

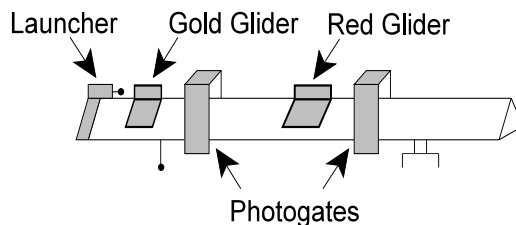
9 Linear Momentum

Name _____

Lab: Collisions

AP/Inquiry Physics

Momentum is an important quantity in physics. Today you will learn how to calculate it and study how the momenta of objects change when they collide. You'll be using an air track, two gliders of unequal mass, a launcher, and two photogates as shown at right. Check that all of the equipment is in the proper place and that the air track is level before you begin.



Base Error

Before collecting the collision data, it is helpful to see how much error is introduced by friction and timing problems in this lab. One way to get some idea of the amount of this error is by launching a glider through both gates and noting the difference in times between the first and second gates.

Launch a red glider and note the time it takes to pass through each gate. Then compute the percent error as follows:

First Gate Time: _____ s

Second Gate Time: _____ s

$$\% \text{ error} = \frac{\text{measured (2nd time)} - \text{theoretical (1st time)}}{\text{theoretical (1st time)}} \times 100$$

Approximate Base Error: _____ % SHOW WORK IN SPACE ABOVE

Observation

Now launch a red glider at a second red glider, which should be at rest between the two photogates.

1. What happens to **each** glider after they collide?

Data Collection

Now a gold glider (0.150 kg) will be launched at a motionless red glider (0.300 kg). Place the gold glider up against the glider launcher. A weak magnet on the launcher will hold it in place.

The launcher has a control box with a dial that controls the force applied. Randomly choose a setting. Before each launch, make sure that the "RECHARGE" light on the launcher control box is out and that both photogate timers have been reset to zero.

When the gold glider is launched, it will pass through the first photogate before striking the red glider. The red glider will then be propelled through the second photogate, while the gold one rebounds back through the first photogate. Record the times from each photogate in for your first trial. (You may not have enough time to clear the timer before the gold glider passes back through its photogate - be prepared for this and decide how to compensate.) Repeat this procedure two more times, for three trials at a certain launch force setting.

	Gold Glider Before Collision	Red Glider Before Collision	Gold Glider After Collision	Red Glider After Collision
Time (s)				
AVERAGE TIMES:				
Velocity (m/s) INSTRUCTIONS ON REVERSE				
Momentum (kg•m/s) INSTRUCTIONS ON REVERSE				

Finding velocity

You can easily find the velocity of a glider as it passes through the photogate by taking the length of the glider and dividing by the time ($v = d / t$). In this case, the gliders are not **accelerating** as they pass through the photogates, so their instantaneous velocity and their average velocity must be the same.

Length of gold glider in meters: _____ Length of red glider in meters: _____

Using the average times from the tables, calculate the velocity of the gliders in meters per second and enter the results in the velocity row. At least one of the velocity vectors you calculated should have been **NEGATIVE**. Think about the experiment and make sure you show any negative signs.

Finding momentum

The product of mass and velocity is called **momentum**. Calculate the momenta that correspond to the velocities you just computed and enter the results in the momentum row. (Remember, the gold glider has a mass of 0.150 kg; the red glider's mass is 0.300 kg.) At least one of the momenta vectors you calculated should have been **NEGATIVE**; show the appropriate negative signs. To see how momentum behaves, you need to compare the combined momenta of the objects before and after the collision.

2. The **total** momentum of the **system** in this experiment is always the momentum of the gold glider added to the momentum of the red glider. Using your table data, find the total momentum of the system **before** the collision occurred.

SHOW YOUR WORK

3. Now find the total momentum of the system **after** the collision.

SHOW YOUR WORK

Your answers to 2 and 3 should be similar. If they are not, your data or your calculations are in error. Re-check your calculations first. **Do not proceed until you have accurate results.**

4. The formula for percentage difference is shown at right. Use your above answers to calculate the percentage difference between the total momentum of the system before and after the collision.

$$\% \text{ difference} = \frac{\text{larger} - \text{smaller}}{\text{average}} \times 100$$

SHOW YOUR WORK

5. Keeping in mind the base error you measured at the start of this lab, your results from this lab illustrate a basic property of the total momentum of a system. It is a property that holds both before and after a collision. State that property below, in your own words:

6. Now write a mathematical equation (using the listed symbols) that shows how the total momentum of this experimental system before the collision is related to the total momentum of the system after collision.

SYMBOLS: m_A = mass of glider A m_B = mass of glider B
 \vec{v}_{Ai} = velocity of glider A before collision \vec{v}_{Bi} = velocity of glider B before collision
 \vec{v}_{Af} = velocity of glider A after collision \vec{v}_{Bf} = velocity of glider B after collision
