Lab 5: Collisions in Two Dimensions

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Abstract

In this experiment, we created inelastic and elastic collisions between two pucks on an air table and collected data on their displacements using Tracker software. We calculated the momenta before and after the collisions (linear for the elastic, linear and angular for the inelastic), as well as the kinetic energy for both. We expect to see momentum conserved for both experiments, kinetic energy conserved in the elastic collision, and kinetic energy to not be conserved in the inelastic collision. The values which we found in this experiment are discussed in the conclusion of this report.

Theory

In this experiment, we investigate the Law of conservation of momentum, $P_f = P_i$, and the Law of conservation of kinetic energy, $K_f = K_i$. Via theoretical physics, we expect that the first law will be true for both elastic and inelastic collisions, and that the second law will hold for elastic collisions but not inelastic collisions. We use the formula $K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ to calculate kinetic energy when we believe that there may be both linear and angular contributions to kinetic energy; the formula simplifies to $K = \frac{1}{2}mv^2$ if there is only a linear contribution or to $K = \frac{1}{2}I\omega^2$ if there is only an angular contribution. Linear momentum is calculated as $P = mv$ while angular momentum is $L = I\omega$. For the second experiment, we convert all displacement values to a center-of-mass frame, which means that x for puck A, for example, is converted via the formula

$$x_{A,cm} = x_A - \frac{m_A x_A + m_B x_B}{m_A + m_B}.$$

As always, we used error propagation in all measurements, and specific error propagation formulae can be found in Section 4.

Apparatus and Procedure

Experiment 1

We weighed two magnetic pucks on the lab scale and made a mark on one to make sure we could distiguish one from the other. We then turned on the airtable and the camera and took a video of us throwing the pucks at each other, taking care to make sure that the throws had as little spin on them as possible. We then processed the video in Tracker as we have done in previous experiments, i.e. using the known length of the ruler as a marker to determine ground truth length in the camera images and manually marking the locations of the centers of the pucks. We then transferred our data from Tracker to Excel in order to process and analyze the data further.

Let `mass.A` and `mass.B` denote the measured masses of the pucks in kg.

```
mass.A <- 0.0184
mass.B <- 0.0188
```

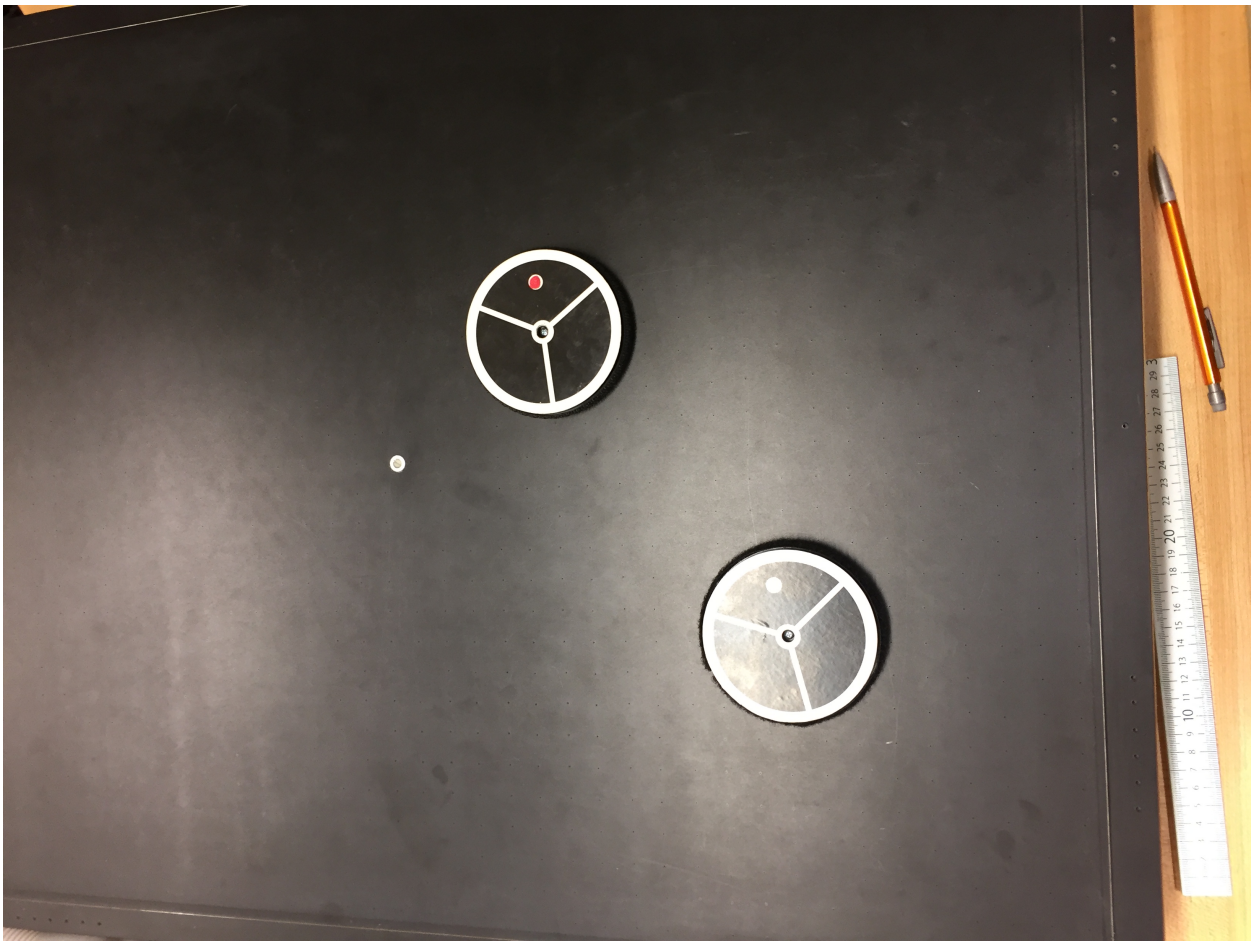


Figure 1: 2 pucks on the airtable, along with a cm ruler on the right side.

Experiment 2

We weighed two velcro-bound pucks on the lab scale and measured one of the radii with a cm ruler. As in the first experiment, we turned on the airtable and the camera and took a video of us throwing the pucks at each other, again attempting to throw with minimal spin. We then processed the video in Tracker in the same way as in the first experiment. After, we transferred our data from Tracker to Excel in order to process and analyze the data, as seen in the following section.

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

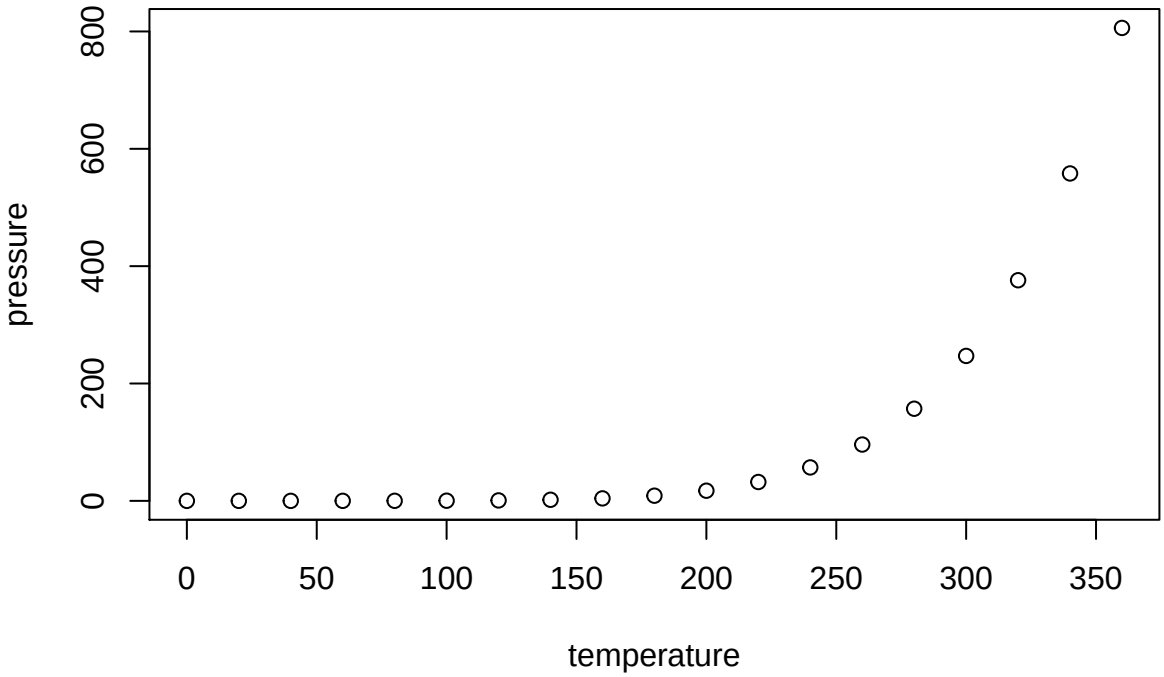
```
summary(cars)
```

```
##      speed           dist
##  Min.   : 4.0   Min.   :  2.00
##  1st Qu.:12.0   1st Qu.: 26.00
```

```
##  Median :15.0   Median : 36.00
##  Mean   :15.4   Mean   : 42.98
##  3rd Qu.:19.0   3rd Qu.: 56.00
##  Max.   :25.0   Max.   :120.00
```

Including Plots

You can also embed plots, for example:



Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.

Figure 2: View of camera suspended above pucks and table.