## *LAB A10: A Conserved Quantity in Completely Inelastic ( = sticky) Collisions*

***10/30/02***

**Goal:** To discover a quantity that is conserved (i.e., that is the same value before the collisions as after the collisions) in collisions of two gliders on a level air track

**Pre-lab:** Before coming to lab,

a) Read this lab handout from "Introduction" to the end of Part 1
b) Format your lab book for Part 1 ONLY in the manner shown on the sample data sheet attached. Spread the columns across two pages of your lab book.
c) Understand the example on the data sheet.
d) In your lab book, write down 3 different algebraic combinations of mass **m** and velocity **v** that make physics sense (more about what this means below). List your quantities after the goal.

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***Setting up***

1) Plug in the cable from one photogate into the Digital Port 1 and the other photogate into the Digital Port 2 on the Lab Pro Interface Box.
2) Log on to your NCSSM account (this step is not necessary for computers on rolling carts).
3) Once the Windows desktop has appeared, click on the Logger Pro 2.1 icon on the desktop. If a Setup Interface box appears, click Scan, then OK. Call the instructor over if the popup box does not disappear after you do that.
4) Go to File and Open. Navigate to the directory Vernier Software/LoggerPro2.1/Experiments/Probes and Sensors/Photogate. Open the file named Collision Timer. A data table with columns for Delta T1, Delta T2, V1 and V2 should now be visible. These Delta T's are the blockage time for each photogate in seconds. There should also be two graphs and a text window – close those, you will only need the data table in this lab.

***Shutting down the equipment at the end of the class period***

1) Remove the Photogate cables from the Lab Pro box, being careful to press on the plastic tab of the connector while pulling out the cable.
2) Log off of your NCSSM account if you logged in.
3) Clean up your station.

**Which Gate is Which?**

Your first job is to experimentally determine which timing data goes with which gate.
Click the Collect button and block a photogate with your hand. Now block the other photogate instead. Pay attention to the values appearing in the table so that you can identify which time data corresponds with which photogate--this is VERY IMPORTANT.

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**Introduction:** A completely inelastic collision is one in which the two colliding objects stick together after the collision (in this case by means of Velcro). In order to be able to analyze and solve problems easily involving completely inelastic collisions, it would be useful if there were some physics quantity (involving the properties of the objects that are colliding; for example, the mass and the velocity of the objects) that remains the same before, during, and after the collision. Such a quantity is said to be ***conserved***.

**Equipment and Techniques**: Air tracks (leveled) will be used with three different gliders:

gold (mass = 0.150 kg)      red (mass = 0.300 kg)      blue (mass = 0.450 kg)

The masses of these gliders will be referred to as M, 2M, and 3M; in this lab we will measure all masses in units of M (***instead*** of the usual SI unit, kilograms).

Post-it notes are used on top of each glider in order to provide flags to block the photogates. The photogate will record the amount of time that the photogate has been blocked.

Be sure that the same width of post-it note is used on all gliders and that the sides of the notes are vertical. (Why?) The gliders must move at constant velocities as they pass through the photogates. (Why?) Therefore, take care not to be pushing a glider while its flag is in the photogate, and be sure that the flags are not inside photogates while the gliders are colliding. Stop the gliders before they rebound from the ends of the track and pass back through the photogates.

**Work in groups of 3, maximum. (Groups of 2 are better)**

**How to choose m-v combinations**: Before starting, each group must agree upon 3 different algebraic combinations of mass and velocity that the group will test for conservation. Each of these quantities (combinations of m and v) must not violate "physics sense." Remember that both mass and velocity have units, and that there are certain things that you cannot do with quantities that have units or with two quantities that have different units. (Also, beware of choosing 2 algebraic combinations that are redundant.) An example of a m-v combination is $\mathbf{v^2/m}$. Once your group has decided on the three quantities that the group will test (***a process that should take no more than 1 minute***), the group should check with the instructor or lab assistant to make sure that the three selected combinations are acceptable. Simple is better than complicated! List each acceptable m-v combination at the top of one of the columns so labeled in part 1 of the data table.

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**Method and Analysis:**

**PART 1**

You will first analyze the simplest completely inelastic collisions: those in which one glider is moving initially and the other is not. Because the gliders stick, only one "object" (the combined mass) will be moving after the collision. With three different gliders available, nine different simple collisions can be performed. You will choose 3 of these collisions to actually perform on the air track. Only 1 of the 3 may use gliders that have the same mass. Try not to use the gold gliders (they don't give good results).

You will record the masses in units of **M**, the blocking distance in units of **L** (the length of a Post-It note), and the block time in units of seconds (record this as part of the denominator as shown in column 3 on the sample data sheet). Thus, the units of speed will be L/s. (What happens if the Post-It notes of both gliders pass through the photogate after collision?) Note also that the mass after the collision is the sum of the masses of the gliders, because they act like one mass.

Now perform your first collision, and record the data (masses and velocities) in the appropriate initial and final columns. Next, calculate the initial and final values of each of your 3 m-v combinations. Is there a candidate m-v combination that seems to be conserved? Because the air track is not perfectly frictionless and level and the gliders may rattle against the track as they collide, no quantity will appear to be perfectly conserved. Differences of as much as 10-15% should be expected.

**On your data table, circle the combination of m and v that you think is most nearly conserved and call the instructor over to check.**

Repeat this process for the remaining collisions only after the instructor has confirmed your conclusion about the first collision. The remaining collisions should validate the result that you obtained during the first collision.

## PART 2

Now you will use your knowledge of which m-v combination quantity is conserved to **predict** the final velocities of the coupled gliders in completely inelastic collisions in which **both** gliders are moving before the collision. That is, you will perform a collision, record the times, and determine the initial and final velocities and the initial and final masses. Because you now know the conserved m-v quantity, you can also use the initial masses/velocities and the final mass to calculate what the final velocity should be. (If two objects are moving before the collision, then the total amount of the conserved quantity initially is the sum of the quantities for each object.)

1) Because velocity is a vector; select a direction for positive; **record this + direction on an air track picture** (which shows the orientation of the air track as you viewed it) in your lab book. When you calculate your velocities, you will need to decide which were positive and which were negative, based on your selection of positive. Since there will be three blockage intervals measured by the photogate for each collision, be sure to correctly match the times with the gliders that produced them, before and after the collision.

2) Collect and record the data for 3 collisions on the air track. **Do at least one collision in which the gliders are moving in opposite directions before the collision and at least one in which the gliders are moving in the same direction before the collision.**

3) Use your data to calculate an expected final velocity for the combined mass. Compare to the final velocity determined with your photogate. Percent differences should be less than 20%.

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## PART 3

Finally, set up a collision of two gliders in which the gliders do not stick (but instead bounce off each other's metal bumpers) during the collision. Collect data and determine whether your conserved quantity for completely inelastic collisions is also conserved for the non-inelastic collision.

### Conclusion