Assignment #5: Lift and Drag — ME 412

due 10/12/2016 before midnight via Learning Suite — **50 possible points**

This homework is of regular length, but is not due for two weeks so as to provide flexibility around the midterm. You should, however, work the first two problems before the midterm as they will help you in your preparation.

Project: Continue gathering background information. Formulate a more detailed plan for your project. Start engaging in "rapid prototypes" (e.g., simplified versions of simulations, experiments, etc.) to refine your direction.

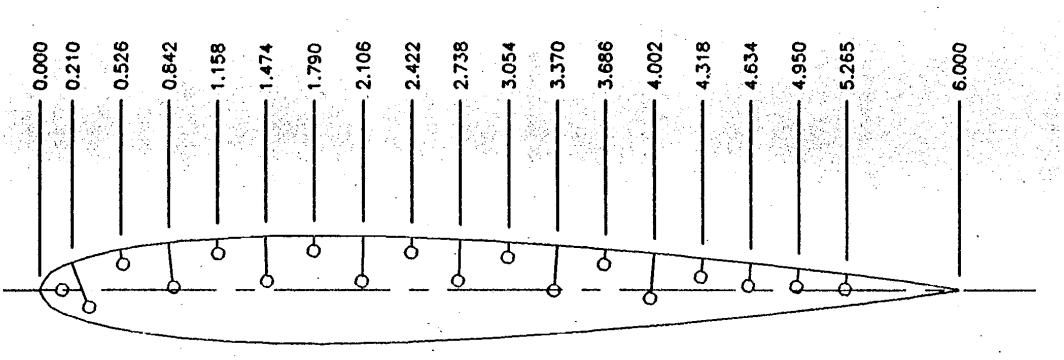
5.1 Munson 9.55

5.2 Munson 9.119

5.3 Using the wind tunnel and provided wing in CB 116, collect pressure data on both the upper and lower surface of the wing. Work in small groups, and make sure everyone is able to participate in the data collection. The key specs are as follows:

Airfoil	NACA 0012
Re	200,000
α (angle of attack)	5°
c (chord)	6 in
b (span)	18 in

The pressure taps are located at the following locations:



After collecting pressure data switch to the wing with the same NACA 0012 profile, but with a sting mount. Use the force balance to measure the normal and axial forces at the same Reynolds number and angle of attack. Be sure to zero out the force coefficients before collecting data.

Tips:

- Bring a flash drive to save your data. The lab computer is not connected to the internet.
- Be sure to zero out the pressure, forces, and sting angle before collecting data.
- Remember to record the pitot probe pressure.
- The pressure taps exist on only one side, so you will need to collect data at two different angle settings (this works because the section is symmetric).
- Pressure in the pitot tube and along the wing are gauge pressure relative to the freestream pressure (measured in the static port on the side of the pitot tube).

Compare your experimental data to that predicted by StarCCM at the same conditions. To help you with the StarCCM portion please complete the StarCCM tutorial: Compressible Flow/Transonic Flow: RAE2822 Airfoil. Remember that although this tutorial is compressible, your NACA 0012 problem should be solved using the incompressible RANS equations (i.e., use the constant density equation of state).

Items to report:

(a) Your experimentally measured pitot total pressure.

(b) The associated wind tunnel speed and Reynolds number.

(c) The axial and normal forces from the wind tunnel.

(d) C_p plots for experiment and CFD overlaid (I recommend plotting $-C_p$ on the y-axis, as is convention, so that the upper plot corresponds to the upper surface of the airfoil).

(e) The lift and drag coefficients found from both methods.

(f) A brief discussion on your findings.

(g) A list of potential sources of error for the experiments and for StarCCM. Be as complete as possible in discussing sources of error.

(h) A screenshot of the pressure distribution from the compressible tutorial problem.

Extra Credit [5 pts]: Use XFOIL to compare the pressure distributions and lift/drag coefficients under the same conditions. NACA sections are defined parametrically so you don't need to load in data points for the airfoil profile. The command "naca 0012" will do it for you.