

# Conservation of Momentum

- Conservation in 1D
- Law of Conservation of Momentum
- Collision types
- Collision calculations
- Conservation in 2D



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# Conservation of Momentum

- The total momentum in any closed system will remain constant.

# Conservation of Momentum in 1D

| Car           |        | Truck         |         |
|---------------|--------|---------------|---------|
| mass (kg)     | 1000   | mass (kg)     | 3000    |
| vel. (m/s)    | 20.0   | vel. (m/s)    | -20.0   |
| mom. (kg m/s) | 20 000 | mom. (kg m/s) | -60 000 |



A diagram illustrating a 1D momentum transfer scenario. A small red car is on the left, and a larger grey truck is on the right. The truck's trailer is red and has the words "MOMENTUM TRANSFER" written on it in black. Both vehicles are on a horizontal road surface.

# Law of Conservation of Momentum

- When two or more objects collide, the collision does not change the total momentum of the two objects. Whatever momentum is lost by one object in the collision is gained by the other.
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# Law of Conservation of Momentum

- $P_{\text{system}} = m_1 v_1 + m_2 v_2$
- The total momentum of the system before the collision equals the total momentum of the system after the collision. Thus,

$$p_{\text{system}} = p'_{\text{system}}$$

$$m_1 \vec{v}_{i_1} + m_2 \vec{v}_{i_2} = m_1 \vec{v}'_1 + m_2 \vec{v}'_2$$

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# Check Your Understanding

- During a football game, a fullback of mass 108 kg, running at a speed of 9.1 m/s [ $\rightarrow$ ], is tackled head-on by a defensive back .....

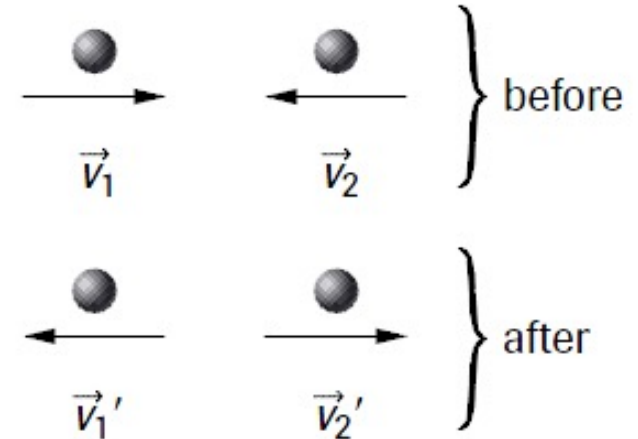
# Collisions

What we have discussed so far are Elastic conditions. There are however three types of collisions.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

# Types of Collisions - Elastic

- The total kinetic energy of the system before the collision is .....

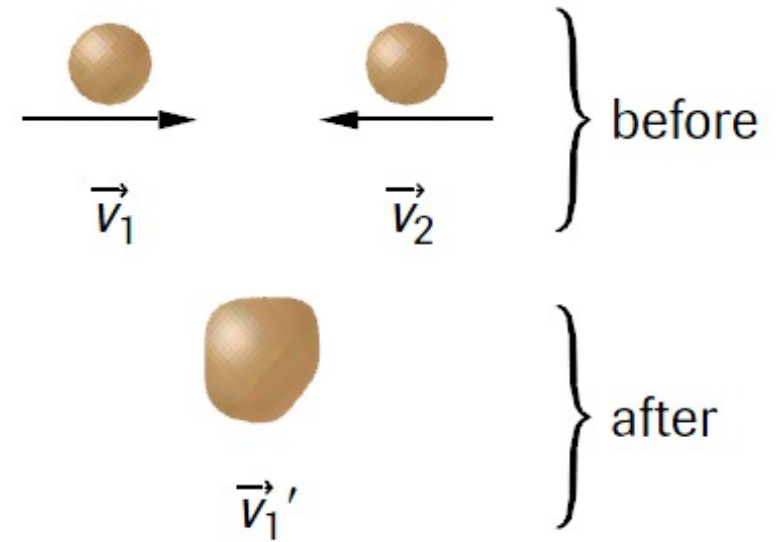


$$E_K' = E_K$$
$$\vec{p}' = \vec{p}$$

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# Completely Inelastic

- \_\_\_\_\_
- Since the objects stick together, they have the same final velocity.



$$E_K' < E_K$$
$$\vec{p}' = \vec{p}$$

# Collision Calculations

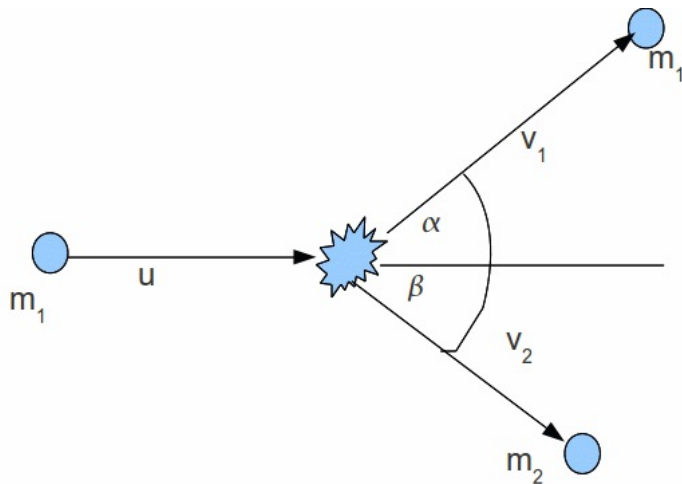
- In all collision calculations momentum is conserved therefore,

$$m_1 \vec{v}_{i_1} + m_2 \vec{v}_{i_2} = m_1 \vec{v}'_1 + m_2 \vec{v}'_2$$

- In completely .....

# Conservation of Momentum in 2D

- 2 Dimensional Collisions – a collision where an object collides at an angle to a second object causing the first object to travel at a different angle to the direction it was originally travelling.
- Momentum is a vector – and as with any vector, it can be resolved into components. Generally, we resolve vectors into horizontal (x) and vertical (y) components.



| Blue Car      |              | Red Car       |               |
|---------------|--------------|---------------|---------------|
| mass (kg)     | 1000         | mass (kg)     | 1000          |
| vel. (m/s)    | 20.0, East   | vel. (m/s)    | 10.0, North   |
| mom. (kg m/s) | 20 000, East | mom. (kg m/s) | 10 000, North |

A diagram showing a simulation of a collision between a blue car and a red car. The blue car is on the left, and the red car is at the bottom. The background is yellow.

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# Check Your Understanding

- A nucleus, initially at rest, decays radioactively, leaving a residual nucleus. In the process, it emits two particles horizontally: an electron with momentum  $9.0 \times 10^{-21} \text{ kgm/s [E]}$ .....
  - a) In what direction does the residual nucleus move? Hint: opposite the combined vector momentums of the other two particles.
  - b) What is the magnitude of its momentum?
  - c) If the mass of the .....