Momentum and Simple 1D Collisions

Go to Linville.ca, select **Computer Simulations** on the left side, then click on **Science 20 Simulations** and choose

Collisions and Momentum. Click on Run Now! when you are re-directed to the simulation.

Introduction: When objects move, they have *momentum*. **Momentum, p, is simply the product of an object's mass (kg) and its velocity (m/s).** The unit for momentum, p, is kg•m/s. Velocity to the right is positive, left is negative.
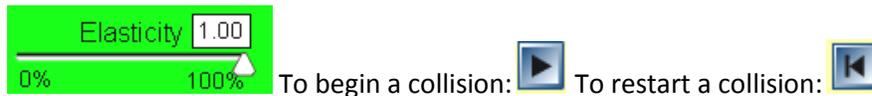
Important Formulas:

Hit and rebound:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

Hit and stick:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}_{1\text{ and }2}'$$

Hit and rebound (bounce)collisions

Set the elasticity control to the 100% setting to make the collisions hit and bounce.

Elasticity 1.00

0%   100%   To begin a collision: ▶ To restart a collision: ◀

1. Investigate the action of a **more-massive moving object striking a less-massive target object**. Press the

   More Data button to select the masses and velocities of the objects, increase the red mass to 5.00 kg.

Ball	Mass kg	Position m	Velocity m/s	Momentum kg m/s
1	0.50	1.00	1.00	0.50
2	1.50	2.00	0.00	0.00

Less Data

Set the velocity control to make the red object move at 1.00 m/s and the green object to be stationary.

- What is the total momentum **before** the collision?

- What is the total momentum **after** the collision?

- What happens to the more-massive object after the collisions?

- What happens to the less-massive target object after the collision?

2. Investigate the action of a **less-massive moving object striking a more-massive stationary target object**.
   o What is the total momentum **before** the collision?

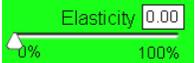
   o What is the total momentum **after** the collision?

   o What happens to the less-massive object?

   o What happens to the more-massive target object?

- Use the simulation to complete the table below.

m_1	m_2	v_1	v_2	p_{total}	v_1'	v_2'
1.20 kg	1.20 kg	+1.50 m/s	-1.80 m/s			
2.40 kg	4.80 kg	+1.30 m/s	0.0 m/s			
2.50 kg	3.90 kg	+4.00 m/s	+2.850 m/s			

3. Change the masses to 2.00 kg each, give the red mass a velocity of 3.00 m/s right and the green mass 3.00 m/s left (-3.00 m/s). Describe the velocity of each mass after the collision.

Hit and Stick Collisions: Slide the Elasticity control to 0% Elasticity 0.00 0% 100% More Data To begin a collision: ▶

To restart a collision: ◀|

4. Make the red mass 2.00 kg and the green mass 1.00 kg. Set the velocity control to make the red object move at 1.00 m/s and the green object to be stationary.
   - What is the total momentum **before** the collision?

   - What is the total momentum **after** the collision?

   - What happens to the more-massive object?

   - What happens to the less-massive target object?

5. Make the red mass 2.00 kg and the green mass 8.00 kg. Set the velocity control to make the red object move at 1.00 m/s and the green object to be stationary.
   - What is the total momentum **before** the collision?

   - What is the total momentum **after** the collision?

   - What happens to the more-massive object?

   - What happens to the less-massive target object?

6. Change the masses to 2.00 kg each, give the red mass a velocity of 3.00 m/s right and the green mass 3.00 m/s left (-3.00 m/s). Describe the velocity of each mass after the collision.

Use the simulation to complete the table below.

m₁	m₂	v₁	v₂	p_total	v₁₂'
1.20 kg	1.20 kg	+1.50 m/s	-1.80 m/s		
2.40 kg	4.80 kg	+1.30 m/s	0.00 m/s		
1.50 kg	5.50 kg	+3.20 m/s	+0.800 m/s		

Conclusion Questions:

1. A 500 gram cart moving at 0.360 m/s to the right collides with a wall and bounces back with a velocity of 0.240 m/s left, what is its change in momentum?

2. A 0.230 kg baseball is thrown with a speed of 41 m/s. What is the ball's momentum?

3. Imagine you are ice skating with your BFF. Both of you at rest, when you shove him/her away from you. You have a mass of 65.0 kg and he/she has a mass of 55.0kg. When you shove off, you move away with a velocity of 2.00 m/s. With what velocity does your BFF move away from you?

4. If a 250 gram cart moving to the right with a velocity of +0.31 m/s collides inelastically with a 500 gram cart traveling to the left with a velocity of -0.22 m/s, what is the total momentum of the system before the collision?

5. What is the resulting velocity of the above two-car system (stuck together)?

6. A 9.0 kg bowling ball races down the lane at 15 m/s before striking a bowling pin (at rest) with a mass of 0.85 kg. If the 0.85 kg pin bounces backward with a velocity of 45 m/s, what is the velocity of the bowling ball after the collision?