Laboratory 3
Two-Dimensional Collisions

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0.1 Objectives

In this lab you will study a collision firsthand. You will use an "air table" to create a collision and record data for the colliding objects that will permit you to test for conservation of momentum and conservation of kinetic energy.

Discuss with your partner how you might test for momentum conservation and kinetic energy conservation. Discuss and agree on what you think is the best way to do these tests. Briefly describe in your lab notebook what you plan to do, making sure you write down any relevant equations.

0.2 Equipment

- air table attached with a rubber hose to a compressed air valve
- air table spark generator and hand/foot pedal
- metal air pucks with rubber tubing
- sheets of carbon paper and newsprint
- device for measuring two-dimensional positions

0.3 Setup

In this lab you will be working with the air tables that permit objects to move in two dimensions in an environment that is as frictionless as possible. When the air valve is turned on, a stream of air is blown through the hoses connected to the pucks. As this air squirts out from under the puck it forms a layer between the bottom of the puck and the surface of the table creating a cushion of air upon which the pucks can "float." The pucks are connected to a spark generator which will send electric current at a known frequency into the pucks and out the puck bottoms as sparks. You will be able to record the locations of the sparks (and so the locations of the pucks) on the table by placing a sheet of carbon paper directly on the surface of the air table. On top of the carbon paper you then place a sheet of newsprint. The pucks move over the surface of the newsprint and the points at which sparks occur are recorded as small dots by the carbon paper on the sheet of newsprint. You turn on the sparks

by pressing the foot/hand pedal. Only when the pedal is held down will sparks appear on the paper. The frequency of the spark generator should be set to 60 Hz so that there is $\frac{1}{60}$ second between each spark. You will allow the sparks to leave a record of the position of the pucks before, during and after a collision.

1 Data Acquisition

1.1 Introduction

Before generating the spark dots on paper, you should just play around with the pucks on the air table for a bit.

- Place a sheet of carbon paper (carbon side up) on the surface of the air table.
- Place a sheet of newsprint on top of the carbon paper.
- Place the pucks on the newsprint.
- Turn on the air valve so a layer of air is formed under the pucks.
- Move the pucks around a bit to see how everything works and then cause some collisions between the pucks.

Decide on a way to push the pucks so you get good two-dimensional collision to analyze.

1.1.1 Obtaining Data

When you are ready, one of you will cause the collision and the other will hold down the pedal throughout the motion to have the sparks recorded. Make sure the spark generator is set to 60 Hz, turn it on, and record the sparks left by the pucks in your collision. **Warning: do not leave the spark generator on longer than necessary to obtain a good record of the puck position before and after the collisions. In any case, only turn on the spark generator when the pucks are in motion. A series of sparks at one position on the table can burn a hole in the air table.**

1.2 Measuring the Puck Positions

Now that you have a spark record of the motion of the two pucks, you can measure the positions of the pucks as a function of time to quantify the collision process. Measuring devices are set up for this purpose and the newsprint with the spark tracks should fit into the frame of the measuring apparatus. You should tape down the newsprint at two of its corners so the paper doesn't move as you make your measurements.

Make a table of data in your notebook as follows: the time in one column and four columns for the corresponding x- and y-positions of each of the two

pucks. Ten positions before the collision and ten after the collision for each puck should suffice.

Before you begin recording your position measurements, don't forget to think about the possible errors you will encounter. Estimate the accuracy of your x- and y-position measurements. What are possible systematic errors involved with the way you will be measuring the positions of the spark marks? (For example: you may need to use both the top and bottom horizontal rulers to measure horizontal positions of your spark records. What errors might this introduce? Similarly you might have to use both the right and left vertical rulers to make your measurements. Will that introduce any errors? Once you have explained any errors you may face and described your accuracy estimate, record your data.

2 Reducing the Data

Your notebook should now contain a table of positions and times for the two pucks. What should you do with your data? Discuss this with your partner: What are you trying to find out and how can the data you have be helpful to you? Is knowledge of the positions and corresponding times enough or would the data be more useful in a different form? Go ahead, talk about it. Briefly describe in your lab notebook what you need to do next. Check with your TA to be sure you have not forgotten anything and then go ahead and check for conservation of momentum and kinetic energy.