Name _____ Class _____ Date _____

Activity P38: Conservation of Linear Momentum (Motion Sensors)

Equipment Needed	Qty	Equipment Needed	Qty
Motion Sensor (CI-6742)	2	Dynamics Cart (w/ Track)	2
Balance (SE-8723)	1	2.2 m Track System (ME-9452)	1

What Do You Think?

How does the total momentum of two carts before an elastic collision compare to the total momentum of two carts after the collision?

Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.

Background

When objects collide, whether locomotives, shopping carts, or your foot and the sidewalk, the results can be complicated. Yet even in the most chaotic of collisions, as long as there are no external forces acting on the colliding objects, one principle always holds and provides an excellent tool for understanding the dynamics of the collision. That principle is called the conservation of momentum. For a two-object collision, momentum conservation is easily stated mathematically by the equation:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

If external forces such as friction are ignored, the sum of the momenta of two carts prior to a collision is the same as the sum of the momenta of the carts after the collision.

SAFETY REMINDERS

- Follow all directions for using the equipment.

For You To Do

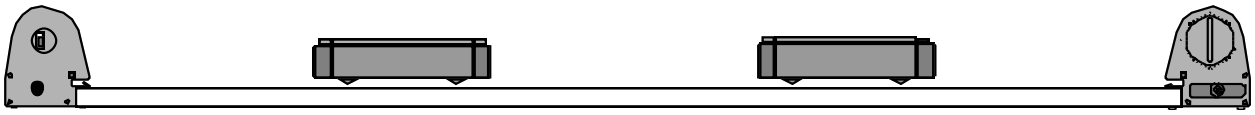
Use Motion Sensors to measure the motion of two carts before and after an elastic collision. Use *DataStudio* or *ScienceWorkshop* to determine the momentum for both carts before and after the collision. Compare the total momentum of the two carts before collision to the total momentum of both carts after collision.

PART I: Sensor Calibration and Equipment Setup

- You do not need to calibrate the sensors for this activity.
- Make sure that magnets are installed in at least one end of each cart so the carts can repel each other during the collision.

1. Place the track on a horizontal surface.
2. Level the track by placing a cart on the track. If the cart rolls one way or the other, use the adjustable feet at one end of the track to raise or lower that end until the track is level and the cart will not roll one way or the other.
3. Use the balance to find the mass of each cart and record the values in the Data Table in the Lab Report section.
4. Mount the Motion Sensor that is connected to Digital Channels 1 and 2 on the left end of the track. Mount the other Motion Sensor on the right end of the track.
5. Adjust each sensor so it can measure the motion of a cart as it moves from the end of the track to the middle and back again. Put the 'SWITCH SETTING' on the sensor to 'Narrow'. Put pencil marks on the track at spots that are 0.15 m (15 cm) from each Motion Sensor.

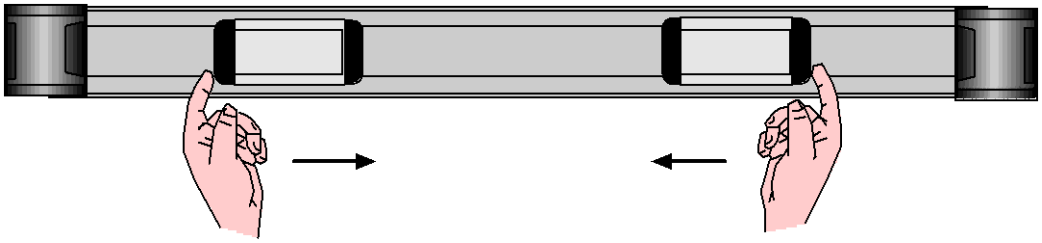
- Remember, the closest that a target can approach the sensor is 15 cm (for the Motion Sensor II, Model CI-6742), or 40 cm (for the Motion Sensor, Model CI-6529).



6. Place a cart at each end of the track. Let the cart on the left be 'cart 1' and the cart on the right be 'cart 2'. Be sure that the magnetic ends of the carts will repel each other.

PART II: Data Recording

1. Prepare to measure the motion of each cart as it moves toward the other cart and then collides elastically. (Be sure the magnetic ends of the carts will repel.)
2. Start recording data. (In *DataStudio*, click 'Start'. In *ScienceWorkshop*, click 'REC'.)



3. Gently push the carts toward each other at the same time.

• Continue collecting data until the carts have collided and returned to the ends of the track.

4. Stop recording data.

• 'Run #1' will appear in the Data list.

Troubleshooting Note: If your data are not smooth, check the alignment of the motion sensors. You may need to increase the reflecting area of each cart by attaching a rectangular cardboard "flag" (about 2 by 6") to the front of the cart. To erase a trial run of data, select "Run #1" in the data list and press the "Delete" key.

Analyzing the Data

Find the slope of the position versus time plot for each cart just prior to collision and the slope of the plot for each cart just after collision. The slope is the average velocity of the cart. Use the velocity and mass of the cart to calculate the momentum of each cart before and after collision. Compare the total momentum of the two carts before the collision with the total momentum of the two carts after the collision.

Momentum is a vector quantity. Since the carts move in opposite directions, one cart's momentum is in the opposite direction to the other cart's momentum. However, each Motion Sensor measures motion away from it as 'positive' and motion toward it as 'negative'. Use the software's built-in calculator to "reverse" the directions of the motion of one of the carts.

Find the Slope

1. Use the Graph display's built-in analysis tools to find the slope of the position vs. time plot just before and just after the collision for each cart.

In *DataStudio*, do the following:

- In the plot for 'cart 1', select a small portion just before collision (e.g., about 10 or 15 data points before the peak).
- Click the 'Fit' menu and select 'Linear'. Record the slope as the 'Velocity Before Collision' for 'cart 1'.
- Repeat the process for a small portion of the plot just after collision and record the slope as the 'Velocity After Collision' for 'cart 1'.
- Do the same analysis for the plot of motion for 'cart 2'.

2. Calculate the momentum before and after the collision for each cart. Calculate the total momentum before and after the collision.
3. Calculate the percentage difference between the total momentum before and the total momentum after the collision.

$$\%\ difference = \frac{pTotal_{Before} - pTotal_{After}}{pTotal_{Before}}$$

Record your results in the Lab Report section.

Name _____ Class _____ Date _____

Lab Report - Activity P38: Conservation of Linear Momentum

What Do You Think?

How does the total momentum of two carts before an elastic collision compare to the total momentum of two carts after the collision?

Data Table

Item	Cart 1	Cart 2
mass (kg)		
velocity before (m/s)		
momentum before (kg•m/s)		
velocity after (m/s)		
momentum after (kg•m/s)		

total momentum$_{before}$ (cart 1&2)	total momentum$_{after}$ (cart 1&2)	percent difference (cart 1&2)

Item	Cart 1	Cart 2
mass (kg)		
velocity before (m/s)		
momentum before (kg•m/s)		
velocity after (m/s)		
momentum after (kg•m/s)		

total momentum before (cart 1&2)	total momentum after (cart 1&2)	percent difference (cart 1&2)

Questions

1. How does the total momentum before the collision compare to the total momentum after the collision?

2. What factors do think may cause there to be a difference between the momentum before and the momentum after collision?