**AP Physics: Lab #6**

**Collisions on an Air Track**

Name ____________________ Hour ______

Lab Partners ______________________________

## Purpose:

* Verify conservation of momentum in collisions on an air track.
* Analyze conservation of kinetic energy in elastic and inelastic collisions on an air track.

## Equipment:

air track & air supply
2 air track carts
2 air track cart flags
2 LabQuest Mini's with USB cord
4 Photogates and Photogate cords
1 Computer with LoggerPro software

## Introduction:

An isolated system is defined as a system of objects in which no outside forces are present. It can be shown that if no outside forces are present, no change in momentum can occur, and the total momentum in the system must remain constant. This result is known as the conservation of momentum, and is valid for all collisions in an isolated system. In equation form, it is stated:

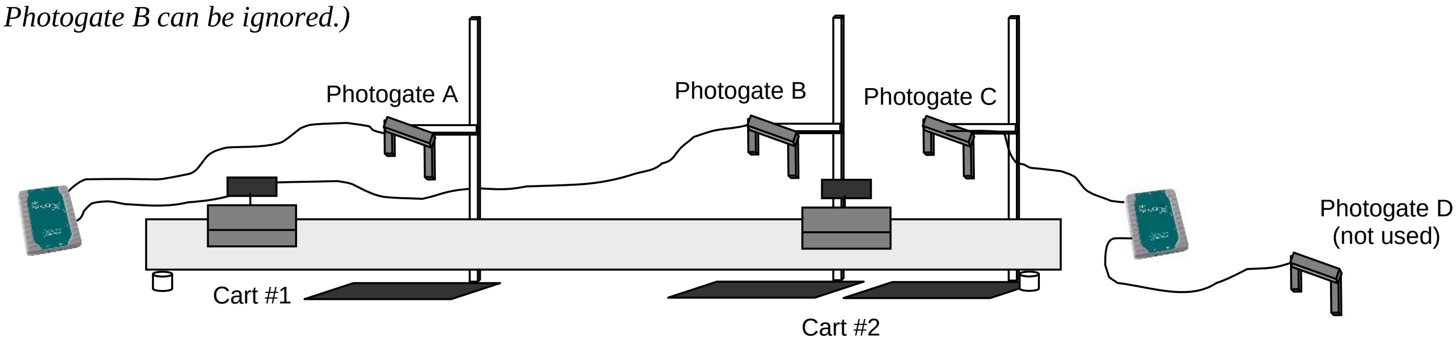
$$m_1 \cdot v_1 + m_2 \cdot v_2 = m_1 \cdot v'_1 + m_2 \cdot v'_2$$

In some cases, the kinetic energy of an isolated system is also conserved. These types of collisions are known as *elastic* collisions. In other collisions kinetic energy is lost, a situation which can occur even if there are no outside forces acting on the system. These types of collisions are known as *inelastic* collisions. The maximum amount of kinetic energy is lost from a system when two objects collide and stick together in what is known as a *perfectly inelastic* collision. This lab activity involves the collection of mass and velocity measurements for two carts before and after a collision on an air track. The total momentum and kinetic energy can then be calculated for the system before and after the collision.

## Procedures:

Use the photogate cords to connect 2 of the photogates to the DIG I and DIG 2 ports of each LabQuest. Use the USB cords to connect both of the LabQuest's to the computer. Then open the "*Lab #6 Template*" LoggerPro file from the class web site or Shared folder *(Note: If a "Sensor Confirmation" message appears when the file opens, click Collect.)* Before continuing with the lab set-up, you will need to determine which photogate is Photogate A, B, C, and D. Click the green Collect button on the LoggerPro toolbar. Carefully block each photogate with your hand, each time observing which set of columns collects data as the photogate is blocked. If the LoggerPro program stops taking data before you finish, simply click Collect again to finish checking the photogates. Use a small piece of tape to identify Photogates A, B, and C. *(Note: Photogate D will not be used for this experiment.)*

Securely attach Photogates A, B, and C to support stands. Turn each photogate head downwards so the flag on each cart is free to pass through the photogate as the cart moves on the air track. Attach flags to the two carts, placing the carts so that the elastic sides will make contact in a collision. Arrange the photogates so that Cart #1 will pass through Photogate A <u>*before*</u> the collision and Photogate B <u>*after*</u> the collision, and Cart #2 will pass through Photogate C <u>*after*</u> the collision. *(Note: For some trials, only Photogates A and C will be needed and the data collected by Photogate B can be ignored.)*



## Procedures (cont):

To collect data, click the green COLLECT button on the LOGGERPRO toolbar. Carefully set Cart #1 into motion, allowing it to collide elastically with Cart #2. The time that each photogate was blocked and the resulting velocity of the cart will be recorded in the Data Columns. If the carts "bounce" back through the photogates again after the collision, they may create additional data points that can be ignored. If the LOGGERPRO continues to collect data after the collision has finished, click STOP to end data collection. Repeat the experiment for 3 trials of elastic collisions with no extra mass added and record all data in Data Table A. Each time, try to achieve approximately the same initial velocity for Cart #1. Then add mass to Cart #1, increasing it to approximately twice the mass of Cart #2. Repeat the experiment for 3 different trials of an elastic collision of carts with unequal masses, recording the velocities of each cart in Data Table B.

Change the position of each cart so that the inelastic sides will make contact in a collision. Perform 3 trials for a perfectly inelastic collision of the two carts with equal mass, recording the velocities in Data Table C. Again, add mass to Cart #1, increasing it to approximately twice the mass of Cart #2. Perform 3 trials for a perfectly inelastic collision of carts with unequal masses, recording the velocities in Data Table D.

## Calculations:

1. Calculate the average velocity of each cart before and after the collision in each trial.
2. Calculate the momentum and kinetic energy of each cart before the collision in each trial.
3. Calculate the momentum and kinetic energy for each cart (or the combined carts) after the collision in each trial.
4. Calculate the percentage change of the total momentum of the system before and after the collision in each trial.
5. Calculate the percentage change of the total kinetic energy of the system before and after the collision in each trial.

## Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Why is the use of the air track an important factor in the accuracy of your results in this experiment?
- Discuss the accuracy of your results for the total momentum of the system before and after the collision. Should your results prove conservation of momentum? Should the type of collision (elastic or inelastic) be a factor in these measurements?
- Discuss the accuracy of your results for the total kinetic energy of the system before and after the collision. Should your results prove conservation of kinetic energy? Should the type of collision (elastic or inelastic) be a factor in these measurements?
- Is it possible for Cart #1 to come to a complete stop in the collision performed during Trial B? Explain your answer, using equations where appropriate. If this collision were to occur, what would the effect be on the velocity of Cart #2 after the collision?

## Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 6 pts
Calculations – 6 pts
Analysis – 10 pts

## Data Table A: Elastic Collision – Equal Mass

Mass 1 = ____________

Mass 2 = ____________

| | $v_1$ | $v_2$ | $v_1'$ | $v_2'$ |
|---|---|---|---|---|
| Trial #1 | | | | |
| Trial #2 | | | | |
| Trial #3 | | | | |
| Average | | | | |

| $p_1$ | $p_2$ | $p_{total}$ |
|---|---|---|
| | | |

| $p_1'$ | $p_2'$ | $p'_{total}$ |
|---|---|---|
| | | |

| $p$ % Change |
|---|
| |

| $KE_1$ | $KE_2$ | $KE_{total}$ |
|---|---|---|
| | | |

| $KE_1'$ | $KE_2'$ | $KE'_{total}$ |
|---|---|---|
| | | |

| $KE$ % Change |
|---|
| |



## Data Table B: Elastic Collision – Unequal Mass

Mass 1 = ____________

Mass 2 = ____________

| | $v_1$ | $v_2$ | $v_1'$ | $v_2'$ |
|---|---|---|---|---|
| Trial #1 | | | | |
| Trial #2 | | | | |
| Trial #3 | | | | |
| Average | | | | |

| $p_1$ | $p_2$ | $p_{total}$ |
|---|---|---|
| | | |

| $p_1'$ | $p_2'$ | $p'_{total}$ |
|---|---|---|
| | | |

| $p$ % Change |
|---|
| |

| $KE_1$ | $KE_2$ | $KE_{total}$ |
|---|---|---|
| | | |

| $KE_1'$ | $KE_2'$ | $KE'_{total}$ |
|---|---|---|
| | | |

| $KE$ % Change |
|---|
| |

## Data Table C: Inelastic Collision – Equal Mass

Mass 1 = ____________

Mass 2 = ____________

| | $v_1$ | $v_2$ | $v'$ |
|---|---|---|---|
| Trial #1 | | | |
| Trial #2 | | | |
| Trial #3 | | | |
| Average | | | |

| $p_1$ | $p_2$ | $p_{total}$ | $p'$ | $p$ % Change |
|---|---|---|---|---|
| | | | | |

| $KE_1$ | $KE_2$ | $KE_{total}$ | $KE'$ | $KE$ % Change |
|---|---|---|---|---|
| | | | | |



## Data Table D: Inelastic Collision – Unequal Mass

Mass 1 = ____________

Mass 2 = ____________

| | $v_1$ | $v_2$ | $v'$ |
|---|---|---|---|
| Trial #1 | | | |
| Trial #2 | | | |
| Trial #3 | | | |
| Average | | | |

| $p_1$ | $p_2$ | $p_{total}$ | $p'$ | $p$ % Change |
|---|---|---|---|---|
| | | | | |

| $KE_1$ | $KE_2$ | $KE_{total}$ | $KE'$ | $KE$ % Change |
|---|---|---|---|---|
| | | | | |