

Chapter-8

Forces and Laws of Motion

EXERCISE-8.1

1 mark

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. a a stone of the same size will have more inertia than a rubber ball.

b A train will have more inertia than a bicycle.

c A five rupees coin will have more inertia than a 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 own team”.

Also identify the agent supplying the force in each case.

Ans. In the given example the velocity of football changes four times. As described below:

i when the football player is supplying the force when he kicks the football to another player.

ii when the other player kicks football towards the goal.

iii When the goalkeeper of other team stops the ball.

iv When the goalkeeper kicks the football towards player of his team.

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

Ans. Some of the leaves may get detached from a tree if we vigorously shake its branch because the some of the leaves due to property of inertia remain at rest while we vigorously shake branch of the tree as a result those leaves detach and fall off.

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 we fall in the forward direction because we are also moving with the speed of bus due to the inertia of motion and when suddenly it puts brakes i.e. comes to rest the lower half of our body also comes to rest but the upper half of our body not being in close contact with bus is still in the phase of motion so we fall in the forward direction.

When the bus accelerates from rest, we are also at rest being on the resting seat as the engine applies force in forward direction we fall backwards due to the inertia now.

EXERCISE-8.2

2 mark

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

Ans. With a balance force the overall impact is absence of movement but with unbalanced forces, the resultant or the bigger force causes the motion. Same is true in the case where a horse pulls a cart. Horse exerts more force on the cart than the cart exerts to resist its movement hence this is an unbalanced force and the cart moves in the direction of horse's pull.

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

Ans. It is difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity because of the third law of newton when the hose ejects large amounts of water at a high velocity in forward direction the water coming out pushes the hose pipe in backward direction and it becomes difficult to hold it.

3. 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. Initial Momentum of rifle and bullet before fire

$$= mv$$

$$= (4\text{ kg} + 50\text{ g}) \times 0\text{ m/s}$$

$$= 0$$

Final Momentum of rifle and bullet after fire

$$= m_1v_1 + m_2v_2$$

$$= 4 \times v + 0.05 \times 35 \text{ where } 50\text{ g} = 0.05\text{ kg}$$

$$v = (0.05 \times 35) / 4 = -0.44\text{ m/s}$$

4. 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 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. Given,

$$m_1 = 100\text{g} = 0.1\text{ kg}$$

$$m_2 = 200\text{g} = 0.2\text{ kg}$$

$$\text{velocity of the first object} = v_1 = 2\text{ m/s}$$

$$\text{velocity of the second object} = v_2 = 1\text{ m/s}$$

$$\text{Momentum before the collision} = m_1v_1 + m_2v_2$$

$$= 0.1 \times 2 + 0.2 \times 1$$

$$= 0.4\text{ kg m/s}$$

$$\text{since velocity of first object after collision} = 1.67\text{m/s}$$

$$\text{If we suppose that velocity of second object} = v$$

As per law of conservation of momentum,

$$m_1v_1 + m_2v_2 = m_1v_1 + m_2v_2 \text{ initial momentum} = \text{final momentum}$$

$$0.4 = 0.1 \times 1.67 + 0.2 \times v$$

$$0.4 = 0.167 + 0.2v$$

$$0.2v = 0.4 - 0.167$$

$$v = 0.2333/0.2 = 2.33/2 = 1.16\text{ m/s}$$

EXERCISE-8.3

4 mark

1. 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. No, it is not possible for the object to be travelling with a non-zero velocity if an object experiences a net zero external unbalanced force since unbalanced forces cannot be equal to zero.

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

Ans. When a carpet is beaten with a stick, dust comes out of it because carpet fibres vibrate in forward and backward direction as carpet is beaten but the loosely bound dust particles due to inertia remain at rest and so they come out.

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 any luggage kept on the roof of a bus with a rope because when bus moves the luggage also gets moving with the velocity same as that of the bus and in the same direction but when bus changes direction or deaccelerates, due to inertia of motion luggage moves in the same direction and may get thrown away from roof of buses.

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

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. c there is a force on the ball opposing the motion.

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 metric tonnes Hint: 1 metric tonne = 1000 kg.

Ans. According to the question,
initial velocity of truck $u = 0$

distance = $s = 400$ m and time = 20 s

mass of truck = 7 metric tonnes = 7000 kg

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

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

$$400 = 0 + 200a$$

$$400 = 200a$$

$$a = 400/200 = 2 \text{ m/s}^2$$

therefore, $F = m \times a = 7000 \times 2 = 14000$ N

6. A stone of 1 kg is thrown with a velocity of 20 m s^{-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. since $v^2 = u^2 + 2as$

$0 = 20^2 + 2 \times a \times 50$ object comes to rest so $v=0$

$$-100a = 400$$

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

therefore, the force of friction between the stone and the ice

$$= -4 \text{ N}$$

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, then calculate:

a the net accelerating force;

b the acceleration of the train; and

c the force of wagon 1 on wagon 2.

Ans. a The net accelerating force = Force exerted by engine – frictional force of track = $40000 - 5000 = 35000$ N

b the acceleration of the train = $a = F/m = \frac{35000}{(5 \times 2000)} = 35000/10000 = 3.5 \text{ m/s}^2$

c the force of wagon 1 on wagon 2

Wagon 1 will have to exert force on all 4 wagons next to it

so mass of other 4 wagons = $2000 \times 4 = 8000$ kg

$F = ma = 8000 \text{ kg} \times 3.5 \text{ m/s}^2 = 28000$ N

EXERCISE-8.4

Frequently Asked Questions

1. 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 s^{-2} ?

Ans. since $F = m \times a = 1500 \times -1.7 = -2550 \text{ N}$ negative sign symbolises acceleration in opposite direction

2. 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

Ans. d mv

3. 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. 200 N

4. 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 m s^{-1} before the collision during which they stick together. What will be the velocity of the combined object after collision?

Ans. Momentum before collision took place = $m_1v_1 + m_2v_2$
 $= 1.5 \times 2.5 + 1.5 \times (-2.5) = 0$

Since the objects stick together after collision hence

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

$$= (1.5 + 1.5) \times v$$

$$= 3v$$

momentum before collision = momentum after collision

$$0 = 3v, v = 0/3 = 0$$

the velocity of the combined object after collision $v = 0$

5. 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. 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 result is the two opposite and equal forces cancel each other but when one of these forces is bigger than inertia so the object moves in the direction of force applied. As this student explains the truck is massive so the force applied cannot overcome force caused by inertia. Therefore, the truck does not move.

6. A hockey ball of mass 200 g travelling at 10 m s^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 m s^{-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 hockey ball = 200g = 0.2 kg

$v_1 = 10 \text{ m/s}$, $v_2 = -5 \text{ m/s}$ return velocity

initial momentum of hockey ball = $0.2 \text{ kg} \times 10 \text{ m/s} = 2 \text{ kg m/s}$

final momentum of hockey ball = $0.2 \text{ kg} \times -5 \text{ m/s} = -1 \text{ kg m/s}$

change in momentum of hockey ball = $2 - (-1) = 2 + 1 = 3 \text{ kg m/s}$

7. A bullet of mass 10 g travelling horizontally with a velocity of 150 m s^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. 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. $v = u + at$

$$0 = 150 + a \times 0.03 \text{ s}$$

$$a = -150/0.03 = -5000 \text{ m/s}^2$$

the distance of penetration of the bullet into the block $(s) = ut + \frac{1}{2} at^2$

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

$$= 4.5 - 2.25$$

$$= 2.25 \text{ m}$$

the magnitude of the force exerted by the wooden block on the bullet

$$m = 10 \text{ g} = 0.01 \text{ kg}$$

$$F = m \times a = 0.01 \text{ kg} \times -5000 \text{ m/s}^2 = -50 \text{ N}$$

8. An object of mass 1 kg travelling in a straight line with a velocity of 10 m s^{-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. Wooden block is stationary at rest so its velocity $(u_2) = 0$

mass of combined object is $= 1 \text{ kg} + 5 \text{ kg} = 6 \text{ kg}$

$$\text{total momentum before the impact} = 1 \times 10 + 5 \times 0 = 10 \text{ kg m/s}$$

law of conservation of momentum:

total momentum just before the impact = total momentum after the impact = 10 kg m/s

therefore, the velocity of the combined object: $10 = 6 \times v = 6v$

$$v = 10/6 = 1.67 \text{ m/s}$$

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

Ans. Initial momentum of the object = $100 \times 5 = 500 \text{ kg m/s}$

Final momentum of the object = $100 \times 8 = 800 \text{ kg m/s}$

since $v = u + at$

$$8 = 5 + a \times 6$$

$$a = 3/6 = 0.5 \text{ m/s}^2$$

since $F = m \times a = 100 \times 0.5 = 50 \text{ N}$