

Experiment #8 Conservation of Momentum Pre-lab Questions Hint

Elastic Collision

Consider a head-on collision between two carts. One is initially at rest and the other moves toward it. The carts bounce off each other in an elastic collision.

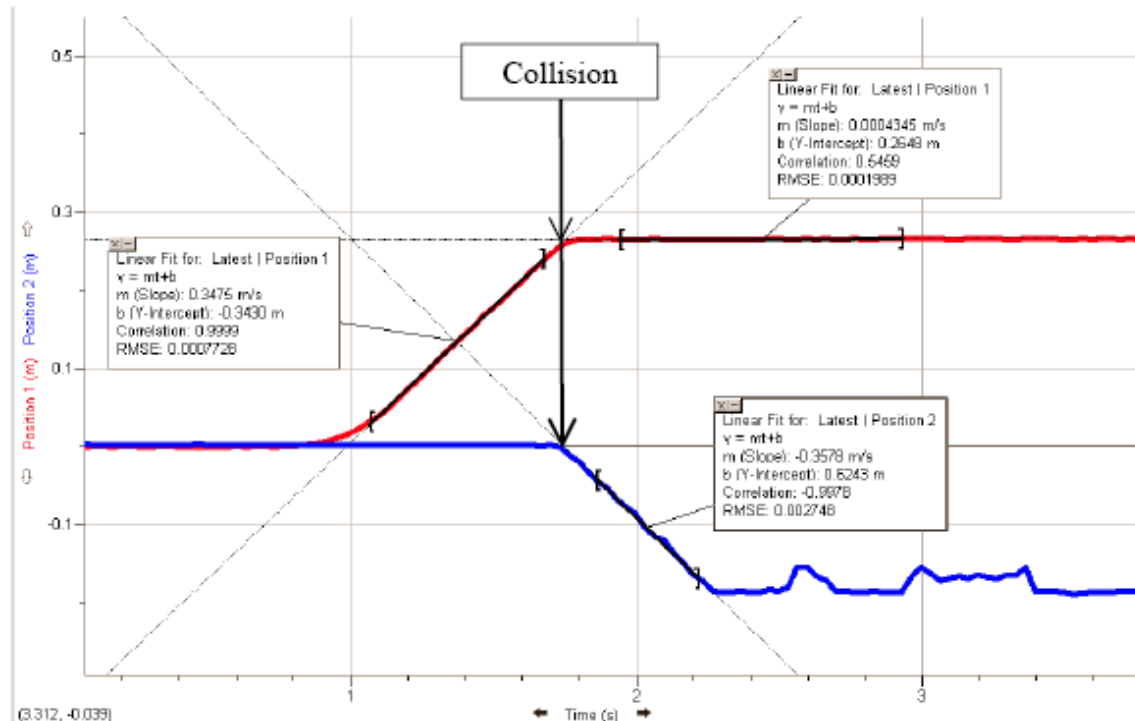


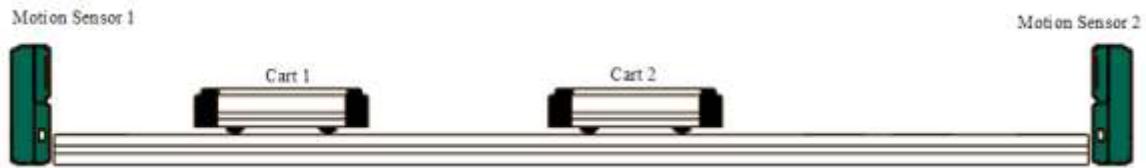
Figure 1: Experimental Data Obtained from Logger Pro for an Elastic Collision

**** IT IS IMPERATIVE THAT YOU UNDERSTAND WHAT THE GRAPH ABOVE MEANS BEFORE YOU GET STARTED! ****

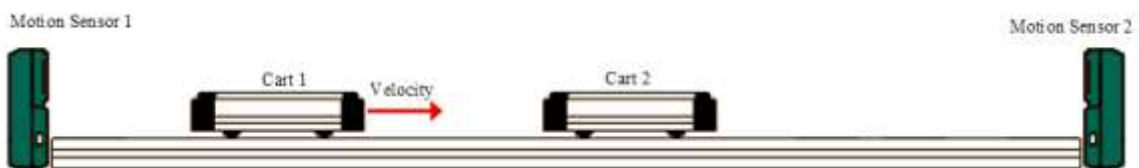
Recall back to lab 2 – where we were first playing with the motion sensors (pull your copy out, or look at the example online if you need a “refresher”). Remember what a positive slope meant and what a negative slope meant. When we had a positive slope measured by a sensor, this means the object being measured was moving *away* from the sensor. When we had a negative slope measured by a sensor, this means the object being measured was moving *toward* the sensor.

Below is the setup for Experiment 8 – Conservation of Momentum. Motion sensor 1 is measuring the distance from itself to cart 1 (this is the red line in the graph above) and motion sensor 2 is measuring the distance from itself to cart 2 (this is the blue line in the graph above). Notice that the two motion sensors are pointing in opposite

directions ... This means there will be a sign conflict when the objects are moving in the same direction! Carefully consider the following in conjunction with your experience from past labs:

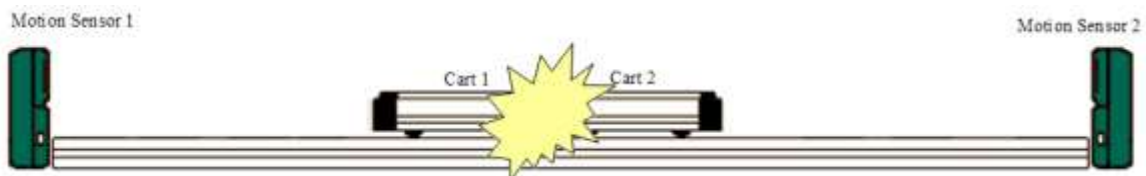


*Figure 2: Experimental Setup before the any motion occurs (No velocities)
(Graph between times 0s and 1s)*



*Figure 3: Experimental operation before the collision (cart 1 is moving to the right and
cart 2 is not moving)
(Graph between times 1s and 1.65s)*

In this situation, motion sensor 1 will record cart 1 moving away from it (hence a positive slope of the red line). The magnitude of the velocity (speed) of cart 1 can be obtained from the absolute value of the slope of the best fit line and the direction is to the right (assume this is the +x direction). Motion sensor 2 will record cart 2 as not moving (hence a zero slope of the blue line).



*Figure 4: Experimental operation at the collision
(Graph at instantaneous time 1.65s)*



*Figure 5: Experimental operation after the collision (cart 1 is not moving and cart 2 is
moving to the right)
(Graph between times 1.65s and 2.2s)*

In this situation, motion sensor 2 will record cart 2 moving *toward* it (hence a *negative* slope of the blue line). The magnitude of the velocity (speed) of cart 2 can be obtained from the absolute value of the slope of the best fit line and the direction is to the right (again, this is the +x direction). Motion sensor 1 will record cart 1 as not moving (hence a zero slope of the red line).

Now, this means that when we are determining the velocities from the graph, we must get BOTH the correct magnitude (from the best fit line) and correct direction (from the analysis above). This means that if we assume the +x direction is to the right, all velocities we obtain during this experiment should be positive (regardless of the sign on the best fit lines), since the velocities are ALL in the same direction.

**** Now that you understand what's going on, you may officially get started. ****

Fill out the tables below and determine whether or not momentum is conserved.

Mass of Cart 1	Mass of Cart 2
0.510 kg	0.498 kg

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]
	0		

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)

**** If the ratio of the total momentum is 1 (or significantly close enough), this means momentum is conserved, and the theory holds true. ****

Show your work here

To determine the velocity of Cart 1 before the collision:

Use the red best fit line from Logger Pro between time 1s and 1.65s. We have done this several times in past labs, so this should be a fairly trivial process.

Compare the equation for kinematic 2D motion for the x-position with the provided trendline:

$$x = v_{o,x}t + x_o$$

To determine the velocity of Cart 1 after the collision:

Use the red best fit line from Logger Pro between time 1.65s and 2.2s.

To determine the velocity of Cart 1 after the collision:

Use the blue best fit line from Logger Pro between time 1.65s and 2.2s.

**** [NOTE: By examining the setup of the system (see comments above), we can see that the second sensor will record a negative velocity toward the sensor for cart 2. We then must change its sign to compensate for the direction the cart is actually moving. Recall that a velocity is *both* a magnitude and direction – so both must be carefully considered when analyzing momentum problems.] ****

To determine the momentums:

We know that momentum is given by:

$$p = mv$$

Using the velocities we found from above, we can plug everything right into the equation for momentum for each case.

To determine the total momentum before and after the collision:

$$p_{Total,before} = \sum_{i=1}^n p_{i,before} = p_{1,before} + p_{2,before}$$

$$p_{Total,after} = \sum_{i=1}^n p_{i,after} = p_{1,after} + p_{2,after}$$

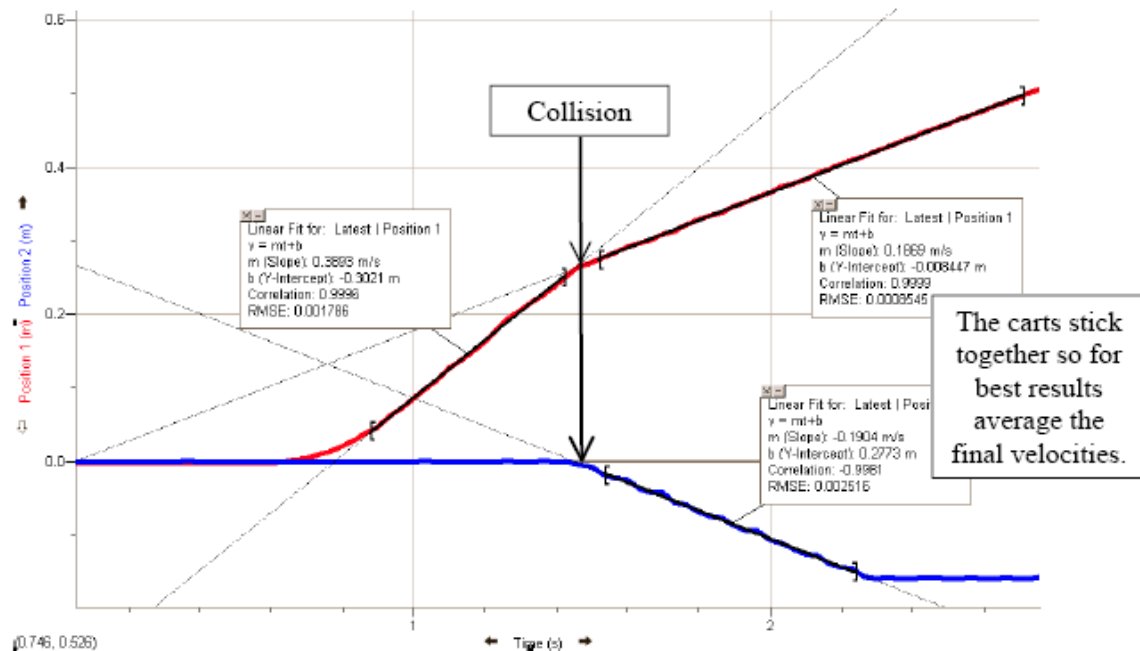
To determine the ratio of total momentums (After/Before):

$$\text{Ratio of total momentums} = \frac{p_{Total,after}}{p_{Total,before}}$$

If the ratio of the total momentum is 1 (or significantly close enough), this means momentum is conserved, and the theory holds true.

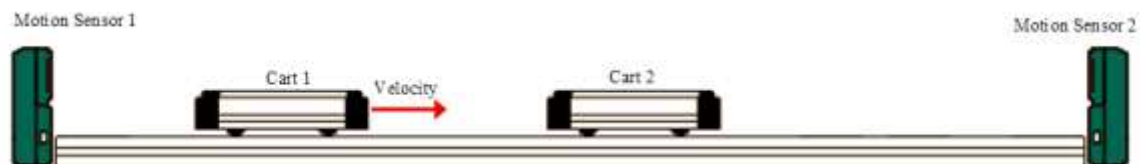
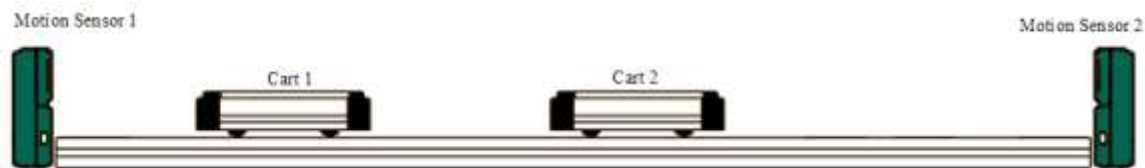
Inelastic Collision

Consider a head-on collision between two carts. One is initially at rest and the other moves toward it. The carts stick to each other in an inelastic collision.

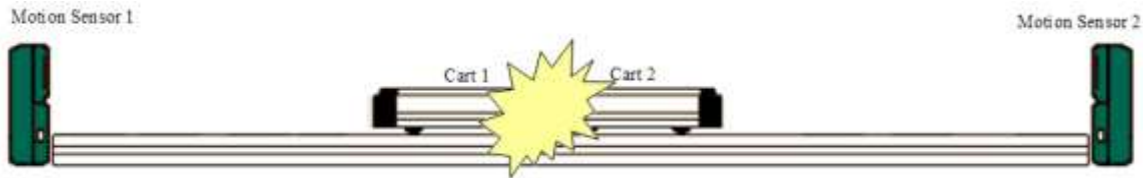


**** AGAIN, MAKE COMPLETELY SURE THAT YOU UNDERSTAND WHAT THE GRAPH ABOVE MEANS BEFORE YOU GET STARTED! ****

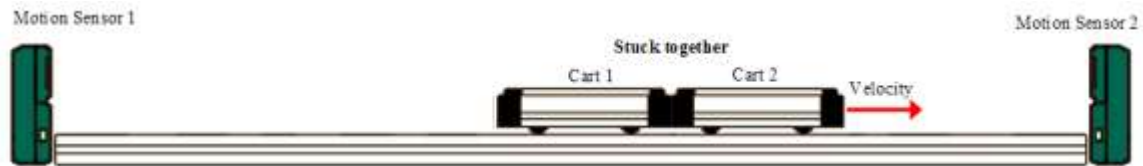
Notice, again, that the two motion sensors are pointing in opposite directions ... This means there will again be a sign conflict when the objects are moving in the same direction! Carefully consider the following in conjunction with your experience from past labs and the problem above:



In this situation, motion sensor 1 will record cart 1 moving away from it (hence a *positive* slope of the red line). The magnitude of the velocity (speed) of cart 1 can be obtained from the absolute value of the slope of the best fit line and the direction is to the right (assume this is the +x direction). Motion sensor 2 will record cart 2 as not moving (hence a zero slope of the blue line).



*Figure 9: Experimental operation at the collision
(Graph at instantaneous time 1.45s)*



*Figure 10: Experimental operation after the collision (cart 1 is stuck to cart 2 and both are moving to the right)
(Graph between times 1.45s and 2.2s)*

In this situation, motion sensor 2 will record cart 2 moving *toward* it (hence a *negative* slope of the blue line). The magnitude of the velocity (speed) of cart 2 can be obtained from the absolute value of the slope of the best fit line and the direction is to the right (again, this is the +x direction). Motion sensor 1 will record cart 1 moving *away* from it (hence a *positive* slope of the red line). The magnitude of the velocity (speed) of cart 1 can be obtained from the absolute value of the slope of the best fit line and the direction is also to the right. Since these two velocities are one in the same (since the carts are stuck together) they should be equal – hence it is appropriate to get the values for the velocity of the carts by averaging the slopes recorded from sensor 1 and sensor 2.

Again, make sure you get BOTH the correct magnitude (from the best fit line) and correct direction (from the analysis above). This means that if we assume the +x direction is to the right, all velocities we obtain during this experiment should be positive (regardless of the sign on the best fit lines), since the velocities are ALL in the same direction.

Fill out the tables below and determine weather or not momentum is conserved.

Mass of Cart 1	Mass of Cart 2
0.510 kg	0.498 kg

Velocity of	Velocity of	Velocity of	Velocity of
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Cart 1 before Collision [m/s]	Cart 2 before Collision [m/s]	Cart 1 after Collision [m/s]	Cart 2 after Collision [m/s]
	0	<see below>	<see below>

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)

Show your work here

This is identical to the process described above for the elastic collision.

**** MAKE SURE that for the velocities after the collision you average out the 2x values you got from the best fit lines! These velocities should be identical since this is an inelastic collision (and the joint mass is moving at the same velocity). ****

To determine the average velocity of the two carts after the collision:

$$\langle v \rangle = \frac{v_1 + v_2}{2} = \frac{0.1869 \frac{m}{s} + 0.1904 \frac{m}{s}}{2} = 0.18865 \frac{m}{s}$$