Forces and Laws of Motion

Force

It is the force that enables us to do any work.

To do anything, either we pull or push the object. Therefore, pull or push is called force.

Example – to open a door, either we push or pull it. A drawer is pulled to open and pushed to close.

Effect of Force:

Force can make a stationary body in motion. For example a football can be set to move by kicking it, i.e. by applying a force.

Force can stop a moving body – For example by applying brakes, a running cycle or a running vehicle can be stopped.

Force can change the direction of a moving object. For example; By applying force, i.e. by moving handle the direction of a running bicycle can be changed. Similarly by moving steering the direction of a running vehicle is changed.

Force can change the speed of a moving body – By accelerating, the speed of a running vehicle can be increased or by applying brakes the speed of a running vehicle can be decreased.

Force can change the shape and size of an object. For example -– By hammering, a block of metal can be turned into a thin sheet. By hammering a stone can be broken into pieces.

Forces are mainly of two types:

1. Balanced Forces
2. Unbalanced Forces

Balanced Forces

If the resultant of applied forces is equal to zero, it is called balanced forces.

Example : - In the tug of war if both the teams apply similar magnitude of forces in oppoisite directions, rope does not move in either side. This happens becasue of balanced forces in which resultant of applied forces become zero.

Balanced forces do not cause any change of state of an object. Balanced forces are equal in magnitude and opposite in direction.

Balanced forces can change the shape and size of an object. For example - When forces are applied from both sides over a balloon, the size and shape of balloon is changed.

Unbalanced Forces

If the resultant of applied forces are greater than zero the forces are called unbalanced forces. An object in rest can be moved because of applying balanced forces.

Unbalanced forces can do the following:

- Move a stationary object.
- Increase the speed of a moving object.
- Decrease the speed of a moving object.
- Stop a moving object.
- Change the shape and size of an object.

Laws of Motion:

Galileo Galilei: Galileo first of all said that object move with a constant speed when no forces act on them. This means if an object is moving on a frictionless path and no other force is acting upon it, the object would be moving forever. That is there is no unbalanced force working on the object.

But practically it is not possible for any object. Because to attain the condition of zero unbalanced force is impossible. Force of friction, force air and many other forces always acting upon an object.

Newton’s Laws of Motion:

Newton studied the ideas of Galileo and gave the three laws of motion. These laws are known as Newton’s Laws of Motion.

- Newton's First Law of Motion - Any object remains in the state of rest or in uniform motion along a straight line, until it is compelled to change the state by applying external force.

- Newton's Second Law of Motion - The rate of change of momentum is directly proportional to the force applied in the direction of force.

- Newton's Third Law of Motion - There is an equal and opposite reaction for evrey action

Newton’s First Law of Motion:

Any object remains in the state of rest or in uniform motion along a straight line, until it is compelled to change the state by applying external force.

Explanation: If any object is in the state of rest, then it will remain in rest untill a exernal force is applied to change its state. Similarly an object will remain in motion untill any exeternal force is applied over it to change its state. This means all objects resist to in changing their state. The state of any object can be changed by applying external forces only.

Newton's First Law of Motion in Everyday Life:

a. A person standing in a bus falls backward when bus is start moving suddenly. This happens because the person and bus both are in rest while bus is not moving, but as the bus starts moving the legs of the person start moving along with bus but rest portion of his body has tendency to remain in rest. Because of this person falls backward; if he is not alert.

b. A person standing in a moving bus falls forward if driver applies brakes suddenly. This happens because when bus is moving, the person standing in it is also in motion along with bus. But when driver applies brakes the speed of bus decreases suddenly or bus comes in the state of rest suddenly, in this condition the legs of the person which are in the contact with bus come in rest while the rest parts of his body have tendency to remain in motion. Because of this person falls forward if he is not alert.

c. Before hanging the wet clothes over laundry line, usually many jerks are given to the cloths to get them dried quickly. Because of jerks droplets of water from the pores of the cloth falls on the ground and reduced amount of water in clothes dried them quickly. This happens because, when suddenly cloth are made in motion by giving jerks, the water droplets in it have tendency to remain in rest and they are separated from cloths and fall on the ground.

d. When the pile of coin on the carom-board hit by a striker; coin only at the bottom moves away leaving rest of the pile of coin at same place. This happens because when the pile is struck with a striker, the coin at the bottom comes in motion while rest of the coin in the pile has tendency to remain in the rest and they vertically falls the carom board and remain at same place.

e. Seat belts are used in car and other vehicles, to prevent the passengers being thrown in the condition of sudden braking or other emergency. In the condition of sudden braking of the vehicles or any other emergency such as accident, the speed of vehicle would decrease or vehicle may stop suddenly, in that condition passengers may be thrown in the direction of the motion of vehicle because of the tendency to remain in the state of motion.

f. The head of hammer is tightened on a wooden handle by banging the handle against a hard surface. When handle of the hammer is struck against a surface, handle comes in rest while hammer over it's head has tendency to remain in motion and thus after some jerks it tightens over the handle.

Mass and Inertia:

The property of an object because of which it resists to get disturbed its state is called Inertia. Inertia of an object is measured by its mass. Intertia is directly proportional to the mass. This means inertia increases with increase in mass and decreases with decrease in mass. A heavy object will have more inertia than lighter one.

In other words, the natural tendecny of an object that resists the change in state of motion or rest of the boject is called intertia.

Since a heavy object has more intertia, thus it is difficult to push or pul a heavy box over the ground than lighter one.

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(Calculation of Momentum)

Question:- 1 - What will be the momentum of a stone having mass of 10 kg when it is thrown with a velocity of 2m/s?

Solution:-

Given,

Mass (m) = 10kg

Velocity (v) = 2m/s

Momentum (p) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, p = 10kg x 2 m/s = 20 kg m/s

Thus the momentum of the stone = 20 kg m/s.

Question: 2 - Calculate the momentum of a bullet of 25 g when it is fired from a gum with a velocity of 100m/s.

Solution:

Given,

Velocity of the bullet (v) = 100m/s

Mass of the bullet (m) = 25 g = 25/1000 kg = 0.025kg

Momentum (p) =?

Or, p = 2.5 kg m/s

Thus the momentum of the bullet = 2.5 kg m/s

Question: 3 - Calculate the momentum of a bullet having mass of 25 g is thrown using hand with a velocity of 0.1 m/s.

Solution:

Given,

Velocity of the bullet (v) = 0.1m/s

Mass of the bullet (m) = 25 g = 25/1000 kg = 0.025kg

Momentum (p) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, p = 0.025 kg x 0.1 m/s

Or, p = 0.0025 kg m/s

Thus the momentum of the bullet = 0.0025 kg m/s

Question: 4 - The mass of a goods lorry is 4000 kg and the mass of goods loaded on it is 20000 kg. If the lorry is moving with a velocity of 2m/s what will be its momentum?

Solution:

Given,

Velocity (v) = 2m/s

Mass of lorry = 4000 kg, Mass of goods on the lorry = 20000 kg

Therefore, total mass (m) of the lorry = 4000 kg + 20000 kg = 24000 kg

Momentum (p) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore,

p = 24000 kg x 2 m/s = 48000 kg m/s

Thus, momentum of the lorry = 48000 kg m/s

Question: 5 - A car having mass of 1000 kg is moving with a velocity of 0.5m/s. What will be its momentum?

Solution:

Given,

Velocity of the bullet (v) = 0.5m/s

Mass of the bullet (m) = 1000 kg

Momentum (p) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, p = 1000 kg x 0.5 m/s

Or, p = 500 kg m/s

Thus the momentum of the bullet = 500 kg m/s

Type – II (Calculation of Mass)

Question: 1 – A vehicle is running with a velocity of 5m/s. If the momentum of the vehicle is 5000 kg m/s, what is its mass?

Solution:

Given,

Momentum (p) = 5000 kg m/s

Velocity (v) = 5m/s

Mass (m) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, 5000 kg m/s = m × 5m/s

$$\Rightarrow m = \frac{5000\ kg\ m/s}{5\ m/s} = 1000\ kg$$

Thus, mass of the vehicle = 1000 kg

Question: 2 – A stone attains a momentum of 1 kg m/s when it flies with a velocity of 2m/s, then what will be mass of the stone?

Solution:

Given,

Momentum (p) = 1 kg m/s

Velocity (v) = 2m/s

Mass (m) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, 1 kg m/s = m × 2m/s

$$\Rightarrow m = \frac{1\ kg\ m/s}{2\ m/s} = 0.5\ kg = 500\ g$$

Thus, mass of the stone = 0.5 kg or 500 g

Question: 3 – When a bullet is fired from a rifle its momentum become 20 kg m/s. If the velocity of the bullet is 1000m/s what will be its mass?

Solution:

Given,

Momentum (p) = 20 kg m/s

Velocity (v) = 1000m/s

Mass (m) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, 20 kg m/s = m × 1000m/s

$$\Rightarrow m = \frac{20\ kg\ m/s}{1000\ m/s} = \frac{1}{50}\ kg = 0.02\ kg = 20\ g$$

Thus, mass of the bullet = 20 g

Question: 4 – When a missile is fired from a tank it gets a momentum of 2000 kg m/s. If the velocity of the missile is 50m/s what will be its mass?

Solution:

Given,

Momentum (p) = 2000 kg m/s

Velocity (v) = 50m/s

Mass (m) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, 2000 kg m/s = m × 50 m/s

$$\Rightarrow m = \frac{2000\ kg\ m/s}{50\ m/s} = 40kg$$

Thus, mass of the missile = 40 g

Question: 5 – A bird is flying with a velocity of 3 m/s. If the momentum of the bird is 3.60 kg m/s what is its mass?

Solution:

Given,

Momentum (p) = 3.60 kg m/s

Velocity (v) = 3 m/s

Mass (m) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

Therefore, 3.60 kg m/s = m × 3 m/s

$$\Rightarrow m = \frac{3.60\ kg\ m/s}{3\ m/s} = 1.20\ kg\ or, 1\ kg\ 200\ g$$

Thus, mass of the bird = 1 kg 200 g

Type – III (Calculation of velocity)

Question: 1 – If the momentum of a flying brick is 50 kg m/s and its mass is 10 kg. Calculate its velocity?

Solution:

Given,

Momentum (m) = 50kg m/s

Mass (m) = 10kg

Velocity (v) =?

We know that,

Momentum (p) = Mass (m) x Velocity (v)

⇒ 50 kg m/s = 10kg × v

$$\Rightarrow v = \frac{50\ kg\ m/s}{10\ kg} = 5\ m/s$$

Thus, velocity of the brick = 5m/s

Question: 2 – A bullet of 25 g is when fired from a piston gets a momentum of 50 kg m/s. Calculate the velocity of bullet.

Solution:

Given,

Momentum (m) = 50kg m/s

Mass (m) = 25 g = 25/1000 kg = 0.025 kg

Velocity (v) =?

We know that,

Momentum (p) = Mass (m) x Velocity (v)

⇒ 50 kg m/s = 0.025 kg × v

$$\Rightarrow v = \frac{50\ kg\ m/s}{0.025\ kg} = 2000\ m/s$$

Thus, velocity of the bullet = 2000 m/s

Question: 3 – A vulture when flying with a velocity 'v' attains a momentum of 20 kg m/s. If the mass of the vulture is 25 kg what is the value of 'v'?

Solution:

Given,

Momentum (m) = 20 kg m/s

Mass (m) = 25 kg

Velocity (v) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

⇒ 20 kg m/s = 25 kg × v

$$\Rightarrow v = \frac{20\ kg\ m/s}{25\ kg} = 0.8\ m/s$$

Thus, velocity of the vulture = 8 m/s

Question: 4 – A brick after falling from a hill collide with ground with a momentum of 100 kg m/s. If the mass of the brick is 5 kg what was its velocity while colliding with the ground?

Solution:

Given,

Momentum (m) = 100kg m/s

Mass (m) = 5kg

Velocity (v) =?

We know that,

Momentum (p) = Mass (m) x Velocity (v)

⇒ 100 kg m/s = 5kg × v

$$\Rightarrow v = \frac{100\ kg\ m/s}{5\ kg} = 20\ m/s$$

Thus, velocity of the brick = 20 m/s

Question: 5 – Calculate the velocity of a missile having mass of 100 kg, if it attains a momentum of 5000 kg m/s when fired from a rocket gun?

Solution:

Given,

Momentum (m) = 5000kg m/s

Mass (m) = 100kg

Velocity (v) =?

We know that, Momentum (p) = Mass (m) x Velocity (v)

⇒ 5000 kg m/s = 100kg × v

$$\Rightarrow v = \frac{5000\ kg\ m/s}{100\ kg} = 50\ m/s$$

Thus, velocity of the missile = 50 m/s

Newton's Second Law of Motion

Newton's second Law of Motion states that The rate of change of momentum is directly proportional to the force applied in the direction of force.

For example; when acceleration is applied on a moving vehicle, the momentum of the vehicle increases and the increase is in the direction of motion because the force is being applied in the direction of motion. On the other hand, when brake is applied on the moving vehicle, the momentum of the vehicle decreases and the decrease is in the opposite direction of motion because the force is being applied in the opposite direction of motion.

Mathematical formulation of Newton's Second Law of Motion:

Let mass of an moving object = m.

Let the velocity of the object changes from 'u' to 'v' in the interval of time 't'.

This means,

Initial velocity of the object = u.

Final velocity of the object = v.

We know that momentum (p) = Mass x velocity

Therefore,

Momentum (p) of the object at its initial velocity u = m x u = mu

Momentum (p) of the object at its final velocity v = m x v = mv

The change in momentum = mv – mu

$$\text{Rate of change of momentum} = \frac{mv - mu}{t} \quad ------ (i)$$

According to the Newton's Second Law of motion force is directly proportional to the rate of change of momentum.

This means, Force ∝ Rate of change of moentum

After substituting the value of rate of change of momentum from equation (i) we get.

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

$$\Rightarrow F \propto \frac{m(v-u)}{t} \ (since\ force\ is\ denoted\ by\ 'F')$$

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

Since, acceleration is the rate of change of velocity, i.e.

$$a = \frac{v-u}{t} ------- (iii)$$

Where,

a = acceleration, u = initial velocity, v = final velocity, and t = time taken to change in velocity

By substituting the value from equation (iii) in equation (ii) we get

$\Rightarrow F \propto m.a$

$\Rightarrow F = k.m.a$-------(iv)

Where, k is proportionality constant.

Since, 1 unit force is defined as the mass of 1kg object produces the acceleration of $1m/s^2$

Therefore, 1 unit of Force = k x 1 kg x $1m/s^2$

Thus k = 1.

By substituting the value of 'k = 1' in equation (iv) we get

$F = m.a$----------(v)

$\Rightarrow$ Force = mass $\times$ acceleration

Thus Newton's Second Law of Motion gives the relation between force, mass and acceleration of an object.

According to the relation obtained above, Newton's Second Law can be modified as follows:

The product of mass and acceleration is the force acting on the object.

The SI unit of Force: Newton (N)

Since Force = Mass x Acceleration

The unit of mass = kg and The unit of acceleration = m/s^2

If force, mass and acceleration is taken as 1 unit.

Therefore,

1 Newton (N) = 1kg x $1m/s^2$

Thus, Newton (N) = kg m/s^2

Equation (v) can be also written as

$$\Rightarrow a = \frac{F}{m} - - - - - - - (vi)$$

This equation is the form of Newton's Second Law of Motion. According to this equation, Newton's Second Law of Motion can also be stated as follow:

The acceleration produced by a moving body is directly proportional to the force applied over it and inversely proportional to the mass of the object.

From the above relation it is clear that

Acceleration increases with increase in force and vice versa.

Acceleration decreases with increase in mass and vice versa.

That's why a small vehicle requires less force to attain more acceleration while a heavy vehicle requires more force to get the same acceleration.

Newton's Second Law of Motion in everyday life:

(a) A fielder pulls his hand backward; while catching a cricket ball coming with a great speed, to reduce the momentum of the ball with a little delay. According to Newton's Second Law of Motion; rate of change of momentum is directly proportional to the force applied in the direction.

While catching a cricket ball the momentum of ball is reduced to zero when it is stopped after coming in the hands of fielder. If the ball is stopped suddenly, its momentum will be reduced to zero instantly. The rate of change in momentum is very quick and as a result, the player's hand may get injured. Therefore, by pulling the hand backward a fielder gives more time to the change of momentum to become zero. This prevents the hands of fielder from getting hurt.

(b) For athletes of long and high jump sand bed or cushioned bed is provided to allow a delayed change of momentum to zero because of jumping of athlete.

When an athlete falls on the ground after performing a high or long jump, the momentum because of the velocity and mass of the athlete is reduced to zero. If the momentum of an athlete will be reduced to zero instantly, the force because of momentum may hurt the player. By providing a cushioned bed, the reduction of the momentum of the athlete to zero is delayed. This prevents the athlete from getting hurt.

(c) Seat belts in car - Seat belts in the vehicles prevent the passenger from getting thrown in the direction of motion. In case of emergency, such as accidents or sudden braking, passengers may be thrown in the direction of motion of vehicle and may get fatal injuries. The stretchable seat belts increase the time of the rate of momentum to be reduced to zero. The delayed reduction of momentum to zero prevents passengers from such fatal injury.

Type – 1 :-

Question – 1 – Calculate the force needed to speed up a car with a rate of $5ms^{-2}$, if the mass of the car is 1000 kg.

Solution:

According to questions:

Acceleration (a) = $5m/s^2$ and Mass (m) = 1000 kg, therefore, Force (F) =?

We know that, F = m x a

= 1000 kg x $5m/s^2$

= 5000 kg m/s^2

Therefore, required Force = 5000 m/s^2 or 5000 N

Question – 2- If the mass of a moving object is 50 kg, what force will be required to speed up the object at a rate of $2ms^{-2}$?

Solution:-

According to the question,

Acceleration (a) = $2ms^{-2}$ and Mass (m) = 50 kg, therefore, Force (F) =?

We know that, F = m x a

= 50 kg x $2m/s^2$

= 100 kg m/s^2

Therefore, required Force = 100 m/s^2 or 100 N

Question – 3 – To accelerate a vehicle to 3m/s2 what force will be needed if the mass of the vehicle is equal to 100 kg?

Solution:

According to the question,

Acceleration (a) = $3m/s^2$ and Mass (m) = 100 kg, therefore, Force (F) =?

We know that, F = m x a

= 100 kg x $3m/s^2$

= 300 kg m/s^2

Therefore, required Force = 300 m/s^2 or 300 N

Type -II

Question -1 – To accelerate an object to a rate of $2m/s^2$, 10 N force is required. Find the mass of object.

Solution:

According to the question:

Acceleration (a) = $2m/s^2$, Force (F) = 10N, therefore, Mass (m) = ?

We know that, F = m x a

$$\Rightarrow 10N = m \times 2m/s^2 \Rightarrow m = \frac{10}{2} kg \Rightarrow m = 5kg$$

Thus, the mass of the object = 5 kg

Question – 2 – If 1000 N force is required to accelerate an object to the rate of 5m/s2, what will be the weight of the object?

Solution:

According to the question,

Acceleration (a) = $2m/s^2$, Force (F) = 1000N, therefore, Mass (m) = ?

We know that, F = m x a

$$\Rightarrow 1000N = m \times 5m/s^2 \Rightarrow m = \frac{1000}{5} kg \Rightarrow m = 200kg$$

Thus, the mass of the object = 200 kg

Question – 3 – A vehicle accelerate at the rate of 10m/s2 after the applying of force equal to 50000 N. Find the mass of the vehicle.

Solution:

According to the question,

Acceleration (a) = 10 m/s^2, Force (F) = 50000N, therefore, Mass (m) = ?

We know that, F = m x a

$$\Rightarrow 50000N = m \times 10m/s^2 \Rightarrow m = \frac{50000}{10} kg \Rightarrow m = 5000kg$$

Thus, the mass of the vehicle = 5000 kg

Type - III

Question – 1 - What the acceleration a vehicle having 1000 kg of mass will get after applying a force of 5000N?

Solution:

According to question:

Mass (m) = 1000 kg, Force (F) = 5000N, Acceleration (a) =?

We know that, Force = Mass x Acceleration or F = m x a

Therefore,

$$5000N = 1000\ kg \times a \Rightarrow a = \frac{5000N}{1000kg} = \frac{5000\ kg\ ms^{-2}}{1000\ kg} = 5\ ms^{-2}$$

Thus acceleration of the vehicle = 5 ms^{-2}

Question – 2 – After applying a force of 1000 N an object of mass 2000 kg will achieve what acceleration?

Solution:

According to the question,

Mass (m) = 2000 kg, Force (F) = 1000N, Acceleration (a) =?

We know that, Force = Mass x Acceleration or F = m x a

Therefore,

$$1000N = 2000\ kg\ \times a\ \Rightarrow a = \frac{1000N}{2000kg} = \frac{1000\ kg\ ms^{-2}}{2000\ kg} = 0.5\ ms^{-2}$$

Thus acceleration of the vehicle = 0.5 ms^{-2}

Question – 3 – An object requires the force of 100N to achieve the acceleration 'a'. If the mass of the object is 500 kg what will be the value of 'a'?

Solution:

According to the question,

Mass (m) = 500 kg, Force (F) = 100N, Acceleration (a) =?

We know that, Force = Mass x Acceleration or F = m x a

Therefore,

$$100N = 500\ kg\ \times a\ \Rightarrow a = \frac{100N}{500kg} = \frac{100\ kg\ ms^{-2}}{500\ kg} = 0.2\ ms^{-2}$$

Thus acceleration of the vehicle = 0.2 ms^{-2}

Type - IV

Question – 1- An object of 50 kg gets the speed of 10m/s in 5 second from zero velocity. Calculate the required force applied by engine of the car.

Solution:

According to the question:-

Initial velocity (u) = 0, final velocity (v) = 10m/s, time (t) = 5 second, Mass (m) = 50 kg,

Therefore, force (F)=?

$$We\ know\ that, Force\ (F) = \ m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, F = \ 50\ kg\ \frac{10m/s - 0}{5s}\ \Rightarrow 50kg\ \times 2ms^{-2}$$

$\Rightarrow$ 100kg ms^{-2} $\Rightarrow$ 100 N

Thus required force = 100 N

Question – 2 – A car having mass of 1500 kg achieve the velocity of 5 m/s in 10 second. Calculate the required force to attain required speed by car.

Solution:

According to the question:

Initial velocity (u) = 0, final velocity (v) = 5m/s, time (t) = 10 second, Mass (m) = 1500 kg,

Therefore, force (F)=?

$$We\ know\ that, Force\ (F) = m\frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, F = 1500\ kg\ \frac{5m/s - 0}{10s} \Rightarrow 1500kg \times \frac{1}{2} ms^{-2}$$

$\Rightarrow$ 750 $kgms^{-2}$ or 750 N

Thus required force = 750 N

Question – 3 – A bus starts from the stop and take 50 second to get the speed of 10m/s. If the mass of the bus along with passengers is 10000 kg, calculate the force applied by the engine of bus to push the bus at the speed of 10m/s.

Solution:

According to the question:

Initial velocity (u) = 0, final velocity (v) = 10m/s, time (t) = 50 second, Mass (m) = 10000 kg,

Therefore, force (F)=?

$$We\ know\ that, Force\ (F) = m\frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, F = 10000\ kg\ \frac{10m/s - 0}{50s} \Rightarrow 10000kg \times \frac{1}{5} ms^{-2}$$

$\Rightarrow$ 2000 $kgms^{-2}$ or, 2000 N

Thus required force = 2000 N

Question – 4 – An object gets 20 second to increase the speed from 10m/s to 50m/s. If the mass of the object is 1000 kg, what force will be required to do so?

Solution:

According to the question:

Initial velocity (u) = 10m/s, final velocity (v) = 50m/s, time (t) = 20 second, Mass (m) = 1000 kg,

Therefore, force (F)=?

$$We\ know\ that, Force\ (F) = m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, F = 1000\ kg\ \frac{50m/s - 10m/s}{50s} \Rightarrow 1000kg \times \frac{40}{50} ms^{-2}$$

$\Rightarrow$ 20 kg $\times$40 ms^{-2} $\Rightarrow$800 $kgms^{-2}$ or 800 N

Thus required force = 800 N

Question – 5 – What force will be required to speed up a car having mass of 1200kg, from 5 m/s to 15m/s in 10 second?

Solution:

According to the question:-

Initial velocity (u) = 5m/s, final velocity (v) = 15m/s, time (t) = 10 second, Mass (m) = 1200 kg,

Therefore, force (F)=?

$$We\ know\ that, Force\ (F) = m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, F = 1200\ kg\ \frac{15m/s - 5m/s}{10s} \Rightarrow 1200kg \times \frac{10m/s}{10s}$$

$\Rightarrow$ 1200 kg $\times$1 ms^{-2} $\Rightarrow$1200 $kgms^{-2}$ or 1200 N

Thus required force = 1200 N

Question – 6 – In how much time an object having mass of 100kg will speed up from 5m/s to 25m/s, if 500N force will be applied over it?

Solution:

According to the question:

Initial velocity (u) = 5m/s, final velocity (v) = 25m/s, Mass (m) = 100 kg, Force (F) = 500N

Therefore, time (t) = ?

$$We\ know\ that, Force\ (F) = \ m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, 500N = \ 100\ kg\ \frac{25m/s - 5m/s}{t} = 100kg\ \times \frac{20m/s}{t}$$

$$\Rightarrow 500N\ \times t = 2000\ kg\ m/s$$

$$\Rightarrow t = \frac{2000kg\ m/s}{500\ kg\ m/s^2} = \ 4s$$

Thus required time = 4 second

Question – 7 – If a force of 1000 N is applied over a vehicle of 500 kg, then in how much time the speed of the vehicle will increase from 2 m/s to 10 m/s?

Solution:

According to the question:

Initial velocity (u) = 2m/s, final velocity (v) = 10m/s, Mass (m) = 500 kg, Force (F) = 1000N

Therefore, time (t) =?

$$We\ know\ that, Force\ (F) = \ m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, 1000N = \ 500\ kg\ \frac{10m/s - 2m/s}{t} = 500kg\ \times \frac{8m/s}{t}$$

$$\Rightarrow 1000N\ \times t = 4000\ kg\ m/s$$

$$\Rightarrow t = \frac{4000kg\ m/s}{1000\ kg\ m/s^2} = \ 4s$$

Thus required time = 4 second

Question – 8 – A vehicle having mass equal to 1000 kg is running with a speed of 10m/s. After applying the force of 1000N for 10 second what will be the speed of vehicle?

According to the question:

Mass of (m) = 1000 kg, Force, (F) = 1000 N, time (t) = 10s, Initial velocity (u) = 5m/s

Therefore, Final velocity (v) =?

$$We\ know\ that, Force\ (F) = m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$Therefore, 1000N = 1000\ kg\ \frac{v - 5m/s}{10s}$$

⇒ 1000 kg m/s^2 × 10s = 1000 kg (v - 5m/s)

⇒ 10000 kg m/s = 1000 kg × v - 5000 kg m/s

⇒ 10000 kg m/s + 5000kg m/s = 1000kg × v

⇒ 15000 kgm/s = 1000 kg × v

$$\Rightarrow v = \frac{15000\ kg\ m/s}{1000\ kg} = 15m/s$$

Thus, the velocity of the vehicle will be 15m/s.

Question – 9 – An object gets the velocity of 10 m/s after applying a force of 500N for 5 second. If the mass of the object is equal to 1000 kg, what was its velocity before applying the force?

Solution:

According to the question:

Mass (m) = 1000 kg, Force (F) = 500N, time (t) = 10m/s, Final velocity (v) = 10m/s

Therefore, Initial velocity (u) =?

$$We\ know\ that, Force\ (F) = m\ \frac{v-u}{t}\ (Since, a = \frac{v-u}{t})$$

$$\Rightarrow 500\ N = 1000\ kg\ \frac{10m/s - u}{10s}$$

$$\Rightarrow 500\ kg\ ms^{-2} = \frac{1000kg \times 10m/s - 1000\ kg \times u}{10s}$$

$\Rightarrow$ 500 kg ms^{-2} × 10s = 10000 kg ms^{-1}-1000 kg × u

$\Rightarrow$ 5000 kg m/s = 10000 kg m/s - 1000 kg × u

$\Rightarrow$ 5000 kg m/s - 10000 kg m/s = -1000 kg × u

$\Rightarrow$ -5000kg m/s = -1000 kg × u

$$\Rightarrow u = \frac{-5000\ kgms^{-1}}{-1000\ kg} = 5m/s$$

Thus speed of object was 5m/s

Type - V -

Question – 1- The acceleration of two objects are 5m/s^2 and 20m/s^2. If mass of both the object would be combined and a force of 50N would be applied on them, what will be their acceleration?

Solution:

In the order to calculate the acceleration of both the objects after combining their mass, first of all their mass will be calculated.

Ist object:

Given, Acceleration (a) = 20m/s^2

Let the mass of one body = m_1

And a force of 50N will be applied over it.

We know that Force (F) = Mass (m) x Acceleration (a)

$\Rightarrow$ 50N = m_1 × 5ms^{-2}

$$\Rightarrow m_1 = \frac{50N}{5ms^{-2}} = 10\ kg$$

2nd Object:

Given, Acceleration (a) = 20m/s^2

Let the mass of one body = m_2

And a force of 50N will be applied over it.

We know that Force (F) = Mass (m) x Acceleration (a)

$\Rightarrow$ 50N = $m_2 \times 5\ ms^{-2}$

$$\Rightarrow m_2 = \frac{50N}{20ms^{-2}} = 2.5\ kg$$

Now their total mass = $m_1 + m_2$ = 10 kg + 2.5 kg = 12.5 kg

In this condition:

Mass (m) = 12.5 kg, Force (F) = 50N, therefore, Acceleration (a) =?

We know that, F = m x a

$$\Rightarrow a = \frac{50N}{12.5\ kg} = 4ms^{-2}$$

Therefore, 50N = 12.5kg × a

Thus, Acceleration = 4 ms^{-2}

Newton's Third Law of Motion

Newton's Third Law of Motion states that there is always reaction for every action in opposite direction and of equal magnitude.

Explanation: Whenever a force is applied over a body, that body also applies same force of equal magnitude and in opposite direction.

Example –

(a) Walking of a person - A person is able to walk because of the Newton's Third Law of Motion. During walking, a person pushes the ground in backward direction and in the reaction the ground also pushes the person with equal magnitude of force but in opposite direction. This enables him to move in forward direction against the push.

(b) Recoil of gun - When bullet is fired from a gun, the bullet also pushes the gun in opposite direction, with equal magnitude of force. This results in gunman feeling a backward push from the butt of gun.

(c) Propulsion of a boat in forward direction – Sailor pushes water with oar in backward direction; resulting water pushing the oar in forward direction. Consequently, the boat is pushed in forward direction. Force applied by oar and water are of equal magnitude but in opposite directions.

Conservation of Momentum –

Law of Conservation of Momentum – The sum of momenta of two objects remains same even after collision.

In other words, the sum of momenta of two objects before collision and sum of momenta of two objects after collision are equal.

Mathematical Formulation of Conservation of Momentum:

Suppose that, two objects A and B are moving along a straight line in same direction and the velocity of A is greater than the velocity of B.

Let the initial velocity of A=u_1

Let the initial velocity of B= u_2

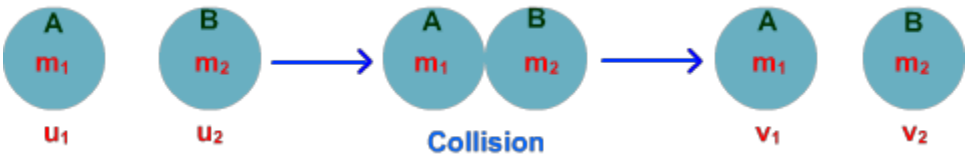
Let the mass of A= m1

Let the mass of B=m2

Let both the objects collide after some time and collision lasts for ' t' second.

Let the velocity of A after collision= v_1

Let the velocity of B after collision= v_2



We know that, Momentum = Mass x Velocity

Therefore,

Momentum of A (F_A) before collision = $m_1 \times u_1$

Momentum of B(F_B) before collision = $m_2 \times u_2$

Momentum of A after collision = $m_1 \times v_1$

Momentum of B after collision = $m_2 \times v_2$

Now, we know that Rate of change of momentum = mass X rate of change in velocity

$$= mass \times \frac{Change\ in\ velocity}{time}$$

Therefore, rate of change of momentum of A during collision, $F_{AB} = m_1\left(\frac{v_1 - u_1}{t}\right)$

Similarly, the rate of change of momentum of B during collision, $F_{BA} = m_2\left(\frac{v_2 - u_2}{t}\right)$

Since, according to the Newton's Third Law of Motion, action of the object A (force exerted by A) will be equal to reaction of the object B (force exerted by B). But the force exerted in the course of action and reaction is in opposite direction.

Therefore,

$$F_{AB} = -F_{BA}$$

$$Or, \quad m_1\left(\frac{v_1 - u_1}{t}\right) = -m_2\left(\frac{v_2 - u_2}{t}\right)$$

$$\Rightarrow m_1(v_1 - u_1) = -m_2(v_2 - u_2)$$

$$\Rightarrow m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$$

$$\Rightarrow m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$$

$$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 ------(i)$$

Above equation says that total momentum of object A and B before collision is equal to the total momentum of object A and B after collision. This means there is no loss of momentum, i.e. momentum is conserved. This situation is considered assuming there is no external force acting upon the object.

This is the Law of Conservation of Momentum, which states that in a closed system the total momentum is constant.

In the condition of collision, the velocity of the object which is moving faster is decreased and the velocity of the object which is moving slower is increased after collision. The magnitude of loss of momentum of faster object is equal to the magnitude of gain of momentum by slower object after collision.

Conservation of Momentum – Practical Application

- Bullet and Gun – When bullet is fired from a gun, gun recoils in the opposite direction of bullet. The momentum of bullet is equal to momentum of gun. Since, the bullet is has very small mass compared to the gun, hence velocity of bullet is very high compared to the recoil of gun. In the case of firing of bullet, law of conservation of momentum is applied as usual.
- In the collision of atoms, the conservation of momentum is applied.
- In the game of snooker, when a ball is hit by stick, the conservation of momentum is applied.

- When the mouth of an inflated balloon is let open, it starts flying, because of conservation of momentum.
- When a cricket ball is hit by bat, the Law of Conservation of Momentum is applied.
- When the coins of carom board are hit by striker, the Law of Conservation of Momentum is applied.
- Newton's cradle is one of the best examples of conservation of momentum.

Conservation of Momentum - Numerical Problems

Question:- 1 – Find the recoil velocity of a gun having mass equal to 5 kg, if a bullet of 25gm acquires the velocity of 500m/s after firing from the gun.

Answer:-

Here given,

Mass of bullet (m1) = 25 gm = 0.025 kg

Velocity of bullet before firing (u_1) = 0

Velocity of bullet after firing (v_1) = 500 m/s

Mass of gun (m_2) = 5 kg

Velocity of gun before firing, (u_2) = 0

Velocity of gun after firing = ?

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 0.025\,kg \times 0 + 5\,kg \times 0 = 0.025\,kg \times 500\,m/s + 5kg \times v_2$$

$$\Rightarrow 0 = 12.5\,kg\,m/s + 5kg \times v_2$$

$$\Rightarrow 5kg \times v_2 = -12.5\,kg\,m/s$$

$$\Rightarrow v_2 = \frac{-12.5\,kg\,m/s}{5kg} = -2.5\,m/s$$

Thus, recoil velocity of gun is equal to 2.5 m/s. Here negative (- ve) sign shows that gun moves in the opposite direction of bullet.

Question:- 2 – A bullet of 5 gm is fired from a pistol of 1.5 kg. If the recoil velocity of pistol is 1.5 m/s, find the velocity of bullet.

Answer:-

Here we have,

Mass of bullet, m_1 = 5 gm = 5/1000 kg = 0.005 kg

Mass of pistol, m_2 = 1.5 kg

Recoil velocity of pistol v_2 = 1.5 m/s

Velocity of bullet v_1 =?

Since, before firing the bullet and pistol are in rest, thus

Initial velocity of bullet, u_1 =0

And initial recoil velocity of pistol, u_2 =0

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 0.005\ kg \times 0 + 1.5\ kg \times 0 = 0.005\ kg \times v_1 + 1.5\ kg \times 1.5\ m/s$$

$$\Rightarrow 0 = 0.005\ kg \times v_1 + 2.25\ kg\ m/s$$

$$\Rightarrow 0.005\ kg \times v_1 = -2.25\ kg\ m/s$$

$$\Rightarrow v_1 = \frac{-2.25\ kg\ m/s}{0.005\ kg} = -450\ m/s$$

Thus, velocity of bullet = 450 m/s, here negative sign with velocity of pistol shows that, bullet moves in the opposite direction of pistol.

Question:- 3 – A boy of 50 kg mass is running with a velocity of 2 m/s. He jumps over a stationary cart of 2 kg while running. Find the velocity of cart after jumping of boy.

Answer:

Here given,

Mass (m_1) of boy = 50 kg

Initial Velocity (u_1) of boy = 2 m/s

Mass (m_2) of cart = 2 kg

Initial Velocity (u_2) of cart = 0

Final velocity of cart (v_2) =?

Since, boy jumped over cart thus, thus the final velocity (v_1) of boy will be equal to that of the cart.

Therefore, $v_1 = v_2$

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 50\ kg \times 2\ ms^{-1} + 2kg \times 0 = 50\ kg \times v_1 + 2\ kg \times v_2$$

$$Since, v_1 = v_2$$

$$Therefore, 100\ kg\ ms^{-1} = 50\ kg \times v_2 + 2\ kg \times v_2$$

$$\Rightarrow 100kg\ ms^{-1} = v_2\ (50\ kg + 2\ kg)$$

$$\Rightarrow 100kg\ ms^{-1} = v_2 \times 52\ kg$$

$$\Rightarrow v_2 = \frac{100kg\ ms^{-1}}{52\ kg} = 1.92\ ms^{-1}$$

Therefore, velocity of cart after jumping of boy over it is equal to 1.92 m/s. Since, velocity has positive sign, thus, cart will go in the same direction of boy.

Question: 4 – While playing football match, Kris collided and got entangled with Tom who was playing for opposite team and running from opposite side. The mass of Kris was 40 kg and the mass of Tom was 60 kg. If Tom was running with a velocity of 3m/s and Kris was running with a velocity of 4 m/s, find the velocity and direction of both of the players after collision assuming other forces were negligible.

Answer:

Given,

Mass of Kris (m_1) = 40 kg

Initial velocity of Kris (u_1) = 4 m/s

Mass of Tom (m_2) = 60 kg

Initial velocity of Tom (u_2) = 3 m/s

Final velocity and direction of both of the player after collision =?

Let final velocity of both of the players after collision = v

Let Kris was coming from left and Tom was coming from right.

Let the velocity of Kris is positive, therefore velocity of Tom will be negative as both were running in opposite directions.

Thus, initial velocity of Kris (u_1) = 4 m/s

And the initial velocity of Tom (u_2) = - 3 m/s

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 40\ kg \times 4\ m\,s^{-1} + 60\ kg \times (-3\ m\,s^{-1}) = 40\ kg \times v + 60\ kg \times v$$

(Because entangled after collision both the player got same velocity.)

$$\Rightarrow 40\ kg \times 4\ m\,s^{-1} + 60\ kg \times (-3\ m\,s^{-1}) = 40\ kg \times v + 60\ kg \times v$$

$$\Rightarrow 160\ kg\ m\,s^{-1} - 180\ kg\ m\,s^{-1} = v(40\ kg + 60\ kg)$$

$$\Rightarrow -20\ kg\ m\,s^{-1} = v \times 100\ kg$$

$$\Rightarrow v = \frac{-20\ kg\ m\,s^{-1}}{100\ kg} = -0.2\ m/s$$

Thus, velocity of both the player would become – 0.2 m/s. Negative velocity shows that they would go from right to left after collision.

Question:- 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) A stone.

(b) A train

(c) A five rupees coin.

Explanation – Inertia is associated with mass. Objects having more mass have more inertia.

Question:- 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.

Answer:

The velocity of football changes four times.

First, when a football player kicks to another player, second when that player kicks the football to the goalkeeper. Third when the goalkeeper stops the football. Fourth when the goalkeeper kicks the football towards a player of his own team.

Agent supplying the force –

First case – First player

Second case – Second player

Third case – Goalkeeper

Fourth case – Goalkeeper

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

Answer: The answer of this cause lies behind the Newton’s First Law of Motion. Initially, leaves and tree both are in rest. But when the tree is shaken vigorously, tree comes in motion while leaves have tendency to be in rest. Thus, because of remaining in the position of rest some of the leaves may get detached from a tree if we vigorously shake its branch.

Question: 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?

Answer:

In a moving bus, passengers are in motion along with bus. When brakes are applied to stop a moving bus, bus comes in the position of rest. But because of tendency to be in the motion a person falls in forward direction.

Similarly, when a bus is accelerated from rest, the tendency to be in rest, a person in the bus falls backwards.

Question: 5 - If action is always equal to the reaction, explain how a horse can pull a cart.

Answer: Horse pushes the ground in backward direction. In reaction to this, the horse moves forward and cart moves along with horse in forward direction.

In this case when horse tries to pull the cart in forward direction, cart pulls the horse in backward direction, but because of the unbalanced force applied by the horse, it pulls the cart in forward direction.

Question: 6 - Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.

Answer: When large amount of water is ejected from a hose at a high velocity, according to Newton's Third Law of Motion, water pushes the hose in backward direction with the same force. Therefore, it is difficult for a fireman to hold a hose in which ejects large amount of water at a high velocity.

Question: 7 - 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.

Answer:

Given,

Mass of rifle (m_1) = 4 kg

Initial velocity of rifle (u_1) = 0

Mass of bullet (m_2) = 50 g = 50/1000 kg = 0.05 kg

Initial velocity of bullet (u_2) = 0

Final velocity (v_2) of bullet = 35 m/s

Final velocity [Recoil velocity] of rifle (v_1)=?

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 4kg \times 0 + 0.5\,kg \times 0 = 4kg \times v_1 + 0.05\,kg \times 35\,m\,s^{-1}$$

$$\Rightarrow 0 = 4kg \times v_1 + 1.75\,kg\,m/s$$

$$\Rightarrow -4kg \times v_1 = 1.75\,kg\,m/s$$

$$\Rightarrow v_1 = \frac{1.75\,kg\,m/s}{-4\,kg} = -0.4375\frac{m}{s} \approx -0.44\,m/s$$

Here negative sign of velocity of rifle shows that rifle moves in the opposite direction of the movement of bullet. Therefore, recoil velocity of rifle is equal to 0.44 m/s.

Question: 8 - 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.

Answer:

Given,

Mass of first object (m_1) = 100 g = 100/1000 kg = 0.1 kg

Initial velocity of first object (u_1) = 2 m/s

Final velocity of first object after collision (v_1) = 1.67 m/s

Mass of second object (m_2) = 200 g = 200/1000 kg = 0.2 kg

Initial velocity of second object ($u_{2)} = 1$ m/s

Final velocity of second object after collision (v_2) =?

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 0.1kg \times 2\,m\,s^{-1} + 0.2\,kg \times 1m\,s^{-1} = 0.1\,kg \times 1.67\,m\,s^{-1} + 0.2\,kg \times v_2$$

$$\Rightarrow 0.2\,kg\,m\,s^{-1} + 0.2\,kg\,m\,s^{-1} = 0.167\,kg\,m\,s^{-1} + 0.2\,kg \times v_2$$

$$\Rightarrow 0.4\,kg\,m\,s^{-1} - 0.167\,kg\,m\,s^{-1} = 0.2\,kg \times v_2$$

$$\Rightarrow v_2 = \frac{0.233\,kg\,m\,s^{-1}}{0.2\,kg} = 1.165\,m\,s^{-1}$$

$$Thus, velocity\ of\ the\ second\ object\ after\ collision = 1.165\,m\,s^{-1}$$

Question: 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.

Answer: When a net zero external unbalanced force is applied on the body, it is possible for the object to be travelling with a non-zero velocity. In fact, once an object comes into motion and there is a condition in which its motion is unopposed by any external force; the object will continue to remain in motion. It is necessary that the object moves at a constant velocity and in a particular direction.

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

Answer: Beating of a carpet with a stick; makes the carpet come in motion suddenly, while dust particles trapped within the pores of carpet have tendency to remain in rest, and in order to maintain the position of rest they come out of carpet. This happens because of the application of Newton's First Law of Motion which states that any object remains in its state unless any external force is applied over it.

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

Answer:- Luggage kept on the roof of a bus has the tendency to maintain its state of rest when bus is in rest and to maintain the state of motion when bus is in motion according to Newton's First Law of Motion.

When bus will come in motion from its state of rest, in order to maintain the position of rest, luggage kept over its roof may fall down. Similarly, when a moving bus will come in the state of rest or there is any sudden change in velocity because of applying of brake, luggage may fall down because of its tendency to remain in the state of motion.

This is the cause that it is advised to tie any luggage kept on the roof a bus with a rope so that luggage can be prevented from falling down.

Question: 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.

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

Explanation: When ball moves on the ground, the force of friction opposes its movement and after some time ball comes to the state of rest.

Question: 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 (Hint: 1 tonne = 1000 kg.)

Answer:

Given,

Initial velocity of truck (u) =0 (Since, truck starts from rest)

Distance travelled, s = 400 m

Time (t) = 20 s

Acceleration (a) = ?

We know that,

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

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

$$\Rightarrow 400\ m = 0 + \frac{1}{2} \times a \times 400\ s^2$$

$$\Rightarrow 400\ m = \frac{1}{\cancel{2}} \times a \times \cancel{400}\ 200\ s^2$$

$$\Rightarrow 400\ m = a \times 200\ s^2$$

$$\Rightarrow a = \frac{400\ m}{200\ s^2} = 2\ m\ s^{-2}$$

Force acting upon truck:

Given mass of truck = 7 ton = 7 X 1000 kg = 7000 kg

We know that, force, P = m x a

Therefore, P = 7000 kg x 2 m s - 2

Or, P = 14000 Newton

Thus, Acceleration = 2 m s - 2 and force acting upon truck in the given condition = 14000 N

Question: 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?

Answer:

Given,

Mass of stone = 1 kg

Initial velocity, u = 20 m/s

Final velocity, v = 0 (as stone comes to rest)

Distance covered, s = 50 m

Force of friction =?

We know that,

$$v^2 = u^2 + 2as$$
$$\Rightarrow (0)^2 = (20\ m/s)^2 + 2\,a \times 50\ m$$
$$\Rightarrow -400\ m^2s^{-2} = 100m\,a$$
$$\Rightarrow a = \frac{-400m^2s^{-2}}{100\ m} = -4\ m\,s^{-2}$$

Now, we know that, force, F = mass x acceleration

Therefore, F = 1 kg X -4ms-2

Or, F = -4ms-2

Thus, force of friction acting upon stone = -4ms-2. Here negative sign shows that force is being applied in the opposite direction of the movement of the stone.

Question: 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.

Answer:-

Given, force of engine = 40000 N

Force of friction = 5000 N

Mass of engine = 8000 kg

Total weight of wagons = 5 x 2000 kg = 10000 kg

(a) The net accelerating force

= Force exerted by engine – Force of fricition

= 40000 N – 5000 N = 35000 N

(b) The acceleration of the train

We know that, F = mass x acceleration

Or, 35000 N = (mass of engine + mass of 5 wagons) X a

Or, 35000 N = (8000 kg + 10000 kg) X a

Or, 35000N = 18000 kg X a

$$Or, a = \frac{35000N}{18000kg} = 1.944\ ms^{-2}$$

(c) The force of wagon 1 on wagon 2

Since, net accelerating force = 35000 N

Mass of all 5 wagons = 10000 kg

We know that, F = m x a

Therefore, 35000N = 10000 kg x a

$$or, a = \frac{35000N}{10000kg} = 3.5\ ms^{-2}$$

$$Therefore, acceleration\ of\ wagons = 3.5\ ms^{-2}$$

$$Thus, force\ of\ wagon\ 1\ on\ 2 = mass\ of\ four\ wagons \times acceleration$$

$$Or, F = 4 \times 2000\ kg \times 3.5\ ms^{-2}$$

$$Or, F = 8000\ kg \times 3.5\ ms^{-2}$$

$$Or, F = 28000\ N$$

$$Thus,$$

$$(a)\ The\ net\ accelerating\ force = 35000N$$

$$(b)\ The\ acceleration\ of\ train = 1.944\ ms^{-2}$$

$$(c)\ The\ force\ of\ wagon\ 1\ on\ 2 = 28000N$$

Question:- 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 s-2?

Answer:

Given,

Mass of the vehicle, m = 1500 kg

Acceleration, a = - 1.7 m s -2

Force acting between the vehicle and road, F =?

We know that, F = m x a

Therefore, F = 1500 kg X 1.7 m s-2

Or, F = - 2550 N

Thus, force between vehicle and road = - 2550 N. Negative sign shows that force is acting in the opposite direction of the vehicle.

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

(a) (mv)2 (b) mv2 (c) Ω mv2 (d) mv

Answer: (d) mv

Explanation:

Given, mass = m, velocity = v, therefore, momentum =?

We know that, momentum, P = mass x velocity

Therefore, P = mv

Thus, option (d) mv is correct

Question: 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?

Answer:

Since, a horizontal force of 200N is used to move a wooden cabinet, thus a friction force of 200N will be exerted on the cabinet. Because according to third law of motion, an equal magnitude of force will be applied in the opposite direction.

Question: 11 - 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?

Answer: Since, two objects of equal mass are moving in opposite direction with equal velocity, therefore, the velocity of the objects after collision during which they stick together will be zero.

Explanation:

Given,

Mass of first object, m1 = 1.5 kg

Mass of second object, m2 = 1.5 kg

Initial velocity of one object, u1 = 2.5 m/s

Initial velocity of second object, u2 = -2.5 m/s (Since second object is moving in opposite direction)

Final velocity of both the objects, which stick after collision, v =?

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 1.5\ kg \times 2.5ms^{-1} + 1.5\ kg \times (-2.5ms^{-1}) = 1.5\ kg \times v + 1.5kg \times v$$

$$\Rightarrow 3.75\ kg\ ms^{-1} - 3.75\ kg\ ms^{-1} = v(1.5\ kg + 1.5\ kg)$$

$$\Rightarrow 0 = v \times 3.00\ kg$$

$$\Rightarrow v = \frac{0}{3.00\ kg} = 0$$

Therefore, final velocity of both the objects after collision will be zero.

Question: 12 - 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: Because of the huge mass of the truck, the force of static friction is very high. The force applied by the student is unable to overcome the static friction and hence he is unable to move the truck. In this case, the net unbalanced force in either direction is zero which is the reason of no motion happening here. The force applied by the student and the force because of static friction are cancelling out each other. Hence, the rationale given by the student is correct.

Question: 13 - 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 at 5 m/s. Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Answer:

Given,

Mass of hockey ball, m = 200 g = 200/1000 kg = 0.2 kg

Initial velocity of hockey ball, u = 10 m/s

Final velocity of hockey ball, v = - 5 m/s (because direction becomes opposite)

Change in momentum =?

We know that,

Momentum = mass x velocity

Therefore, Momentum of ball before getting struck = 0.2 kg x 10 m/s = 2 kg m/s

Momentum of ball after getting struck = 0.2 kg x - 5m/s = - 1 kg m/s

Therefore, change in momentum = momentum before getting struck – momentum after getting struck

= 2 kg m/s – (-1 kg m/s) = 2 kg m/s + 1 kg m/s = 3 kg m/s

Thus, change of momentum of ball after getting struck = 3 kg m/s

Question:- 14 - 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 of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

Answer:

Given,

Mass of bullet, m = 10 g = 10/1000 kg = 0.01 kg

Initial velocity of bullet, u = 150 m/s

Since bullet comes to rest, thus final velocity, v =0

Time, t = 0.03 s

Distance of penetration, i.e. Distance, covered (s)=?

Magnitude of force exerted by wooden block =?

We know that,

$$v = u + at$$

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

$$\Rightarrow -150ms^{-1} = a \times 0.03\ s$$

$$\Rightarrow a = -\frac{150ms^{-1}}{0.03s} = -5000\ m\ s^{-2}$$

We know that,

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

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

$$\Rightarrow s = 4.5m - 2500\ m\ s^{-2} \times 0.0009\ s^2$$

$$\Rightarrow s = 4.5\ m - 2.25\ m$$

$$\Rightarrow s = 2.25\ m$$

Magnitude of force exerted by wooden block

We know that, Force = mass x acceleration

Or, F = 0.01 kg x – 5000 m s-2 = - 50 N

Therefore,

Penetration of bullet in wooden block = 2.25 m

Force exerted by wooden block on bullet = - 50 N. Here negative sign shows that force is exerted in the opposite direction of bullet.

Question: 15 - An object of mass 1 kg travelling in a straight line with a velocity of 10 m/s 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:

Given, mass of moving object, m1 = 1 kg

Mass of the wooden block, m2 = 5kg

Initial velocity of object, u1 = 10 m/s

Initial velocity of wooden block, u2 = 0

Final velocity or moving object and wooden block, v =?

Total momentum before collision and after collision =?

We know that,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 1\,kg \times 10\,m\,s^{-1} + 5\,kg \times 0 = 1\,kg \times v + 5kg \times v$$

$$\Rightarrow 10\,kg\,ms^{-1} = v(1kg + 5kg)$$

$$\Rightarrow 10\,kg\,ms^{-1} = v \times 6kg$$

$$\Rightarrow v = \frac{10\,kg\,ms^{-1}}{6\,kg} = 1.66\,m/s \quad ----(i)$$

Total momentum of object and wooden block just before collision

$$= m_1u_1 + m_2u_2$$

$$= 1\,kg \times 10\,m\,s^{-1} + 5\,kg \times 0 = 10\,kg\,ms^{-1}$$

Total momentum just after collision

$$= m_1v_1 + m_2v_2 = m_1v + m_2v = v\,(m_1 + m_2)$$

(Since both the objects move with same velocity 'v' after collision)

$$= (1\,kg + 5kg) \times \frac{10}{6} m/s \quad (From\ equation\ (i))$$

$$= 6\,kg \times \frac{10}{6} m/s = 10\ kg\,ms^{-1}$$

Thus,

Velocity of both the object after collision = 1.66 m/s

Total momentum before collision = 10 kg m/s

Total momentum after collision = 10 kg m/s

Question: 16 - An object of mass 100 kg is accelerated uniformly from a velocity of 5 m/s to 8 m/s in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Answer:

Given,

Initial velocity, u = 5 m/s

Final velocity, v = 8 m/s

Mass of the given object, m = 100 kg

Time, t = 6 s

Initial momentum and Final momentum =?

Magnitude of force exerted on the object =?

We know that,

Momentum = mass x velocity

Therefore, initial momentum = mass x initial velocity

= 100 kg X 5 m/s = 500 kg m/s

Final momentum = mass x final velocity

= 100 kg x 8 m/s = 800 kg m/s

We know that,

$$v = u + at$$
$$\Rightarrow 8\,m/s = 5m/s + a \times 6s$$
$$\Rightarrow 8m/s - 5m/s = a \times 6s$$
$$\Rightarrow 3m/s = a \times 6s$$
$$\Rightarrow a = \frac{3m/s}{6s} = 0.5\,ms^{-2}$$

Now, Force exerted on object = Mass x Acceleration

= 100 kg 0.5 m/s/s

= 50 N

Question: 17 - 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 stuck 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 larger 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: We know, that as per the Law of Conservation of Momentum; total momentum of a system before collision is equal to the total momentum of the system after collision.

In this case, since the insect experiences a greater change in its velocity so it experiences a greater change in its momentum. From this angle, Kiran's observation is correct.

Motorcar is moving with a larger velocity and has a bigger mass; as compared to the insect. Moreover, the motorcar continues to move in the same direction even after the collision; which suggests that motorcar experiences minimal change in its momentum, while the insect experiences the maximum change in its momentum. Hence, Akhtar's observation is also correct.

Rahul's observation is also correct; because the momentum gained by the insect is equal to the momentum lost by the motorcar. This also happens in accordance to the law of conservation of momentum.

Question: 18 - 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 m/s-2.

Answer:

Given,

Mass of dumb-bell = 10 kg

Distance, s = 80 cm = 80/100 = 0.8 m

Acceleration, a = 10 m/s/s

Initial velocity of dumb-bell, u = 0

Momentum =?

We know that,

$$v^2 = u^2 + 2as$$
$$\Rightarrow v^2 = 0 + 2 \times 10ms^{-2} \times 0.8m$$
$$\Rightarrow v^2 = 16m^2s^{-2}$$
$$\Rightarrow v = \sqrt{16m^2s^{-2}} = 4m/s$$

Now, we know that, momentum = mass x velocity

= 10 kg x 4 m/s = 40 kg m/s

An object of mass 2 kg is sliding with a constant velocity of 4 m/ s on a frictionless horizontal table. The force required to keep the object moving with the same velocity is

(a) 32 N (b) 0 N (c) 2 N (d) 8 N

Ans: (b]

Rocket works on the principle of conservation of

(a) mass (b) energy (c) momentum (d) velocity

Ans: [c]

A car is moving at 45 km/hr.A constant force acts on the car for 10 sc .So that it's velocity becomes 63 km/hr .The distance travelled by car during this interval of 10 sec is :

a) 100 m b) 150 m c) 200 m d) 50 m Ans: [b]

What is the definition of balanced and unbalanced force?

Ans: When two equal forces acting on an object in opposite directions called balanced force. *When something does not move the forces are balanced, e.g. Gravity pulls a table down but that table is pushed up by the floor or the ground it stands on so doesn't' move.*

An Unbalanced force is needed for something to change movement or change direction, e.g. a seesaw moving up and down because the forces are not equal.

Net force: - The sum of all the forces acting on a body is known as net force.

Difference between Balanced force and unbalanced force.

Ans: **Balanced force**:- If net force on a body is zero it is called balanced force. Balanced forces do not cause a change in motion. They are equal in magnitude and opposite in direction. Therefore, the resultant of these forces will be zero.

Example: Two persons pushing a box with the same force in opposite directions.

Unbalanced forces:- If net force on a body is non-zero it is called unbalanced force.

Forces whose resultant is not equal to zero are called unbalanced forces. For example: Anarm wrestling competition among a strong person and a weak one. The resultant force will be in the direction of the force applied by the strong person.

What Is Inertia

Ans: By Newton's law we know that ,a body at rest will remain at rest and a body in motion will continue in a straight line unless it is compelled by an external force.This tendency of a body is called inertia.So we can say that 'Inertia is that property of a body due to which it resists a change in its state of rest or of uniform motion.'

When the brakes are applied to the bike the back seater moves forward why?

When the bike accelerates suddenly the back seater who was initially at rest experiences a force of friction at the point of contact between him and the bike. His inertia of rest tries to keep him at rest which results in a backward push. Thus, the back seater moves backwards when the bike accelerates suddenly.

When the brakes are applied the inertia of motion of the back seater tries to keep him in motion so he moves forward.

There are three solids made up of aluminium, steel and wood, of the same shape and same volume. Which of them would have highest inertia?

Ans: Since steel has greatest density and greatest mass, therefore, it has highest inertia.

As the mass is a measure of inertia, the ball of same shape and size, having more mass than other balls will have highest inertia.

Two balls of the same size but of different materials, rubber and iron are kept on the smooth floor of a moving train. The brakes are applied suddenly to stop the train. Will the balls start rolling? If so, in which direction? Will they move with the same speed? Give reasons for your answer

Ans: Yes. the balls will start rolling in the direction in which the train was moving. Due to the application of the brakes, the train comes to rest but due to inertia the balls try to remain in motion, therefore, they begin to roll.

Since the masses of the balls are not the same, therefore, the inertial forces are also not same on both the balls. Thus, the balls will move with different speeds.

Horse need continues of force in order to move a cart with a constant speed. Why?

Horse need continues of force in order to move a cart with a constant speed to balances the force of friction.

Write a short note on third law of motion

Ans: **Third law of motion** : This law deals with the forces between bodies that appear in pairs. *It says that "every action has an equal and opposite reaction"*

When you stand on the ground, your weight pushes the ground downwards; does this make the ground to move downward? No, because the ground pushes you upward with a force equal to your weight and hence these equal and opposite forces cancel out and you stand on the ground balanced.

Force by you on the ground and force on you by the ground are two equal and opposite forces acting in pairs at the surface that is common to both you and the ground.

Newton's 3 rd law of motion is applicable wherever there is action-reaction force pair. Like walking, shooting with a pistol, collision, rocket propelling, etc.

How a karate player can break a pile of tiles with a single blow of his hand?

Ans: Karate player strikes the piles in a very short time in a very small area. Since, impulse, I = F × t Þ F = I/t. If 't' will be very short the force becomes very large and act on smaller area .This produce enough pressure by his hand on break the brick

Define momentum?

Ans: Momentum (Linear momentum) for moving body is defined as the product of mass and velocity. If a body is moving with velocity, v and having mass, m then momentum of body is p = m x v.

Momentum is a vector quantity. Its direction is the same as that of velocity. SI unit of momentum (p) is kg-m/s

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

Cricket ball has more momentum than the tennis ball due to greater mass. That's why it is easier to stop a tennis ball than a cricket ball moving with the same speed.

Why a goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal.

Ans: To reduce the force exerted by ball on hand by increasing time as F = I/t.

A passenger in a moving train tosses a coin which falls behind him. Why?

Ans: Because that motion of the train is accelerated.

State and explain the three laws of Newton?

Ans: **First law of motion**: Newton's First law explains the "natural" motion of an object when it is left free. The law says that- *Every object continues in its state of rest, or of uniform motion in a straight line with unchanging speed, unless compelled to do otherwise by forces acting upon it*.

So, naturally an object at rest will remain at rest and an object moving with a constant speed in a straight line will keep moving, unless they are disturbed by a force.

This property of matter to continue its state of rest or of uniform motion is called "Inertia". Hence, this law is also called the Law of Inertia.

Second law of motion: Newton's 2nd law of motion relates the external force (F) acting on a body with the mass (m) of the body; and is mathematically written as F = ma, 'a' is the acceleration of the body due to the force. *It states that the acceleration of a body due to net external force acting on it is equal to the net force divided by the mass of the body*.

The difficulty you face while pushing or pulling a heavier box compared to a lighter box is explained by the 2nd law of motion.

Third law of motion: This law deals with the forces between bodies that appear in pairs. *It says that every action has an equal and opposite reaction*. When you stand on the ground, your weight pushes the ground downwards; does this make the ground to move downward? No, because the ground pushes you upward with a force equal to your weight and hence these equal and opposite forces cancel out and you stand on the ground balanced. Force by you on the ground and force on you by the ground are two equal and opposite forces acting in pairs at the surface that is common to both you and the ground.

Q 1: . A car of mass 200 kg moving at 36 km/h is brought to rest after it covered a distance of 10 m. Find the retarding force acting on the car.

Answer:

Mass of the car (m) = 200 kg Initial speed (u) = 36 km/h = 10 m/s Final velocity (v) = 0

Distance covered (S) = 10 m

v2 - u2 = 2aS 0 - 100 = 2 x a x 10 - 100 = 20 aa = - 100/20 = -5 m/s2

F = ma = 200 x 5 = -1000 N

Retarding force = 1000 N

Q 2: What will be the change in acceleration of a sliding block, if its mass is doubled while a constant force is acting on it?

Answer:

Force exerted on the block (F) = ma

Let force acting on the object when the mass is doubled be equal to F_1 i.e., Mass (m_1) = 2 m

Acceleration produced = a_1 F_1 = 2m x a_1 Given F = F_1

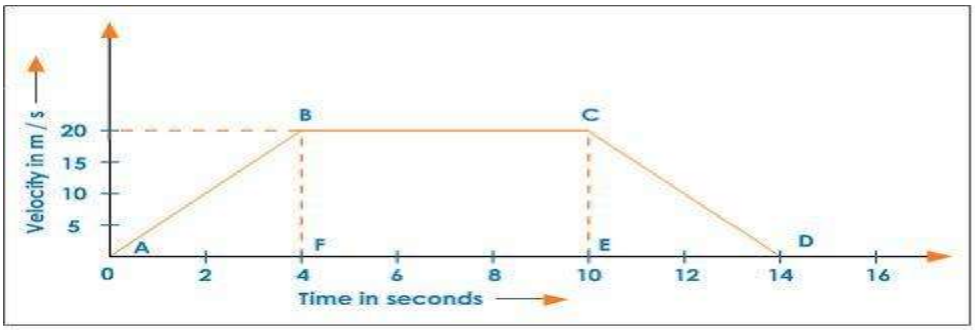
$a_1 = a/2$

i.e., acceleration is reduced to half.

$\therefore ma = 2 ma_1$

$a = 2 a_1$

Q 3: The figure below show a velocity time graph for a scooterist having a total mass of 150 kg. From the graph calculate - a) The acceleration in first 4 seconds b) The distance covered in the first 4 seconds. c) The force acting in the first 4 seconds.



***Answer*:**

a) The acceleration in the first four seconds is given by the slope of the graph AB.

AB = BF/AF =*20-0/4 =5* m/s^2

b) The distance covered in the first four seconds = area of Δ ABF

= 1/2 bh = 1/2 AF x BF=1/2 x 4 x 20 = 40m

c) Force acting on the body in the first four seconds = ma = 150 x 5 = 750 N

Q 4: A certain force exerted for 1.2 seconds raises the speed of an object from 1.8 m/s to 4.2 m/s. Later the same force is applied for 2 seconds. How much does the velocity change in 2 seconds?

Answer: Initial velocity (u) = 1.8 m/s. Final velocity (v) = 4.2 m/s Time (t) = 1.2 seconds

First calculate acceleration

a = *(v-u)/t = (4.2 - 1.8)/1.2*= 2 m/s^2

As the same force acts for the next two seconds the acceleration produced will be the same. The final velocity in the first case will now become the initial velocity.

We have to calculate the final velocity at end of 2 seconds.

Acceleration (a) = 2 m/s^2 Intial velocity (u) = 4.2 m/s, t = 2 s Final velocity (v) = ?

[First equation of motion]

v = u + at [First equation of motion]

= 4.2 + 2 x2 = 4.2 + 4 = 8.2 m/s

Change in velocity in two seconds = 8.2 - 4.2 = 4 m/s

Question 1
Why a goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal?
a.Keep the ball in hands firmly
b.Reduce the force exerted by the ball
c.To exert larger force on the ball
d. None of these

Question 2
A IITJEE text book of mass M rests flat on a horizontal table of mass m placed on the ground. Let $R_{x->y}$ be the constant force exerted by the body x on body Y. According to Newton third law, which of the following is an action-reaction pair of forces?
a. (M+m)g and $R_{table->book}$
b. $R_{ground->table}$ and $mg+R_{book->table}$
c. $R_{ground->table}$ and $R_{table->ground}$
d. Mg and $R_{table->book}$

Question 3
what options are true about momentum
a. Momentum is a vector quantity
b. The Unit of Momentum is kgm/s
c. Momentum is a scalar quantity
d. When two bodies acts on each other and no external force is acting on the system, then the momentum remains constant

Question 4
What is not true of unbalanced forces?
a. It can change the velocity of the object
b. It can change the direction
c. Change the momentum
d. Change the shape of the body

Question 5
An object of mass 100kg is accelerated uniformly from a velocity of 4 m/s to 8 m/s in 2 seconds. Calculate the initial and final momentum of the object
a. 400 kgm/s,800 kgm./s
b. 100 kgm/s,400 kgm./s

c. 200 kgm/s,400 kgm./s
d. 400 kgm/s,400 kgm./s

Question 6
Find the magnitude of the force exerted on the object in the above question?
a. 250N
b. 50N
c.100N
d. 200 N

Question 7
Which are laws of Newton's ?
a. Law stating action and reaction are equal and opposite
b. Product of mass and acceleration.
c. Tendency of a body to oppose any change in its state of rest or uniform motion
d. All the above

Question 8
Which of the followings works on the principle of momentum?
a. A gun recoils after firing
b. Rocket
c. The case of hose pipe
d. All the above

Question 9
A boy of mass 50 Kg running at 5 m/s jumps on to a 20Kg trolley travelling in the same direction at 1.5 m/s. What is the common velocity?
a. 4m/s
b. 3 m/s
c. 3.5 m/s
d. None of the above

Question 10
which of these are vector quantities?
a. momentum
b. Force
c. Impulse
d. Inertia

Solution

1. b
2. c
3. a,b,d
4. d
5. a
Initial momentum =mvi=100×4=400mvi=100×4=400 kgm/s
Final Momentum = mf=100×8=800mf=100×8=800 kg/s
6. d
$a=\Delta vt=8-42=2a=\Delta vt=8-42=2$ m/s^2
Force=mass×acceleration=100×2=200Force=mass×acceleration=100×2=200 N

7. d
8. d
9. d
Since no external force, law of conservation of momentum can be applied
Initial Momentum
pi=50×5+20×1.5=280pi=50×5+20×1.5=280 kgm/s
Final momentum pf=70×v=70vpf=70×v=70v where v is the common velocity
Now we know that
Initial momentum=Final momentum
280=70v280=70v
V=4m/s

10. (a),(b) and (c)

Other questions

Question 1
What is impulse? Prove that Impulse is equal to change in momentum?

Question 2
State all the law Newton's law of Motion? And Give example for each law

Question 3
What is the law of conservation of Momentum? A car of mass 200 kg moving with 3m/s collides with another car of mass 300 Kg moving in the same direction at 2 m/s .They collide and move together after that. What is the common velocity?

Question 4

Explain these statements

a. when an cyclist moving stop pedaling ,Cycle get stops after some time. Which force is responsible for stopping

Answer : Force of friction opposes the motion and stops the cycle

b. Why people sitting in bus fall backward when bus suddenly starts?

Answer: This is because of inertia, the people tends to remain in a state of rest even when the bus start moving

c. A karate player can break a pile of tiles with a single blow of his hand?

Answer: This is because the karate player moves his hand very fast ,This way large momentum of fast moving hand reduces to zero in very short time and this result in very high force on the slab and they break

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

Answer: This is because force of stick moves the carpet but dust due to inertia remains at rest and start coming out

Question 5

An 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.

Solution:

Total mass, m = mass of engine + mass of wagons

Or, m=8000+5×2000=18000m=8000+5×2000=18000 kg.

(a) The net accelerating force, F = Engine force - Frictional force

Or, F = 40000 - 5000 = 35000 N

(b) The acceleration of the train

$a=Fm=3500018000=1.94a=Fm=3500018000=1.94$ m/s^2

(c) The force of wagon 1 on wagon 2

Assuming Frictional Force on all the wagons and engine

Frictional resistance of 4 wagons

= 5000×(2000×4)18000=2222.22N5000×(2000×4)18000=2222.22N

Accelerating force on 4 wagons =2000×4×1.944=15552N2000×4×1.944=15552N

Hence total force exertred by wagon on wagon 2= Accelerating force +Frictional

resistance
=2222.22+15552=17774.22N=2222.22+15552=17774.22N

Assumining frictional force on engine only
Accelerating force on 4 wagons =2000×4×1.944=15552N2000×4×1.944=15552N

Question 6
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.
Solution Ball comes to rest because of frictional force.Hence (c) is the correct option

Question 7
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.
Solution
The velocity of the ball changes four times.
a. When a football player kicks the football, its speed changes from zero to a certain value.In this case, force applied by player helps to change the velocity of the ball.This at first changes the velocity of the ball.
b. Another player kicks the ball towards the goal post. This changes the direction of the ball. Therefore, its velocity also changes. In this case, the player applied a force to change the velocity of the ball. The velocity of the ball has changed 2nd time
c. The goalkeeper collects the ball. In other words, the ball comes to rest. Thus, its speed reduces to zero from a certain value. The goalkeeper applied an opposite force to stop/change the velocity of the ball.Hence, its velocity changes third time.
d. The goalkeeper kicks the ball towards his team players. Hence, the speed of the

ball increases from zero to a certain value. Hence, its velocity changes once again. In this case, the goalkeeper applied a force to change the velocity of the ball.

Question 1. An object of mass 6 kg is sliding on horizontal surface, with a uniform velocity of 8 m/ s . Assuming force of friction offered by the surface to be zero, The force required to maintain the motion of object with the same uniform velocity is
(a) 0 Newton
(b) 2 Newtons
(c) 8 Newtons
(d) 32 Newtons
Answer. (a) 0 Newton

Question 2. There will be a change in the speed or in the direction of motion of a body when it is acted upon by
(a) Zero Force
(b) Balanced Force
(c) An Unbalanced force
(d) Uniform force
Answer. c) An Unbalanced force

Question 3. Force required in accelerating a 3 kg mass at 5 m/s^2 and a 4 kg mass at 4 m/s^2, will be
(a) Zero in both the cases
(b) Same in both the cases
(c) greater for 3 kg mass at 5 m/s^2
(d) greater for 4 kg mass at 4 m/s^2
Answer. (d) greater for 4 kg mass at 4 m/s^2

Question 4. Which of the Expression to find the Force is correct ?
(a) F= m/a
(b) F= ma
(c) F= a/m
(d) F= ma/m
Answer. F= ma

Question 5. Inertia of a body is quantitative measure of its.
(a) velocity

(b) acceleration
(c) Mass
(d) Force
Answer. (c) Mass

Question 6. Rocket works on the principle of conservation of
(a) velocity
(b) Mass
(c) Linear Momentum
(d) Energy
Answer. (c) Linear Momentum

Question 7. In the following example, try to identify the number of times the velocity of 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."
(a) Three times
(b) Four times
(c) Five times
(d) Six times
Answer. (a) Three times

Question 8. A bullet of mass 40gm is fired from a gun of mass 8kg with a velocity of 800 m/s, calculate the recoil velocity of gun
(a) 1m/s
(b) -1m/s
(c) 2m/s
(d) -4m/s
Answer. (d) -4m/s

Question 9. A passenger in a moving train tosses a coin. The coin will fall back
(a) Behind him
(b) In front of him
(c) On his hands
(d) On the side of the train
Answer. (c) On his hands

Question 10. A hammer of mass 300 g, moving at 40m/s, strikes a nail. The nail stops the hammer in a very short time of 0.02 s. The force of the nail on the

hammer is
(a) 600N
(b) 1200N
(c) 2000N
(d) 2500N
Answer. (a) 600N

Question 11. The action and reaction forces referred to in the third law
(a) May act on different objects
(b) Must act on different objects
(c) Must act on the same object
(d) Need not be equal in magnitude but act in the same direction
Answer. (b) Must act on different objects

Question 12. An object will continue to accelerate until the
(a) The velocity changes direction
(b) Resultant force on it is increased continuously
(c) Resultant force begins to decrease
(d) Resultant force on it is zero
Answer. (d) Resultant force on it is zero

Question 13. Type of inertia that tends to resist the change in case of an "Athlete often jumps before taking a long jump "
(a) Inertia of direction
(b) Inertia of motion
(c) Uniformly accelerated motion
(d) Inertia of rest
Answer. (b) Inertia of motion

Question 14. Qualitative definition of Force is given by
(a) Newton's law of gravitation
(b) Newton's first law of motion
(c) Newton's Second law of motion
(d) Newton's third law of motion
Answer. (b) Newton's first law of motion

Question 15. The object shown below moves with constant velocity. Two forces are acting on the object.

Considering negligible friction , the resultant force will be
(a) 3 N towards left
(b) 5 N towards right
(c) 10 N towards left
(d) 19 N towards left
Answer. (b) 5 N towards right

1. Which of the following statement is not correct for an object moving along a straight path in an accelerated motion?

- (a) Its speed keeps changing
- (b) Its velocity always changes
- (c) It always goes away from the earth
- (d) A force is always acting on it

2. According to the third law of motion, action and reaction

- (a) always act on the same body
- (b) always act on different bodies in opposite directions
- (c) have same magnitude and directions
- (d) act on either body at normal to each other

3. A goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal. This enables the goal keeper to

- (a) exert larger force on the ball
- (b) reduce the force exerted by the ball on hands
- (c) increase the rate of change of momentum
- (d) decrease the rate of change of momentum

4. The inertia of an object tends to cause the object
- (a) to increase its speed
- (b) to decrease its speed
- (c) to resist any change in its state of motion
- (d) to decelerate due to friction

5. A passenger in a moving train tosses a coin which falls behind him. It means that motion of the train is
- (a) accelerated
- (b) uniform
- (c) retarded
- (d) along circular tracks

6. An object of mass 2 kg is sliding with a constant velocity of 4 m s^{-1} on a frictionless horizontal table. The force required to keep the object moving with the same velocity is
- (a) 32 N
- (b) 0 N
- (c) 2 N
- (d) 8 N

7. Rocket works on the principle of conservation of
- (a) mass
- (b) energy
- (c) momentum
- (d) velocity

8. A water tanker filled up to 2 / 3 of its height is moving with a uniform speed. On sudden application of the brake, the water in the tank would
- (a) move backward
- (b) move forward
- (c) be unaffected
- (d) rise upwards

Answers to Multiple Choice Questions

1. (c)	2. (b)	3. (b)	4. (c)	5. (a)
6. (b)	7. (c)	8. (b)		