

## Inelastic Collision Analysis Lab

### Teacher's Guide

**Topic:**

Momentum and Collisions

**The following information is provided to the student:**

**Question:**

What is the evidence that momentum is conserved in an inelastic collision between two carts? In what manner does the evidence support the law of momentum conservation?

**Purpose:**

To gather convincing evidence that total system momentum is conserved in an inelastic collision between two carts AND to describe how the evidence supports the law of momentum conservation.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include the provided table. One example calculation should be shown for each type of calculation. The Conclusion/Discussion should provide a thorough analysis of the results, identifying successful and unsuccessful trials; specific evidence from each trial which indicate success (or lack thereof) should be elaborated upon. Percent error or percent difference calculations should be performed and a complete error analysis included within the discussion.

**Materials Required:**

Two carts; accompanying masses; mass balance; track; computer-interfaced motion detectors.

**Description of Procedure:**

Two carts are placed on a track with their Velcro strips facing each other. Cart 1 is positioned on the end of the track next to a motion detector; Cart 2 is positioned in the middle of the track. The motion detector is prepared to collect data. Cart 1 is given a light push while Cart 2 remains stationary in the middle of the track. The two carts collide, stick together and travel at the same speed after the inelastic collision. The motion detector is used to determine the speed of Cart 1 before the collision and the speed of the two carts after the collision. Masses are placed upon the carts to alter the mass of the two colliding objects and measurements are repeated.

**Alternative Materials and Procedure:**

Air tracks and gliders can be used as a substitute for the tracks and carts. A photogate system can be used as a substitute for the computer-interfaced motion detectors.

**Safety Concern:**

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

**Suggestions, Precautions, Notes:**

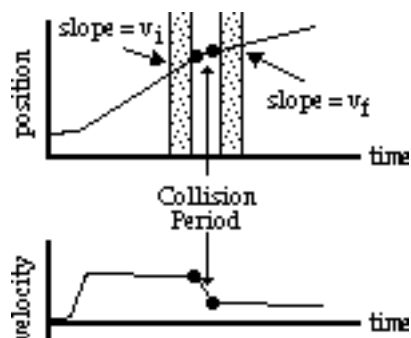
## The Laboratory

1. [Pasco Scientific](#) is one of several companies which sells low-friction carts equipped with magnets (for elastic collisions), Velcro strips (for inelastic collisions), plungers (for explosions), additional masses and a mass tray. These are ideal for collision studies and other mechanics labs. Their lowest cost model is ME-6950.
2. To lengthen the lifetime of the carts, remind students to roll the carts at very low speeds. Also remind students that your ears still work and are able to hear carts bouncing off the track and onto the table. Also remind students that you are the one who ultimately assigns them their grade in the course.
3. The acquisition of data from the computer can be difficult. Directions for acquiring data from the computer are provided in the Auxiliary Materials section below.
4. Many commercially sold carts are packaged with masses which can be placed upon the carts. These masses typically have an identical mass as the cart's mass. Fortunately, this allows students to not only explore momentum conservation quantitatively, but also in a qualitative manner. For instance, if the amount of mass which is moving is tripled (by the inelastic collision of a cart of mass  $m$  with a stationary cart of mass  $2m$ ), then the speed at which the mass moves is one-third of the original speed.
5. Inform students of the need to give Cart 1 a push to start it in motion and then to pull their hand away so that it doesn't interfere with the motion detector's ability to detect the cart's motion.

### Auxiliary Materials:

The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.

Orient the carts so that their Velcro strips are facing each other. Conduct a number of inelastic collisions on the low-friction track. Vary the mass of the *carts* using bricks ( $m_{\text{cart}} = 0.25 \text{ kg}$ ;  $m_{\text{brick}} = 0.25 \text{ kg}$ ). Use the motion detectors and the Logger Pro software to determine speeds of the moving carts. Identify the collision location by carefully observing the two graphs. Determine the speed of the carts immediately before and immediately after each collision. One way to determine the speed values is to highlight the graph during the 0.1-0.2 second prior to the collision and then to click on the **Linear Fit** button on the Button strip at the top of the page. Take care to obtain reasonable and representative speed values. **Note:** the motion detectors cannot detect objects located within 40 cm of the detector.



### Primary Data:

| Trial | $m_1$ (kg) | $m_2$ (kg) | Before Collision |             | After Collision   |
|-------|------------|------------|------------------|-------------|-------------------|
|       |            |            | $v_1$ (m/s)      | $v_2$ (m/s) | $v_1 = v_2$ (m/s) |
| 1     |            |            |                  | 0           |                   |
| 2     |            |            |                  | 0           |                   |
| 3     |            |            |                  | 0           |                   |
| 4     |            |            |                  | 0           |                   |

## The Laboratory

|   |  |  |  |   |  |
|---|--|--|--|---|--|
| 5 |  |  |  | 0 |  |
|---|--|--|--|---|--|

### Secondary Data:

| Trial | Before Collision |                |                    | After Collision |                |                    | Δ Momentum       |                  |
|-------|------------------|----------------|--------------------|-----------------|----------------|--------------------|------------------|------------------|
|       | p1<br>(kg•m/s)   | p2<br>(kg•m/s) | Ptotal<br>(kg•m/s) | p1<br>(kg•m/s)  | p2<br>(kg•m/s) | Ptotal<br>(kg•m/s) | Δ p1<br>(kg•m/s) | Δ p2<br>(kg•m/s) |
| 1     |                  | 0              |                    |                 |                |                    |                  |                  |
| 2     |                  | 0              |                    |                 |                |                    |                  |                  |
| 3     |                  | 0              |                    |                 |                |                    |                  |                  |
| 4     |                  | 0              |                    |                 |                |                    |                  |                  |
| 5     |                  | 0              |                    |                 |                |                    |                  |                  |

### Scoring Rubric:

| M7. Inelastic Collision Analysis Lab  | Score     |
|---|-----------|
| <ul style="list-style-type: none"> <li>— Included, labeled and organized all parts of the lab report.</li> <li>— Data section includes the provided table; measured values are reasonably accurate. Calculations are correct; example calculations are shown for <math>p_1</math>, <math>p_1'</math>, <math>p_2'</math>, <math>p_{tot}</math>, and <math>p_{tot}'</math>; work is organized and labeled.</li> <li>— Conclusion/Discussion of Results describes how the evidence suggests that momentum is conserved (or not conserved); actual data values are referenced in an effort to establish <i>the proof</i>. An error analysis is conducted; a percent difference is calculated, comparing <math>p_{tot}</math> and <math>p_{tot}'</math>; work is shown.</li> </ul> | ____/____ |

### Connections to The Physics Classroom Tutorial:

The following readings are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/momentum/u4l2d.cfm>

<http://www.physicsclassroom.com/Class/momentum/u4l2dd.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 7, 8 and 10 of the Momentum and Collisions module are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>