ENEE 691 Homework 1

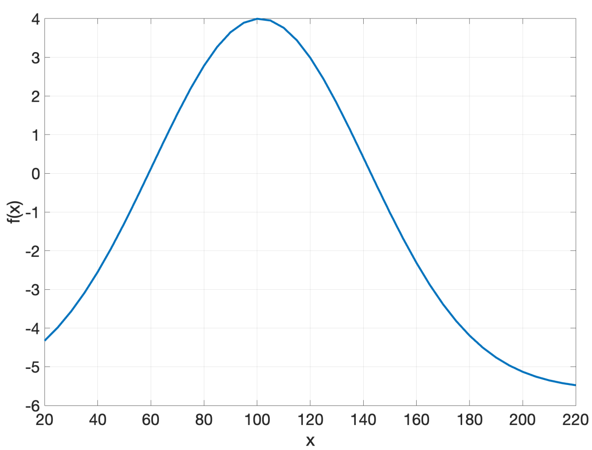
Spring 2023

Due date: 9:00 AM, February 14, 2023.

Question 1 (30 points)

Please download the dataset1.csv (if you are using Python) or dataset1.mat (if you are using MATLAB) from our github repo, click here. If you don't know how to download a file from a github repo, please see the footnote.[1] The first column of this dataset is some x values and the second column is $f(x)$.

a) Plot the data and save it as a png file, e.g. figure1.png. The output should look like this:

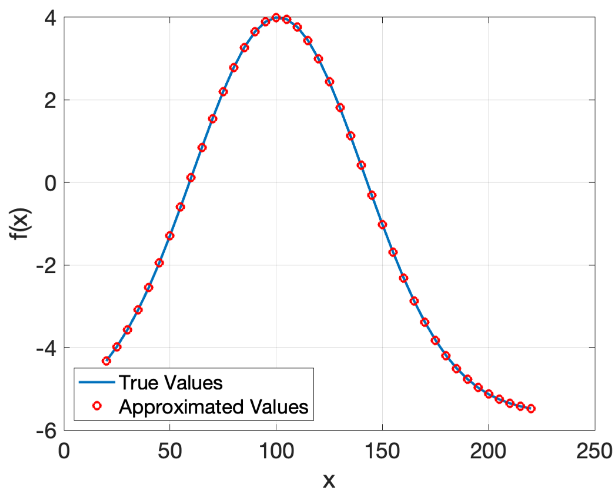


b) We know that $f(x)$ is in the following form but we don't know what α values we should use. Your second task is finding these α values with fsolve (either in MATLAB or Python).

[1] Click on the file you wish to download from GitHub to open the individual file. From here, right click the Raw button at the top of the file, select Save Link As..., choose the location on your computer where you want to save the file, and select Save

$$f(x) = \frac{\alpha_1 x^2 e^{-\left(\frac{x-\alpha_2}{\alpha_3}\right)^2}}{1+\alpha_4 x^2} - \alpha_5 \tag{1}$$

Please use [20 60 80 2 5] as your initial guess and print the final values you determine. e.g.,
$\alpha_1 = ...,$
$\alpha_2 = ...,$ etc.
and plot x vs $f(x)$ for both true and predicted values, e.g.



c) The α values used to generate Figure 1 were: [24 101 57 2.5 5.6]. Please comment on fsolve estimates vs. true values.
Note: This question is created to demonstrate you that if you have an equation without unknown parameters to describe the data, then you can find those parameters with fsolve.

Question 2 (30 points)

Again either in MATLAB or Python, create a function which returns $f(x)$ for the input x for

$$f(x) = \frac{24x^2 e^{\left(\frac{x-101}{57}\right)^2}}{1+2.5x^2} - 5.6 \tag{2}$$

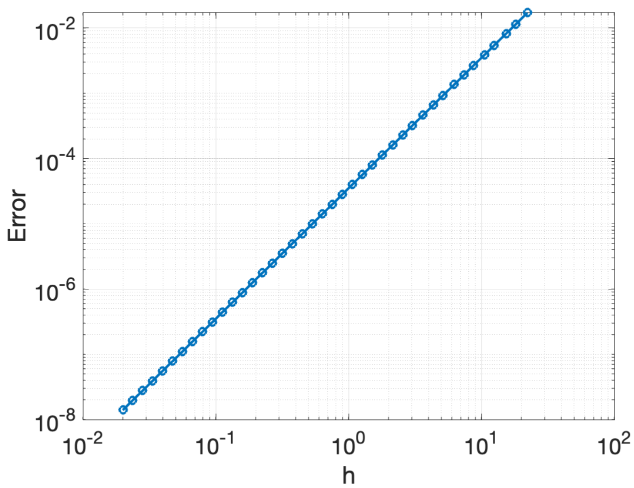
a) Find two x values that give $f(x) = 0$ using the bisection method. You need to conduct two different searches. One should focus on the range [50, 70]. The other one should search for $x \in [130, 150]$. If you prefer the Newton-Raphson method, you are more than welcome but in that case you will need to evaluate the derivative of $f(x)$.

b) Find the x value where $f(x)$ has a local maxima. In other words, find the derivative of the function given in Eq. (2) numerically (using any of the methods we discussed) and determine where it is equal to 0 (zero). You should search for an x value $\in [90, 110]$.

Question 3 (40 points)

According to MATLAB's internal integrator, the integral of Eq. (2) from $x = 20$ to $x = 220$ is $-173.271095694271053045608606966 91$. [2]

a) Calculate the integral of the function described in Eq. (2) from $x = 20$ to $x = 220$ numerically by taking N uniformly samples using the Riemann mid-point integration rule. Choose N values between 10 and 1000. Plot the error in a log-log scale, where error is defined as $|(TrueValue - Prediction)/TrueValue|$. Your solution should look like this:



b) What's the slope of this curve? Please comment on it.

c) Use the quadrature formula given below to approximately calculate $\int_{20}^{220} f(x)dx$ for the function described in Eq. (2).

$$\int_a^b f(x)dx \approx \ell \times \sum_{n=1}^{32} f(\hat{x}_n)w_n$$

where $\hat{x}_n = a + \ell * (1 + x_n)$ and $\ell = (b - a)/2$. Comment on the accuracy.

[2] When the integral result is negative, it means that the are under the curve where $f(x) < 0$ is larger than the area under the curve where $f(x) < 0$.

$x_n =$

```
-0.997263861840000
-0.985611511540000
-0.964762255600000
-0.934906076000000
-0.896321155800000
-0.849367613800000
-0.794483796000000
-0.732182118000000
-0.663044266000000
-0.587715758000000
-0.506899908000000
-0.421351276000000
-0.331868602000000
-0.239287362000000
-0.144471962000000
-0.048307666000000
 0.048307666000000
 0.144471962000000
 0.239287362000000
 0.331868602000000
 0.421351276000000
 0.506899908000000
 0.587715758000000
 0.663044266000000
 0.732182118000000
 0.794483796000000
 0.849367614000000
 0.896321156000000
 0.934906076000000
 0.964762256000000
 0.985611512000000
 0.997263862000000
```

$w_n =$

```
0.007018610009470
0.016274394730906
0.025392065309262
0.034273862913021
0.042835898022227
0.050998059262376
0.058684093478536
0.065822222776362
0.072345794108849
0.078193895787070
0.083311924226947
0.087652093004404
0.091173878695764
0.093844399080805
0.095638720079275
0.096540088514728
0.096540088514728
0.095638720079275
0.093844399080805
0.091173878695764
0.087652093004404
0.083311924226947
0.078193895787070
0.072345794108849
0.065822222776362
0.058684093478536
0.050998059262376
0.042835898022227
0.034273862913021
0.025392065309262
0.016274394730906
0.007018610009470
```

Bonus Question (20 points)

Download the DataThief app from https://datathief.org/ and extract the data from one of the figures provided in a paper you recently read. Please provide a copy of the original figure and extracted one! Note that DataThief requires Java installed on your computer.