You must participate in the lab; otherwise, the lab report will not be accepted.

Conservation of Linear Momentum

Do not print out the instruction page(s). Do not copy and paste the sentences on this page to your report.

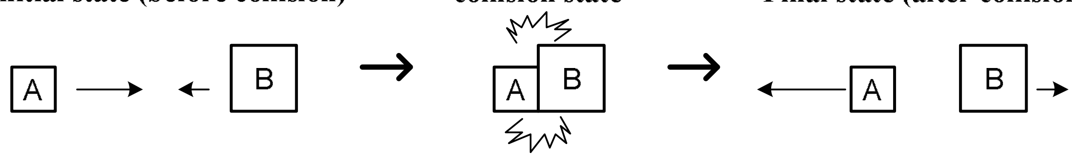
Equations and keywords

Momentum is a physical quantity which expresses an object moving at a constant velocity:

$$\vec{p} = m\vec{v}$$

Momentum is a vector and the direction is also taken into account. Momentum is conserved in the event of collision. The following equation expresses that the initial total momentum is equal to the final total momentum:

Initial state (before collision) **collision state** **Final state (after collision)**



$$m_A\vec{v}_A^{\,\text{ini}} + m_B\vec{v}_B^{\,\text{ini}} = m_A\vec{v}_A^{\,\text{fin}} + m_B\vec{v}_B^{\,\text{fin}}$$

The total momentum is always conserved with a constant velocity; however, the conservation of kinetic energy depends on how they collide. If the collision is perfectly elastic, kinetic energy is conserved. However, if not, such as deformation and cohesion of the objects, the certain amount of energy is lost. This is called inelastic collision.

Objectives:

- To learn and verify conservation of linear momentum
- To see the differences of elastic and inelastic collisions in terms of conservation laws of momentum and energy

Procedure:

❶ Go at the web page: http://phet.colorado.edu/sims/collision-lab/collision-lab_en.html Use the introduction.

❷ When you click "Play", the motion of collision starts. Click "Pause" after collision.

❸ Click "Restart" if you use the same input data.

❹ Click "Reset All" to reset all of the data to start a new simulation.

❺ Click "More Data" to see velocities and other values.

❻ All of the data taken are entered in the designated Excel file. Change the conditions as indicated; read the final velocities; and necessary physical quantities are calculated by the spread sheet.

Lab report:
Do not print out the Excel spread sheet, but show them to instructor before you leave the lab. Complete questions in the question sheet. Then, attach them to your introduction and discussion to submit as a report.

Question sheet for Conservation of Linear Momentum

Name ______________________________________Sign from instructor ______________

To have instructor's signature, fill out and calculate the tables in simulation I and simulations V, VI, and VII.

Simulation I (Varying with mass)

Fill out the data of the first four columns from the Excel sheet and calculate total of the initial and final momenta (last two columns). [Note that the units of momentum are kg·m/s.]

p_{1i}	p_{2i}	p_{1f}	p_{2f}	$p_{1i} + p_{2i}$	$p_{1f} + p_{2f}$

- Question 1: Is the momentum above conserved? Why do you conclude so?

- Question 2: How does the total momentum change as the mass increases?

Simulation II (Varying with speed 1: Small hits large)

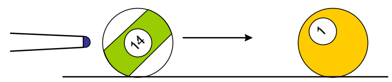
- Question 1: Is the momentum for this part conserved? (You do not need to show all of the calculation, but make sure if it is conserved for each trial.)

- Question 2: Find any tendency or interesting discovery from the data set. (Write at least one.)

Simulation III (Varying with speed 2: Equal mass collision)

- Question 1: Is the momentum for this part conserved? (You do not need to show all of the calculation, but make sure if it is conserved for each trial.)

- Question 2: By observing the data for the total of initial and final momenta in this simulation, how do you describe it in collision with equal masses? Think about the collision with billiard balls.



Simulation IV (Varying with speed 3: Large hits small)

- Question 1: Is the momentum for this part conserved? (You do not need to show all of the calculation, but make sure if it is conserved for each trial.)

- Question 2: Find any tendency or interesting discovery from the data set. (Write at least one.)

Simulation V (Varying with elasticity 1: Small hits large)

- Question 1: Is the momentum for this part conserved? (You do not need to show all of the calculation, but make sure if it is conserved for each trial.)

- Question 2: Read the data of KE_i (Initial total kinetic energy) and KE_f (Final total kinetic energy) in the spread sheet. Is the energy for this part conserved? (The condition of conservation is that $KE_i = KE_f$.)

Simulation V, VI, and VII (Inelastic collision)

- Question 1: Is it true that all of simulations here indicate that momentum is always conserved while the energy is lost due to diminishing the elasticity?

Fill out the following data from the spread sheet and calculate the percentage of energy lost. The elasticity is 100% for the first trial and decreasing by 25% each until 0. [Note that the unit of energy is J; and multiply 100 by $|KE_i - KE_f|/KE_i$ to obtain the percentage.]

Also make sure the values are based on the following equations:

$$KE_i = \tfrac{1}{2} m_1 v_{1i}^2 + \tfrac{1}{2} m_2 v_{2i}^2 \text{; and } KE_f = \tfrac{1}{2} m_1 v_{1f}^2 + \tfrac{1}{2} m_2 v_{2f}^2$$

Simulation V				Simulation VI				Simulation VII		
KE_i	KE_f	$\frac{\lvert KE_i - KE_f \rvert}{KE_i}$		KE_i	KE_f	$\frac{\lvert KE_i - KE_f \rvert}{KE_i}$		KE_i	KE_f	$\frac{\lvert KE_i - KE_f \rvert}{KE_i}$

- Question 2: How does each case (small-hits-large / equal-mass-collision / large-hits-small) lose energy after collision with respect to elasticity? Do they make sense to you?

For the lab report

Print out this file except the first instruction page. You may type or write in the tables by pen or pencils. Attach your introduction, discussions and conclusion.