Lab 4: Conservation of Momentum in Collisions

Purpose

The purpose of this experiment is to show that momentum is conserved in collisions.

Introduction

When two carts collide with each other, the total momentum (**p = mv**) of both carts is conserved regardless of the type of collision. An elastic collision is one in which the two carts bounce off of each other with no loss of kinetic energy (accomplished in this lab by use of the carts' magnetic bumpers). A completely inelastic collision is one in which the two carts stick to each other (accomplished in this lab by use of the velcro patches on one side of the carts).

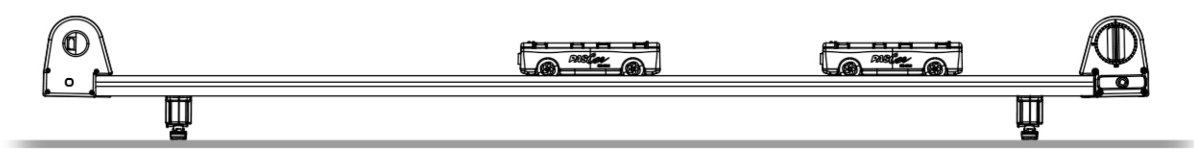
Regardless of the type of collision the total momentum of the system is always conserved and thus the equation below should hold.

$$P_{\text{intitial}} = P_{\text{final}}$$
$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'. \qquad \textbf{Eq. 1}$$

Procedure

1. Level the track by setting a cart on the track to see which way it rolls. Adjust the track legs until the cart placed at rest on the track will not move.

2. Place a black motion sensor on one end and a blue motion sensor on the other end.



3. Connect the blue motion sensor to the passport terminal and the black motion sensor to the digital terminals (yellow on 1 and black on 2) of the data collection interface.

4. On the SparkVue software create a new experiment with two graph displays: one graph display of velocity versus time for each motion sensor.

NOTE: The motion sensors are pointed in opposite directions. In this orientation, one sensor by default will measure positive velocity for an object moving left to right, while the other will measure negative velocity for the same object. **To make things easier on this lab you want to plot the absolute value of the velocity sensor readings.**

5. Create two new "User Defined Data" sources, one for each sensor. On the equation builder for the User Defined Data generator create the calculation "Velocity1 = abs([Velocity1])" where [Velocity1] is the velocity data measured by sensor 1. Do the same for the velocity from sensor 2.

6. Select the newly defined Velocity1 and Velocity2 for the vertical axis of your plots.

7. The motion sensors have a selector switch; make sure that they are in the cart mode.

PART 1: Inelastic Collisions

1. Perform each of the following inelastic collisions (make sure cars stick together!):

Equal Masses

a) Place one cart at rest in the middle of the track. Give the other cart an initial velocity toward the cart at rest.

Unequal Masses

Put one or two mass bars in one of the carts so that the mass of one cart is greater than the other cart. (Weigh the carts and record the masses in **Table 1**).

b) Place the lighter cart at rest in the middle of the track. Give the heavier cart an initial velocity toward the cart at rest.

c) Start the carts at opposite ends of the track at approximately the same speed toward each other.

PART 2: Elastic Collisions

2. Set up the carts so the magnetic ends or spring bumpers face each other, so the carts will repel each other when they collide. Repeat a) through c) in step 4 and record your data on **Table 2**.

Data Collection

Table 1. Inelastic Collisions

	M1	M2	V1 initial	V2 initial	V final (V1 final = V2 final)
a)					
b)					
c)					

Table 2. Elastic Collisions

	M1	M2	V1 initial	V2 initial	V1 final	V2 final
a)						
b)						
c)						

Analysis

For each of the cases, calculate the momentum before and after the collision using **Eq. 1** and record the results in **Tables 3** and **4**. For the **% difference** column use the following equation

$$\%\ \text{difference} = \frac{|p_{\text{total initial}} - p_{\text{total final}}|}{p_{\text{total initial}}} \times 100. \quad \textbf{Eq. 2}$$

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Table 3. Inelastic Collisions

	$p1_{initial}$ = $M1*V1_{initial}$	$p2_{initial}$ = $M2*V2_{initial}$	$P_{initial}$ = $(p1+p2)_{initial}$	P_{final} = $(M1+M2)\ V_{final}$	% difference
a)					
b)					
c)					

Table 4. Elastic Collisions

	$p1_{initial}$ = $M1*V1_{initial}$	$p2_{initial}$ = $M2*V2_{initial}$	$p1_{final}$ = $M1*V1_{final}$	$p2_{final}$ = $M2*V2_{final}$	$P_{initial}$= $p1+p2_{initial}$	P_{final}= $p1+p2_{final}$	% diff.
a)							
b)							
c)							

1. Was the momentum conserved in all your collisions? If not, in which cases it wasn't conserved and what was the % difference?

2. What factors do you think may cause for there to be a difference between the momentum before and the momentum after collisions?

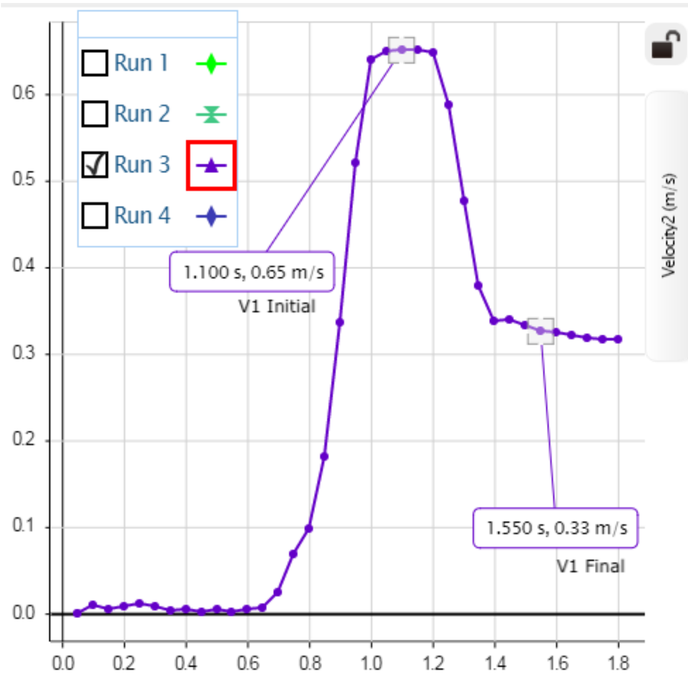
3. When two carts moving toward each other have the same mass and the same speed, they stop when they collide and stick together (inelastic collision). What happens to each cart's momentum? Is momentum conserved? Explain

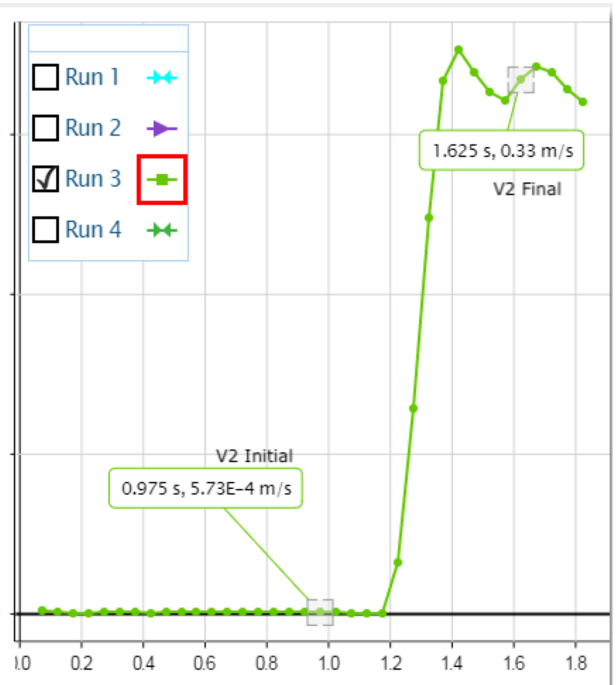
4. Kinetic energy is not conserved in inelastic collisions, where does this energy go?

Appendix: Example Raw Data

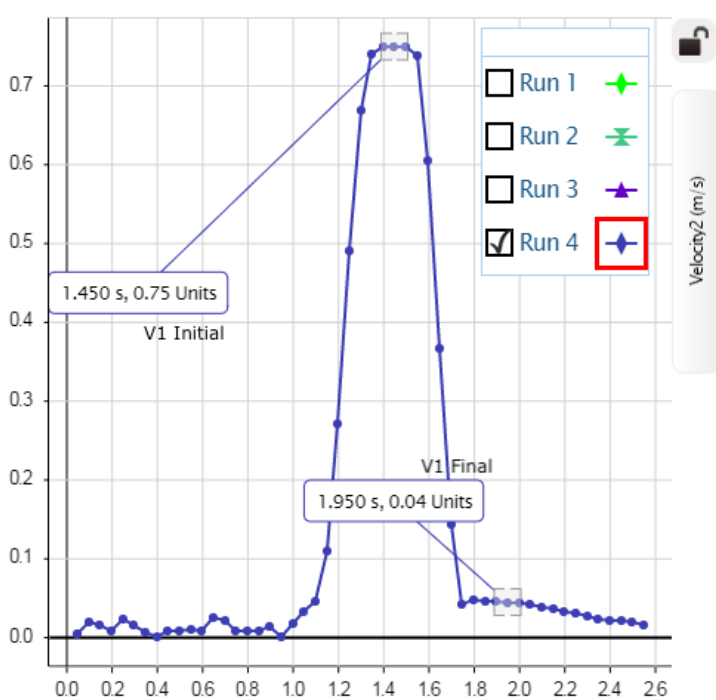
Use the following images as an example on how to read the raw data from SparkVue

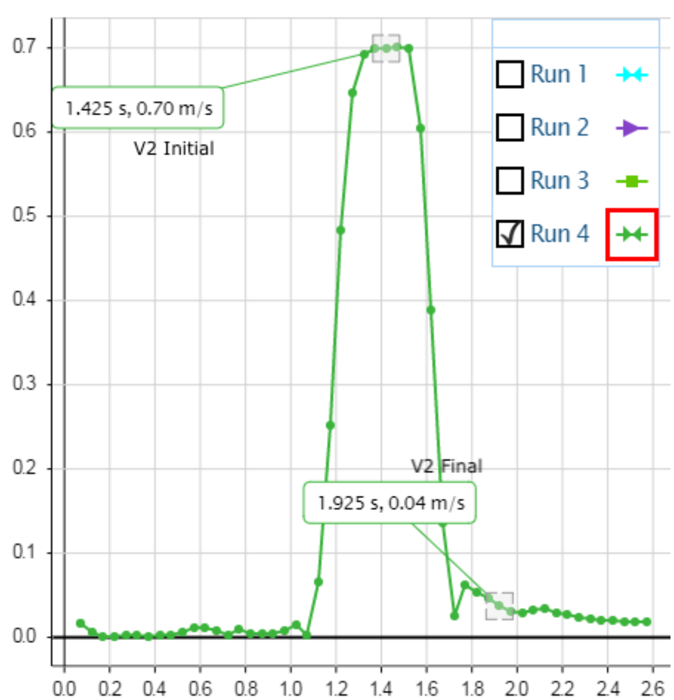
Inelastic with Cart2 Initially at rest. Similar to case a) on Part 1.



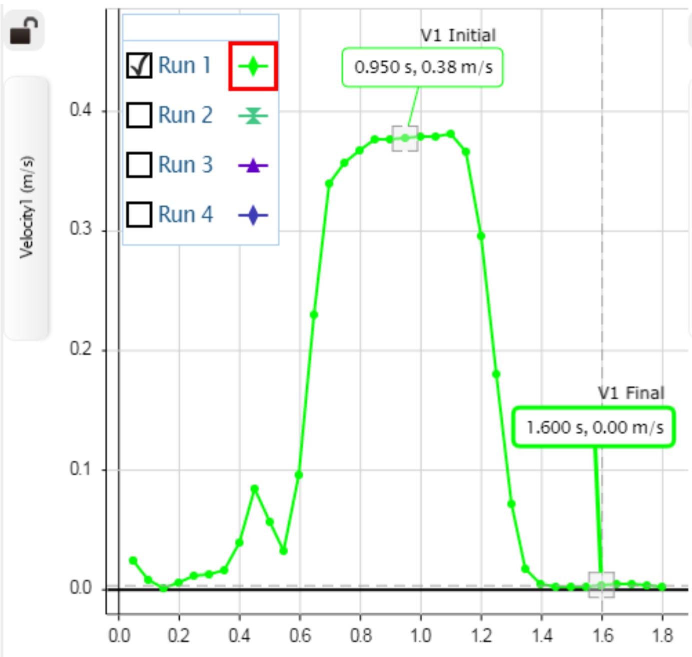


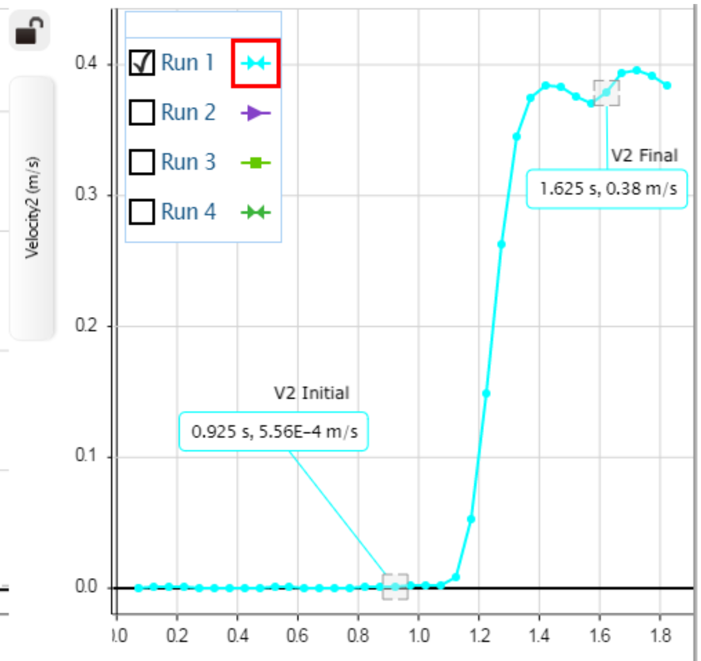
Inelastic with Cart1 and Cart2 initially in motion and bouncing from each other. Similar to b) and c) on Part 1.





Elastic with Cart2 initially at rest. Similar to case a) on Part 2.





Elastic with Cart1 and Cart2 initially in motion and bouncing from each other. Similar to case b) and c) on Part 2