Chapter 6
Momentum and Collision

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Curriculum

Standard 4: Forces and Motion

Standard Sc. 4.2 : Understanding of characteristics and various types of motion of natural objects, investigative process for seeking knowledge and scientific mind, and communication of acquired knowledge for useful purposes.

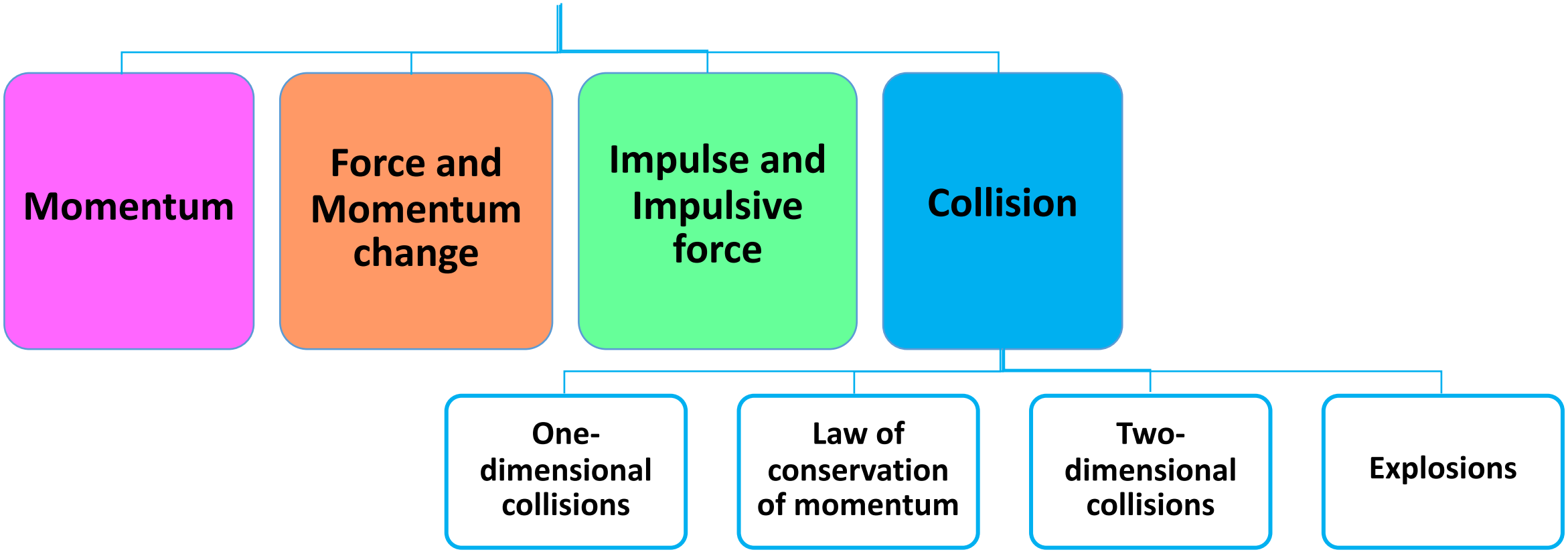
Curriculum

Course Description Grade 10-12

1. Explain momentum and the relationship between force and momentum changed.

2. Explain the collision of an objects, law of conservation of the momentum and collision analysis of objects.

Momentum and Collision



Momentum

Momentum is the quantity that tells the state of the object of motion. Momentum is a vector quantity in the same direction as the direction of velocity. Momentum is the product of the mass and velocity of an object.

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

Momentum : experiment 1

Objective

- To observe the difference in the strength of the sandbag.

Equipment

- Sandbag 500 g

Momentum : experiment 1

Method

- Hold 1 bag of sandbag above the other hand about 30 centimeters.
- Fall the sand bag and get a sandbag falling stay in the hand and try not to move.
- Repeat again hold 1 bag of sandbag upper and fall the sand bag and get a sandbag falling stay in the hand.
- Compare force sandbag on the hand

Momentum : experiment 1

Conclusion

From the experiment the force used to receive the sandbag at low velocity the force is less than that the force used to receive the sandbag is faster velocity.

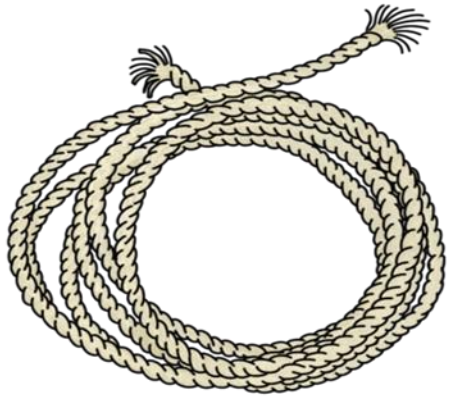
Momentum : experiment 2

Objective

- To observe the difference in the strength of the sandbag.

Equipment

- Sandbag 500 g
- Rope



Momentum : experiment 2

Method

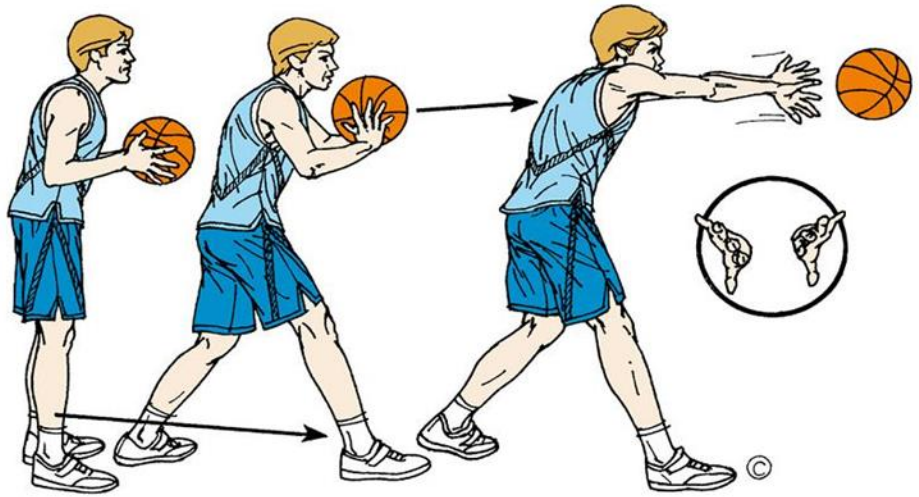
- Hold 1 bag of sandbag above the other hand About 30 centimeters.
- Fall the sand bag and get a sandbag falling stay in the hand and try not to move.
- Repeat again hold 2 bag of sandbag.

Momentum : experiment 2

Conclusion

From the experiment the force of the sandbag is different mass but moving at the same velocity. The force used to receive the sandbag at heavier mass is over than that the force used to receive the sandbag is lesser mass.

Momentum



$$\boxed{\vec{P}=m\vec{v}}$$

m = Mass of object (kg)
$\vec{v}$ = Velocity of object (m/s)
$\vec{P}$ = Momentum of object (kg.m/s)

Newton's first law of motion can be written in the form of momentum. The momentum of the object is always constant, in addition there is a non-zero result to act on objects.

Example

Ex One child has a mass of 40 kg velocity of walk 0.8 m/s to the east.
Find the momentum of a child.

m = 40 kg
$\vec{v}$ = 0.8 m/s

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

$$\vec{P} = 40\text{kg} \times 0.8\ \text{m/s}$$

$$\vec{P} = 32\ \text{kg.m/s}$$

Ans. Momentum is 32 kg.m/s to the east

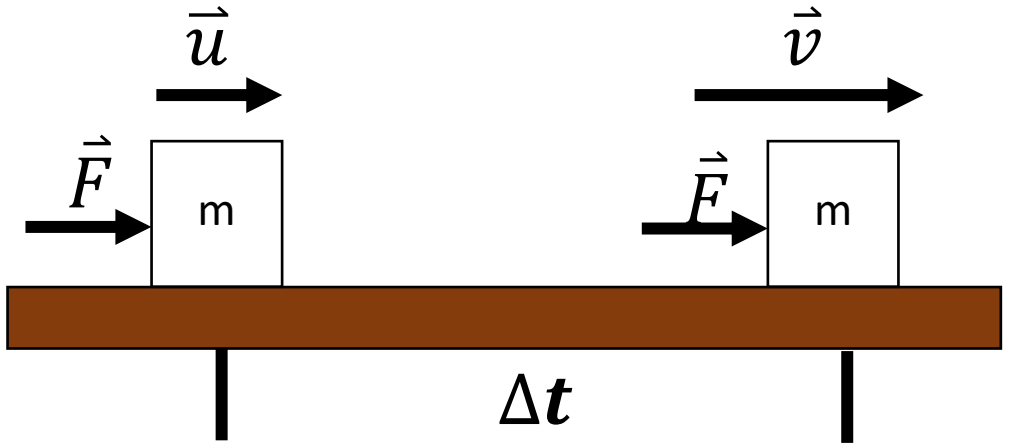
Exercise

1. Find the momentum of a bird has a mass 30 g fly with velocity 8 m/s to the west.

2. Find the momentum of a truck has a mass 1.5× ⟦10⟧^4 kg is moving with velocity 36 km/hr to the east.

3. Find the velocity of a tiger has mass 40 kg has momentum of 760 kg m/s to the east.

Force and Momentum change



Consider the mass object "m" on the frictionless area moving with velocity "$\vec{u}$" constant force "$\vec{F}$" action on objects in time "Δt" the velocity of the object changes "$\vec{v}$"

Force and Momentum change

From the Newton's second law of motion.

$$\vec{F} = m\vec{a}$$

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

$$\vec{F} = \frac{m\vec{v}-m\vec{u}}{\Delta t}$$

$$\boxed{\vec{a} = \frac{\vec{v}-\vec{u}}{\Delta t}}$$

Force and Momentum change

- $m\vec{u} = \vec{P}_1$ The momentum of the object before the force.
- $m\vec{v} = \vec{P}_2$ The momentum of the object after the force.
- $m\vec{v} - m\vec{u} = \vec{P}_2 - \vec{P}_1$ The momentum of the object changes in time Δt
- $\frac{m\vec{v} - m\vec{u}}{\Delta t} = \frac{\vec{P}_2 - \vec{P}_1}{\Delta t}$ This is rate momentum change.

$$\vec{F} = \frac{\Delta \vec{P}}{\Delta t}$$

Determined $\Delta \vec{P}$ is the momentum change

Newton’s second law of motion

Can be said one way the force acting on any object is equal to the rate of the momentum change of the object.

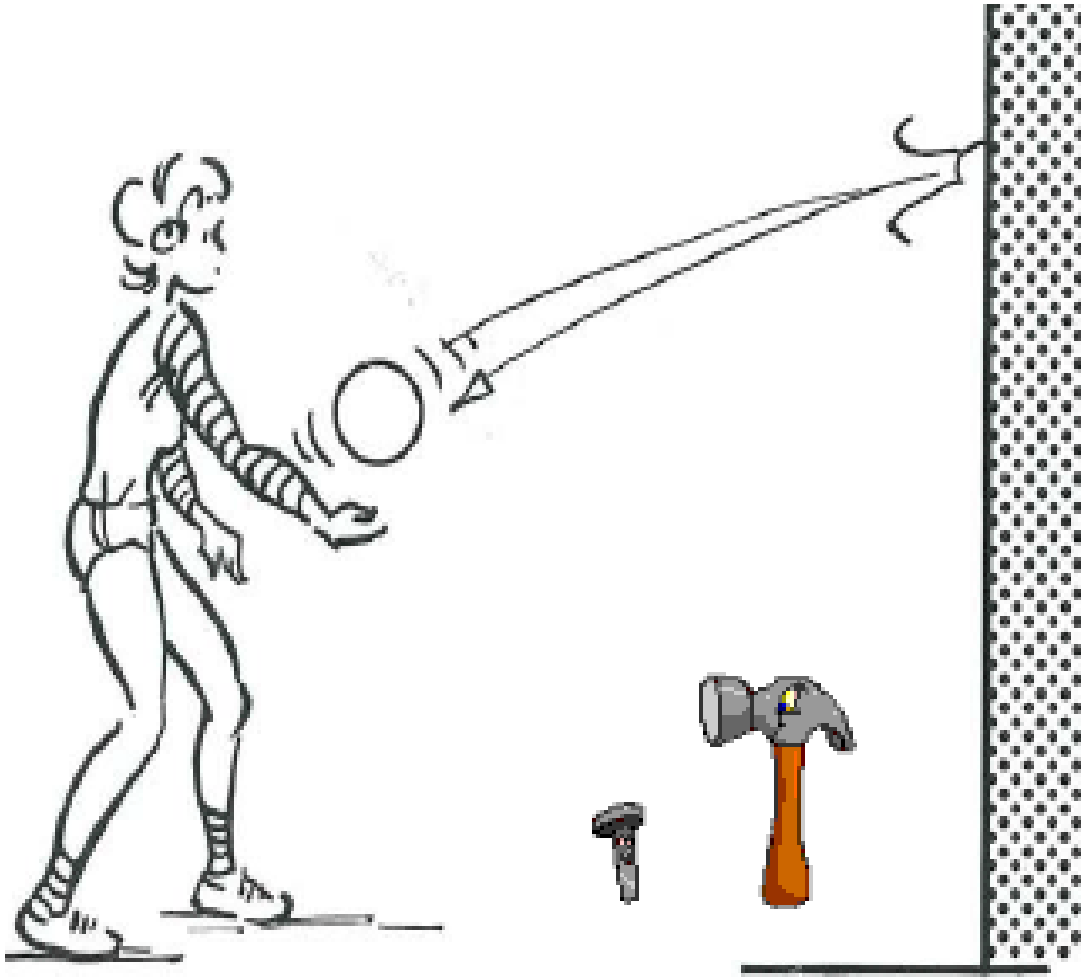
Impulse and Impulsive force

If resultant force $\vec{F}$ action on objects in a short period of time $\Delta t \rightarrow 0$, $\vec{F}$ is impulsive force and $\vec{F}\Delta t$ is impulse, $\vec{I}$.

$$\vec{I} = \vec{F}\Delta t = \Delta\vec{P} = m\vec{v} - m\vec{u}$$

Impulse the vector is in the same direction as the resultant force and unit is **N.s** or **kg.m/s** .

Impulse and Impulsive force



Collision

One-dimensional collisions

- One-dimensional collisions is the collision in a straight line. Both objects are in the same line as before and after collisions.

- The sum of the kinetic energy of the system is constant is “Elastic Collision”

- The sum of the kinetic energy of the system is unstable is “Inelastic Collision”

Collision

One-dimensional collisions

- Elastic collision

An elastic collision is an encounter between two bodies in which the total kinetic energy of the two bodies after the encounter is equal to their total kinetic energy before. Elastic collisions occur only if there is no net conversion of kinetic energy into other forms. A perfectly elastic collision is defined as one in which there is no loss of kinetic energy in the collision. An elastic collision is defined as one in which both conservation of momentum and conservation of kinetic energy are observed.

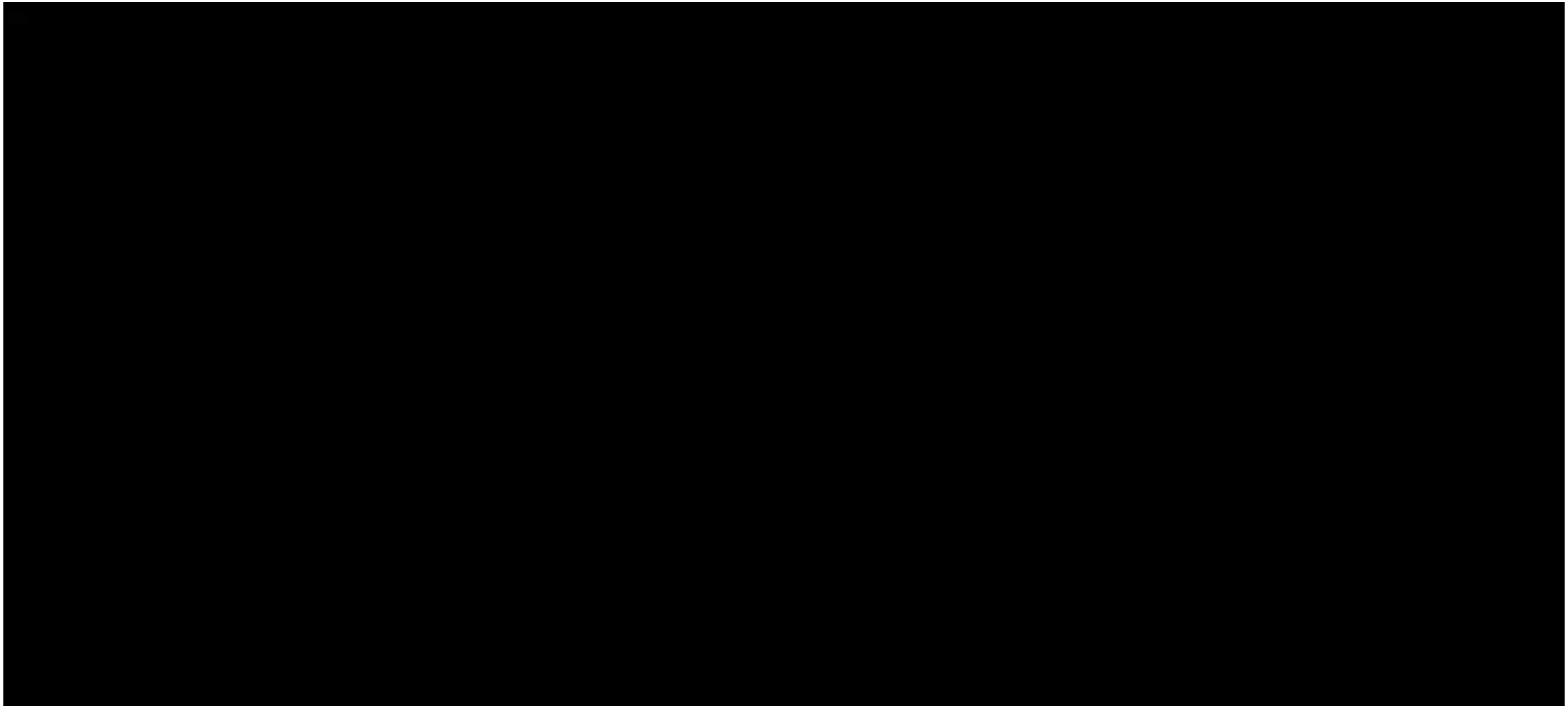
Collision

One-dimensional collisions

- Inelastic collision

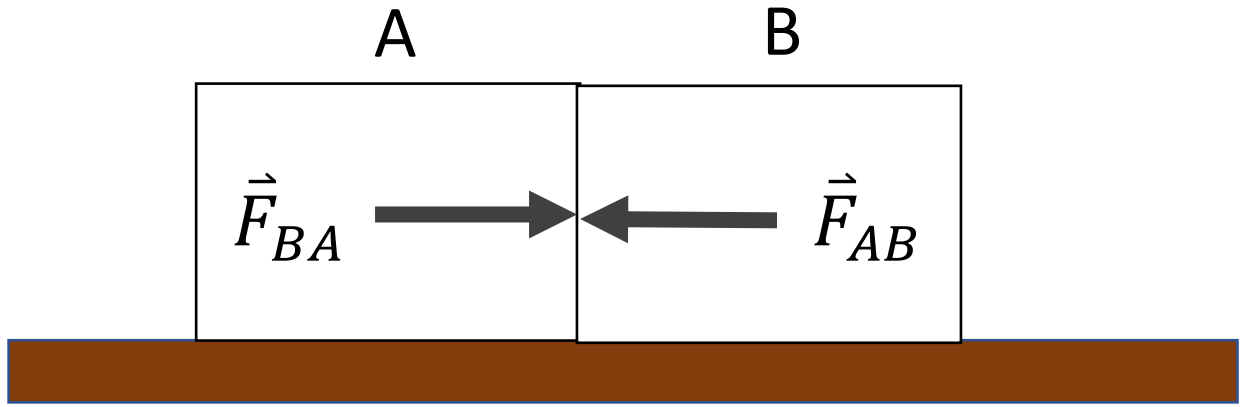
An inelastic collision is any collision between objects in which some energy is lost. A special case of this is sometimes called the "perfectly" inelastic collision. In a perfectly inelastic collision, two objects collide and stick together. The momentum of the objects before the collision is conserved, but the total energy is not conserved. The final velocity of the combined objects depends on the masses and velocities of the two objects that collided.

Collision



Collision

Law of conservation of momentum



The system consists of two objects colliding there is a non-zero result for each object. The force is the action force and reaction force as a Newton's third law of motion cause the momentum of each object changes.

Collision

Law of conservation of momentum

$\vec{F}_{AB}$ = Force the object B act on objects A.

$\vec{F}_{BA}$ = Force the object A act on objects B.

Δt = Moment with object collision.

By Newton's third law of motion

$$\vec{F}_{BA} = -\vec{F}_{AB}$$

Collision

Law of conservation of momentum

$$m_B \frac{(\vec{v}_B - \vec{u}_B)}{\Delta t} = -m_A \frac{(\vec{v}_A - \vec{u}_A)}{\Delta t}$$

$$m_B \vec{v}_B - m_B \vec{u}_B = -m_A \vec{v}_A + m_A \vec{u}_A$$

$$m_A \vec{u}_A + m_B \vec{u}_B = m_A \vec{v}_A + m_B \vec{v}_B$$

$$\sum \vec{p}_{before\ collision} = \sum \vec{p}_{after\ collision}$$

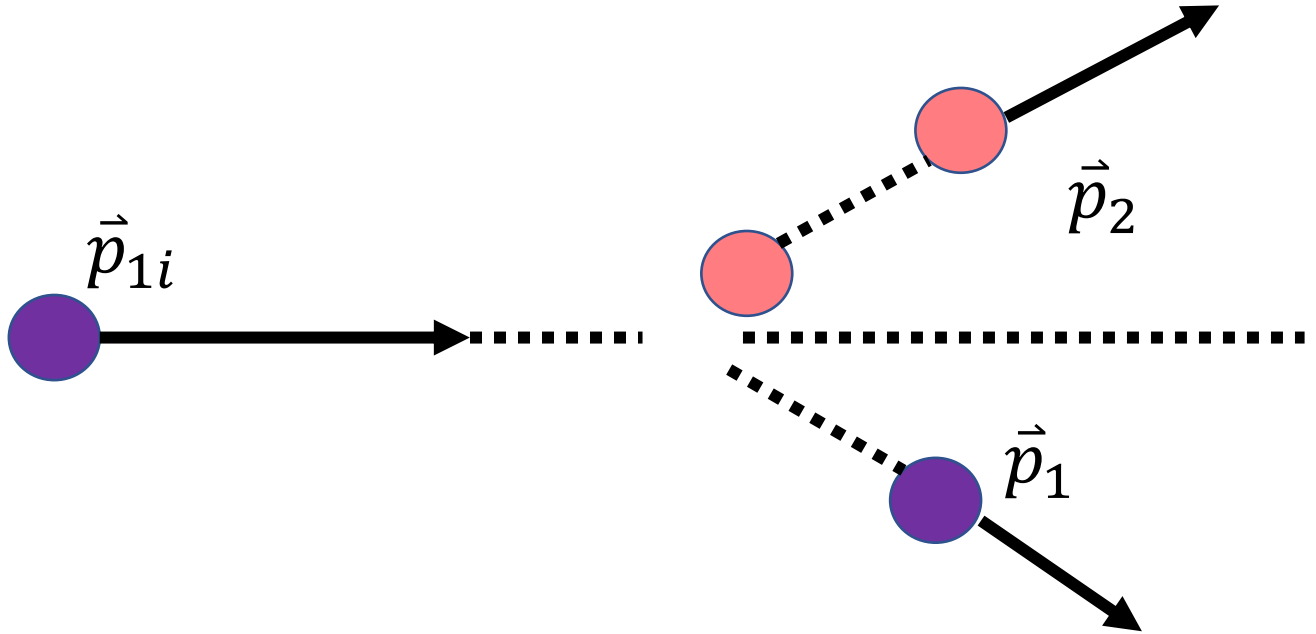
Collision

Two-dimensional collisions

Collision of the object after the collision, both objects may splatter in different directions. Not in the same line or move apart in the same angle because the motion of the mass center of the moving object does not collide with the mass center of the collision object.

Collision

Two-dimensional collisions

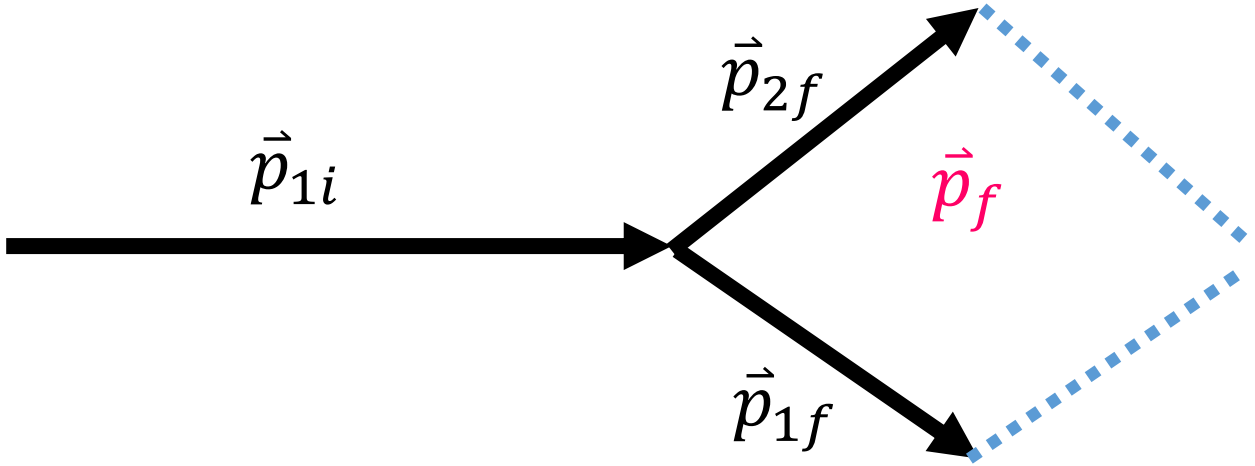


Before the collision

After the collision

Collision

Two-dimensional collisions



$$\vec{p}_{1i} = \vec{p}_f$$

Collision

Explosions

The explosion of an object with internal energy, the momentum of the system is constant but the kinetic energy is unstable.

Conclusion of momentum

Momentum

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

Force and Momentum change

$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$

Impulse and Impulsive force

$\vec{I} = \vec{F}\Delta t = \Delta\vec{p}$

$= m\vec{v} - m\vec{u}$

Collision

- **One-dimensional collisions**
  - Elastic Collision
  - Inelastic Collision
- **Law of conservation of momentum**
- **Two-dimensional collisions**
- **Explosions**

Reference

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The End !!