Elastic and Inelastic Collisions

Objectives

In this lab you will

- test the Laws of Conservation of Momentum and Energy as they apply to one- and two-dimensional collisions.
- use the *Exploration of Physics*™ software to simulate the collision of two pucks.

Equipment

Exploration of Physics™ simulation software.

Theory

The (linear) momentum of an object of mass m moving with velocity $\boldsymbol{v}$ is given by $\boldsymbol{p} = m\boldsymbol{v}$. If there is more that one object present in the system, the total (linear) momentum is simply equals the vector sum of the individual momenta: $m_1\mathbf{v_1} + m_2\mathbf{v_2} + \ldots$ The total mechanical energy of the system is the scalar sum of the individual energies: $E_1 + E_2 + \ldots$ The Law of Conservation of Linear Momentum states that the total linear momentum of a system of objects is conserved only if the net external force acting on the system is zero. The Law of Conservation of Mechanical Energy states that the total mechanical energy E is conserved only if there are no non-conservative forces acting on the system.

Specifically, in a system consisting of two objects of momenta $\boldsymbol{p}^{red}$ and $\boldsymbol{p}^{blue}$, the Law of Conservation of Linear Momentum may be expressed as $(\boldsymbol{p}^{red} + \boldsymbol{p}^{blue})_i = (\boldsymbol{p}^{red} + \boldsymbol{p}^{blue})_f$ where subscript i indicates the initial value and f indicates the final value of the total momentum. Similarly, the Law of Conservation of Mechanical Energy may be expressed as $(K^{red} + K^{blue})_i = (K^{red} + K^{blue})_f$ where we have assumed that only the kinetic energy changes in the system. *Elastic* collisions conserve both momentum and energy; *inelastic* collisions conserve only momentum.

Procedure

Set-Up and Data Collection

1) Open the *Exploration of Physics*™ program on your computer. Click on "Motion" and then click on "2D collisions." Familiarize yourself with the software.

2) The masses of the pucks can be changed by adjusting the two slide bars at the top of the left column (see Figure 1 below). To move a particular puck, right click on it and drag it wherever you wish. To change its initial velocity, click on its initial velocity arrow and stretch it to make a larger velocity.

3) The "coefficient of restitution" slide bar determines how elastic you wish to make the collision: 0 = perfectly inelastic and 1 = perfectly elastic.
4) If you wish to view the full trail of the collision in pause mode, check the circle "CM Trail On/Off".

5) To run the simulation click on "Play." Use "Stop" button to restart from the beginning.

6) "Pause" whenever you want to record the velocities after collision. The time, position, and velocity components are displayed. Note that the x-component of velocity is positive (+) whenever the mass moves to the right and the y-component is (+) whenever it moves upward. Otherwise these two components are (–). Be sure to record the signs in your data tables.

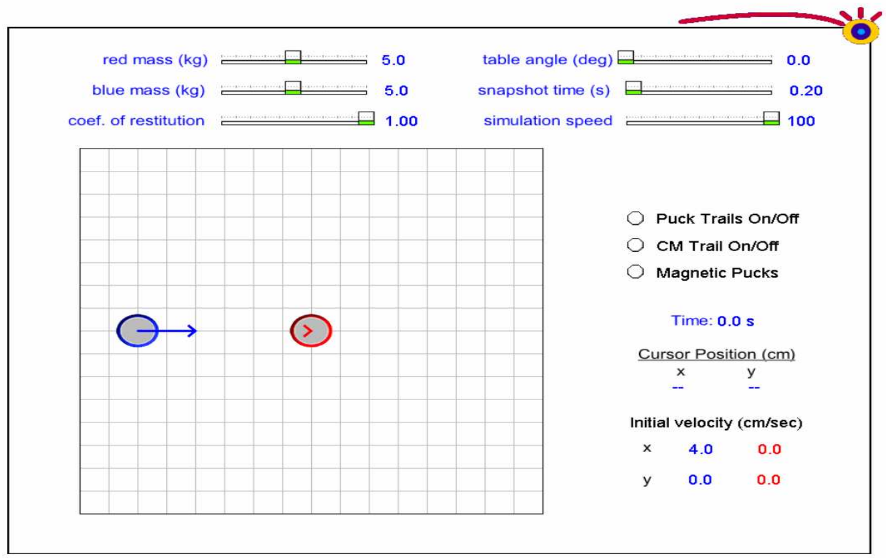

Figure 1

Each student is required to submit a completed data sheet in order to receive full credit.

Data Sheet – Elastic and Inelastic Collisions

Name ____ Date ______________

Partners' Names ____

Case 1: Elastic Head-on, Equal Masses, Stationary Target (Red)

Set $m^{blue} = m^{red} = 5$ kg Coefficient of restitution = 1

	INITIAL			**FINAL**		
	velocity	momentum	kinetic en.	velocity	momentum	kinetic en.
Blue	4 cm/s					
Red	0					
TOTAL						

Is the total velocity conserved in this case? Explain your answer.

Is the total momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.

Case 2: Inelastic Head-on, Equal Masses, Stationary Target (Red)

Set $m^{blue} = m^{red} = 5$ kg Coefficient of restitution = 0

	INITIAL			**FINAL**		
	velocity	momentum	kinetic en.	velocity	momentum	kinetic en.
Blue	4 cm/s					
Red	0					
TOTAL						

Is the total velocity conserved in this case? Explain your answer.

Is the total momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.

Case 3: Elastic Head-on, Unequal Masses, Stationary Target (Red)

Set $m^{blue} = 0.1$ kg, $m^{red} = 10$ kg Coefficient of restitution = 1

	INITIAL			**FINAL**		
	velocity	momentum	kinetic en.	velocity	momentum	kinetic en.
Blue	5 cm/s					
Red	0					
TOTAL						

Is the total velocity conserved in this case? Explain your answer.

Is the total momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.

Case 4: Elastic Head-on, Unequal Masses, Stationary Target (Red)

Set $m^{blue} = 5$ kg, $m^{red} = 10$ kg Coefficient of restitution = 1

	INITIAL			**FINAL**		
	velocity	momentum	kinetic en.	velocity	momentum	kinetic en.
Blue	4 cm/s					
Red	0					
TOTAL						

Is the total velocity conserved in this case? Explain your answer.

Is the total momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.

Case 5: Elastic Head-on, Equal Masses, Moving Target (Red)

Set $m^{blue} = m^{red} = 5$ kg Coefficient of restitution = 1

	INITIAL			FINAL		
	velocity	momentum	kinetic en.	velocity	momentum	kinetic en.
Blue	4 cm/s					
Red	-2 cm/s					
TOTAL						

Is the total velocity conserved in this case? Explain your answer.

Is the total momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.

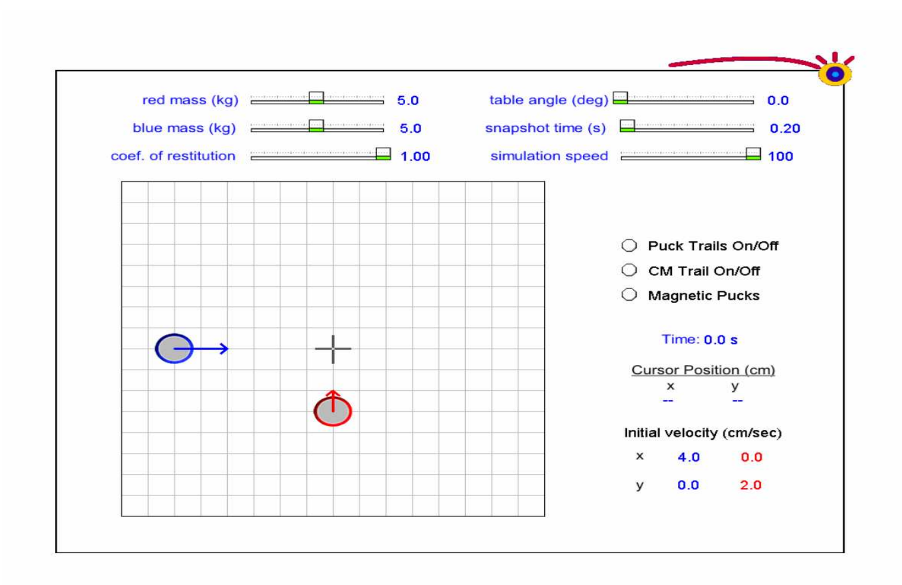

Figure 2

Case 6: 2-d Elastic Head-on, Equal Masses, Moving Target

Set up the pucks as shown in Figure 2.

Set $m^{blue} = m^{red} = 5$ kg Coefficient of restitution = 1

Initial Data:

	x-velocity	y-velocity	x-momentum	y-momentum	kinetic energy
Blue	4 cm/s	0			
Red	0	2 cm/s			
TOTAL					

Final Data:

	x-velocity	y-velocity	x-momentum	y-momentum	kinetic energy
Blue					
Red					
TOTAL					

Is the total x momentum conserved in this case? Explain your answer.

Is the total y momentum conserved in this case? Explain your answer.

Is the total kinetic energy conserved in this case? Explain your answer.