Lecture 9, Sep 29, 2021

Identifying and Choosing Closed Systems

- A closed system is any system that does not transfer energy in/out of it
- Identify all objects that change state or state of motion, and group them together to make a closed system

Elastic Collisions in Isolated and Closed Systems

- The difference in speed remains the same after an elastic collision
- Relative speed remains the same but relative velocity is negated

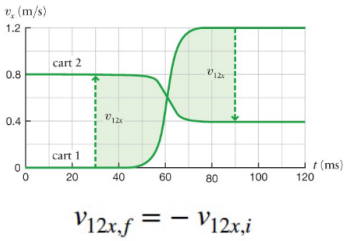

Figure 1: relative speed

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- Conservation of momentum, conservation of energy and elastic collisions can be derived from each other
  - $k_i = k_f$
    $\implies \frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$
    $\implies m_1(v_{1f}^2 - v_{1i}^2) = m_2(v_{2f}^2 - v_{2i}^2)$
    $\implies m_1(v_{1f} + v_{1i})(v_{1f} - v_{1i}) = m_2(v_{2f} + v_{2i})(v_{2f} - v_{2f})$
    $\implies \Delta p_1(v_{1f} + v_{1i}) = \Delta p_2(v_{2f} + v_{2i})$
- In an elastic collision $k_i = k_f$
- Energy is measured in Joules: $1\text{J} = 1\text{kg} \cdot \text{m}^2/\text{s}^2 = 1\text{m} \cdot \text{kg} \cdot \text{m}/\text{s}^2 = 1\text{N} \cdot \text{m}$

Quantifying (In)Elastic Collisions

- We can quantify how elastic a collision is with the *coefficient of restitution*: $e \equiv \frac{v_{12f}}{v_{12i}}$
- The coefficient of restitution is the ratio between the final difference in *speed* and initial difference in *speed*
- The coefficient of restitution is positive, even though the direction of velocity reverses in an elastic collision
- Elastic collisions have $e = 1$, while totally inelastic collisions have $e = 0$