Lab 4: Collisions

Cambrie Cowser, Ava Hoeinghaus, Joaquin Salas

Texas A&M University
College Station, TX 77843, US.

Abstract: *The purpose of this lab was for students to understand the concepts of; the law conservation of momentum, determine the elasticity of a collision, and calculate the angle of collision. Data was collected via the tracking camera. Students slid hockey pucks across the table and allowed them to colliced. This act was recorded by the camera and collected. multiple trials of the same collision at 8 different angles were observed. The data that was collected will be used to find the velocity vectors and calculate the angles of collision and the total momentum within the system before and after the collision.*

Keywords: Momentum, Elasticity, Kinetic Energy

1. Introduction

The purpose of this lab is to demonstrate the law of conservation of momentum by using data analysis, given physics equations, and error analysis. To do this, the lab uses two hockey pucks and observes their collisions at various angles. Once the data is collected, the lab continues by calculating the angle of collision and the elasticity. The most important data collected is the velocities of the two pucks, this data can then be used to determine the angle of collision, which is determined by the following formula.

$$\theta = cos^{-1}\left(\frac{\overline{v}_2 \bullet \overline{v}_1}{|v_2||v_1|}\right) \qquad \textbf{Equation 1}$$

According to the law of conservation of momentum, momentum is always conserved therefore the momentum of the before and after the collision should be equal

$$P = mv \qquad \textbf{Equation 2}$$

The kinetic energy formula will be used to calculate the amount of kinetic energy before and after the collision of the hockey pucks. The equation uses velocity to determine the total kinetic energy.

$$KE = \frac{1}{2}mv^2 \qquad \textbf{Equation 3}$$

2. Experimental Procedure

The lab begins by launching MobaXTerm and logging into the terminal, copying the Python file onto the terminal, and editing the camera distance to fit all four corners of the table for when the experiment is being performed. It then proceeded to require students collect the tools that are needed for this experiment, this included two pucks and multiple different colored stickers so that the camera could track the collision. To collect the data, then ran several trials to perfect the collision at the right speed, making sure the camera was tracking the stickers. In total, the group should perform a total of 8 trials, ranging

from straight head on collision and lessening the angle to 90 degrees for three trials, taking a trial at 90 degrees, then three more to about 15-25 degrees. After each trial, proceed to save the data to the desktop and plot a graph of the collision to ensure that the data is accurate. After the trials, groups gather the data and create a drive to store it and proceed to verify valid data with the TA .

3. Results and Analysis

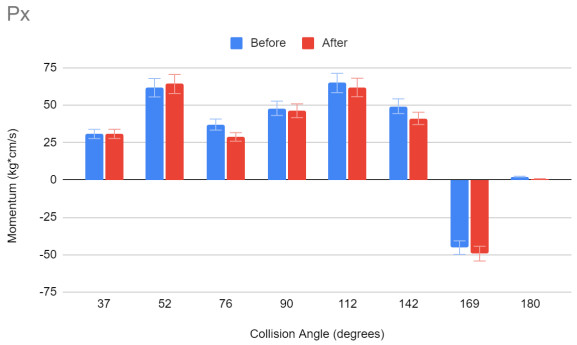

Figure 1: Momentum of the System in the X-Direction Before and After the Collision

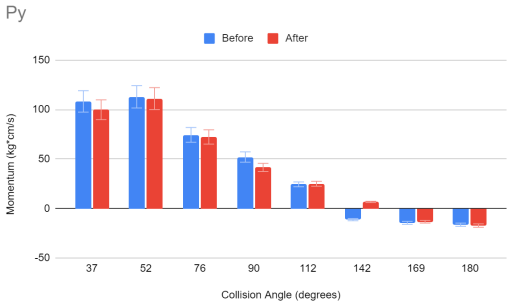

Figure 2: Momentum of the System in the Y-Direction Before and After the Collision

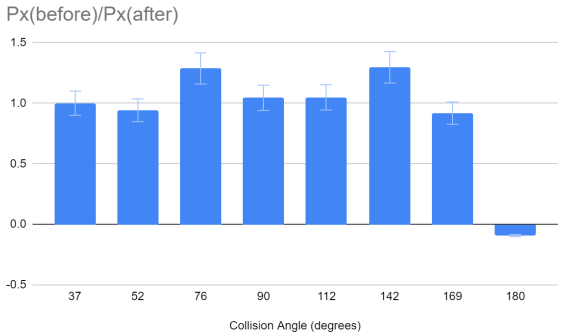

Figure 3: Ratio of Momentum of the System Before vs the Momentum of the System After in the X-Direction

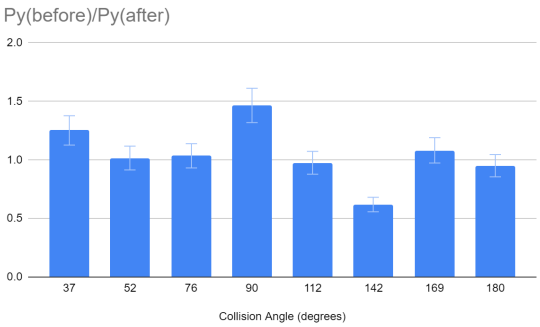

Figure 4: Ratio of Momentum of the System Before vs the Momentum of the System After in the Y-Direction

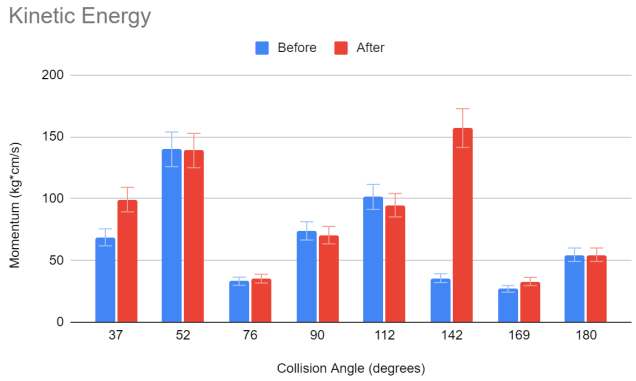

Figure 5: Total Kinetic Energy in the System Before and After the Collision

Results in Figures 1 and 2 show that the momentum of the system before the collision is equal to the momentum of the system after the collision. This stays true to the principle of conservation of momentum, which states that in the absence of external forces, the total momentum of an isolated system remains constant. It is important to mention that the experiment took place in the real world, where several factors might affect the laws of momentum conservation. Factors could be human error or simply inaccuracy of measuring devices, this can lead to small imperfections in results. Human error may play the biggest role in weakening the conservation of momentum because of the friction on the table for example due to two lab partners trying to perfectly collide the two pucks. There may be errors on the speed, angle, and the pucks could not ideally collide.

Elastic collisions are characterized by the conservation of both momentum and kinetic energy, with no energy being lost to other forms such as heat or sound. Our data analysis and plot show that the collisions resemble elastic behavior (Figures 3-5). Our observations demonstrate that the pucks rebounded with the same momentum as before the collisions; in Figures 3 and 4 by diving, the ratio is very close to one. In Figure 5, the kinetic energy is also similar before and after the collision. This behavior aligns with the principles of elastic collisions, where both momentum and kinetic energy are preserved. The minimal energy loss indicates that the collisions are elastic.

4. Conclusions

In conclusion, from the graphs above where momentum and kinetic energy are plotted together with before and after effects of the collision, we can see that the data is most consistent with that of an elastic collision. Despite possible small errors, this experiment was conducted as precisely as possible, and resulted in accurate data, allowing us to easily analyze the data and conclude that the momentum is conserved after the collision and that the collision has characteristics very similarly to an elastic collision.