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# Chapter – 9 Force and Laws of Motion

## Class 9 Science NCERT Textbook – Page 118

**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?**

**Answer:**

(a) Mass of a stone is more than mass of a rubber ball with same size. So, inertia of stone is more than a rubber ball.

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

(c) A five-rupee coin has more inertia than a rupee coin as its mass is more than one-rupee coin.

**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 following the force in each case.**

**Answer**: The velocity of football changes four times, when

a) a football player hit the football to player.
b) the player hit football to the goalkeeper.
c) the goalkeeper stops the football.
d) the goalkeeper hits the football.

**Q3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.**

**Answer** Some leaves of a tree get detached when on shaking its branches as they are in inertia of motion and the leaves are at inertia of rest.

**Q4. Why do you fall in the forward direction when a moving bus brakes to a stop and fall backwards when it accelerates from rest?**

**Answer**: When the bus starts from rest, the lower part of our body is in motion with the bus called inertia of motion and body is at rest called inertia of rest. So, we fall in

the forward direction when a moving bus put brakes and we fall backwards when it comes to rest.

## Class 9 Science NCERT Textbook – Page 126 and 127

**Q1. If action is always equal to the reaction, explain how a horse can pull a cart.**

**Answer:** Yes, according to Newton's third law of motion, action is always equal to the reaction. So, force is applied by the Earth on the horse in the forward direction. So, the cart moves forward and a horse can pull a cart.

**Q2. Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.**

**Answer:** It is difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity because the hose moves in the backward direction and so is difficult to hold large amounts of water at a high velocity as it applies equal force of reaction in the backward direction so as to conserve momentum.

**Q3. 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.**

**Answer:**

As, $$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

So, $$4 \times 0 + \left(\frac{50}{100}\right) \times 0 = 4v + \frac{50}{1000} \times 35$$

$$4v = -\frac{35}{20}$$

$$v = -\frac{35}{80} m/s$$

$$v = -0.4375\ m/s$$

**Q4. Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2 $m\ s^{-1}$ and 1 $ms^{-1}$, respectively. They collide and after the collision, the first object moves at a velocity of 1.67 $ms^{-1}$. Determine the velocity of the second object.**

**Answer:**

Before Collision After collision

| A | B | | A | B |
|---|---|---|---|---|
| 100 g | 200g | → | 100g | 200g |
| 2m/s | 1m/s | | v=? | 1.67 $ms^{-1}$ |

Initial momentum of A = $\frac{100}{1000} \times 2 = 0.2kg$

Initial momentum of B = $\frac{200}{1000} \times 1 = 0.2kg - 1$

∴ Total momentum of A and B before collision

$$= 0.2 + 0.2 = 0.4\ kg\ ms^{-1}$$

The velocity of A after collision = $v$

Momentum of A after collision = $\frac{100}{1000} \times V = 0.1V$

Momentum of B after collision = $\frac{200}{1000} \times 1.67 = 0.33kgms - 1$

Total momentum of A and B after collision

$$= 0.1 \times v + 0.334$$

According to the law of conservation of momentum,

Momentum of A and B after collision = momentum of A and B before collision

0.1 × v + 0.334 = 0.4

0.1 × v = 0.4 − 0.334

$$V = 0.66m\ s^{-1}$$

So, the velocity of the second object = $0.66m\ s^{-1}$.

## Class 9 Science NCERT Textbook – Page 128 and 129

**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.**

**Answer:**

Yes, when an object has a net zero external force, the object travels with a non-zero velocity. It is due to:

a) The object travels in the straight line and has uniform speed.
b) No change in the magnitude.
c) No change in the direction of motion.
d) Friction between the ground and object is zero.
e) The resistance of air on moving the object is zero.

**Q2. When a carpet is beaten with a stick, dust comes out of it. Explain?**

**Answer:**

When a carpet is beaten with the stick then the force of stick moves the carpet slightly but the dust particles are at rest due to inertia So, it comes out of it.

**Q3. Why is it advised to tie any luggage kept on the roof of a bus with a rope?**

**Answer:**

It is advised to tie luggage kept on roof of a bus with a rope because;

a) If the bus moves all of a sudden, due to its inertia of rest, luggage kept on roof of the bus is at rest and luggage will fall from the bus.
b) If the bus stops all of a sudden, due to its inertia of motion, the luggage kept on the roof of the bus, is in motion and will fall from the bus.
c) If the luggage kept on the roof of a bus is tied with a rope, will not fall when the bus starts or stops suddenly.

**Q4. A batsman hits a cricketer 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.**

**Answer:** c) There is a force on the ball opposing the motion.

**Q5. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 sec. Find its acceleration. Find the force acting on it if its mass is 7 tonnes (Hint: 1 tonne = 1000 kg.)**

**Answer:**

Initial velocity, $u = 0$

Distance travelled, $s = 400\ m$

Time, $t = 20\ sec$

Acceleration, $a = ?$

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

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

$$400 = 0 + \frac{1}{2}\ \times a\ \times 400$$

$$400 = a\ \times 200$$

$$a = \frac{400}{200}$$

$$a = 2\ m/s^2$$

The acceleration is $2\ m/s^2$

Force, $F = m\ \times a$

$$F = 7\ \times 1000\ \times 2$$

$$F = 14000\ N$$

The force is 14000 newtons.

**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?**

**Answer:**

Initial velocity, $u = 20\ ms^{-1}$

Final velocity, $v = 0$

Distance travelled, $s = 50\ m$

Acceleration, $a = ?$

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

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

$$0 = 400 + 100\,a$$

$$100\,a = -400$$

$$a = -\frac{400}{100}$$

$$a = -4\,ms^{-2}$$

Force, $F = m \times a$

$$F = 1 \times (-4)N$$

$$F = -4\,N$$

So, the force of friction is 4 newtons.

**Q7. 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, the calculate:**

a) **The net accelerating force and**
b) **The acceleration of the train.**

**Answer:**

a) Force applied by the engine is 40000 N and the force of friction by the track is 5000N

force, F = Force of engine – Force of friction

$$= 40000 - 5000$$
$$= 35000\,N$$
$$So, accelarting\ force\ (F)\ by\ the\ engine\ is\ 35000\ newtons.$$

b) The mass of one wagon of train is 200 kg, so the mass of 5 wagons of train will be 2000 × 5 = 10000 kg. so, the mass of whole train is 10000 kg.

force = mass × acceleration

$$F = m \times a$$
$$35000 = 10000 \times a$$
$$a = \frac{35000}{10000}\,ms^{-2}$$

$$a = 3.5\ ms^{-2}$$

$$The\ accelartion\ of\ the\ train\ is\ 3.5\ ms^{-2}$$

**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 $1.7\ ms^{-2}$?**

**Answer:**

Mass of vehicle, $m = 1500\ kg$

Acceleration, $a = -1.7\ ms^{-2}$

$$F = m \times a$$

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

$$F = -2550\ N$$

So, the force of vehicle and the road is 2550 newtons. Negative sign is the force acts in opposite direction to the motion of the vehicle.

**Q9. 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)** $mv$

**Answer:** d) $mv$

**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?**

**Answer:**

The wooden cabinet moves at constant velocity, i.e force of 200 N is used to overcome the force of friction, as no force is applied to produce acceleration.

So, the force of friction applied on the cabinet is equal to the force applied, that is 200 N.

**Q11. 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 $ms^{-1}$ before the collision during which they stick together. What will be the velocity of the combined object after collision?**

**Answer:**

Mass of first object, $m_1 = 1.5\ kg$

Velocity of first object, $v_1 = 2.5\ ms^{-1}$

Momentum of first object $= m_1 \times v_1$

$$= 1.5 \times 2.5$$

$$= 3.75\ kg\ ms^{-1}$$

Mass of second object, $m_2 = 1.5\ kg$

Velocity of second object, $v_2 = -2.5\ ms^{-1}$

Momentum of second object $= m_2 \times v_2$

$$= 1.5 \times (-2.5)$$

$$= -3.75\ kg\ ms^{-1}$$

Total momentum $= 3.75 + (-3.75)$

Before collision $= 3.75 - 3.75$

$$= 0\ kg\ ms^{-1}$$

The combined mass of the two objects:

$$m_1 + m_2 = 1.5\ kg + 1.5\ kg = 3.0\ kg.$$

If the velocity of combined objects after collision is $v\ ms^{-1}$.

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

After collision $= 3.0 \times v$

According to conservation of momentum:

Total momentum before collision = Total momentum after collision

$$0 = 3.0 \times v$$

$$v = \frac{0}{3.0}$$

$$v = 0\ ms^{-1}$$

So, the velocity of objects after the collision will be zero m / sec which shows that objects will stop after the collision.

**Q12. 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.**

**Answer:**

The student's answer is not justified, that the two opposite and equal forces nullify each other, as the force of action and reaction do not act on the same body, but on two different bodies.

So, the massive truck does not move because force applied is smaller than the force of friction between the wheels of the truck and road.

So, the force applied is unable to overcome the force of friction, so, truck will not move.

**Q13. 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 magnitude of change of momentum occurred in the motion of the hockey ball y the force applied by the hockey stick.**

**Answer:**

a) Mass of hockey ball, $m_1 = 200\ g$

$$= \frac{200}{1000}\ kg$$

$$= 0.2\ kg$$

$$Initial\ velocity, v_1 = 10\ ms^{-1}$$
$$Initial\ momentum = m_1 \times v_1$$
$$= 0.2 \times 10$$
$$= 2\ kg\ ms^{-1}$$

b) Mass of hockey ball, $m_2 = 200\ g$

$$= 0.2\ kg$$

Final velocity, $v_2 = -5\ ms^{-1}$

Final momentum $= m_2 \times v_2$

$$= 0.2 \times (-5)$$
$$= -1\ kg\ ms^{-1}$$

c) Change in momentum = Final – Initial momentum

$$= -1 - 2$$
$$= -3\ kg\ ms^{-1}$$

Thus, the change in momentum of hockey ball is $3\ kg\ ms^{-1}$.

**Q14. A bullet of mass 10 g travelling horizontally with a velocity of 150 $ms^{-1}$ strikes a stationary wooden block and comes to rest in 0.03 sec. 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.**

**Answer:**

Initial velocity, $u = 150\ ms^{-1}$

Final velocity, $v = 0$

Time, $t = 0.03\ sec$

$$v = u + at$$
$$0 = 150 + a \times 0.03$$
$$0.03\ a = -150$$
$$a = -\frac{150}{0.03}$$
$$a = -5000\ ms^{-2}$$

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

$$(0)^2 = (150)^2 + 2 \times (-5000) \times s$$

$$0 = 22500 - 10000 \times s$$

$$10000\ s = 22500$$

$$s = \frac{22500}{10000}$$

$$s = 2.25\ m$$

The distance of penetrating bullet in block of wood is 2.25 m.

Force, $F = m \times a$

$$F = \frac{10}{1000}\ kg\ \times (-5000)\ ms^{-2}$$

$$F = 50\ N$$

The force applied by the wooden block on the bullet is 50 newtons.

**Q15. 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.**

**Answer:**

Mass of object, $m_1 = 1\ kg$

Velocity of object, $v_1 = 10\ ms^{-1}$

Momentum of object $= m_1 \times v_1$

$= 1 \times 10\ kg\ ms^{-1}$

$= 10\ kg\ ms^{-1}$

Mass of wooden block, $m_2 = 5\ kg$

Velocity of wooden block, $v_2 = 0$

Momentum of wooden block $= m_2 \times v_2$

$= 5 \times 0$

$0\ kg\ ms^{-1}$

Total momentum $= 10 + 0$

Before impact $= 10\ kg\ ms^{-1}$

The law of conservation of momentum states that the total momentum after impact is same as the total momentum before the impact.

So, the total momentum after the impact is$10\ kg\ ms^{-1}$.

Total momentum $= 10\ kg\ ms^{-1}$

Total mass of object $= 1\ kg + 5\ kg$

Wooden block $= 6\ kg$

Velocity of object and wooden block $= v\ ms^{-1}$

$$10 = 6 \times v$$

$$v = \frac{10}{6}$$

$$v = 1.67\ ms^{-1}$$

The velocity of the object and wooden block is 1.67 metre/ second.

**Q16. An object of mass 100 kg is accelerated uniformly from a velocity of 5 $ms^{-1}$ to 8 $ms^{-1}$ in 6 sec. Calculate the initial and final momentum of the object. Also find the momentum of the force exerted on the object.**

**Answer:**

i) Initial momentum $= mass \times initial\ velocity$

$$= 100 \times 5$$

$$= 500\ kg\ ms^{-1}$$

ii) Final momentum $= mass \times final\ velocity$

$$= 100 \times 8$$

$$= 800\ kg\ ms^{-1}$$

$$Force = \frac{Change\ in\ momentum}{Time\ taken}$$

$$= \frac{800 - 500}{6}$$

$$= \frac{300}{6}$$

$$= 50\ N$$

The force applied on the object is 50 N.

**Q17. 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 struck 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 large 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.**

**Answer:**

a) Kiran suggest that the insect has more change in momentum than the change in momentum of the motorcar is wrong.
b) Akhtar suggest that the motorcar was moving with more velocity, apply more force on the insect, is also wrong.
c) Rahul suggest that both the motorcar and the insect have same force and momentum is correct. Both have same force as the action (force) and reaction (force) are equal and opposite and the magnitude of change in momentum is also the same.

**Q18. 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 $ms^{-2}$.**

**Answer:**

Initial velocity, $u = 0$

Final velocity, $v = ?$

Acceleration, $a = 10\ ms^{-2}$

Distance, $s = 80\ cm$

$$\text{Height} = \frac{80}{100}\ m$$

$$= 0.8\ m$$

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

$$v^2 = (0)^2 + 2 \times 10 \times 0.8$$

$$v^2 = 16$$

$$v = \sqrt{16}$$

$$v = 4\ ms^{-1}$$

Momentum = $mass \times velocity$

$$= 10\ kg\ \times 4\ ms^{-1}$$

$$= 40\ kg\ ms^{-1}$$

The momentum of falling dumb-bell towards the floor is 40 kg $ms^{-1}$. So, the dumb-bell applies an equal amount of momentum to the floor.