2D-COL

Collisions in Two Dimensions

revised August 2021

(*Students in PHYS 123 will do this experiment; PHYS 115 and 121 students will instead do the Collisions—Conservation of Momentum laboratory.*)

Learning Objectives:

During this lab, you will

1. communicate scientific results of a collaboration in writing.
2. estimate the uncertainty in a quantity that is calculated from quantities that are uncertain.
3. develop creative problem-solving skills.
4. test a physical law experimentally.

A. A Free-Form Lab

This lab is designed to be more free-form than those you have done in the past. Therefore, we are not providing a formal write-up of procedures. Rather, you and your partners should think through and plan the necessary steps to make measurements required to test momentum and energy conservation for two-dimensional collisions. The basic goal of the lab is to measure, for a variety of conditions, the initial and final momenta and kinetic energies of the bodies in the system. To turn your results into quantitative statements you ultimately need to calculate the fractional change in the total momentum and total kinetic energy:

$$\varepsilon_{\vec{P}} = \frac{\left|\Delta\vec{P}\right|}{\left|\vec{P}_i\right|} \qquad (1)$$

$$\varepsilon_K = \frac{\left|\Delta K\right|}{\left|k_i\right|} \qquad (2)$$

as well as their uncertainties, where $\Delta\vec{P}$ is the change in momentum, $\vec{P}_i$ is the initial momentum, ΔK is the change in kinetic energy, and K_i is the initial kinetic energy.

There are a variety of conditions you can vary: relative masses, elasticity, initial velocities different from zero, large or small scattering angles, etc. Explore at least as many cases as there are members in your group, that is, three or four–or more if you can come up with interesting cases.

B. Some General Guidelines

Use one notebook and write one group paper (turn in notebook pages before you leave and upload to Canvas one paper per group in one week, as usual).

Use unprimed and primed symbols to denote values before and after the collision, respectively.

Share tasks of recording, calculating, writing, etc., but note that all group members are responsible for everything that goes into the paper! One way to distribute your effort might be to have each person calculate one case and be the "checker" on another.

Think through all the necessary quantities you will need to make your calculations, including those needed for uncertainty calculations. You will need to think through which quantities are important sources of uncertainty. Do you get results that are consistent with the expectations of the appropriate conservation law? If not, are there additional assumptions that you have not taken into account? Do you have the necessary information to correct for them?

Your methods, analysis, calculations and interpretations should all provide evidence that you have carefully thought through the characteristics of your system, the theories you are applying, and the conclusions that you draw.

C. Video Capturing and Analysis

It is suggested that you use Logger Pro to both record and analyze the data for this lab. In order to capture video:

1. Ensure that the USB webcam is plugged into the computer
2. To record a collision, open Logger Pro → Insert → Video Capture
3. To change the video capture duration hit the "Options…" button in the Video Capture window and adjust the duration.
4. To start Recording hit "Start Capture," to stop press the same button or wait for the video duration to elapse. *Be sure to have a known length in the video window so you can calibrate distances.*
5. After a video has been recorded, a new window should be created behind the Video Capture window within which you may analyze your data.

In order to analyze the video:

1. Hit the "Enable/Disable video analysis" button (the button with the three red dots and a black arrow) to get the analysis toolbar which should appear to the right of the window.
2. Hit the "Set Origin" button (third from the top) and choose a place on the image to define as your origin.
3. Hit the "Set Scale" button (fourth from the top) and click and drag your cursor along the known length in your image. Then type in the distance (and units) for this in the dialog box.
4. Hit the "Add Point" button (second from top) and select the center of mass of a ball in the video to mark its position. The software will automatically step to the next frame so you can track the center of mass of the ball before the collision.
5. After the collision, hit the "Set Active Point" button (sixth button from the top) and add a new point series. Continue to track the ball with the new points after the collision.
6. Go back to the beginning of the movie, add a new point series, track the other ball before the collision, then add a new set of points and track it after the collision.
7. You now have a table of the raw Time, (x,y) position and (x,y) velocity for both balls before and after the collision.