

AA 321 — Aerospace Laboratory

Lab Three: 2D Wing

University of Washington

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1 Background and objectives

The purpose of this experiment is to introduce another method of measuring aerodynamic forces on a body. Forces in these experiments will be determined by monitoring static pressures at various locations on a NACA 0016 two-dimensional wing, mounted vertically in the 3x3 wind tunnel. There are 43 static pressure ports on the wing surface around its midspan, one at the tip of the leading edge, and 21 on each side of the wing. For this experiment a “pitch and pause” method is used because the wing must be at a stable condition to allow the Scanivalve to sequentially scan all ports, which takes about one minute per angle of attack. The wing angle of attack α is varied from -4° to $+20^\circ$ for four different values of q . You will process these pressure data to determine the drag, lift, and pitching moment coefficients of the 2D wing as a function of q and α . Tufts have been attached to the wing surface to facilitate visualization of the flow behavior, as well as a stream from a fog machine to visualize streamlines.

The data collected consists of the following test matrix:

1. Indicated: q , 20, 30, 40, and 45 psf
2. Angles of attack: -4° , -2° , 0° , 2° , 4° , 6° , 8° , 10° , 12° , 14° , 16° , 18° , 20°

Be sure to watch the video before beginning your analysis!!

During the experiment, the tufts and fog machine indicate the dynamic behavior of the flow over the wing at various angles-of-attack. In laminar conditions, the tufts are straight and aligned in the direction of local flow. In turbulent conditions the tufts wiggle at amplitudes and frequencies dependent on the level of turbulence. *Hand sketches of fog/tuft behavior are expected to be in your notebooks for this lab.* Be sure to observe the flow carefully, in particular the sudden changes between qualitative “regimes” of flow.

2 Data reduction and questions

The files you've been given consists of about five different complete data sets. Look through all of these sets and analyze the one which you find to be the highest quality. Then consider the following in analysis of the data provided, where all tested q_{ind} should be on the same plot unless otherwise stated:

1. Choose a value of q_{ind} and plot the pressure data as a function of port number for three angles of attack (all on the same plot). Comment!
2. Plot the pressure coefficient c_p vs. x/c for each q_{ind} (use multiple plots if necessary).
3. Plot the lift coefficient c_l vs. angle of attack α . Compare with theory.
4. Plot the drag coefficient c_D vs. angle of attack α .
5. Plot the center of pressure location x_{cp} vs. angle of attack α .
6. The moment coefficient c_m about the quarter chord vs. α , and compare with theory.
7. Determine the angle of attack at which the wing generates zero lift.
8. Why were you told to use q_{ind} instead of q_{true} for the above analysis?
9. Describe your observations of the flow visualization.
10. Determine the stall angle. How does it compare with the flow observations?
11. What influence might the tufts have on the stall angle so determined?
12. Comment on possible experimental errors and their degree of influence on the data/analysis.
13. Comment on the effect and degree of influence that ambient temperature has on the data set.