Investigation 11C: Elastic collisions

Essential question: How can we predict the outcome of an elastic collision?

Part 1: Simulation of Elastic collisions between balls

In this interactive simulation a green rubber ball collides with a stationary red rubber ball in a model of a perfectly elastic collision. Both balls may move after the collision. Investigate what happens when the balls have the same or different masses.

1. Run the simulation for the mass combinations listed for the green and red balls.
2. For each combination record the masses and initial and final values for velocities, p_{total} and $E_{k\ total}$. in Table 1 below. Let $v_1 = 2$ m/s.

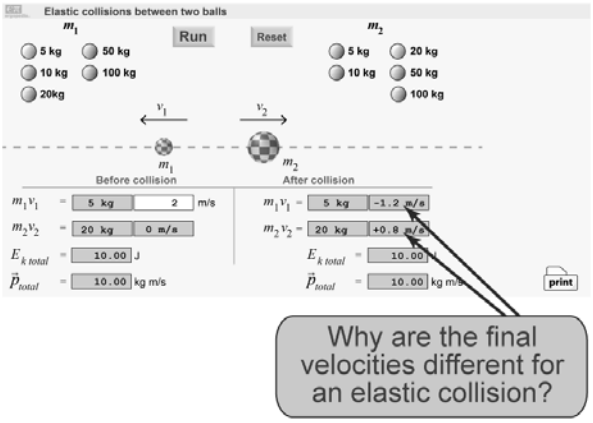


Table 1: Elastic collision results

Before collision						After collision					
m_1 (kg)	v_1 (m/s)	m_2 (kg)	v_2 (m/s)	p_{tot} (kg m/s)	E_{tot} (J)	m_1 (kg)	v_1 (m/s)	m_2 (kg)	v_2 (m/s)	p_{tot} (kg m/s)	E_{tot} (J)
5	2	5	0			5		5			
10	2	5	0			10		5			
50	2	5	0			50		5			
5	2	10	0			5		10			
5	2	50	0			5		50			

Questions

a. Describe the velocities before and after the collision when: the masses are equal; the green ball has less mass; the green ball has more mass.

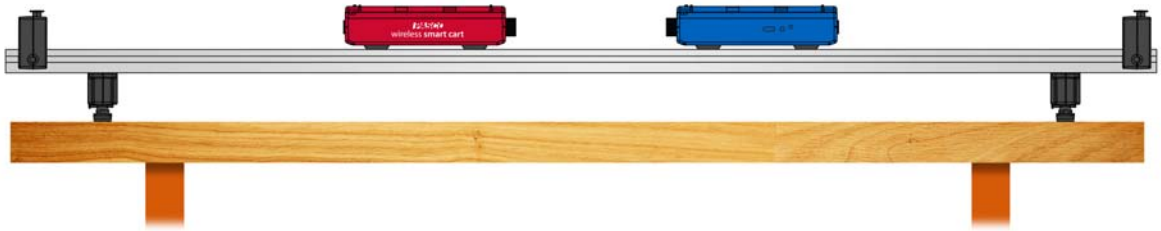
b. If this had been an inelastic collision investigation, how would your E_{tot} values in Table 1 be different?

c. As a result of the collision, does the total momentum of the system increase, decrease, or remain the same? Does the total kinetic energy increase, decrease, or remain the same?

Part 2: Elastic collisions between carts

How well can a physical experiment approximate a perfectly elastic collision? A collision between two carts is nearly elastic, but not completely. In this experiment, you will push a red Smart Cart into a stationary blue Smart Cart and explore how the total kinetic energy and momentum of this system is affected by a collision between the carts, and how it compares to the simulation.

1. Attach a magnetic bumper to the front of each cart, and then set a red cart and a blue cart on a level track with the magnetic bumpers facing each other, as shown. Adjust the track feet to make sure the track is as level as possible.



2. Open the experiment file **11C_ElasticCollisions**, and then power-on the Smart Carts and connect them to your computer using Bluetooth.
3. Begin collecting data, gently pushing the red cart toward the blue cart allowing them to collide. Stop recording data once carts have collided.
4. Use your software to find the velocity of each cart before and after the collision.
5. Run the experiment for different combinations of masses for the two carts (0.25 kg = mass of empty cart) adding cart masses as necessary. Use Table 2 to record the velocities for each run.
6. Calculate the total system momentum and kinetic energy before and after each collision. Record the values in your table and examine the table for patterns.

Table 2: Elastic collision results

Before collision						**After collision**					
m_1 (kg)	v_1 (m/s)	m_2 (kg)	v_2 (m/s)	p_{tot} (kg m/s)	E_{tot} (J)	m_1 (kg)	v_1 (m/s)	m_2 (kg)	v_2 (m/s)	p_{tot} (kg m/s)	E_{tot} (J)
0.25		0.25	0			0.25		0.25			
0.25		0.75	0			0.25		0.75			
0.75		0.25	0			0.75		0.25			

Questions

a. Describe the velocities before and after the collision when: the cart masses are equal; the blue cart has more mass; the red cart has more mass.

b. As a result of the collision, does the total momentum of the system increase, decrease, or remain the same? Does the total kinetic energy increase, decrease, or remain the same?

c. How does the physical experiment differ from the interactive investigation? Does this make sense? Why or why not?

Applying new knowledge

1. Define what is meant by an elastic collision. How does it differ from an inelastic collision?

2. A 10 kg ball moving at +3.0 m/s strikes a stationary 10 kg ball. If the collision is elastic, then what are the velocities of the two balls after the collision?

3. A 1.0 kg ball moving at +1.0 m/s strikes a stationary 3.0 kg ball. After the collision, the two balls stick together and move at +0.25 m/s. Was the collision elastic? Show your work and explain your answer.

4. A 3.0 kg puck moving at +2.0 m/s strikes a stationary 2.0 kg puck. After the collision, the 3.0 kg puck has a velocity of +0.40 m/s.

   a. Use conservation of momentum to find the velocity of the 2.0 kg puck after the collision.

   b. Was the collision elastic? Show your work and explain your answer.