$ The initial and final momenta of the object are $500\ \mathrm{kg\ m\ s^{-1}}$ and $800\ \mathrm{kg\ m\ s^{-1}}$ respectively and the magnitude of the force exerted is 50 N

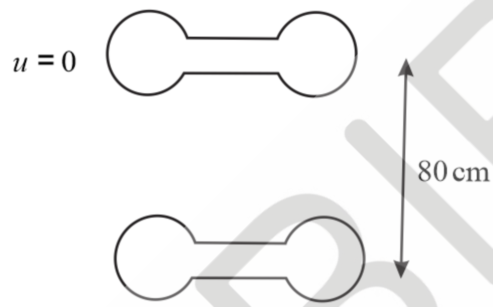
17. Akhtar, Kiran and Rahul were riding in a motorcar that was moving with a high velocity on an expressway when an insect hit the windshield and got stuck on the windscreen. Akhtar and Kiran started pondering over the situation. Kiran suggested that the insect suffered a greater change in momentum as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

Solution:

During the impact, the force exerted by the insect and force exerted by the motorcar becomes action and reaction pair. From Newton's third law of motion action and reaction must be equal in magnitude. Hence both the motor car and the insect are gone through the same change in momenta. Therefore, the explanation given by Rahul is correct, while explanations given by Akhtar and Rahul are wrong.

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 $10\ \mathrm{m\ s^{-2}}$.

Solution:



Given

the mass of the dumb-bell $m = 10\ \mathrm{kg}$

The initial velocity of the dumb-bell $u = 0$

Distance through which it is falling, $S = 80\ \mathrm{cm} = 0.8\ \mathrm{m}$

Downward acceleration $a = 10\ \mathrm{m\ s^{-2}}$

From equations of motion,

$v^2 - u^2 = 2aS$

$\Rightarrow v = \sqrt{2 \times 10 \times 0.8} = 4\ \mathrm{m\ s^{-1}}$

Momentum with which dumb-bell hits the ground $P = 10\ \mathrm{kg} \times 4\ \mathrm{m\ s^{-1}} = 40\ \mathrm{kg\ m\ s^{-1}}$

$\therefore$ The momentum transferred by the dumb-bell to the ground is $40\ \mathrm{kg\ m\ s^{-1}}$

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