Lesson 3: 1-D Conservation of Momentum

We can measure the momentum of any number of objects before and after they have a collision.

- A collision is when two or more objects strike each other, and exert a relatively large force during a relatively short period of time.
  - This force acting during a time period results in impulse.
- For now we will only look at how to figure out problems with two objects in a head-on collision, called either ***1 dimensional*** or ***linear*** collisions.
  - The objects must move in a straight line... they can ***not*** move off at any sort of angle.
- It was noticed in Newton's time that the **total momentum of all objects before** a collision equals the **total momentum of all objects after**.
  - This is true if the objects are acting in an **isolated system** (nothing entering or leaving) and there are **no external forces** acting on the objects.
- To this day the **Conservation of Momentum** remains a fundamental law of physics. Like all conservation laws, it essentially means whatever you started with you still have at the end.

Isolated: No **matter** or **energy** is allowed to enter or leave the system.
Closed: No **matter** is allowed to enter or leave the system. **Energy** can enter or leave.
Open: **Energy** and **matter** can enter or leave.

Before the Collision	***After the Collision***
momentum of object "a" = p_a	momentum of object "a" = p_a'
momentum of object "b" = p_b	momentum of object "b" = p_b'

So, a formula for two objects that collide would look like…

$$p_{total} = p_{total}'$$
$$p_a + p_b = p_a' + p_b'$$
$$m_a v_a + m_b v_b = m_a v_a' + m_b v_b'$$

Note: We will be using the symbol "*prime*" (a little tick like this **'**) to represent "*after the collision*."

You do have to be careful with how you solve these collision problems

- After the collision the two objects might bounce apart (**Example 1**)...
- ...or the objects might stick together (**Example 2**).

Example 1: Objects bounce apart

A 0.15kg blue billiard ball moving at 8.0m/s to the right hits a similar red billiard ball at rest. If the blue ball continues to move to the right at 2.5m/s, **determine** the velocity of the red ball.

$$p_{total} = p_{total}'$$
$$p_b + p_r = p_b' + p_r'$$
$$m_b v_b + m_r v_r = m_b v_b' + m_r v_r'$$
$$0.15kg(8.0m/s) + 0.15kg(0m/s) = 0.15kg(2.5m/s) + 0.15kg(v_r')$$
$$v_r' = 5.5m/s \text{ [right]}$$

Example 2: Objects stick together
Two balls of clay, a blue one being 2.3kg and the second red one being 5.6kg, hit each other and stick together. If the blue one was moving to the right at 12m/s, and the red was moving at 8.1m/s to the left, **determine** their final velocity.

Since the two lumps are stuck together, you add the masses together after the collision. Also, since they are one big lump now, they must have the same velocity, so you only have v'.

$$p_{total} = p_{total}'$$
$$p_b + p_r = p_b' + p_r'$$
$$m_b v_b + m_r v_r = m_b v_b' + m_r v_r'$$
$$m_b v_b + m_r v_r = v' (m_b + m_r)$$
$$2.3kg (+12m/s) + 5.6kg (-8.1m/s) = v` (2.3kg + 5.6kg)$$
$$v' = - 2.2 \text{ m/s [left]}$$

Example 2 (sticking together) showed a situation where the two objects stick together after hitting each other.

- This is a very common sort of question, since it could involve objects like two train cars colliding and then locking together afterwards.
- It is also possible for two objects to be stuck together at the start, and then go apart afterwards.
  - If this happens you'd just have to reverse the left and right hand sides of the formula.

Homework

p476 #2
p477 #2
p478 #1
p479 #2