# MTE 203 – Advanced Calculus

# (Spring 2024)

## MATLAB Laboratory Worksheet 1[1]

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[1] Please note that this Laboratory Worksheet must reflect your individual work and that submissions are individual

## Objectives

1. Get familiar with creating MATLAB function and script files.
2. Learn how to use the MATLAB 'fsolve' command to find the roots of a system of non-linear equations using a given set of initial guesses.
3. Learn how to do simple plots in Matlab

## Solving a System of Non-Linear Equations

Consider the following system of three non-linear equations:

$$\begin{cases} x_1 x_2^2 - 5x_3 + e^{x_3} = 6 \\ x_1 - 3e^{x_2 \cdot x_3} = -5 \\ 8x_3 - {x_2}^3 - 6e^{x_1 \cdot x_2} = -10 \end{cases}$$

1. Write the three non-linear equations given above as functions of the variables $x_1$, $x_2$, and $x_3$:

$$\begin{cases} f(x_1, x_2, x_3) = x_1 x_2^2 - 5x_3 + e^{x_3} - 6 \\ g(x_1, x_2, x_3) = x_1 - 3e^{x_2 \cdot x_3} + 5 \\ h(x_1, x_2, x_3) = 8x_3 - {x_2}^3 - 6e^{x_1 \cdot x_2} + 10 \end{cases}$$

   a. Using a single variable array, create a Matlab function that takes the $x_1$, $x_2$, and $x_3$ and returns $f$, $g$, and $h$.

   b. Save the associated "*.m" file as "TripleFunc_<Lastname>.m".

2. Write a MATLAB script to find the solution to these non-linear equations using the Matlab function "fsolve". Save the associate *.m file script as "Nonlinear_<Lastname>.m".
3. Solve the system of non-linear equations using your script for the two "first initial guesses" listed in Table 1
   a. Write all the roots you obtained for each initial guess in the specified roots' fields in Table 1.
   b. Calculate the numerical values of the functions $f$, $g$, and $h$ for all the roots found for each initial guess into your TripleFunc function. Write these values in the specified function values' fields in Table 1.

**Table 1. First initial guesses and solutions**

| First initial guess: $x_0 = (-0.5 \quad 0.5 \quad -0.5)$ | Roots found | Corresponding function values for the roots |
|---|---|---|
| | -3.59560520513912 | -4.38760139331862e-11 |
| | -0.247098840509286 | -4.73825423341623e-11 |
| | 3.07166892435778 | -1.78123293892440e-09 |
| Second initial guess $x_0 = (0.5 \quad 0.5 \quad 0.5)$ | Roots found | Corresponding function values for the roots |
| | -3.59560520499866 | 5.60298474283627e-11 |
| | -0.247098840487167 | -1.25677246387568e-12 |
| | 3.07166892436092 | -9.36264399342690e-11 |

**4.** Compare the function values obtained for both initial guesses.

a. Are they the same (Yes/No)? No, but almost.

b. Why or why not? Please explain in a maximum of 3 sentences.

They are almost same. We expect them to be very similar, as they are solving for the same roots (and all be similar to zero). However, they could be finding different roots, which would cause them to be slightly different (but ideally still 0, or close to it). In this case, they are slightly different because they are using numerical methods which aren't precise.

c. What exactly does MATLAB predict with fsolve? Please explain in one or two sentences

Matlab predicts the values for X1, X2, and X3 that satisfy the non-linear system of equations. This is similar to solving a linear system of equations, except there is added complexity because the system is non-linear.

## Basic Plotting of functions of 1 variable

1. Create a script called "Plots_<LastName>.m".
2. Using the command **plot**, plot three plots of the function $g(x_1, x_2, x_3)$ in a single plot. Use a domain of [-5, 0] for the horizontal axis of the plots.
   **a.** Plot 1 should be the function $g(x_1, x_2, x_3)$ as a function of $x_1$, with $x_2$ and $x_3$ assigned constant values equal to the roots found with the first initial guess. Use a blue line with linewidth of 2 points.

**b.** Plot 2 should be the function $g(x_1, x_2, x_3)$ as a function of $x_2$, with $x_1$ and $x_3$ assigned constant values equal to the roots found with the first initial guess. Specify a dashed red line with circle markers size 4.

**c.** Plot 3 should be the function $g(x_1, x_2, x_3)$ as a function of $x_3$, with $x_1$ and $x_2$ assigned constant values equal to the roots found with the first initial guess. Specify a black, dash-dotted line style.

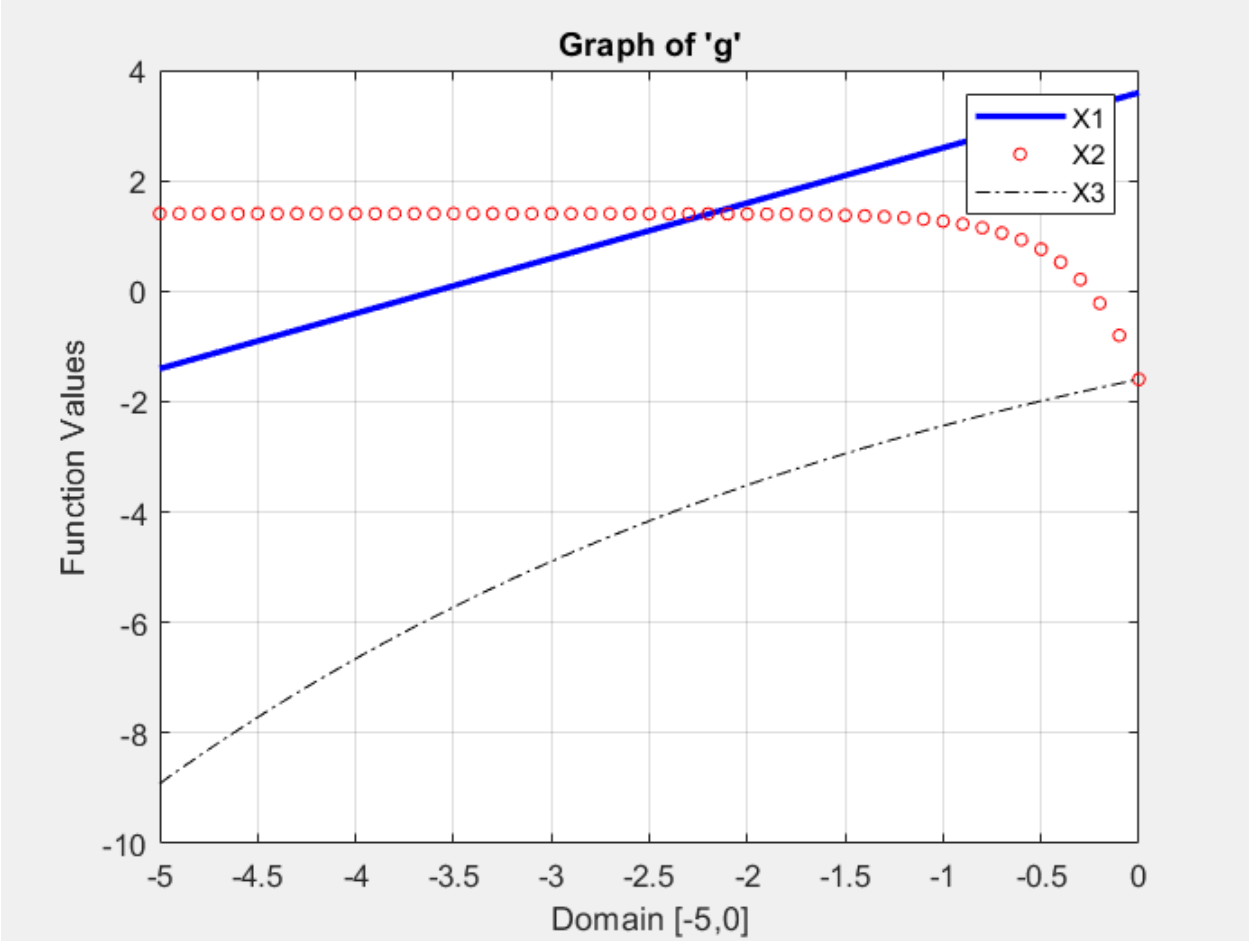


**Figure 1: Graph of G with respect to each variable**

3. Using the command **subplot**, create a figure containing the plot 1, 2 and 3 in the above question 2 as subplots. Create two subplots across the upper half of the figure and a third subplot that spans the lower half of the figure. Use a domain of [0, 5] for the horizontal axis of the plots.

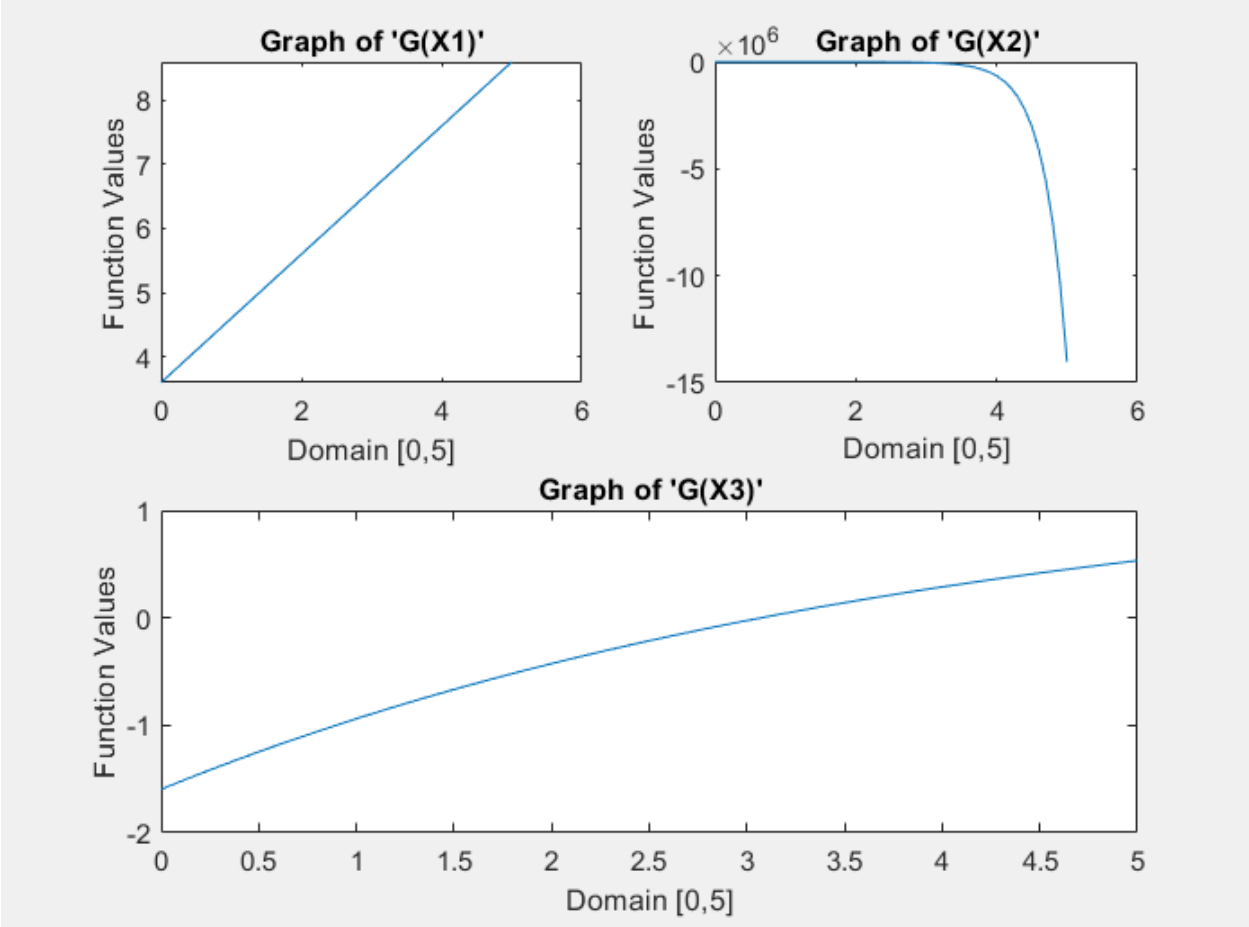


**Figure 2: Graph of G with respect to each variable, separated**

**Note:** All plots should include title, axes labels, legends, different color lines, styles and markers (as specified), and caption.

4. Look at the figures obtained in questions 2 and 3. Should the functions reach zero at the same value on the horizontal axis? Please explain in one or two sentences.

They should not reach zero at the same time, they should reach zero at the found root, which is what is observed. (ie. When x is -3.59, the graph of g(X1) should equal 0, because that was the found root).

Once you complete all the required questions, please save this document as **MATLAB Worksheet 1_<Lastname>.docx.**

## LEARN Submission:

Submit your files using the corresponding **Dropbox folder in LEARN**. Upon finishing your worksheet, you should have your completed word file and the following *.m files:

- TripleFunc_<Lastname>.m
- Nonlinear_<Lastname>.m
- Plots_<Lastname>.m

**Make sure that you submit two files:**

1. Your worksheet file saved as a **pdf** and named as **W1_name_lastname.pdf**
2. All associated *.m files listed above inside **one single zipped file** named **W1_code_name_lastname.zip**

**IMPORTANT:**
**Please note that we will grade only the latest submitted version of these two files (the pdf file and the zipped file) in the LEARN Dropbox.**