Law of conservation of angular momentum:

"If net applied torque on a particle is zero, then its angular momentum is conserved."

Proof:

If the moment of inertia of a particle is I, angular velocity is ω and the angular momentum is L, then

$$L = I\omega$$

Differentiating with respect to time we get

$$\frac{dL}{dt} = \frac{d}{dt}(I\omega)$$

$$= I\frac{d\omega}{dt}$$

$$= I\alpha \text{......................}(1)$$

But if the applied torque is τ

$$\text{Then } \tau = I\alpha \text{ ....}(2)$$

Law of conservation of angular momentum:

"If net applied torque on a particle is zero, then its angular momentum is conserved."

Comparing equation (1) and (2).

$$\frac{dL}{dt} = \tau$$

if $\tau = 0$ then,

$$\frac{dL}{dt} = 0$$

$\square$ L = constant

So, if the applied torque is zero the angular momentum remains constant i.e; conserved.

Conservation Theorem of Energy

Conservation Theorem of Energy:

Statement: "*Energy may be transformed from one kind to another, but it cannot be created or destroyed; the total energy is constant.*"

This is the principle of the conservation of energy.

This theorem can be expressed as

$$\Delta K + \Delta U + Q + (Change\ in\ other\ form\ of\ energy) = 0$$

Here, ΔK is the change in kinetic energy.

ΔU is the change in potential energy.

Q is the heat produced due to friction.

Conservation Theorem of Momentum

Statement:

"If the vector sum of the external forces on a system is zero, the total momentum of the system is constant."

Let us consider an idealized system consisting of two particles that interact with each other but not with anything else. Each particle exerts a force on the other; according to Newton's third law, the two forces are always equal in magnitude and opposite in direction. Hence the impulses that act on the two particles will be equal and opposite, and the changes in momentum of the two particles will be equal and opposite.

Let $\vec{F}_{\text{B on A}}$ be the force exerted by particle B on particle A and $\vec{F}_{\text{A on B}}$ be the force exerted by A on B.

Therefore, the rate of change of momentum of the two particles is

$$\vec{F}_{B\ on\ A} = \frac{d\vec{P}_A}{dt}, \qquad \vec{F}_{A\ on\ B} = \frac{d\vec{P}_B}{dt} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, $\vec{P}_A =$ momentum of particle A.

$\vec{P}_B =$ Momentum of particle B.

Since $\vec{F}_{B\ on\ A}$ and $\vec{F}_{A\ on\ B}$ are equal and opposite, then

$$\vec{F}_{B\ on\ A} = -\vec{F}_{A\ on\ B}$$

$$\Rightarrow \vec{F}_{B\ on\ A} + \vec{F}_{A\ on\ B} = 0 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Conservation Theorem of Momentum

From equation (1) and (2), we get

$$\frac{d\vec{P}_A}{dt} + \frac{d\vec{P}_B}{dt} = 0$$

$$\Rightarrow \frac{d}{dt}(\vec{P}_A + \vec{P}_B) = 0$$

$$\Rightarrow \frac{d\vec{P}}{dt} = 0 \qquad [\vec{P} = Total\ momentum = \vec{P}_A + \vec{P}_B$$

$$\therefore \vec{P} = Constant.$$

Collision

If two bodies collide with each other for a very short time with a force of very high magnitude then it is called collision.

In a collision a relatively large force acts on each colliding particle for a relatively short time. The basic idea of a "collision" is that the motion of the colliding particles changes rather abruptly and that we can make a relatively clean separation of times that are "before the collision" and those that are "after the collision".

There are two types of collision:

i. Elastic Collision

ii. Inelastic Collision

Elastic Collision: A collision in which the kinetic energy of the system is the same after the collision as before is called elastic collision.

Inelastic Collision: A collision in which the total kinetic energy after the collision is less than that before the collision is called an inelastic collision.