Experiment 05: Momentum

Table and Group: ________ Participants: ________________________________
Each group will turn in one common report. ________________________________

In all three parts $M_1$ refers to the incoming, moving, cart, $M_2$ refers to the initially stationary cart, $V_{in}$ refers to the initial velocity of the incoming cart, $V_{out}$ is the velocity of $M_1$ (and also $M_2$ in the inelastic collision) after the collision. The masses of the carts are all 0.25 kg, don’t forget to add whatever additional weights you used. Be sure to include the units on all quantities and make sure that they are consistent.

Part One: Impulse and Change in Momentum

The goal of this part is to investigate directly the prediction that

$$\vec{p}_{final} - \vec{p}_{initial} = M_1 \vec{V}_{out} - M_1 \vec{V}_{in} = \int \vec{F} dt$$

Enter your data for bouncing a cart from the spring below.

$V_{in}$= ________________ $V_{out}$= ________________ $M_1$= ________________

Calculate: $\vec{p}_{final} - \vec{p}_{initial}$= ________________

Integral of Force versus Time= ________________

Interpretation: Do you think that your data support the prediction?

Part Two: Inelastic Collisions

The goal of this part is to compare momentum ($\vec{p} = m\vec{v}$) before and after an inelastic collision. Enter the results measured by your group for an inelastic collision below.

$M_1$= ________________ $M_2$= ________________ $M_1 + M_2$= ________________

$V_{in}$= ________________ $V_{out}$= ________________

Calculate: $p_{initial}$= ________________ $p_{final}$= ________________

Interpretation: Do you think that your data support the prediction?
Part Three: Elastic Collisions

The goal of this part is to investigate the prediction for the velocity after an elastic collision. You will check only the velocity of the incoming cart, for which the result is expected to be:

\[ \vec{V}_{\text{out}} = \frac{M_1 - M_2}{M_1 + M_2} \vec{V}_{\text{in}} \]

Enter the results measured by your group for elastic collisions below. Be careful of the signs of the velocity before and after the collisions.

**Part ThreeA: Incoming cart lighter** \((M_1 < M_2)\)

\[
\begin{align*}
M_1 &= \underline{\phantom{000}} \\
M_2 &= \underline{\phantom{000}} \\
V_{\text{in}} &= \underline{\phantom{000}} \\
V_{\text{out}} &= \underline{\phantom{000}}
\end{align*}
\]

Calculate: Use the masses and incoming speed to predict \(V_{\text{out}} = \underline{\phantom{000}}\)

Interpretation: Do you think that your data support the prediction (magnitude and sign)?

**Part ThreeB: Incoming cart heavier** \((M_1 > M_2)\)

\[
\begin{align*}
M_1 &= \underline{\phantom{000}} \\
M_2 &= \underline{\phantom{000}} \\
V_{\text{in}} &= \underline{\phantom{000}} \\
V_{\text{out}} &= \underline{\phantom{000}}
\end{align*}
\]

Calculate: Use the masses and incoming speed to predict \(V_{\text{out}} = \underline{\phantom{000}}\)

Interpretation: Do you think that your data support the prediction (magnitude and sign)?

**If you finish early: Additional analysis of elastic collision**

In the elastic collisions, the struck cart rebounds off of the spring. As you did in Part 1 above, you can use the integral of the Force versus time plot to find the change in momentum of the cart. See the writeup for discussion of how to use this information to study the elastic collision in more detail.