CHAPTER 8

Force and Laws of Motion

NCERT FOCUS

ANSWERS

Topic 1

1. (i) Velocity of the football changes when first player kicks the ball towards another player of his team.

(ii) Velocity of the football again changes when another player kicks the football towards the goal.

(iii) Velocity of the football also changes when the goalkeeper of the opposite team stops the football by collecting it.

(iv) Velocity of the football again changes when the goalkeeper kicks it towards a player of his team.

Thus, the velocity of the football changes four times.

In first and second cases, the force is supplied by the foot of players. In third case, force is supplied by the hands of the goalkeeper. In fourth case, as the goalkeeper hits the football with his foot, so the foot of the goalkeeper supplies the force.

2. The cabinet will move with constant velocity, if net external force acting on it is zero. Since a horizontal force of 200 N acts on the cabinet therefore, net external force acting on it will be zero if frictional force of 200 N acts on it. Thus, frictional force = 200 N will be exerted on the cabinet.

Topic 2

1. **(a)** A stone has more mass than a rubber ball of the same size. As mass is a measure of inertia, therefore, stone has more inertia than a rubber ball.

(b) A train has greater inertia than a bicycle, because train is much heavier than a bicycle.

(c) A five-rupees coin is heavier than a one-rupee coin. Therefore, inertia of a five-rupees coin is more than the inertia of a one-rupee coin.

2. When a tree is vigorously shaken, the branches of the tree come in motion but the leaves tend to continue in their state of rest due to inertia of rest. As a result of this, leaves get separated from the branches of the tree and hence fall down.

3. When a moving bus brakes to a stop, our feet come to rest with the bus. But upper part of our body continues to move forward on account of inertia of motion. That is why we tend to fall in the forward direction.

However, when the bus accelerates from rest, lower part of our body moves with the bus. The upper part of the body tries to maintain itself at rest on account of inertia of rest. Therefore, we tend to fall backwards.

4. Initially, both carpet and the dust herein are at rest. When the carpet is beaten with a stick, the carpet is set into motion. Due to inertia of rest, the dust particles tend to remain at rest. As a result, the dust particles falls off.

5. A luggage is usually tied with a rope on the roof of buses. When a moving bus suddenly stops, the luggage on its roof tends to continue in the state of motion due to inertia of motion. Hence the luggage falls down from the roof of the bus. Similarly, when a bus suddenly starts, the luggage on the roof of the bus tends to continue in the state of rest and hence falls down from the roof of the bus. Thus, to avoid the falling of the luggage, it is tied with a rope on the roof of a bus.

6. Here, $u = 0$, $s = 400$ m

$t = 20$ s, $m = 7$ tonnes $= 7000$ kg

(i) Using, $s = ut + \frac{1}{2}at^2$

$400 = 0 + \frac{1}{2}a \times 400 = 200\,a$

$\therefore \quad a = 2 \text{ m s}^{-2}$

(ii) $F = ma = 7000 \times 2 = 14000$ N

7. Here, $m = 1$ kg, $u = 20 \text{ m s}^{-1}$

$v = 0$, $s = 50$ m, $F = ?$

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

$0 - (20)^2 = 2a \times 50 = 100\,a$

or $\quad a = \frac{-400}{100} = -4 \text{ m s}^{-2}$

Then, force of friction, $F = ma$

$\therefore \quad F = 1(-4) = -4$ N

Negative sign indicates that force of friction is opposing the motion of the ball.

8. **(a)** Net accelerating force

= Force exerted by engine – Frictional force

$= 40000 - 5000 = 35000$ N

(b) Acceleration, $a = \frac{\text{accelerating force}}{\text{mass of train}}$

$= \frac{35000 \text{ N}}{10000 + 8000 \text{ kg}} = 1.94 \text{ m s}^{-2}$

9. Here, $m = 1500$ kg, $a = -1.7 \text{ m s}^{-2}$, $F = ?$

$F = ma$

$F = 1500\,(-1.7)$ N $= -2550$ N

Negative sign indicates that the force is opposing the motion of the vehicle.

10. (d) : Momentum = mass × velocity = mv

11. Yes, when external unbalanced force on an object is zero, the object can be travelling with a non-zero velocity. The necessary conditions are :

(i) The object should already be moving with a uniform speed along a straight line.

(ii) There should be no change in magnitude of velocity and also no change in the direction of motion.

(iii) The resistance to motion due to air must be zero.

(iv) The resistance to motion due to friction between the object and the ground must be zero.

If any of the four conditions stated above is not met with, the answer will be no. This is because external unbalanced force is needed for initiating the motion and also for any subsequent change (decrease/increase) in its velocity.

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

Initial velocity of bullet (u) = 150 m s^{-1}

Final velocity of bullet (v) = 0

Time (t) = 0.03 s

Acceleration on bullet (a) = ?

Distance penetrated by bullet (s) = ?

Force acting on the bullet (F) = ?

(i) Applying, $v = u + at$

$\Rightarrow \quad 0 = 150 \text{ m s}^{-1} + a \times 0.03 \text{ s}$

$\Rightarrow \quad -a \times 0.03 \text{ s} = 150 \text{ m s}^{-1}$

or $\quad a = -\dfrac{150 \text{ m s}^{-1}}{0.03 \text{ s}} = -5000 \text{ m s}^{-2}$

Applying, $s = ut + \dfrac{1}{2}at^2$

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

= 4.5 m – 2.25 m = 2.25 m

(ii) Applying, $F = ma$

Force acting on bullet (F) = 0.01 kg × (– 5000 m s^{-2}) = – 50 N

Minus sign denotes that wooden block exerts force in the direction opposite to the direction of motion of the bullet.

13. (a) Here, $u = 0$

Using $s = ut + 1/2\,at^2 = \dfrac{at^2}{2}$

$\therefore \quad a = \dfrac{2s}{t^2}$

Time in seconds	Distance in metres	$a = \dfrac{2s}{t^2}$
0	0	0
1	1	2
2	8	4
3	27	6
4	64	8
5	125	10
6	216	12
7	343	14

Thus acceleration is increasing.

(b) As $F = ma$, therefore, $F \propto a$. Hence, the force must also be increasing uniformly with time.

14. Here, mass of motorcar, m = 1200 kg

Let each person exerts a force F on the motorcar.

Total force applied by two persons = $F + F = 2F$

As this force gives a uniform velocity to the motorcar along a level road, it must be a measure of the force of friction (f) between the motorcar and the road, *i.e.*, $f = 2F$.

When three persons push the motorcar,

Total force applied = $F + F + F = 3F$

Force that produces acceleration (a = 0.2 m s^{-2}), *i.e.*,

$ma = 3F - f = 3F - 2F = F$

or $\quad F = ma = 1200 \times 0.2 = 240$ N

15. The force of nail on the hammer,

$F = \dfrac{\text{Change in momentum of hammer}}{\text{Time}}$ or $F = \dfrac{m(v-u)}{t}$

$= \dfrac{0.50 \text{ kg}(0 - 50 \text{ m s}^{-1})}{0.01 \text{ s}} = -2500 \text{ N}$

Minus sign denotes the force exerted by the nail on the hammer is acting in the direction opposite to that of hammer.

16. Here, mass, m = 1200 kg

Initial velocity, u = 90 km h^{-1}

$= 90 \times \dfrac{5}{18} = 25 \text{ m s}^{-1}$

Final velocity, v = 18 km h^{-1} $= 18 \times \dfrac{5}{18} = 5 \text{ m s}^{-1}$

Time, t = 4 s

(i) Acceleration, $a = \dfrac{\text{Change in velocity}}{\text{Time}}$

$= \dfrac{v-u}{t} = \dfrac{5-25}{4} = -5 \text{ m s}^{-2}$

(ii) Change in momentum = $mv - mu = m(v - u)$

= 1200(5 – 25) = – 24000 kg m s^{-1}

Magnitude of change in momentum = 24000 kg m s^{-1}

(iii) Force, $F = ma$ = 1200(–5) = – 6000 N

$\therefore$ Magnitude of force = 6000 N

17. Here, $m = 10$ kg, $s = 80$ cm = 0.8 m, $a = 10$ m s^{-2}
$u = 0, v = ?, p = ?$
From, $v^2 - u^2 = 2as$, $v^2 - 0 = 2 \times 10 \times 0.8 = 16$
or $v = \sqrt{16} = 4$ m s^{-1}
Momentum transferred, $p = mv = 10 \times 4$
= 40 kg m s^{-1}

18. Here, $m = 100$ kg, $u = 5$ m s^{-1}
$v = 8$ m s^{-1}, $t = 6$ s
Initial momentum of object, $p_1 = mu$
= 100 × 5 = 500 kg m s^{-1}
Final momentum of object, $p_2 = mv$
= 100 × 8 = 800 kg m s^{-1}

$$\text{Now, Force} = \frac{\text{change in momentum}}{\text{Time}}$$

$$= \frac{\text{Final momentum} - \text{Initial momentum}}{\text{Time}}$$

$$= \frac{800 - 500}{6} = \frac{300}{6} = 50 \text{ kg m s}^{-1} = 50 \text{ N}$$

19. Mass of ball (m) = 200 g = 0.2 kg
Initial velocity of ball (u_1) = 10 m s^{-1}
$\therefore$ Initial momentum of ball = mu_1
= 0.2 kg × 10 m s^{-1} = 2 N s
Final velocity of ball (u_2) = – 5 m s^{-1}
(Minus sign denotes that ball is moving in opposite direction.)
$\therefore$ Final momentum of ball = mu_2
= 0.2 kg × – 5 m s^{-1} = – 1 N s
$\therefore$ Change in momentum
= Final momentum – Initial momentum
= – 1 N s – 2 N s = – 3 N s

Minus sign denotes that change in momentum is in the direction opposite to the direction of initial momentum of the ball.

20. Kiran's suggestion is incorrect as momentum is always conserved, *i.e.*, change in momentum of insect must be equal to that of motorcar.

Akhtar's suggestion is incorrect for the same reason as stated above.

Rahul's suggestion is correct, *i.e.*, insect and motorcar experience same force and change in momentum. However, the insect died because, it was unable to bear the large force and large change in momentum.

21. Student's justification is not correct. Two equal and opposite forces cancel each other if they act on the same body. According to the third law of motion, action and reaction forces are equal and opposite but they both act on different bodies. Hence, they cannot cancel each other.

When we push a massive truck, then the force applied on the truck is not sufficient to overcome the force of friction between the tyres of the truck and ground. Hence the truck does not move. The truck will move only if the force applied on it is greater than the frictional force.