

Collisions

In this experiment we will study collisions of pucks on an air hockey table. Although the table will be available for demonstration purposes, pre-recorded videos of collisions will be used to save time. You will extract data on the motion of the objects frame-by-frame as you did earlier in the semester with the basketball shot and use it to draw conclusions about momentum and kinetic energy in the system of two pucks before and after the collision. You will analyze two videos, one of an elastic collision and one of an inelastic collision.

The Experiment:

Materials - air hockey table and pucks (for demonstration), electronic balance, ruler/calipers, pre-recorded collision files, Logger Pro

The video files can be downloaded from the course webpage on Blackboard.

- 1)** Two of the pre-made videos are labeled as elastic collisions. View both of them and choose one for your group to analyze. You can also play with the air hockey demonstration set up for the lab. At some point during the lab you should use the balance to measure the mass of each puck and use the calipers to measure the size of the puck for use in your calculations.
- 2)** Just by watching the video, predict on your prediction sheet the “x” and “y” components of the momentum for each puck before and after the collision. Also include the momentum of the center of mass on each graph. Now do the same for the kinetic energy, with separate lines to indicate the translational and rotational kinetic energy of each puck before and after the collision. Label each of your lines so that it is clear which corresponds each puck.
- 3)** Import the video into Logger Pro using the menu option “Insert > Movie”. Click the button at the bottom-right corner of the video (with the red dots) to open the video analysis tools. Use the “Set Origin” and “Set Scale” buttons (the third and fourth from the top) to choose a coordinate system and a scale. Use the “Add Point” button (the second from the top) to map the position of each object frame-by-frame through the collision until one of them hits the wall. You can start mapping from the first frame where the pucks begin moving. Place your points on the peg at the center of the puck. Use the “Add Point Series” option under the “Set Active Point” button (the sixth one down) to generate data for the other puck.
- 4)** You should now have the components of the position and velocity as a function of time for each object. Logger Pro has a convenient feature that will generate the center of mass data from the data for both objects. Just use the “Add Center of Mass Series” feature under the “Add Point Series” button once you have data for both pucks.
- 5)** We now have a lot of columns to juggle and moving through the table on the left is cumbersome. Use the “Data Browser” (under “Data > Data Browser”) to help you manage all of your columns.

Make sure all of them have names that make them clearly identifiable. You can also create and delete new calculated columns this way.

6) The data we've taken is enough to completely analyze the momentum and translational kinetic energy in the system before and after the collision, but to analyze the rotational kinetic energy we need to find each puck's angular speed. Create an additional set of data points for the position of the white dot on each puck as a function of time. Logger Pro automatically generates velocity components for these points. Taking the difference of these velocity components with the velocity components you already have for the center of the puck will give the components for the puck's tangential velocity about its rotation axis. From these, we can find the dot's total tangential speed and then its angular speed. Create a new calculated column that uses a formula to compute the angular speed from the two sets of velocity components. Do this for both pucks.

7) Assuming each puck of mass M and radius R is a disk with moment of inertia $I = \frac{1}{2}MR^2$, we now have all the information necessary to compute and analyze the momentum and kinetic energy before and after the collision. There are multiple ways to do this from all the columns of data we have, so decide as a group how you will go about it. Some possible things you can do are listed.

- Remember that you can find average values by selecting regions before and after the collision and using the "Statistics" button. You can create additional calculated columns for momentum and kinetic energy to find averages, or you can use the averages from the velocity data directly and multiply by constant factors of M and I .
- You can calculate and compare the impulse each object feels to see whether or not they are equal. This will give you the net change in the momentum.
- You can compare the momentum results from the individual puck data to that of the center of mass series.
- You can analyze by what percentage the total kinetic energy changes, or separately by how much the translational and rotational kinetic energies change in the collision. Can the rotational energy be safely ignored or not?

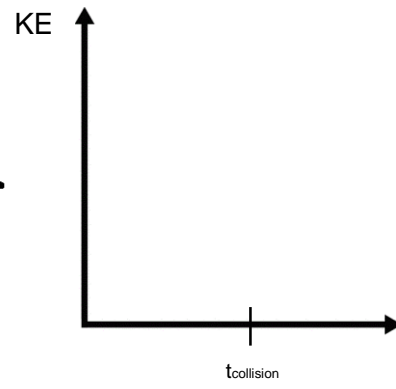
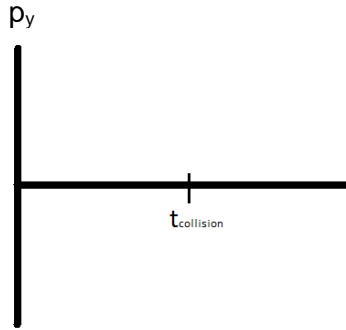
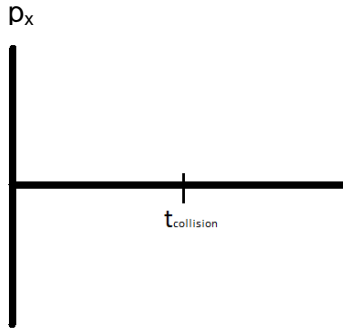
Ultimately you want focus on determining whether or not momentum and kinetic energy are conserved in the collision and quantifying this. Choose how and what you want to calculate and graph to present as part of your analysis. There is no right or wrong way to do this, but less is usually more. Don't include a large number of graphs in your report unless you need them all to make a convincing argument to the reader. Comment on your predictions as part of your analysis.

8) Save and start a new file in Logger Pro. Repeat steps 1-7 using one of the inelastic collision videos and perform the same analysis in this new file. Compare your results with your predictions and with those from the elastic collision video. How do your results differ in the two cases? Note that the final moment of inertia for the system when the pucks are stuck together is $I = 3MR^2$. Include a simple calculation in your report that uses the parallel axis theorem to show that this is true. The final rotation axis is now where the pucks are joined. To get the angular speed you will need to define sets of data points that measure the tangential velocity of one of the pucks relative to this new axis.

Prediction Sheet

Momenta of elastic collision

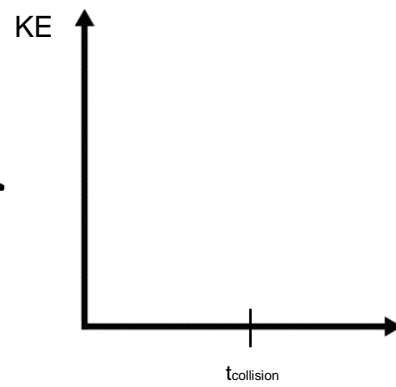
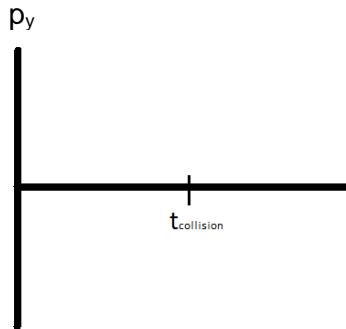
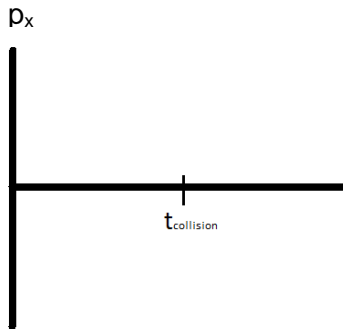
Kinetic energy of elastic collision



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Momenta of inelastic collision

Kinetic energy of inelastic collision



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