NCERT Solutions for class 9 science chapter 9 Force and Laws of Motion

Q1. 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:

We know that inertia is defined by the mass of the body. So the body has more mass/weigth will have more inertia.

(a) In the case of rubber ball and stone of the same size, the stone will have greater mass so its inertia will be more as compared to a rubber ball.

(b) The train has much more mass as compared to the bicycle so the inertia of the train is larger.

(c) A five rupees coin has more weight than one rupee coin so the inertia of five rupees coin is more.

Q2. 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".

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Also, identify the agent supplying the force in each case.

Answer:

Velocity has both magnitude and direction. Thus change in any of magnitude or direction results in a change in velocity.

In the given case, when the player kicks the ball to another player the direction of the ball is changed thus velocity is changed.

The second player then pushes the ball in a forward direction, so velocity changes. Then the goalkeeper brings ball at rest hence velocity changes (magnitude is changed). After that he kicks the ball thus increase the speed and direction is opposite, hence velocity changes again.

The agent of supplying force is 1st player, 2nd player, goalkeeper, and goalkeeper respectively.

Q3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.

Answer:

This can be explained with the help of the concept of inertia. When the tree is at rest, its leaves are also at rest. But when we bring the tree in motion by means of shaking it, due to the inertia of leaves they still tend to be in rest. Thus force is acting on leaves vigorously with changing direction rapidly. This results in detaching of leaves from the tree.

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Q4 . 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 the situation of a moving bus, the passengers are also in motion along with the bus. Now when brakes are applied the bus comes to rest but due to the inertia of passengers they still tend to move in the forward direction, Thus they move in the forward direction after applying brakes.

Now when the bus is rest, the passengers are also at rest. The inertia tend them to be at rest. That's why when bus accelerates they move in a backward direction.

NCERT textbook solutions for class 9 science chapter 9 Force and Laws of Motion Topic 9.5

Q1. If action is always equal to the reaction, explain how a horse can pull a cart.

Answer:

For motion, horse applies force on the ground and thus the frictional force of the ground pushes the horse forward (action-reaction pair). Thus horse applies force on the cart and cart applies backward force on the horse but due to unbalanced force, the horse moves in the forward direction.

Q2. Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.

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Answer:

This can be explained with the help of Newton's third law of motion (action-reaction pair). When the velocity of water is more i.e., water is coming out with higher force thus the reaction force on the hose is also large. This makes it difficult for a fireman to hold the hose.

Q3. From a rifle of mass 4 kg, a bullet of mass 50 g is fired with an initial velocity of 35 m s^{-1}. Calculate the initial recoil velocity of the rifle.

Answer:

Here we will use conservation of momentum :

Initial momentum of system (rifle + bullet) = Final momentum of system

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

or $4 \times 0 + 0.05 \times 0 = 4 \times v_1 + 0.05 \times 35$

or $-4 \times v_1 = 1.75$

or $v_1 = -0.4375\ m/s$

The negative sign shows that velocity is opposite to that of the bullet. This is because the force on the rifle will be opposite by bullet (action-reaction pair).

Q4. Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2 m s^{-1} and 1 m s^{-1}, respectively. They collide and after the collision, the first object moves at a velocity of 1.67 m s-1. Determine the velocity of the second object.

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Answer:

In this question we will use conservation of momentum :

Initial momentum = Final momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

or $0.1 \times 2 + 0.2 \times 1 = 0.1 \times 1.67 + 0.2 \times v_2$

or $v_2 = \frac{0.233}{0.2}$

or $v_2 = 1.165\ m/s$

Hence required velocity is 1.165 m/s.

NCERT solutions for class 9 science chapter 9 Force and Laws of Motion: Solved Exercise Questions-

Q 1. An object experiences a net zero external unbalanced force. Is it possible for the object to be traveling 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 and the object is in motion then there will be a condition in which its motion is unopposed by any external force. Then as a result object will continue to remain in motion. The velocity, in this case, will be constant and in a particular direction.

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

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Answer:

During beating the carpet we bring it in the motion. But the dust particles have a tendency to be at rest so they resist the motion. This is why they come out of the carpet. The factor responsible for this is **inertia** .

Q 3. Why is it advised to tie any luggage kept on the roof of a bus with a rope?

Answer:

This is because the luggage has some mass so the inertia. When the bus is in motion, the luggage is also in motion. But when the bus stops suddenly, the luggage still tends to move with the same velocity due to inertia. Thus it may fell down. Similarly, when the bus starts from the rest, the luggage tends to be in rest thus it is pushed in a backward direction.

Q 4. A batsman hits a cricket ball which then rolls on 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:

The frictional force present between the ground and the ball acts in the opposite direction of the motion of the ball. Thus balls stop after travelling a few distances.

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Hence option (c) is correct.

Q 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 :

From the equations of motion we can write :

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

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

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

And the force acting on the truck is given by :

$$F = ma$$

$$= 7000 \times 2$$

$$F = 14000\ N$$

Q 6. A stone of 1 kg is thrown with a velocity of 20 m s $^{-1}$ across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice?

Answer:

By the equation of motion, we know that,

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

or $0^2 = 20^2 + 2a \times 50$ (Since ball comes to rest thus final velocity is zero.)

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

The acceleration is negative. This implies that the force is opposing the motion.

The force is given by :

$$F = ma$$

or $F = 1 \times (-4) = -4\ N$

Hence the frictional force between stone and ice is 4 N.

Q 7. (a) 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:

- the net accelerating force and

Answer:

The net accelerating force is given by :

Net accelerating force = Force by engine - Frictional force

$= 40000 - 5000 = 35000\ N$

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Q 7.(b) 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:

- the acceleration of the train

Answer:

We know that the force is given by :

$F = ma$

or $35000 = (8000 + 10000)a$

or $a = \frac{35000}{18000} = 1.944\ m/s^2$

Thus acceleration of the train is $1.944\ m/s^2$.

Q 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:

By Newton's law of motion, we have :

$F = ma$

and $= 1500 \times 1.7$

or $F = -2550\ N$

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Thus the retarding force required is 2550 N in the direction opposite to the motion of the vehicle

Q 9. What is the momentum of an object of mass m, moving with a velocity v?

(a) $(mv)^2$ (b) mv^2 (c) $\frac{1}{2}mv^2$ (d) mv

Answer:

We know that the momentum of a body is given by:-

Momentum = Mass $\times$ Velocity

Thus we have : $p = mv$

Hence option (D) is correct.

Q 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:

By Newton's third law it is clear that the frictional force acting on the cabinet will be 200 N. (Note that the limit of frictional force depends upon the mass of the body and the coefficient of friction between the bodies. So it might be possible that if frictional force acting is less than 200 N).

Q 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 the collision?

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Answer:

The velocity of the combined mass after the collision will be zero.

This can be found using the law of conservation of the momentum :

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

or $mu + m(-u) = (2m)v$

or $2mv = 0$

Thus $v = 0$

Q 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 :

The student is correct. The force applied by him is less than the static friction present between tyres of the truck and the road (as the mass of truck is large thus the frictional force is also high). Thus the force applied by the student is balanced by the static frictional force which is the action-reaction pair.

Q 13. A hockey ball of mass 200 g travelling at 10 m s $^{-1}$ is struck by a hockey stick so as to return it along its original path with a velocity at 5 m s $^{-1}$. Calculate the magnitude of change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

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Answer:

The change in the momentum is given by :

$$\Delta p = m\Delta v$$

or $= 0.2 \times (-5 - 10)$

or $= -3\ Kg\ m/s$

In the above equation, we have taken $v = -5\ m/s$ as its direction is opposite.

Q 14. A bullet of mass 10 g travelling horizontally with a velocity of 150 m s $^{-1}$ strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

Answer:

By the equation of motion we know that:-

$$v = u + at$$

Putting values of v, u and t in the equation :

$$0 = 150 + a \times 0.03$$

or $$a = \frac{-150}{0.03}$$

or $a = -5000\ m/s^2$

Now we have :

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

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

or $$= 2.25\ m$$

Hence the distance of penetration of the bullet in the block is 2.25 m.

Now for the force we have :

$$F = ma$$

or $$= 0.01 \times (-5000) = -50\ N$$

Thus the retarding force acting on the bullet is 50 N.

Q 15. An object of mass 1 kg travelling in a straight line with a velocity of 10 m s $^{-1}$ collides with, and sticks to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object .

Answer:

For calculating the velocity of the combined mass we need to use the law of conservation of momentum.

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

or $$1 \times 10 + 5 \times 0 = (1 + 5)v$$

or $$v = \frac{10}{6}$$

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or $v \ = \ 1.66 \ m/s$

Now, the momentum before the collision is :

$$p_i \ = \ m_1 u_1 \ + \ m_2 u_2$$

or $= \ 1 \times 10 \ + \ 5 \times 0 \ = \ 10 \ Kg \ m/s$

By momentum conservation, final momentum is also $10 \ Kg \ m/s$.

Q 16. An object of mass 100 kg is accelerated uniformly from a velocity of 5 m s $^{-1}$ to 8 m s $^{-1}$ in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Answer:

The momentum is given by :

$$p \ = \ mv$$

Initial momentum is : $p_i \ = \ mu \ = \ 100 \times 5 \ = \ 500 \ Kg \ m/s$

And the final momentum is :

$$p_f \ = \ mv \ = \ 100 \times 8 \ = \ 800 \ Kg \ m/s$$

Also, the force is defined as rate of change of momentum.

Thus $F \ = \ \frac{p_f \ - \ p_i}{t}$

or $= \ \frac{800 \ - \ 500}{6} \ = \ 50 \ N$

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Hence the force exerted on the body is 50 N.

Q 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 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:

Kiran's observation:- The insect experiences a greater change in its velocity as the mass of insects is much less as compared to the motorcar so it experiences a greater change in its momentum. Thus Kiran's observation is correct.

Akhtar's observation:- We know that motorcar has a larger velocity and has a bigger mass as compared to the insect. Also, the motorcar continues to move in the same direction even after the collision. This suggests that the change in momentum of a motorcar is very less, whereas the insect experiences a great change in its momentum.

Rahul's observation:- The momentum gained by the insect is equal to the momentum lost by the motorcar (law of conservation of momentum). Thus his observation is also correct.

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Q 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 :

For calculating momentum, we need the final velocity of the bell.

By equation of motion we can write :

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

or $v^2 = 0^2 + 2 \times 10 \times 0.8$

or $v = 4\ m/s$

Thus the momentum is : $p = mv$

or $= 10 \times 4 = 40\ Kg\ m/s$

NCERT solutions for class 9 science chapter 9 Force and Laws of Motion: Solved Additional Exercises

Q A1. (a) The following is the distance-time table of an object in motion:

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

Time in seconds	**Distance in metre**

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0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

Answer:

From the table, the relation between time and distance can be seen.

$$s = t^3$$

Thus the velocity of the particle is increasing with time.

$$v = \frac{ds}{dt} = 3t^2$$

and $$a = \frac{dv}{dt} = 6t$$

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Hence acceleration increases linearly with time.

Q A1. (b) The following is the distance-time table of an object in motion:

- What do you infer about the forces acting on the object?

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

Answer:

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i)Velocity is the change in distance with time. So the velocity is increasing non uniformly, so the acceleration increases with the time.

$$F = ma$$

ii) Thus the net force acting on the body is also increasing.

Q A2. Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2 m s^{-2}. With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort.)

Answer:

From the question, it is clear that two-person pushes the car with constant velocity. But when the third person pushes it has some acceleration. Thus the third person is responsible for the acceleration generated.

Force by the third person is given by :

$$F = ma$$

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

Hence the force from each man is 240 N.

Q A3. A hammer of mass 500 g, moving at 50 m s^{-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?

Answer:

Thus the force is given by :

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$$F = m\frac{v-u}{t}$$
$$= 500 \times 10^{-3}(\frac{0-50}{0.01}) = -2500N$$

or $= \ 0.5 \times (-5000) \ = \ -2500 \ N$

The negative sign implies that the force by the nail on the hammer is in the opposite direction.

Q A4. A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also, calculate the magnitude of the force required.

Answer:

The initial and final velocities are :

$u \ = \ 90 \times \frac{5}{18} \ = \ 25 \ m/s$

and $v \ = \ 18 \times \frac{5}{18} \ = \ 5 \ m/s$

Using the equation of motion we can write :

$v \ = \ u \ + \ at$

or $5 \ = \ 25 \ + \ a \times 4$

or $a \ = \ -5 \ m/s^2$

Now the force is given by :

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$F = ma$

or $= 1200 \times (-5) = -6000\ N$

And the change in momentum is : $\Delta p = m\Delta v$

or $= 1200(-20) = -24000\ Kg\ m/s$

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