CS/MATH 375, Fall 2021 — HOMEWORK # 1

Due : Aug. 31 at 6pm on UNM Learn

Instructions

- **Report:** In general, your report needs to read coherently. That is, start off by answering question 1. Fully answer the question, and provide all the information needed to understand your answer. If Matlab code or output is part of the question, include that code or output (e.g., screenshot) alongside your narrative answer. If discussion is required for a question, include that. *Your report should include your Matlab scripts, code output, and any figures.*
- **What to hand in:** Submission must be one **single PDF** document submitted on UNM Learn.

  Overall, your report is your narrative explanation of what was done, your answers to the specific questions, and how you arrived at your answers. If discussion is required for a question, include that. *Your report should include your Matlab scripts, code output, and any figures.*
- **Partners:** You are strongly encouraged to **work in pairs**. If you work with a partner, only one partner should submit a homework, but write both collaborators' names at the top. Groups of more than 2 students are not allowed.
- **Typesetting:** If you write your answers by hand, then make sure that your handwriting is readable. Otherwise, I cannot grade it.
- **Plots:** All plots/figures in the report must be generated in Matlab or Python and not hand drawn (unless otherwise specified in the homework question).

  In general, make sure to (1) title figures, (2) label both axes, and (3) include a legend for the plotted data sets. The font-size of all text in your figures must be large and easily readable.
- **Generating PDFs:** See the UNM Learn homework page for tips.

---

1. Suppose `z=[10 40 70 90 20 30 50 60]`. What does this vector look like after each of these commands? (Assume that the commands are done sequentially)

   (a) `z(1:3:7)=zeros(1,3)`

   (b) `z([3 4 1])=[]`

2. (a) Use the `linspace` function to create vectors identical to the following created with colon notation:

i. `t=1:4:25`

ii. `x=-11:1`

(b) Use colon notation to create vectors identical to the following created with the `linspace` function:

i. `v=linspace(-10,-8,6)`

ii. `r=linspace(0,1,5)`

3. Given that `t=0:0.1:1; y=sin(pi*t);`, write a single-line MATLAB code that returns the following.

(a) $\sum_{k=1}^{N} t_k$ (use the built-in Matlab `sum` routine)

(b) $\sum_{k=1}^{N} t_k y_k$

(c) $\sum_{k=1}^{N} t_k^2$

4. Write a MATLAB script to plot x, $\exp(x)$, x^2, x^3 over the interval $0 \le x \le 1$ using `plot`, `semilogy`, `semilogx`, and `loglog`.

All the curves for one plot should be on the same figure/axis. Each curve should have a different color. Each plot should be clearly labeled, use large fonts, have a title and labels on each axis, and have a legend to describe each curve. Submit your figures and comment on the advantages / disadvantages of the different plotting commands.

5. (a) Write a MATLAB function called `my_mean` which takes four arguments: a function name `fun`, a number `a`, another number `b` satisfying `a<=b`, and a positive integer `N`. The function `my_mean` should return an approximate value for

$$\int_a^b f(x)\,dx,$$

where $f(x)$ represents the function `fun`. The approximate value should be calculated via the formula

$$\int_a^b f(x)\,dx \approx \frac{h}{2}(f(x_1) + f(x_N)) + \sum_{j=2}^{N-1} hf(x_j),$$

where $h = (b-a)/(N-1)$ and $x_j = a+(j-1)h$. An example call to the function would look like

$$\texttt{my\_mean}(@\texttt{sin}, 0, 2, 100)$$

It is recommended that you use the above `linspace` function or colon notation to create your vector of x_j points, and that you use the `sum` function for computing the approximate integral.

(b) Matlab lets you easily create more complicated functions from simpler, built-in ones like `sin`, `log` or `sqrt`. Write another function, `my_fun`, which returns the value of $x\,e^x$ given an input x. The function `my_fun` should be a function of `x` only. The input `x` could be a vector.

(c) Use `my_mean` and `my_fun` to compute an approximation to

$$\mathcal{M} = \int_{-1}^{1} xe^x \, dx.$$

Compute approximations for $N = 10, 20, 40, 80, 160, 320, 640$, and 1280. In this case the exact solution can be computed with pen and paper. Show that the exact value is

$$\frac{2}{e}.$$

Plot the absolute error between $\mathcal{M}$ and your approximations vs. N. You may want to use `loglog` for the plot. **Make sure to use `xlabel` and `ylabel` to label your plot**.

(d) Print a table listing, in each row, N, the corresponding approximation of $\mathcal{M}$, and the absolute error between the approximation and $\mathcal{M}$. Do you see a pattern?