ALMUSTAQBAL UNIVERSITY COLLEGE

ميكانيك/ المرحلة الاولى/قسم الفيزياء الطبية

المحاضرة الثامنة

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Conservation of Linear Momentum

The linear momentum of a particle is defined as the product of the mass of the particle times the velocity of that particle. Conservation of momentum of a particle is a property exhibited by any particle where the total amount of momentum never changes. Linear momentum of a particle is a vector quantity and is denoted by

Conservation of Linear Momentum

According to the conservation of linear momentum,

If the net external force acting on a system of bodies is zero, then the momentum of the system remains constant.

We have to remember that the momentum of the system is conserved and not that of the individual particles. The momentum of the individual bodies in the system might increase or decrease according to the situation, but the momentum of the system will always be conserved, as long as there is no external net force acting on it.

Conservation of Linear Momentum Formula

The principle of conservation of momentum states that if two objects collide, then the total momentum before and after the collision will be the same if there is no external force acting on the colliding objects.

Conservation of linear momentum formula mathematically expresses the momentum of the system remains constant when the net external force is zero.
Initial momentum = Final momentum

$$P_i = P_f$$

Linear Momentum Formula

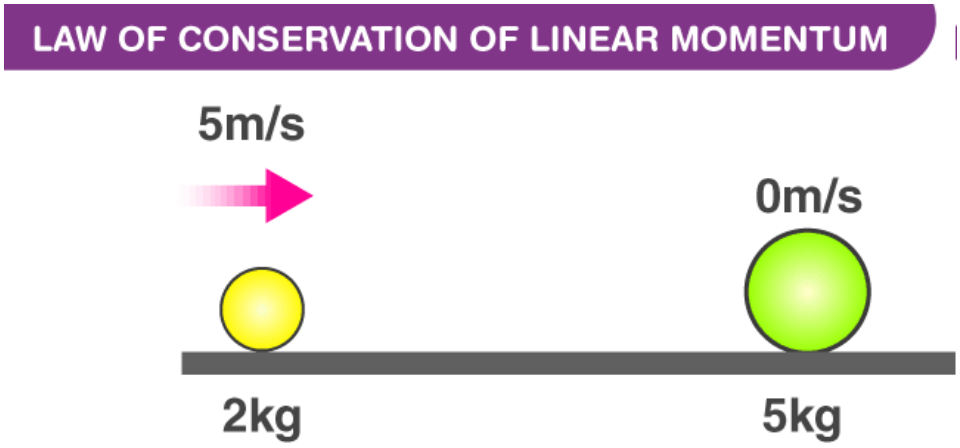
Linear momentum is mathematically expressed as:

$\vec{p}$
= m
$\vec{v}$

$\vec{p}$
is the linear momentum

$\vec{v}$
is the linear velocity

m is the mass of the body



Conservation Of Linear Momentum Equation

The law of conservation of momentum can be explained from the second law of motion. Newton's second law of motion says that the rate of change of linear momentum of a body is equal to the net external force applied to it.

Mathematically it is expressed as:

$$\frac{dP}{dt}$$
$$= \frac{(mv)}{dt}$$
$$= m\frac{dv}{dt}$$
$$= ma$$
$$= F_{net}$$

If the net external force acting on a body is zero, then the rate of change of momentum is also zero, which means that there is no change in momentum.

Conservation Of Linear Momentum Example

Two bodies of mass M and m are moving in opposite directions with the velocities v. If they collide and move together after the collision, we have to find the velocity of the system.

Since there is no external force acting on the system of two bodies, momentum will be conserved.

Initial momentum = Final momentum

$(Mv – mv) = (M+m)V_{Final}$

From this equation, we can easily find the final velocity of the system.

Conservation Of Linear Momentum Applications

One of the applications of conservation of momentum is the launching of rockets. The rocket fuel burns are pushed the exhaust gases downwards, and due to this, the rocket gets pushed upwards. Motorboats also work on the same principle, it pushes the water backward and gets pushed forwards in reaction to conserve momentum

Statement:

According to the law of conservation of linear momentum, for an object or system of objects, the total momentum of the system is always conserved if no external force acts on them

The unit of $kg.m.s^{-1}$ and the dimensional formula is MLT^{-1}. The mathematical representation of the law of conservation of linear momentum is given as:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Proof:

Consider collision between two balls. The momentum of these two balls before collision is given as:

$P1_i = m_1u_1$

$P2_i = m_2u_2$

The total momentum of the balls before the collision is given as:

$P_i = P1_i + P2_i$

$P_i = m_1u_1 + m_2u_2$

$F1_2$ is the force exerted by the m_1 during the collision on m_2.

$F2_1$ is the force exerted by the m_2 during the collision on m_1.

Therefore, $F1_2 = F2_1$

There is a change in the velocity of these balls after the collision which is given as:

$P1_f = m_1v_1$

$P2_f = m_2v_2$

The total momentum of the balls after the collision is given as:

$P_f = P1_f + P2_f$

$P_f = m_1v_1 + m_2v_2$

From Newton's second law:

Force = Change in momentum / time interval

$F1_2 = m_2v_2 – m_2u_2 / t$

$F2_1 = m_1v_1 – m_1u_1 / t$

From Newton's third law:

$F1_2 = F2_1$

Therefore, we get:

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Frequently Asked Questions – FAQs

State the principle of conservation of linear momentum.

The principle of conservation of momentum states that if two objects collide, then the total momentum before and after the collision will be the same if there is no external force acting on the colliding objects.

Write some applications of conservation of linear momentum.

One of the applications of conservation of momentum is the launching of rockets. The rocket fuel burns are pushed the exhaust gases downwards, and due to this, the rocket gets pushed upwards. Motorboats also work on the same principle, it pushes the water backward and gets pushed forwards in reaction to conserve momentum.

Does friction affect the conservation of momentum?

Yes, friction affects momentum. As friction increases, momentum decreases.

The law of conservation of momentum is based on which law of motion?

The law of conservation of momentum is based on Newton's third law of motion which states that every force has a reciprocating equal and opposite force.

Write the mathematical expression for the law of conservation of momentum.

The momentum observation principle can be mathematically represented as:

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

In the equation, m_1 and m_2 are masses of the bodies, u_1 and u_2 are the initial velocities of the body.

v_1 and v_2 are the final velocities of the bodies.