MATH2059 Numerical Methods

Homework 1 - MATLAB Basics

Self-Study Exercises (Do not report these exercises):

1. Work on the following questions from the book "Applied Numerical Methods with MATLAB", 3rd edition, Chapra: 2.1, 2.2, 2.3, 2.4, 2.18.

Exercises to be reported:

1. The butterfly curve is given by the parametric equations below. Generate values of x and y for values of t from 0 to 100 with $\Delta t = 1/16$. Construct 2D plots of (a) x and y versus t and (b) y versus x. Use `subplot` to stack these 2 plots vertically and make the plot in (b) square. Include titles and axis labels on both plots and a legend for (a). For (a), employ a dotted line for y in order to distinguish it from x.

$$x = \sin(t)\left(e^{\cos t} - 2\cos 4t - \sin^5\frac{t}{12}\right)$$
$$y = \cos(t)\left(e^{\cos t} - 2\cos 4t - \sin^5\frac{t}{12}\right)$$

2. The butterfly curve given above can also be represented in polar coordinates as given below. Generate values of r for values of θ from 0 to 8π with $\Delta\theta = \pi/32$. Use the MATLAB function polar to generate the polar plot of the butterfly curve with a dashed red line. Employ the MATLAB Help to understand how to generate the plot.

$$r = e^{\sin\theta} - 2\cos(4\theta) - \sin^5\left(\frac{2\theta - \pi}{24}\right)$$

3. The sine function can be evaluated by the following infinite series:

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots$$

Create an M-file to implement this formula so that it computes and displays the values of $\sin x$ as each term in the series is added. In other words, compute and display in sequence the values for:

$$\sin x = x$$
$$\sin x = x - \frac{x^3}{3!}$$
$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!}$$
$$\vdots$$

up to the order term of your choosing. For each of the preceding, compute and display the percent relative error as:

$$\%\text{error} = \frac{\text{true} - \text{series approximation}}{\text{true}} \times 100\%$$

As the test case, employ the program to compute sin(0.9) for up to and including eight terms— that is, up to the term $x^{15}/15!$. Plot the (percent relative error) versus (number of terms) graph. Don't forget to add labels to the axes and a title to your plot.

4. Develop a function function M-file that returns the difference between the passed function's maximum and minimum value given a range of the independent variable. In addition, have the function generate a plot of the function for the range. Test it for the following cases:
(a) $f(t) = 8e^{-0.25t}\sin(t-2)$ from $t = 0$ to 6π.
(b) $f(x) = e^{4x}\sin(1/x)$ from $x = 0.01$ to 2.
(c) The built-in `humps` function from $x = 0$ to 2.

How to Submit Your Homework:

1. Each student should submit his/her own homework. You can discuss the questions with your friends, but you must write your own code. Group work is not allowed.

2. Write a detailed report, which includes explanations about each part in each question. Explain how your scripts and functions work, i.e., which parts of your functions/scripts accomplish which task and how it is accomplished. Include the outputs of your functions to your report. You can save a figure as a *.jpg image file using "File —> Save as" in the Figure window. Then, you can include the jpg image to your Word document.

3. Don't forget to put detailed comments into your functions/scripts to explain what your code is doing. Also indicate the inputs and outputs in the comment section. (% sign is used to put comments in MATLAB)

4. Combine your report and MATLAB codes into a single file. Plots should go into the report. Name your zip file as "name_surname_studentnumber_hw_no.zip". For example, a student whose name is Ayşe Çalışkan and student number is 1234567 will name her file as: "ayse_caliskan_1234567_hw1.zip" for the first homework. Also, write your name, surname and student number as comments at the beginning of your codes.

5. Some of the students may be asked to make a demo of their homework to the teaching assistant.

6. Submit the homework via Google classroom.