Object:

The purpose of this experiment is to acquaint the student with the wind tunnel as a useful tool to determine the aerodynamic characteristics of various wing and/or flight vehicle configurations. Another purpose is to verify that the lift and drag curves for various configurations are actually as presented in the courses, and to illustrate the utility of some of the equations to reduce aerodynamic data to useful dimensionless forms. In this experimental set, the students determine the aerodynamic characteristics of a NASA 0015 airfoil, and then they use the model data to predict the behavior of a full-scale wing under certain flight conditions.

Experimental Procedure:

Use the NASA 0015 wing model to conduct wind tunnel tests in the Aerolab 12 inch diameter test section wind tunnel. Follow the procedure presented here. Since the wing model is a symmetrical airfoil, and it is known that a symmetrical airfoil produces zero lift at zero angle of attack, it is important to set the adjustable angle of attack scale to read zero degrees when the wing is producing zero lift. This is in effect correcting for strut interference and eliminating the effects of tare lift.

Mount the model in the wind tunnel at zero angle of attack and zero all measurement scales: lift, drag, and velocity, using the procedures explained in the laboratory. Make sure the model is securely mounted. Take special care to ensure that no small screws are dropped into the balance mechanism. Follow the steps listed below in conducting the experiment:

1) Make note of the configuration used.

2) Record barometric pressure and room air temperature for calculating air density using the perfect gas law.

3) Turn the tunnel on and adjust air speed to the desired value (usually starting at 45 mph) by adjusting the gap between the diffuser and the test section.

4) Record the values of the lift force, the drag force, the angle of attack and velocity.

5) Increase the angle of attack by 2° and repeat step 4 taking care to maintain a constant air speed in the test section.
6) Continue taking readings of lift, drag, and velocity for every $2^\circ$ across the entire angle of attack range. Take readings every $1^\circ$ in the vicinity of the stall.

7) Remove the model from the tunnel and record all dimensions necessary to determine the reference areas, chord (or reference) lengths, and any other pertinent geometry.

8) Measure the drag of the model support by self at all speeds tested, so this drag can be subtracted from the total drag to get the drag of the model alone.

**Data Presentation:**

Plot lift and drag coefficient versus angle of attack, as well as lift to drag ratio versus angle of attack. Be sure to "fair" smooth curves through the data, and do not just let the computer blindly connect points showing exaggerated data scatter.

**Calculations:**

Calculate the model lift and drag coefficient for each value of angle of attack using the following standard equations:

\[
C_L = \frac{L}{q \times S} \quad \text{(Lift coefficient)}
\]

\[
C_D = \frac{D - D_T}{q \times S} \quad \text{(Drag coefficient)}
\]

\[
Re = \frac{\rho \times V \times L_C}{\mu} \quad \text{(Reynolds Number)}
\]

\[
q = \frac{\rho \times V^2}{2} \quad \text{(Dynamic pressure)}
\]

D is the drag force produced

$D_T$ is support drag (also called tare drag)

$\rho$ is the density of air

$V$ is the free-stream velocity -- that is the airspeed far from the lifting surface

$S$ is the surface area of the lifting surface

$L$ is the lift force produced

$L_C$ is the characteristic length of the wing

Present your data as a plot of lift coefficient, $C_L$, and drag coefficient, $C_D$, versus angle of attack. Identify the configuration tested on the graph. Calculate the test Reynolds number and
label it on the graph. For the calculations, you can neglect wind tunnel wall corrections and Reynolds number effects.

Using the information from your airfoil data plots, answer the following questions, making any required calculations to determine the answers:

1. What would you expect to be a reasonable cruising angle of attack for a finite span wing having the same aspect ratio as your model test? Why?

2. Determine the sea-level stalling speed of an aircraft using this wing and having a gross weight of 1700 Lbs and a wing area of 160 ft². Remember that stalling speed is the minimum speed the airplane can fly at when the wing is producing its maximum lift coefficient.

3. Consider an aircraft using the NASA 0015 airfoil on a wing of 26 ft span and 6.5 ft chord. The aircraft is cruising at 100 knots at a wing angle of attack of 4° and at an altitude of 8000 feet. Determine the lift and drag force acting on the wing. The density at 8000 ft can be found from Appendix C in Munson’s fluids text.

**Experiment Write-up:**

Present the results of your experiment, and the calculations and answers to the above questions in a standard short report format. Hand calculations may be included in an Appendix. All graphs should be neatly presented on separate pages including complete labeling so the graphs can "stand alone." A detailed conclusion must be written as part of the report.

The following DATA SHEET should be used to record your test data and submitted in the appendix of the laboratory report.
**DATA SHEET**

Date__________________

Model Designation _____________________________ (airfoil, etc.)

Model Dimensions:    Wing Span_______________ Chord_______________

Barometric Pressure ________________Room Temperature ________________

<table>
<thead>
<tr>
<th>Angle of Attack, $\alpha$ (deg)</th>
<th>Lift, $L$, lb</th>
<th>Total Drag, $D$, lb</th>
<th>Tare Drag, $D_T$, lb</th>
<th>Net Drag, lb</th>
<th>Velocity $V$, mph</th>
</tr>
</thead>
</table>