

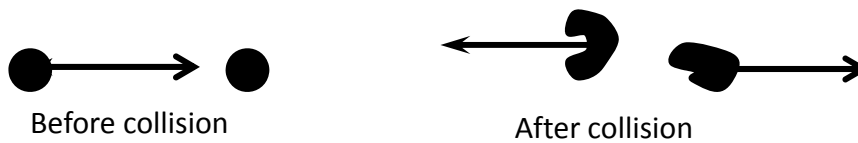
Collisions:

In physics, we separate collisions into several categories:

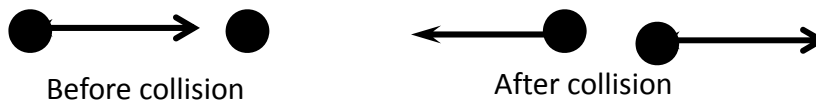
Completely inelastic: the objects stick together after the collision. Kinetic energy is not conserved.



Partially inelastic: the objects separate after they collide, but are deformed in some way. Kinetic energy is not conserved.



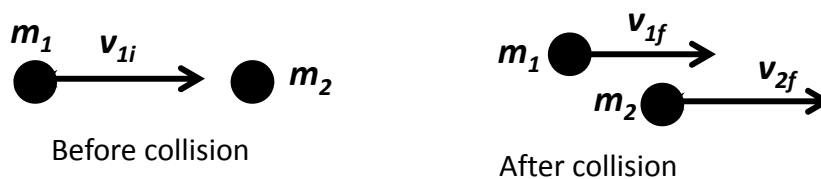
Completely elastic: the objects separate and remain unchanged. Kinetic energy is conserved.



Let's look at some different cases:

Case 1: Completely elastic, object 1 of mass m_1 moves with speed v_{1i} , object 2 of mass m_2 is at rest.

After colliding, objects 1 and 2 move with speeds v_{1f} and v_{2f} .



* The net external force on an isolated system is zero.

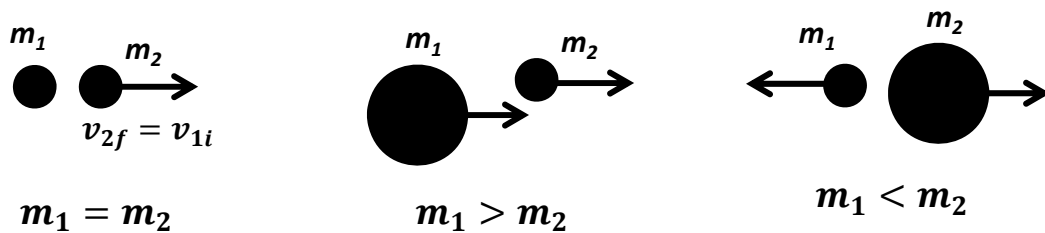
Case 1 (continued):

Conservation of momentum: $m_1 v_{1i} = m_1 v_{1f} + m_2 v_{2f} \Rightarrow v_{1i} - v_{1f} = \frac{m_2}{m_1} v_{2f}$

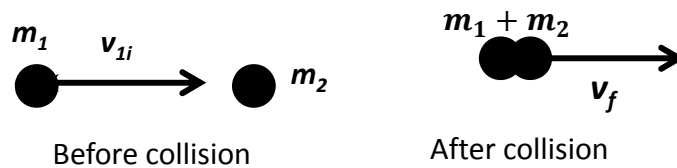
Conservation of energy: $\frac{1}{2} m_1 v_{1i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 \Rightarrow v_{1i} + v_{1f} = v_{2f}$

Solving: $v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$ and $v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i}$

- \Rightarrow If $m_1 = m_2$, then after the collision, object 1 will be at rest and object 2 will move with the velocity that object 1 had before the collision
- \Rightarrow If $m_1 > m_2$, then after the collision, both objects will continue moving in the same direction
- \Rightarrow If $m_1 < m_2$, then after the collision, objects 1 and 2 will move in opposite directions (i.e., object 1 will "bounce" off object 2)



Case 2: Completely inelastic, object 1 of mass m_1 moves with speed v_{1i} ,
object 2 of mass m_2 is at rest.



Conservation of momentum: $m_1 v_{1i} = (m_1 + m_2) v_f \Rightarrow v_f = \frac{m_1}{(m_1 + m_2)} v_{1i}$

Kinetic energy lost:

$$KE_{\text{Lost}} = \frac{1}{2} m_1 v_{1i}^2 - \frac{1}{2} (m_1 + m_2) v_f^2 = \frac{1}{2} m_1 v_{1i}^2 \frac{m_2}{m_1 + m_2}$$

The greatest energy loss occurs when $m_2 > m_1$. If $m_2 \gg m_1$, then almost all the kinetic energy is lost.