# Conservation of Linear Momentum

NAME___________________ PHYSICS Lab

**Momentum** is the product of mass and velocity. Since momentum is a vector quantity, we will need to be concerned with both its magnitude and direction. When one object strikes another object, a number of different things might happen depending on their relative masses. You will investigate the **Law of Conservation of Momentum** during three different types of collisions: **ELASTIC, INELASTIC and EXPLOSIONS.**

Mass of cart #1 = __g = __kg Mass of cart #2 = __g = __kg Mass of cart #3 = __g = __kg

Width of flag (#1) = __cm = __m Width of flag (#2) = __cm = __m

Set up a pair of photogate timers in gate mode so that the "flags" of each cart will break the infrared beam of the timer. These will measure the time interval that the beam is broken.

*Two of the collisions involve a moving cart with a second cart at rest. For these cases an attempt will be made to repeat the collision several times at the same initial velocity. The plunger on the cart can be depressed and released to propel the cart with the same velocity every time with some practice. Launch one of the carts five or six times and allow it to pass through a photogate timer in "Gate" mode. The speed will be consistent if the time readings are consistent. Practice launching until it can be launched with the same velocity every time to the extent that this is possible.*

## ELASTIC COLLISIONS

1. This collision will be between gliders $m_1$ and $m_2$ which have essentially the same mass with $m_2$ initially at rest in the center of the track. Cart $m_1$ will collide (with repulsive magnets facing each other) with $m_2$ and essentially stop, and $m_2$ will move in the direction $m_1$ was moving before the collision. Record the times of each photogate timer in *DATA TABLE 1*.

2. This collision will be between gliders $m_1$ and $m_3$ (add a bar mass to $m_2$ to make $m_3$) with $m_3$ initially at rest in the center of the track. Cart $m_1$ will collide (with repulsive magnets facing each other) with $m_3$. After the collision $m_1$ will rebound, and $m_3$ will move in the original direction of $m_1$'s motion. The same timer can be used to obtain $m_1$'s original and final times if its memory is ON. Simply depress the toggle switch to get the *second reading by subtracting the first time from the time you see*. Record the times of each photogate timer in *DATA TABLE 2*.

## INELASTIC COLLISIONS

3. This collision will be between gliders $m_1$ and $m_2$ which have essentially the same mass with $m_2$ initially at rest in the center of the track. Align the carts so the velcro fastens upon collision. Allow the photogate timers to record times for $m_1$ before and $m_{12}$ combined after the collision.

4. Repeat the experiment but send $m_3$ toward a resting $m_1$. Allow the photogate timers to record times for $m_3$ before and $m_{31}$ combined after the collision.

## EXPLOSIONS

5. Place carts $m_1$ and $m_2$ next to one another with the plunger depressed and "locked" into place. Place photogate timers in position to measure the times of the 'exploding" carts. Depress the plunger and record the times in the DATA & RESULTS section.

6. Repeat the experiment above but with $m_1$ and $m_3$. Depress the plunger and record the times in the DATA & RESULTS section.

**DATA & RESULTS:**
**CALCULATIONS:**

1. Calculate the velocities of each cart using the photogate timers and length of flags. Let the velocities of the carts to the right be positive and those to the left negative.
2. Calculate the momentum of each of the carts before and after colliding.
3. For the cases where there are more than one cart contributing to the momentum either before or after colliding, **calculate the total momentum** and record these values in the Calculations table.
4. Calculate the percentage difference between the total momentum.

**% difference = [(difference b/s before and after momentum) / average of the before and after momentum] * 100%**

**ELASTIC COLLISION** *DATA TABLE 1*

| | | **Time (s)** |
|---|---|---|
| | **CART # (with mass in kg)** | **Trial 1** |
| $m_1$ before | | |
| $m_2$ after | | |

*DATA TABLE 2*

| | | **Time (s)** |
|---|---|---|
| | **CART # (with mass in kg)** | **Trial 1** |
| $m_1$ before | | |
| $m_3$ after | | |
| $m_1$ after | | |

*CALCULATIONS TABLE 1*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** |
|---|---|---|---|
| $m_1$ before | | | |
| $m_2$ after | | | |

*CALCULATIONS TABLE 2*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** | **Total momentum** |
|---|---|---|---|---|
| $m_1$ before | | | | |
| $m_3$ after | | | | |
| $m_1$ after | | - | - | |

**INELASTIC COLLISION** *DATA TABLE 3*

| | | **Time (s)** |
|---|---|---|
| | **CART # (with mass in kg)** | **Trial 1** |
| $m_1$ before | | |
| $m_{12}$ after | | |

*DATA TABLE 4*

| | | Time (s) |
|---|---|---|
| | **CART #** **(with mass in kg)** | **Trial 1** |
| $m_3$ before | | |
| $m_{31}$ after | | |

*CALCULATIONS TABLE 3*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** |
|---|---|---|---|
| $m_1$ before | | | |
| $m_{12}$ after | | | |

*CALCULATIONS TABLE 4*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** |
|---|---|---|---|
| $m_3$ before | | | |
| $m_{31}$ after | | | |

**EXPLOSIONS** *DATA TABLE 5*

| | | Time (s) |
|---|---|---|
| | **CART #** **(with mass in kg)** | **Trial 1** |
| $m_1$ after | | |
| $m_2$ after | | |

*DATA TABLE 6*

| | | Time (s) |
|---|---|---|
| | **CART #** **(with mass in kg)** | **Trial 1** |
| $m_1$ after | | |
| $m_3$ after | | |

*CALCULATIONS TABLE 5*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** |
|---|---|---|---|
| $m_1$ after | | | |
| $m_2$ after | | | |

*CALCULATIONS TABLE 6*

| | **Average Time (s)** | **Average Velocity (m/s)** | **Momentum (kgm/s)** |
|---|---|---|---|
| $m_1$ after | | | |
| $m_3$ after | | | |

**QUESTIONS & CONCLUSION:**

1. Calculate the percent difference b/w the before and after momenta for one elastic and one inelastic collision. Do these differences indicate that momentum has been conserved?

2. Suggest any specific errors that are affecting the results concerning momentum conservation.

3. Is kinetic energy conserved in these collisions? Check for one elastic and one inelastic collision by comparing the total KE before colliding with the KE afterward.

4. Energy is never created nor destroyed so what form did the energy change into if it's no longer kinetic?