# Exercise using the program 'XFOIL'

*Taks: Use Xfoil software with inviscid and viscous flow. Choose a NACA profile.*

In this assignment you will learn how to run Xfoil for basic airfoil analysis. You will also learn how the Reynolds number affects the airfoil performance.

The following two informations are useful to solve the present assignment:
- With inviscid flow the Drag is 0. Assuming viscous flow the airfoil will produce Drag. The total drag is given by two contribution: the friction drag and pressure drag. In Xfoil the total drag, pressure drag and friction drag coefficients are given separately with CD, CDp, CDf, respectively. Hence CD=CDp+CDf.
- You will mainly use two commands in the present assignment. The command "pacc" in conjunction with "aseq" (see the tutorial for details). The output file saved with "pacc" will contain the following columns: angle of attack, lift coeff., drag coeff., pressure drag coeff., pitching moment coeff., upper and lower transition points. The output file can be opened with Excel or Matlab.

**-Potential Theory-**

Choose a NACA profile and load it into Xfoil. Run the program for $\alpha$=0, 5 and 10 degrees. Write down the CL that you will find in the window that pops up, showing the airfoil geometry and the $C_p$ distribution (make sure you are in .OPERi directory).

**-Viscous flow-**

Now use Xfoil software with viscous flow. In the .OPERi directory write the command "visc". The program will ask you to insert the Reynolds number. Start with $Re = 5 \cdot 10^5$. Again make sure you are in the .OPERv directory. Write "pacc" to start the polar accumulation and save a new file. Run the program for a series of angles of attack from -5 to 20 degrees with 1 degree of increment. Repeat the computation for $Re = 5 \cdot 10^6$. A the end you will have two output files with the airfoil characteristics.

**Plot the following graphs:**
- Graph1. Plot the curves CL($\alpha$) (CL in function of ($\alpha$)) for Re=5e5 and Re=5e6. Overlap the three values found with the inviscid analysis.
- Graph2. Plot the curves CD($\alpha$) for Re=5e5 and Re=5e6.
- Graph3. Plot the curves CD($\alpha$), CDp($\alpha$), CDf($\alpha$)

**Questions**
1) Do you think that CL can be approximated with the potential theory?
2) How does $Re$ affect the CL($\alpha$) and CD($\alpha$) curves?
3) What are, approximately, the stall angles of attack, $\alpha_s$, in the 2 cases? Compare the values.
4) Refer to Graph 3. Which drag coeff. component is contributing mostly to

CD? Consider both low and high angles of attack.

N.B. If Xfoil does not converge, there are some tricks to try:
- press ! and return
- increase the number of iterations ('iter')
- Xfoil uses the previous solution, so stepping up to a point helps: 'alfa 0' followed by 'alfa 10' may not converge immediately, but 'alfa 9' followed by 'alfa 10' will probably work