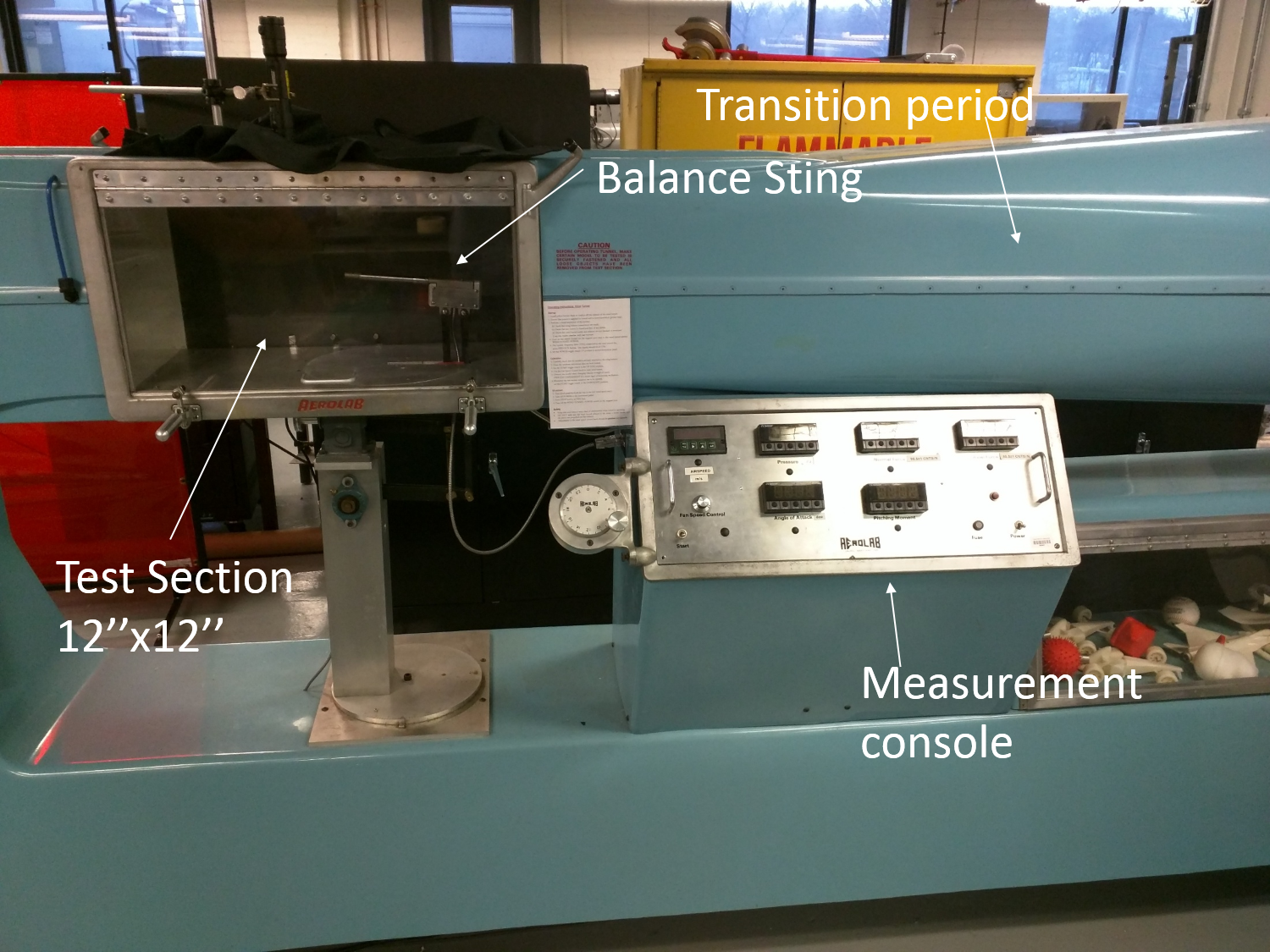
**Wind Tunnel I –Pre Lab**

**Objectives:**

Explore how aerodynamic forces affect flow separation on different bodies when exposed to various flows, using a wind tunnel.

**Apparatus:**

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**Procedure:**

Collecting data for the 3 spheres (1.5”, 3”, 4”)

1. Follow startup procedure provided by Operating Instructions: Wind Tunnel
2. Secure model to the sting balance fixture.
3. Adjust the sting balance fixture to an attack angle of zero degrees.
4. Follow operation procedure provided by Operating Instructions: Wind Tunnel
5. Collect data for the axial force and airspeed on the sphere over the complete range of air speeds at smooth and gradual intervals.
6. Using Reynolds number correlations for a sphere, along with the equation for smooth sphere drag coefficient (Eq 1 appendix) to make a Cd vs Re table for collected data that will be compared to data from published values.

Collecting data for 4” sphere with turbulent trip and golf ball

1. Apply a ring of trip wire to surface of 4” sphere that faces the entrance region of the wind tunnel and repeat steps (2-5)
2. Remove the 4” sphere following the operation procedure and repeat steps (2-5) for the golf ball.

Collecting data for Clark-Y airfoil model

1. Attach the Clark-Y airfoil model to the sting balance while observing safety protocol listed in Operating Instructions: Wind Tunnel.
2. Adjust the angle of attack for the sting balance to -6 degrees.
3. Set the airflow velocity of the wind tunnel to ~40m/s following the operation procedure provided by Operating Instructions: Wind Tunnel.
4. Measure and record the axial and normal forces for the airfoil at this angle of attack.
5. Vary the angle of attack from -6 to +20 degrees in 2 degree increments and record the axial and normal forces for each of these angles of attack.
6. Using the documentation and equations provided for 3-D lift theory to calculate the coefficient of both lift and drag as functions of angle of attack and plot them. Compare to published values.
7. Make sure that the laser apparatus for flow visualization is situated correctly for use following Operating Instructions: SAFEX Fog Generator.
8. Emit fog into the entrance of the wind tunnel following Operating Instructions: 1W GaN 445 nm Laser
9. Observe and record a video of the flow over the airfoil in order to visualize the flow.
10. Follow shutdown procedure provided by Operating Instructions: Wind Tunnel, SAFEX Fog Generator, and 1W GaN 445 nm Laser.

**Relevant theory:**

The model will experience both lift force and drag force during the operation of the wind tunnel. These forces must be understood in order to test their effects on the body.

Drag force occurs along the body in the direction of the flow and comes in two forms, viscous and pressure drag. Viscous drag forms when fluid in the viscous layer running over the model creates shear stresses on the body; these will only appear where there is a momentum boundary layer adjacent to the body. The pressure drag comes from the pressure of the fluid on the surface of the body and the boundary layer of the fluid separating from the body.

Lift Force is perpendicular to the top surface of the model and is also a result of pressure on the body from the fluid. If this force is not balanced by the perpendicular drag forces, the body will be lifted.

In order to identify drag and lift forces (FD and FL) respectively there are equations that relate the experiment parameters. From previously defined theory we can set the equations for lift and drag forces as:

Where FN is the normal force, and FA is the axial force applied to the model geometry. The angle of attack is denoted by, α, and dictates the orientation of the object, with respect to horizontal axis. The angle of attack has a large influence over the lift and drag forces. At extreme angles of attack stall is known to occur, this is where the drag forces overpower lift forces. In practical terms, when an aerial object stalls, it will fall from the sky.

To put lift and drag forces into context, they are often displayed as non-dimensional coefficients (cL and cD) and are determined using the following equations:

and

Where FL,D are the magnitude of the lift or drag forces, over the kinetic energy of the forced flow, and the area is frontal area or the platform area, depending on which coefficient is being calculated.

Cross-sectional areas of objects that are specifically designed to create lift are called airfoils, like the asymmetrical shape of plane wings. Airfoils create lift by creating a circulation of air that pushes the wing up as it flows by the wing. The front of the airfoil facing the flow is called the leading edge, and contains the largest curvature. The airfoil then tapers down to the trailing edge, which also will have a very high curvature.

The upper section of an airfoil is designed to allow the flow to pass by a high velocity with low pressure on the wing, while the lower surface has slower fluid that creates a pressure differential between the top and the bottom, therefore generating lift.

While the flow over an airfoil is 3D, to create a reasonable experiment, the airfoil will be treated as 2D; only the forces in the axial and normal to the flow will be investigated. This is possible by assuming that the aspect ratio of the wing is infinite. Once the data is collected, a correction factor will can be applied to adjust for the infinite AR.

Possible Sources of Error

While testing particular geometries there are inherent limitations to simplified theory and the test apparatus. For theory there are several assumptions meant to simplify fluid dynamic calculations that may adversely affect our collected results. The simplification of a three dimensional object to an infinitely long 2D shape will provide error, as well as the assumption of incompressible flow. Finding the correct Reynolds number will be a challenge assuming static air density. It is assumed that the wind tunnel is calibrated properly. One of which is ignoring flow vortices that occur from flow over an edged shape, for the airfoil testing this will have a definite effect on the observed measurements.

**Data Table:**

**Insert links to files and use standard naming convention:**

**<group >\_<lab name>\_v<version number>**

|  |
| --- |
| [**B3\_WindTunnel\_Matlab\_V1.m**](file:///\\samba.lafayette.edu\shared\me_475_3b\Wind%20Tunnel%201\B3_WindTunnel_Matlab_V1.m) |
| **Revision Number: V1** |
| **Revision Comments:** |

**Roles and Responsibilities:**

Kevin: Objective, Relevant Theory

David: Procedures

Sam: Matlab

Jorge: Apparatus

Justin: Relevant Theory

Chris: Procedures, Editing

**Wind Tunnel I – Lab Observations**

**Create a new version of your data file if it was changed following the pre-lab.**

|  |
| --- |
| **A4\_WindTunnel\_Data\_v2.xlsx** |
| **Revision Number:** |
| **Revision Comments:** |

**Insert relevant pictures (or links if media file is large). This is expected to unedited media with initial observations. Not everything included in this section will be seen in the report, but it is critical to record as much as you can as it is difficult to know what will turn out to be most important to your interpretation of the data.**

**Wind Tunnel I – Post Lab**

The main method for analyzing the data found during the experiment was to read in the data of the various objects, then calculated the coefficient of drag and Reynolds’s number for each. These values were then plotted against each other and against Schlichting’s data.

|  |
| --- |
| **A4\_WindTunnel\_Analysis\_m.xlsx** |
| **Revision Number:** |
| **Revision Comments:**  IMPORTANT! DO NOT BEGIN MATLAB FILE NAMES WITH A NUMBER! MATLAB WILL RETURN A CRYPTIC ERROR |

**Roles and Responsibilities:**

Kevin:

David:

Sam:

Jorge:

Justin:

Chris: