Crash, Boom, Bang!

Please read the entire lab write-up prior to starting so that you know what is expected of you.

Purpose:
In this activity you will investigate an aspect of motion called momentum. An object's momentum is a vector that is defined as the product of its mass and velocity. A system's momentum is the vector sum of the momenta of its parts. It is your goal to identify, experimentally, a relationship between a system's momentum before and after a particular interaction (for example, a system made up of two objects colliding). You will need to collect data and use it as evidence to support your claims about the relationship of the momentum before and after such an interaction.

Set-up:
For this activity you will need the linear track, two motion sensors, two Airlinks, two metal carts, one red plastic cart, four additional masses, and a bubble leveler. Set up the equipment as shown below (Fig. 1). Use the bubble leveler to check that the linear track is level so that a cart set on it does not readily move to one direction, adjust the legs of the track if necessary. Set the sensors to cart mode and adjust them so that they are pointed towards the carts.

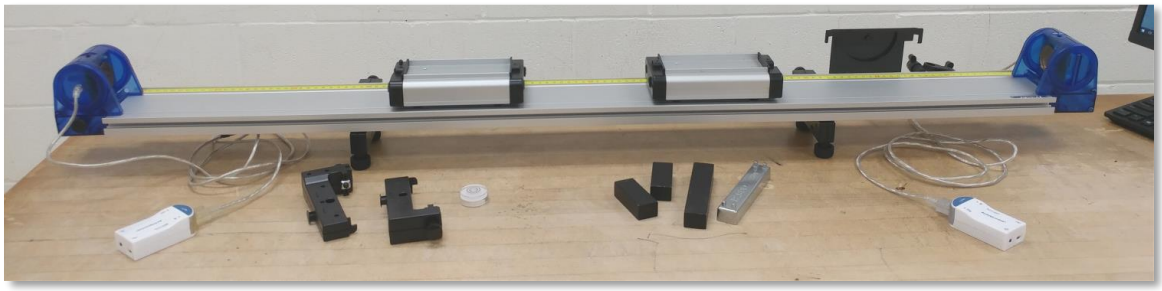

Fig. 1 - Momentum Equipment Setup

Attach the Airlinks to the motion sensors and get them linked to Capstone. Set the sampling rate to 100 Hz. Using 

and  tools, set up two velocity vs time graphs with a common time axis. Set one graph to record velocity readings from one motion sensor, then set the other graph to record readings from the second sensor. Make sure you can identify which graph (and which cart) is corresponding to each sensor reading. Since velocity is a vector, you may also need to establish +/- sign conventions and record the velocities accordingly for each interaction. Remember that the motion sensors do not collect accurate data until the cart is 15cm away. **CAUTION: Make sure the carts do not hit the sensors causing them to drop or fall to the floor.**

Activity:

In this experiment you will investigate three types of interactions which are described in Parts A, B and C. For each of type of interaction, you need to do the following:

- Collect data needed to verify and establish the relationship between a system's momentum before and after a particular interaction as stated in your goal. Do this for at least four different mass combinations by adding masses to one or both carts. Use the coordinate tool  on your Capstone graphs to identify the velocities that you need for your calculations.

- Label, record and organize your data in an easy to read data table in Excel with a title to reflect the type of interaction being investigated. Indicate quantities that should be negative. Perform all the calculations needed to establish your claim.
- Print the best graph obtained for this interaction with the points used for the calculations indicated. Make sure the type of interaction is identified on your printout.
- Print out a copy of the completed data table/s. Put the names of the members of your group on the printout.

Part A

Using the two metal carts, investigate what happens when the **two carts collide and stick together**. Do this using the ends of the carts having non-repelling magnets. Ensure that the Velcro tabs actually hold the two carts together, and make sure that the carts do not "jump" the track. Practice pushing the carts towards each other before you start recording.

Part B

For your second interaction again use the metal carts, however this time do not allow the carts to stick together. **The carts will collide but move separately after collision**. Make sure that the ends of the carts containing the repulsive magnets carts face one another. Ensure that the carts do not hit each other or "jump" the track. Again, practice setting the carts in motion before taking data.

Part C

For this third interaction you will use one metal cart and one plastic cart. **This time instead of having a collision we will have an explosion!** Arrange the carts so the plunger of the plastic cart is between the two carts. Be careful about setting the plunger with too much tension, as the recoiling cart may cause damage to the motion detectors. For this explosion set the carts in motion so that they stay in contact. While they are freely moving together down the track release the plunger with a gentle tap using a pencil to the trigger on top of the plastic cart. Do your best to not influence the motion of the carts when you release the plunger. Be sure to record data during this entire interaction. Practice releasing the plunger using the pencil before taking data.

Discussion/Questions:

1. For each interaction, how does the momentum of the system before the interaction compare to the momentum of the system after the interaction? Show a calculation (for each type of interaction) to illustrate and support your answer.

2. For each of the interaction types, how do the changes in the momentum of cart one compare to the changes in momentum of cart two? Again, show calculations (one calculation for each type of interaction) using your data to support your answer.

3. Determine the ratio of the system momentum before the interaction to the system momentum after the interaction. Do this for each mass combination for each interaction type. Determine the average and standard deviation of your ratios for each interaction type. Explain your results and any significant deviation from what you expect.