# Analysis of Inelastic Collision To Confirm The Law of Conservation of Momentum


## Abstract:

A fundamental law of momentum is that momentum is conserved unless an external force is applied. In this experiment, we determined that this law was held true through video analysis of an inelastic collision between a moving empty cart (500g) and an identical stationary cart holding 500g of external mass. It was found that the post-collision velocity closely aligned with the predicted value, indicating that momentum was conserved at the collision instance. However, the combined motion of the carts gradually decelerates due to friction, which is consistent with the theory that momentum is not conserved when there is an external force. The main sources of error in this experiment were the systematic error introduced by frictional loss during the brief collision and random error from video analysis. However, the effect of these errors appears to be minimal and would not affect our conclusion.


## Purpose:

In this experiment, we attempted to prove the law of conservation of momentum for an inelastic collision between two carts through video analysis.

## Hypothesis:

It is predicted that overall momentum is not conserved due to an external force being friction, which will show a curve in the displacement time graph. Velocity after collision is expected to follow the law of conservation of momentum, being $\frac{m_1 v_1}{m_1 + m_2}$ due to a change in mass and one cart having no initial momentum.

## Method:

We started by placing one cart (500g) with 0g of additional mass 0.37m away from another identical cart with no additional mass at the end of the track. A camera was placed in a location that could record the entire track and the motion of the collision and a height that eliminates parallax error. The cart at the end of the track was given a push, resulting in an inelastic collision with the stationary cart. This process was repeated multiple times, up to 500g of additional mass, and the collision that demonstrated the most apparent momentum loss was graphed and analyzed using Tracker ( 500g additional mass collision).

## Results:

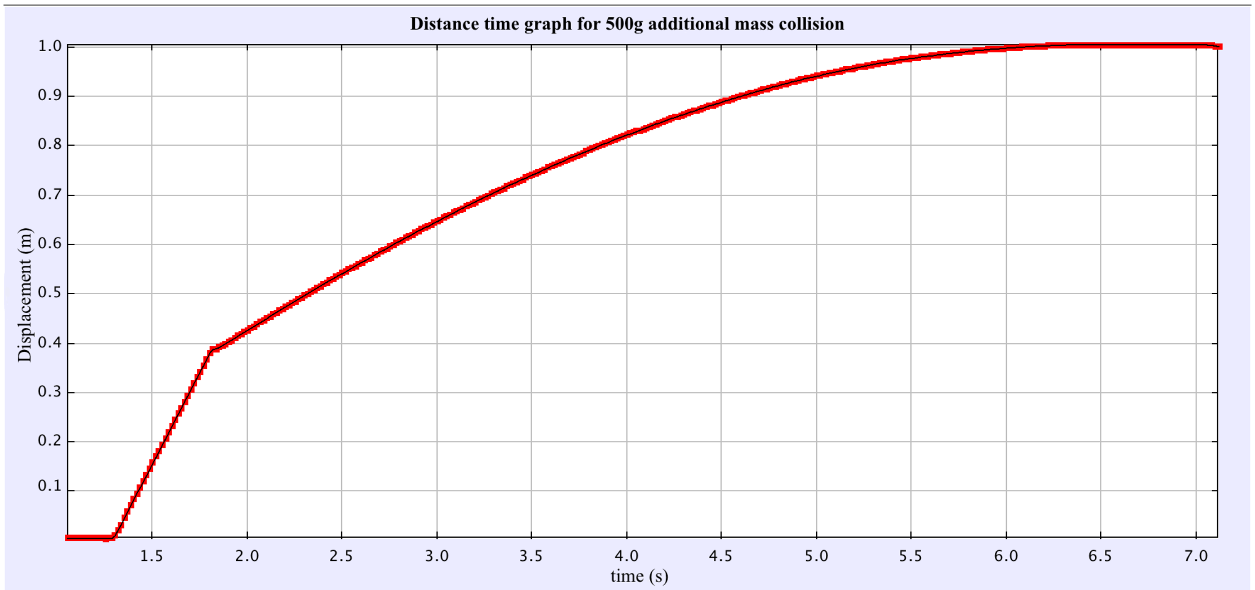


***Fig.1*** (Horizontal displacement graphed against time in Tracker for 500g additional mass collision; Noticeable curve shown in the section after collision; Tangent value (*velocity*) for **t** at **1.78s** and **1.92s** is **0.744m/s** and **0.245m/s** respectively; collision happened at **t** = **1.80 s**)

## Discussion:

Due to the consistency in initial velocity and high graphical accuracy, collision graphs for all masses end up with a similar general shape, concluding with the same result. Thus, only one graph is necessary to explain and perform analysis. As shown in *Fig.1*, the recorded post-collision velocity is 0.245 m/s, which is only a slight difference from the predicted value of 0.248m/s. This suggests that momentum is greatly conserved before and after the collision.

The overall curvature of the graph (*Fig.1*) shows that the carts decelerate, indicating that momentum is not conserved for the system containing two carts and masses. This aligns with our prediction and the theory, where momentum is not conserved when there is an external force applied. In this case, the external force was friction, as our system only included the two carts and the additional mass.

Potential sources of error include random error from inconsistency in graphical analysis and systematic error from both assumptions in mass and from friction during the brief period of time that the collision happens. As the difference between predicted and recorded velocity is minimal, the impact of these errors is likely insignificant and should not compromise the validity of our conclusion.

## Conclusion:

Data recorded supported the hypothesis: momentum is conserved for the collision but lost throughout the entire trip due to an external force being friction. The minimal deviation from the predicted value strongly supports our hypothesis and conclusions, and the general curvature of the graph is consistent with the theory. Further experiments could focus on determining the value of friction, and its numerical impact on the collision, or attempt to mostly remove the effect of friction.