KEB-45250 Numerical Techniques for Process Modeling
Assignment Wing 2D

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Introduction

We use the classic NACA 0012 airfoil, see Fig. 1, validation case for our assignment. See NASA for details (https://turbmodels.larc.nasa.gov/naca0012_val.html). It should be easy to find other references as well. It is recommended to spend a while learning how large a domain, how fine a mesh, and what kind of turbulence model you need.

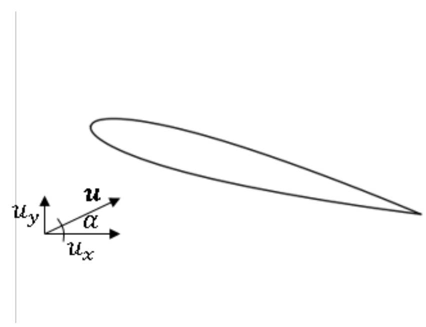

Figure 1: NACA 0012

The case can be solved in 2D and steady state.

The measured values are usually given using dimensionless numbers. It should not matter much how you choose the dimensions, but the values in Table 1 work.

Input values

The angle of attach is based on the last digit of student number. All other parameters are the same for all, see Tables 1-2. If care is taken with the dimensionless number, other dimensional values can also be used.

	Value	Name
α	See Table 2	angle of attach
Re	6×10^6	Reynolds number
μ	$1.02 \times 10^{-5}\, Ns/m2$	dynamic viscosity
ρ	$1.03\, kg/m^3$	density
L	$1\, m$	chord length

Table 1: Inputs

last digit	1	2	3	4	5	6	7	8	9	0
α (°)	3	4	5	6	7	8	9	10	11	12

Table 2: Choose the angle of attach based on your student numbers last digit. Example: 12345$\underline{6}$ -> $\alpha = 8\,°$

Provided files

- Measurement data from NASA
  - LadsonForceData.txt
- This pdf, and the LyX files used to create it
- Geometry file
- An intentionally coarse and small mesh for testing
- Some, maybe useful code
  - code_snippets.py

Returning a report

Deadline Sunday 29.03. at 23:55.

Return the report by email to antti.mikkonen@tut.fi. I will send a answer email withing 24 hours. If you receive no such email, assume that something went wrong.

Requirements for the report

- Calculate drag and lift coefficients
- Easy to read report. Shorter is better as long as it contains the necessary information.
- Two turbulence models

    - Both must make sense but only one needs to give correct results

- Mesh independency study. You may use a mesh from a 3rd party for comparison.
- Mesh quality
- Discretization schemes
- Convergence
- Governing equations
    - For turbulence models, the transport equations and turbulent viscosity definition are enough
    - If wall functions are used, give their equations
- Boundary conditions
- Domain

Course grading

- Exam
    - must be passed, grading 0-5
    - 60% weight
- Assignment I
    - must be passed, grading 0-5
    - 25% weight
    - CFD
    - Two options (one must be done)
        - This assignment
        - Python FVM solution of Blasius boundary layer
        - If you do both, you can get 5-10% extra
    - The report must be completed in time
        - Late, acceptable return results in grade 1
    - Returned report may be
        - accepted
            - grading 1-5
        - accepted with corrections
            - after corrections, grading 0-5
        - failed with corrections

        - after corrections, grade 0-1
    - failed
        - grade 0
- Assignment II
    - must be passed, grading 0-5
    - 15% weight

Bag of tricks

- Your calculations are likely to be sensitive to
    - near wall mesh quality
    - near wall turbulence
    - size of the domain. You likely need a large domain.
- When using structured grids, large jumps in mesh size may cause discontinuities in the field values
- Similar, but not the same, tutorials
    - https://confluence.cornell.edu/display/SIMULATION/FLUENT+-+Flow+over+an+Airfoil
    - WS04_Airfoil tutorial in the Fluent quick start by EDR&Medeso
    - 2D Combustion Chamber meshing tutorial by EDR&Medeso
- I would highly recommend learning to use scientific writing tools. I personally recommend LyX. Equations are easy to write. Figures are automatically updated. Cross references, citations, section numbers, etc. are automatically updated.

LyX equation example

LyX makes scientific writing a lot easier. It has all the power of LaTeX with a easy to use graphical interface. If you open this file in LyX, you will see the Eq. 1 in a very similar format as in this pdf.

$$\frac{\partial\rho\mathbf{u}}{\partial t}+\nabla\cdot\left(\rho\mathbf{uu}\right)=\mathbf{\nabla}\cdot\boldsymbol{\tau}-\nabla p+\mathbf{f}_{b} \tag{1}$$

The following is the raw LaTeX code for the same equation.

```
\frac{\partial\rho\mathbf{u}}{\partial t}
+\nabla\cdot\left(\rho\mathbf{uu}\right)
=\mathbf{\nabla}\cdot\bm{\tau}
-\nabla p+\mathbf{f}_{b}
```

Reference to the equation 1.