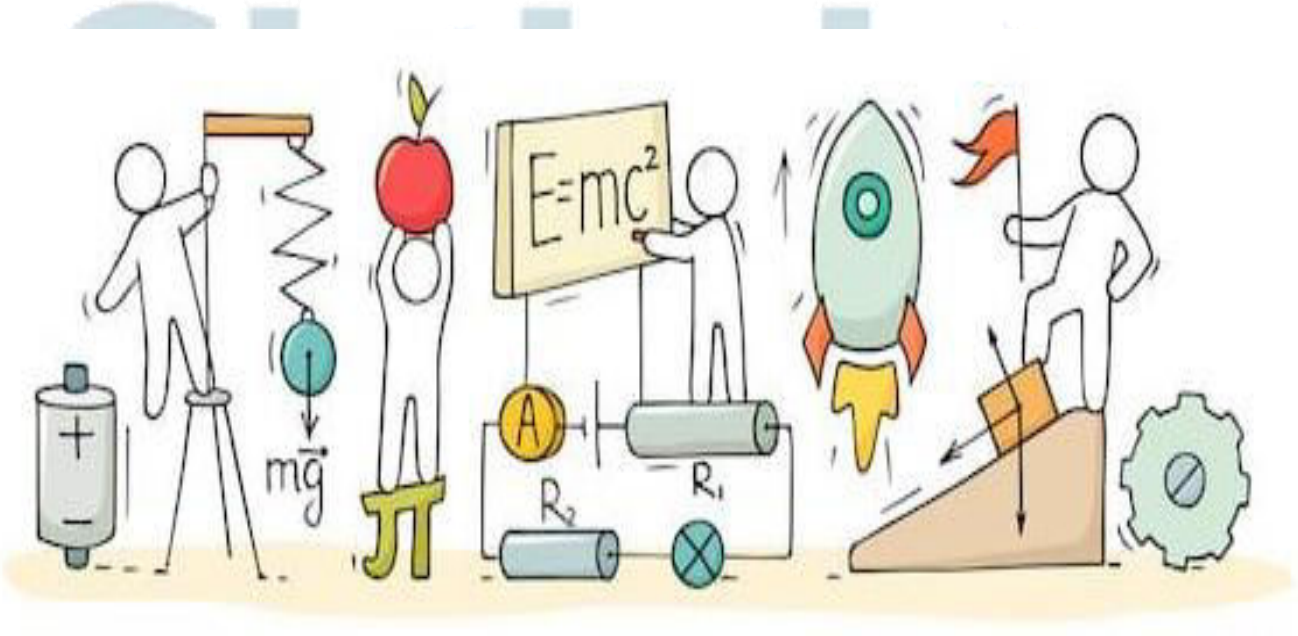
Shiksha CLASSES

PHYSICS

Chapter 8: Force and Laws of Motion



Force and Laws of Motion

- While studying kinematics, we have already studied about the position, distance and displacement, and acceleration of a moving particle.
- Here in this chapter, we would take our understanding one step further to learn about origins of acceleration or force.
- Here we will specifically consider the cause behind the moving objects i.e. what causes the objects to move.
- Thus, we will learn the theory of motion based on the ideas of mass and force and the laws connecting these physical concepts to the kinematics quantities.
- Concept of force is central to all of physics whether it is classical physics, nuclear physics, quantum physics or any other form of physics
- So, what is force? When we push or pull anybody, we are said to exert force on the body
- Push or pull applied on a body does not exactly define the force in general. We can define force as an influence causing a body at rest or moving with constant velocity to undergo acceleration
- There are many ways in which one body can exert force on another body. Few examples are given below

  (a) Stretched springs exerts force on the bodies attached to its ends

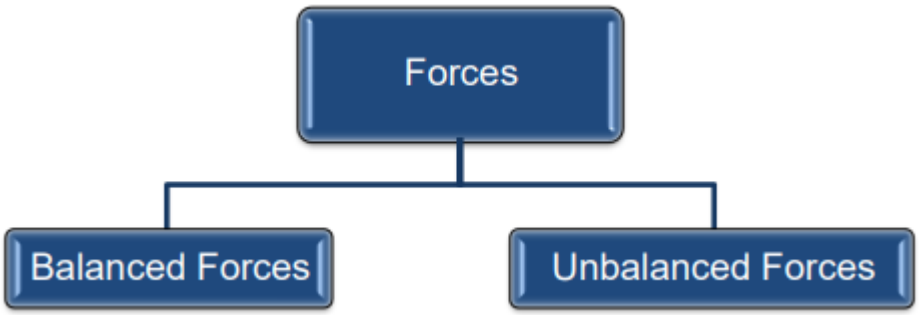
  (b) Compressed air in a container exerts force on the walls of the container

  (c) Force can be used to deform a flexible object
- Force of gravitational attraction exerted by earth is a kind of force that acts on every physical body on the earth and is called the weight of the body

Force

- Force is used in our everyday actions such as pushing, pulling, twisting, lifting, pressing and stretching.
- A force can produce the following **effects**:
  - ✓ **Move** a body at rest.
  - ✓ **Stop** a moving body.
  - ✓ **Change the speed** of a moving body.
  - ✓ **Change the direction** of a moving body.
  - ✓ **Change the shape and size** of a body.

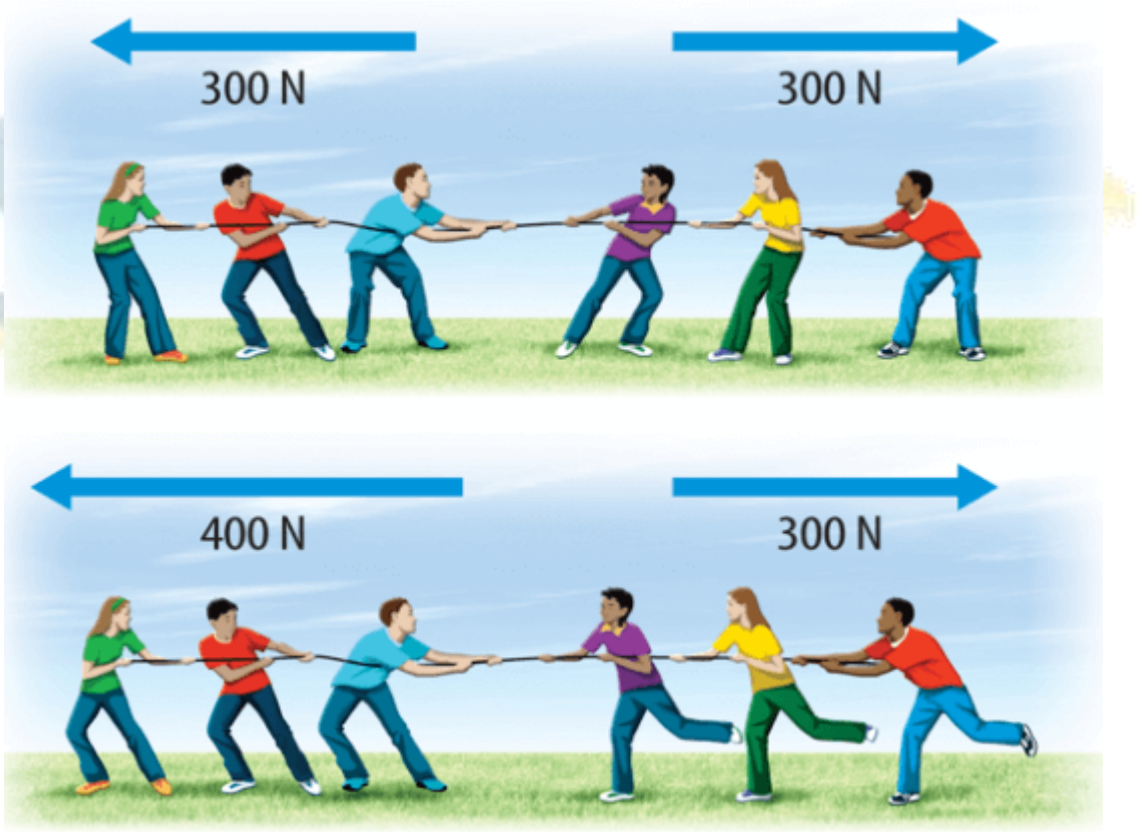
Balanced and Unbalanced Forces



Balanced and Unbalanced Forces

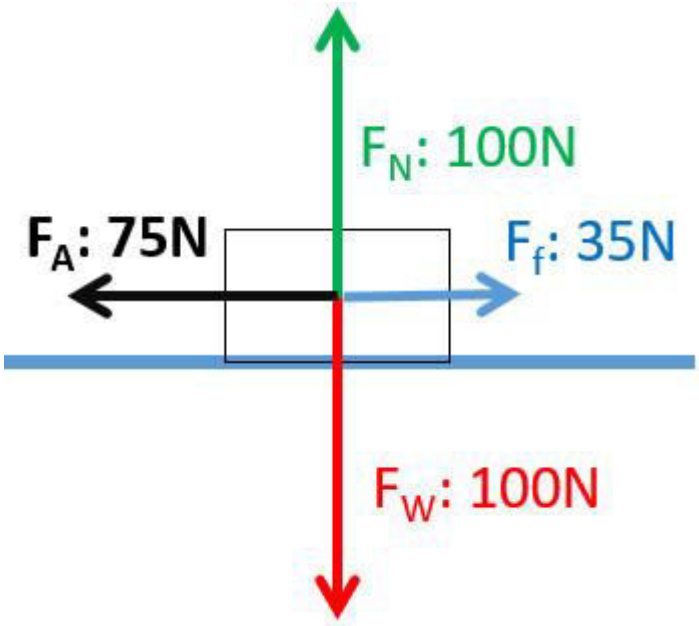
When balanced forces are applied to an object, there will be no net effective force acting on the object. Balanced forces do not cause a change in motion.

Unbalanced forces acting on an object change its speed and/or direction of motion. It moves in the direction of the force with the highest magnitude.



Net force

When multiple forces act on a body, they can be resolved into one component known as the net force acting on the object. For Example:



Balanced Forces

- If the resultant of all forces acting on a body is zero then the forces are called balanced forces.
- To understand this concept consider an object rests on a surface such as a block on the table as shown below in the figure 1. Weight of the block is balanced by the reaction force from the table. The table pushes up against the block.

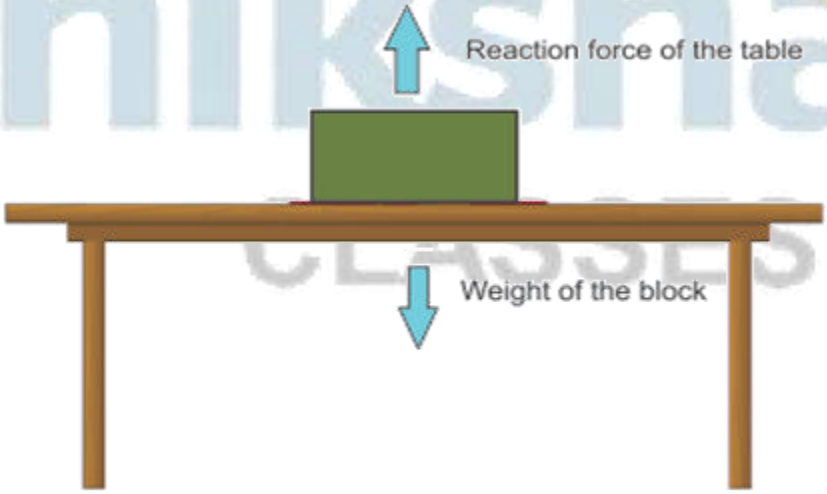


Figure 1. Balanced forces acting on the block

So the weight of a block lying on a table is balanced by the reaction force from the table top

- If the forces on an object are balanced (or if there are no forces acting on it) than the object that is not moving stays still and the object that is moving continues to move at the same speed and in the same direction.
- Although balanced forces cannot produce motion in a stationary body or stop a moving body but they can however change the shape of the body.

Unbalanced Forces

- If the resultant forces acting on a body is not zero the forces are called unbalanced forces.

- To understand this consider the figure 2 which shows a block on a horizontal table and two

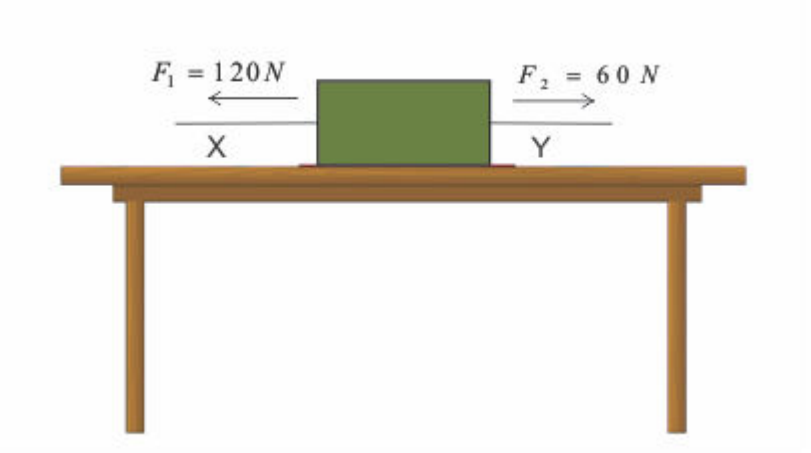


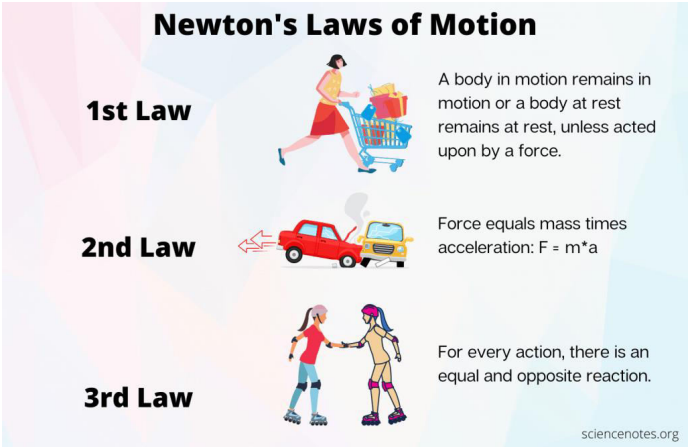
Figure 2. Unbalanced forces acting on the block

strings X and Y are tied to the two opposite faces of the block.

Let us now pull the block using this string in two different directions such that two opposite forces of different magnitudes acts on the block.

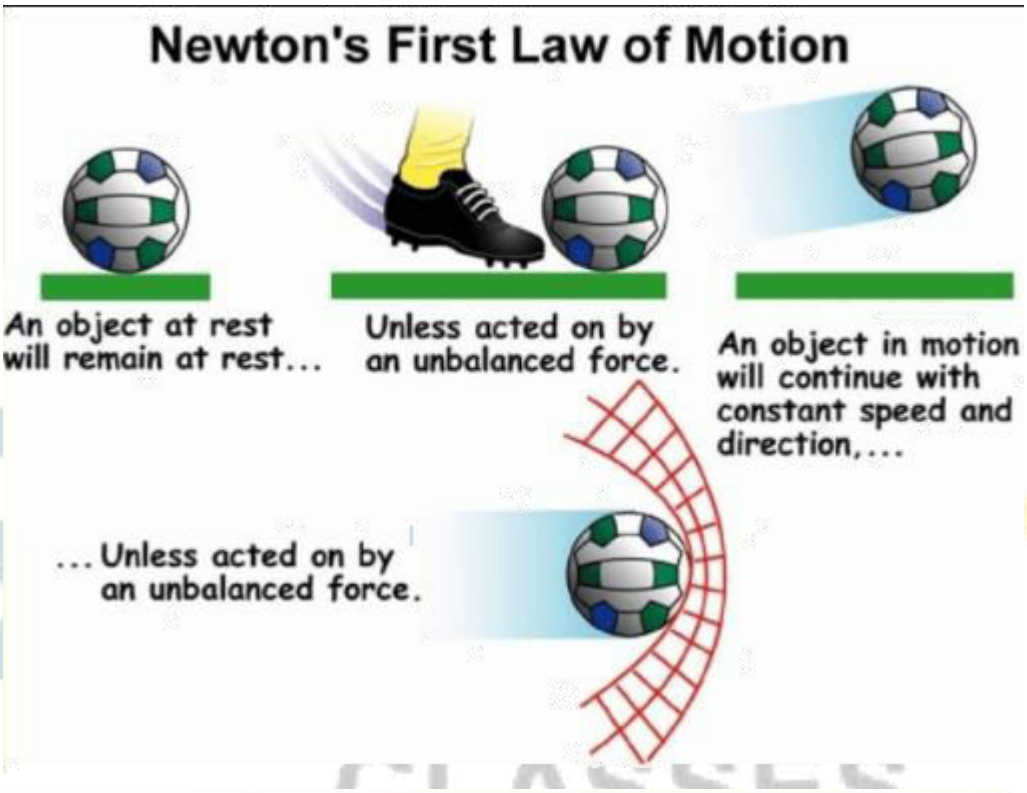
- Since two forces acting on the block are of different magnitude the block would begin to move in the direction of the greater force.
- Thus, the two forces acting on the block are not balanced and the unbalanced force acts in the direction the block moves.
- So unbalanced forces can move a stationary body and they can stop a moving body.
- The size of the overall force acting on an object is called the resultant force. If the forces are balanced, this is zero. In the example above, the resultant force is the difference between the two forces F_1 and F_2, which is 120 - 60 = 60 N.
- If all the forces acting on a body result in an unbalanced force, then the unbalanced force can accelerate the body. It means that a net force or resulting force acting on a body can either change the magnitude of its velocity or change the direction of its velocity.
- The force that opposes the relative motion between the surfaces of two objects in contact and acts along the surfaces in contact is called the force of friction or simply friction.

Laws of motion



- Newton gave three laws of motion that describe the motion of bodies. These laws are known as Newton's Laws of motion.
- They describe the relationship between the forces acting on a body and its motion due to those forces.
- The three laws of motion were first compiled by Sir Isaac Newton in his work Principia Mathematica, first published in 1687. Newton used these laws to explain and investigate the motion of many physical objects and systems.
- We shall now learn about Newton's First law of motion

Newton's First Law of Motion



A body continues to be in a state of rest or in a state of uniform motion along a straight line unless acted upon by an external unbalanced force.

The first law of motion is stated as:

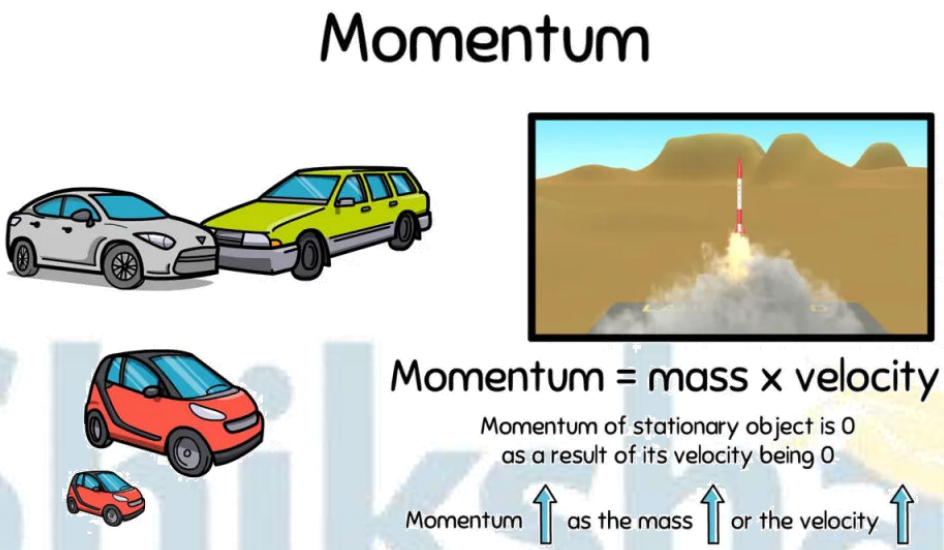
- An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.
- All objects resist a change in their state of motion. The tendency of undisturbed objects whether they are at rest or moving with uniform velocity is called inertia. Hence, the first law of motion is also known as the law of inertia.
- Greater the inertia of the body greater will be the force required to bring the change in the state of rest or uniform motion of the body.
- Mass is the measure of the inertia of the body so heavier objects have more inertia

than lighter objects. For example, a ball of 2Kg has more inertia then a football and it takes more effort to kick a 2Kg ball then it takes to kick a football.

- Another example is even a small child can push a toy car. However, An adult also can't push a loaded vehicle forward.
- Newton's first law of motion gives us a definition of force. It says that

  Force is something that changes or tends to change the state of rest or uniform motion of a body

Momentum



- Before discussing about second law of motion we shall first learn about momentum of a moving object.
- From our daily life experiences like during the game of table tennis if the ball hits a player, it does not hurt him. On the other hand, when a fast-moving cricket ball hits a spectator, it may hurt him.
- This suggests that impact produced by moving objects depends on both their mass and velocity.
- So, there appears to exist some quantity of importance that combines the object's mass and its velocity called momentum and was introduced by Newton.
- Momentum can be defined as "mass in motion". All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion.
- The momentum, p of an object is defined as the product of its mass, m and velocity, v. That is,

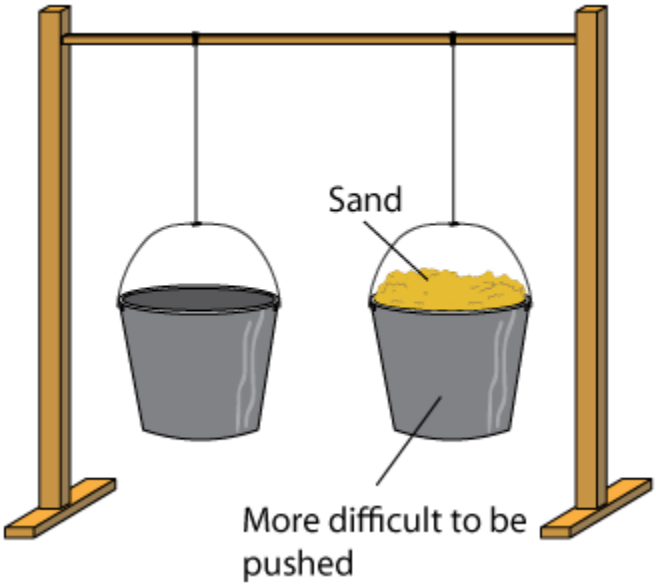
  momentum $p=mv$ (1)
- Momentum has both direction and magnitude, so it is a vector quantity. Its direction is the same as that of velocity, v.

- The SI unit of momentum is kilogram-meter per second (kg m s^{-1}).
- Since the application of an unbalanced force brings a change in the velocity of the object, it is therefore clear that a force also produces a change of momentum.
- We define the momentum at the start of the time interval is the initial momentum and at the end of the time interval is the final momentum.
- When the object moves then it gains momentum as the velocity increases. Hence greater the velocity greater is the momentum.

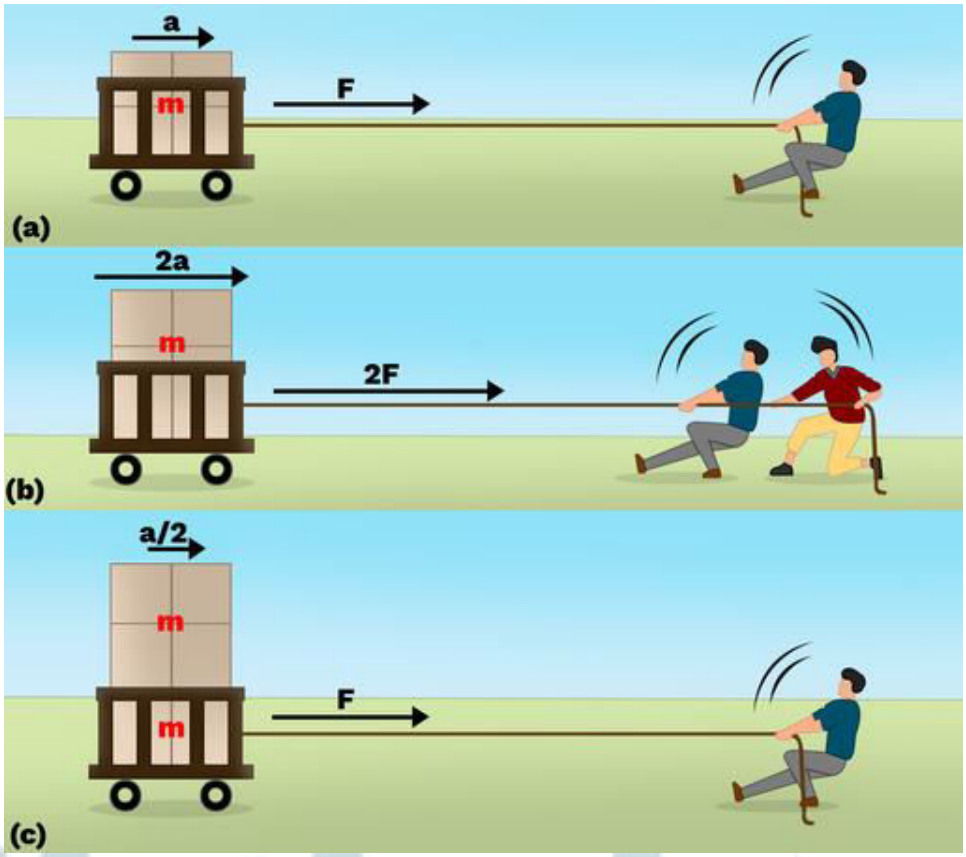
Inertia

Basically, all objects have a tendency to resist the change in the state of motion or rest. This tendency is called inertia. All bodies do not have the same inertia. Inertia depends on the mass of a body. Mass of an object is the measure of its inertia.

More the mass → more inertia and vice versa.



Newton's Second Law of Motion



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

- If a body of mass 'm' moving with an initial velocity 'u' is accelerated to a velocity 'v' by the application of a constant force 'F' in time 't', then according to Newton's second law of motion

$$\text{Force} \propto \frac{\text{Change of momentum}}{\text{Time taken}}$$

If mu is the initial momentum and mv is the final momentum:

Change in momentum =

$$\text{or, } F \propto \frac{mv - mu}{t}$$

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

$$\left[\text{we know that } \left(\frac{v-u}{t}\right) = a\right]$$

$$\text{or, } F \propto m \times a$$

$$F = kma$$

In SI units, k = 1

$$\therefore F = ma$$

mv

The force 'F' is applied for time 't' so that the final velocity of the body becomes 'v'.

- **Force** acting on a body is the **product of mass of the body and its acceleration**. i.e., **F = ma**
- The SI unit of force is kg m s^{-2}. This is also known as Newton and represented by the symbol N. A force of one Newton produces an acceleration of 1 ms^{-2} in a body of mass 1 kg.

  1 Newton = 1 kg × 1 m/s^2

Concept of system

The part of the universe chosen for analysis is called a system.

Everything outside the system is called an environment.

For example, a car moving with constant velocity can be considered a system. All the forces within the car are internal forces and all forces acting on the car from the environment are external forces like friction.

Conservation of momentum

The total momentum of an isolated system is conserved.

Isolated system → net external force on the system is zero.

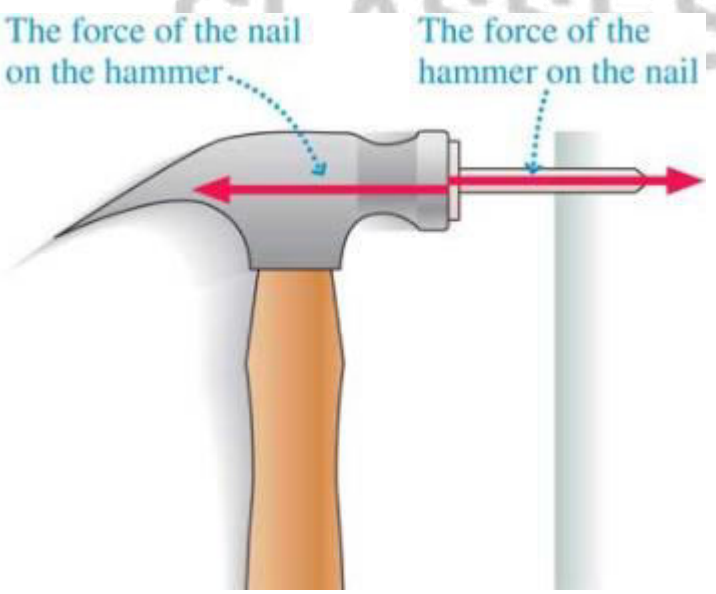
Example: Collision of 2 balls A and B.

From Newtons 3rd law F_{AB} = -F_{BA}

$\Rightarrow m_A \frac{V_a - U_a}{t} = m_B \frac{V_b - U_b}{t}$

$\Rightarrow m_A U_A + m_B U_B = m_A V_A + m_B V_B$

Newton's Third Law of Motion



Newton's Third Law of Motion

For every action force, there is a reaction force equal in strength and opposite in direction.

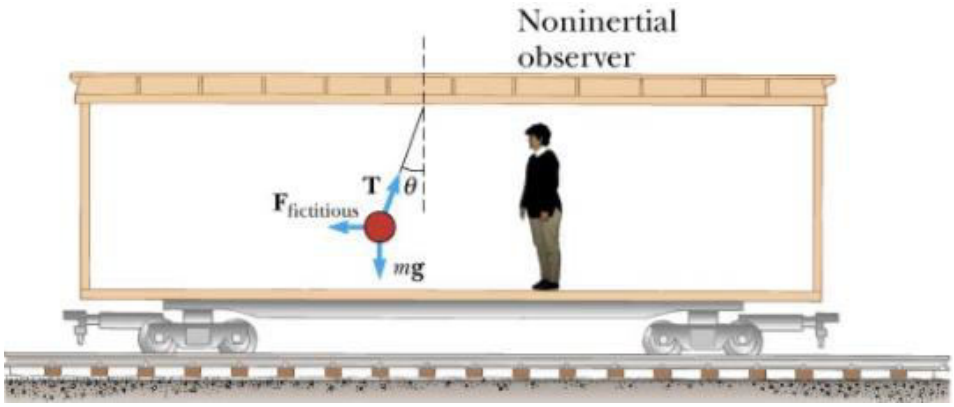
To every action, there is an equal and opposite reaction.

- The action and reaction forces act on two different bodies and never cancel each other.
- Although the action and reaction forces are always equal in magnitude, the forces may not produce acceleration of equal magnitude because they act on different bodies which may have different masses.

Inertial and Non-inertial frames

A non-inertial frame of reference is a frame of reference in which Newton's laws of motion do not hold. A non-inertial reference frame is a frame of reference that is undergoing acceleration with respect to an inertial frame. An accelerometer at rest in a non-inertial frame will, in general, detect a non-zero acceleration.

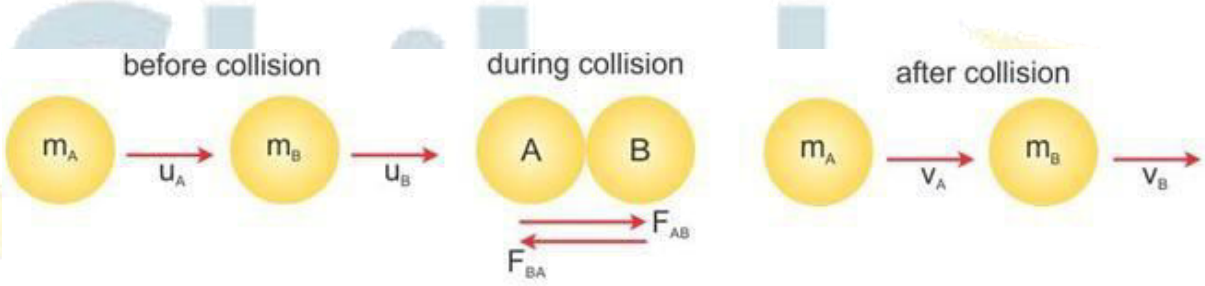
A frame of reference where Newton's Laws hold is known as an inertial frame of reference.



Law of Conservation of Momentum

According to the law of conservation of momentum, **the sum of momenta of two objects before collision is equal to the sum of momenta after collision**, provided there is no external unbalanced force acting on the objects.

Total momentum before collision = Total momentum after collision



i.e.

$m_A u_A + m_B u_B = m_A u_A + m_B v_B$

where m_A and m_B are masses of the bodies u_1 and u_2 are initial velocities of the bodies v_1 and v_2 are final velocities of the bodies

- All applications of Newton's third law of motion can be explained in terms of the law of conservation of momentum.
- When a bullet is fired from a gun, the gun moves backwards. The **recoil velocity** v_2 of the gun $v_2 = -\frac{m_1 v_1}{m_2}$ where v_1 is the velocity of the bullet of mass m_1 and m_2 is the mass of the gun.

Class : 9th Science
Chapter- 9 : Force And Laws Of Motion

Force And Laws Of Motion

Newton's Law of Motion

1st Law
The tendency of undisturbed objects to stay at rest or keep moving with the same velocity until unless, nonzero external force acting on it

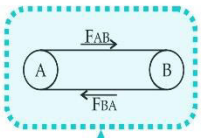
Lesser mass has lessor inertia

2nd Law
With rate of change of momentum with respect to time is equal to a non-zero external force acting on object.

$$\frac{\Delta p}{\Delta t} = \bar{f} = m\bar{a}$$

3rd Law
Every action has an equal and opposite reaction

$\vec{F}_{AB} = \vec{F}_{BA}$ or, $\vec{F}_{AB} + \vec{F}_{BA} = \vec{0}$



Reference equation

Kinemetic Equation of Motion

1. $u = u \pm at$
2. $s = ut \pm \frac{1}{2} at^2$
3. $u2 = u^2 \pm 2as$

In case of gravity replace "a' by "g" and 's' by 'h' in above equation

Units and Dimensions

- Mass ⊾ (kg) [M]
- Weight ⊾ $W = m \times g$ = kg m/s^2 [MLT^{-2}]
- Momentum ⊾ $\vec{p} = m \times \vec{v}$ = kg m/s [MLT^{-1}]

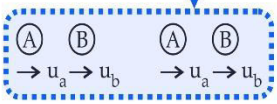
Force is a push or pull acting on a body

Types of force
- Muscular Force
- Magnetic Force
- Gravitational Force
- Electrostatic Force
- Frictional Force→

(Always opposes the motion of objects)

Law of conservation of momentum

Momentum before collision is equal to momentum after



Total momentum before the collision = Total momentum after the collision

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

Important Questions

➢ Multiple Choice Questions:

1. Which of the following statements 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 goalkeeper to

(a) exert larger force on the ball

(b) reduce the force exerted by the balls on the 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 ms-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 23 of its height is moving with a uniform speed. On a sudden application of brakes, the water in the tank would

(a) move backward

(b) move forward

(c) be unaffected

(d) rise upwards

9. If the mass of a body is doubled and its velocity becomes half, then the linear momentum of the body will

(a) remain same

(b) become double

(c) become half

(d) become four times.

10. When a number of forces acting simultaneously on a body bring about a change in its state of rest or of uniform motion in a straight line, then these forces acting on the body are said to be

(a) balanced forces

(b) equal forces

(c) unbalanced forces

(d) opposite forces

11. When a car at high speed makes a sharp turn, the driver in a car tends to get thrown to the side opposite to the turn. This is due to the

(a) inertia of motion

(b) inertia of time

(c) inertia of rest

(d) inertia of direction

12. A man is standing on a boat in still water. If he walks towards the shore, then the boat will

(a) move away from the shore

(b) move towards the shore

(c) remain stationary

(d) none of these

13. Which of the following is an incorrect statement?

(a) Mass is measure of inertia of a body.

(b) Newton's first law of motion is the law of inertia.

(c) Unbalanced force produces constant velocity.

(d) Newton's third law talks about the direction of the force.

14. A ball is thrown vertically upward in a train moving with uniform velocity. The ball will

(a) fall behind the thrower

(b) fall ahead of the thrower

(c) return back to the thrower

(d) fall on the left of the thrower

15. Which of the following is not an application of conservation of linear momentum?

(a) While firing a bullet, the gun must be held tight to the shoulder

(b) When a man jumps from a boat to the shore

(c) A rocket explodes on midway from the ground

(d) A body suspended from the hook of a spring balanced in a lift which is accelerated downward

➢ Very Short Question:

1. Define force.

2. What is S.I. unit of force?

3. Define one Newton.

4. What is balanced force?

5. What is frictional force?

6. What is inertia?

7. State Newton's first law of motion.

8. State Newton's second law of motion.

9. What is momentum?

10. State Newton's III law of motion.

➢ Short Questions:

1. State the difference in balanced and unbalanced force.

2. What change will force bring in a body?

3. When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side. Explain why?

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

5. Why do fielders pull their hand gradually with the moving ball while holding a catch?

6. In a high jump athletic event, why are athletes made to fall either on a cushioned bed or on a sand bed?

7. How does a karate player breaks a slab of ice with a single blow?

8. What is law of conservation of momentum?

➢ Long Questions:

1. Explain Newton's second law of motion and with the-help of an example show how it is used in sports.

2. State all 3 Newton's law of motion. Explain inertia and momentum.

3. Define force. Give its unit and define it. What are different types of forces?

➢ Assertion Reason Questions:

1. For two statements are given- one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

   a. Both Assertion and Reason are correct, and reason is the correct explanation for assertion.

   b. Both Assertion and Reason are correct, and Reason is not the correct explanation for Assertion.

   c. Assertion is true but Reason is false.

   d. Both Assertion and Reason are false.

   Assertion: If the net external force on the body is zero, then its acceleration is zero.

   Reason: Acceleration does not depend on force.

2. For two statements are given- one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

   a. Both Assertion and Reason are correct, and reason is the correct explanation for assertion.

   b. Both Assertion and Reason are correct, and Reason is not the correct explanation for Assertion.

   c. Assertion is true but Reason is false.

   d. Both Assertion and Reason are false.

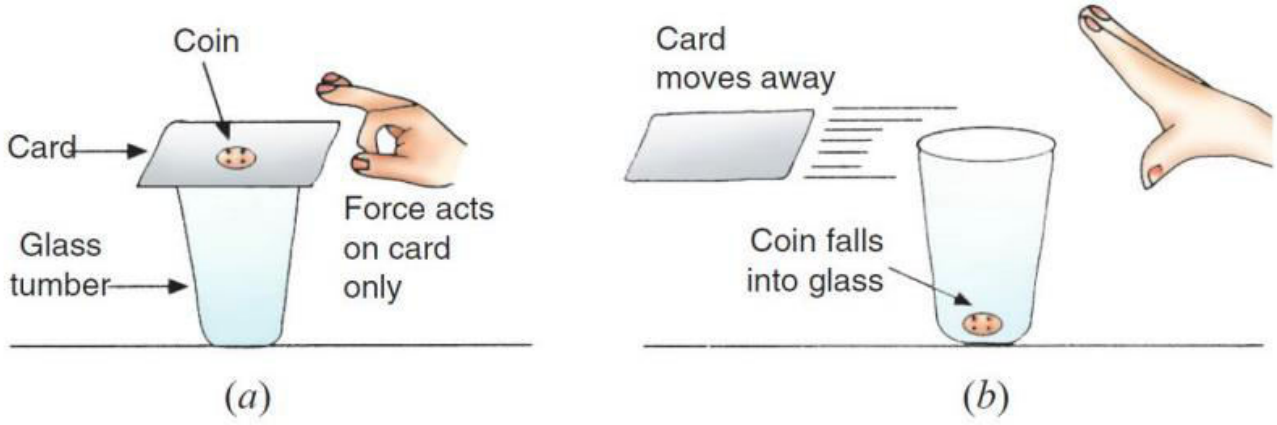
   Assertion: A rocket works on the principle of conservation of linear momentum.

   Reason: For two bodies system when there is a change in momentum of one body, the same change occurs in the momentum of the second body but in the opposite direction.

➢ Case Study Question:

1. Read the following and answer any four questions from (i) to (v)

   We take a glass tumbler and place a thick square card on its mouth as shown in Figure (a). A coin is then placed above this card in the middle. Let us flick the card hard with our fingers. On flicking, the card moves away but the coin drops into the glass tumbler [see Figure (b)].



   (i) Give reason for the above observation.

   (a) The coin possesses inertia of rest, it resists the change and hence falls in the glass.

   (b) The coin possesses inertia of motion; it resists the change and hence falls in the glass.

   (c) The coin possesses inertia of rest, it accepts the change and hence falls in the glass.

   (d) The coin possesses inertia of rest, it accepts the change and hence falls in the glass.

   (ii) Name the law involved in this case.

(a) Newton's second law of motion.

(b) Newton's first law of motion.

(c) Newton's third law of motion.

(d) Law of conservation of energy

(iii) If the above coin is replaced by a heavy five rupee coin, what will be your observation. Give reason.

(a) Heavy coin will possess more inertia so it will not fall in tumbler.

(b) Heavy coin will possess less inertia so it will fall in tumbler.

(c) Heavy coin will possess more inertia so it will fall in tumbler.

(d) Heavy coin will possess less inertia so it will not fall in tumbler.

(iv) Name the law which provides the definition of force.

(a) Law of conservation of mass

(b) Newton's third law.

(c) Newton's first law

(d) Newton's second law.

(v) State Newton's first law of motion.

(a) Energy can neither be created nor be destroyed, it can be converted from one form to another, total amount of energy always remains constant.

(b) A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless it is acted upon by an external unbalanced force.

(c) For every action in nature there is an equal and opposite reaction.

(d) The acceleration in an object is directly related to the net force and inversely related to its mass.

2. Read the following and answer any four questions from (i) to (v)

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.

(i) Whose suggestion is correct?

(a) Akhtar's suggestion is incorrect as momentum is never conserved

(b) Kiran's suggestion is incorrect as momentum is always conserved

(c) Rahul's suggestion is incorrect as momentum is never conserved

(d) All of them have given correct suggestion.

(ii) Define momentum.

(a) Momentum is the product of mass and displacement.

(b) Momentum is the product of mass and distance.

(c) Momentum is the product of mass and velocity.

(d) Momentum is the product of mass and acceleration.

(iii) What is the SI unit of momentum?

(a) SI unit of momentum is kg

(b) SI unit of momentum is kg/s.

(c) SI u nit of momentum is kg. m/s.

(d) SI u nit of momentum is m/s.

(iv) Find the momentum of a man of mass 75 kg when he walks with a velocity of 2 m/s.

(a) P = 75 kgm/s

(b) P = 15 kgm

(c) P = 37.5 kgm/s

(d) P =150 kgm/s

(v) What is velocity?

(a) Distance travelled in given time.

(b) Rate of change of momentum.

(c) Rate of displacement.

(d) Shortest distance travelled.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (d) A force is always acting on it
2. (b) always act on different bodies in opposite directions
3. (d) decrease the rate of change of momentum
4. (c) to resist any change in its state of motion
5. (a) accelerated
6. (b) 0 N
7. (c) momentum
8. (b) move forward
9. (a) remain same
10. (d) opposite forces
11. (a) inertia of motion
12. (a) move away from the shore
13. (c) Unbalanced force produces constant velocity.
14. (c) return back to the thrower
15. (c) A rocket explodes on midway from the ground

➢ Very Short Answers:

1. Answer: It is a push or pull on an object that produces acceleration in the body on which it acts.
2. Answer: S.I. unit of force is Newton.
3. Answer: A force of one Newton produces an acceleration of 1 m/s2 on an object of mass 1 kg.

   1 N = 1 kg m/s^2
4. Answer: When forces acting on a body from the opposite direction do not change the state of rest or of motion of an object, such forces are called balanced forces.
5. Answer: The force that always opposes the motion of object is called force of friction.
6. Answer: The natural tendency of an object to resist a change in their state of rest or of uniform motion is called inertia.
7. Answer: An object remains in a state of rest or of uniform motion in a straight line unless acted upon by an external unbalanced force.
8. Answer: The rate of change of momentum of an object is proportional to the applied

unbalanced force in the direction of the force.

9. Answer: The momentum of an object is the product of its mass and velocity and has the same direction as that of the velocity. The S. I. unit is kg m/s. (p = mv)
10. Answer: To every action, there is an equal and opposite reaction and they act on two different bodies.

➢ Short Answers:

1. Answer:

Balanced Force	Unbalanced Forces
The forces exerted on the object are equal in magnitude and opposite in direction	Forces applied on the object are unequal in magnitude
Net force is zero	Net force is not zero
Body will be at rest	Unbalanced forces makes the body move
It does not change the state of rest or of motion of an object.	It changes the state of rest or motion of an object

2. Answer: Force can bring following changes in the body:
   - It can change the speed of a body.
   - It can change the direction of motion of a body,
   - It can change the shape of the body.
3. Answer: It is due to law of inertia. When we are sitting in car moving in straight line, we tend to continue in our straight-line motion. But when an unbalanced force is applied by the engine to change the direction of motion of the motorcar. We slip to one side of the seat due to the inertia of our body.
4. Answer: While moving in a bus our body is in motion. On jumping out of a moving bus our feet touches the ground and come to rest. While the upper part of our body stays in motion and moves forward due to inertia of motion and hence we can fall in forward direction.

   Hence, to avoid this we need to run forward in the direction of bus.
5. Answer: While catching a. fast moving cricket ball, a fielder on the ground gradually pulls his hands backwards with the moving ball. This is done so that the fielder increases the time during which the high velocity of the moving ball decreases to zero. Thus, the acceleration of the ball is decreased and therefore the impact of catching the fast moving ball is reduced.
6. Answer: In a high jump athletic event, athletes are made to fall either on a cushioned bed or on a sand bed so as to increase the time of the athlete's fall to stop after making the jump. This decreases the rate of change of momentum and hence the force.

7. Answer: A karate player applied the blow with large velocity in a very short interval of time on the ice slab which therefore exerts large amount of force on it and suddenly breaks the ice slab.

8. Answer: Momentum of two bodies before collision is equal to the momentum after collision.

   In an isolated system, the total momentum remain conserved.

➢ Long Answers:

1. Answer: Newton's second law of motion: The rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force.

   Let us assume:

   Object of mass m, is moving along a straight line with an initial velocity 'u', It is uniformly accelerated to velocity v in time 't by the application of force,

F throughout the time 't'.

Initial momentum of the object $= \rho_1 = mu$

Final momentum of the object $= \rho_2 = mv$

The change in momentum $\propto \rho_2 - \rho_1$

$\propto mv - mu$

$= m(v - u)$

$$\text{The rate of change of momentum} \propto \frac{m(v-u)}{t}$$

$$\therefore \text{Applied force } F \propto \frac{m(v-u)}{t}$$

$$F = \frac{km(v-u)}{t}$$

$$\therefore \quad F = kma \qquad \therefore a = \frac{v-u}{t}$$

k = constant of proportionality

F = kg m/s^2 = Newton

Use of second law of motion in sports:

In cricket field, the fielder gradually pulls his hands backward while catching a ball. The fielder catches the ball and gives swing to his hand to increase the time during which the high velocity of the moving ball decreases to zero.

The acceleration of the ball is decreased and therefore the impact of catching the fast

moving ball4s reduced.

If not done so, then the fast moving ball will exert large force and may hurt the fielder.

2. Answer: Newton's I law of motion: An object remains in a state of rest or of uniform motion in a straight line unless acted upon by an external unbalanced force.

   Newton's II law of motion: The rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the-force.

   Newton's III law of motion: To every action, there is an equal and opposite reaction and they act on two different bodies.

   Inertia: The natural tendency of an object to resist a change in their state of rest or of uniform motion is called inertia.

   Momentum: The momentum of an object is the product of its mass and velocity and has the same direction as that of the velocity. Its S.I. unit is kgm/s. p = m x v

3. Answer: Force: It is a push or pull on an object that produces acceleration in the body on which it acts.

   A force can do 3 things on a body

   (a) It can change the speed of a body.

   (b) It can change the direction of motion of a body.

   (c) It can change the shape of the body.

   The S.I. unit of force is Newton.

   Newton: A force of one Newton produces an acceleration of 1 m/s2 on an object of mass 1 kg.

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

   Types of forces:

   - Balanced force: When the forces acting on a body from the opposite direction do not change the state of rest or of motion of an object, such forces are called balanced forces.
   - Unbalanced force: When two opposite forces acting on a body move a body in the direction of the greater force or change the state of rest, such forces are called as unbalanced force.
   - Frictional force: The force that always opposes the motion of object is called force of friction.

➢ Assertion Reason Answer:

1. (c) Assertion is true but Reason is false.
2. (a) Both Assertion and Reason are correct, and reason is the correct explanation for

assertion.

➢ Case Study Answer:

1. **Answer:**

(i) (a) The coin possesses inertia of rest; it resists the change and hence falls in the glass.

(ii) (b) Newton's first law of motion.

(iii) (c) Heavy coin will possess more inertia so it will fall in tumbler.

(iv) (c) Newton's first law

(v) (b) A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless it is acted upon by an external unbalanced force.

2. **Answer:**

(i) (b) Kiran's suggestion is incorrect as momentum is always conserved

(ii) (c) Momentum is the product of mass and velocity.

(iii) (c) SI u nit of momentum is kg. m/s.

(iv) (d) P =150 kgm/s

Solution:

Momentum, P = m x v

= 75 x 2

= 150 kg.m/s

(v) (c) Rate of displacement