Simulation Worksheet: Collisions in One Dimension

Name: _____ Date: _____

Background:

The momentum of an object of mass *m* and velocity $\vec{v}$ is $\vec{p} = m\vec{v}$.

For a one-dimensional collision between two objects of mass m_1 and m_2, conservation of momentum means that:

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

where i and f denote the initial (before collision) and final (after collision) states.

The elasticity of a collision is defined as: $k = \frac{v_{2f} - v_{1f}}{v_{1i} - v_{2i}}$

The kinetic energy of an object is: $E_K = \frac{1}{2}mv^2$

Exercise 1. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 1.0.

	Initial velocity	**Initial momentum**	**Initial kinetic energy**
Mass 1 = 1 kg	+1 m/s	+1 kg m/s	0.5 J
Mass 2 = 1 kg	-1 m/s	-1 kg m/s	0.5 J
Totals	----------	0	1.0 J

	Final velocity	**Final momentum**	**Final kinetic energy**
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 1 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Exercise 2. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 1.0. The only change from exercise 1 is the mass of ball 2.

	Initial velocity	Initial momentum	Initial kinetic energy
Mass 1 = 1 kg	+1 m/s	+1 kg m/s	0.5 J
Mass 2 = 3 kg	-1 m/s	-3 kg m/s	1.5 J
Totals	----------	-2 kg m/s	2.0 J

	Final velocity	Final momentum	Final kinetic energy
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 3 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Exercise 3. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 1.0. The only change from exercise 2 is the mass of ball 2.

	Initial velocity	Initial momentum	Initial kinetic energy
Mass 1 = 1 kg	+1 m/s	kg m/s	J
Mass 2 = 5 kg	-1 m/s	kg m/s	J
Totals	----------	kg m/s	J

	Final velocity	Final momentum	Final kinetic energy
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 5 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Exercise 4. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 0.0. ← Note this! The only change from exercise 1 is the elasticity value.

	Initial velocity	Initial momentum	Initial kinetic energy
Mass 1 = 1 kg	+1 m/s	+1 kg m/s	0.5 J
Mass 2 = 1 kg	-1 m/s	-1 kg m/s	0.5 J
Totals	----------	0	1.0 J

	Final velocity	Final momentum	Final kinetic energy
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 1 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Exercise 5. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 0.0. ← Note this! The only change from exercise 3 is the elasticity value.

	Initial velocity	Initial momentum	Initial kinetic energy
Mass 1 = 1 kg	+1 m/s	kg m/s	J
Mass 2 = 5 kg	-1 m/s	kg m/s	J
Totals	----------	kg m/s	J

	Final velocity	Final momentum	Final kinetic energy
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 5 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Exercise 6. Use the following settings with the simulation, and then see if you can predict the values of the velocities after the collision. Set the elasticity to 0.5. ← Note this! The only change from exercise 5 is the elasticity value.

Hint: use the momentum conservation equation and the elasticity equation to give you two equations that allow you to solve for the two unknowns.

	Initial velocity	**Initial momentum**	**Initial kinetic energy**
Mass 1 = 1 kg	+1 m/s	kg m/s	J
Mass 2 = 5 kg	-1 m/s	kg m/s	J
Totals	----------	kg m/s	J

	Final velocity	**Final momentum**	**Final kinetic energy**
Mass 1 = 1 kg	m/s	kg m/s	J
Mass 2 = 5 kg	m/s	kg m/s	J
Totals	----------	kg m/s	J

Is momentum conserved here? [ ] yes [ ] no

Is kinetic energy conserved here? [ ] yes [ ] no

Try various settings. Under what conditions is momentum conserved in these collisions? (In other words, under what conditions is the total momentum the same before and after the collision?) Is this consistent with the law of conservation of momentum, which states that the total momentum of a system is conserved unless the system is acted upon by a net external force?

Under what conditions is kinetic energy conserved in these collisions?