

PS 12a

## Lab 4: Momentum and Energy

**Lab Time:**

Names:

- 1.
- 2.
- 3.

In this lab you will write a Matlab 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.

### Scripting Overview

Load the data arrays from the class website (Files-Lab files-Pick correct lab time) into a the “current” folder. Also download the “importfromCSV.m” file and place this in the current folder. You can load the data from the csv file by using “importfromCSV(filename.csv)” at the top of your code.

Ultimately you want to write an awesome script to make beautiful plots for different data sets where you only need to change the csv filename to switch data. You will also need to write some code to compute a numerical derivative! Publish your code to the lab dropbox at the end of lab.

Your script should plot four graphs onto one figure “subplot(4,1,1-4)”:

- 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)
- 4.) Kinetic energy vs. time of the carts and the total momentum (lab frame)

The script should also include:

- 1.) A way to trim the data
- 2.) Define the set-up so sensor 1 is at  $x=0$  meters
- 3.) A way to run a moving average of the data (hint: smooth)
- 4.) Axis labels and titles on all of the graphs
- 5.) Comments!!

You will use this script to answer the questions for the four different experiments. Additionally, you should publish your script and sets of plots and upload them to the Lab4 drop box on the course site.

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”.

## **Experiment I: Clay Cart Collisions**

**Q1. 1:** Describe the important points in the carts motion and explain the corresponding features of the graph.

**Q1.2:** Are any of the momenta conserved? Use your data to support your answer. Make sure you analyze the whole data set, not just the initial collision.

**Q1.3:** Is the drop in the kinetic energy during the collision consistent with what you expect? Please compare the theoretical prediction with the experimental results. (Hint: Find the initial and final velocities from the momentum graphs and calculate the kinetic energies.) Where did the mechanical energy of the system go?

## **Experiment 2: Bumper Cars**

**Q2.1:** Is this collision elastic or inelastic? How do you know?

**Q2.2:** Interpret the total kinetic energy graph. Give a plausible explanation for each feature.

## **Experiment 3: Push-Me Pull-Me**

**Q3.1:** Interpret the COM motion.

**Q3.2:** What causes the peculiar shape of the total momentum and energy curves? (Explain the dips and the overall decrease)

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

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

**Q4.2:** Use this to calculate the angle of the incline. (Ignore any air resistance)