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1. Introduction:

- Momentum is a measure of an object's resistance to stopping or changing its motion.
- It helps us to understand motion and explain collisions.

Examples:



A fast-moving player has Momentum.



A fast-moving coaster has Momentum.



A punch also has Momentum



The skateboard has Momentum

2. What is Momentum?

- Momentum is a measure of how much **Motion** an object has.
- It represents the quantity of motion an object has and how difficult it is to stop or change its motion.

Key properties:

- A heavier or faster-moving object has more Momentum.
- Momentum depends on both the speed and the direction of motion.
- In a closed system,

Total momentum before and after a collision remains constant.

Example:

• If a Truck and a Car are moving at the same speed, the Truck has more momentum because it has more mass.



• A small car hitting a truck won't move the truck much, because the truck has way more Momentum.



3. How to calculate Momentum?

- Momentum depends on Mass and Velocity.
- It is a Vector Quantity.
- Mathematically,

$\mathbf{p} = \mathbf{m} \mathbf{x} \mathbf{v}$

- Where, p = Momentum
 - **m** = Mass
 - **v** = Velocity

SI Unit: Kilogram-meter per second (kg.m/s)

Example: A car has a mass of 1000 kg and is moving at a velocity of 20 m/s in North side. What's the Momentum of car in the direction it's moving?

Solution:

- **Given:** m = 1000 kg
 - **v** = 20 m/s

Using the Formula,

Putting the values,

p = 1000 x 20 = 20,000

The car's momentum is $20,000 \text{ kg} \cdot \text{m/s}$ in the direction it's moving.

4. Can Momentum be Positive or Negative?

Yes, Momentum can be both positive and negative, which indicates the direction of an object's motion.

• Positive Acceleration:

Directional Reference:

Object moves in the defined positive direction (e.g., right/east/up/north).

Meaning of Signs:

+p: Object moves in the positive direction.

Example: A 10 kg soccer ball is kicked eastward at 5 m/s.

Solution: Let East = positive (+) direction.

p = m x v p = 10 x 5 = +50

• Negative Acceleration:

Directional Reference:

Object moves in the opposite (negative) direction (e.g., left, west, down)

Meaning of Signs:

-p: Object moves in the negative direction.

Example: A 10 kg soccer ball is kicked westward at 5 m/s.

Solution: Let West = negative (-) direction.

 $\mathbf{p} = \mathbf{m} \mathbf{x} \mathbf{v}$

p = 10 x 5 = -50

5. Relationship between Force, Momentum and

Acceleration:

- Momentum and Acceleration are fundamental concepts in physics, connected through **Newton's Second Law of Motion**.
- Momentum depends on velocity, any change in velocity (i.e. acceleration) causes a change in momentum.

But Since,

Acceleration(a) =
$$\frac{V - U}{t}$$

And Momentum is:

Momentum (p) = m x v

Then change in momentum is:

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

Substituting this into equation 1,

Force (F) =
$$\frac{m \times \Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$$

It says:

- The Force acting on an object is equal to the rate of change of its Momentum.
- If an object's momentum changes quickly, a large force is involved.
- If it changes slowly, the force is smaller.
- It can also be written as,

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

6. Solved Examples

Problem1: A cricket ball of mass 0.2 kg is moving at a speed of 25 m/s. What is the momentum of the ball?

Solution:

- **Given: m** = 0.2 kg
 - v = 25 m/s

Using the Formula,

 $\mathbf{p} = \mathbf{m} \mathbf{x} \mathbf{v}$

Putting the values,

 $p = 0.2 \times 25 = 5$

The momentum of the cricket ball is 5 kg·m/s.

Problem2: A car of mass 1200 kg moves backward with a velocity of 5 m/s. What is its momentum?

Solution:

Given: • m = 1200 kg

• **v** = 5 m/s

Using the Formula,

 $\mathbf{p} = \mathbf{m} \mathbf{x} \mathbf{v}$

Putting the values,

The momentum of the car is -6000 kg·m/s.

7. FAQs

1. What is momentum?

Momentum is a measure of the motion of an object and is the product of its mass and velocity. It is a vector quantity, meaning it has both magnitude and direction.

2. What is the principle of conservation of momentum?

The principle states that in a closed system (no external forces acting), the **Total momentum** before a collision is equal to the total momentum after the collision

3. How to Calculate Momentum? Formula for Momentum:

$p = m \times v$

Where,

- **p** = Momentum
- m = Mass
- **v** = Velocity

4. What is SI Unit of Momentum?

SI Unit for Momentum is kilogram-meter per second (kg·m/s)

5. Is Momentum a Vector?

Yes, Momentum is a Vector Quantity which depends on both direction and magnitude.