ME 355 – System Modeling and Numerical Methods
Fall 2023

Project 3

Due Friday, November 3 by 11:59 pm
Preliminary functions are due Friday, October 27 by 11:59 pm
This project must be turned in on Blackboard.

Glaucoma is the second leading cause of vision loss worldwide. High intraocular pressure almost always accompanies vision loss. It is postulated that the high pressure damages a subset of cells in the eye that are responsible for vision.

You a currently a Ph.D. student in a lab studying this phenomenon. You postulate that the relationship between vision loss and pressure can be described as

$$VL = A \exp\left(k \int_{25}^{t} (P - 13)\, dt\right) \%$$

where VL is percent vision loss, P is the intraocular pressure in mm-Hg, t is time in years, and k and A are constants. From previous experiments and prior knowledge, you estimate that $\boldsymbol{A = 4}$ **and** $\boldsymbol{k = 0.013}$.

You've collected intraocular pressure data for a patient. Your goal is to examine their VL over the patient's lifetime. The patient data is stored in a comma separated (csv) file with headers where the first column is the patient's age in years and the second column is the intraocular pressure in mm-Hg. The file name is *PatientA.csv*.

Functions

To complete this task, you will need to develop **2** Python functions each in their own Python file. Preliminary versions of these functions are due on the date specified above. To get full credit for the preliminary functions you must have made a legitimate attempt. You may make changes to the functions after the preliminary function due date and prior to the final due date.

1. **trapezoid.py**
   integral = trapezoid(Y, X)
   This function calculates the integral using the trapezoidal method of the experimental data X and Y such that X = [x1, x2, x3, x4, …, xn] and Y = [f(x1), f(x2), f(x3), f(x4), …, f(xn)]. You cannot use the numpy.trap() function to solve this! You must code the trapezoidal method yourself!

2. **importcsv.py**
   [X, Y] = importcsv(filename, header = True)
   This function imports **comma delimited** data from a file. filename is a string of the name of the file to import including the '.csv' and header is either True or False. If header is True, ignore the first line of the data. If header is False, do not ignore the first line of the data. The data is then output as X data (the first column of the data) and Y data (the second column of the data). X and Y must be 1-dimensional arrays or lists! To return multiple values in a Python function, you can use the command *return [X, Y]*.
   You should use the command numpy.loadtxt() with the optional inputs delimiter and skiprows. The advice a general Google search yields will most likely lead you astray! Note, you can extract full columns or rows of an array using [:] similarly to MATLAB.

To import these functions into your project3.py file, you will need to make sure all 3 files are in the same folder and use the statement *from trapezoid import ** and *from importcsv import **. This will allow you to call the functions in your own code. An example of doing so is the following.

```
from trapezoid import *
result = trapezoid([1,2], [3,4])
print(result)
```

Patient Analysis

For your project, you want to provide a short analysis to show your advisor in preparation of your manuscript. Your analysis should include the following sections.

1. Title Page
2. Introduction
   This introduction should be able to introduce the problem to someone who has never seen this document. You must include the percent vision loss equation in this section. You do NOT need to describe your code or the integration methods.
3. Figures and Tables
   All plots will be in the form of y-axis versus x-axis.
   All plots and figures must have a **descriptive** caption.
   The Table must be created in Word.
   You will have to create all plots in a Python file called project3.py. **All plots must be created in Python!** You **must** import the csv data in your project3.py file to create your plots. It will be useful to see how the test.py file calls the *test.csv* data.
   a. Table of the age in years (t) and intraocular pressure in mm-Hg (P) for Patient A.
   b. Plot of the intraocular pressure in mm-Hg (P) versus age in years (t) for Patient A.
   c. Plot of the percent vision loss (VL) versus age in years (t) for Patient A. There should be 3 sets of data on this plot. You will need to experiment with different types of markers (matplotlib.markers — Matplotlib 3.4.3 documentation) so that all your data is easily visible. You must estimate the percent vision loss using:
      i. The trapezoidal function you created above.
      ii. The trapezoidal method from numpy (numpy.trapz())
      You can import the trapz() function using the command *from numpy import trapz*.
      iii. The Simpson's method from scipy (scipy.integrate.simpson())
      You can import the simpsons() function using the command *from scipy.integrate import simpson*.
      You may also find it useful that you can extract the first n values of a 1D array by using [:n] where n is the number of values you want, similarly to MATLAB.
4. Discussion
   This section should contain the following:
   a. A discussion of what the different integration methods are doing with the data in Table 1 and Figure 1.
   b. A discussion of the percent vision loss based on the 3 different integration methods.

Deliverables

Be sure to submit all 4 files!

1. trapezoid.py
2. importcsv.py
3. project3.py
4. Patient Analysis PDF

Rubric (Total 100 Points)

Function 1 – **20 Points**
Function 2 – **20 Points**
Turned in preliminary functions on time **– 10 points**

Patient Analysis – **40 Points**
- Title Page – **5 Points**
- Introduction – **5 Points**
- Figures and Tables – **20 Points**
- Discussion – **10 Points**

Professional Format and Code Comments – **10 Points**

Notes for Report

For any equations, please use the equation editor.
For Figures and Tables, please follow the guidelines outlined in the example report on Blackboard.
Include a title page.

Notes for Functions

These notes do not apply to the **project3.py** file.
All functions must be named EXACTLY as listed above. This includes capitalization.
Functional inputs and outputs must be EXACTLY as defined in the Functions section.

Test Data

If you run the following code below in the Python shell, you should get the following output. Do note, this does NOT guarantee your code is correct.

Save the *test.py* and *test.csv* file in the same location as your functions, and then execute the *test.py* file. You should get the following.

```
4.0
[3. 5.] [4. 6.]
[1. 3. 5.] [2. 4. 6.]
```