LECTURE 6.2 – INELASTIC COLLISIONS

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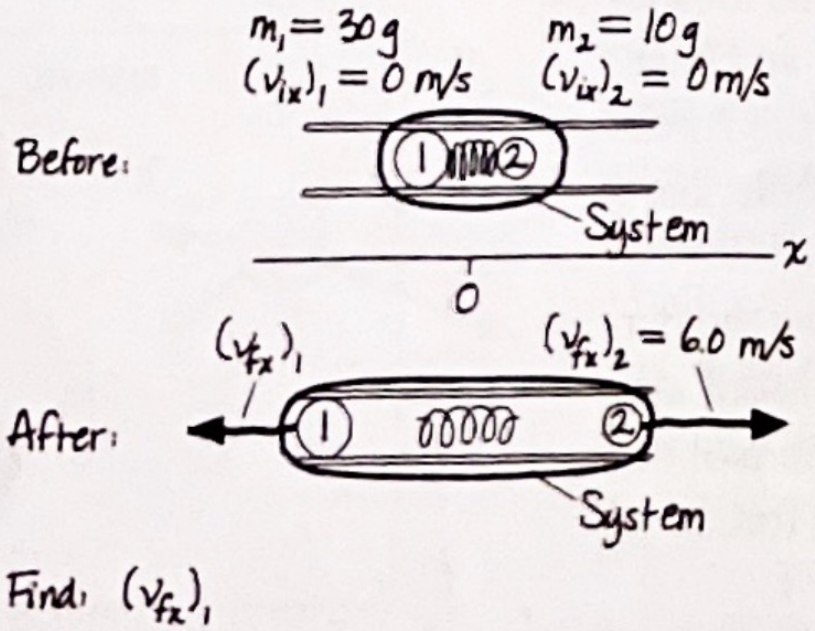
EXAMPLE 9.3 **Two balls shot from a tube**

A 10 g ball and a 30 g ball are placed in a tube with a massless compressed spring between them. When the spring is released, the 10 g ball flies out of the tube at a speed of 6.0 m/s. With what speed does the 30 g ball emerge from the other end?

MODEL The two balls are the system. The balls interact with each other, but they form an isolated system because, for each ball, the upward normal force of the tube balances the downward gravitational force to make $\vec{F}_{net} = \vec{0}$. Thus the total momentum of the system is conserved.

FIGURE 9.15 Before-and-after pictorial representation for two balls shot out of a tube.



REVIEW (EXAMPLE #1)

Since the balls are initially at rest, $\vec{P}_i = \vec{0}$.

Therefore, $\vec{P}_f = \vec{0}$.

$$m_1 v_{i,1} + m_2 v_{i,2} = m_1 v_{f,1} + m_2 v_{f,2} = 0$$

Since the initial velocities are $0\,\frac{\mathrm{m}}{\mathrm{s}}$,

$$m_1 v_{f,1} + m_2 v_{f,2} = 0$$

$$v_{f,1} = -\frac{m_2}{m_1}\left(v_{f,2}\right) = -\frac{10\mathrm{g}}{30\mathrm{g}}\left(6.0\,\frac{\mathrm{m}}{\mathrm{s}}\right) = -2.0\,\frac{\mathrm{m}}{\mathrm{s}}$$

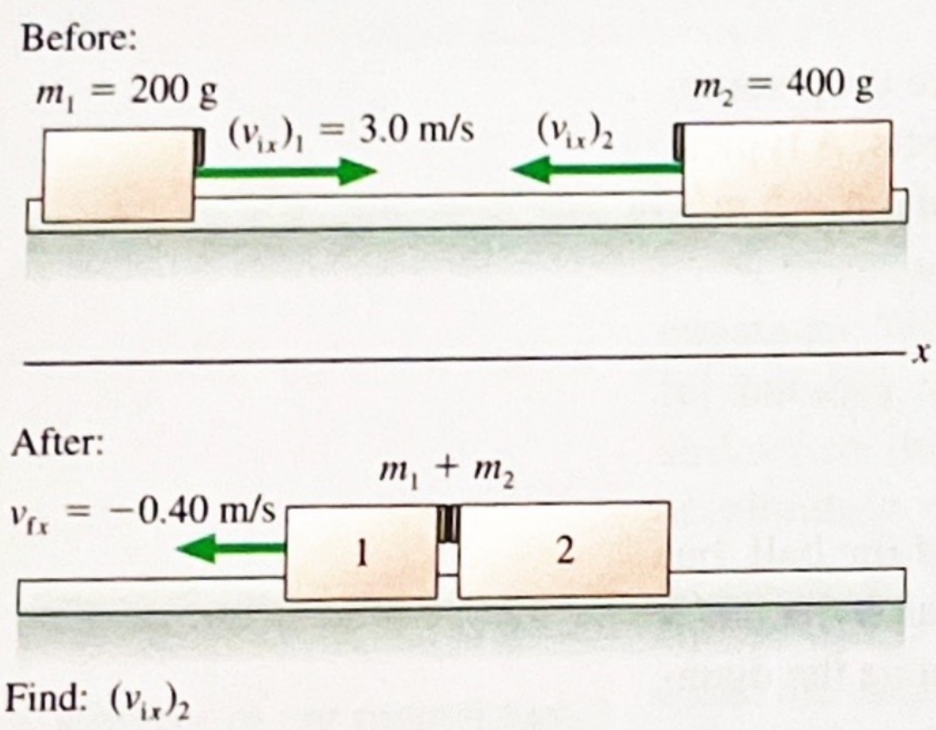
INELASTIC COLLISIONS

- A collision in which two (or more) objects stick together and move with a common final velocity is called a *perfectly inelastic collision*.
- A collision in which two (or more) objects bounce apart is called an *elastic collision*.

EXAMPLE 9.5 **An inelastic glider collision**

In a laboratory experiment, a 200 g air-track glider and a 400 g air-track glider are pushed toward each other from opposite ends of the track. The gliders have Velcro tabs on the front and will stick together when they collide. The 200 g glider is pushed with an initial speed of 3.0 m/s. The collision causes it to reverse direction at 0.40 m/s. What was the initial speed of the 400 g glider?

FIGURE 9.19 The before-and-after pictorial representation of an inelastic collision.



INELASTIC COLLISION (EXAMPLE #2)

From the Law of Conservation of Momentum: $P_i = P_f$

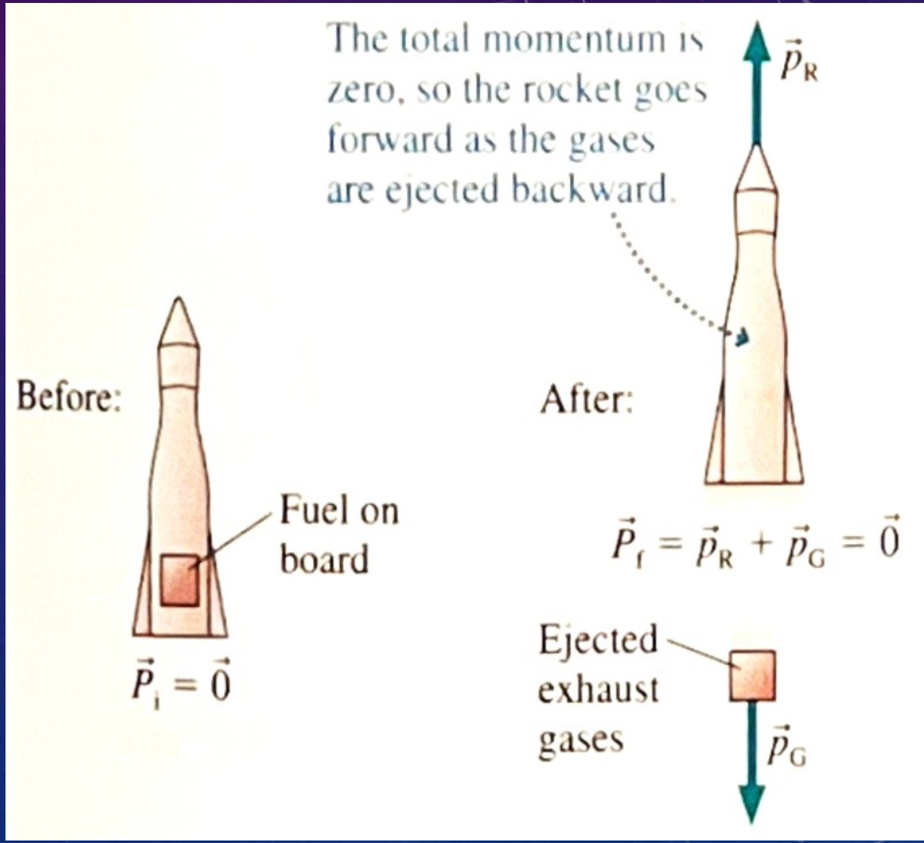
$$m_1 v_{i,1} + m_2 v_{i,2} = (m_1 + m_2) v_f$$

$$v_{i,2} = \frac{(m_1 + m_2) v_f - m_1 v_{i,1}}{m_2}$$

$$v_{i,2} = \frac{(0.2\text{kg} + 0.4\text{kg})\left(-0.4\,\frac{\text{m}}{\text{s}}\right) - (0.2\text{kg})\left(3.0\,\frac{\text{m}}{\text{s}}\right)}{0.4\text{kg}} = -2.1\,\frac{\text{m}}{\text{s}}$$

EXPLOSIONS

- Particles of a system moving apart from each other after a brief interaction is an *explosion*.
- Explosive forces are *internal* forces. This could be from an expanding spring, expanding hot gases, etc.
- If the system is isolated, the total momentum will be conserved.
- In the example of rocket thrust, a rocket doesn’t push against anything external. The system includes the rocket AND the exhaust.



EXPLOSIONS (EXAMPLE #3)

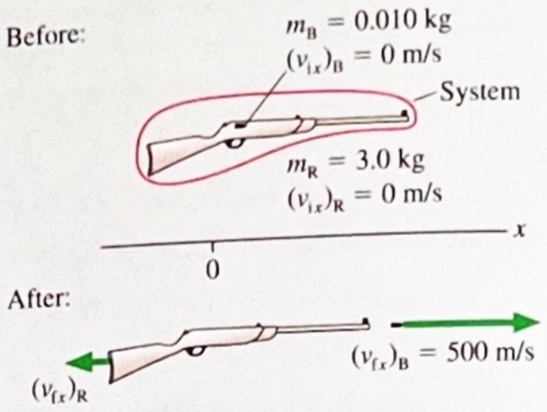
EXAMPLE 9.7 Recoil

A 10 g bullet is fired from a 3.0 kg rifle with a speed of 500 m/s. What is the recoil speed of the rifle?

MODEL A simple analysis would say that the rifle exerts a force on the bullet and the bullet, by Newton's third law, exerts a force on the rifle, causing the rifle to recoil. However, this is a little *too* simple. After all, the rifle has no means by which to exert a force on the bullet. Instead, the rifle causes a small mass of gunpowder to explode. The expanding gas then exerts forces on *both* the bullet and the rifle.

Let's define the system to be bullet + gas + rifle. The forces due to the expanding gas during the explosion are internal forces, within the system. Any friction forces between the bullet and the rifle as the bullet travels down the barrel are also internal forces. Gravity, the only external force, is balanced by the normal forces of the barrel on the bullet and the person holding the rifle, so $\vec{F}_{net} = \vec{0}$. This is an isolated system and the law of conservation of momentum applies.

FIGURE 9.21 Before-and-after pictorial representation of a rifle firing a bullet.



The initial momentum of the system is $\vec{P} = \vec{0}$. Since the system is considered isolated, $\vec{P_i} = \vec{P_f}$.

$$m_B v_{i,B} + m_R v_{i,R} = m_B v_{f,B} + m_R v_{f,R} = 0$$

$$v_{f,R} = -\frac{m_B}{m_R} v_{f,B} = -\left(\frac{0.010\text{kg}}{3.0\text{kg}}\right)\left(500\,\frac{\text{m}}{\text{s}}\right) = -1.7\,\frac{\text{m}}{\text{s}}$$