Name(s): ________________________________ Date: _________ Period: ___

ACTIVITY #5 MOMENTUM CONSERVATION

Contributed by Jane Bray Nelson

PURPOSE: ____

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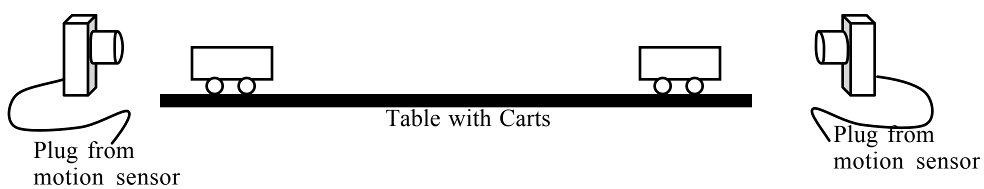
MATERIALS AND PROCEDURES:

1. Turn on the interface device and connect two motion sensor devices to the interface box. (Once you have finished step 2, you can unplug the second sensor and share it back and forth with other students if equipment is scarce. Just make sure that the second sensor is plugged in when you are actually making a data run.)
2. Make sure the computer or screen device detects that two sensors are plugged in and activated.
3. Select a graphical display of position versus time for one of the motion sensors.
4. Add another position time graph to the first. Make sure that the second is time locked to the first so that you can tell what each motion is doing at the same time.
5. Since one of the motion sensors will be facing the other, the signs that they give to the data will be reversed relative to each other. It is important that you keep track of the direction that the carts are moving. All rightward motion will be recorded as having positive velocity regardless of the slope of the position time graph line. All leftward motion will be recorded as having negative velocity regardless of the slope of the position time graph line.
6. Set up "frictionless" carts as shown in the diagram and follow the instructions, which are listed below.



7. Try to get the table that you will use to roll the carts upon as level as possible ... within reason.
8. Determine and record the mass of each of two carts you will use. Keep track of the mass of the cart associated with each motion sensor.
9. You want to have a mixture of total initial momentum values … both in magnitude and direction. Do this by varying the initial conditions. **If you are going to share class data**, then odd numbered tables push both carts towards each other for your first run and even numbered tables push both carts towards the right, + velocities. Make sure the left cart can catch and "hit" the right cart at a location that can be detected by the sensors. Even numbered tables push both carts towards each other for your second run and odd numbered tables push both carts towards the left, - velocities. Make sure the right cart can catch and "hit" the left cart at a location that can be detected by the sensors.
10. Make sure the motion sensors record the motion as you push the carts so that they gently collide.
11. For each cart determine the slope of the position time graph just before and just after the collision. For each cart record the mass, direction and velocity data for each run.

12. When you have finished one run, you may be asked to do more than one run and then share class data or to do several runs. **If you are sharing data**, then do only one more run, but this time put one or two bricks on one of your carts. Odd number tables add one brick and even number tables add two. Determine the mass of the brick(s) and add it to the mass of the cart for this run's data. Ask your instructor if you need to do several runs or are sharing class data.
13. Make a graph of the total final momentum, vertical, versus the total initial momentum, horizontal, for at least eight personal collisions, or you may be asked to use all the class data values.

DISTANCE BETWEEN THE MOTION SENSORS. ____________ meters

Data Run #	Mass Cart 1 (kg)	Initial Direction of Cart 1	Initial Velocity 1 (m/s)	Final Direction of Cart 1	Final Velocity 1 (m/s)	Initial Momentum 1 (kg*m/s)	Final Momentum 1 (kg*m/s)
Data Run #	**Mass Cart 2 (kg)**	**Initial Direction of Cart 2**	**Initial Velocity 2 (m/s)**	**Final Direction of Cart 2**	**Final Velocity 2 (m/s)**	**Initial Momentum 2 (kg*m/s)**	**Final Momentum 2 (kg*m/s)**

Data Run #	Total Momentum of both carts Initially (kg*m/s)	Total Momentum of both carts Finally (kg*m/s)

QUESTIONS:

1. What characteristic of a position-time graph is used to determine the velocity of the carts? ___________________________ Why? ____
2. What is the equation that you used to determine the momentum of the cart? ______________
3. Newton's Third Law of Motion states that the force applied to cart 1 by cart 2 is _________ ____
4. Therefore, it follows that the impulse given to cart 1 by cart 2 is ________________________ ____
5. An impulse causes a change in ____
6. If the change in momentum experienced by cart 1 is equal but opposite to the change in momentum experienced by cart 2, then the initial total momentum of the system should be equal to ____
7. Write the equation of the line of your momentum graph using symbols for the variables. Include your slope value and the Y intercept with their units as appropriate. ______________ ____
8. What do you expect the value of the slope to be? __________ Why _____________________ ____
9. What is your percent difference between the actual slope and the expected slope? Show your work. ____________________
10. What does the term "Conservation of Momentum" mean? ______________________________ ____
11. What factors do you think may cause there to be a difference between the momentum before and the momentum after the collision? ____

CONCLUSION: ____
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ACTIVITY #5 MOMENTUM CONSERVATION (TEACHER NOTES)

PURPOSE: *To determine the relationship between the total initial momentum of a system and the total final momentum of that system.*

It is important that the students are very careful to keep track of the direction of the carts and assign the correct sign to the velocity values. The fact that momentum is a vector becomes clear if the directions are wrong. Conservation will not be shown if the signs are reversed randomly.

During the wrap up discussion time, make it clear that velocity is not conserved. It is momentum that is conserved.

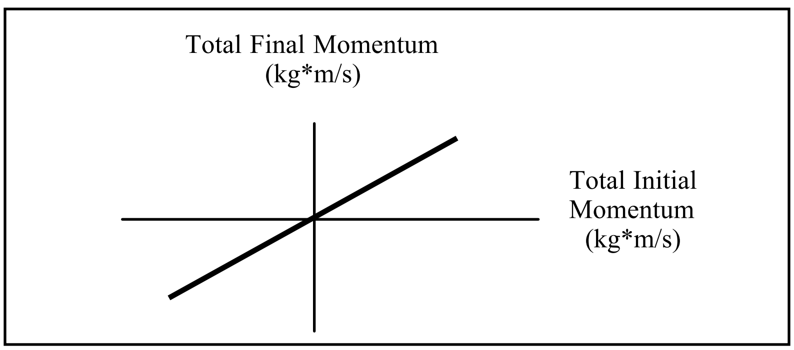
If all the collision occur between carts going towards each other, the total momentum stays too close to the 0,0 part of the graph. To ensure some positive and some negative values, students are asked to vary the initial conditions of collision.

DISTANCE BETWEEN THE MOTION SENSORS. ____________ **meters**

Sample Classroom data used to graph

Data Run #	Total Momentum of both carts Initially (kg*m/s)	Total Momentum of both carts Finally (kg*m/s)
	-0.385	*-0.334*
	-0.350	*-0.250*
	-0.270	*-0.280*
	+0.195	*+0.155*
	+0.065	*+0.060*
	+0.240	*+0.230*
	+0.450	*+0.400*

Graph of sample classroom data. The slope is 0.87. Data points will be scattered around line.



QUESTIONS:

1. What characteristic of a position-time graph is used to determine the velocity of the carts?
   Slope Why? *$v = \Delta d/\Delta t$*
2. What is the equation that you used to determine the momentum of the cart? *$P = m*v$*
3. Newton's Third Law of Motion states that the force applied to cart 1 by cart 2 is *equal to the force applied to cart 2 by cart 1*

4. Therefore, it follows that the impulse given to cart 1 by cart 2 is ______________________ *equal to the impulse given to cart 2 by cart 1*
5. An impulse causes a change in *momentum*
6. If the change in momentum experienced by cart 1 is equal but opposite to the change in momentum experienced by cart 2, then the initial total momentum of the system should be equal to *the total final momentum of the system.*
7. Write the equation of the line of your momentum graph using symbols for the variables. Include your slope value and the Y intercept with their units as appropriate. ______________ $P_{total\ final} = 0.87\ P_{total\ initial}$ *The units for the slope cancel and it is a pure number*
8. What do you expect the value of the slope to be? *1* Why *For a closed system, the total momentum after the collision should equal the total momentum before the collision.*
9. What is your percent difference between the actual slope and the expected slope? Show your work. *1.00 – 0.87 = 0.13* *100 * (0.13/ 1.00) = 13%*
10. What does the term "Conservation of Momentum" mean? *To save, not to lose, to have as much afterwards as before, the final amount equals the initial amount*
11. What factors do you think may cause there to be a difference between the momentum before and the momentum after the collision? *If the carts collide too hard, some momentum is given to the table or the track. In that case the system is not closed.*

CONCLUSION: *The final momentum of the system equals the initial momentum of the system if the system is closed (i.e., there are not unbalanced external forces on the system).*