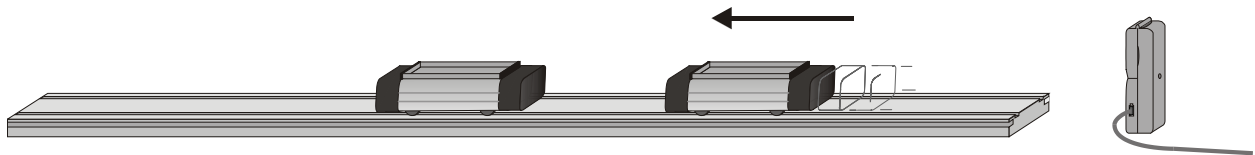


# Momentum, Energy and Collisions

The collision of two carts on a track can be described in terms of momentum conservation and, in some cases, energy conservation. If there is no net external force experienced by the system of two carts, then we expect the total momentum of the system to be conserved. This is true regardless of the force acting between the carts. In contrast, energy is only conserved when certain types of forces are exerted between the carts.

Collisions are classified as *elastic* (kinetic energy is conserved), *inelastic* (kinetic energy is lost) or *completely inelastic* (the objects stick together after collision). In this experiment you can observe completely inelastic collisions and test for the conservation of momentum and energy.



## OBJECTIVES

- Observe completely inelastic collisions between two carts, testing for the conservation of momentum.
- Measure energy changes during completely inelastic collisions.

## MATERIALS

LabQuest  
LabQuest App  
Motion Detector

dynamics cart track  
two low-friction dynamics carts with  
Velcro™ bumpers

## PRELIMINARY QUESTIONS

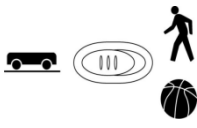
1. Consider a head-on collision between two cars. One is initially at rest and the other moves toward it. After the collision they stick together. Sketch a position vs. time graph for each car, starting with time before the collision and ending a short time afterward.
2. Is momentum conserved in this collision? Is kinetic energy conserved? How can you tell?

## PROCEDURE

1. Measure the masses of your carts and record them in your data table. Label the carts as cart 1 and cart 2.

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2. Set up the track so that it is horizontal. Test this by releasing a cart on the track from rest. The cart should not move.
3. Practice creating gentle collisions by placing cart 2 at rest in the middle of the track and release cart 1 so it rolls toward the first cart, Velcro bumper toward Velcro bumper. The carts should stick together after the collision and roll smoothly away from the collision site.
4. Place a Motion Detector at the cart 1 end of the track. Always roll cart 1 from this end of the track.
5. If your Motion Detector has a switch, set it to Track. Connect the Motion Detector to DIG 1 of LabQuest and choose New from the File menu. 
6. Start data collection. Repeat the collision you practiced above. Make sure you keep your hands out of the way of the Motion Detector after you push the cart.
7. Use the graph of position vs. time to verify that the Motion Detector can track the cart properly throughout the entire range of motion. You may need to adjust the position of the Motion Detector. If necessary, repeat to the previous step.
8. From the velocity graph you can determine an average velocity before and after the collision for each cart. You should see two approximately constant regions in your velocity graph, corresponding to the cart speed before the collision and then the speed of the two carts together after the collision. If you cannot see two such regions, repeat data collection. To repeat, return to Step 6.
9. Measure the average velocity during the time interval before the collision.
  - a. Tap and drag your stylus across the region of the graph that corresponds to the first constant-velocity region to select the region.
  - b. Choose Statistics from the Analyze menu. The mean velocity for the time interval will be displayed. Record this as the initial velocity in your data table.
10. Measure the average velocity during the time interval *after* the collision.
  - a. Tap and drag across the region of the graph that corresponds to the second constant-velocity region to select the region.
  - b. Choose Statistics from the Analyze menu. The mean velocity for the time interval will be displayed. Record this as the initial velocity in your data table. Note that the carts have the same velocity after collision since they are stuck together.
  - c. Choose Statistics from the Analyze menu to turn off statistics.
11. Repeat the collision and analysis two more times for a total of three runs.

## DATA TABLE

Mass of cart 1 (kg)	Mass of cart 2 (kg)
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Run number	Velocity of cart 1 before collision (m/s)	Velocity of cart 2 before collision (m/s)	Velocity of cart 1 after collision (m/s)	Velocity of cart 2 after collision (m/s)
1		0		
2		0		
3		0		

Run number	Momentum of cart 1 before collision (kg·m/s)	Momentum of cart 2 before collision (kg·m/s)	Momentum of cart 1 after collision (kg·m/s)	Momentum of cart 2 after collision (kg·m/s)	Total momentum before collision (kg·m/s)	Total momentum after collision (kg·m/s)	Ratio of total momentum after/before
1		0					
2		0					
3		0					

Run number	KE of cart 1 before collision (J)	KE of cart 2 before collision (J)	KE of cart 1 after collision (J)	KE of cart 2 after collision (J)	Total KE before collision (J)	Total KE after collision (J)	Ratio of total KE after/before
1		0					
2		0					
3		0					

## ANALYSIS

1. Determine the momentum ( $mv$ ) of each cart before the collision, after the collision, and the total momentum before and after the collision. Calculate the ratio of the total momentum after the collision to the total momentum before the collision. Enter the values in your data table.
2. Determine the kinetic energy ( $\frac{1}{2}mv^2$ ) for each cart before and after the collision. Calculate the ratio of the total kinetic energy after the collision to the total kinetic energy before the collision. Enter the values in your data table.
3. If the total momentum for a system is the same before and after the collision, we say that momentum is *conserved*. If momentum were conserved, what would be the ratio of the total momentum after the collision to the total momentum before the collision?

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4. If the total kinetic for a system is the same before and after the collision, we say that kinetic energy is *conserved*. If kinetic were conserved, what would be the ratio of the total kinetic energy after the collision to the total kinetic energy before the collision?
5. For your three runs, inspect the momentum ratios. Even if momentum is conserved for a given collision, the measured values may not be exactly the same before and after due to measurement uncertainty. The ratio should be close to one, however. Is momentum conserved in your collisions?
6. Repeat the preceding question for the case of kinetic energy. Is kinetic energy conserved in your completely inelastic collisions?

## EXTENSIONS

1. Perform the momentum and energy calculations for the data tables using a spreadsheet.

The following extensions require two Motion Detectors. Use a second Motion Detector to measure the speed of cart 2.

2. Explore elastic collisions by measuring the speeds of carts 1 and 2 separately. Use magnetic bumpers to study elastic collisions, and magnetic-to-Velcro collisions to study inelastic (but not completely inelastic) collisions.
3. Using a collision cart with a spring plunger, create a super-elastic collision; that is, a collision where kinetic energy increases. The plunger spring should be compressed and locked before the collision, but then released during the collision. Measure momentum before and after the collision. Is momentum conserved in this case? Is energy conserved?
4. Using the magnetic bumpers, consider other combinations of cart mass by adding weight to one cart. Are momentum or energy conserved in these collisions?
5. Using the magnetic bumpers, consider other combinations of initial velocities. Begin with having both carts moving toward one another initially. Are momentum and energy conserved in these collisions?