ME 683: Computational Gas Dynamics

Coding Assignment 1: 1D Wave Equation

Feb 4^{th}-11^{th} 2025

Weightage: 5%

The goal is to solve the linear advection equation

$$u_t + au_x = 0$$

where u is the dependent variable and a is the wave speed, for the following setup:

- Domain: $x \in [-1, 1]$ in m
- Initial condition:

$$u(x,0) = e^{-(\frac{x}{2\sigma})^2} \quad \sigma = 1/8$$

- Wave Speed (a): 2 m/s
- No of cells (N): 200 ($\Delta x = 0.01$)
- Time step (Δt): 0.0025 s
- Total time (t): 1 s
- Periodic boundary condition

Gaussian wave is expected to come back to its initial form after one revolution around the domain. Note that the wave should just stop where it began without changing shape (in a perfect world). You are expected to write a C++/Fortran/Matlab/Python code that implements Lax-Friedrichs, Lax Wendroff, FTFS, FTBS and Upwind Scheme and simulate the above problem. In a single line graph, show the u vs x plot at the initial condition ($t = 0$) and u vs x results from various FDM/FVM schemes after 1 s. Also, calculate the L-2 error norm:

$$L^2 = \sqrt{\frac{\sum_{k=1}^{N}(u_{exact}(x_k) - u_{numerical}(x_k))^2}{\sum_{k=1}^{N} u_{exact}(x_k)^2}}$$

You have to submit your code, line plot and error norm table (in a doc/odf/pdf document). The plots should have proper title, labels and legends. Please add relevant and detailed comments to your code; negative marking for codes with no comments. Mail zip/tar file (RollNo.zip, no other names allowed) of your plots+code to *tapan.mankodi@iitg.ac.in* and *harshal.srivastava@iitg.ac.in* by 9:00 PM, February 11^{th} 2025 (Tuesday). Late submissions have 50% penalty.

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