#419592

Topic: Newton's Second Law

A constant retarding force of $50\ N$ is applied to a body of mass $20\ kg$ moving initially with a speed of $15\ ms^{-1}$. How long does the body take to stop?

Solution

Retarding force, F = 50 N

Mass of the body, m = 20 kg

Initial velocity of the body, u = 15 m/s

Final velocity of the body, v = 0

Using Newtons second law of motion, the acceleration (a) produced is given by:

$F = ma$

$50 = 20 \times a$

$a = -50/20 = -2.5 m/s^2$

Using the first equation of motion, the time (t) taken by the body to come at rest

$v = u + at$

$t = -u/a = -15/-2.5 = 6s$

#419595

Topic: Newton's Second Law

A constant force acting on a body of mass $3.0kg$ changes its speed from $2.0m\ s^{-1}$ to $3.5m\ s^{-1}$ in $25s$. The direction of the motion of the body remains unchanged. What is the magnitude and direction of the force?

Solution

Mass of the body, m = 3 kg

Initial speed of the body, u = 2 m/s

Final speed of the body, v = 3.5 m/s

Time, t = 25 s

Using the first equation of motion, the acceleration (a) produced in the body can be calculated as:

$v = u + at$

$a = (v - u)/t$

$= (3.5 - 2)/25 = 0.06 m/s^2$

As per Newton's second law of motion, force is given as:

$F = ma$

$= 3 \times 0.06 = 0.18N$

Since the application of force does not change the direction of the body, the net force acting on the body is in the direction of its motion.

#419601

Topic: Newton's Second Law

The driver of a three-wheeler moving with a speed of $36\ km/h$ sees a child standing in the middle of the road and brings his vehicle to rest in $4.0\ s$ just in time to save the child. What is the average retarding force on the vehicle? The mass of the three-wheeler is $400\ kg$ and the mass of the driver is $65\ kg$.

Solution

Initial speed of the three-wheeler, $u = 36km/h = 10m/s$

Final speed of the three-wheeler, v = 0 m/s

Time, t = 4 s

Mass of the three-wheeler, m = 400 kg

Mass of the driver, m' = 65 kg

Total mass of the system, M = 400 + 65 = 465 kg

Using the first law of motion, the acceleration (a) of the three-wheeler can be calculated as:

$v = u + at$

a = (v - u) / t= (0 - 10) / 4 = -2.5 m/s^2

The negative sign indicates that the velocity of the three-wheeler is decreasing with time.

Using Newtons second law of motion, the net force acting on the three-wheeler can be calculated as:

$F = Ma = 465 \times (-2.5) = -1162.5N$

The negative sign indicates that the force is acting against the direction of motion of the three-wheeler.

#419610

Topic: Newton's Second Law

A body of mass $0.40kg$ moving initially with a constant speed of $10ms^{-1}$ to the north is subject to a constant force of $8.0N$ directed towards the south for $30s$. Take the instant the force is applied to be $t = 0$, the position of the body at that time to be $x = 0$, and predict its position at $t = -5s, 25s, 100s$

Solution

Mass of the body, $m = 0.40kg$

Initial speed of the body, u = 10 m/s due north

Force acting on the body, F = –8.0 N

Acceleration produced in the body, $a = F/m = -8.0/0.40 = -20ms^{-2}$

(i)

At t = –5 s

Acceleration, a' = 0 and u = 10 m/s

$s = ut + \dfrac{1}{2}a't^2$

= 10 × (–5) = –50 m

(ii)

At t = 25 s

Acceleration, $a'' = -20m/s^2$ and u = 10 m/s

$s' = ut' + (1/2)a''t^2$

$= 10 \times 25 + (1/2) \times (-20) \times 25^2$

$= 250 - 6250 = -6000m$

(iii)

At t = 100 s

For 0 ≤ t ≤ 30 s

$a = -20ms^{-2}$

$u = 10m/s$

s1 = ut + (1/2)a"t^2

= 10 × 30 + (1/2) × (-20) × 30^2

$= 300 - 9000 = -8700m$

#419661

Topic: Newton's Second Law

Explain why

(a) A horse cannot pull a cart and run in empty space.

(b) Passengers are thrown forward from their seats when a speeding bus stops suddenly.

(c) It is easier to pull a lawn mower than to push it.

(d) A cricketer moves his hands backwards while holding a catch.

Solution

(a) While trying to pull a cart, a horse pushes the ground backward with some force. The ground in turn exerts an equal and opposite reaction force upon the feet of the horse. This reaction force causes the horse to move forward.

An empty space is devoid of any such reaction force. Therefore, a horse cannot pull a cart and run in empty space.

(b) This is due to inertia of motion. When a speeding bus stops suddenly, the lower part of a passenger's body, which is in contact with the seat, suddenly comes to rest. However, the upper part tends to remain in motion (as per the first law of motion). As a result, the passenger's upper body is thrown forward in the direction in which the bus was moving.

(c) While pulling a lawn mower, a force at an angle is applied on it, as shown in the given figure.

The vertical component of this applied force acts upward. This reduces the effective weight of the mower.

On the other hand, while pushing a lawn mower, a force at an angle is applied on it, as shown in the following figure.

In this case, the vertical component of the applied force acts in the direction of the weight of the mower. This increases the effective weight of the mower.

Since the effective weight of the lawn mower is lesser in the first case, pulling the lawn mower is easier than pushing it.

(d) According to Newtons second law of motion, we have the equation of motion:

$F = ma = m\,v/t$ …**(i)**

Where,

F = Stopping force experienced by the cricketer as he catches the ball

m = Mass of the ball

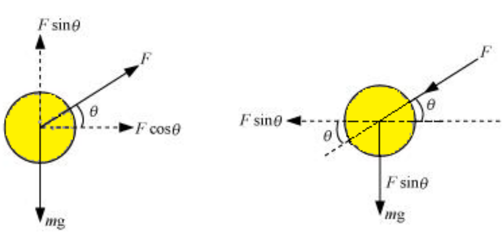
t = Time of impact of the ball with the hand

It can be inferred from equation (i) that the impact force is inversely proportional to the impact time, i.e.,

$F \propto 1/t$ ….(ii)

Equation (ii) shows that the force experienced by the cricketer decreases if the time of impact increases and vice versa.

While taking a catch, a cricketer moves his hand backward so as to increase the time of impact (t). This is turn results in the decrease in the stopping force, thereby preventing the hands of the cricketer from getting hurt.



#419687

Topic: Newton's Second Law

A stream of water flowing horizontally with a speed of $15\ ms^{-1}$ gushes out of a tube of cross-sectional area $10^{-2}\ m^2$, and hits a vertical wall nearby. What is the force exerted on the wall by the impact of water, assuming it does not rebound ?

Solution

Speed of the water stream, v = 15 m/s

Cross-sectional area of the tube, A = 10^{-2} m^2

Volume of water coming out from the pipe per second,

$V = Av = 15 \times 10^{-2}$ m^3/s

Density of water, = 10^3 kg/m^3

Mass of water flowing out through the pipe per second = density $\times V$ = 150 kg/s

The water strikes the wall and does not rebound. Therefore, the force exerted by the water on the wall is given by Newtons second law of motion as:

F = Rate of change of momentum = P / t

= mv / t

= 150 $\times$ 15 = 2250 N

#464570
Topic: Newton's First Law

Soni says that the acceleration in an object could be zero even when several forces are acting on it. Do you agree with her? Why?

Solution

Yes, I agree with Soni.
When all the forces, which are acting on a body cancel out each other, then we may say that the net force on that body is zero. For a uniformly moving body, the net force acting on it will be zero. So, it's acceleration will be zero.

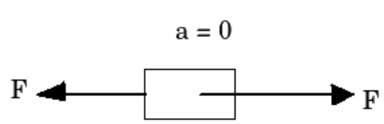
Yes, I agree with Soni that the acceleration in an object could be zero even when several forces are acting on it.
Let equal and opposite forces (F) act on an object, they cancel out each other so that the net external force experienced by the object is zero which makes the object to move with zero acceleration.

$F_{external} = ma$

$\therefore\ F_{external} = 0 \quad \implies a = 0$

$\therefore\quad v_f = v_i$

Thus an object will kept on moving with a constant velocity v if it was also moving initially.



#464656
Topic: Newton's First Law

An object experience 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.

Solution

$F_{external} = ma$

If $F_{external} = 0 \quad \implies a = 0$

$\therefore\quad v_f - v_i = 0$

$\implies v_f = v_1$

Thus if an object was moving with any velocity initially, then it will move with non-zero velocity even when it experiences a net zero unbalanced force.

By Newton's First law of motion, a body remains in the state of rest or uniform motion unless an external force is applied on it. So, if the body has some initial velocity and net force applied is zero, it will continue to move with the same initial velocity.

#464657

Topic: Newton's First Law

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

Solution

When a carpet is beaten with a stick, the dust comes out of it because of law of inertia.

Initially the dust particles are at rest along with the carpet. Beating the carpet with the stick makes the carpet to move but the dust particles remain at rest due to inertia at rest, thus the dust gets detached from the carpet.

#464658

Topic: Newton's First Law

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

Solution

When the bus moves in forward direction, the luggage kept on the roof also moves along with the bus in forward direction. Now when the bus suddenly stops, it comes to rest but the luggage is still in motion in forward direction due to inertia of motion, thus the luggage falls off the roof of bus.

Hence it is advised to tie it.

#464659

Topic: Newton's Second Law

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 a stop because

A The batsman did not hit the ball hard enough

B Velocity is proportional to the force exerted on the ball

$\boxed{\text{C}}$ 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

When the ball rolls on the ground, the ground exerts a friction force on the ball in the opposite direction of its motion. Due to this friction force, the ball retards (gets slowed down) and finally stops after some time covering small distance.

#464660

Topic: Newton's Second Law

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

Solution

Given data:

Mass of stone(m)=7000 kg

Distance(S)=400 meter

Time(t)=20 second

1)We have to find the acceleration of the truck

So from the equation of motion $S = ut + \frac{1}{2}a \times t^2$; where $u = 0$

$S = \frac{1}{2}a \times t^2$

$a = \frac{2 \times S}{t^2} = \frac{2 \times 400}{20 \times 20} = 2\frac{m}{sec^2}$

2)Force acting on truck

So,from newton's 2^{nd} law of motion

$\vec{F} = ma = 7000 \times 2 = 14000N = 14kN$

Initial velocity of the truck, $u = 0$

Distance covered by the truck, $s = 400\ m$

Time taken to cover that distance, $t = 20\ s$

Let the acceleration of the truck be a

$$s = ut + \frac{1}{2}at^2$$
$$400 = (0)20 + \frac{1}{2}a(20)^2$$
$$a = 2\ m/s^2$$

Mass of the truck $M = 7\ tonnes = 7000\ kg \quad (\because 1\ tonne = 1000\ kg)$

$F = Ma = 7000 \times 2 = 14000\ N$

#464662

Topic: Newton's Second Law

A stone of 1kg is thrown with a velocity of 20m s^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50m. What is the force of friction between the stone and the ice?

Solution

Before we proceed we have to make a free body diagram of the stone-ice system.In the figure we are seeing that frictional force is acting in leftward while the stone in moving rightward direction.One thing we have to fix in our mind that frictional force will always act opposite to the direction of motion of body.

Now on resolving the forces,

$f - ma$ or $f = ma$ ------(1)

also form the equation of motion $v^2 = u^2 + 2as$ here final velocity is zero,so $v = 0$

$u^2 = -2as$

$a = \frac{-u^2}{2s} = -\frac{20^2}{2\times50} = -4\frac{m}{sec^2}$

on substituting the given data in equation(1)

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

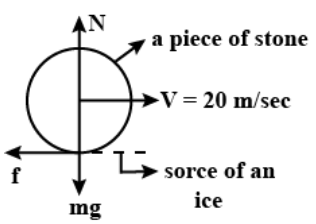


FIG: Free body diagram of system

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

Final velocity of the stone, $v = 0$

Distance covered, $s = 50$ m

$$v^2 - u^2 = 2as$$
$$0 - (20)^2 = 2a \times 50$$

$a = -4\ ms^{-2}$ (- sign shows retardation)

Thus friction force acting between the stone and the ice, $f = ma$

$f = 1 \times 4 = 4\ N$ against the direction of motion

#464666

Topic: Newton's Second Law

A 8000kg engine pulls a train of 5 wagons, each of 2000kg, along a horizontal track. If the engine exerts a force of 40000N and the track offers a friction force of 5000N, then calculate:

(a) The net accelerating force:

(b) The acceleration of the train; and

(c) The force of wagon 1 on wagon 2.

Solution

Given : Mass of engine $M = 8000$ kg

Mass of each wagon $m = 2000$ kg

Frictional force acting in backward direction $f = 5000$ N

(a) : The net force acting on the train $F' = F - f = 40000 - 5000 = 35000$N

(b) : Let the acceleration of the train be a

$\therefore \quad F' = (5m + M)a$

$35000 = (5 \times 2000 + 8000)a \qquad \implies a = 1.944\ ms^{-2}$

(c) : External force is applied directly on wagon 1 only. The net force on last four wagons is equal to the force applied by wagon 2 by wagon 1.

Let the acceleration of the wagons be a'

$35000 = (5m)a' \qquad \implies 35000 = 10000 \times a'$

Acceleration of the wagons $a' = 3.5\, ms^{-2}$

Mass of last 4 wagons $m' = 4 \times 2000$kg

$\therefore$ Net force on last 4 wagons $F_1 = 8000 \times 3.5 = 28000$ N

Thus force on wagon 2 by wagon 1 is 28000 N.

#464668

Topic: Newton's Second Law

An automobile vehicle has a mass of 1500kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of $1.7\ m\ s^{-2}$?

Solution

given data:

mass of vehicle=1500kg

Retardation=1.7m/{sec^2

Here we can define this negative acceleration as retardation,which state that body is accelerating in opposite direction of applied force.

from newton's 2nd law of motion

$f = ma$

where f is the frictional force actin between the vehicle and the road,which will always act opposite to the direction of motion of body.

$f - ma = 0$

$f = ma = 1500 \times 1.7 = 2550N$

Given : Retardation or negative acceleration $|a| = 1.7\ ms^{-2}$

Mass of the vehicle $m = 1500kg$

Thus the force between the vehicle and the road $|f| = ma$

$|f| = 1500 \times 1.7 = 2550N$

#464669

Topic: Newton's Second Law

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

A $(mv)^2$

B mv^2

C $\frac{1}{2}mv^2$

D $\boxed{mv}$

Solution

We know that momentum,which is a scalar quantity.So according to definition for a moving body it's motion is measured by the product of it's mass and velocity.

hence, $\vec{p} = mv$

where

$\vec{p}$=momentum of a body.

m=mass of the body.

v=velocity of the body

S.I unit of momentum is kg.m/sec.

Momentum of an object is defined as the product of its mass and the velocity with which the object is moving.

Let velocity of the object be v and its mass be m

$\therefore \text{Momentum, } P = mv$

#464671

Topic: Newton's Second Law

Using a horizontal force of 200N, 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?

Solution

For an object to move with constant velocity, net external force experienced by it must be equal to ZERO i.e $F_{external} = 0$

Thus a friction of 200 N must be exerted on the cabinet so that it moves with a constant velocity under the applied horizontal force of 200 N.

#464673

Topic: Linear Momentum and its Conservation

Two objects, each of mass 1.5kg, are moving in the same straight line but in opposite directions. The velocity of each object is 2.5m s^{-1} before the collision during which they stick together. What will be the velocity of the combined object after collision?

Solution

Given : $m_1 = m_2 = 1.5\ kg$

$u_1 = 2.5\ ms^{-1}$

$u_2 = 2.5\ ms^{-1}$

Total mass of the combined system, $M = m_1 + m_2 = 2 \times 1.5 = 3kg$

Let the velocity of the combined system after the collision be v

Applying conservation of momentum before and after the collision :

$m_1u_1 - m_2u_2 = Mv$

$1.5 \times 2.5 - 1.5 \times 2.5 = 3v$

$\implies v = 0$

#464675

Topic: Newton's Third Law

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.

Solution

When we push a truck parked along the roadside, then the road applies a static friction force in the opposite direction of force applied on the truck to oppose the motion of truck. The static friction is adjustable in nature, i.e., the road offers only the required amount of friction force to keep the truck at rest. If we apply more force, the road applies more friction force (up to a highest value, known as limiting value of static friction. Hence the friction force cancels out the force applied.

Here student's justification is that the two opposite and equal forces cancel each other and hence the truck does not move. However, the student did not specify which two forces the student is talking about. The statement is valid for force on truck and friction. If the student referred to action and reaction force, then the explanation is invalid because those act on different bodies. Here, action is acting on truck while reaction is acting on the man pushing the truck.

#464679

Topic: Newton's Second Law

A hockey ball of mass 200g travelling at 10m s^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5m s^{-1}. Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Solution

Initial velocity of the ball, $u = -10\ ms^{-1}$ (- sign shows the opposite direction)

Final velocity of the ball, $v = 5\ ms^{-1}$

Mass of the ball, $m = 200\ g = 0.2\ kg$

Net change in the momentum of the ball, $\Delta P = P_f - P_i$

$\Delta P = mv - mu = m \times 5 - m \times (-10)$

$\therefore \Delta P = 15 \times m = 15 \times 0.2 = 3\ kg\ m\ s^{-1}$

#464684

Topic: Newton's Second Law

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

Solution

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

Final velocity of the bullet, $v = 0$

Mass of the bullet, $m = 10\ g = 0.01\ kg$

Time taken by the bullet to come to rest, $t = 0.03\ s$

Let distance of penetration be s

$v = u + at$

$0 = 150 + a(0.03)$

$\implies a = -5000\ ms^{-2}$ (- sign shows retardation)

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

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

$s = 2.25\ m$

Magnitude of the force exerted by the wooden block, $|F| = m|a|$

$|F| = 0.01 \times 5000 = 50\ N$

#464690

Topic: Linear Momentum and its Conservation

An object of mass 1kg travelling in a straight line with a velocity of 10m s^{-1} collides with and sticks to a stationary wooden block of mass 5kg. 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.

Solution

Given : $m_1 = 1kg$ $m_2 = 5kg$ $u_1 = 10\ ms^{-1}$ $u_2 = 0$

Momentum of the system just before collision, $P_i = m_1u_1 + m_2u_2$

$P_i = 1 \times 10 + 5 \times 0 = 10\ kgms^{-1}$

Mass of the combined object, $M = m_1 + m_2 = 6kg$

Let velocity of combined object be v

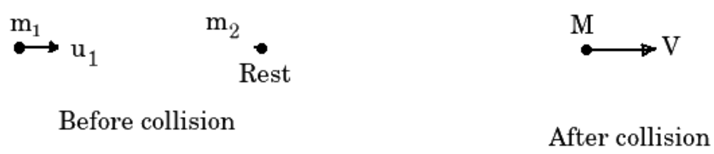
According to conservation of momentum, momentum of the system just after the collision, $P_f = P_i$

$\implies P_f = 10\ kg\,m\,s^{-1}$

$Mv = 10$

or, $6 \times v = 10$

or, $v = 1.67\ m/s$



#464693

Topic: Newton's Second Law

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

Solution

Initial velocity $u = 5m/s$

final velocity $v = 8m/s$

time $= 6s$

mass $= 100kg$

We know that Momentum $= velocity \times mass$

So, Initial Momentum $= initialvelocity \times mass = 5 \times 100 = 500kgm/s$

Final Momentum $= Finalvelocity \times mass = 8 \times 100 = 800kgm/s$

Also, Force $= mass \times acceleration$

by newtons first law of equation,

$v = u + at$

$\Rightarrow a = \frac{v-u}{t} = \frac{8-5}{6} = 0.5m/s^2$

So, Force $= mass \times acceleration = 100 \times 0.5 = 50N$

Mass of the object, $m = 100\ kg$

Initial velocity of the object, $u = 5\ ms^{-1}$

Final velocity of the object, $v = 8\ m/s$

Thus initial momentum of the object, $P_i = mu = 100 \times 5 = 500\,kg\ m\ s^{-1}$

Final momentum of the object, $P_f = mv = 100 \times 8 = 800\ kg\ m/s$

Time taken to change the velocity, $t = 6\ s$

$v = u + at$

$8 = 5 + a(6)$

$\implies a = 0.5\ ms^{-2}$

$F = ma = 100 \times 0.5 = 50\ N$

#464699

Topic: Newton's Third Law

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.

Solution

Kiran's statement:

Change in momentum of the insect and the motorcar is equal by conservation of momentum. The velocity of insect changes significantly because its mass is very small compared to the motorcar. Similarly, the velocity of motorcar is very insignificant because its mass is very large compared to the insect. Hence, Kiran's statement is false.

Akhtar's statement:

By newton's third law of motion, action and reaction force are equal and opposite and they act on different bodies. Hence, the motorcar and insect both experience the same force. Since the mass of the insect is very small compared to the motorcar, it suffers a huge change of velocity as compared to the car. Due to this, insect dies. Hence, Akhtar's statement is false.

Rahul's Statement:

As discussed before, both the motorcar and the insect experience the same force and change in momentum. Hence, Rahul's statement is correct.

#464703

Topic: Newton's Second Law

How much momentum will a dumb-bell of mass 10kg transfer to the floor if it falls from a height of 80cm ? Take its downward acceleration to be 10m s^{-2}

Solution

Given,

Mass$= 10kg$

Height, $S = 80cm = 0.8m$

$g = 10m/s^2$

by third equation of motion, we can get velocity,

$v^2 = u^2 + 2gS$

$\Rightarrow v^2 = 2 * 10 * 0.8 = 16 = 4m/s$

So, velocity $= 4m/s$

Now Momentum ,$= mass \times velocity$

So, $\Rightarrow 10 \times 4 = 40kgm/s$

Given : Height from which it falls $h = 80$cm $= 0.8$ m

Mass of the dumb-bell $m = 10kg$

Initial velocity of the dumb-bell $u = 0$

Let its velocity when it strikes the floor be v

Using $v^2 - u^2 = 2ah$

$v^2 - 0 = 2 \times 10 \times 0.8$ $\implies v = 4\ ms^{-1}$

Change in momentum of the dumb-bell $\Delta P = mv - mu$

$\Delta P = 10 \times 4 - 0 = 40 kgms^{-1}$

Hence the dumb-bell transfer the momentum of $40\ kgms^{-1}$ to the floor

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#464707

Topic: Newton's Second Law

The following is the distance-times table of an object in motion:

Time in seconds	Distance in metres
0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

(a) What conclusion can you draw about the acceleration? Is it constant, increasing, decreasing, or zero?

(b) What do you infer about the forces acting on the object?

Solution

According to the data given, we conclude that the distance covered by an object is directly proportional to the cube of time taken.

$\therefore\ \ x \propto t^3$ $\implies x = kt^3$ where k is constant

Differentiating w.r.t time, $\dfrac{dx}{dt} = k(3t^2)$

Differentiating again w.r.t time, $\dfrac{d^2x}{dt^2} = \dfrac{d}{dt}(3kt^2) = 6kt$

$\implies$ Acceleration of the object $\dfrac{d^2x}{dt^2} = a = 6kt$

Hence, the acceleration of the object is not constant and increases with time.

Force acting on the object $F = ma = m(6kt)$

$\implies F = 6kmt$ i.e force acting on the object increases with time.

(a)

For zero acceleration, $s = vt$ is valid.

For constant acceleration, $s = ut + (1/2)at^2$ is valid by second equation of motion.

From given data, $s = t^3$. Hence, it is not constant and non-zero.

Since $s \propto t^2$ for constant acceleration, and $s \propto t^3$ in the given problem, change in velocity is more in the given problem. Hence, it is increasing. This is also explained mathematically below:

$$v = \frac{s_2 - s_1}{t_2 - t_1} = constant \times \frac{t_2^3 - t_1^3}{t_2 - t_1} = constant \times (t_2^2 + t_1^2 + t_1t_2)$$

Without loss of generality, we can assume $t_1 = 0$

So, $v = constant \times t_2^2$

We know, $a = \Delta v / \Delta t$

$a = constant \times t_2$

Since time is increasing, acceleration increases.

(b) Since acceleration is increasing, applied force is increasing.

#464710

Topic: Newton's Second Law

Two persons manage to push a motorcar of mass 1200kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2m s^{-2}. With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort.)

Solution

Given data:

Mass of motorcar=1200kg

acceleration produced by 3 person by pulling motorcar of same mass(1200kg)=0.2ms$^-2$

From newton's 2nd law of motion

$F = ma$

so force exerted on car by three person at a time is

$F = 1200 \times 0.2 = 240N$

if three person can produce 240 newton amount of force,so for 1 person

Force produced by one person=$\frac{240}{3} = 80N$

Given : Mass of the motorcar $M = 1200kg$

Acceleration of motor car $a = 0.2\ ms^{-2}$

Total external force acting on the car by the three persons, $F_T = Ma$

$F_T = 1200 \times 0.2 = 240\ N$

Thus force applied by each person, $f = \dfrac{F_T}{3} = \dfrac{240}{3} = 80\ N$

#464714

Topic: Newton's Second Law

A hammer of mass $500\ g$, moving at $50\ ms^{-1}$, strikes a nail. The nail stops the hammer in a very short time of $0.01\ s$. What is the force of the nail on the hammer?

Solution

Given : Mass of the hammer, $M = 500g = 0.5kg$

Initial velocity of the hammer, $u = 50\,ms^{-1}$

Final velocity of the hammer, $v = 0$

Time taken, $t = 0.01\ s$

Thus change in momentum of the hammer, $\Delta P = mv - mu$

$\Delta P = 0 - 0.5 \times 50 = -25\,kg\ ms^{-1}$

Force of the nail on hammer, $|F| = \dfrac{|\Delta P|}{t} = \dfrac{25}{0.01} = 2500\ N$

#464716

Topic: Newton's Second Law

A motorcar of mass 1200kg is moving along a straight line with a uniform velocity of 90km/h. Its velocity is slowed down to 18km/h in 4s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required.

Solution

Given : Mass of the motorcar, $M = 1200kg$

Initial velocity of the car, $u = 90\ km/h = 25\ m/s$ $(\because 1km/h = \frac{5}{18}m/s)$

Final velocity of the car, $v = 18\ km/h = 5\ m/s$

Time taken $t = 4\ s$

$\Delta P = mv - mu$

$\Delta P = 1200 \times 5 - 1200 \times 25 = -24000kg\ m/s$

$v = u + at$

$5 = 25 + a \times 4$

$\implies a = -5\ m/s^2$ (-ve shows retardation)

$|F| = m|a| = 1200 \times 5 = 6000\ N$