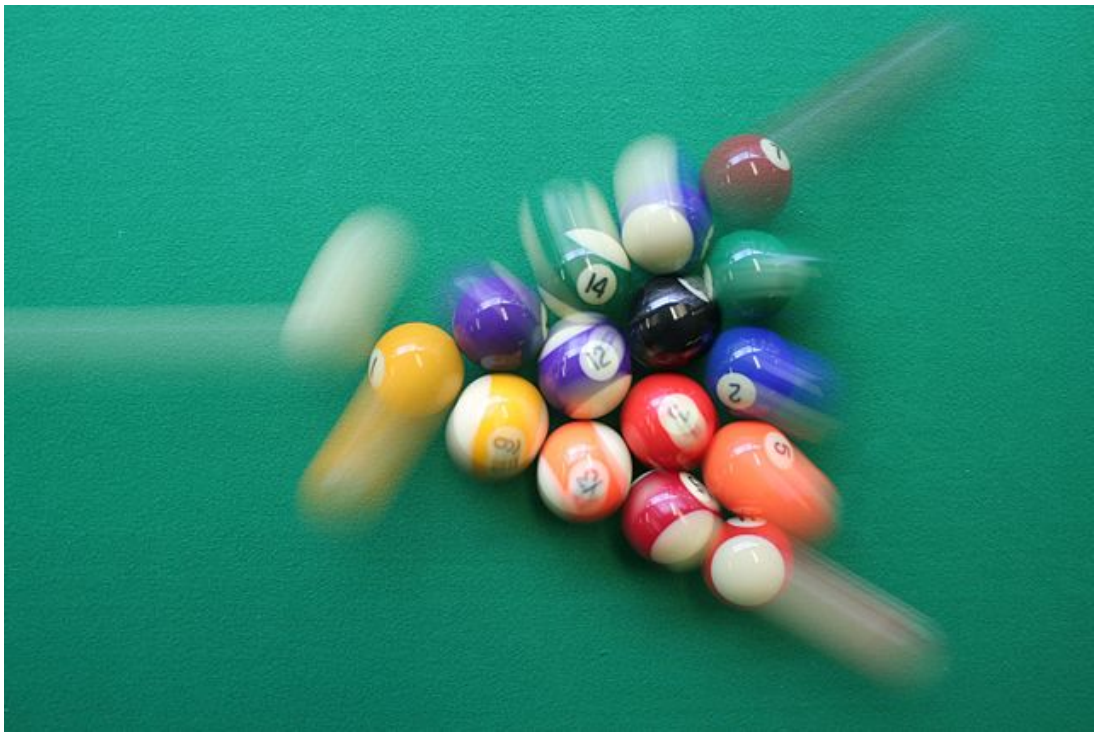
Momentum and Collisions

See online here

Momentum can be understood by looking at the mass and velocity of an object. Mass is a property of an object that measures the amount of matter in an object. Velocity is the amount of distance an object travels over a given time. It is a vector quantity so directionality is also expressed. Momentum is the product of mass and velocity, also a vector quantity. In practicality, momentum refers to the quantity of motion possessed by an object. The unit of momentum is kilogram-meter per second (kg-m/s).

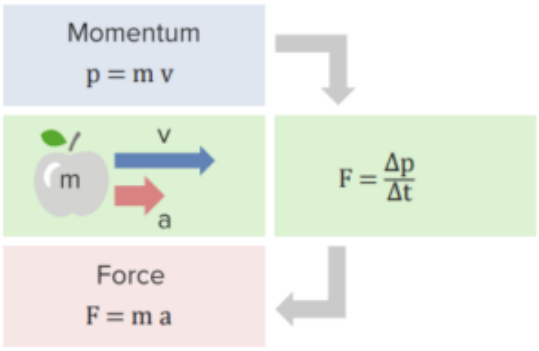


Momentum: Definition

Momentum is a vector quantity used to describe the motion of an object. Its direction is parallel to the motion of that object.

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

p ⇒ momentum (kg m/s or N s)
m ⇒ mass (kg)



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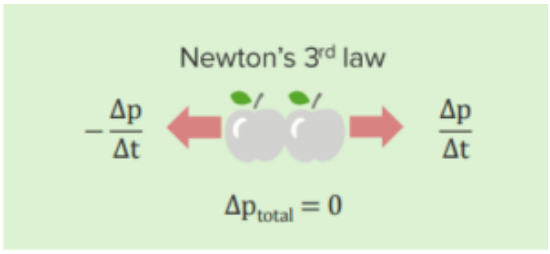

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The law of conservation of momentum

The law of conservation of momentum states that in an isolated system that does not have any interaction with its environment, all momentum is constant. When 2 objects collide, the total momentum of these 2 objects before the collision is equal to their total momentum after the collision.

Impulse

Impulse can be defined as the change in momentum over time caused by an average force. It is defined as follows:

$$\vec{I} = \Delta p = F_{av} * \Delta t$$

$\vec{I}$ ⇒ impulse (kg m/s)

F_{av} ⇒ average force (N or kg m/s^2)
p ⇒ momentum (kg m/s or N s)
Δt ⇒ duration of the impulse (s)

Moment of Inertia

A static/rigid body has resistance. Once a force sets a rigid body in rotating motion, a moment of inertia occurs. Moment of inertia depends on the body's mass distribution in relation to the axis.

$$J = \int_{v} r^2 * \rho \, dV$$

J ⇒ moment of inertia (kg m^2)
r ⇒ axis of rotation
ρ ⇒ mass distribution

Angular momentum

Angular momentum can be thought of as ‘swirl’ or ‘spin’. It describes the direction and speed of a rotation about an axis. Angular momentum increases under the following conditions:

- the bigger the body’s mass
- the higher the body’s velocity
- the longer the distance from the axis

The following equation defines angular momentum:

$$\mathbf{L = r\ p}$$

Collisions

Central collision

$$\mathbf{\Delta p \Rightarrow collision\ [(kg\ m)/s]}$$

A collision can be defined as a change in momentum over time. The following equation defines collision:

$$\mathbf{\Delta p = F\ \Delta t}$$

There are 2 types of collision:

- Elastic collision: Kinetic energy is conserved.
- Inelastic collision: A part of the kinetic energy is converted into internal energy.

If the centers of gravity of the colliding bodies move along a straight line, such collision is defined as a straight-line central collision.

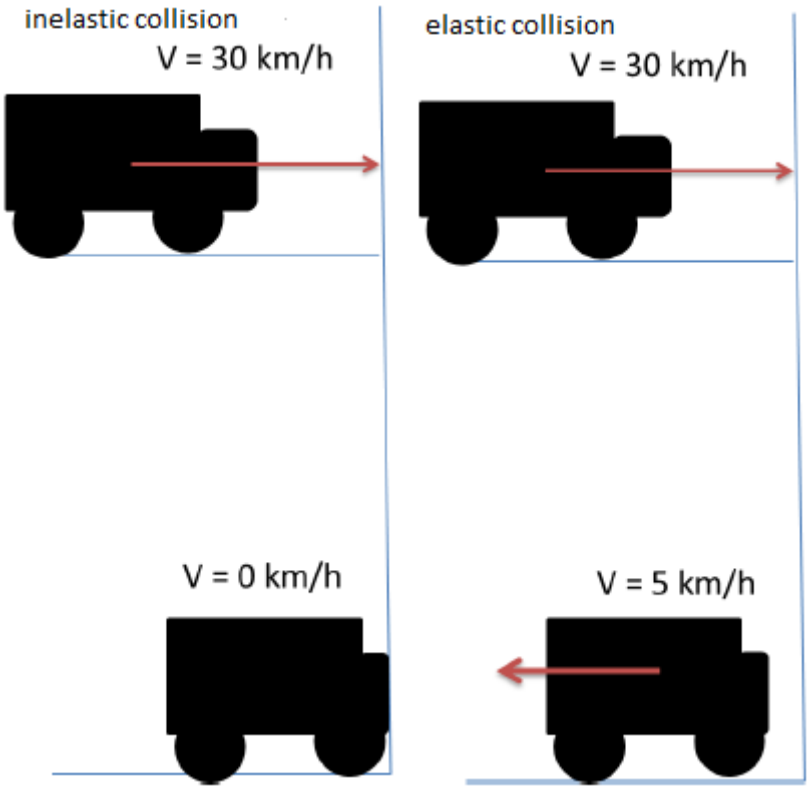

Image: Inelastic and elastic collision. By Lecturio

Notes