UCF Physics PHZ 3150: Introduction to Numerical Computing
Fall 2021 Homework 10
Due November 4 2021

Goals: practice coding in Python and plotting.

Problem 1 (**5 points**). Make a new folder named `hw10_<yourname>` under you `handin` folder. As always, your log is part of your homework. After each problem number, give your answer and the names of any files you are handing in for each problem. If you made a HW10 entry in your log in a prior session and want to change it, just copy it to the current (last) session, and edit there. We will grade the last entry only. All text related to one assignment should be in one entry, with the problems done in order.

Problem 2 (**15 points**) Holidays are coming and you need to find out how much wrapping paper you will need and how many presents you can fit in every box you want to put under the tree! Create a class `holiday_frenzy` that uses the dimensions `a,b,c` of a box to calculate the box's surface area and volume. Assume that your dimensions are in inches. The class should also know how much wrapping paper you have (in inches^2) and how many presents you want to fit in your box. Use a proper initiation function.

Your class should contain:

a) An initiation function
b) a function that returns the surface area of the box (e.g., `surface_area`),
c) a function that returns the volume of the box (e.g., `volume`),
d) a function that checks if you have enough wrapping paper (`enough_paper`)
e) a function that checks if your box can fit all the presents (`fits;` assuming that the average volume of a gift is 25 inches^3) and
f) a function (`print_gift`) that combines all these information and lets you know (with print() statements) if you have enough wrapping paper to wrap your box, if your gifts fit in the box, or if nothing is right.

   Test it `for (a, b, c, number_of_gifts, wrap_paper_available) = (10,10,10,15,800)` ; `(10,10,10,55,1000)` and `(100,20,10,55,300)`.

Problem 3 (**14 points**) A piston has a volume V containing dry air (an ideal gas) with pressure P and temperature T. Under the ideal gas law $\frac{PV}{T} = const$. Under adiabatic expansion, where no heat is added or removed, $PV^{\gamma} = const$, where $\gamma = c_p = c_v = 1.4$ for dry air, and c_p and c_v are the heat capacities at constant pressure and volume, respectively.

Consider a piston that starts with volume 1 liter and pressure 1 atm at 300 K. It compresses to 0.1 liter.

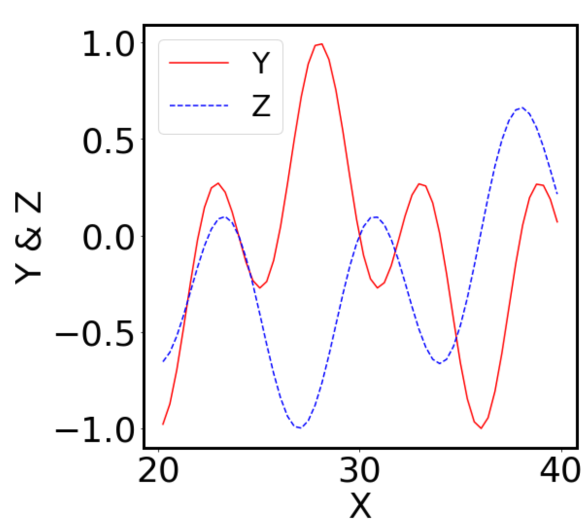
a) (**7 points**) Define a function `piston(V,P0,V0,T0,gamma)` that takes an array of N volumes, initial (P; V; T) values, and γ. Calculate the pressures for the piston volumes in V, using the adiabatic law. Then, calculate the temperatures using the ideal gas law. Return an (N, 3) array containing (P; V; T) values. Remember to use good coding style and to include a docstring!
Print the returned array for V = np.linspace(1,0.1,40).

b) (**7 points**) Make a 3D plot of your (P; V; T) triples as a curve in space. Be sure to include labels with units on each axis and a title. Save the plot as PNG using the appropriate naming conventions.

Problem 4. (**25 points total**) Make a numpy array `x` equal to `linspace(12, 46, 100)`. Make array `y` equal to $sin\left(\frac{2\pi x}{16}\right) * cos\left(\frac{2\pi x}{8}\right)$ and an array `z` equal to $cos\left(\frac{\pi x}{9}\right) * sin\left(\frac{\pi x}{6}\right)$.

a) (**5 points**) Plot y(x) and z(x) for 20<x<40. Make the plot publication ready like the one below.

b) (**5 points**) Scan arrays x,y and z and print the elements of x and y where both y and z are positive.



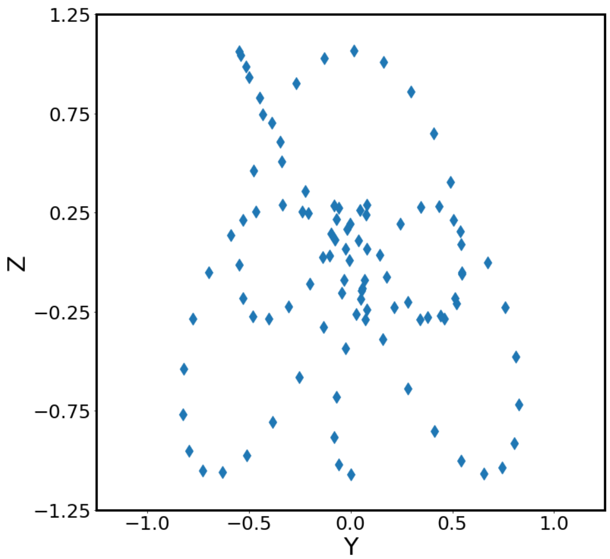
c) (**2 points**) Make two 2D arrays of zeros: `data` and `data2`, both with sizes equal to (length of x, length of y).

d) (**5 points**) Use a double for loop to populate arrays `data` and `data2`. `data[i,j]` should be equal to `y[i]*z[j]` and `data2[i,j]` equal to `y[i]/z[j]`.

e) (**3 points**) In one line (not for loop), print `z` where `y` is positive and less than 0.4. In one line, print `data` where `y` is positive and less than 0.2 in the x dimension and where `z` is negative and larger than -0.16 in the y dimension.

f) (**1 points**) Make array `datatr` which is the transpose of array `data`.

g) **(4 points**) Make a publication ready plot of column 2 of `datatr` versus column 42 of `data2`.



Problem 5 (**11 points**). Go to the group_github_assignment in your GitHub Desktop app: https://classroom.github.com/a/UtctEamo
You will be split in 2 teams: one should be named Team 1 and the other Team 2. You will need to work with all members of your team to do the following:

Create a new branch (i.e, other than the Main) and give it a unique, characteristic name (e.g., Team_1_branch and Team_2_branch). Then:

a) Team 1 will make a function coordinates(x,R) that uses an array x and radius R (don't define them yet though) and calculates all y coordinates (past HW) of a circle. Then make a function sphere_properties(R) that calculates the diameter and surface of a sphere with the same radius R. Make a screenshot of the functional code and save it with the appropriate name in your HW folder.

b) Team 1 will commit and publish their branch. Check on the webbrowser, you should all then see a message that the current branch is published, and you can create a “Pull Request” and continue the collaboration in GitHub.

c) Team 1 should click on the button and check your GitHub. You should see under “Pull requests” that you have pushed the new branch, which is now ready to be compared with the Main. Click on the “compare and pull request button”. It should show you that the branches are able to merge (i.e., there are no potentially fatal conflicts with the Main branch). Go on to make a Pull request and give some information on what your change to the branch was. Make a screenshot of the webbrowser showing that you did this and save it with the appropriate name in your HW folder.

d) Everyone should be able to see it, make comments if they want, and finally can agree to merge the branch with the Main. Merge your branch with the Main branch. Check out under “Code”. Your file with the function (or the main code) is now part of the Main branch and can be used by everyone in the team. Make a screenshot of the webbrowser showing that your code is part of the Main branch and save it with the appropriate name in your HW folder.

e) Team 2 then will make a function volume(R) that calculates the volume of a sphere with the given radius. Team 2 will create an array x = np.arange(-10, 10, 0.5) and assign a radius R = 2, and call and print the results of all three functions: give R what are the y coordinates of the circle and what is the diameter, surface and volume of the sphere?

f) Team 2 will follow the above steps and make sure all functions are merged in the main branch: they should commit and publish their branch, make a pull request (it should show you that the branches are able to merge (i.e., there are no potentially fatal conflicts with the Main branch), give some information on what the change to the branch was etc. Check out under “Code”. The complete file with the functions and main code calling the functions should now be part of the Main branch and can be used by everyone in the team. Make a screenshot of this and save with the appropriate name in your HW folder.

When all this is done you should have a fully functional code with a main program that calls three functions to calculate the diameter, surface and volume of a sphere. You have successfully created a mini community-written code!

Problem 6 (**10 points**). Prepare and submit your homework. Write what you will do to make and submit the zip file into your log. Don't forget to also commit your finalized log and push it to GitHub. When satisfied, close the log, copy it to your homework directory, and run the commands to make and submit the zip file. Turn the file in on WebCourses.