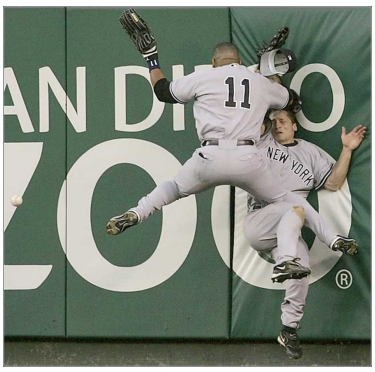
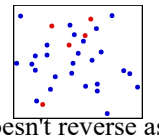
8.4 – Collisions



Types of Collisions

Elastic – Deformation occurs during collision, but objects spring back into shape afterwards.

Ex: Gas molecules, billiard balls.



Inelastic – Deformation occurs, but doesn't reverse as objects spring apart.
Objects might stick together.

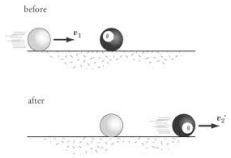
Ex: Crashing cars, clay thrown at a wall, bumper cars.

Momentum and Energy: Elastic Collisions

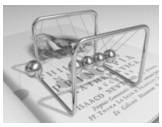
Momentum and kinetic energy are conserved.

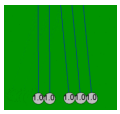
$$P_1 = P_2$$

$$K_1 = K_2$$



Newton's Cradle demo; track cradle demo.





Velocity of Elastic Collisions

Final velocities of elastic collisions:

Object 1: $$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{1_0} + \left(\frac{2m_2}{m_1 + m_2}\right)v_{2_0}$$

Object 2: $$v_2 = \left(\frac{2m_1}{m_1 + m_2}\right)v_{1_0} - \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{2_0}$$

These can be used for any two objects, but simplify if one is initially resting.

Depending on masses, objects can bounce backwards or be propelled forward with greater speed.

Massive Incoming Object

Consider a really massive ball hitting a much lighter resting one.

$m_1 >> m_2$:

$$v_1 \approx v_{1_0} \text{ and } v_2 \approx 2v_{1_0}$$

Bowling ball vs golf ball demo.

Light Incoming Object

Consider a really light ball hitting a much heavier resting (or moving) one.

$m_1 << m_2$:

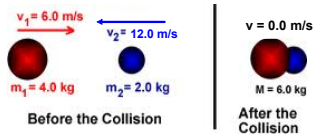
$$v_1 \approx -v_{1_0} \text{ and } v_2 \approx 0$$

Golf ball vs. bowling ball demo.

Momentum and Energy: Inelastic Collisions

Momentum is conserved, NOT kinetic energy.

Imagine two clay blobs with equal momentum colliding and sticking.



Net momentum was zero before, and zero afterward.

Kinetic energy was positive, now is zero: sound, frictional heat expend energy.

$$K_f < K_i$$

Momentum and Energy: Inelastic Collisions

Mathematically:

$$P_1 = P_2$$
$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$$

Also, if one object is stationary, the ratio of kinetic energy from initial to final conditions is:

$$\frac{K_f}{K_i} = \frac{m_1}{m_1 + m_2}$$

1. Inelastic Example

A 5.4 kg lump of clay traveling 8.0 m/s collides with a stationary 3.5 kg lump and sticks to it. How fast is the lump traveling after the collision?

$$P_1 = P_2$$

$$P_1 = m_1 v_1 + m_2 v_2 = 5.4\,kg \bullet 8.0\frac{m}{s} + 0\,kg\frac{m}{s} = 43.2\,kg\frac{m}{s}$$

$$P_1 = P_2 = (m_1 + m_2) v_2$$

$$v_2 = \frac{P_1}{(m_1 + m_2)} = \frac{43.2\,kg\frac{m}{s}}{5.4\,kg + 3.5\,kg} = 4.9\frac{m}{s}$$

2. Inelastic Example

A 6.2 kg blob traveling 7.5 m/s along the positive x-axis collides and sticks to a 4.5 kg blob going towards it at 14 m/s . What is the velocity afterwards?

$$P_1 = P_2$$

$$P_1 = m_1 v_1 + m_2 v_2 = 6.2\,kg \bullet 7.5\frac{m}{s} + 4.5\,kg \bullet -14\frac{m}{s} = -16.5\,kg\frac{m}{s}$$

$$P_1 = P_2 = (m_1 + m_2) v_2$$

$$v_2 = \frac{P_1}{(m_1 + m_2)} = \frac{-16.5\,kg\frac{m}{s}}{6.2\,kg + 4.5\,kg} = -1.5\frac{m}{s}$$

Homework

Read 6.5 in your book

8.4 Problems in your Booklet
Due: next class