Online Lab: Conservation of Momentum

Name: Date:

Instructor: Section:

Objective:

Elastic and inelastic collisions are performed with two carts of different masses. In both cases, momentum is conserved. The total kinetic energy before and after the collision is also studied.

Theory:

The momentum of either a cart depends on its mass and velocity is defined as:

$$p = mv \tag{1}$$

The direction of the momentum is the same as the direction of the velocity. During a collision, the total momentum of the system of two objects cart is conserved because the net force on the cart system is zero. This means that the total momentum just before the collision is equal to the total momentum just after the collision. If the momentum of one cart decreases, the momentum of the other cart increases by the same amount. This is true regardless of the type of collision, and even in cases where kinetic energy is not conserved. The law of conservation of momentum is stated as

$$\vec{p}_{TotalBeforeCollision} = \vec{p}_{TotalAfterCollision} \tag{2}$$

The kinetic energy of a cart also depends on its mass and speed but kinetic energy is a scalar.

$$KE = \frac{1}{2}mv^2 \tag{3}$$

The total kinetic energy of the system of two carts is found by adding the kinetic energies of the individual carts.

1. **Fill in the Blank**. Choose from the given words below the correct word that matches the definition for each of the Conservation of Momentum property below.

   Each word is only used ONCE.

Conservation of Energy	Conservation of Momentum		
Elastic Collision	Inelastic Collision	negative	positivwe

   (a) _____ states that when no net external force acts on a system, the total momentum of the system remains constant in time.

   (b) _____ states that the total energy of an isolated system remains constant, the total energy of the system remains conserved over time.

   (c) _____ are collisions in which energy is not conserved.

   (d) _____ are collisions in which energy is conserved.

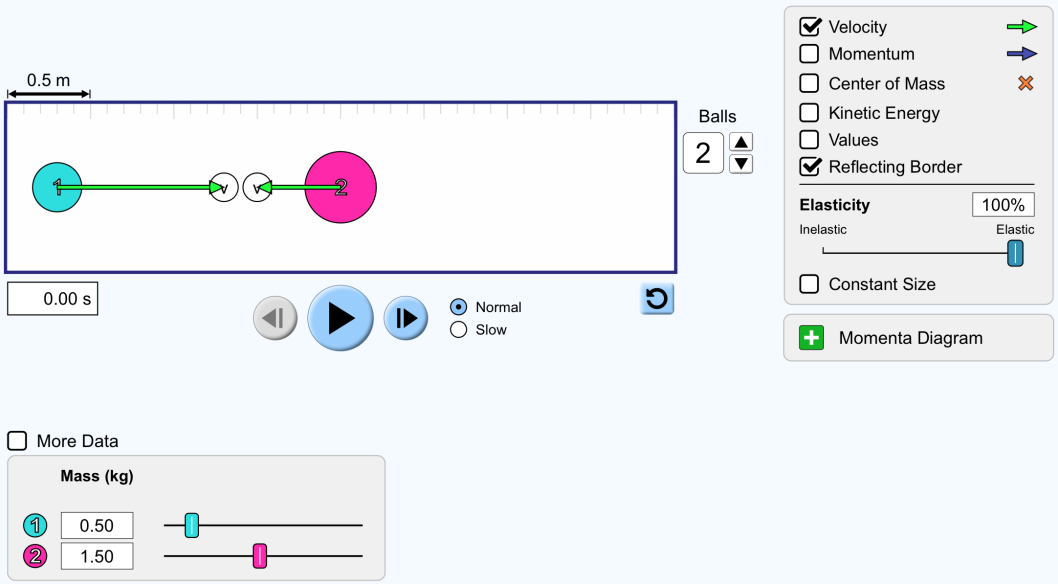
   (e) Velocity vectors represent the direction of travel. A _____ sign points left.

   (f) Velocity vectors represent the direction of travel. A _____ sign points right.

Online Conservation of Momentum Instructions: Elastic Collisions

1. Go to the following website:
   https://phet.colorado.edu/sims/html/collision-lab/latest/collision-lab_en.html

2. Click **Intro** on the bottom of the simulation.
   The figure below shows what you should see on your screen



3. Check the **More Data** box. Record the masses (m_1 and m_2) and the initial values of velocity (v_{i_1}, v_{i_2}) and momentum (p_{i_1}, p_{i_2}).

More Data

	Mass (kg)	Position (m) x	Velocity (m/s) v_x	Momentum (kg m/s) p_x
1	0.50	-1.70	1.00	0.50
2	1.50	0.00	-0.50	-0.75

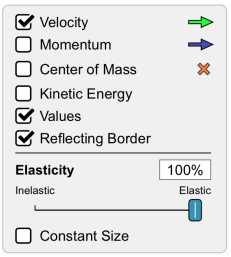
4. Change the mode to **Slow** and Click **Play.** Click Stop after balls collide.

5. Record the final velocities (v_{f_1}, v_{f_2}) and momentum (p_{f_1}, p_{f_2}).

More Data

	Mass (kg)	Position (m) x	Velocity (m/s) v_x	Momentum (kg m/s) p_x
1	0.50	-1.38	-1.25	-0.63
2	1.50	-0.33	0.25	0.38

Conservation of Momentum: Elastic Collisions



1. Setup the Simulator with the following settings.
   (a) Check the **Show Values** box (see Control Panel to the Right.)
   (b) Check the **Velocity Vectors** box (see Control Panel to the Right.)
   (c) Set the **Elasticity to 100%** so the arrow is directly above the word "Elastic".
2. **For each of the mass set values in the Elastic collisions Table of your Lab Report, Record the initial velocities (v_{i_1}, v_{i_2}) and momentum (p_1, p_2)** in Table 1.
3. **Start** the collision by hitting the **Play Button**
4. **PAUSE** the collision just after the balls collide.
5. **Record** the final velocities (v_{f_1}, v_{f_2}) and momentum (p'_1, p'_2) in Table 1.
6. **Calculate** the initial and final Kinetic Energies (KE_i, KE_f) for each mass set. Record these values in Table 2.
7. **Calculate** the total momentum before and after the collision ($p_1 + p_2$) and ($p'_1 + p'_2$) for each mass set. Record these values in Table 2.

Table 1: Conservation of Momentum

m_1 (kg)	m_2 (kg)	v_{i_1} (m/s)	v_{i_2} (m/s)	p_1 $(kg\ m/s)$	p_2 $(kg\ m/s)$	v_{f_1} (m/s)	v_{f_2} (m/s)	p'_1 $(kg\ m/s)$	p'_2 $(kg\ m/s)$
0.5	1.5								
3.0	1.5								
3.0	3.0								

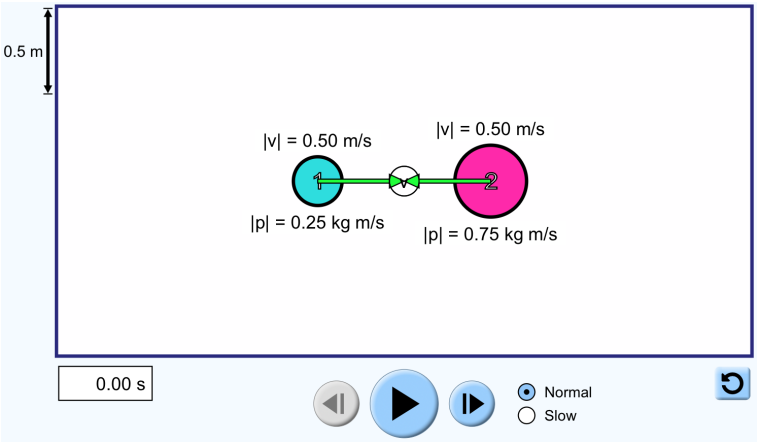
Table 2: Total Momentum and Kinetic Energy

m_1 (kg)	m_2 (kg)	$\vec{p}_{TotalBeforeCollision}$ $p_1 + p_2$ $(kg\ m/s)$	$\vec{p}_{TotalAfterCollision}$ $p'_1 + p'_2$ $(kg\ m/s)$	KE_i (J)	KE_f (J)
0.5	1.5				
3.0	1.5				
3.0	3.0				

Online Conservation of Momentum Instructions: Inelastic Collisions

1. Click **Intro** on the bottom of the simulation.
2. Change the ball arrangement to the 3rd option. **Slow** so the balls collide head on.

3. The figure below shows what you should see on your screen



4. Check the **More Data** box. Record the masses (m_1 and m_2) and the initial values of velocity (v_{i_1}, v_{i_2}) and momentum (p_{i_1}, p_{i_2}).
NOTE: We are only interested in the x-direction v_x and p_x.

More Data

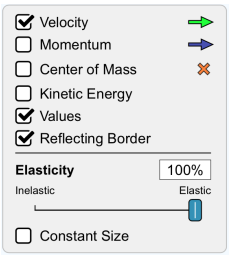
	Mass (kg)	Position (m)		Velocity (m/s)		Momentum (kg m/s)	
		x	y	v_x	v_y	p_x	p_y
1	0.50	-0.50	0.00	0.50	0.00	0.25	0.00
2	1.50	0.50	0.00	-0.50	0.00	-0.75	0.00

5. Change the mode to **Slow** and Click **Play.** Click Stop after balls collide.
6. Record the final velocities (v_{f_1}, v_{f_2}) and momentum (p_{f_1}, p_{f_2}).

More Data

	Mass (kg)	Position (m)		Velocity (m/s)		Momentum (kg m/s)	
		x	y	v_x	v_y	p_x	p_y
1	0.50	-0.43	0.00	-0.25	0.00	-0.13	0.00
2	1.50	-0.06	0.00	-0.25	0.00	-0.38	0.00

Conservation of Momentum: Inelastic Collisions



1. Setup the Simulator with the following settings.
   (a) Check the **Show Values** box (see Control Panel to the Right.)
   (b) Check the **Velocity Vectors** box (see Control Panel to the Right.)
   (c) Set the **Elasticity to 0%** so the slider is directly below the word "Inelastic".
2. **For each of the mass set values in Table in your Lab Report, Record the initial velocities (v_{i_1}, v_{i_2}) and momentum (p_1, p_2)** in the Table.
3. **Start** the collision by hitting the **Play Button**
4. **PAUSE** the collision just after the balls collide.
5. **Record** the final velocities (v_{f_1}, v_{f_2}) and momentum (p'_1, p'_2) in the Table.
6. **Calculate** the initial and final Kinetic Energies (KE_i, KE_f) for each mass set. Record these values in the table provided in your lab report.

Table 3: Conservation of Momentum

m_1 (kg)	m_2 (kg)	v_{i_1} (m/s)	v_{i_2} (m/s)	p_1 $(kg\ m/s)$	p_2 $(kg\ m/s)$	v_{f_1} (m/s)	v_{f_2} (m/s)	p'_1 $(kg\ m/s)$	p'_2 $(kg\ m/s)$
0.5	1.5								
3.0	1.5								
3.0	3.0								

Table 4: Total Momentum and Kinetic Energy

m_1 (kg)	m_2 (kg)	$\vec{p}_{TotalBeforeCollision}$ $p_1 + p_2$ $(kg\ m/s)$	$\vec{p}_{TotalAfterCollision}$ $p'_1 + p'_2$ $(kg\ m/s)$	KE_i (J)	KE_f (J)
0.5	1.5				
3.0	1.5				
3.0	3.0				

Conclusions: Elastic

1. Calculate the change in Kinetic Energy ($\Delta E_K = KE_f$ - KE_i) during the collision.

2. What can you conclude about the Law of Conservation of Momentum and Conservation of Energy for Elastic Collisions?

Conclusions: Inelastic

1. Calculate the change in Kinetic Energy ($\Delta E_K = KE_f$ - KE_i) during the collision.

2. What can you conclude about the Law of Conservation of Momentum and Conservation of Energy for Inelastic Collisions?