# 9. Force and Newton's laws of motion

## Exercises

### 1 A. Question

Which one of the following is not correct - Action and reaction

A. act on the same body

B. is equal

C. is opposite

D. act on different bodies

### Answer

From Newton's third law, every action has an equal and opposite reaction acting on the same body. Option (A) says that action and reaction force acts on the same body which is true as to every action done on any object there is a reaction force by object. Option (B) and option (C) says that the force is equal and opposite which is also true. The force applied on any object has an equal and opposite reaction. But the option (D) says that the force and reaction forces are on different bodies which are not true. Because a reaction force is applied by the same object on which an action force is applied.

### 1 B. Question

If the forces acting on an object are balanced, then

A. the object will be accelerated

B. the object will be in motion

C. the object will be at rest

D. the object loses its shape

### Answer

In the question it is given that the forces acting on a body are balanced which signifies that the net force on the body is zero. That is there is no net force acting on the body. Option (A) says that the body will be accelerated but we know that for acceleration a net force is required. Hence this option is not right. Option (B) says that the object will be in motion which is also wrong because without a net external force there is no motion of the body at all. Option (C) states that the body will be at rest and this is the right option because if all the forces are cancelling out each other there will be no net force which will ultimately results in the stationary/rest position of the

object. Option (D) can also be true if the forces applied are enormous. But it is not specified in the question that the forces are that much huge. Hence, we will conclude that this is also not right option.

**1 C. Question**

The correct way to write the SI unit of force is

A. Newtons

B. newton

C. newtons

D. Newton

**Answer**

The concept of force is discovered by Sir Issac Newton and after him we have named the SI unit of force as Newton. Option (A) states Newtons which is wrong because Newtons represent multiple units which is not right. And option (C) and (B) are starting with small letters and we know that a name never starts with a small alphabet. Hence Option (D) is right because it is starting with a capital latter as well as it represent a single SI unit force.

**2 A. Question**

Fill in the blanks with suitable words

Inertia of an object is proportional to its _____ .

**Answer**

Inertia of an object is proportional to its mass.

Explanation: Inertia of a body is the resistive force which opposes its motion. And as we know that more the mass the resistive force will be more. Hence, from this we can conclude that inertia of any body is directly proportional to its mass.

**2 B. Question**

Fill in the blanks with suitable words

The S.I unit of momentum is _____ .

**Answer**

- The S.I unit of momentum is kilogram meter per second or $kg.ms^{-1}$.

Explanation: Momentum is a quantity which shows important information of the object. Momentum is defined as the product of the mass and the velocity of the object, i.e.

$$p = m \times v$$

Where p is momentum of the object and m, v represents mass and the velocity respectively. Hence the SI unit of mass is kg and velocity is m/s that is why the SI unit of the momentum is $kg.ms^{-1}$.

**2 C. Question**

Fill in the blanks with suitable words

To cause acceleration in an object the necessary factor is unbalanced____ .

**Answer**

To cause acceleration in an object the necessary factor is unbalanced force.

Explanation: According to Newton's second law whenever a force is applied on an object there will be change in the momentum of the object. And we know that the momentum is $\{ p = m \times v \}$ where v is velocity. Now, we know that the mass of the object is constant and if there is change in momentum that will be causing change in velocity. And change in velocity is called acceleration. Hence, if and only if an unbalanced force is applied on any object it will result in change of its momentum which will further results in changing its velocity. So to cause acceleration we must apply an unbalanced force.

**2 D. Question**

Fill in the blanks with suitable words

Newton's first law of motion is also called law of _____.

**Answer**

- Newton's first law of motion is also called law of inertia.

Explanation: According to Newton's first law: An object tends to stay in the position of rest or in constant motion until and unless acted upon by an external force. Now, inertia is a type of resistive force which always opposes any change in the position of the object. For instance if an object is in state of rest, inertia will tend to remain that object in state of rest. But if that object is moving with constant velocity, inertia will tend to remain that object in continuous motion. Hence, if we see the concept of inertia and Newton's First law they resembles too each other. That is why newton's First Law is also referred as law of Inertia.

**2 E. Question**

Fill in the blanks with suitable words

The suitcases kept in a moving bus, move forward when the brakes are applied suddenly. This is due to _____.

**Answer**

The suitcases kept in a moving bus, move forward when the brakes are applied suddenly. This is due to Inertia.

Explanation: Inertia of a body is the resistive force which opposes its motion. For instance, in this case the suitcase is moving with a velocity with the bus, but as bus stops the inertia will tend to remain that object in continuous motion. That is why the suitcase will move forward.

**3 A. Question**

Answer the following

In a tug of war game, if the two teams exert equal forces, none of the teams win. Why?

**Answer**

In the question it is given that the forces exerted by both the teams are equal which signifies that the net force on the rope is zero. That is there is no net force acting on the rope. Now the rope will be at rest because if both the forces are cancelling out each other there will be no net force which will ultimately results in the stationary/rest position of the rope. Hence, if and only if an unbalanced force is applied on the rope then it will move. And then the team which has applied more force will win. But if the forces exerted are equal none of the team will win.

**3 B. Question**

Answer the following

Which of the following has greater momentum?

a. An object of mass 2 kg moving with uniform velocity of 2 $ms^{-1}$.

b. An object of 1 kg mass moving with uniform velocity of 3 $ms^{-1}$.

**Answer**

A. An object of mass 2 kg moving with uniform velocity of 2 $ms^{-1}$.

Explanation: Momentum is defined as the product of the mass and the velocity of the object, i.e.

$$p = m \times v$$

Where p is momentum of the object and m, v represents mass and the velocity respectively.

**Case 1:** Information from the question:

Mass of the object = **2 kg**

Velocity of the object = **2 $ms^{-1}$**

Hence for momentum,

Momentum of an object = mass × velocity

= 2 × 2

= **4 kg $ms^{-1}$**

**Case 2:** Information from the question:

Mass of the object = **1 kg**

Velocity of the object =**3 $ms^{-1}$**

Hence for momentum,

Momentum of an object= mass × velocity

= 1 × 3

= **3 kg $ms^{-1}$**

Now, momentum in **Case 1** is more than in **Case 2.** Hence we can observe that momentum is quantity which depends on both mass as well as velocity of the object.

**3 C. Question**

Answer the following

Which of the following has greater inertia?

(a) 50 paise coin

(b) one rupee coin

(c) five rupee coin.

**Answer**

(c) five rupee coin.

Inertia of a body is the resistive force which opposes its motion. And we know that more the mass the resistive force will be more i.e. from this we can conclude that inertia of any body is directly proportional to its mass. Now, if we compare the masses of 50 paisa coin, one rupee coin and five rupee coin we will find out that the five rupee coin has maximum mass which suggest that the inertia of the five rupee coin will be maximum in the given three cases. So, in short the easy way to find out about inertia is to look upon the mass of the object. More the mass more will be its inertia.

**3 D. Question**

Answer the following

State any two illustrations for Newton’s third law of motion.

**Answer**

According to Newton’s Third Law of Motion:

Every action done on an object has an equal and opposite reaction on the body.

Two Important things to note:

1. The reaction will be equal and opposite.

2. Both action and reaction are applied on the same object.

Two illustrations for this law are:

1. One of the major illustrations is in rocket science, as the rocket moves in the space by following the Newton's third law. Actually, when rocket moves in the space it pushes the gas outside from it, i.e., rocket applies force on the gases in the backward direction. As a reaction, the gases put equal amount of force on the rocket in the opposite direction and the rocket moves in the forward direction. That is away from the Earth.

2. Take an example of a person who slams the wall with his fist. The force applied by the person through his fist on the wall is equal to the force applied by the wall on the fist. Harder the person slams the wall, more he gets hurt. Similar procedure is followed when a person kicks the football.

In both these illustration we have observed that there is a reaction force in first case it was by the gases and in the second case it was by the wall. Hence these are some classic illustrations of the Newton’s Third Law.

**3 E. Question**

Answer the following

Distinguish between balanced and unbalanced forces.

**Answer**

| Balanced Force | Unbalanced Force |
|---|---|
| Balanced forces are resultant force which happens when all the forces acting on an object cancel out each other. | Unbalanced forces are resultant force which happens when all the force acting on an object does not cancel out each other. |
| This type of forces does not produce any type of motion in the object however they can produce some type of distortion of the object. | This type of forces generally results in the motion of the object. |
| For balanced force the forces are in opposite direction and the net external force in this is 0. | For unbalanced force the forces are generally not in opposite direction and the net external force in this case is not zero. |
| Example: In the tug of war game if both the team applies equal and opposite forces the resultant force will be balanced force and there will be no motion produce. | Example: In the tug of war game if team A applies more force than team B then the resultant force will be unbalanced force and the rope will move towards team A. |

**3 F. Question**

Answer the following

State Newton's second law of motion, in terms of momentum.

**Answer**

According to Newton's Second law:

Whenever a force is applied on an object there will be change in the momentum of the object.

OR

The rate of change of momentum is directly proportional to the force applied.

From these two statements we should conclude that the change in momentum is only possible by applying a force or a force applied always change the momentum of the object. As we know that the momentum is { $p = m \times v$ } where v is velocity. Now, we know that the mass of the object is constant and if there is change in momentum that will be causing change in velocity. And change in velocity is called acceleration. Hence, if and only if an unbalanced force is applied on any object it will result in change of its momentum which will further results in changing its velocity. So to cause acceleration we must apply an unbalanced force.

**4 A. Question**

Give reasons for the following

It is dangerous to get down from a moving bus even if the bus is moving slowly.

**Answer**

Yes, it is very dangerous to get down from a moving bus, because of the inertia of the body. Let us suppose that there is a man who is trying to get down from a moving bus. The concept here is that when the bus is moving, man is also moving with it. And man has inertia of motion that is his body will try to be in state of motion. But if he gets down suddenly his body will stop. And as a result he will get hurt after falling down.

In short when the bus is moving, man has inertia of motion but if he gets down that inertia will try to keep him in motion, which will eventually results into injury of the man.

**4 B. Question**

Give reasons for the following

An athlete in long jump runs a distance before taking the leap.

**Answer**

This is an application case of Newton's Second Law. It is very intelligent act to take a long run before the jump. The key concept here is of momentum. As we know that momentum depends on the mass and velocity of the object. The athlete tries to acquire momentum as high as possible by taking a long run, by doing so he increasing his velocity which ultimately results into increment of momentum.

And momentum plays a very crucial role in long jump, as you must observe that momentum is directly proportional to the length of jump, more the momentum more the length of jump.

Hence, that is why athlete takes long run before the jump.

**4 C. Question**

Give reasons for the following

Usually a fielder in a cricket match moves his hands in the direction of motion of cricket ball, after taking the catch.

**Answer**

This is an application case of Newton's Second Law. You see that when a batsman hits a ball with his bat, he applies great force on the ball. And from the second law we know that force is directly proportional to the change in momentum. This implies that when batsman hits the ball, he actually increases the momentum of the ball.

If you think of something coming towards you with such great momentum you will not dare to stop it. But it is the job of fielder so as he stops the ball,

he actually decreases the momentum of the ball. And by doing so a great force is applied on his hand which can cause injury to his hands. The solution to this problem is as the fielder catches the ball he does not decrease the momentum suddenly he moves his hand in the direction of motion of cricket ball. In doing so he decreases the momentum slowly, and this will not apply that much force and will not hurt his hands.

**5 A. Question**

Solve the Problems

Calculate the force required to change the velocity of an object of mass 8 kg from 4 $ms^{-1}$ to 6 $ms^{-1}$ in 2 second.

**Answer**

Information from the question:

Mass of the object = 8 kg.

Initial velocity of the object = 4 $ms^{-1}$.

Final velocity of the object = 6 $ms^{-1}$.

Time taken to change the velocity = 2 seconds.

As we know from Newton's second law that,

$$F = m \times a$$

Where F is the force require to produce acceleration of 'a' on a body of mass 'm'.

Hence we require acceleration to calculate how much force is required and acceleration is change in velocity in per unit time. So for acceleration,

$$a = \frac{v - u}{t}$$

Where v is final velocity, u is initial velocity and t is time taken by the object.

So, this implies acceleration $a = \frac{6-4}{2}$

$$= 1\ m/s^2$$

Force required for producing acceleration,

$$force = mass \times acceleration$$

$$= 8 \times 1$$

$$= 8\ Newton$$

**5 B. Question**

Solve the Problems

A force of 25 Newton is applied on an object of mass 10 kg moving with a velocity of 5 $ms^{-1}$. If the object gains a velocity of 10 $ms^{-1}$, calculate the time taken.

**Answer**

Information from the question:

Mass of the object = 10 kg.

Initial velocity of the object = 5 $ms^{-1}$.

Final velocity of the object = 10 $ms^{-1}$.

Force used to change the velocity = 25 Newton.

As we know from Newton's second law that,

$$F = m \times a$$

Where F is the force require to produce acceleration of 'a' on a body of mass 'm'.

So, this implies acceleration $a = \frac{F}{m}$

$$= \frac{25}{10}$$

$$= 2.5\ m/s^2$$

Hence from acceleration we will calculate time taken. As acceleration is change in velocity in per unit time. So for acceleration,

$$a = \frac{v - u}{t}$$

Where v is final velocity, u is initial velocity and t is time taken by the object.

Time taken by object for producing acceleration,

$$\text{time taken} = \frac{\text{Final velocity} - \text{Initia;l velocity}}{\text{acceleration of the object}}$$

$$= \frac{10 - 5}{2.5}$$

$$= \frac{5}{2.5}$$

**= 2 seconds.**