Momentum in Collisions

Mechanics: momentum, impulse, conservation of momentum	GLX setup file: **momentum**

Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
2	PASPORT Motion Sensor	PS-2103
1	1.2 m PASCO Track	
2	GOcar	ME-6951
1	Hooked Mass Set	SE-8759
1	Balance	SE-8723

Purpose

The purpose of this activity is to investigate the momentum of two carts before and after they collide.

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 net external forces acting on the colliding objects, one principle always holds and provides an excellent tool for understanding the collision. That principle is called the *conservation of momentum*. For a two-object collision, momentum conservation is stated mathematically by the following equation:

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

If external forces (such as friction) are ignored, the total momentum of two carts prior to a collision (left side of equation) is the same as the total momentum of the carts after the collision (right side of equation).

The change in momentum for each cart is its mass times its change in velocity.

$$m_1 \Delta v_1 = m_2 \Delta v_2$$
$$m_1 \left(v_1' - v_1 \right) = m_2 \left(v_2' - v_2 \right)$$

Safety Precautions

* Follow all directions for using the equipment.

Preview

Use two Motion Sensors to measure the motion of two carts before and after they collide. Compare the momentum of the carts before they collide with the momentum after they collide.

Pre-Lab Questions

1. How would you calculate the total momentum for two carts that are about to collide?

2. How will the momentum of two carts *after* they collide compare to the momentum of the two carts *before* the collision?

Procedure

GLX Setup

3.   Turn on the GLX (⏻) and open the GLX setup file labeled **momentum**. (Check the Appendix at the end of this activity.)

12:31:32 PM 07/12/06   momentum

Fig. 1: Graph screen

*   The file is set up so that motion is measured 20 times per second (20 Hz). The Graph screen opens with a graph of Velocity (m) versus Time (s). The graph shows the measurements from both sensors. The file uses a calculation on the data from one of the sensors so that motion away from that sensor will appear to be negative and motion toward it will be positive.

4.   Connect the first Motion Sensor to sensor port 1 on the top of the GLX. Connect the second Motion Sensor to sensor port 2 on the GLX. Set the range selection switch on both sensors to 'near' (cart).
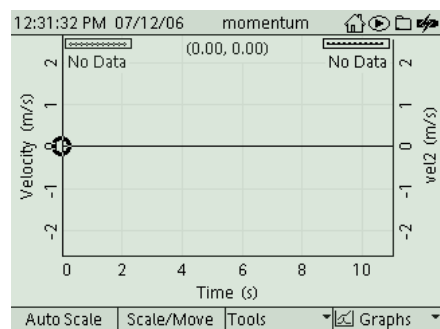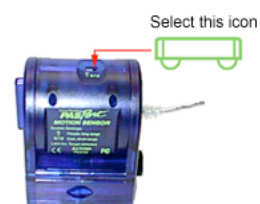

Select this icon

Equipment Setup

1.   Set up the track so that it is level. (Place a cart on the track. If the cart rolls one way or the other, adjust the track to raise or lower one end.)

2.   Attach the first sensor at the left end of the track. Attach the second sensor at the right end of the track.

3.   Measure and record the mass *m* of each cart.

*   NOTE: The procedure is easier if one person handles the carts and a second person handles the Xplorer GLX.
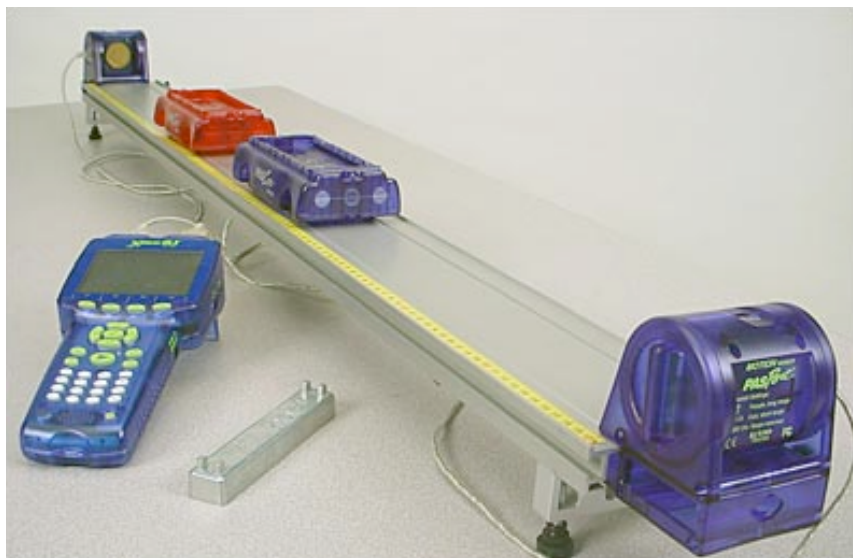

Fig. 2 Equipment setup

Record Data

1. Place the two carts on the track. Label the cart in front of sensor #1 as cart #1. Label the other cart as cart #2. (Don't put a cart closer than 15 cm (0.15 m) in front of a sensor).

2. Press Start (▶) to start recording data.

3. Collide the two carts.

4. Press ▶ to stop recording.

On-the-Spot Analysis

Use the Graph screen to examine the velocity versus time for the first data run. Determine the velocity *before* the collision and *after* the collision for both carts. Calculate the momentum of each cart. Compare the total momentum of the two carts *after* the collision to the total momentum of the two carts *before* the collision.

Fig. 3: Select 'Smart Tool'

5. To find the velocity of the cart in front of sensor #1, use the Smart Tool. Press *F3* (F3) to open the 'Tools' menu. Sele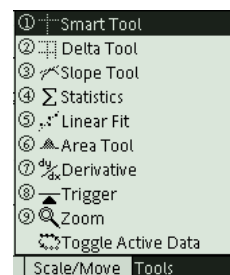ct 'Smart Tool' and press ✔ to activate your choice. Use the arrow keys to move the 'Smart Tool' to the velocity of the cart before the collision. Record the value in the Data Table. Next, use the arrow keys and 'Smart Tool' to find the velocity of the cart after the collision. Record the value.

Fig. 4: Velocity 'before'

6. To see the data for the cart in front of sensor #1, press *F4* (F4) to open the 'Graphs' menu. Use the arrow keys to select 'Graph 2' and press ✔ to activate your choice.

7. Turn on the 'Smart Tool'. In 'Graph 2', use the arrow keys and 'Smart Tool' to find the velocity of the cart before and then after the collision. Record the values in the Data Table.
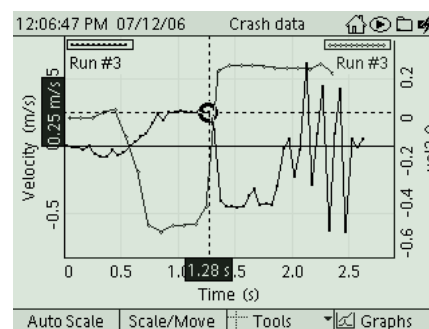
Record Data: Try *Other* Types of Collisions

1. Repeat the data recording and 'on-the-spot' analysis for ten more collisions.

- Vary the masses of the carts.

Fig. 5: Select 'Graph 2'

- Try different types of motion such as one cart initially at rest, or both carts moving in the same direction with one cart overtaking the other.

- Vary the type of collision (for example: elastic, inelastic).

2. Record your values for the masses and velocities of the carts in the Data Table.
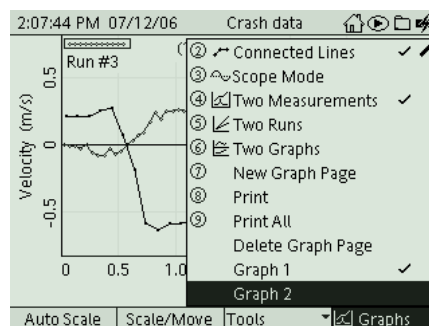
Analysis

1. To change the Graph screen to show a specific run of data, press ✓ to activate the vertical axis menu. Press the arrow keys (∧) to move to 'Run #_' in the upper left hand corner or upper right corner. Press ✓ to open the menu, select the data run in the menu, and press ✓ to activate your choice.

2. Repeat the analysis process for each of your runs of data.

Record your results and answer the questions in the Lab Report section.

Appendix: Opening a GLX File

To open a specific GLX file, go to the Home Screen (⌂). In the Home Screen, select Data Files and press ✓ to activate your choice. In the Data Files screen, use the arrow keys to navigate to the file you want. Press F1 to open the file. Press the Home button to return to the Home Screen. Press F1 to open the Graph.

12:32:04 PM 07/12/06	momentum	⌂⊙▭
RAM	Flash	

RAM: Size = 11.8 MB, Free = 11.6 MB

momentum	[Open]	1 KB	[Modified]
Crash data		23 KB	07/12/06
pendulum		4 KB	07/12/06
shm spring		4 KB	07/11/06
shm spring data		8 KB	07/11/06
Activity 10 data 2		67 KB	07/11/06
Activity 10 Data		67 KB	07/11/06

| Open | Save | Delete | Files |

Lab Report – Activity 14: Momentum in Collisions

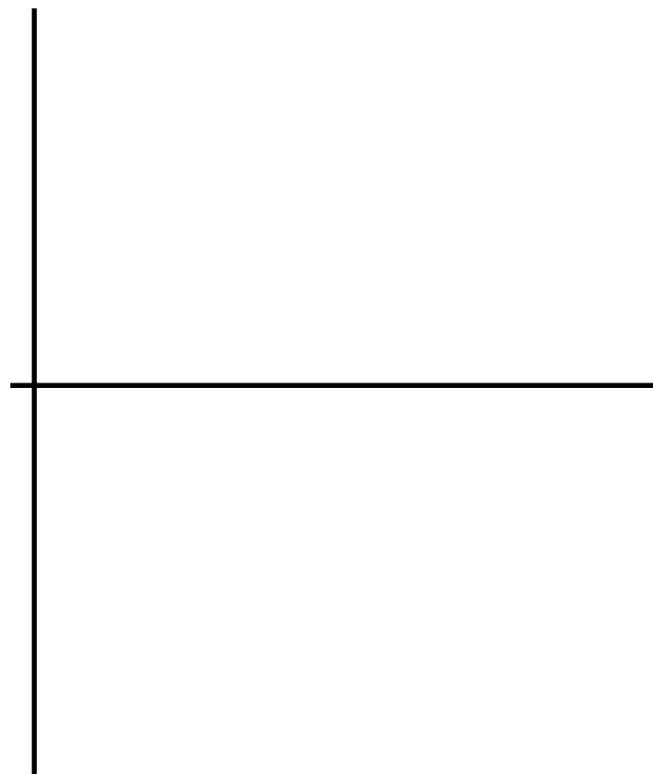**Name** _____ **Date** _____

Pre-Lab Questions

1.   How would you calculate the total momentum for two carts that are about to collide?

2.   How will the momentum of two carts *after* they collide compare to the momentum of the two carts *before* the collision?

Data

Sketch a graph for one run of velocity versus time. Include units and labels for your axes.

Data Table 1

Item	Cart 1 Mass (kg)	Cart 2 Mass (kg)	Before		After	
			Velocity, cart 1 (m/s)	Velocity, cart 2 (m/s)	Velocity, cart 1 (m/s)	Velocity, cart 2 (m/s)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Calculations

Calculate the total momentum before and the total momentum after for each collision.

Item	Momentum Before (kg•m/s)	Momentum After (kg•m/s)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Questions

1.   In general, how does the momentum after a collision compare to the momentum before the collision?

2.   In which type of collision was the before-and-after difference in momentum the least? In which type of collision was the difference the most?

3.   What factors might cause the total momentum after a collision to not equal the total momentum before the collision?

4.   For a theoretical head-on collision between two carts of equal mass and equal speed, what is the total momentum before the collision?

5.   Discuss the momentum of a firecracker at rest compared to the momentum of the firecracker after it explodes.

6.   Imagine two carts, one with twice the mass of the other, that are going to have a head-on collision. In order for the two carts to be at rest after the collision, how fast must the less massive cart move compared to the more massive cart?