## The Project: Spacecraft - Asteroid Collisions

PELA is working to develop a mission that will send unmanned spacecraft to explore a recently- discovered asteroid belt in another solar system. The density of asteroids in the belt is unusually high, and the asteroids themselves are moving, with a wide range of velocities that are similar in magnitude to the spacecraft velocity. As a result, the probability for collisions between the spacecraft and one or more asteroids is high.

The engineers who designed the spacecraft have constructed it such that it can withstand multiple asteroid collisions without damage. However, the influence of these collisions on the spacecraft’s motion needs to be understood, so that the spacecraft’s control software can be appropriately programmed to set the spacecraft back on its original course after it collides with an asteroid.

Your job is to provide a set of collision data that simulate the collisions that might happen between the spacecraft and an asteroid. Because both objects have similar rigid surfaces, spherical shapes, and similar masses, you decide to generated these simulated data by colliding two moving pucks on a frictionless air hockey table.

**Your team has now been hired to run a series of simulated collisions to build up a database, and to analyze such data in preparation for the real mission.**

## Equipment:

* Tracking Camera
* Air hockey pucks
* Frictionless air table.

## The data:

We ask that you collect data as follows:

1. Run a set of at least eight trial collisions between identical pucks in a frictionless air table. In each collision the pucks will collide at different initial angles.
   1. One of the collisions should be about “head on” (180o angle between the velocity vectors of the pucks), and another should be at 90o.
   2. The remaining six should include three angles from 180o -> 90o and three from 90o -> 0o.
   3. For each collision, collect information on the position, velocity, and acceleration of both pucks before and after the collision. You will need to determine the actual collision angle measured from your tracking camera data.

## Data analysis and presentation of the solution:

Your team must prepare 2-3 page written report (including figures) analyzing the data and summarizing the results. The report must include the following:

1. Indicate the methodology used to find the collision angle of the trial collisions from the recorded data.
2. A discussion of theoretical expectations for conservation of momentum in the collision between two pucks if the air table were perfectly leveled and frictionless.
3. A plot showing the momentum component in the x-direction of the system of two pucks before and after collision for all trial collisions as a function of the collision angle of the trial. Estimate the uncertainty on those measurements and indicate how you estimated that uncertainty from the recorded data.
4. Using the info from the plot above, plot the ratio of the x-component of momentum after the collision to the same component before the collision, also as a function of collision angle. Make sure to estimate the uncertainty on the ratio. Discuss from this new plot if, within errors, the x- component of momentum is the same before and after the collisions, and if your data doesn’t match that explain why that could be.
5. Redo plot 3. this time for the y-component of the momentum
6. Redo plot and analysis 4. this time for the y-component of the momentum
7. A plot showing the sum of the kinetic energy of the two pucks before and after the collisions for all trial collisions, including an estimation of the uncertainty. Briefly indicate how that uncertainty was estimated
8. A plot of the fraction of kinetic energy final to Kinetic energy initial (Kfinal/Kinitial), and a discussion of whether or not the collisions could be deemed elastic within the errors of your measurements.

**Last updated: Oct 18, 2019.**