

Lab 4: Momentum and Energy

In this lab you will write a script to analyze collisions between objects. You will study the interactions from multiple reference frames and consider how the total energy changes with elastic and inelastic collisions. We only have one air track setup so your TF will do demonstrations and then post the data on the lab section of the course site.

Warm Up

Consider the following situation. A cart on an airtrack collides with a second cart of equal mass that is at rest. The two carts stick together.

- A.) Draw a diagram of the situation and label all of the parts.
- B.) Make the left hand side of the airtrack $X=0$ meters. Draw graphs for position vs. time, and momentum vs. time for each of the carts, and the COM (center of mass) for the lab frame.

Scripting Overview

Load the data arrays from the `.csv` into a new workspace, then immediately save that workspace with a descriptive name. All of your scripting should be done in a `.m` file (no manipulating arrays in the command window!). You can load the saved workspace using the command: `load('workspace.mat');`

Ultimately you want to write an awesome script to make beautiful plots for different data sets where you only need to change the argument of the `load` function to switch data. You will also need to write some code to compute a numerical derivative!

Your script should plot three graphs onto one figure:

1. Position vs. time of the carts and Center of Mass (COM) in the lab frame
2. Position vs. time of the carts and COM in the COM frame
3. Momentum vs. time of the carts and the total momentum (lab frame)

Make sure the graphs have all of the following:

- Three Subplots with three individual plots on each.
- Use a different color for cart 1, cart 2, and the COM. Repeat these colors for the other graphs.
- Axis labels and titles of size 20. Make sure you include units.
- Legends for each graph
- Try to manipulate figure size and placement (Hint: `get(0,'ScreenSize')`, `doc figure`)

Make sure your script has the following:

- *Correct Header
- *Broken into distinct sections
- *Lots of comments

You will use this script to answer the questions for the four different experiments. Additionally, you should publish your script once and each print one copy of each set of plots. Attach these to the end of the lab.

Questions asking you to “interpret” a graph require a qualitative description of the data (sketching is fine), a comparison of the measured data to theory, and a discussion of any discrepancies or other “weird stuff”.

****Important:** At the end of the lab email yourself a copy of the script and the collected data.

Experiment 1: Clay Cart Collisions

Q1.1: Interpret the position vs. time graph. Are there any interesting features?

Q1.2: Is momentum conserved? Use your data to support your answer. Make sure you analyze the whole data set, not just the initial collision.

Q1.3: Calculate the coefficient of restitution, C_r , for the carts.
$$C_r = - \left[\frac{v'_{1x} - v'_{2x}}{v_{1x} - v_{2x}} \right]$$

Experiment 2: Bumper Cars

Q2.1: Interpret the position vs. time graph. Are there any interesting features?

Q2.2: Is momentum conserved? Use your data to support your answer. Make sure you analyze the whole data set, not just the initial collision.

Q2.3: Calculate the coefficient of restitution, C_r , for the carts.
$$C_r = - \left[\frac{v'_{1x} - v'_{2x}}{v_{1x} - v_{2x}} \right]$$

Q2.4: Is this collision elastic or inelastic? How do you know?

Experiment 3: Push-Me Pull-Me

Q3.1: Interpret the COM motion.

Q3.2: What causes the peculiar shape of the total momentum curve?

Experiment 4: Push-Me-Pull-Me on an Incline

Q4.1: What is the acceleration of the COM?

Q4.2: What is the angle of the incline? (Ignore any air resistance)