AerE 343L: Aerodynamics Laboratory II

Lab Instructions

Lab #2: Airfoil Pressure Distribution Measurements and Calibration of a Small Wind Tunnel

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Lab Exercise #2:
Airfoil Pressure Distribution and Small Wind Tunnel Calibration

In this lab exercise you will use the pressure sensor you calibrated last week along with a Scanivalve pressure scanner to acquire pressure from pressure taps in a NACA 0012 airfoil. You will also calibrate a small wind tunnel that will be used in the future for calibrating a hot wire anemometer.

Part 1: Wind Tunnel Calibration

This small wind tunnel is used to calibrate velocity measurement devices. You will use it to calibrate a hot wire anemometer during the next lab exercise. This week, you must calibrate the wind tunnel itself.

Calibrating this tunnel involves determining the dynamic pressure at the exit of the tunnel as a function of the pressure drop across the contraction. You will use this relationship to calibrate the hot wire anemometer next time.

IMPORTANT: The hot wire you will be calibrating with this tunnel will be used to measure flow in a boundary layer. Because of this, you will need to use this tunnel for VERY low speeds. Be sure to calibrate the tunnel at speeds as low as possible (1-2 m/s) up to 10 m/s or so.

What will be available to you in the lab:

- A thermometer and barometer for observing ambient lab conditions (for calculating atmospheric density).
- A computer with a data acquisition system capable of measuring the voltage from your pressure transducers.
- A Setra manometer with a range of 15 inH_2O (output voltage is 3.00 inH_2O/volt)
- A Mensor manometer with a range of 10 inH_2O
- A Pitot tube on a stand to measure the dynamic pressure at the outlet of the wind tunnel nozzle.
- A small open-circuit wind tunnel with pressure taps across the contraction

Steps:

- Choose a primary operator and have the TA record your choice.
- Connect pressure tubing to measure the pressure drop across the contraction of the duct.
- Connect pressure tubing to measure the dynamic pressure from the Pitot tube.
- Orient the Pitot tube in an appropriate position for measuring the dynamic pressure of the flow coming out.
- Calibrate the pressure drop in the small hot wire calibrator:
    - Measure the pressure drop across the contraction over a range of velocities (i.e. dynamic pressures). In the future, you can use this pressure drop to estimate the velocity at the outlet.

Required Plots:

- For the small calibrator wind tunnel: Plot of dynamic pressure at the outlet versus the pressure drop across the contraction. This will render a calibration curve that you will use next time to calibration your hot wire sensors.

Part 2: Airfoil Pressure Distribution

What you will have available to you for this portion of the lab:

- A Pitot probe already mounted to the floor of the wind tunnel for acquiring dynamic pressure throughout your tests.
- A Setra manometer to be used with the Pitot tube to measure the incoming flow velocity.
- A thermometer and barometer for observing ambient lab conditions (for calculating atmospheric density).
- A computer with a data acquisition system capable of measuring the voltage from your manometer.
- The pressure sensor you calibrated last week
- A NACA 0012 airfoil that can be mounted at any angle of attack up to 16.0 degrees.
- Two 16-channel Scanivalve DSA electronic pressure scanners.

Steps:

- Choose a primary operator and have the TA record your choice.
- Choose a wind tunnel velocity at which to conduct your tests (incoming flow velocity = 10~15m/s is recommended).
- Connect tubing to supply wind tunnel static pressure (from the Pitot tube static port) to the reference port of your pressure sensor.
- Make sure that the Setra manometer pressures are connected properly.
- Conduct your airfoil pressure measurement experiments.
    - Use the Scanivalve to measure pressures about the NACA 0012 airfoil in the Bill James Tunnel.
    - Measure pressure distributions for the following angles of attack: $AOA = -4°,\ 0°, 4°,\ 8°, 12°, 16°$ and/or any others you wish. You can set the angle of attack by mounting the protractor on the end plate of the airfoil model in the wind tunnel.
    - **Important:** DO NOT TOUCH THE AIRFOIL WHEN CHANGING THE ANGLE OF ATTACK. ONLY HANDLE THE BARS ON EACH END.
    - Repeat your measurements by resetting the airfoil at the above angles of attack as many time as you have time for. This will give you an opportunity to reduce your precision uncertainty.

Required Plots

- Plots pressure coefficient (C_p) distributions about the airfoil for some typical angles of attack considered.
- Plots of C_L and C_D over the whole range of angle of attack you considered.

Lab Exercise #2:

Airfoil Pressure Distribution and Wind Tunnel Calibration

Writeup Guidelines

The report for this project should be a formal report. See course website for the details on exactly what constitutes a formal report.

Required Plots:

- Plots of C_L and C_D vs. angle of attack for the NACA 0012 airfoil.
- Plot of C_p at angle of attack $AOA = -4°,\ 0°, 4°,\ 8°, 12°, 16°$ for the NACA 0012 airfoil.
- Plot of dynamic pressure vs. the pressure drop between the inlet and out let of the wind tunnel contraction for the small calibration wind tunnel (including a curve fit).

Your report must provide details on:

- The flow speed you used for the airfoil pressure distribution measurements.
- Discussion of the plots of the pressure coefficient (C_p) distributions of the airfoil.
- Discussion of C_L and C_D calculated from your C_p distributions—and how you calculated them.
- Estimates of the location of the stagnation point for each angle of attack you consider.
- Estimate of the stall angle (if possible) from your measurements.
- Tunnel velocity, Reynolds number of tests (with respect to the airfoil chord length of 12 inches).
- Discussion about the results of the small wind tunnel calibration tests.
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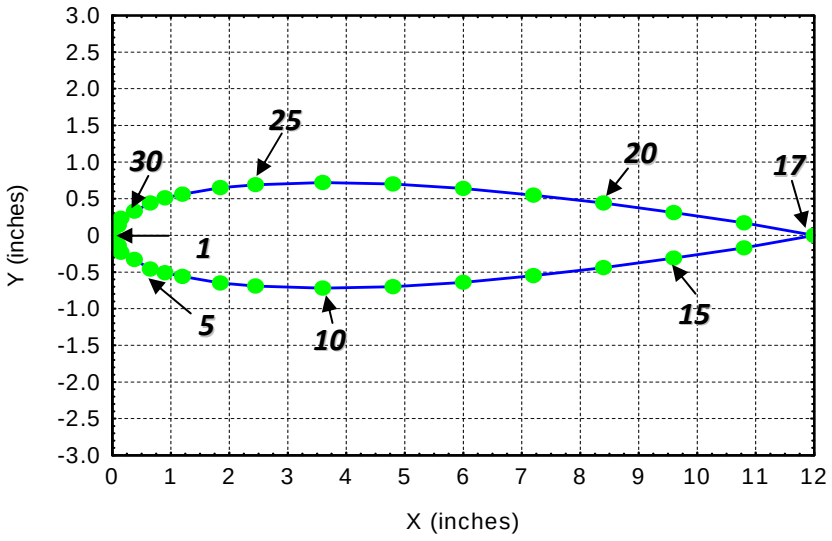
Pressure tabs on the NACA 0012 airfoil



The coordinate of the pressure tabs on the NACA 0012 airfoil

Tap No.	X (in)	Y (in)
1	0	0
2	0.1	-0.14
3	0.15	-0.23
4	0.38	-0.33
5	0.65	-0.46
6	0.9	-0.51
7	1.2	-0.56
8	1.85	-0.65
9	2.45	-0.69
10	3.6	-0.72
11	4.8	-0.7
12	6	-0.64
13	7.2	-0.55
14	8.4	-0.44
15	9.6	-0.31
16	10.8	-0.17
17	12	0
18	10.8	0.17
19	9.6	0.31
20	8.4	0.44
21	7.2	0.55
22	6	0.64
23	4.8	0.7
24	3.6	0.72
25	2.45	0.69
26	1.85	0.65
27	1.2	0.56
28	0.9	0.51
29	0.65	0.44
30	0.38	0.33
31	0.15	0.23
32	0.1	0.14