# Airfoil Lab

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**Figure 1a.** Coefficient of lift on the y-axis versus angle of attack on the x-axis for the NACA0012 air foil at a chord Reynolds number of 1.5 \* 105. The experimental data has been plotted over published results using black square markers. Each marker is accompanied by error bars that represent the uncertainty of the data acquisition to within a 95% confidence interval.

A graph showing a line graph

Description automatically generated with medium confidence

**Figure 1b.** Coefficient of drag on the y-axis versus angle of attack on the x-axis for the NACA0012 air foil at a chord Reynolds number of 1.5 \* 105. The experimental data has been plotted over published results using black square markers. Each marker is accompanied by error bars that represent the uncertainty of the data acquisition to within a 95% confidence interval.

A graph showing the growth of a company

Description automatically generated

A graph of a number of points

Description automatically generated with medium confidence

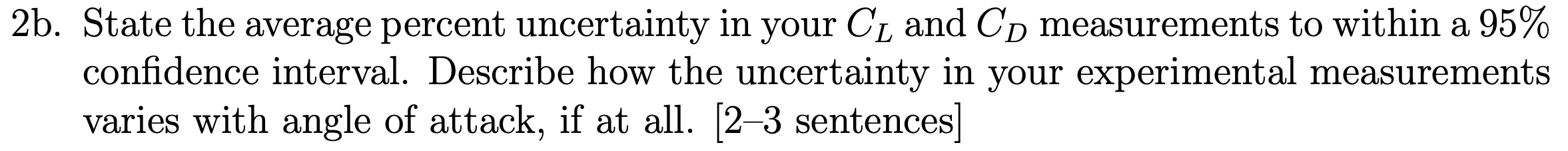
**Figure 1c.** (Left) Coeffcient of pressure on the y-axis versus distance along the chord on the x-axis for the NACA0012 airfoil at an angle of attack of 5 degrees at the chord Reynolds number of 1.5 \* 105. The blue markers represent the data measurements on the upper surface while the red markers represent the measurements on the bottom surface.(Right) Coeffcient of pressure on the y-axis versus distance along the chord on the x-axis for the NACA0012 airfoil at an angle of attack of 12 degrees at the chord Reynolds number of 1.5 \* 105. The blue markers represent the data measurements on the upper surface while the red markers represent the measurements on the bottom surface. The published results for this airfoil show stall occurring at an angle of attack of 10owhile the measured results show stall occurring at an angle of attack around 9o .

Short-Answer Questions

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2a. Based on the present lift and drag measurements at ReC = 1.5 \*105, stall is observed to occur at an angle of attack of about 9o. Starting from an angle of attack of 0o and working our way up to 9o, the measured lift coefficient slowly increases from about 0.25 to 0.85 and the measured drag coefficient slowly increases from about 0.02 to 0.025. After the angle of attack of 9o, the coefficient of lift starts to decline down to about 0.65 and the drag coefficient drastically increases up to around 0.29 at an angle of attack of 16o.



2b. The average percent uncertainty in the coefficient of lift and drag for this experiment was 16.7% and 3.07% respectively for a 95% confidence interval. The uncertainty in the experimental measurements is consistent with the behavior of the coefficient of lift and drag where the uncertainty is smaller before stall and slightly increases after stall.

A close-up of a paper

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2c. The first way in which the measured values disagree from the published results at a similar Reynolds number is that the coefficient of lift at zero angle of attack for the published results is zero while the experimental value is 0.24. This is due to the experimental setup where the pivot support is located at the center of mass and not the center of pressure which creates a moment that results in a non-zero lift coefficient for an angle of attack of zero. The second way in which the measured values disagree from the published results at a similar Reynolds number is that the coefficient of drag trends higher and non-linearly after stall as compared to the approximately linear trend after stall for the published results. After stall, at angles of attack of 11, 14, and 16 degrees, the measured drag coefficient is 0.133, 0.251, and 0.294 which show a trend of discrete non-linear jumps while the published results at the same angles of attack are 0.117, 0.171, and 0.210 respectively which shows a rough linearly increasing trend.

As ReC increases, the max coefficient of lift for the published results increases as well which is also increasing the angle of attack at which stall occurs. As ReC increases for the drag coefficient, the point at which the drag coefficient has a jump discontinuity and a massive increase in drag increases resulting in a larger angle of attack needed for stall.

A close-up of a plane

Description automatically generated

2d. The speed at which the UAV would have to be flying in order for the wind tunnel results to be applicable was found using similitude by matching Reynolds numbers. The Reynolds number in the experiment was 1.5\*105. To calculate the speed of the UAV, we can set this Reynolds number equal to the equation

After substituiting in 1.5\*105 for Rec, 15.34\*10-6 m2/s for and 0.1524 m for c, we find that Vw is equal to 15.1 m/s.

To find the mass that the UAV could have to ensure it would be flying at the speed Vw, we can utilize the equation

FL =

After substituiting in 15.1 m/s for Vw, 1.2 kg/m3 for , 0.279 m2 for Ap, and 9.81 m/s for g, we find that the mass m of the UAV is 3.89 kg.