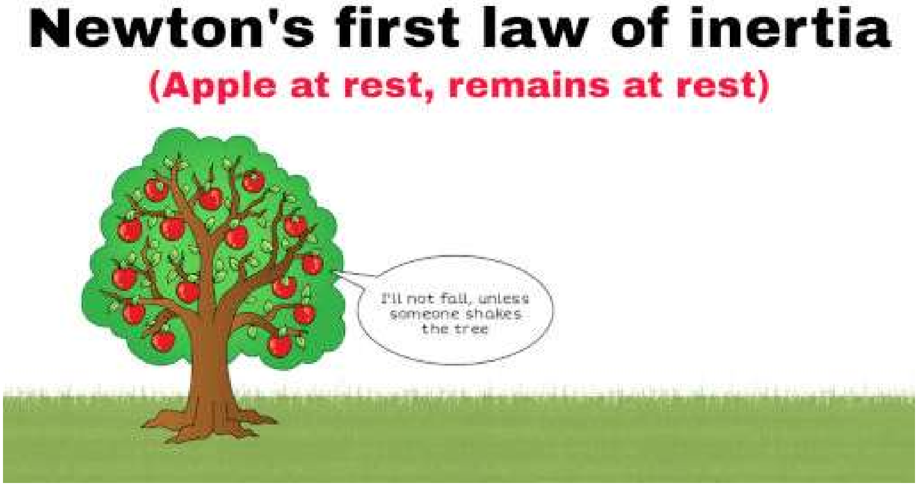
Force and Laws of Motion Class 9 GSEB Solutions Science Chapter 8

Page No. 91

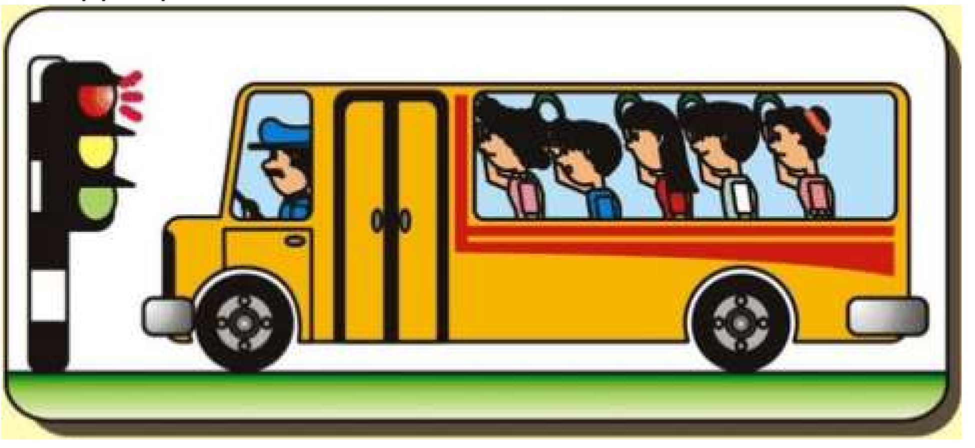
Q1. Which of the following has more inertia?
(a) A rubber ball and a stone of the same size?
(b) A bicycle and a train?
(c) A five rupees coin and one-rupee coin?
Ans:
(a) Out of a rubber ball and a stone of the same size, the mass of the stone is larger; so the stone has more inertia than a rubber ball.
(b) Out of a bicycle and a train, the train has a much larger mass than the bicycle, so the train has more inertia.
(c) Out of five rupees and one rupee coins, a five rupee coin has a larger mass and hence more inertia.

Q2. In the following example, try to identify the number of times the velocity of the ball changes.
"A football player kicks a football to another player of his team who kicks the football towards the goal. The goalkeeper of the opposite team collects the football and kicks it towards a player of his own team".
Also identify the agent supplying the force in each case.
Ans: The velocity of the ball changes four times in the following ways:
(a) Player 1 changes the velocity by kicking it.
(b) Player 2 changes the velocity by kicking it to the goal.
(c) The goalkeeper changes the velocity by, collecting the ball.
(d) The goalkeeper changes the velocity by kicking the ball.
Q3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.
Ans: The leaves of the tree have inertia of rest. When the branch is shaken, it moves, but the leaves tend to be in a state of rest due to their inertia. Thus, they get detached from the tree.



Q4. Why do you fall in the forward direction when a moving bus apply brakes to stop and fall back when it accelerates from rest?
Ans:

- In a running bus, our speed is equal to the speed of the bus. As a moving bus brakes to a stop, the lower part of our body being in contact with the bus comes to rest, but the upper part due to inertia of motion remains in the state of motion.



The bus stops suddenly, Passenger jerks forward

- Hence, we fall in the forward direction. When the bus accelerates from rest, the feet come into motion while the upper part of the body remains at rest due to the inertia of rest; hence, we fall backwards.

Exercises: Page No. 97

Q1. 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, it is possible for the object to be travelling with a non-zero velocity if it experiences a net zero external unbalanced force.
- This is due to the inertia of motion. If the body is initially moving with some velocity on a smooth surface, then it will continue to move with the same velocity, though the net external force acting on the body is zero.
  Example: When we stop pedalling a moving bicycle, the bicycle begins to slow down and finally comes to rest. This is again because of the friction forces acting opposite to the direction of motion. The force of friction opposes the motion of the bicycle. If there were no unbalanced force of friction and no air resistance, a moving bicycle would go on moving forever.

Q2. When a carpet is beaten with a stick, dust comes out of it. Explain.
Ans: When the carpet is beaten, it is suddenly set into motion. The dust particles tend to remain at rest due to the inertia of rest, therefore, dust comes out of it.

Q3. Why is it advised to tie any luggage kept on the roof of a bus with a rope?
Ans: The luggage kept on the roof possesses inertia. As the bus moves, brakes to stop or takes a turn, the luggage might fall off. Thus, it should be tied with a rope.

Q4. A batsman hits a cricket ball which then rolls on 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: When the ball rolls on the flat surface of the ground, its motion is opposed by the force of friction (the friction arises between the ground and the ball). This frictional force eventually stops the ball. Therefore, the correct answer is (c).
If the surface of the level ground is lubricated (with oil or some other lubricant), the friction that arises between the ball and the ground will reduce, which will enable the ball to roll for a longer distance.

Q5. 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 metric tonnes
(Hint: 1 metric tonne = 1000 kg.)
Ans:
Initial velocity of truck (u) = 0
Time (t) = 20 s
Distance covered (S) = 400 m
Acceleration (a) = ?
Mass of truck (m) 7 tonne = 7000 kg
Force on truck We know ; (F) = ?
We know:
$S = ut\ \ 1/2\ at^2$
$400 = 0 \times 20\ 1/2 \times a \times (20)^2$
$400 = 200a$
$\mathbf{a = 2ms^{-2}}$
Force on truck (F) = ma
= 7000 x 2
= 14000 N

Q6. A stone of 1 kg is thrown with a velocity of 20 ms^{-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:
Mass, m = 1kg; Initial velocity, u = 20 ms^{-1};
Final velocity, v = 0;
distance travelled, s = 50 m

Acceleration, $a = \frac{v^2 - u^2}{2s}$

$= \frac{0-(20)^2}{2 \times 50} = -4\ ms^{-2}$

Force exerted = ma

= 1 kg x (- 4) ms^{-2} = - 4N

Friction = 4 N against the direction of motion.

Q7. An 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

Ans: (a) Given, the force exerted by the train (F) = 40,000 N

The force of friction = -5000 N (the negative sign indicates that the force is applied in the opposite direction)

Net accelerating force = sum of all forces

= 40,000 N + (-5000 N)

= 35,000 N

(b) Total mass of the train = mass of engine + mass of each wagon

The total mass of the train = 8000kg + 5 × 2000kg = 18000 kg.

As per the second law of motion, F = ma (or: a = F/m)

Therefore, acceleration of the train = (net accelerating force) / (total mass of the train)

= 35,000/18,000 = 1.94 ms^{-2}

The acceleration of the train is **1.94 ms^{-2}**

Q8. 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 ms^{-2}?

Ans: Here, the mass of the automobile, m = 1,500 kg

Acceleration, a = 1.7 ms^{-2}

F = ma = 1500 kg x (-1.7 ms^{-2})

= -2,550 kg ms^{-2}

= -2,550 N

Negative sign indicates that the force is in a direction opposite to the motion of the vehicle.

Page No. 98

Q9. What is the momentum of an object of mass m, moving with a velocity v?

(a) $(mv)^2$

(b) mv^2

(c) $1/2mv^2$

(d) mv

Ans: (d) mass x velocity

The momentum of an object is defined as the product of its mass m and velocity v.

Momentum = mass x velocity

Hence, the correct answer is mv, i.e., option (d).

Q10. 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?
Ans: Since the velocity of the cabinet is constant, its acceleration must be zero. Therefore, the effective force acting on it is also zero. This implies that the magnitude of opposing frictional force is equal to the force exerted on the cabinet, which is 200 N. Therefore, the total friction force is -200 N.

Q11. 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 force cancel each other Comment on this logic and explain why the truck does not move.
Ans: The logic given by the student is wrong; because the action and reaction forces do not act on the same body; but act on different bodies.
The reason for not moving the truck is as follows:

- The truck is massive, so it has a very large inertia. Moreover, it is parked on the ground; there is a frictional force between the truck and the ground.
- The force exerted by us on the truck is insufficient to overcome the force of friction; so these are balanced forces on the truck; (force exerted by us plus force of friction in opposite direction); that is net force is zero; and hence, the truck does not move.

Q12. A hockey ball of mass 200 g travelling at 10 ms^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 ms^{-1}. Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.
Ans:
Mass of ball (m) = 200 g = 0.2 kg
Initial velocity of ball (u_1) = 10 ms^{-1}
Final velocity of ball (u_2) = 5 ms^{-1}
(Negative sign denotes that the ball is moving in the opposite direction)
Initial momentum of ball = $mu_1 = 0.2 \times 10 = 2$ Ns
Final momentum of ball = $mu_2 = 0.2 \times (-5) = -1$ Ns
Change in momentum = Final momentum - Initial momentum
= -1 - 2 Ns = **-3 Ns**
Negative sign denotes that change in momentum is in the direction opposite to the direction of initial momentum of the ball.

Q13. A bullet of mass 10g travelling horizontally with a velocity of 150 ms^{-1} strikes a stationary wooden block and comes to rest in 0.03s. 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:
Mass of bullet (m) = 10 g = 0.01 kg
The initial velocity of a bullet (u) = 150 ms^{-1}
The final velocity of a bullet (v) = 0
Time (t) = 0.03 secs
Acceleration on the bullet (a) = ?
Force acting on wooden block (F) = ?
Distance penetrated by the bullet (s) = ?
We know:
v = u + at
0 = 150 + (a × 0.3)
a × 0.03 = -150
a = -5000 ms^{-2} (Negative sign indicates that the velocity of the bullet is decreasing.)
We know:
S = ut + 0.5at^2
s = 150 × 0.03 + (-5000) × $(0.03)^2$ = 4.5 + 2.25 = **6.75m**
We know:
F = ma
Force acting on bullet (F) = ma = 0.01 × (-5000) = **-50N**
Negative sign denotes that wooden block exerts force in the direction, opposite to the direction of motion of the bullet.

Q14. An object of mass 1 kg travelling in a straight line with a velocity of 10 ms^{-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: Mass of the object, m1 = 1 kg
The velocity of the object before the collision, v1=10 ms^{-1}
Mass of the stationary wooden block, m2 = 5 kg
The velocity of the wooden block before the collision, v2 = 0
∴ Total momentum before collision
$=m_1v_1+m_2v_2$
=1(10)+5(0)=10 $kgms^{-1}$
It is given that after the collision, the object and the wooden block stick together.
The total mass of the combined system $=m_1+m_2$
The velocity of the combined object = v
According to the law of conservation of momentum:
Total momentum before collision = Total momentum after collision
$m_1v_1+m_2v_2=(m_1+m_2)v$
1 (10) + 5 (0) = (1 + 5) v
v = 10/6 = 5/3 ms^{-1}
The total momentum after collision is also 10 $kgms^{-1}$
Total momentum just before the impact =10 $kgms^{-1}$
Total momentum just after the impact =(m1+m2)v=6×5/3=10 $kgms^{-1}$

Hence, the velocity of the combined object after collision = 5/3 ms−1

Q15. An object of mass 100 kg is accelerated uniformly from a velocity of 5 ms^{-1} to 8 ms^{-1} in 6s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Ans:

Mass of object (m) = 100 kg

Initial velocity (u) = 5 ms^{-1}

Final velocity (v) = 8 ms^{-1}

Time (t) = 6 s

Initial momentum ($P_{initial}$) = mu = 100 × 5 = 500 Ns

Final momentum (P_{final}) = mv = 100 × 8 = 800 Ns

Force exerted on the object (F) = [(mv - mu) / t] = (800 - 500)/6 = 300/6 = 50N

Q16. 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: As per the law of conservation of momentum, the total momentum before the collision between the insect and the car is equal to the total momentum after the collision. Therefore, the change in the momentum of the insect is much greater than the change in momentum of the car (since force is proportional to mass).

Akhtar's assumption is partially right. Since the mass of the car is very high, the force exerted on the insect during the collision is also very high.

Kiran's statement is false. The change in momentum of the insect and the motorcar is equal to the conservation of momentum. The velocity of an insect changes accordingly due to its mass as it is very small compared to the motorcar. Similarly, the velocity of a motorcar is very insignificant because its mass is very large compared to the insect.

Rahul's statement is completely right. As per the third law of motion, the force exerted by the insect on the car is equal and opposite to the force exerted by the car on the insect. However, Rahul's suggestion that the change in the momentum is the same contradicts the law of conservation of momentum.

Q17. How much momentum will a dumbbell of mass 10 kg transfer to the floor if it falls from a height of 80 cm and does not rebound? Take its downward acceleration to be 10ms^{-2}.

Ans:

Height, h = 80 cm = 0.8 m

Mass, m = 10 kg ; Initial velocity, u = 0

Acceleration, a = 10 ms^{-2}

Final velocity, v = $\sqrt{u^2 + 2ah}$

$= \sqrt{0 + 2 \times 10 \times 0.8} = 4\ \mathrm{ms}^{-1}$

Momentum transferred = mv = 10 kg x 4 ms^{-1}

= 10 kg x 4 ms^{-1}

= 40 kgms^{-1}