Class 9 Science Ch 8 Force and Laws of Motion

Q.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 property of an object to resist changes in its state of motion. It depends on the mass of the object — greater the mass, greater the inertia.
Now, let's answer each part:
(a) A rubber ball and a stone of the same size

Ans: Stone

Reason: Stone has more mass than a rubber ball of the same size, so it has more inertia.

(b) A bicycle and a train

Ans: Train

Reason: A train has significantly more mass than a bicycle, so it has much more inertia.

(c) A five-rupees coin and a one-rupee coin

Ans: Five-rupees coin

Reason: A five-rupees coin is heavier than a one-rupee coin, so it has more inertia.

Q.2. In the following example, try to identify the number of times the velocity of the ball changes.

Ans; "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 ball's velocity changes 3 times in total:
When the first football player kicks it to the second player.
When the second player kicks it towards the goal.
When the goalkeeper kicks it towards his teammate.

Q.3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.

Ans: When we vigorously shake the branch of a tree, the branch starts moving suddenly. However, the leaves attached to it tend to remain in their original position due to inertia of rest.

Because of this, the leaves do not move along with the branch immediately. As a result, the force between the branch and the leaves increases, and some of the leaves may get detached and fall off.

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

Ans: When a moving bus brakes-to a stop: When the bus is moving, our body is also in motion, but due to sudden brakes, the lower part of our body comes to rest as soon as the bus stops. But the upper part of our body continues to be in motion and hence we fall in forward direction due to inertia of motion.

When the bus accelerates from rest we fall backwards: When the bus' is stationary our body is at rest but when the bus accelerates, the lower part of our body being in contact with the floor of the bus comes in motion, but the upper part of our body remains at rest due to inertia of rest. Hence we fall in backward direction.

Class 9 Science NCERT Textbook – Page 126-127

Q.1 If action is always equal to the reaction, explain how a horse can pud a cart?

Ans: The third law of motion states that action is always equal to the reaction but they act on two different bodies.
In this case the horse exerts a force on the ground with its feet while walking, the ground exerts an equal and opposite force on the feet of the horse, which enables the horse to move forward and the cart is pulled by the horse.

Q.2. Explain, why is it difficult for a fireman to hold a hose, which ejects a large amount of water at a high velocity.

Ans: The water that is ejected out from the hose in the forward direction comes out with a large momentum and equal amount of momentum is developed in the hose in the opposite direction and hence the hose is pushed backward. It becomes difficult for a fireman to hold a hose which experiences this large momentum.

Q.3. From a rifle of mass 4 kg, a bullet of mass 50 g is fired with an initial velocity of 35 m/s. Calculate the initial recoil velocity of the rifle.

Ans:

Given:

Mass of rifle = 4 kg
Mass of bullet = 50 g = 0.05 kg
Velocity of bullet = 35 m/s
Let the recoil velocity of rifle = V m/s

Using law of conservation of momentum:

Before firing, total momentum = 0

After firing,

Momentum of bullet = 0.05 × 35 = 1.75 kg·m/s

Momentum of rifle = 4 × V

Total momentum after firing = 1.75 + 4V

According to the law of conservation of momentum:

1.75 + 4V = 0

⇒ 4V = -1.75

⇒ V = -1.75 / 4

⇒ V = -0.4375 m/s

Answer:

The recoil velocity of the rifle is **–0.4375 m/s** (opposite to the direction of the bullet).

Q.4 Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2 m/s and 1 m/s respectively.
They collide and after the collision the first object moves at a velocity of 1.67 m./s. Determine the velocity of the second object.

Ans: Given:

Mass of first object = 100 g = 0.1 kg
Mass of second object = 200 g = 0.2 kg
Initial velocity of first object = 2 m/s
Initial velocity of second object = 1 m/s
Final velocity of first object = 1.67 m/s
Let final velocity of second object = v m/s

Using law of conservation of momentum:

Total initial momentum = Total final momentum
$(0.1 \times 2) + (0.2 \times 1) = (0.1 \times 1.67) + (0.2 \times v)$
$0.2 + 0.2 = 0.167 + 0.2v$
$0.4 = 0.167 + 0.2v$
$0.4 - 0.167 = 0.2v$
$0.233 = 0.2v$
$v = 0.233 \div 0.2$
$v = 1.165$ m/s

Q.5 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 object.

Ans: Yes, it is possible for the object to move with a non-zero velocity even when the net external unbalanced force is zero. According to **Newton's First Law of Motion**, if no unbalanced force acts on an object, it will continue to move with **constant velocity in a straight line**.

Condition:

The object must not be accelerating or changing direction. It should move with **uniform motion** (same speed and direction).

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

Ans: When the carpet is beaten, it moves suddenly, but the dust particles remain at rest due to inertia. As a result, the dust gets detached from the carpet and falls off. This shows that objects at rest tend to remain at rest unless a force acts on them.

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

Ans: It is advised to tie luggage on the roof of a bus because when the bus suddenly stops or turns, the luggage tends to keep moving due to its inertia. This can cause the luggage to fall off and cause damage or injury. Tying it with a rope keeps it secure and prevents accidents.

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:

Ans: (c) there is a force on the ball opposing the motion.
This force is friction, which acts in the opposite direction and slows down the ball until it stops.

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 (1 tonne = 1000 kg).

Ans: Using the formula:

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

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

$400 = 200a$

$a = 2\ m/s^2$

Mass = 7000 kg

Force = ma = 7000 × 2 = 14000 N

6. A stone of 1 kg is thrown with a velocity of 20 m/s 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:

Mass (m) = 1 kg

Initial velocity (u) = 20 m/s

Final velocity (v) = 0 m/s (comes to rest)

Distance (s) = 50 m

Step 1: Find acceleration using

$v^2 = u^2 + 2as$

$0 = (20)^2 + 2 \times a \times 50$

$0 = 400 + 100a$

$a = -400 \div 100 = \mathbf{-4\ m/s^2}$

Step 2: Find force using

$F = m \times a = 1 \times (-4) = \mathbf{-4\ N}$

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, calculate:

(a) the net accelerating force

(b) the acceleration of the train:

Ans:

Given:

Mass of engine = 8000 kg

Mass of each wagon = 2000 kg

Number of wagons = 5

Total mass of wagons = 5 × 2000 = 10000 kg

Total mass of train = 8000 + 10000 = **18000 kg**

Force by engine = 40000 N

Friction force = 5000 N

(a) Net accelerating force = Applied force − Friction

= 40000 − 5000 = **35000 N**

(b) Acceleration = Net force ÷ Total mass

= 35000 ÷ 18000 = **1.94 m/s²**

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/s²?

Ans: Force = ma = 1500 × (-1.7) = -2550 N

So, a force of 2550 N in the opposite direction is needed to stop it.

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

Momentum = mass × velocity = 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 force that will be exerted on the cabinet?

Ans: If the cabinet moves at constant velocity, friction force = applied force = 200 N

11. 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: The student's logic is incorrect. According to Newton's Third Law, action and reaction forces are equal in magnitude, opposite in direction, but they act on different objects, not on the same object. So they do not cancel each other.

The truck does not move because the force applied by the person is not enough to overcome the friction between the truck's tyres and the road and the inertia of the heavy truck. Therefore, even though the person applies force, the truck remains at rest.

12. A hockey ball of mass 200 g travelling at 10 m/s is struck by a hockey stick so as to return it along its original path with a velocity of 5 m/s. Calculate the magnitude of change of momentum.

Initial momentum = $0.2 \times 10 = 2$ kg·m/s

Final momentum = $0.2 \times (-5) = -1$ kg·m/s

Change in momentum = final – initial = $-1 - 2 = -3$ kg·m/s

Magnitude = 3 kg·m/s

13. A bullet of mass 10 g travelling horizontally with a velocity of 150 m/s strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration and the force exerted by the block.

Ans: Given:

Mass of bullet (m) = 10 g = 0.01 kg

Initial velocity (u) = 150 m/s

Final velocity (v) = 0 m/s (comes to rest)

Time (t) = 0.03 s

Step 1: Calculate acceleration using the formula

$a = (v - u) \div t$

$a = (0 - 150) \div 0.03 = -5000$ m/s²

Step 2: Calculate distance of penetration using

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

$s = (150 \times 0.03) + \frac{1}{2} \times (-5000) \times (0.03)^2$

$s = 4.5 - 2.25 = 2.25$ m

Step 3: Calculate force using

$F = m \times a$

$F = 0.01 \times (-5000) = -50$ N

(Negative sign indicates the force is opposing motion)

14. An object of mass 1 kg travelling with velocity 10 m/s collides and sticks to a stationary wooden block of mass 5 kg. Calculate the total momentum before and after impact and velocity of combined object.

Ans: Given:

Mass of object (m_1) = 1 kg

Initial velocity of object (u_1) = 10 m/s

Mass of block (m_2) = 5 kg

Initial velocity of block (u_2) = 0 m/s

Formula:

Total momentum before collision = $m_1 \times u_1 + m_2 \times u_2$

Total momentum after collision = $(m_1 + m_2) \times v$

By law of conservation of momentum:

$m_1 \times u_1 + m_2 \times u_2 = (m_1 + m_2) \times v$

Calculation:

Before collision:

$= 1 \times 10 + 5 \times 0 = 10$ kg·m/s

After collision:

$(1 + 5) \times v = 6v$

$10 = 6v$

$v = 10 \div 6 = 1.67$ m/s

15. An object of mass 100 kg is accelerated uniformly from velocity 5 m/s to 8 m/s in 6 s. Calculate initial and final momentum. Also, find the force.

Ans: Given:

Mass (m) = 100 kg

Initial velocity (u) = 5 m/s

Final velocity (v) = 8 m/s

Time (t) = 6 s

Formulas:

Initial momentum = m × u

Final momentum = m × v

Force = (Final momentum − Initial momentum) ÷ Time

or

Force = m × a, where a = (v − u) ÷ t

Calculations:

Initial momentum = 100 × 5 = 500 kg·m/s

Final momentum = 100 × 8 = 800 kg·m/s

Change in momentum = 800 − 500 = 300 kg·m/s

Force = 300 ÷ 6 = 50 N

16. Akhtar, Kiran and Rahul were riding in a car moving fast. An insect hits the windscreen and gets stuck. Kiran says the insect's momentum changed more, Akhtar says the car applied more force, Rahul says both had equal forces and momentum change. Who is correct?

Rahul is correct.

Ans: According to Newton's Third Law, the force on both bodies is equal and opposite. So, both the insect and car experience equal force and equal change in momentum, but the effect is greater on the insect due to its small mass.

17. How much momentum will a dumb-bell of mass 10 kg transfer to the floor if it falls from a height of 80 cm? (g = 10 m/s^2)

Solution:

Given:

Mass (m) = 10 kg

Height (h) = 80 cm = 0.8 m

Acceleration due to gravity (g) = 10 m/s^2

Step 1: Find velocity just before hitting the floor using

$v^2 = u^2 + 2gh$

Initial velocity (u) = 0 (since it falls from rest)

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

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

Step 2: Calculate momentum using

Momentum = m × v

= 10 × 4 = 40 kg·m/s