Force and Laws of Motion

Question 1:

What name is given to the product of mass and velocity of a body ?

Solution :

The product of mass and velocity of a body is called momentum.

Question 2:

Name the physical quantity which is considered to be a measure of the quantity of motion of a body.

Solution :

Momentum is the measure of quantity of motion of a body

Question 3:

What is the SI unit of momentum ?

Solution :

The SI unit of momentum is kilogram meters per second(kg.m/s)

Question 4:

State whether momentum is scalar or vector.

Solution :

Momentum is a vector quantity and is dirceted along the direction of velocity.

Question 5:

What is the total momentum of the bullet and the gun before firing ?

Solution :

The total momentum of the bullet and the gun before firing would be zero because velocities of both of them will be zero.

Question 6:

Name the physical quantity whose unit is kg.m/s.

Solution :

Momentum has its SI unit as kilogram meters per second(kg.m/s)

Question 7:

What will be the momentum of a body of mass 'm' which is moving with a velocity V ?

Solution :

Momentum of a body of mass 'm' and velocity 'v' will be

$p = m \times v$

Question 8:

What is the usual name of the forces which cannot produce motion in a body but only change its shape ?

Solution :

Balanced forces cannot produce motion in a body but can its shape.

Question 9:

Name the unbalanced force which slows down a moving bicycle when we stop pedalling it.

Solution :

Frictional force slows down a moving bicycle when we stop pedaling it.

Question 10:

State whether the following statement is true or false :

Unbalanced forces acting on a body change its shape.

Solution :

The given statement is false.

Question 11:

When a ball is dropped from a height, its speed increases gradually. Name the force which causes this change in speed.

Solution :

Force of gravity causes this change in speed.

Question 12:

Name the property of bodies (or objects) to resist a change in their state of rest or of motion.

Solution :

Inertia is the property of bodies to resist a change in their state of rest or motion

Question 13:

What is the other name of Newton's first law of motion ?

Solution :

Newton's first law of motion is also known as Galileo's law of inertia.

Question 14:

The mass of object A is 6 kg whereas that of another object B is 34 kg. Which of the two objects, A or B, has more inertia ?

Solution :

Object B has more inertia. Since mass is a measure of inertia of a body and object B has greater mass, so it will have greater inertia.

Question 15:

Name the scientist who gave the laws of motion.

Solution :

Isaac Newton gave the laws of motion.

Question 16:

State whether force is a scalar or a vector quantity.

Solution :

Force is a vector quantity.

Question 17:

With which physical quantity should the speed of a running bull be multiplied so as to obtain its momentum ?

Solution :

The speed of the running bull should be multiplied with its mass to get its momentum.

Question 18:

Fill in the following blanks with suitable words :

(a) ……is a measure of the inertia of a body.

(b) When a running car stops suddenly, the passengers are jerked …….

(c) When a stationary car starts suddenly, the passengers are jerked …….

(d) Newton's first law of motion is also called Galileo's law of ……

(e) If there were no unbalanced force of…… and no…… resistance, a moving bicycle would go on moving for ever.

Solution :

a) Mass

b) forward

c) backward

d) inertia

e) friction; air

Question 19:

Explain why, it is easier to stop a tennis ball than a cricket ball moving with the same speed.

Solution :

Since the speed of tennis ball and cricket ball is same, the momentum of cricket ball will be higher due to its mass being greater than mass of tennis ball. So, less force is required to stop a tennis ball than to stop a cricket ball.

Question 20:

Explain the meaning of the following equation : .

$p = m \times v$

where symbols have their usual meanings.

Solution :

$p = m \times v$

This equation signifies that momentum of a body is the product of its mass and its velocity.

Here, p is momentum of the body

m is the mass of the body

v is the velocity of the body.

Question 21:

Explain how, a karate player can break a pile of tiles with a single blow of his hand.

Solution :

A karate player can break a pile of tiles with a single blow because he strikes the pile with his hand very fast. In doing so, the large momentum of his hand is reduced to zero in a very short time. This exerts a large force on the pile of tiles which is sufficient to break them apart.

Question 22:

Calculate the momentum of a toy car of mass 200 g moving with a speed of 5 m/s.

Solution :

Mass of the toy car,

m = 200 g = 0.2 kg

Speed, v = 5 m/s

Momentum, p = m x v

= 0.2 x 5 = 1 kg.m/s

Question 23:

What is the change in momentum of a car weighing 1500 kg when its speed increases from 36 km/h to 72 km/h uniformly ?

Solution :

Mass of car = 1500 kg

Velocity v_1 = 36 km/hr = 10 m/s

Momentum p_1 = 1500 x 10 = 15000 kg.m/s

Velocity v_2 = 72 km/hr = 20 m/s

Momentum p_2 = 1500 x 20 = 30000 kg.m/s

Change in momentum = p_2-p_1= 30000 – 15000 = 15000 kg.m/s

Question 24:

A body of mass 25 kg has a momentum of 125 kg.m/s. Calculate the velocity of the body.

Solution :

Mass of the body, m = 25 kg

Momentum p = 125 kg.m/s

p = m x v

Mass of the body, m = 25 kg
Momentum p = 125 kg.m/s
p = m x v

$$v = \frac{P}{m} = \frac{125}{25} = 5 \text{ m/s}$$

Velocity of the body is 5 m/s

Question 25:

Calculate the momentum of the following :

(a) an elephant of mass 2000 kg moving at 5 m/s

(b) a bullet of mass 0.02 kg moving at 400 m/s

An elephant of mass 2000 kg moving at a speed of 5 m/s

A bullet of mass 0.02 kg moving at a speed of 400 m/s

Solution :

a) Mass of elephant = 2000kg

Velocity = 5 m/s

Momentum = 2000 x 5 = 10000 kg.m/s

b) Mass of bullet = 0.02 kg

Velocity = 400 m/s

Momentum = 0.02 x 400 = 8 kg.m/s

Question 26:

Which of the two, balanced forces or unbalanced forces, can change the shape of an object ? Give an example to illustrate your answer.

Solution :

Balanced forces can change the shape of the object. For example, when a balloon is pressed between hands, then balanced forces (equal and opposite forces) act on the balloon due to which the shape of the balloon changes.

Question 27:

Describe the term 'inertia' with respect to motion.

Solution :

Inertia of motion is the property of a body due to which it resists a change in its state of uniform motion. For eg., if there is no air resistance and no friction to oppose the motion of a moving bicycle, it will go on moving forever.

Question 28:

State Newton's first law of motion. Give two examples to illustrate Newton's first law of motion.

Solution :

Newton's first law of motion states that a body at rest will remain at rest, and a body in motion will continue in motion in a straight line with a uniform speed unless it is compelled by an external force to change its state of rest or of uniform motion. For example, a book lying on a table remains on the table unless we lift it with the force of our hands. And, on a frictionless surface, a moving car continues to be in the state of motion until brakes are applied on it.

Question 29:

On what factor does the inertia of a body depend ? Which has more inertia, a cricket ball or a rubber ball of the same size ?

Solution :

Inertia of a body depends on its mass. A cricket ball has more inertia than a rubber ball of the same size because it has more mass than the rubber ball.

Question 30:

Why do the passengers in a bus tend to fall backward when it starts suddenly ?

Solution :

When a bus starts suddenly, its passengers tend to fall backwards because due to their inertia, the passengers tend to remain in a state of rest even when the bus starts moving.

Question 31:

Explain why, a person travelling in a bus falls forward when the bus stops suddenly.

Solution :

When a bus stops suddenly, its passengers tend to fall forward because due to their inertia, the passengers tend to remain in a state of motion even though the bus has come to rest.

Question 32:

Give reason for the following :

When a hanging carpet is beaten with a stick, the dust particles start coming out of it.

Solution :

When a hanging carpet is beaten with a stick, the carpet moves to and fro with the force of the stick while the dust particles remain in their state of rest on account of their inertia and thus dust particles separate out from the carpet.

Question 33:

When a tree is shaken, its fruits and leaves fall down: Why ?

Solution :

When a tree is shaken, the tree moves to and fro while the fruits and leaves remain in their state of rest on account of their inertia and thus fruits and leaves separate from the tree and fall from the tree.

Question 34:

Explain why, it is dangerous to jump out of a moving bus.

Solution :

It is dangerous to jump out of a moving bus because the jumping man, who is moving with the high speed of the bus would tend to remain in state of motion due to inertia even on falling to the ground and get hurt due to resistance offered by the ground.

Question 35:

What is the momentum in kg.m/s of a 10 kg car travelling at (a) 5 m/s (b) 20 cm/s, and (c) 36 km/h ?

Solution :

Mass of car, m = 10 kg

Momentum = m x v

a) Velocity, v = 5 m/s Momentum = 10 x 5 = 50 kg.m/s

b) Velocity, v = 20 cm/s = 0.2 m/s Momentum = 10 x 0.2 = 2 kg.m/s

c) Velocity, v = 36km/hr = 10 m/s Momentum = 10 x 10 = 100 kg.m/s

Question 36:

(a) Define momentum of a body. On what factors does the momentum of a body depend ?

(b) Calculate the change in momentum of a body weighing 5 kg when its velocity decreases from 20 m/s to 0.20 m/s.

Solution :

a) Momentum is the physical quantity which is the measure of the quantity of motion of a moving body. It depends on mass and velocity of the body.

b) Mass of body = 5 kg

Velocity v_1 = 20 m/s

Momentum p_1 = 20 x 5 = 100 kg.m/s

Velocity v_2 = 0.2 m/s

Momentum p_2 = 5 x 0.2 = 1 kg.m/s

Change in momentum = $p_2 - p_1$ = 1-100 = -99 kg.m/s (Negative sign shows that momentum decreases)

Question 37:

(a) Define the term 'force'.

(b) State the various effects of force.

Solution :

a) Force is an influence which tends to set a stationary body in motion or stop a moving body; or which tends to change the speed and direction of a moving body; or which tends to change the shape and size of a body.

b) Various effects of force are

i) A force can move a stationary body.

ii) A force can stop a moving body.

iii) A force can change the speed of a moving body.

iv) A force can change the direction of a moving body.

v) A force can change the shape and size of a body.

Question 38:

Give one example each where :

(a) a force moves a stationary body.

(b) a force stops a moving body.

(c) a force changes the speed of a moving body.

(d) a force changes the direction of a moving body.

(e) a force changes the shape (and size) of a body.

Solution :

a) Kicking a stationary football.

b) Applying brakes to a moving bicycle.

c) Pressing an accelerator to speed up a moving car.

d) A moving cricket ball hit by a bat.

e) Flattening of dough by a rolling pin to make chapatis.

Question 39:

(a) What do you understand by the terms "balanced forces" and "unbalanced forces" ? Explain with examples.

(b) What type of forces – balanced or unbalanced – act on a rubber ball when we press it between our hands ? What effect is produced in the ball ?

Solution :

a) If the resultant of all the forces acting on a body is zero, the forces are called balanced forces. These forces do not change the state of rest or of uniform motion of a body but can change the shape of the body. For example, when a balloon is pressed between hands, then balanced forces (equal and opposite forces) act on the balloon due to which the shape of the balloon changes.

If the resultant of all the forces acting on a body is not zero, the forces are called unbalanced forces. These forces change the state of rest or of uniform motion of a body. For eg., if we push a toy car lying on the ground, it starts moving due to the unbalanced force exerted by our hands.

b) When we press a rubber ball between our hands, balanced forces acts on it and hence its shape changes.

Question 40:

(a) What happens to the passengers travelling in a bus when the bus takes a sharp turn ? Give reasons for
your answer.

(b) Why are road accidents at high speeds very much worse than road accidents at low speeds ?

A road accident at high speeds of vehicles

A road accident at low speeds of vehicles

Solution :

a) When a bus takes a sharp turn, the passengers tend to fall sideways because of their inertia or their tendency to continue moving in a straight line.

b) Road accidents at high speeds are much worse than road accidents at low speeds because the momentum of vehicles at high speeds is very high and causes a lot of damage to the

vehicles and injuries to the passengers during collision.

Lakhmir Singh Physics Class 9 Solutions Page No:57

Question 51:

A plastic ball and a clay ball of equal masses, travelling in the same direction with equal speeds, strike against a vertical wall. From which ball does the wall receive a greater amount of momentum ?

Solution :

The wall will receive equal momentum from both the balls because both balls have equal mass and velocity.

Question 52:

A moving bicycle comes to rest after sometime if we stop pedalling it. But Newton's first law of motion says that a moving body should continue to move for ever, unless some external force acts on it. How do you explain the bicycle case ?

Solution :

In this case, the bicycle has been compelled to change its state of motion by the external force of air resistance and friction. If there were no air resistance and no friction to oppose the motion of the bicycle, then according to the first law of motion, the bicycle would go on moving forever.

Question 53:

A man throws a ball weighing 500 g vertically upwards with a speed of 10 m/s.

1. What will be its initial momentum ?
2. What would be its momentum at the highest point of its flight ?

Solution :

Mass of ball = 500 g = 0.5 kg
Initial velocity = 10 m/s

1. Initial momentum = 0.5 x 10 = 5 kg.m/s
2. Velocity at the highest point = 0 m/s

Momentum at the highest point = 0.5 x 0 = 0 kg.m/s

Question 54:

A car is moving on a level road. If the driver turns off the engine of the car, the car's speed decreases gradually and ultimately it comes to a stop. A student says that two forces act on the car which bring it to a stop. What could these forces be ? Which of these two forces contributes more to slow down and stop the car ?

Solution :

The two forces acting on the car are force of friction and air resistance. Force of friction contributes more to slow down and stop the car.

Question 55:

There are two types of forces X and Y. The forces belonging to type X can produce motion in a stationary object but cannot change the shape of the object. On the other hand, forces belonging to type Y cannot produce motion in a stationary object but can change the shape of the object. What is the general name of the forces such as (a) X, and (b) Y ?

Solution :

a) X are unbalanced force.

b) Y are balanced forces.

Lakhmir Singh Physics Class 9 Solutions Page No:74

Question 1:

Which physical quantity corresponds to the rate of change of momentum ?

Solution :

Force corresponds to the rate of change of momentum.

Question 2:

State the relation between the momentum of a body and the force acting on it.

Solution :

The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.

Question 3:

What is tire unit of force ?

Solution :

The SI unit of force is newton(N)

Question 4:

Define one newton force.

Solution :

A newton force is defined as that force which when acting on a body of mass of 1 kg produces an acceleration of $1 m/s^2$ in it.

Question 5:

What is the relationship between force and acceleration ?

Solution :

Force acting on a body is directly proportional to the acceleration produced in the body.

Force acting on a body is directly proportional to the acceleration produced in the body.

$F \propto a$

Question 6:

If the mass of a body and the force acting on it are both doubled, what happens to the acceleration ?

Solution :

Acceleration remains same since

$$a = \frac{F}{m}$$

Now if force is doubled i.e. 2F and mass is doubled i.e. 2m

Then acceleration $a = \frac{2F}{2m} = \frac{F}{m}$

Acceleration remains same since

Now if force is doubled i.e. 2F and mass is doubled i.e. 2m

Then acceleration

Question 7:

Name the physical quantity whose unit is ‘newton’.

Solution :

Newton is the SI unit of force.

Question 8:

Which physical principle is involved in the working of a jet aeroplane ?

Solution :

Jet airplanes work on the principle of conservation of momentum.

Question 9:

Name the principle on which a rocket works.

Solution :

Rockets work on the principle of conservation of momentum.

Question 10:

Is the following statement true or false :

A rocket can propel itself in a vacuum.

Solution :

True, because rocket does not require air for obtaining uplift or for burning its fuel.

Question 11:

What is the force which produces an acceleration of 1 m /s^2 in a body of mass 1 kg ?

Solution :

Mass, m = 1 kg

Acceleration, a =

1m/s^2

Force F = m x a = 1

x 1= 1N

Question 12:

Find the acceleration produced by a force of 5 N acting on a mass of 10 kg.

Solution :

Force F =5 N

Mass m = 10 kg

Force F =5 N
Mass m = 10 kg
Acceleration $a = \frac{F}{m} = \frac{5}{10} = 0.5\ m/s^2$

Question 13:

A girl weighing 25 kg stands on the tloor. She exerts a downward force of 250 N on the floor. What force does the floor exert on her ?

Solution :

The force exerted by the floor on her = the downward force exerted by the girl =250 N

This is due to Newton's third law of motion which states that to every action there is an equal and opposite reaction.

$a = \frac{F}{m}$

Question 14:

Name the physical quantity which makes it easier to accelerate a small car than a large car.

Solution :

Less mass of the small car makes it easier to accelerate a small car than a large car because acceleration is inversely

proportional to mass of the car

Question 15:

Fill in the following blanks with suitable words :

(a) To every action, there is an…….. and…… reaction

(b) Momentum is a…….. Its emit is……

(c) Newton's second law of motion can be written as Force = mass x …… or Force = …….. of change of……

(d) Forces in a Newton's third law pair have equal…… but act in opposite……..

(e) In collisions and explosions, the total …… remains constant, provided that no external……..

Solution :

a) Equal; opposite

b) Vector; kg.m/s

c) Acceleration; rate; momentum

d) Magnitude; directions

e) Momentum; force

Question 16:

Explain the meaning of the following equation :

F = m x a

where symbols have their usual meanings

Solution :

Force is directly proportional to the product of 'mass' of the body and the 'acceleration' produced in the body by the action of force.

F = m x a

where F is the force applied on the body

m is the mass of the body

a is the acceleration produced in the body

Question 17:

To take the boat away from the bank of a river, the boatman pushes the bank with an oar. Why ?

Solution :

To take boat away from the bank of a river, the boatman pushes the bank with the oar. The bank exerts an equal and opposite force on the boat which makes the boat move forward away from the bank.

Question 18:

Why does a gunman get a jerk on firing a bullet ?

A gunman gets a jerk on firing a bullet.

Solution :

Gunman gets a jerk on firing a bullet because when a bullet is fired from a gun, the force sending the bullet forward is equal to the force sending the gun backwards but due to high mass of the gun, it moves only a little distance backwards giving a jerk to the gunman.

Question 19:

If action is always equal to reaction, explain why a cart pulled by a horse can be moved.

Solution :

To make the cart move, the horse bends forward and pushes the ground with its feet. When the forward reaction to the backward push of the horse on the ground is greater than the opposing frictional forces of the wheels, the cart moves.

Lakhmir Singh Physics Class 9 Solutions Page No:75

Question 20:

Explain how a rocket works

Solution :

A rockets works on the principle of action and reaction. In a rocket, the hot gases produced by the rapid burning of fuel rush out of a jet at the bottom of the rocket at a very high speed. The equal and opposite reaction force of the downward going gases pushes the rocket upward with a great speed.

Question 21

Do action and reaction act on the same body or different bodies ? How are they related in magnitude and direction ? Are they simultaneous or not ?

Solution :

Action and reaction act on two different bodies. Action and reaction are equal in magnitude but they act in opposite directions and there is simultaneous action and reaction.

Question 22

If a man jumps out from a boat, the boat moves backwards. Why ?

Solution :

When a man jumps out from a boat, the boat moves backwards due to the fact that to step out of the boat, the man presses the boat with his foot in the backward direction. The push of the man on the boat is action. The boat exerts an equal force on the man in the forward direction and since the boat is not fixed and is floating, it moves backwards due to the action force exerted by the man.

Question 23

Why is it difficult to walk on a slippery road ?

Solution :

It becomes very difficult to walk on a slippery road because of the fact that on a slippery road, the friction is much less, and we cannot exert a backward action force on slippery ground which would produce a forward reaction force on us.

Question 24:

Explain why, a runner presses the ground with his feet before he starts his run.

Solution :

To start his run, a runner bends forward and pushes the ground with his feet in the backward direction. In turn ground exerts a reaction force on the runner in the forward direction which makes him run.

Question 25:

A 60 g bullet fired from a 5 kg gun leaves with a speed of 500 m/s. Find the speed (velocity) with which the gun recoils (jerks backwards).

Solution :

Mass of bullet, m_1 = 60g = 0.06 kg

Velocity of bullet v_1 = 500 m/s

Mass of gun m_2 = 5 kg

Recoil velocity v_2

According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$0.06 \times 500 = 5 \times v_2$

Mass of bullet, m_1 = 60g = 0.06 kg
Velocity of bullet v_1 = 500 m/s
Mass of gun m_2 = 5 kg
Recoil velocity v_2
According to the law of conservation of momentum
$m_1 \times v_1 = m_2 \times v_2$
$0.06 \times 500 = 5 \times v_2$

$$v_2 = \frac{0.06 \times 500}{5} = 6 \text{ m/s}$$

Question 26:

A 10 g bullet travelling at 200 m/s strikes and remains embedded in a 2 kg target which is originally at rest but free to move. At what speed does the target move off ?

Solution :

Mass of bullet, m_1 = 10g = 0.01 kg

Velocity of bullet v_1 = 200 m/s

Mass of block with the bullet as bullet gets embedded in it, m_2 = 2+0.01 = 2.01 kg

Recoil velocity v_2

According to the law of conservation of momentum $m_1 \times v_1 = m_2 \times v_2$

$0.01 \times 200 = 2.01 \times v_2$

Mass of bullet, m_1 = 10g = 0.01 kg
Velocity of bullet v_1 = 200 m/s
Mass of block with the bullet as bullet gets embedded in it, m_2 = 2+0.01 = 2.01 kg
Recoil velocity v_2
According to the law of conservation of momentum
$m_1 \times v_1 = m_2 \times v_2$
$0.01 \times 200 = 2.01 \times v_2$

$$v_2 = \frac{0.01 \times 200}{2.01} = 0.99 \text{ m/s}$$

Question 27:

A body of mass 2 kg is at rest. What should be the magnitude of force which will make the body move with

a speed of 30 m/s at the end of 1 s ?

Solution :

Mass of the body = 2kg

Initial velocity u = 0

Final velocity v = 30 m/s

Time t = 1 s

Mass of the body = 2kg
Initial velocity u = 0
Final velocity v = 30 m/s
Time t = 1 s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{30-0}{1} = 30 \text{ m/s}^2$$

Force = m x a =2 x 30 = 60 N

Question 28:

A body of mass 5 kg is moving with a velocity of 10 m/s. A force is applied to it so that in 25 seconds, it attains a velocity of 35 m/s. Calculate the value of the force applied.

Solution :

Mass of the body = 5 kg

Initial velocity u = 10 m/s

Final velocity v = 35 m/s

Time t = 25 s

Mass of the body = 5 kg
Initial velocity u = 10 m/s
Final velocity v = 35 m/s
Time t = 25 s

Acceleration $a = \frac{v-u}{t} = \frac{35-10}{25} = 1\ m/s^2$

Force = m x a =5 x 1 = 5 N

Question 29:

A car of mass 2400 kg moving with a velocity of 20 m s^{-1} is stopped in 10 seconds on applying brakes. Calculate the retardation and the retarding force.

Solution :

Mass of the car = 2400 kg

Initial velocity u = 20 m/s

Final velocity v = 0 m/s

Time t = 10 s

Mass of the car = 2400 kg
Initial velocity u = 20 m/s
Final velocity v = 0 m/s
Time t = 10 s

Retardation $a = \frac{v-u}{t} = \frac{0-20}{10} = -2\ m/s^2$

Force = m x a =2400 x -2 = - 4800 N

Question 30:

For how long should a force of 100 N act on a body of 20 kg so that it acquires a velocity of 100 m/s ?

Solution :

Mass of the body = 20 kg

Initial velocity u = 0 m/s

Final velocity v = 100 m/s

Force F = 100 N

Mass of the body = 20 kg
Initial velocity u = 0 m/s
Final velocity v = 100 m/s
Force F = 100 N

Acceleration $a = \frac{F}{m} = \frac{100}{20} = 5\ m/s^2$

Time $t = \frac{v-u}{a} = \frac{100-0}{5} = 20\ s$

Question 31:

How long will it take a force of 10 N to stop a mass of 2.5 kg which is moving at 20 m/s ?

Solution :

Mass of the body = 2.5 kg

Initial velocity u = 20 m/s

Final velocity v = 0 m/s

Force F = 10 N

Mass of the body = 2.5 kg
Initial velocity u = 20 m/s
Final velocity v = 0 m/s
Force F = 10 N

Acceleration $a = \frac{F}{m} = \frac{10}{2.5} = 4\ m/s^2$

Since v < u, so acceleration will have a negative sign $a = -4\ m/s^2$

Time $t = \frac{v-u}{a} = \frac{0-20}{-4} = 5\ s$

Question 32:

The velocity of a body of mass 10 kg increases from 4 m/s to 8 m/s when a force acts on it for 2 s.

(a) What is the momentum before the force acts ?

(b) What is the momentum after the force acts ?

(c) What is the gain in momentum per second ?

(d) What is the value of the force ?

Solution :

Mass of the body = 10 kg

Initial velocity u = 4 m/s

Final velocity v = 8 m/s

Time t = 2 s

a) Momentum before force acts $p_1 = m \times u = 10 \times 4 = 40$ kg.m/s

b) Momentum after force acts $p_2 = m \times v = 10 \times 8 = 80$ kg.m/s

c) Gain in momentum for 2 s = $p_2 - p_1 = 40$ kg.m/s

Mass of the body = 10 kg
Initial velocity u = 4 m/s
Final velocity v = 8 m/s
Time t = 2 s
a) Momentum before force acts $p_1 = m \times u = 10 \times 4 = 40$ kg.m/s
b) Momentum after force acts $p_2 = m \times v = 10 \times 8 = 80$ kg.m/s
c) Gain in momentum for 2 s = $p_2 - p_1 = 40$ kg.m/s

Gain in momentum per second = $\frac{40}{2} = 20$ kg.m/s

d) Acceleration $a = \frac{v-u}{t} = \frac{8-4}{2} = 2\ m/s^2$

Force = $m \times a = 10 \times 2 = 20$ N

Question 33:

A gun of mass 3 kg fires a bullet of mass 30 g. The bullet takes 0.003 s to move through the barrel of the gun and acquires a velocity of 100 m/s. Calculate :

(i) the velocity with which the gun recoils.

(ii) the force exerted on gunman due to recoil of the gun

Solution :

Mass of the gun $m_1 = 3$ kg

Mass of bullet $m_2 = 30\ g = 0.03$ kg

Velocity of bullet $v_2 = 100$ m/s

i) According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$3 \times v_1 = 0.03 \times 100$

Mass of the gun $m_1 = 3$ kg
Mass of bullet $m_2 = 30\ g = 0.03$ kg
Velocity of bullet $v_2 = 100$ m/s
i) According to the law of conservation of momentum
$m_1 \times v_1 = m_2 \times v_2$
$3 \times v_1 = 0.03 \times 100$

Recoil velocity $v_1 = \frac{100 \times 0.03}{3} = 1$ m/s

ii) Initial velocity of the gun u = 0 m/s
Final velocity of the gun v = 1 m/s
Time t = 0.003 s

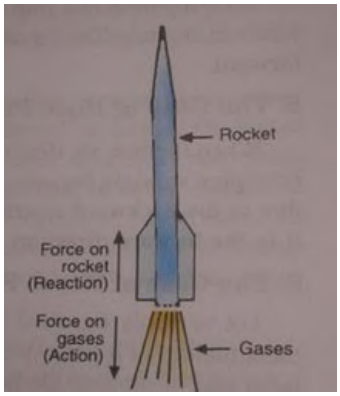
Acceleration $a = \frac{v-u}{t} = \frac{1-0}{0.003} = \frac{1000}{3}\ m/s^2$

Force = $m \times a = 3 \times \frac{1000}{3} = 1000$ N

Question 34:

Draw a diagram to show how a rocket engine provides a force to move the rocket upwards. Label the diagram appropriately.

Solution :



Question 35:

Name the laws involved in the following situations :

(a) the sum of products of masses and velocities of two moving bodies before and after their collision remains the same.

(b) a body of mass 5 kg can be accelerated more easily by a force than another body of mass 50 kg under similar conditions

(c) when person A standing on roller skates pushes another person B (also standing on roller skates) and makes him move to the right side, then the person A himself gets moved to the left side by an equal distance.

(d) if there were no friction and no air resistance, then a moving bicycle would go on moving for ever.

Solution :

a)Law of conservation of momentum

b)Newton's second law of motion

c) Newton's third law of motion

d)Newton's first law of motion

Question 36:

(a) State and explain Newton's second law of motion.

(b) A 1000 kg vehicle moving with a speed of 20 m/s is brought to rest in a distance of 50 metres :

(i) Find the acceleration.

(ii) Calculate the unbalanced force acting on the vehicle.

Solution :

(a) According to Newton's second law of motion: The rate of change of momentum of a body is directly proportional to the applied force, and takes place in the direction in which the force acts.

Consider a body of mass m having initial velocity u. the initial momentum of this body will be mu. Suppose a force F acts on this body for time t causing the final velocity to be v. The final momentum of the body will be mv. Now the change in momentum is mv mu and the time taken for this change is t. So according to Newton's second law of motion,

(a) According to Newton's second law of motion: The rate of change of momentum of a body is directly proportional to the applied force, and takes place in the direction in which the force acts.
Consider a body of mass m having initial velocity u. the initial momentum of this body will be mu. Suppose a force F acts on this body for time t causing the final velocity to be v. The final momentum of the body will be mv. Now the change in momentum is mv – mu and the time taken for this change is t. So according to Newton's second law of motion,

$$F \propto \frac{mv-mu}{t}$$

$$\propto \frac{m(v-u)}{t}$$

But $\frac{(v-u)}{t}$ represents change in velocity with time i.e. acceleration 'a'. So by replacing $\frac{(v-u)}{t}$ with a in the above relation, we get

$$F \propto m \times a$$

Thus, the force acting on a body is directly proportional to the product of mass and acceleration produced in the body by the action of the force.
Thus, Newton's second law gives the relationship between force and acceleration.

(b) Mass of the vehicle, m = 1000kg
Initial velocity u = 20 m/s
Final velocity v = 0 m/s
Distance covered before stopping, s = 50 m
Using third equation of motion

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

$0^2 - 20^2 = 2 \times a \times 50$

Acceleration, $a = \frac{-400}{2 \times 50} = -4\ m/s^2$

Unbalanced Force = m x a = 1000 x -4 = -4000 N

Question 37:

(a) Explain why, a cricket player moves his hands backwards while catching a fast cricket ball.
(b) A 150 g ball, travelling at 30 m/s, strikes the palm of a player's hand and is stopped in 0.05 second. Find the force exerted by the ball on the hand.

Solution :

a) A player moves his hands backwards while catching a fast ball because a fast moving ball has a large momentum and in stopping this ball, its momentum has
to be reduced to zero. Now, when a cricket player moves back his hands on catching the fast ball, then the time taken to reduce the momentum of the ball is increased. So, the rate of change of momentum of ball is decreased and hence a small force is exerted on the hands of the player and the hands of the player do not get hurt.
b)Mass of ball = 150 g = 0.15 kg
Initial velocity u = 30 m/s
Final velocity v = 0 m/s
Time t = 0.05 s

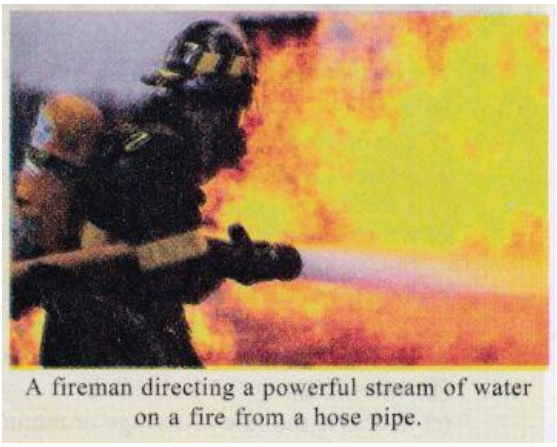
a) A player moves his hands backwards while catching a fast ball because a fast moving ball has a large momentum and in stopping this ball, its momentum has to be reduced to zero. Now, when a cricket player moves back his hands on catching the fast ball, then the time taken to reduce the momentum of the ball is increased. So, the rate of change of momentum of ball is decreased and hence a small force is exerted on the hands of the player and the hands of the player do not get hurt.
b) Mass of ball = 150 g = 0.15 kg
Initial velocity u = 30 m/s
Final velocity v = 0 m/s
Time t = 0.05 s

Acceleration $a = \frac{(v-u)}{t} = \frac{0-30}{0.05} = -6000\ m/s^2$

Force = m x a = 0.15 x 6000 = 90 N

Question 38:

(a) State Newton's third law of motion and give two examples to illustrate the law.
(b) Explain why, when a fireman directs a powerful stream of water on a fire from a hose pipe, the hose pipe tends to go backward.



A fireman directing a powerful stream of water on a fire from a hose pipe.

Solution :

a) According to Newton's third law of motion: Whenever one body exerts a force on another body, the second body exerts an equal and opposite force on the first body. In other words, to every action, there is an equal and opposite reaction. Two examples to illustrate this law-

When a man jumps out from a boat, the boat moves backwards. This is due to the fact that to step out of the boat, the man presses the boat with his foot in the backward direction. The push of the man on the boat is action. The boat exerts an equal force in the forward direction and since the boat is not fixed and is floating, it moves backwards due to the action force exerted by the man.

Gunman gets a jerk on firing a bullet from his gun. This is because when a bullet is fired from a gun, the force sending the bullet forward is equal to the force sending the gun backwards but due to high mass of the gun, it moves only a little distance backwards giving a jerk to the gunman.

b) When a fireman directs a powerful stream of water on a fire, the hose pipe tends to go backward due to the reaction force of the water rushing through it in the forward direction at a great speed.

Lakhmir Singh Physics Class 9 Solutions Page No:76

Question 39:

(a) State the law of conservation of momentum.

(b) Discuss the conservation of momentum in each of the following cases :

(i) a rocket taking off from ground.

(ii) flying of a jet aeroplane.

Solution :

a) According to the law of conservation of momentum: When two (or more) bodies act upon one another, their total momentum remains constant (or conserved) provided no external forces are acting. It means that when one body gains momentum, then some other body loses an equal amount of momentum i.e. momentum is neither created nor destroyed.

b)

a. Rocket taking off from the ground The chemicals inside the rocket burn and produce very high velocity blast of hot gases. These gases pass out through the tail nozzle of the rocket in the downward direction with tremendous speed and the rocket moves up to balance the momentum of the gases. The gases have a very high velocity ang hence a very large momentum. An equal momentum is imparted to the rocket in the opposite direction, so that it goes up with a high velocity.

b. Flying of jet aeroplane

In jet aeroplanes, a large volume of gases produced by the combustion of fuel is allowed to escape through a jet in backward direction. Due to high velocity, the backward rushing gases have a large momentum. They impart an equal and opposite momentum to the jet aeroplane due to which it moves forward with a great speed.

Question 40:

(a) If a balloon filled with air and its mouth untied/ is released with its mouth in the downward direction, it

moves upwards. Why ?

(b) An unloaded truck weighing 2000 kg has a maximum acceleration of 0.5 m/s^2. What is the maximum acceleration when it is carrying a load of 2000 kg ?

Solution :

a) If of a balloon filled with compressed air and its mouth untied is released with its mouth in the downward direction, the balloon moves in the upward direction because the air present in the balloon rushes out in the downward direction. The equal and opposite reaction of

downward going air pushes the balloon upwards.

b) Mass of the unloaded truck, m_1= 2000 kg

Acceleration a_1 = 0.5 m/s^2

Mass of loaded truck, m_2 = 2000+ 2000 = 4000 kg

Acceleration a_2

$m_1 \times a_1 = m_2 \times a_2$

b) Mass of the unloaded truck, m_1= 2000 kg
Acceleration a_1 = 0.5 m/s^2
Mass of loaded truck, m_2 = 2000+ 2000 = 4000 kg
Acceleration a_2
$m_1 \times a_1 = m_2 \times a_2$

$$a_2 = \frac{2000 \times 0.5}{4000} = 0.25\ m/s^2$$

Lakhmir Singh Physics Class 9 Solutions Page No:77

Question 51:

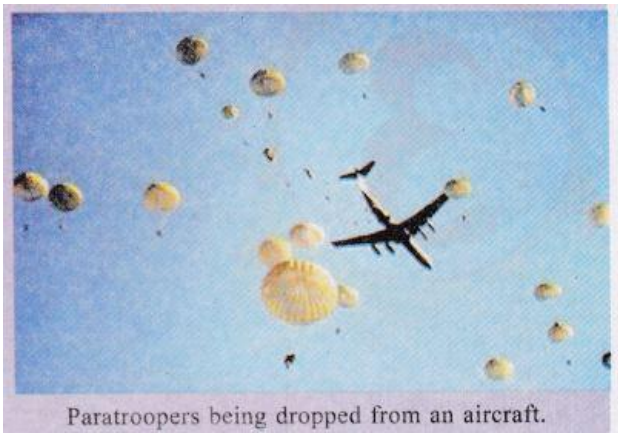
Why are car seat-belts designed to stretch some what in a collision ?

Solution :

Car seat-belts are somewhat stretchable so as to increase the time taken by the passengers to fall forward. Due to this, the rate of change of momentum of passengers is reduced and hence less stopping force acts on them. So the passengers do not get hurt.

Question 52:

The troops (soldiers) equipped to be dropped by parachutes from an aircraft are called paratroopers. Why do paratroopers roll on landing ?



Paratroopers being dropped from an aircraft.

Solution :

The paratroopers roll on landing to increase the time taken to reduce the momentum of their body. Thus, the rate of change of momentum is reduced and hence less force is exerted on their legs and they do not get hurt.

Question 53:

Why would an aircraft be unable to fly on the moon ?

Solution :

An aircraft needs air because air moving under the wings of aircraft is strong enough to hold it up and air is also required to burn the fuel in aircraft engines. Since there is no air on moon, an aircraft cannot fly on moon.

Question 54:

Explain why it is possible for a small animal to fall from a considerable height without any injury being caused when it reaches the ground.

Solution :

It is possible for a small animal to fall from a considerable height without being injured

because a small animal has small mass, so the momentum produced is less. When the small animal falls to the ground with less momentum, less opposing force of ground acts on it and hence no injury is caused to it

Question 55:

A boy of mass 50 kg running at 5 m/s jumps on to a 20 kg trolley travelling in the same direction at 1.5 m/s. What is their common velocity ?

Solution :

Mass of the boy, m_1= 50 kg

Speed of boy, u_1 = 5 m/s

Mass of trolley m_2 = 20 kg

Speed of trolley u_2 =1.5 m/s

Combined mass of boy and trolley, m = 20+ 50 = 70 kg

Combined velocity v

Acc. to the law of conservation of momentum

$m_1u_1 + m_2u_2 = mv$

$50 \times 5 + 20 \times 1.5 = 70 \times v$

Mass of the boy, m_1= 50 kg
Speed of boy, u_1 = 5 m/s
Mass of trolley m_2 = 20 kg
Speed of trolley u_2 =1.5 m/s
Combined mass of boy and trolley, m = 20+ 50 = 70 kg
Combined velocity v
Acc. to the law of conservation of momentum
$m_1u_1 + m_2u_2 = mv$
$50 \times 5 + 20 \times 1.5 = 70 \times v$

$$v = \frac{250 + 30}{70} = 4 \text{ m/s}$$

Question 56:

A girl of mass 50 kg jumps out of a rowing boat of mass 300 kg on to the bank, with a horizontal velocity of 3 m/s. With what velocity does the boat begin to move backwards ?

Solution :

Mass of the boat m_b = 300 kg

Velocity of boat v_b

Mass of girl m_g = 50 kg

Velocity of girl v_g = 3 m/s

Acc. to the law of conservation of momentum

$m_bv_b=m_gv_g$

$300 \times v_b = 50 \times 3$

Mass of the boat m_b = 300 kg
Velocity of boat v_b
Mass of girl m_g = 50 kg
Velocity of girl v_g = 3 m/s
Acc. to the law of conservation of momentum
$m_bv_b=m_gv_g$
$300 \times v_b = 50 \times 3$

$$v_b = \frac{50 \times 3}{300} = 0.5 \text{ m/s}$$

Question 57:

A truck of mass 500 kg moving at 4 m/s collides with another truck of mass 1500 kg moving in the same direction at 2 m/s. What is their common velocity just after the collision if they move off together ?

Solution :

Mass of first truck, m_1= 500 kg

Speed of first truck, u_1 = 4 m/s

Mass of second truck, m_2 = 1500 kg

Speed of second truck, u_2 =2 m/s

Combined mass of both trucks, m = 1500 + 500 = 2000 kg

Combined velocity v

Acc. to the law of conservation of momentum

$m_1u_1 + m_2u_2 = mv$

500 x 4 + 1500 x 2 = 2000 x v

Mass of first truck, m_1= 500 kg
Speed of first truck, u_1 = 4 m/s
Mass of second truck, m_2 = 1500 kg
Speed of second truck, u_2 =2 m/s
Combined mass of both trucks, m = 1500 + 500 = 2000 kg
Combined velocity v
Acc. to the law of conservation of momentum
$m_1u_1 + m_2u_2 = mv$
500 x 4 + 1500 x 2 = 2000 x v

$$v = \frac{2000 + 3000}{2000} = 2.5 \text{ m/s}$$

Question 58:

A ball X of mass 1 kg travelling at 2 m/s has a head-on collision with an identical ball Y at rest. X stops and Y moves off. Calculate the velocity of Y after the collision.

Solution :

Mass of the ball x, m_1= 1 kg

Speed of ball x, u_1 = 2 m/s

Mass of ball y, m_2 = 1 kg

Speed of ball y, u_2 =0 m/s (at rest)

Velocity of ball x after collision, v_1 = 0 m/s

Velocity of ball y after collision, v_2

Acc. to the law of conservation of momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

1 x 2 + 1 x 0 = 1 x 0 + 1 x v_2

Mass of the ball x, m_1= 1 kg
Speed of ball x, u_1 = 2 m/s
Mass of ball y, m_2 = 1 kg
Speed of ball y, u_2 =0 m/s (at rest)
Velocity of ball x after collision, v_1 = 0 m/s
Velocity of ball y after collision, v_2
Acc. to the law of conservation of momentum
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
1 x 2 + 1 x 0 = 1 x 0 + 1 x v_2

$$v_2 = \frac{1x2}{1} = 2 \text{ m/s}$$

Question 59:

A heavy car A of mass 2000 kg travelling at 10 m/s has a head-on collision with a sports car B of mass 500 kg. If both cars stop dead on colliding, what was the velocity of car B ?

Solution :

Mass of car A, m_1= 2000 kg

Speed of car A, v_1 = 10 m/s

Mass of car B, m_2 = 500 kg

Speed of car B, v_2

Acc to law of conservation of momentum

$m_1v_1 = m_2v_2$

2000 x 10 = 500 x v_2

Mass of car A, m_1= 2000 kg
Speed of car A, v_1 = 10 m/s
Mass of car B, m_2 = 500 kg
Speed of car B, v_2
Acc to law of conservation of momentum
$m_1v_1 = m_2v_2$
$2000 \times 10 = 500 \times v_2$
$v_2 = \frac{2000 \times 10}{500} = 40$ m/s

Question 60:

A man wearing a bullet-proof vest stands still on roller skates. The total mass is 80 kg. A bullet of mass 20 grams is fired at 400 m/s. It is stopped by the vest and falls to the ground. What is then the velocity of the man ?

Solution :

Mass of the man, m_1= 80 kg

Speed of man, v_1

Mass of bullet m_2 = 20 g = 0.02 kg

Speed of bullet v_2 = 400 m/s

Acc to law of conservation of momentum

$m_1v_1 = m_2v_2$

$80 \times v_1 = 0.02 \times 400$

Mass of the man, m_1= 80 kg
Speed of man, v_1
Mass of bullet m_2 = 20 g = 0.02 kg
Speed of bullet v_2 = 400 m/s
Acc to law of conservation of momentum
$m_1v_1 = m_2v_2$
$80 \times v_1 = 0.02 \times 400$
$v_1 = \frac{400 \times 0.02}{80} = 0.1$ m/s