LAB 5: COLLISIONS

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Abstract *The conservation of momentum equation and the kinetic equations relationship to the elasticity of collisions were used to determine if the momentum of two colliding hockey pucks were conserved and what type of collisions they were. A tracking camera allowed for the velocities to be calculated for these calculations while the mass was constant.*

Keywords: *elastic, momentum, kinetic, conservation*

1. Introduction

The goal of this lab is to determine whether momentum is conserved in collisions as well as calculate their elasticity. To get these collisions, two hockey pucks at certain angles were thrown onto each other at a similar velocity. Through the conservation of momentum, it is known that the momentum before the collision should equal the momentum after the collision. Therefore, the masses and velocities before the collision should have an equal relationship with those values after the collision.

In order to determine the elasticity, the kinetic energy equation is needed. Different types of collisions, such as elastic and inelastic, have certain relationships with kinetic energy. Therefore, the kinetic energy of the pucks before the collisions needed to be compared with the kinetic energy afterwards in order to determine what type of elasticity these collisions have.

2. Experimental Procedure

To prepare for the tracking of the collisions, the python script 6_track_motion_and_print.py was selected and duplicated so that modifications could be made. In the duplicated script, the names of the output files were changed from example6 to collision examples. Additionally, to configure the capturing software, since the camera was about 92 centimeters above the airtable, the camera distance was changed to 92 to ensure accurate unit conversion within the script.

When the setup was complete, the airtable itself was prepped with a marker. Several straight lines were drawn with the aid of a ruler, setting the planned trajectories of the pucks during each of the 8 trials. Each set of lines drawn made an angle that would be later calculated in the data analysis when determining the angle of the collision. The airtable was then activated, and the script to capture the data recorded each trial. After each of the trials the .csv files and the videos that were recorded were renamed and analyzied.

3. Results and Analysis

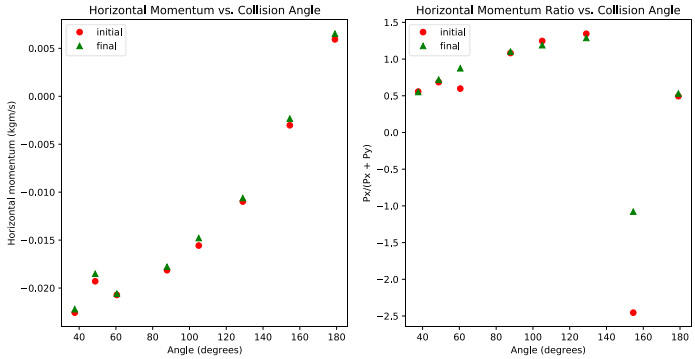

Figure 1: Horizontal Momentum

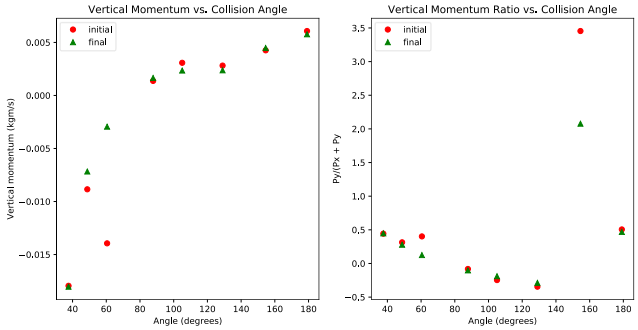

Figure 2: Vertical Momentum

Figures 1-2.1 shows the momentum before and after the collision across all trials with varying collision angles.

$$\vec{P} = m \cdot \vec{v} \qquad \textit{Equation 1}$$

By taking the given masses of the pucks and multiplying them by their velocity vectors, as seen in Equation 1, the momentum before and after the collision was calculated, and the results were plotted in a way that would illustrate the difference of momentum. Since most of the data points, representing before and after snapshots, are within proximity, it becomes evident that momentum was conserved across the horizontal and vertical axes.

$$KE = \frac{1}{2}mv^2 \qquad \textit{Equation 2}$$

Moreover, with the data collected, the collisions' elasticity was also able to be determined. Similar to momentum, by finding the kinetic energy before and after the collision using Equation 2 and then taking difference, the results would yield whether or not energy was conserved. If conserved, indicated by $\Delta KE = 0$ then the collision for that particular angle was elastic.

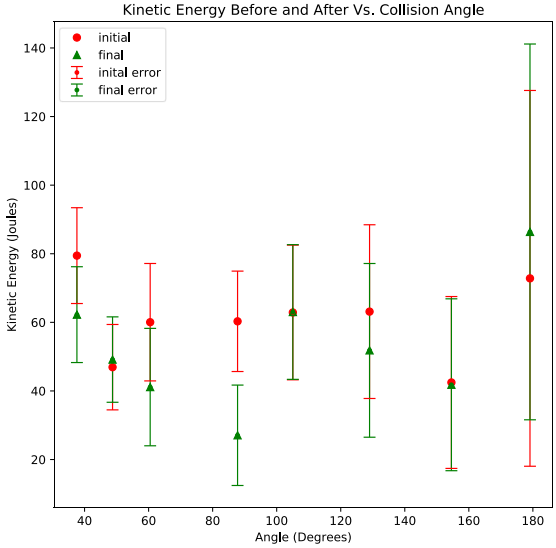

Figure 3: Kinetic Energy Before and After

Based on the data points on Figure 3, it appears that the change in kinetic energy wasn't constant throughout all angles of collision, nor did there appear to be any visual trend. In some trials, the kinetic energy before the collision and the kinetic energy afterwards appeared unchanged; however the trials that showed a large difference between the kinetic energy before and after the collision indicates an inelastic interaction where energy was lost. Curiously enough, some readings also indicated instances where the kinetic energy increased after the collision which should be impossible unless an external force acted on the pucks as they moved. Fortunately, these discrepancies were explainable due to the random errors that occurred during the experiment, data analysis, and calculations. When uncertainty is taken into account, nearly all of the collisions reflect that kinetic energy remained the same, thus nearly all the collisions were elastic.

Additionally, in order to calculate the angles used to create the graphs, the resultant velocity vectors for each were calculated using the x and y components. From there, the angle of collision was found using the dot product formula as shown below.

$$\vec{A} \cdot \vec{B} = \left|\vec{A}\right|\left|\vec{B}\right| \cos \boldsymbol{\theta} \qquad \textbf{\textit{Equation 3}}$$

4. Conclusions

Hockey pucks were thrown to a certain point at different angles and collided. A tracking camera allowed for the discovery of the velocity of these pucks. From the plots above, it can be concluded that momentum in both x and y directions is preserved, barring the few statistical and experimental outliers, which may have resulted from faulty data collection. Moreover, with uncertainty, the values of kinetic energy prove that the values of kinetic energy prove that nearly all collisions are indeed elastic collisions. Therefore, this data proved that momentum is conserved in elastic collisions.