

# Modeling 1D Collisions

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## Learning Goals

By the end of this lab, you should be able to...

- Correctly apply the Law of Conservation of Momentum to collisions.
- Describe energy transformations that occur during a collision.

## Here's the Big Idea

At the most superficial level, in today's lab you will take measurements of a collision of your choice and perform analysis to see whether momentum and kinetic energy are conserved in the collision. At a deeper level, however, this lab gives you a chance to get some hands-on experience with modeling. Each of the collisions will be a model of a collision that could happen in real life. You'll get to show off your creative side as you decide what pieces of lab equipment you can use to model each real-life *object*. You will also get to put your imagination on display as you decide how your equipment will collide such that the real-life *interactions* are appropriately modeled on your lab bench.

**Q1**

**Question 1:** Perform the collisions of the two PASCO carts as described below and:

**Include in the Lab Work/Lab Participation document:**

### For each model

1. Identify the model, model 1 or model 2, which are described below (you will analyze both) and the specifics about the carts' masses.
2. A **velocity graph** from one trial.
  - a. Indicate the regions or points on the graph where the initial and final velocities were determined, immediately before and after the collision.
  - b. graph key - which car is represented by what graph/color
3. An explanation of how the graph is used to find the initial and final velocity for each object.
4. Vector diagram for model 1 with labels.
  - a. Momenta vectors and the resultant BEFORE collision.
  - b. Momenta vectors and the resultant AFTER collision.
  - c. Change of the momentum of the system vector.
5. Raw Data Tables *completed*.

6. Discrepancy Diagrams: (refer to [Everything About Plotting with Logger Pro](#) - Document Tutorial part 3 and [Taylor's reading](#), section 2.3)
  - a. For the momentum of the system (showing the change in momentum, including uncertainty)
  - b. For the kinetic energy of the system (showing the change in kinetic energy, including uncertainty). What is expected for model 2 for the change of kinetic energy?
7. Is the momentum of the system conserved during the collision? How do you know?
8. Is the kinetic energy of the system conserved during the collision? How do you know?
9. Is the collision elastic, inelastic, or neither? Why?
10. Describe any energy transformation that occurs during the collision.

### Models:

1) Collide two carts of *different masses*, originally B-D side moving towards each other (The carts will not make physical contact. Their magnets will repel each other).

**Note:** Do not let the two carts stick together after the collision!

Make sure side D has tapes over the velcro.

The plunger should be all the way IN. Don't let it trigger during the trials.

2) Two carts (masses of your choice), A-D side initially at rest and put close together (plunger all the way in), are sent in opposite directions (similar to an explosion).

### Useful Notes:

#### 1. Equipment

- Dynamics carts (one with sides A & B, one with sides C & D)
- Vernier motion sensors (cart setting)
- Cardboard box with weights
- Level

#### 2. Equipment Notes:

##### a. Carts

Your collisions will either be between two carts or between a cart and the box. Here's what happens when the various labeled ends of the carts collide. Feel free to test these out yourself.

- A-C (plunger all the way in) – The carts will stick together using Velcro.
- A-C (plunger all the way out) – That carts will bounce off of each other.
- A-C (plunger cocked) – The plunger will fire when the carts collide. (This is a little unreliable.)
- A-D (plunger all the way in) – The carts will bounce off of each other.
- A-D (plunger all the way out) – That carts will bounce off of each other.
- A-D (plunger cocked) – The plunger will fire when the carts collide. (This is a little unreliable.)
- B-C – The carts will not make physical contact. Their magnets will repel each other.
- B-D – The carts will not make physical contact. Their magnets will repel each other.

### b. Motion Sensors:

Make sure the motion sensors are on *cart* setting. This can be done by locating the Sensitivity Switch under the pivoting head.

### c. Logger Pro:

Use *Logger Pro Collisions Template* and download it from the module on Canvas. This template corrects for the fact that the two motion sensors are pointing in opposite directions. If you do not use the template, you must switch the direction of one of the sensors by:

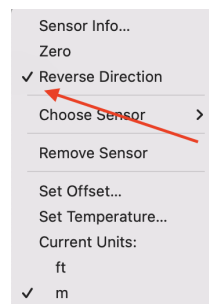
- Click on the sign that indicates the sensor on the top left corner of the Logger Pro screen.



- Locate Dig/Sonic 2 and click on the Motion Sensor picture.



- Select Reverse Direction. A check mark appears.



### 3. Vector Diagrams - only for model 1

- a. Add the momenta vectors of both carts and draw the resultant vector (momentum of the system) BEFORE collision. Use x-axis as a reference direction. While drawing to scale is not required, considering the respective length of each vector in relation to the other one (which one should be longer/shorter) would be helpful.
- b. Do the same for AFTER collision.
- c. Then, find the vector of the change of momentum,  $\Delta P$ .
- d. Labeling (remember that all quantities below are vectors. Their directions matter when finding the resultant vector):
  - i.  $p_{1i}$  - momentum of the first car *before* collision
  - ii.  $p_{2i}$  - momentum of the second car *before* collision
  - iii.  $P_i$  - momentum of the **system** *before* collision (capital  $P$ )
  - iv.  $p_{1f}$  - momentum of the first car *after* collision
  - v.  $p_{2f}$  - momentum of the second car *after* collision
  - vi.  $P_f$  - momentum of the **system** *after* collision (capital  $P$ )
  - vii.  $\Delta P$  - change of the momentum of the system (capital  $P$ )

### 4. Running the experiment and collecting data:

Measure the velocities of each piece of equipment **right before and right after the collision**.

When you turn the “Examine” tool on, a vertical line will appear on the plot. As you move your mouse, the vertical line will move. Logger Pro will display the y-value at which this vertical line intersects your data. That is, it gives an instantaneous velocity value. To turn on the “Examine”

tool, click .

Perform the collisions at least *six times* and collect the data using the motion detectors. Try to keep the initial velocities of both carts the same for your repeated trials.

Save only 2 runs in each Logger Pro file. Each model should have three files total. Then, each student (groups of three students) analyzes one file per model with two graphs recorded to find the velocities before and after the collision. The groups with two students should figure out how to split the work.

Use the Raw Data & Calculation Template posted in the Canvas module to organize your data and the calculations.



*Time to Clean Up!*

Please clean up your station according to the Station Cleanup! Slideshow found in the lab module.