Middle East Technical University - Department of Computer Engineering

CENG 371

Scientific Computing

Fall' 2024-2025

Homework 1

Due Date: 7 November 2024, Thursday, 23:55
Late Submission Policy will be explained below

Question 1 (35 points)

Let $f(x) = x\left(\frac{x+1}{x} - 1\right) - 1$ and $g(n) = f(n)/\epsilon$. Plot $g(n)$ for $n \in [1, 1000]$ where $n \in \mathbb{Z}$ (a.k.a. n is an integer).

1. **(5 pts)** Include the plot in your PDFs.

2. **(5 pts)** Which of the values of n satisfy $g(n) = 0$?

3. **(15 pts)** Explain why $g(n) \neq 0$ of majority of n.

4. **(10 pts)** $g(n)$ seems to grow in size. Why?

Question 2 (65 points)

Generate an array of numbers k where $k_i = 1 + (10^6 + 1 - n_i) \times 10^{-8}$, $n \in [1, 10^6]$, and $n \in \mathbb{Z}$.

1. **(5 pts)** Calculate the theoretical result for the sum of the element of k.

2. **(5 pts)** In no more than two sentences, explain the idea of *pairwise summation* (You can find the algorithm online)

3. **(15 pts)** Calculate the sum of the elements of k using
    a. Naive summation $(\sum_{k=1}^{10^6} k_i)$
    b. Compensated summation (Kahan summation)
    c. Pairwise summation
   in both **single** and **double** precision.

> Please refer to this link for calculating in single precision (for Matlab).

4. **(15 pts)** Compare the methods' errors and runtimes.

5. **(25 pts)** Comment on your results. As a suggestion, you can comment on the differences, possible improvements, etc.

Regulations and Submission

- **Programming Language:** You can use any programming language, **however Matlab is recommended**. Other good choices are Python (via Numpy package), and Octave (open source alternative to Matlab). Students can download Matlab (please refer to this link).

- Most of the points will be granted to the **explanation/discussion parts** of the questions. Make sure you **reflect your reasoning** cleanly and concisely.

- Most of your points will come from the PDF text, however; you should submit your code as well.

- Please make sure that your reports are readable, clean, and concise. **Note that the organization of your PDF will also be subject to grading**. You can get bonus/penalty points based on it.

- Uploaded codes should be clean and understandable similar to the PDFs. The codes will not be graded rigorously (such as black-box testing) since there aren't standard language or script arguments. However, these will be visually inspected.

> As of Matlab 2020, you can define multiple functions inside a single script, you may want to structure your code that way.

- **Late Submission Policy:** Accepted with a deduction of $5 \times d^2$; where d is the number of late days submitted.

- Submission will be done via Odtuclass, (class.ceng.metu.edu.tr).

- Please upload both your code and your findings (as a PDF) to the system in a zip file.