Name _____ Date _____ Period _____

The Coefficient of Restitution

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, also click the **New Experiment** button to obtain your own random cart data.

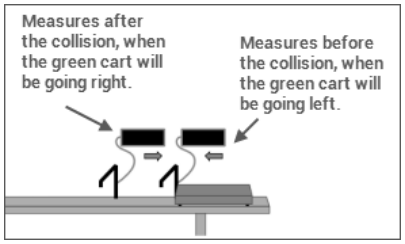
Part II: Measure the Carts

You will need the length of each cart to perform the calculations in the rest of the lab. 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. Be sure to convert your values to meters if you want to use SI units.

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 (Elastic case)



Set the **Carts' Direction** to opposite direction and the **Collision Behavior** to elastic. 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 each photogate will appear on the corresponding display. Notice the purple and green arrows to help you keep track of which cart and which direction of travel is being measured. You want to be especially careful to notice which photogate is measuring the carts' travel before the collision and which one is measuring after the collision. If you need to hit Start Carts for a few more dry runs to see what is happening, don't be afraid to do it.

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. Then use the lengths of the carts and the times they took to pass through the photogates to calculate the carts' velocities. 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.

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

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Part IV: Calculate the Coefficient of Restitution

The formula for coefficient of restitution is as follows, where v_2 and v_1 are the velocities of the two objects after collision and u_2 and u_1 are their velocities before the collision:

$$C_R = \left| \frac{v_2 - v_1}{u_2 - u_1} \right|$$

When you perform your calculations, don't be tempted to ignore the signs of your velocities just because of the absolute value in the formula. To see why, try ignoring the signs in $|8 + (-3)| = |8 + 3|$. Unless $5 = 11$, ignoring the signs isn't such a good idea.

Use this formula to calculate the coefficient of restitution and enter it below, using the extra space in the table to show your work.

Coefficient of restitution (elastic case)	

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: Compare the Partially Elastic Case

This time, set the **Carts' Direction** to opposite and the **Collision Behavior** menu to partially elastic, then repeat the same steps you did before.

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

Coefficient of restitution (partially elastic case)	

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Part VI: The Inelastic Case

Now set the **Carts' Direction** menu to opposite and the **Collision Behavior** to inelastic. You will repeat the calculations much as you did before, except that the carts will stick together on impact. Therefore, there will be only one photogate to measure the post-collision velocity. When you calculate the velocity for the carts that are stuck together, be very sure to use the total length of the two carts since the photogate measured the time required for both carts to pass through.

	Elapsed time	Length	Velocity (with sign!)
Purple cart before collision			
Green cart before collision			
Carts stuck together after collision			

When you calculate the coefficient of restitution for this case, notice that both the purple and the green carts have the same velocity after the collision—the velocity of the stuck carts.

Coefficient of restitution (inelastic case)	

Part VI: Draw Conclusions

In what type of collision will the coefficient of restitution always be zero? _____

In what type of collision will the coefficient of restitution be equal to one? _____

In what type of collision will the coefficient of restitution be between zero and one? _____

If a garbage bag full of pudding fell to the earth, what coefficient of restitution would you expect? Explain.

_____

The rules of racquetball require the racquetball to have properties that equate to a coefficient of restitution between 0.82 and 0.85 when the ball bounces off the floor. Describe the possible consequences of using a racquetball in which the coefficient of restitution is too low. What if it were too high? (In racquetball, players stand in an enclosed court with hard walls; hitting the ball off the walls is allowed. Players often get hit by the ball, making goggles quite important for safety.)

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