Chapter 9: Linear Momentum and Collisions-*Continued*

PHY0101/PHY101

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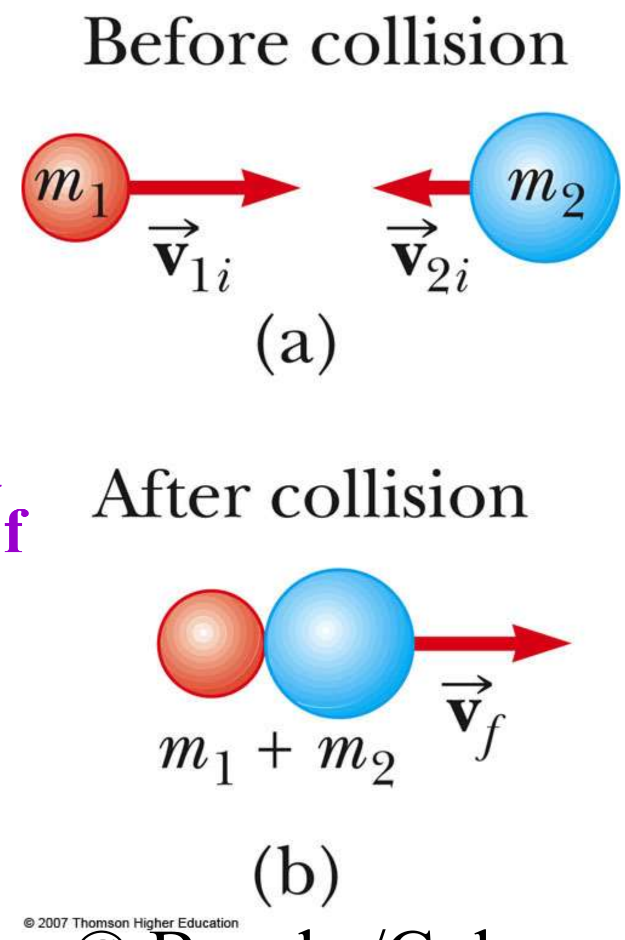
Perfectly Inelastic Collisions

- The objects stick together, so they have the same velocity after the collision →

$$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$$



Inelastic Collisions

- Given some information, using conservation laws, we can determine a lot about collisions without knowing forces of collision.
- To analyze all collisions:

Rule 1:

Momentum is *ALWAYS* conserved in a collision!

$$\Rightarrow \quad m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

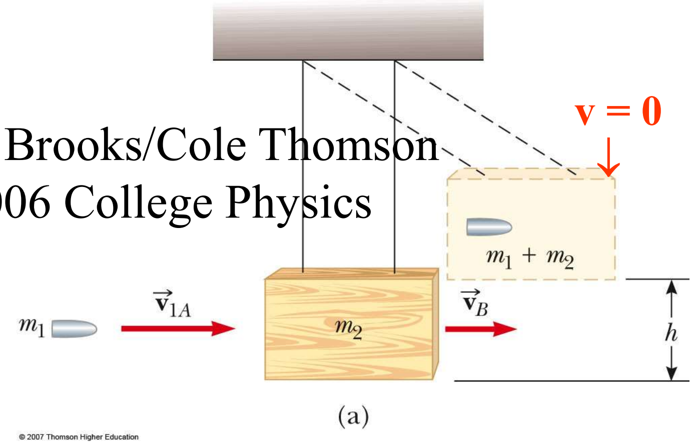
HOLDS for *ALL* collisions

- **Total Kinetic energy (KE) is conserved for** ***ELASTIC COLLISIONS ONLY*!!**
- ***Inelastic Collisions*** ≡ Collisions which are ***NOT*** elastic.
- Is KE conserved for Inelastic Collisions? ***NO*** Is momentum conserved for Inelastic Collisions?

  YES (**Rule 1**: Momentum is ***ALWAYS*** conserved in a collision!).
- ***Special Case*****:** **Perfectly Inelastic Collisions** ≡ Inelastic collisions in which the 2 objects collide and ***stick together***.
- ***KE IS NOT CONSERVED FOR THESE!!***

Example 9.6 Ballistic Pendulum

- Bullet, mass $\mathbf{m_1}$, shot with velocity $\mathbf{v_{1A}}$ into a block, mass $\mathbf{m_2}$. Inelastic collision! Swing up together until stopping at height $\mathbf{h}$ above bottom. High speed camera & measurement gives $\mathbf{h}$. Given $\mathbf{h}$, determine the $\mathbf{v_{1A}}$ of bullet.



Momentum Conservation: $\mathbf{m_1 v_{1A} = (m_1 + m_2) v_B}$

$$\Rightarrow \quad \mathbf{v_B = (m_1 v_{1A})/(m_1 + m_2)}$$

Mechanical Energy Conservation:

$$\mathbf{(½)(m_1 + m_2)(v_B)^2 + 0 = 0 + (m_1 + m_2)gh}$$

$$\mathbf{\Rightarrow v_{1A} = [1 + (m_2/m_1)](2gh)^{½}}$$

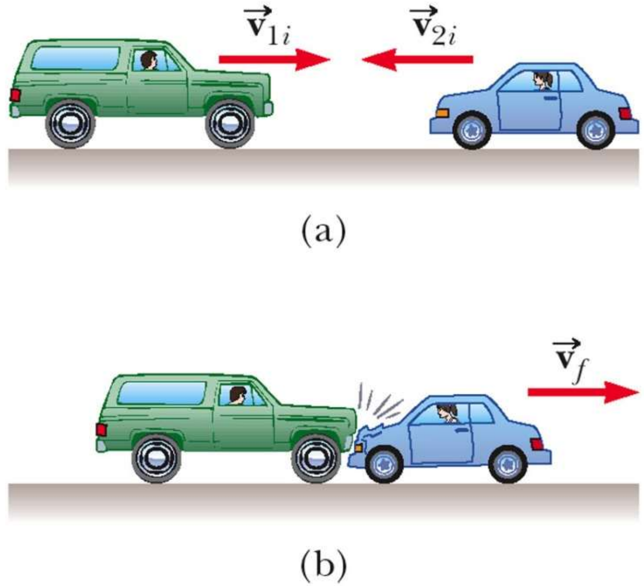
An SUV Versus a Compact

An SUV with mass 1.80×10^3 kg is travelling eastbound at +15.0 m/s, while a compact car with mass 9.00×10^2 kg is travelling westbound at -15.0 m/s. The cars collide head-on, becoming entangled.

Find the speed of the entangled cars after the collision.

Find the change in the velocity of each car.

Find the change in the kinetic energy of the system consisting of both cars.



An SUV Versus a Compact

Find the speed of the entangled cars after the collision.

$$m_1 = 1.80 \times 10^3 kg, v_{1i} = +15 m/s$$

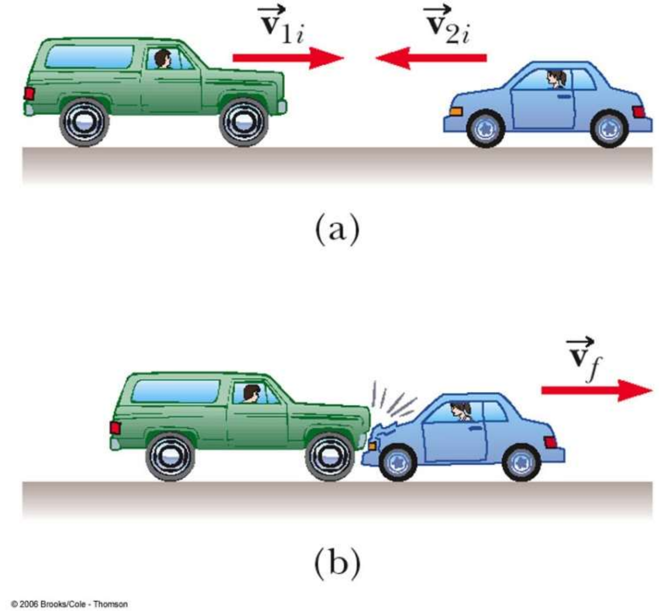
$$m_2 = 9.00 \times 10^2 kg, v_{2i} = -15 m/s$$

$$p_i = p_f$$

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2}$$

$$v_f = +5.00 m/s$$



An SUV Versus a Compact

Find the change in the kinetic energy of the system consisting of both cars.

$$m_1 = 1.80 \times 10^3 kg, v_{1i} = +15 m/s$$

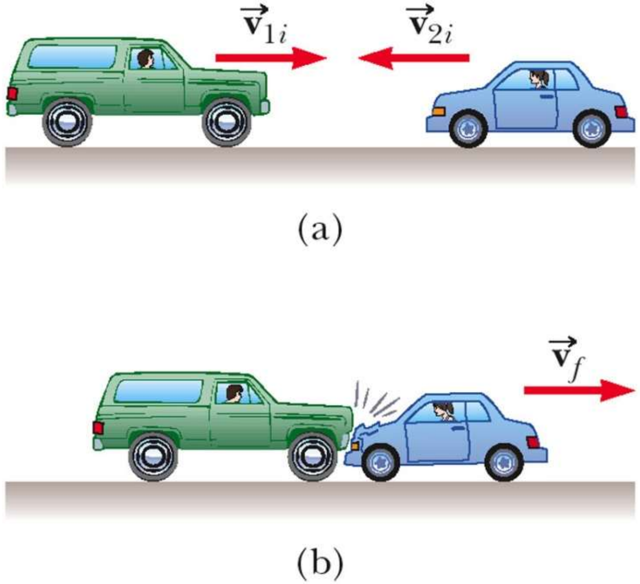
$$m_2 = 9.00 \times 10^2 kg, v_{2i} = -15 m/s$$

$$v_f = +5.00 m/s$$

$$KE_i = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = 3.04 \times 10^5 J$$

$$KE_f = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 = 3.38 \times 10^4 J$$

$$\Delta KE = KE_f - KE_i = -2.70 \times 10^5 J$$



Summary of Types of Collisions

- In an elastic collision, both momentum and kinetic energy are conserved

$$v_{1i} + v_{1f} = v_{2f} + v_{2i}$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

- In an inelastic collision, momentum is conserved but kinetic energy is not

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

- In a *perfectly* inelastic collision, momentum is conserved, kinetic energy is not, and the two objects stick together after the collision, so their final velocities are the same

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$