Assignment - 3

Assigned: April 26, 2024 Due: May 3, 2024 Max. marks: 100

General Instructions

- Submit a hard-copy of the solutions either in-class or in TAs office NAC-1, Room no. 322.
- Upload a scanned copy of the solutions and the codes you have developed as a single zipped folder on Moodle.
- Do not email your solutions/codes. Emailed submissions will not be graded.

Programming Questions

1. (40 points) Recall the problem statement from Assignment 1 wherein you computed the derivative of a function using fourth-order accurate Padé scheme and tri-diagonal LU decomposition/Thomas algorithm for $f(x) = \sin(5x)$. Starting from its serial code, write its corresponding OpenACC program (you do not need to use the recursive doubling approach). Optimize the code to avoid unnecessary data transfer and improve execution time. Plot the analytical and the numerical solution for $n = 100$ and number of gangs = 10. Plot the time taken by the full parallel solver for $n = 1000$ for number of gangs = $1000, 100, 10$. It is understood that in Thomas algorithm there is not much scope for parallelization; only parallelize whereever possible and this question helps in correctly developing the OpenACC program.

2. (60 points) You are given a serial C code that performs Cholesky decomposition, which decomposes a symmetric positive definite matrix into a lower and an upper triangular matrix that are transposes of each other. Thus, given a matrix $A[N][N]$, it outputs a lower-triangular matrix $L[N][N]$ such that $A = LL^T$. The computation is specified as below.

$$\mathtt{L}(i,j) = \begin{cases} i = j & : \sqrt{\mathtt{A}(i,i) - \sum_{k=0}^{i-1} \mathtt{L}(i,k)^2} \\ i > j & : \dfrac{\mathtt{A}(i,j) - \sum_{k=0}^{j-1} \mathtt{L}(i,k)\mathtt{L}(k,j)}{\mathtt{L}(j,j)} \end{cases}$$

The given serial code performs minor adjustments to reduce chances of overflows and underflows. Parallelize the given code using OpenACC ensuring correctness. You are free to modify the code. Optimize the OpenACC parallel code that you develop for data transfer, parallelism, and number of gangs. Plot the time taken by the serial and the parallel codes for N = 10, 100, 1000 in the same plot. For $N = 10$ show and ensure that the lower triangular matrix obtained is the same between serial and parallel solutions.