# Conservation of Linear Momentum

Name_____ TA_____

Partners_____

Section #_____ Date_____

In this lab we are going to use the air track/glider system to investigate the conservation of momentum and kinetic energy during the collision of two objects.

To determine the velocity of the glider, we use a piece of tape as a "flag". If the flag width is L and flag blocks the photogate for a time period of T (called "time in gate" in Datastudio), we know the velocity V = L / T.

Momentum of a mass moving at velocity v is **P** = m**v**. For a system of multiple objects, the total momentum is the vector sum of the momenta of individual objects.

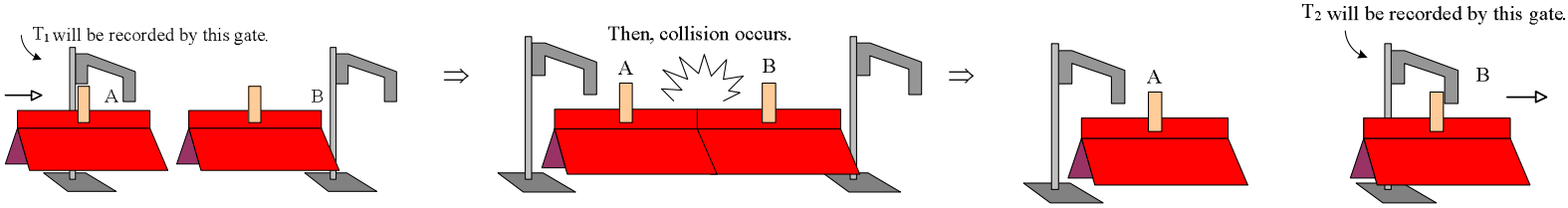
Kinetic energy of a mass moving at velocity v is $E_k = \frac{1}{2}mv^2$. For a system of multiple objects, the total energy is the sum of the individual objects' energy.

During any collision, the system's total momentum is always conserved. Kinetic energy is conserved only if the collision is elastic. For inelastic collisions, part of kinetic energy is lost (converted to other forms of energy).

## 1. Collision of two objects of equal mass

Use the two large gliders (collision carts). Place glider #2 between the two photogates. Push the glider A against B. Let them collide by the leaf springs (or magnetic repulsion) with no Velcro.

Our system (the two gliders) should have momentum conserved, which means during the collision, 100% of glider A's momentum $P_1$ should be transferred to B. However, due to various reasons, $P_1$ and $P_2$ you obtain from the experiment may not be exactly the same.




Flag width $L_1$ _____ Flag width $L_2$ _____

$m_1$ _____ $m_2$ _____

| Trial # | $T_1$ | $T_2$ | $V_1$ | $V_2$ | $P_1$ | $P_2$ | % difference |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |

Find the percentage difference $\frac{|P_1 - P_2| \times 100}{(P_1 + P_2)/2}$ (%) for each value.

**Is the momentum conserved?**

**2. Collision of two objects of unequal mass**

Use the one large and one small gliders (or two carts with and without a weight). Place glider B between the two photogates. Push the glider A against the B. Let them collide by the leaf springs (or magnetic repulsion) with no Velcro. Notice that this time the glider A will not stop after the collision. So you need to determine the final velocity of A glider as well.

Our system (the two gliders) should have total momentum conserved, which means the initial total momentum of the system should be the same as the final total momentum.

Note: Momentum is a vector. In this one-dimensional problem, if the velocities are in different directions, be sure to use appropriate signs.

***Draw the simple diagram as shown in the first part. Make sure which is $T_1$(initial), $T_1$(final), and $T_2$.***

Flag width $L_1$ _____ Flag width $L_2$ _____

$m_1$ _____ $m_2$ _____

***Make sure with your instructor about how many trials you should do for this case.***

| Trial # | $T_1$ initial | $T_1$ final | $T_2$ | $V_1$ initial | $V_1$ final | $V_2$ |
|---|---|---|---|---|---|---|
| 1 large hits small | | | | | | |
| 2 small hits large | | | | | | |

| Trial # | $P_1$ initial | $P_1$ final | $P_2$ | (Total P) init | (Total P) final | % difference |
|---|---|---|---|---|---|---|
| 1 large hits small | | | | | | |
| 2 small hits large | | | | | | |

Find the percentage difference $\frac{(\text{Total } P)init - (\text{Total } P)final}{((\text{Total } P)init + (\text{Total } P)final)/2} \times 100(\%)$ for each trial.

**Is the momentum conserved?**

### 3. Completely inelastic collision

Use the two large gliders. Place glider #2 between the two photogates. Push the glider A against the B. Let them collide by the leaf springs with Velcro so after collision they stick together.

Although the collision is completely inelastic, the total momentum is still conserved. However, 50% of the kinetic energy is lost, if the two masses are equal.

***Draw the simple diagram as shown in the first part. Make sure which is $T_1$ and $T_{1+2}$.***

Flag width $L_1$ _____ Flag width $L_2$ _____

$m_1$ _____ $m_2$ _____

| Trial # | $T_1$ | $T_{1+2}$ | $V_1$ | $V_{1+2}$ | $P_1$ | $P_{1+2}$ | % difference $\frac{\lvert P_1 - P_{1+2}\rvert}{(P_1 + P_2)/2} \times 100\ (\%)$ |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

**Is the momentum conserved?**

| Trial # | $KE_1 = \frac{1}{2} m_1 V_1^2$ | $KE_2 = \frac{1}{2} (m_1 + m_2) V_{1+2}^2$ | % difference $\frac{\lvert KE_1 - KE_2\rvert}{(KE_1 + KE_2)/2} \times 100\ (\%)$ |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

**Is the energy conserved or not?**

**NOTE:**

1. Use Kg for masses, m for lengths, kg·m/s or N·s for momentum in, and J for energy.
2. In your report be sure to write some comments on your results. If your results are different from what are predicted theoretically, discuss the possible reasons.