PHY353L **Homework** **January 16, 2024**

This homework is intended to provide a common basis to practice data analysis. Some general advice about approaching this and similar problems:

1. The first thing you have to do is figure out how to read data from a file. In Python using the numPy package this would be a numPy.loadtext( ) command. In Mathematica this can be some sort of a `ReadList[ ..., Number]` command.

2. Find a way to condense the structure of the commands, that is, loop over an index as opposed to repeating a command.

3. In Mathematica, avoid referring to previous output by number (%1198, e.g.), this will get you in trouble at some inopportune time.

4. Avoid hardwiring numbers into your commands. Make use of structures like (in Python) `len(myData)` or (in Mathematica) `Length[ ...]` and `Dimension[ ...]` wherever possible.

5. Try to avoid using a packages's built in functions for manipulating Gaussian distributions. Instead, use the more general `curve_fit( ...)` (from the python scipy package) or `NonlinearModelFit[ ...]` (in Mathematica) command with your own functions defined.

First, download the data file SampleData_Spring2024.dat from the Files section off the Canvas site. This a plain text file of numbers. The first column is time in some units. The rest of the columns have the x,y, and z components of the position of a few particles from a simulation. In this exercise you will preform various calculations, plots and analysis of this data.

(1) Plot several of the columns of data as a function of column 1, the time. In Mathematica discrete data is plotted with the `PlotList[ ... ]` command. In python, it would be a matplotlib.plot( ) command. Plot the x-coordinates of the the first 3 particles as a function of time on a single plot. This is the sort of graphic you might want to put in a paper, but it needs some tidying up. Do the following: shift the x-axis down just enough that the data is no longer running into it, label the axes, change the aspect ratio to stretch it horizontally, and adjust the size to make it a bit bigger than originally rendered. Finally, you need to get this image into your paper. Export the cleaned up graph as a PDF or PNG file (right click and Save As), and submit that image file in addition to your compiled code. (Do NOT crop a screen shot!)

(2) Compute the mean and standard deviation (SD) of all the columns after the first. Present your results as a table.

(3) Compare the average value of z for the first 6 particles. Are they different? How do you decide what is 'different?' Is there an intrinsic scale for measuring such a difference? In answering this question, think about your answer to the previous question.

(4) Make a histogram plot of columns 2 and 5. What is the connection between these plots and question 2?

(5) Make a plot of column 2 versus column 3. The points in your plot should be connected by lines. You can think of this as a parametric plot of x-y position versus time, with the time being the distance along the curve. This is known as a spaghetti plot.

(6) Now extend the last idea and make a 3-D plot. In Mathematica, you can make 2-D plots such as was asked for in the previous question with `ListLinePlot[ ... ]` . There is no 3-D version of this command, and you will have to use `Graphics3D[ ... ]` .

(7) Now extend the last idea and make a 3-D plot for more than one particle. Can you make one such a plot for the first six 6 particles?

(8) Suggest what physical situation the data is computed for. Start by describing in words the result of the last two problems.

(9) Fit the plot from question 4 to a Gaussian function. The fitting results provide a way to assess the Standard Deviation of the Mean (SDM), which is different from the standard deviation of the distribution. What is it, and how does it compare to the estimates from question 2? Is a Gaussian a good fitting function?

First 2 problems due Thursday, January 25, 2023. Remainder due Thursday, February 1.