TFES Lab (ME EN 4650)
Airfoil Aerodynamics

Required Figures

Captions

A meaningful and comprehensive caption must accompany all figures. For the three figures, the caption is placed *below* the figure and includes the label Figure 1x., where x denotes the letter a–c according to the plot order listed below. Note, because plot 1c includes two subplots side-by-side, the caption needs to differentiate the two subplots using "(left)" and "(right)" labels — see Figure 4 of the Handout as an example.

Plots

1a. Plot of C_L (y-axis) versus α (x-axis) comparing your data to previously published results. Download the provided Matlab figure file entitled: `NACA0012_CL.fig`, open this file in Matlab, and plot your data on this figure. Include error bars on C_L that represent the uncertainty to within a 95% confidence interval. The y-axis limits should extend from 0 to 1.4. The x-axis limits should extend from 0 to 20 deg. Plot your data using a marker (e.g., ○ or □) and connect the markers with a dashed line to better discern the trend. Include the chord Reynolds number of your data in the legend.

1b. Plot of C_D (y-axis) versus α (x-axis) comparing your data to previously published results. Download the provided Matlab figure file entitled: `NACA0012_CL.fig`, open this figure in Matlab, and plot your data on this figure. Include error bars on C_D that represent the uncertainty to within a 95% confidence interval. The y-axis limits should be extend from 0 to 0.3. The x-axis limits should extend from 0 to 20 deg. Plot your data using a marker (e.g., ○ or □) and connect the markers with a dashed line to better discern the trend. Include the chord Reynolds number of your data in the legend.

1c. Create two suplots of the pressure coefficient C_p (y-axis) versus distance along the chord x/c (x-axis). The two subplots should be placed side-by-side. The **left** subplot should contain the data for an angle of attack *below* stall; while the **right** subplot should contain the data for an angle of attack *above* stall. In both subplots, use ○ for the top surface and □ for the bottom surface. Include a legend in both subplots. Include a single figure caption for the two subplots. In the figure caption, state the chord Reynolds number and angles of attack for both subplots, as well as the actual stall angle.

Short-Answer Questions

2a. State the angle of attack at which stall occurs (α_{stall}) for your data. Your response should in the following form (where XX denotes the value from your data): "Based on the present lift and drag measurements at Re_c =XX, stall is observed to occur at an angle of attack of about XX°." Describe how your measured lift and drag coefficients vary with angle of attack. [3–4 sentences]

2b. State the average percent uncertainty in your C_L and C_D measurements to within a 95% confidence interval. Describe how the uncertainty in your experimental measurements varies with angle of attack, if at all. [2–3 sentences]

2c. Compare your data to previously published results and examine Re_c trends:

- State 2 ways each that your measured C_D and C_L values disagree with previously published results at a similar Re_c. Be specific in your response. For example, do not simply state that your values are larger than the published data, but provide the actual numeric values, both for your data and the previously published results. [4 sentences]
- Examine the trends in the previously published results, and state 2 ways each that C_D and C_L vary with Re_c. [2–4 sentences]

2d. Imagine that you are trying to use your experimental results to select the correct size electric motor to power a small Unmanned Aerial Vehicle (UAV) such as the one shown, where the wings are comprised of NACA 0012 airfoils. The total wingspan is $L = 4$ ft. and the chord is $c = 6$ in. Assume that the cross-section of each wing is uniform, i.e., the wings do not taper and the planform area looks rectangular. State the speed V_w at which the UAV would have to be flying in order for your wind tunnel results to be applicable. If the UAV were cruising at V_w, state the maximum mass it could have (to ensure that it would remain flying at this speed). Use an air density and air viscosity consistent with what is typically observed in Salt Lake City at around 23°C. [2–3 sentences with equations]