

Numerical Methods of Thermo-Fluid Dynamics I

Winter Semester 2017-2018

DELIVERABLE TASK III: Numerical Solution of 2D Lid-drive Cavity Flow

Given: Monday, 08/01/2018

Deadline: 11/02/2018

Chair of Fluid Mechanics
Department of Biochemical Engineering, Technical Faculty
Friedrich-Alexander University Erlangen-Nuremberg



Dr. Manuel Münsch, M.Sc. Nan Chen

Deliverable Task III

In the third deliverable task you will write a MATLAB code to solve the two-dimensional Navier–Stokes equations for lid-driven cavity flow. The computational domain is square $(x, y) = [0, 1] \times [0, 1]$ and the dimensionless Navier–Stokes equations

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \quad (1)$$

$$\frac{\partial u}{\partial t} + \frac{\partial(u^2)}{\partial x} + \frac{\partial(uv)}{\partial y} = -\frac{\partial p}{\partial x} + \frac{1}{\text{Re}} \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right), \quad (2)$$

$$\frac{\partial v}{\partial t} + \frac{\partial(uv)}{\partial x} + \frac{\partial(v^2)}{\partial y} = -\frac{\partial p}{\partial y} + \frac{1}{\text{Re}} \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right), \quad (3)$$

must be advanced in time $t \in [0, 0.1]$. The following boundary conditions will be used:

$$\begin{aligned} u(x, 1, t) &= 1, & u(x, 0, t) &= u(0, y, t) = u(1, y, t) = 0, \\ v(x, 0, t) &= v(x, 1, t) = v(0, y, t) = v(1, y, t) = 0, \end{aligned}$$

and initially the fluid is at rest

$$u(x, y, 0) = v(x, y, 0) = 0.$$

The deliverable task should contain the source codes (50p) and a written report (50p) describing the following results:

- (10p) Choose a grid with proper resolution and run the code with several time-steps, what is the maximum time-step you can use at $\text{Re}=0.1$? Explain this phenomenon in terms of the stability requirements we discussed for advection-diffusion equations.
- (20p) Run the simulation with $\text{Re} = 0.1$, generate 5 figures for the streamlines and 5 figures for the pressure contours of the whole domain at $t = 0 : 0.02 : 0.1$, explain the properties of the flow.

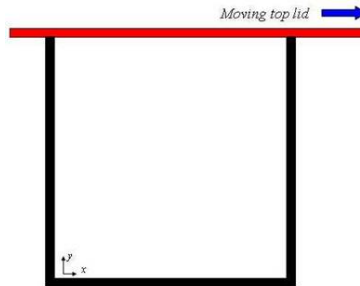


Figure 1: lid-driven cavity flow.

- (20p) Change the Reynolds number to $Re = 1$. Generate two figures comparing $u(0.5, y)$ and $v(0.5, y)$ for $Re = 0.1, 1$ at $t = 0.1$, explain the differences.

The Deliverable Task III must be submitted to `nan.chen@fau.de` until
February 11th, 2018, 23:59.