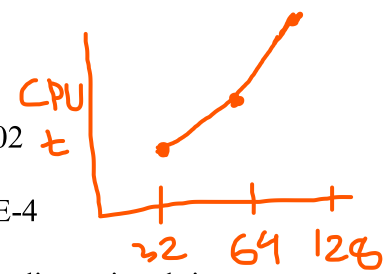
ME/AOE 6434
Term Project
Hard copy of reports due by 5 pm May 10 2022
Spring 2022

Solve the driven cavity problem using the following:

1. [5 points] Write the incompressible continuity and momentum equations in non-dimensional form using the lid velocity as the characteristic velocity and the length of the square cavity as the characteristic length scale. Show the derivation and the final form of the non-dimensional equations. Governing equations and boundary conditions
2. [10 points] Assume a uniform grid distribution and discretize the equations on a staggered grid using the finite-volume method with central differencing for all terms. Also formulate the pressure equation using the continuity equation. Show how you will treat the boundaries for all equations (x and y momentum and pressure equation). Numerical discretization
3. [10 points] Symbolically represent the fractional step algorithm using the discretized form of the equations with the Adams-Bashforth time advancement scheme showing the proper time levels used. Algorithm and solution procedure
4. Write a computer program to solve the set of equations and obtain a solution. For each case set the initial field to be zero. Integrate in time till you reach a steady state solution. At each time step the pressure equation average L2 norm should converge to a residue of at least1.E-5. Specify what solver you use for the pressure equation. Steady state can be assumed when the average L2 norm of the change in x- and y- directional velocities of the interior nodes between two time steps is less than 1.E-8.

   You will calculate the following cases:

   A. [40 points] Re =100:
      i. N = 32×32 finite volumes, Δt = 3.125E-3, 6.25E-3, 0.02
      ii. N=64×64 finite volumes, Δt = 5.0E-4, 1.0E-3, 3.0E-3
      iii. N=128×128 finite volumes, Δt = 1.25E-4, 2.5E-4, 5.0E-4



   Plot the L2 norm of the change in solution (u-velocity) versus the non-dimensional time units on a **semi-log** plot to show convergence to steady state. Comment on the trends.

   Compare (plot) the u-velocity distribution at x=0.5 and the v-velocity distribution at y=0.5 with the data given in Tables I and II in the Ghia&Ghia paper for all three grids on the same plot using one representative time step. Comment on the trends.

   Also plot the CPU time for convergence to steady state versus the grid resolution for all time steps. Comment on the trends. Can you derive an approximate power law relationship between the two?

   B. [20 points] For Re = 1000, use the largest permissible time step on a 128×128 finite-volume grid. State the time step you use. How does it compare to Re=100 and why? Discuss and explain.

Compare the number of non-dimensional time units taken for convergence with the equivalent calculations for Re=100. Comment on and explain your observations.

Compare (plot) the u-velocity distribution at x=0.5 and the v-velocity distribution at y=0.5 with the data given in Tables I and II in the paper.

C. [5 points] Finally, state what you would do algorithmically to improve the performance of your computer program to make it reach steady state faster.

5. [10 points] Presentation of results and final report. You should treat the final report as if you are writing a paper. For example:
   1. Abstract
   2. Introduction
   3. Problem description
   4. Governing Equations and boundary conditions
   5. Numerical discretization
   6. Algorithm and solution procedure
   7. **Results – Clearly demarcate results as (A), (B) and (C) reflecting the questions above. Each Figure should have a proper legend and caption with appropriate figure numbering. Follow the same procedure for Tables if you have any.**
   8. Summary and Conclusions.

   I will expect a fully word-processed report.

   Attach your computer program in an Appendix