WIND TUNNEL LABORATORY NOTES

MAE 175A

Week I

Calibration of the Wind Tunnel

SUMMARY:

The wind tunnel calibration system consists of the computer, control console, power inverter, wind tunnel, pitot tube, pressure transducer and amplifier assembly and the Lab-view software, shown in figure 1.
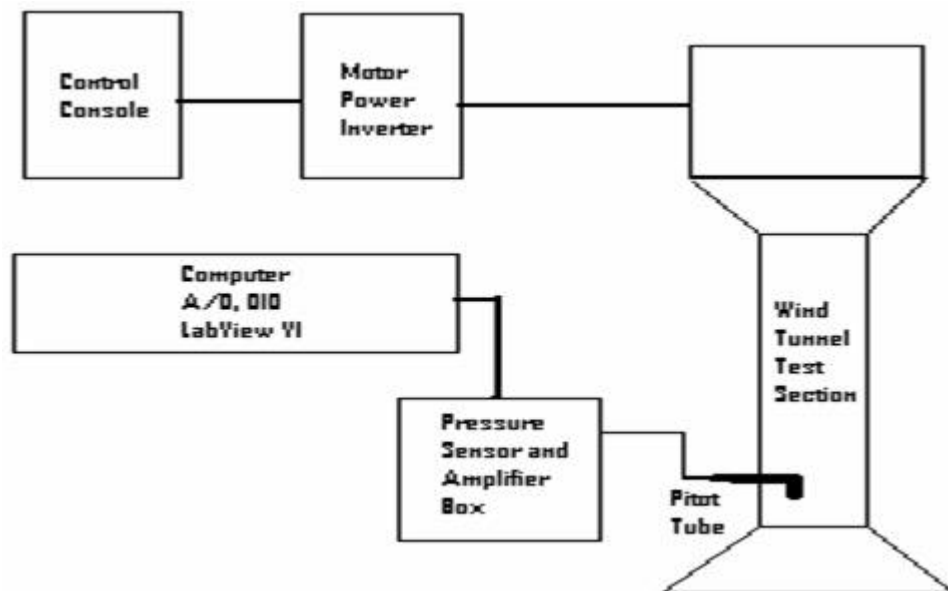

Figure 1: Block Diagram of Wind Tunnel Calibration System

PROCEDURE:

1. Turn the power on to the Computer, the Control Console (insure at this point 00 is displayed on the LEDs and press the Power Update button). Turn on the Power Inverter and then the Pressure sensor and Amplifier Box in the order listed. When Windows has finished loading, double click on the icon labeled "Calibration" on the Desktop. Allow the VI (Virtual Instrument) to load.

2. The control Console has three rocker switches on the front panel. To start the flow in the tunnel, press the switch labeled "Power Setting" in the appropriate direction. When the window displays the desired "Percent Full Power" on the LED display, release the pressure on the switch. Press the silver pushbutton labeled "Power Update" until it clicks. This applies the displayed power setting to the inverter to set the flow to the desired Percent of Full Power setting. The

power setting is an arbitrary number which is a repeatable power setting used for reference. The numbers are used only for adjusting the power for tunnel calibration. . When taking data, use the value displayed on the VI front panel "Flow Setting."

3. Wait approximately 30 seconds for the flow in the tunnel to stabilize and start the *Calibration VI* by pressing the arrow at the top of the screen. When the VI is running, verify the Flow Setting window value is the desired setting. This value may be slightly different from the value entered on the Control Console LED display. The value displayed on the VI is the actual value from the wind tunnel power inverter and should be used for the calibration data. Follow the onscreen instructions. Record the front panel Stagnation Pressure value and pressure value standard deviation. Also record the Flow Setting and its associated standard deviation. If the numbers are toggling and too unstable for a given measurement, press the "Terminate VI" button on the Front Panel of the VI to lock the data, then record the values displayed. The VI should be started again for the next data point. Repeat the procedure for all desired speed settings.

NOTES:

The data acquired by the *Calibration VI* is the **mean** value calculated from 1000 samples. The **standard deviation** is also derived from 1000 samples.

Never attempt to start the wind tunnel at full power setting. The inverter and fan motor may not synchronize and the system will then shut down.

Increment the Power Setting LED values at no more than 25% of full power for each step.

Insure the door to the wind tunnel is closed prior to starting the fan to **Minimize Noise Exposure**.

Week II

Airfoil Pressure Distribution and Wake Survey

SUMMARY:

The wind tunnel pressure distribution and wake survey system consists of the computer, control console, power inverter, wind tunnel, pitot tube, wing with pressure ports, wake survey rake, pressure transducer and amplifier assembly and the Lab-view software. A system block diagram is shown below. See figure 1 for block diagram.

PROCEDURE:

1. Turn the power on to the Computer, the Control Console (insure at this point 00 is displayed on the LEDs and press the Power Update button). Turn on the Power Inverter and then the Pressure sensor and Amplifier Box in the order listed. When Windows has finished loading, double click on the icon labeled "Pressure" on the Desktop. Allow the VI to load.

2. The control Console has three rocker switches on the front panel (see figure 2, below). To start the flow in the tunnel, press the switch labeled "Power Setting" in the appropriate direction. When the window displays the desired "Percent Full Power" on the LED display, release the pressure on the switch. Press the silver pushbutton labeled "Power Update" until it clicks. This applies the displayed power setting to the inverter to set the flow to the desired Percent of Full Power setting. The power setting is an arbitrary number which is a repeatable power setting used for reference. The numbers are used only for adjusting the power for tunnel calibration. When taking data, use the value displayed on the VI front panel "Flow Setting."

3. Wait approximately 30 seconds for the flow in the tunnel to stabilize and start the *Pressure VI* by pressing the arrow at the top of the screen (Step 1). When the VI is running, verify the Flow Setting window value is the desired setting. This value may be slightly different from the value entered on the Control Console LED display. The value displayed on the VI is the actual value from the wind tunnel power inverter and should be used for the pressure data.

4.   Adjust the Angle of Attack of the wing by pressing the Increase/Decrease Angle of Attack switch on the front panel of the Control Console until the desired value is displayed on the front panel of the VI in the lower left hand corner (angle in degrees). When the desired flow setting has been attained and the AOA is as desired, press the Scan Ports (Step 2.) button on the front panel of the VI. The AOA, Flow Setting and Pitot pressure data is locked as indicated by the green LED above the data windows. **Do not attempt to change these values while the Scan Ports button is depressed**. When the data is displayed on the bar graphs, press the Log Data (Step 3) button. There are 36 ports and the VI takes 1000 samples of each pressure value. It takes about 30 seconds to obtain a set of data. Enter the appropriate file name when prompted and the data will be saved. The data point is the mean of 1000 samples and has an associated standard deviation value stored directly below the data point.

5. Adjust the Flow Setting and the Angle of Attack as desired and repeat the process for all data to be taken. **Remember that the Scan Ports and Log Data buttons must be released when adjusting the Flow Setting and Angle of Attack.** Verify that the Data Locked LED is extinguished.
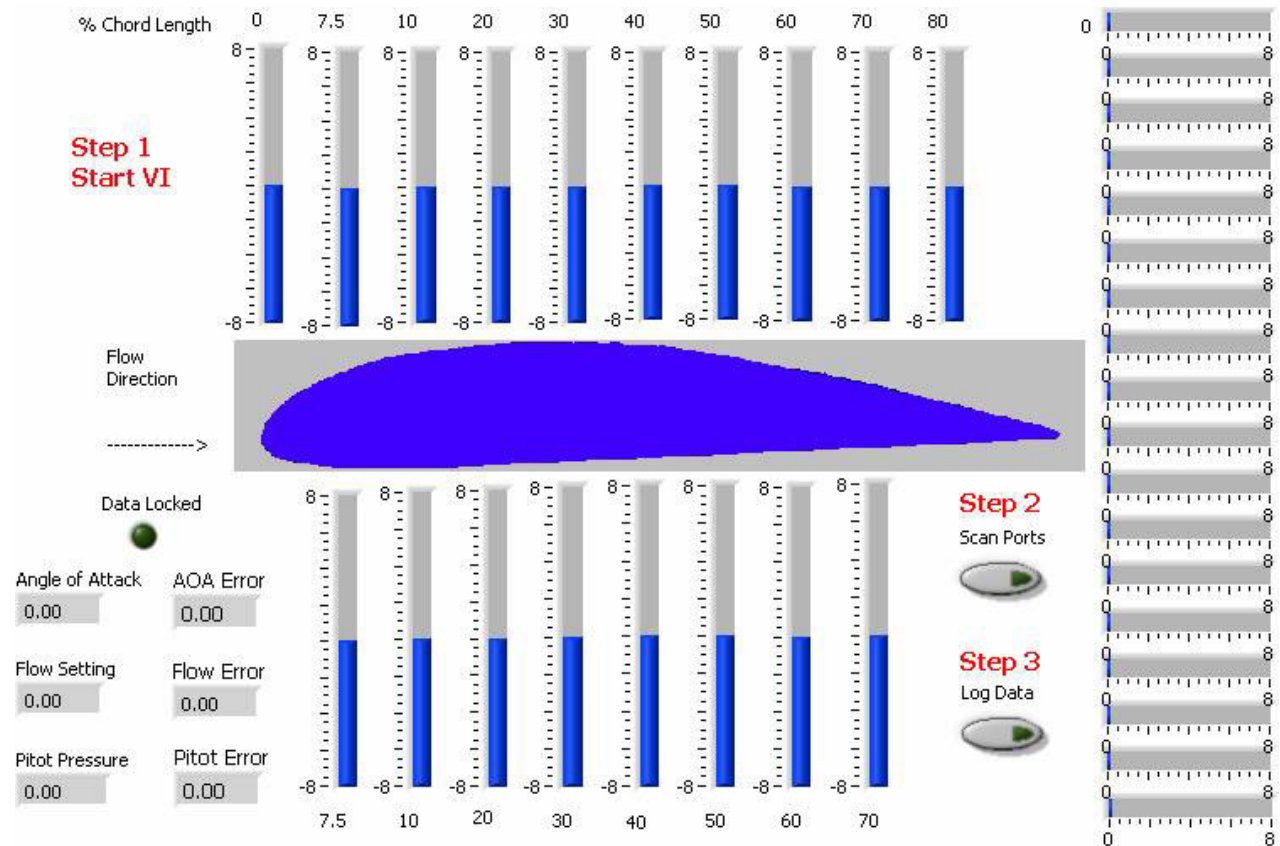

Figure 2: Pressure VI front panel display.

NOTES:

The data is the **mean** value calculated from 1000 samples. The **standard deviation** is also derived from 1000 samples.

Angle of Attack is in degrees. All pressure values are in inches of water. Flow Setting is Percent of Full Power.

Never attempt to start the wind tunnel at full power setting. The inverter and fan motor may not synchronize and the system will then shut down.

Increment the Power Setting LED values at no more than 25% of full power for each step.

Insure the door to the wind tunnel is closed prior to starting the fan to **Minimize Noise Exposure**.

Strain Gauge Sting Balance

SUMMARY:

The wind tunnel Strain Gage Balance system consists of the computer (with A/D, D/A and DIO board installed), control console, power inverter, wind tunnel, pitot tube, pressure transducer and amplifier assembly, Strain gage balance, Angle of Attack Controller, Translation Stage and Lab-view software

The wind tunnel flow speed is controlled by the Control Console. The controller generates a DC signal that is applied to the power inverter. The power inverter converts the low level DC control signal into a power signal that is applied to the fan motor on the wind tunnel which rotates the fan via two v-belts. This in turn creates the flow of air through the tunnel. The Balance VI displays the Pitot pressure (in Inches of Water), The Angle of Attack (in Degrees), the Flow Setting (% Full Power), the Normal Force (in pounds), the Axial Force (in Pounds) and the Pitching Moment (in Inch Pounds). The Angle of Attack of the epoxy wing is adjusted by the Angle of Attack Controller. A stepper motor mounted on the translation stage rotates a gear box that elevates the wing. A potentiometer mounted on the translation stage measures the angle of attack and sends a voltage to the A/D converter of the computer which is then converted to a digital value and displayed on the front panel. The Strain Gage Balance is shown in figure 3.
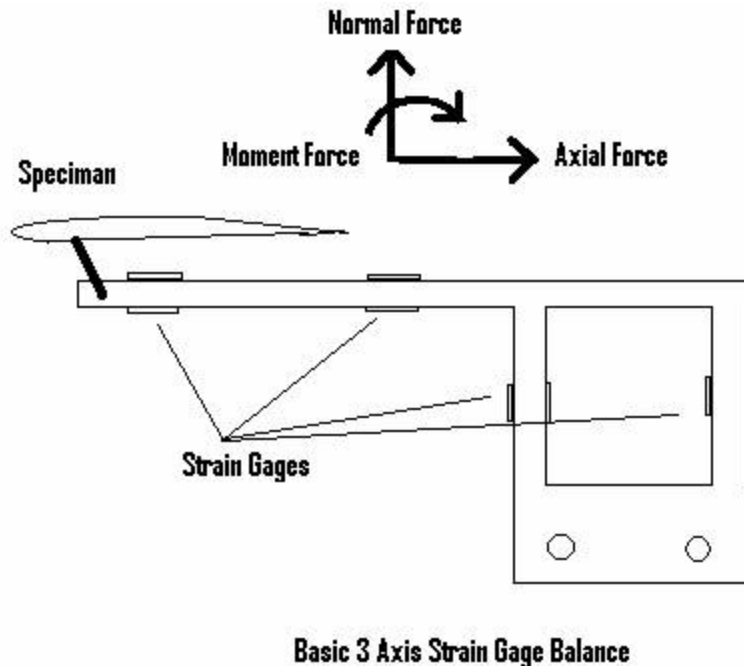

Figure 3: Simplified Schematic of the Strain Gage Sting Balance

The horizontal beam portion has strain gages mounted on it to measure the normal and moment forces. The axial force is measured using two strain gage bridges mounted on two vertical beams of the balance assembly. The low level signals are routed to an amplifier that amplifies the signal voltage by a factor of 2000. These amplified signals are then routed to the A/D converter on the computer and converted into digital values which are then displayed on the front panel of the VI. The result is a mean and standard deviation of 1000 samples. The pitot pressure is sensed at the stagnation port of the pitot tube and is then sent to a transducer that converts the difference of the stagnation pressure and the static pressure into an electrical signal. This signal is then routed to the A/D converter of the computer and displayed on the front panel of the VI. The Flow Setting signal is obtained from the output of the Power Inverter and sent to the computer's A/D and displayed on the front panel of the VI.

PROCEDURE:

1. Turn on the power to the computer, the Power Controller, the Power Inverter, The Pressure Transducer and Amplifier box, the SCXI Controller box, the HP power supply and the Stepper Indexer in that order. When Windows boots, enter the appropriate password and allow the system files to load. Double click on the "Balance" icon and allow the VI to load.

2. The VI has indicators on the front panel for the various data values to be used in the lower left hand side of the VI. Press the arrow at the upper left hand side to start the VI. The data displays will be visibly active. Press the red button labeled "Push to Scan" under the "Main Controls" sub-panel. The data will scroll on the chart recorder display.

3. Adjust the flow setting value on the power controller by depressing the Power Setting Rocker Switch on the Power Controller in the appropriate direction. When the desired Power Setting is displayed by the LEDs, press the silver Power Update button until it clicks to transfer the value to the Power Inverter.

4. To increase the angle of attack, apply upward pressure on the upper switch and observe the value on the front panel of the VI. To decrease, apply downward pressure on the lower switch and observe the change on the VI front panel.

5. The data displays will update automatically and the values displayed on the front panel can be recorded to disk. To record the data, press the red button labeled "Log Data" on the "Main Controls" sub-panel. The VI will prompt for a file name and path. Enter the desired information and the data will be saved. Subsequent data will be appended to the same file. If it is desired to change the file name, stop the VI, then restart it. When the Log Data button is pressed, the VI will prompt for a new file name.

NOTES:

The data is the **mean** value calculated from 1000 samples. The **standard deviation** is also derived from 1000 samples.

Never attempt to start the wind tunnel at full power setting. The inverter and fan motor may not synchronize and the system will then shut down.

Increment the Power Setting LED values at no more than 25% of full power for each step.

Insure the door to the wind tunnel is closed prior to starting the fan to **Minimize Noise Exposure**.