Name _____ Date _____ Period _____

# The Conservation of Momentum

## Part I: Open the Lab

In your web browser (mobile phones not recommended), navigate to www.gigaphysics.com, then click **Virtual Labs** in the heading bar and **Conservation of Momentum** from the list of labs. If you're using a computer that someone else just used for this lab, you should also click the **New Experiment** button to obtain your own random cart data.

## Part II: Measure the Carts

You will need the length and mass of each cart to perform the calculations in the rest of the lab. To find the mass, use the mouse to drag the cart over the electronic balance and release the cart on top of the balance. The balance reads in grams. Do this for both carts and record your data in the table below. (To return the carts to the track, you can drag the carts anywhere off the balance or click the **Reset Carts** button.)

To find the carts' lengths, drag the ruler to the carts. Though the ruler contains tick marks only every centimeter, try to estimate the tenths digit. Also convert your values to meters and kilograms if you want to use SI units.

| | | | |
|---|---|---|---|
| Mass of purple cart | | Mass of green cart | |
| Length of purple cart | | Length of green cart | |

Warning: If you do not complete this lab all in one sitting, or if you click the **New Experiment** button, this data will change, and you will have to take new measurements to use for the remainder of the lab!

## Part III: Determine the Carts' Velocities

Set the **Carts' Direction** to same direction and the **Collision Behavior** to inelastic. Click the **Start Carts** button and watch what happens. You will see the carts pass through the various photogates, and when they do, the time it takes the cart to pass through the photogate will appear on the display. Notice the purple and green arrows to help you keep track of which cart (and in some cases which direction of travel) was being measured. The arrow that is half green and half purple indicates that the carts are stuck together as they pass that point. If you want, you can hit the Start Carts button a couple of times to get used to what the simulation is showing you.

When you're ready, hit **Start Carts** one last time and record the photogate data in the chart below. (The photogate timers read in seconds.) Also add the length data from above into the chart to help organize your work. For the case in which the carts are stuck together, be sure to add the lengths of the carts. Then use the lengths of the carts and the times it took to pass through the photogate to calculate the carts' velocities.

| | Elapsed time | Length | Velocity |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Carts stuck together after collision | | | |

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## Part IV: Calculate the Carts' Momenta

Using the fact that momentum is equal to mass times velocity, calculate the momentum of each cart and enter your results in the table below. Don't forget that you already found the masses of the carts in part II. Remember to use the total mass of the two carts when the two carts have stuck together.

| | Mass | Velocity (from part III) | Momentum |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Carts stuck together after collision | | | |

Now calculate the total momentum of the two carts before and after the collision. Note that after the collision, there is only one set of carts stuck together, so there is no need to add anything for that total.

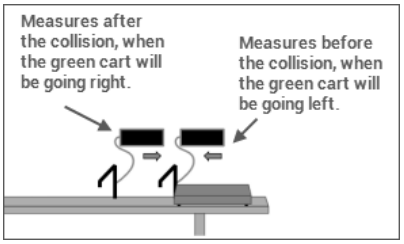
| | Purple cart's momentum | Green cart's momentum | Total momentum |
|---|---|---|---|
| Before collision | | | |
| After collision | -------- | -------- | |

Assuming your instructor wants you to, it may be wise to show your results to your instructor before proceeding. That way you can correct any errors before repeating them in the next set of calculations.

## Part V: Investigate Another Case

This time, set the **Carts' Direction** menu to opposite and the **Collision Behavior** to elastic. Repeat the same steps you did before, with a couple of modifications to the calculations.

First, when you calculate the velocities, make sure that you give cars going opposite directions opposite signs. The most intuitive practice is to let carts moving to the right have positive velocities and carts moving to the left have negative velocities. Then, use these signs when you calculate momentum and total momentum. If you forget, you won't get the answers you expect.




Secondly, be careful to keep track of which photogate measured the motion before the collision. Remember to look at the arrows just below the photogates to tell which direction is being measured. Then watch what direction the carts are going before and after the collision; hit **Start Carts** for a couple of dry runs first if it helps.

| | Elapsed time | Length | Velocity (with sign!) |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Purple cart after collision | | | |
| Green cart after collision | | | |

**Continued on the next page…**

| | Mass | Velocity (from page 2) | Momentum |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Purple cart after collision | | | |
| Green cart after collision | | | |

| | Purple cart's momentum | Green cart's momentum | Total momentum |
|---|---|---|---|
| Before collision | | | |
| After collision | | | |

## Part VI: One More Case

Now repeat the experiment once more, but this time you choose the conditions. Select any combination **of Carts' Direction** and **Collision Behavior** that you haven't used yet and write your selection below.

| Carts' Direction | | Collision Behavior | |
|---|---|---|---|

| | Elapsed time | Length | Velocity (with sign!) |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Purple cart (or both) after collision | | | |
| Green cart (if alone) after collision | | | |

| | Mass | Velocity (from above) | Momentum |
|---|---|---|---|
| Purple cart before collision | | | |
| Green cart before collision | | | |
| Purple cart (or both) after collision | | | |
| Green cart (if alone) after collision | | | |

| | Purple cart's momentum (if alone) | Green cart's momentum (if alone) | Total momentum |
|---|---|---|---|
| Before collision | | | |
| After collision | | | |

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### Part VII: Draw Conclusions

What did you notice about the total momentum before the collision and the total momentum after the collision in each of the above cases?

The phenomenon you should have noted in the previous question is called *conservation of momentum*. What do you think it means to say something is *conserved* in the context of physics?

Do you think there any combination of conditions in this lab under which momentum would not have been conserved? Explain your answer.