MAE 253 – Experimental Aerodynamics I
Lab 5 – Airfoil Aerodynamics (Drag)

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Outline

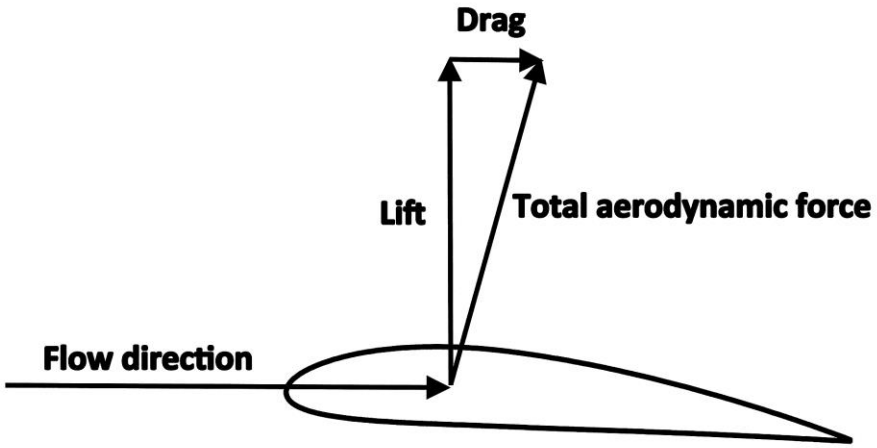
- Lab 5 - Objective
- Lab 5 – Theory
- Lab 5 - Expectations

Lab 5 - Objective

- Breakdown of automation techniques in LabView.
- Study the drag characteristics of the airfoil.

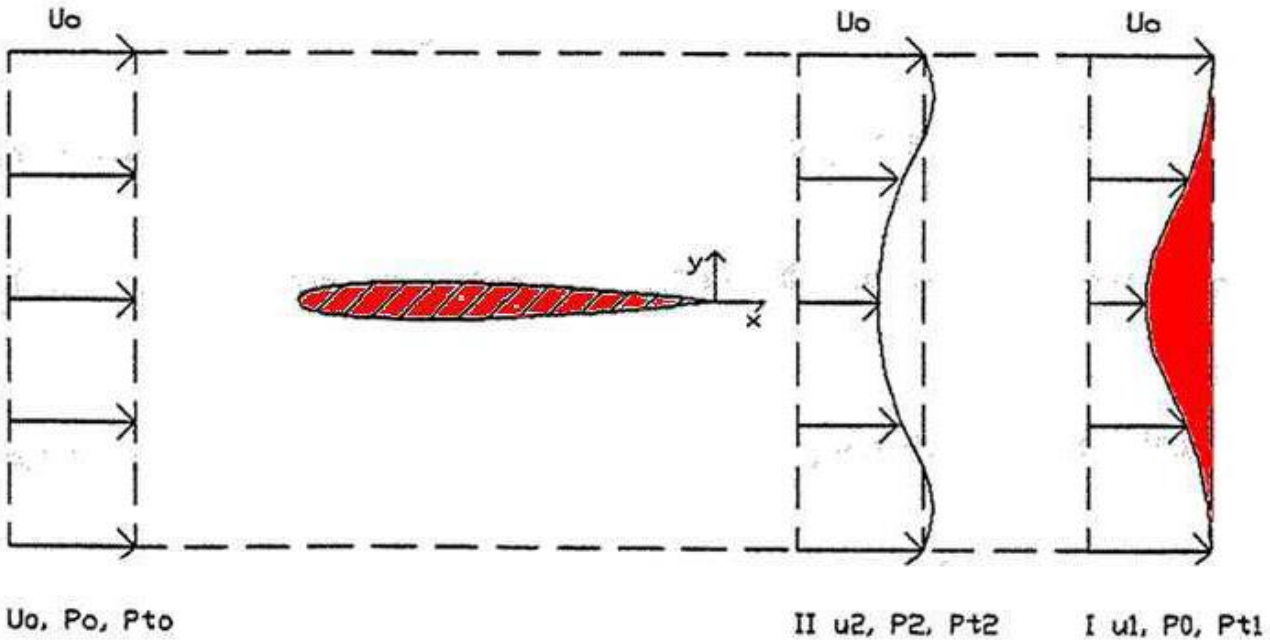
Lab 5 - Theory

- Drag is the parallel (to oncoming flow direction) component of the force exerted on a body due to the fluid flow.
- $C_d = \frac{D}{\frac{1}{2}\rho_\infty V_\infty^2 \, c}$
  - C_d – coefficient of lift
  - D – lift force
  - ρ – density of fluid
  - V_∞ - freestream velocity
  - c – airfoil chord



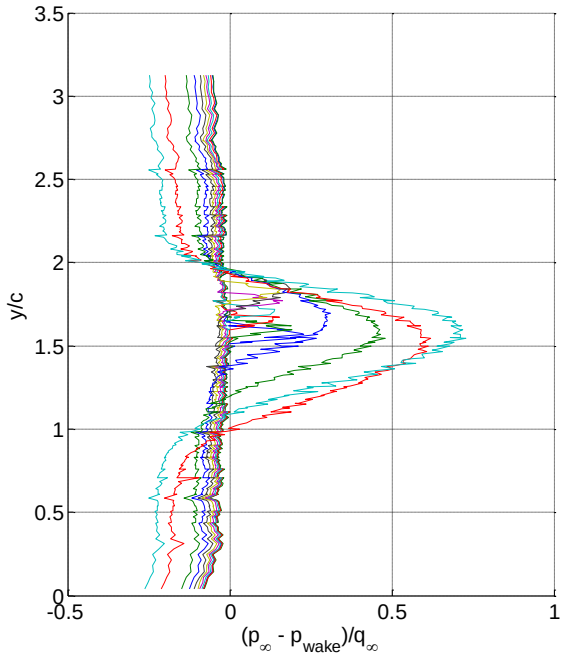
Lab 5 - Theory

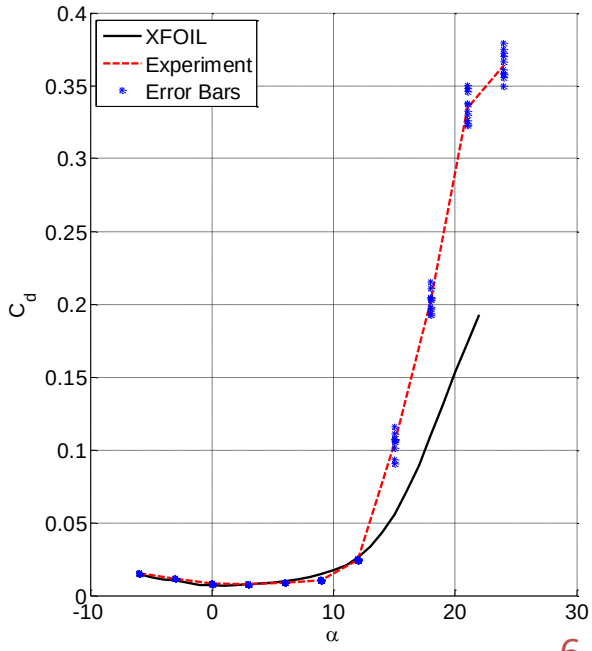
- The profile drag of the airfoil can be calculated by measuring the pressure/momentum deficit in the wake of the airfoil.
- Done using the wake-rake system.
- Area under the pressure deficit curve gives us the drag coefficient.
  - $C_d = \frac{1}{cq_\infty}\int_{wake}(p_{\infty,total} - p_{wake,total})dy$
  - In MATLAB, the trapz() function gives you the area under a curve.



Lab 5 – Expectations

- Data acquired:
  - Total pressure data at different angles of attack and Reynolds numbers.
  - 10 readings per angle of attack.
- Co-plot the pressure-deficit distributions at all angles of attack for a given Reynolds number.
- Plot the C_d vs. α curve for the airfoil and compare the data to XFOIL predictions.
- Constants:
  - airfoil chord, c = 0.3048m
  - density, ρ_{air} = 1.18 kg/m^3
  - dynamic viscosity, μ_{air} = 1.846x10^{-5} Pa s
  - TF = 1.2512





Lab 5 – Interim Correction to C_d Data

- Due to wind tunnel restrictions, static pressure at the point of measurement was unable to recover to freestream conditions.
- As an interim correction, while calculating C_d for the given angle-of-attack, only consider the positive pressure deficit area curve (as shown in red) instead of the complete area under the curve (outlined in black).
- ***Note that this is just a fix.*** To get accurate C_d values, you will have to apply the pressure correction equations given in Schlichting's 'Boundary-Layer Theory'.