Board – CBSE | Class –9th | Topic – Force and Laws of Motion

1. 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 a one-rupee coin?

Ans. Inertia is the measure of the mass of the body. The greater is the mass of the body; the greater is its inertia and vice-versa.

(a) Mass of a stone is more than the mass of a rubber ball for the same size. Hence, the inertia of the stone is greater than that of a rubber ball.

(b) Mass of a train is more than the mass of a bicycle. Hence, the inertia of the train is greater than that of the bicycle.

(c) Mass of a five rupee coin is more than that of a one-rupee coin. Hence, the inertia of the five rupee coin is greater than that of the one-rupee coin.

2. 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 team".

Also, identify the agent supplying the force in each case.

Ans. The velocity of the ball changes four times as a football player kicks the football, its speed changes from zero to a certain value. As a result, the velocity of the ball gets changed. In this case, the player applied a force to change the velocity of the ball. Another player kicks the ball towards the goal post. As a result, the direction of the ball gets changed. Therefore, its velocity also changes. In this case, the player applied a force to change the velocity of the ball. The goalkeeper collects the ball. In other words, the ball comes to rest. Thus, its speed reduces to zero from a certain value. The velocity of the ball has changed. In this case, the goalkeeper applied an opposite force to stop/change the ball's velocity. The goalkeeper kicks the ball towards his team players. Hence, the speed of the ball increases from zero to a certain value. Hence, its velocity changes once again. In this case, the goalkeeper applied a force to change the velocity of the ball.

3. Explain why some leaves may get detached from a tree when vigorously shaking its branch.

Ans. Some leaves of a tree get detached when we shake its branches vigorously. This is because when the branches of a tree are shaken, it moves to and fro, but its leaves tend to remain at rest. This is

because the inertia of the leaves tends to resist the to and fro motion. Due to this reason, the leaves fall from the tree when shaken vigorously.

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

Ans. Due to the inertia of the passenger. Everybody tries to maintain its state of motion or state of rest. If a body is at rest, then it tries to remain at rest. If a body is moving, then it tries to remain in motion. In a moving bus, a passenger moves with the bus. As the driver applies brakes, the bus comes to rest. But, the passenger tries to maintain his state of motion. As a result, a forward force is exerted on him. Similarly, the passenger tends to fall back when the bus accelerates from rest. This is because when the bus accelerates, the inertia of the passenger tends to oppose the forward motion of the bus. Hence, the passenger tends to fall back when the bus accelerates forward.

5. If action is always equal to the reaction, explain how a horse can pull a cart.

Ans. A horse pushes the ground in the backward direction. According to Newton's third law of motion, the Earth's reaction force on the horse in the forward direction is exerted. As a result, the cart moves forward.

6. Explain why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.

Ans. Due to the backward reaction of the water being ejected, When a fireman holds a hose, which is ejecting large amounts of water at a high velocity, then a reaction force is exerted on him by the ejecting water in the backward direction. This is because of Newton's third law of motion. As a result of the backward force, the stability of the fireman decreases. Hence, it is difficult for him to remain stable while holding the hose.

7. From a rifle of mass 4 kg, a bullet of mass 50 g is fired with an initial velocity of 35 m s^{-1}. Calculate the initial recoil velocity of the rifle.

Ans. Mass of the rifle, $m_1 = 4kg$

Mass of the bullet, $m_2 = 50g = 0.05kg$

Recoil velocity of the rifle $= v_1$

The bullet is fired with an initial velocity,$v_2 = 35\ m/s$

Initially, the rifle is at rest.

Thus, its initial velocity, v = 0

The total initial momentum of the rifle and bullet system $= (m_1 + m_2)v = 0$

The total momentum of the rifle and bullet system after firing.

$= m_1v_1 + m_2v_2 = 4(v_1) + 0.05 \times 35 = 4v_1 + 1.75$

According to the law of conservation of momentum.

Total momentum after the firing = Total momentum before the firing

$4v_1 + 1.75 = 0$

$v_1 = \frac{1.75}{4} = -0.4375 \frac{m}{s}$

The negative sign indicates that the rifle recoils backwards with a velocity of 0.4375 m/s.

8. Two objects of masses 100 g and 200 g move along the same line and direction with velocities of 2 m s^{-1} and 1 m s^{-1}, respectively. They collide, and after the collision, the first object moves at a velocity of 1.67 m s^{-1}. Determine the velocity of the second object.

Ans. Mass of one of the objects, $m_1 = 100$ g $= 0.1$ kg

Mass of the other object, $m_2 = 200$ g $= 0.2$ kg

The velocity of m_1 before the collision, $v_1 = 2$ m/s

The velocity of m_2 before the collision, $v_2 = 1$ m/s

The velocity of m_1 after the collision, $v_3 = 1.67\ m/s$

The velocity of m_2 after collision $= v_4$

According to the law of conservation of momentum.

Total momentum before collision = Total momentum after the collision

$\therefore m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$

$(0.1)2 + (0.2)1 = (0.1)1.67 + (0.2)v_4$

$0.4 = 0.167 + 0.2v_4$

$\therefore v_4 = 1.165\ m/s$

Hence, the velocity of the second object becomes 1.165 m/s after the collision.

9. The following is the distance-time table of an object in motion.

Time in seconds	Distance in metres

0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

(a) What conclusion can you draw about the acceleration? Is it constant, increasing, decreasing, or zero?

(b) What do you infer about the forces acting on the object?

Ans. (a) There is an unequal change of distance in an equal interval of time.

Thus, the given object has a non − uniform motion since the object's velocity increases with time, the acceleration increases.

(b) According to Newton's second law of motion, the force acting on an object is directly proportional to the acceleration produced in the object. In the given case, the increasing acceleration of the given object indicates that the force acting on the object also increases.

10. Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. Three persons can push the same motorcar to produce an acceleration of 0.2 m s^{-2}. With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort)

Ans. Mass of the motor car = 1200 kg

Only two persons manage to push the car. Hence, the acceleration acquired by the car is given by the third person alone.

Acceleration produced by the car, when it is pushed by the third person, a = 0.2 m/s^2

Let the force applied by the third person be F.

From Newton's Second Law of Motion.

Force = Mass × Acceleration

F = 1200 × 0.2 = 240 N

Thus, the third person applies a force of magnitude 240 N.

Hence, each person applies a force of 240 N to push the motor car.

11. A hammer of mass 500 g, moving at 50 m s^{-1}, strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer?

Ans. Mass of the hammer, m = 500 g = 0.5 kg

Initial velocity of the hammer, u = 50 m/s

Time taken by the nail to stop the hammer, t = 0.01 s

The velocity of the hammer, v = 0 (since the hammer finally comes to rest)

From Newton's second law of motion.

$Force,\ F = \frac{m(v-u)}{t} = \frac{0.5(0-50)}{0.01} = -\ 2500N$

The hammer strikes the nail with a force of −2500 N. Hence, from Newton's third law of motion, the force of the nail on the hammer is equal and opposite, i.e., +2500 N.

12. A motorcar of mass 1200 kg moves along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also, calculate the magnitude of the force required.

Ans. Mass of the motor car, m = 1200 kg

Initial velocity of the motor car, u = 90 km/h = 25 m/s

Final velocity of the motor car, v = 18 km/h = 5 m/s

Time taken, t = 4 s

According to the first equation of motion.

v = u + at

5 = 25 + a (4)

a = -5 m/s^2

Change in momentum = mv − mu = m (v−u)

= 1200 (5 − 25) = -24000 kg m s^{-1}

Force = Mass × Acceleration

= 1200 × (-5) = - 6000 N

Acceleration of the motor car = -5 m/s^2

Change in momentum of the motor car = -24000 kg m s^{-1}

Hence, the force required to decrease the velocity is -6000 N.

(Negative sign indicates the retardation, decrease in momentum and retarding force, respectively)