P101 Lab: One Dimensional Collisions
Instructor: James Cutright

Instructions: Please do not write on this lab. Instead, everything that you do in the lab can be submitted as an excel sheet. Doing the calculations in this lab can be very repetitive: it is suggested that you collect your data directly on an excel spreadsheet, and then write excel equations to handle the data analysis. Each part should get its own sheet.

Equipment Needed:

Computer	850 Universal Interface
Aluminum Dynamics Cart with Plunger	Aluminum Dynamics Cart without Plunger
Aluminum Track	Black Dynamics Cart Weights
Scale	
2 Old Motion Sensors (Black) **or** 2 New Motion Sensors (Transparent Blue) (Notes: Don't take one of each. There is no program that can accommodate that. There is no real difference between old and new. The new ones are not any better.)	

Part 1: Inelastic Collisions

Theory: In this part of the lab you are going to use two dynamics carts to create an inelastic collision. In lecture we learned that kinetic energy is not conserved in an in-elastic collision, but momentum is, which means that:

$$\vec{P_0} = \vec{P_{A0}} + \vec{P_{B0}} = \vec{P_F} = \vec{P_{AF}} + \vec{P_{BF}}$$

Procedure: The plunger side of the cart does not have magnets in it. You can use that side and the Velcro on it to create inelastic collisions. Set up your motion sensors and track as shown below.
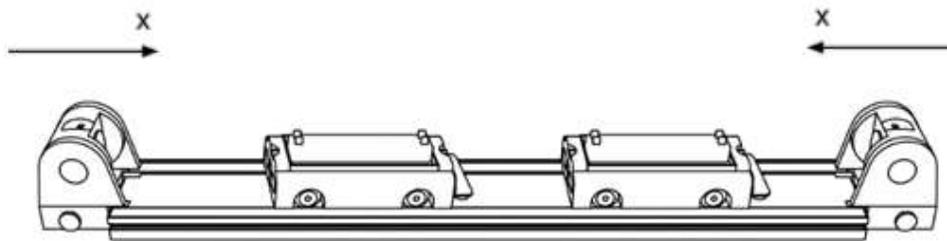
To Set up the Motion Sensors:
- Place the motion sensors at either end of the dynamics track facing inwards, as shown in the diagram above.
- Make sure to turn on the 850 Universal Interface.
- **Set up for the black motion sensors:** Connect the yellow cable for one to Port 1, and the black cable to Port 2. For the other detector, plug the yellow cable into Port 3, and the black cable into Port 4.

- **Set up for the blue motion sensors:** There is only one connection that you need to make for each detector. Connect the motion sensors to Pasport 1 and Pasport 2 (Large square ports).
- Check the motion detector setting (small switch on top): should be on the picture of a cart.
- Go to the google drive/labs/lab 8. In there you will find two programs called "PHYS101_Collisions_Old Sensors.cap" and "PHYS101_Collisions_New Sensors.cap". Download the old file if you are using the black sensors. The new file is for the blue sensors. Open the file that you downloaded.
- Test your system by hitting "Record". The motion sensors click when they are working. Move a cart around on the track, so you can see what the data looks like.
- Notice that in the diagram of the set up each motion sensor has its own coordinate system. You need to take this into account when you are using both sensors. An object with a positive velocity, according to one sensor, will have a negative velocity relative to the other. You should see this in the sample data that you took while moving the cart around.
- When you collect your data, it is important to pick one of the coordinate systems. Make sure you are consistent in your data taking. Do not switch back and forth between coordinate systems.
- There is sample data shown on the last pages of the lab. Those should help you figure out how to analyze your data and read the velocity vs time plots that the experiment generates.

Connections for two old motion sensors.

Connections for two new motion sensors.

Collecting Your Data

1) In part 1 of this lab you will perform 5 experiments that involve an inelastic collision. On the last page of this lab is a set of sample data. It shows you how to figure out the initial and final velocity of a cart using your motion sensor.
2) There are three suggested data tables given below. The top table is the data from the experiment. The bottom tables are for the analysis of the data.
3) The second table is for calculating the amount of momentum before and after the collision. Once you have that, you will want to find the difference between the values and the percent difference between the values. You will want to do the same thing for the third table, which is used to calculate the kinetic energy of the system.

Data Runs:

1) Have Cart B at rest, and run Cart A into it. Record your velocity data.
2) Put 1 or 2 black metal masses on top of Cart B, and run Cart A into it.
3) Remove the mass from Cart B, and put it into Cart A. Crash Cart A into Cart B.
4) Remove all the masses from the carts. Depress the plunger on the cart, and Velcro the carts together. Hit the switch on the plunger, so the carts explode apart.
5) Repeat part 4, but add a couple of masses to Cart B.

Run	Cart 1 (Plunger)			Cart 2 (Magnet)		
	V_0 (m/s)	$V_{f\,exp}$ (m/s)	Mass (kg)	V_0 (m/s)	$V_{f\,exp}$ (m/s)	Mass (kg)
Run 1						
Run 2						
Run 3						
Run 4						
Run 5						

Run	P_0(kgm/s)	P_f(kgm/s)	raw diff	% diff
Run 1				
Run 2				
Run 3				
Run 4				
Run 5				

Run	KE_0(J)	KF_f(J)	raw diff	% diff
Run 1				
Run 2				
Run 3				
Run 4				
Run 5				

Questions Part 1: Include the answers to your questions on your spreadsheet.
1) Is energy conserved in an inelastic collision? If not, where does the energy go?
2) Is momentum conserved in an inelastic collision?
3) How did the mass of the carts affect the outcome of the inelastic collisions?
4) You have observed 5 different inelastic collisions. Give a real-world example of each.
5) Explain how the motion sensors work. What is the speed of sound in air?

Part 2: Elastic Collisions

Theory: From class we learned that both kinetic energy and momentum are conserved in an elastic collision, which means the following, in principle, for the following experiments:

$$\vec{P_0} = \vec{P_{A0}} + \vec{P_{B0}} = \vec{P_F} = \vec{P_{AF}} + \vec{P_{BF}} \qquad KE_0 = KE_{A0} + KE_{B0} = KE_F = KE_{AF} + KE_{BF}$$

Procedure: In this part of the lab you will collect data in the same way that you did in Part 2. If you collide the side of the dynamics carts without a plunger, you should see the magnets inside repel, which will make the collision elastic. Create a data table like the one used in part 1.

Data Runs: (Note: There are 8 data runs for the elastic collisions)
1) Have Cart B at rest, and run Cart A into it. Record your velocity data.
2) Put a couple of masses on top of Cart B, and run Cart A into it.
3) Remove the mass from Cart B, and put it into Cart A. Crash Cart A into Cart B.
4) Remove all of the mass from the two carts. Have them run into each other head on.
5) Add a couple of masses to Cart B and repeat experiment 4.
6) Remove the masses from the two carts. Have Cart A rear-end Cart B while both carts are moving in the same direction.
7) Repeat 6, but put a lot of mass in Cart B.
8) Repeat 6 again, but remove the mass from Cart B, and put it in Cart A.

**Questions Part 2:** Include the answers to your questions on your spreadsheet.
1) Is energy conserved in an elastic collision? What about momentum?
2) How did the mass of the carts affect the outcome of the collisions?
3) Is there such a thing as a purely elastic collision? Does your data support your answer?
4) You have observed 8 different elastic collisions. Give a real-world example of each.

Sample Data

When you get your data, it won't look exactly like what is shown below. You may have to zoom in with your mouse cursor, to get a good look at the data. On the top ribbon of the graph is a small button labeled with a crosshair. You can add multiple coordinate tools to a graph. That is suggested, because it makes gathering data from a plot faster.

Reading the First Graph (In-Elastic Collision):

1) The velocity of the cart starts at zero.
2) The cart's velocity increases when I push on it. It eventually reaches some maximum value and coasts for a little bit.
3) The cart runs into another cart in-elastically. You can see this because the velocity of the cart suddenly decreases to a lower, but still positive, speed.
4) The velocity right at the beginning and end of the collision is what you are interested in. Make sure to use the coordinate tool to measure those.
5) At the end of the plot, I stop both carts with my hand.
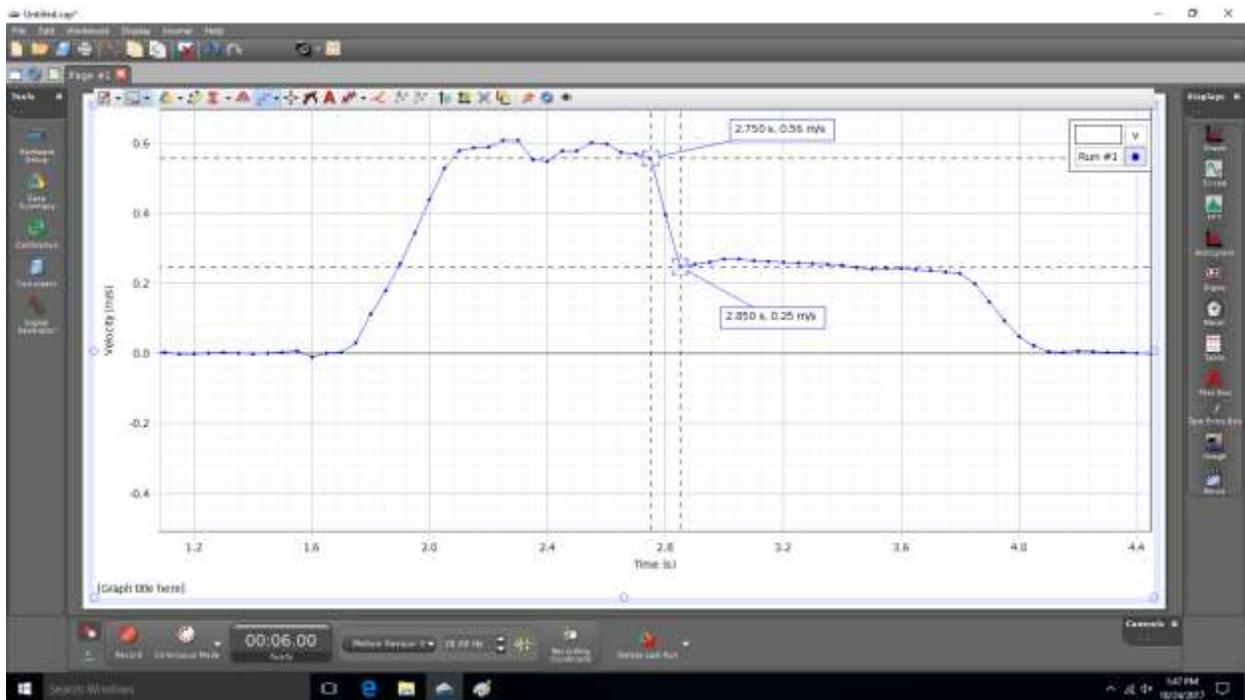
Reading the Second Graph (Elastic Collision):

1) In this case the carts bounce off of each other, so their final velocities are different. That means you need two plots.
2) For each cart you need to use the coordinates tool to find the initial and final velocity. Make sure you pay attention to the time when the collision occurs, so you can match up your velocity data.
3) You might notice that the motion sensors are out of sync. This happens because they turn on and off one after the other. It is okay if two of your data points are 0.005 seconds apart. More than that and the data will not be useable.