# 14026 WEEK 9 DEMO

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# AGENDA

- Team Status
- Pressure Sensors & Board
- Orifice Plates & Trachea Resistance
- Actuation
- Leak Tests
- Flow Meter Validation
- Lung Compliance
- Maximum Lung Volume
- Demonstrate prototype can be hooked up to read and store values
- Set Expectations

# TEAM STATUS

| | Status | Comments | Lead |
|---|---|---|---|
| **Week 3-5 Planned Tasks** | | | |
| Demonstrate LabView can be used to log in values read by the pressure sensor | | | Mike |
| Test that pressure sensors are | | Done | Leslie |
| Present a soldered PCB board with established connections to pressure sensors | | | Leslie |
| Test A5: Pressure Measurement Capability (test pressure sensors are accurate) | | We have a functional relationship but not a significant amount of points. | Andrew & Soham |

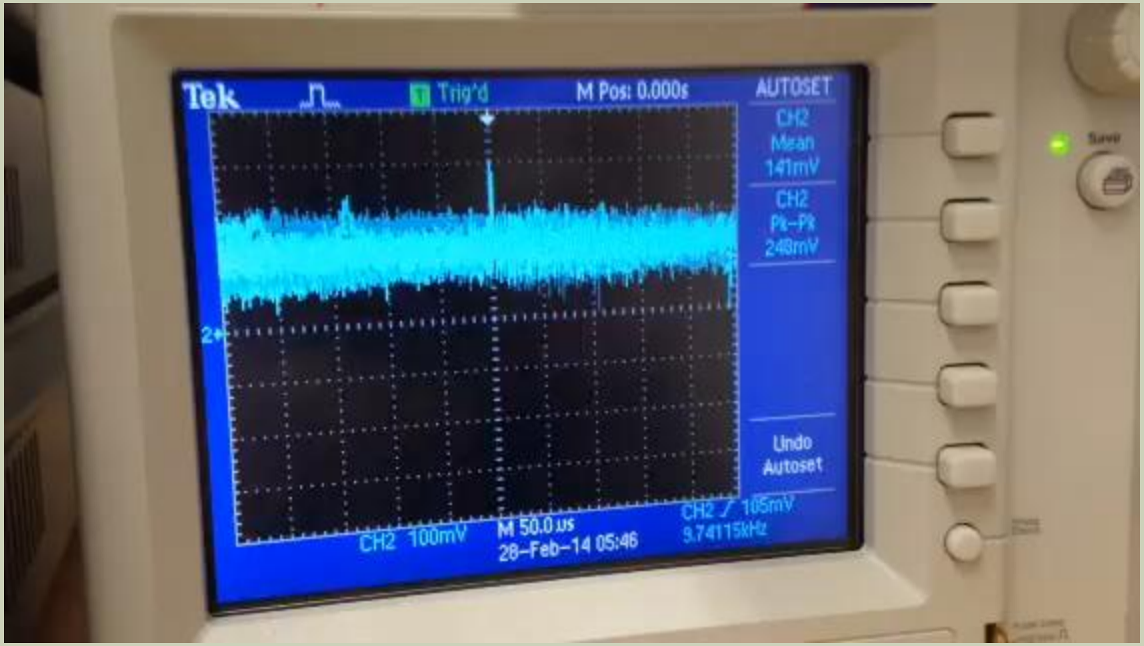
# TEAM STATUS

| Week 6-8 Planned Tasks | | | |
|---|---|---|---|
| Build the remaining orifice plates | | Functional but need slight adjustments. | Andrew |
| Build actuation setup | | Done | Danielle |
| Program actuation | | Done | Mike |
| Install and test DAQ Board | | Done | Soham |
| Finish updates to LabView program | | Need to add the solenoid valve | Mike |
| Demonstrate four modes can be read and stored by the tester | | Need final assembly completed | All |
| Test A1: Leak Test Configuration 1 | | Done | Kristeen & Stephanie & Leslie |
| Test A2: Flow Meter Validation | | Customer during last demo said assuming flow meter was correct is fine. If time later will try to come back and put constant flow through it. | Mike & Danielle |
| Test A3: Lung Compliance | | Done | Leslie & Danielle & Kristeen |
| Test A4: Leak Test Configuration 2 | | Done | Andrew & Soham |
| Test A6: Resistance of Trachea & Lung (airway resistance analysis) | | Done | Andrew |
| Test A7: Leak Test Configuration 3 | | Need final assembly completed | Kristeen & Stephanie |
| Test A8: Maximum Lung Volume | | Done | Danielle & Mike |

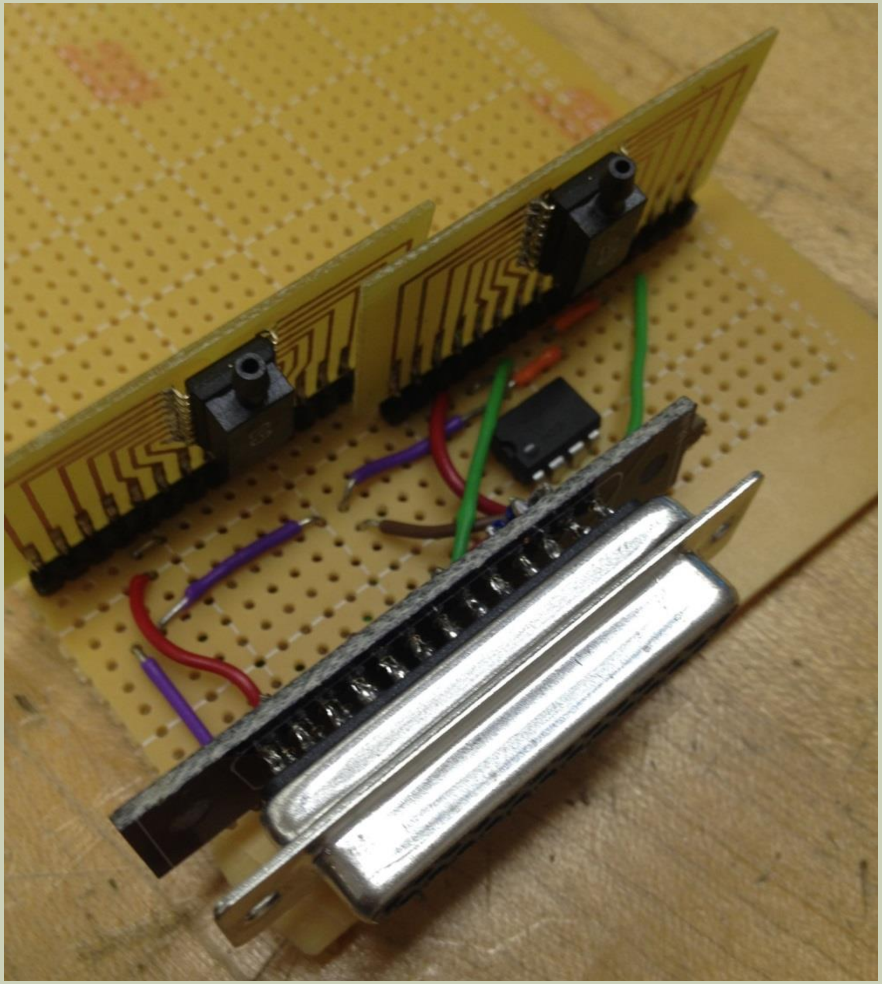
# PRESSURE SENSORS & BOARD

| | Identifying & Selecting Problem PSP 1 | Analyzing Problem PSP 2 | Generating Potential Solutions PSP 3 | Selecting & Planning Solution PSP 4 | Implementing Solution PSP 5 | Evaluating Solution PSP 6 |
|---|---|---|---|---|---|---|
| Rating | R1 | R2 | R3 | Y4 | Y5 | G6 |
| CRITICAL | The pressure sensor is not reading a voltage change on the o-scope. | 1) Pressure sensor is defective. 2)Team does not know what they are doing. | 1) Seek expert advice to confirm that team has it hooked it up right. 2) We could buy additional pressure sensors. 3) Look for different pressure sensors. 4) Switch to a digital manometer. | Seek expert advice to confirm the team has hooked it up right. | Went over testing setup with Dr Slack. Suggested that we get a breakout board to check that pins are not touching. Having Dr Fuller build us a breakout board. Will resume testing to evaluate the solution. | Using the breakout boards we found that the newly purchased pressure sensors did show a voltage change for change in pressure. |
| | Op-Amp started smoking when power was applied. | 1) Traces are incorrect, input voltage pin was grounded. 2) Op-Amp orientation was wrong. 3) Soldering the pressure sensor pins could have caused a short. 4) Op-Amp is defective. | 1) Continuity testing 2) Analyze all chip pin outs and compare with PCB layout. 3) Test op-amp directly by applying power and observing voltage with o-scope. | Analyze all chip pin outs and compare with PCB layout. Then, perform continuity testing. | Looked at the connections online versus the PCB layout. Team found that input voltage was grounded. Team will create a new board layout and build on a breadboard. | The op-amp works on the breadboard. This was tested by hooking it up to the o-scope. |

# PRESSURE SENSORS WORKING

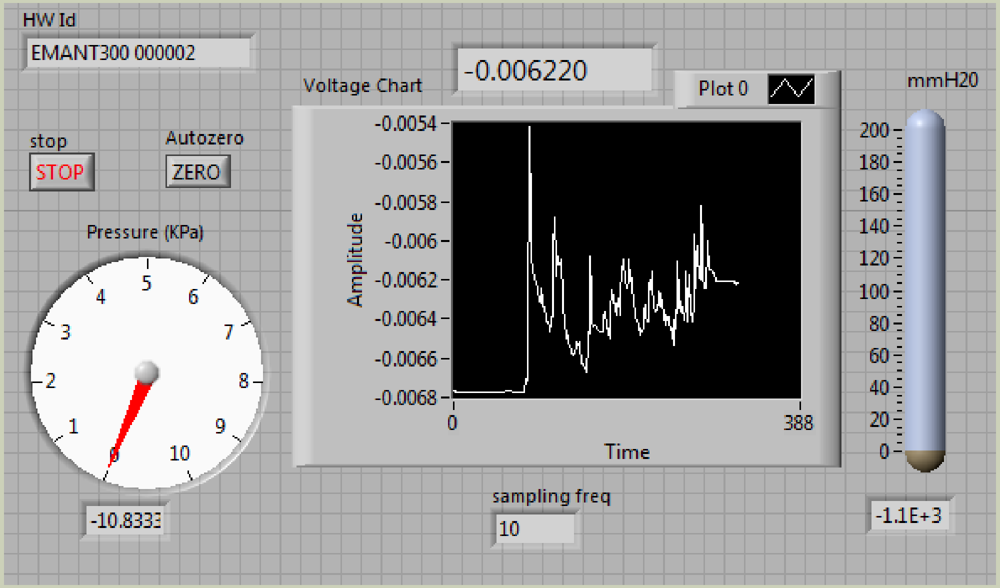



# NEW LAYOUT DESIGN



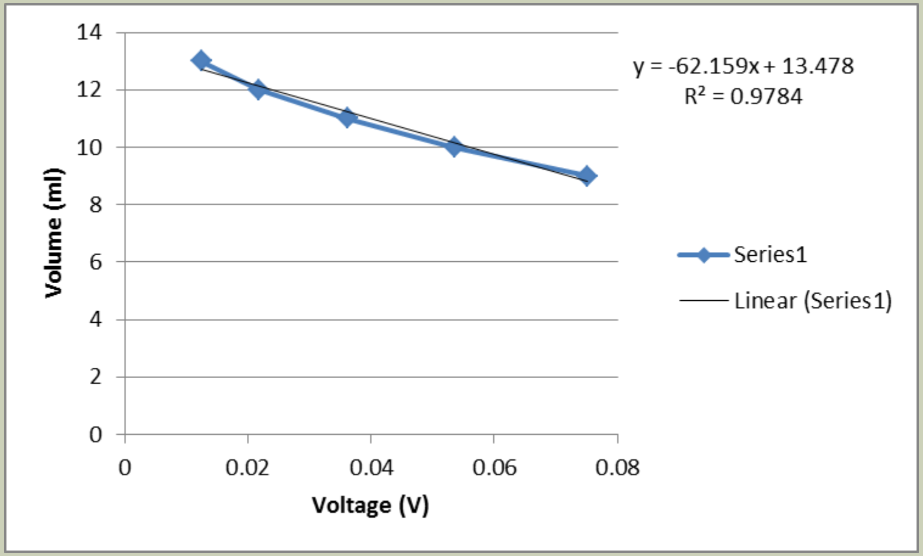
# LABVIEW WITH PRESSURE SENSORS

- Labview measures voltage changes associated with increased pressure.



# TESTING PRESSURE SENSORS

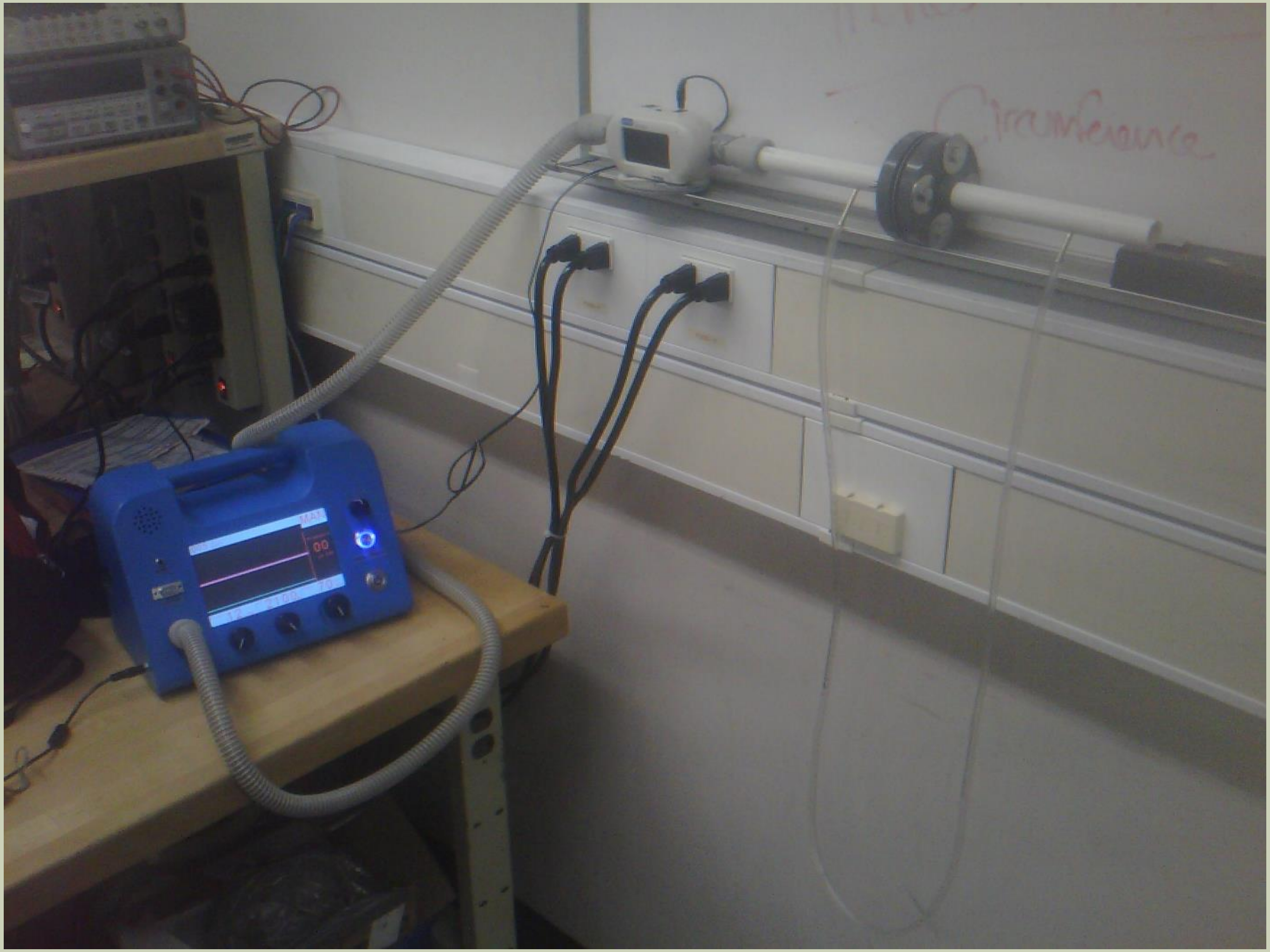
- Accuracy of pressure sensors
- Piezoelectric material used in sensors
- Must be calibrated, 97% linear relationship between volume and voltage



# ORIFICE PLATES

| | Identifying & Selecting Problem PSP 1 | Analyzing Problem PSP 2 | Generating Potential Solutions PSP 3 | Selecting & Planning Solution PSP 4 | Implementing Solution PSP 5 | Evaluating Solution PSP 6 |
|---|---|---|---|---|---|---|
| Rating | R1 | R2 | R3 | Y4 | Y5 | G6 |
| MAJOR | Having trouble getting in the queue to waterjet the orifice plates. | 1) Could not get a hold of Mr Bonzo. | 1) Build the orifice plate in the machine shop. Pros- plate will be built. Cons- it will not be as precise. 2) Continue to try to get a hold of Bonzo. Pros- will hopefully get rifice plate waterjetted. Cons- Need to move forward. | Continue to try to get a hold of Mr Bonzo | Found Mr Bonzo in his office after MSD meeting. | The team has an orifice plate built. |
| ORDINARY | Unexpected results from first round of orifice plate validation testing | 1) Empirical correction coefficients were inaccurately used for this circumstance 2)Plate has incorrect diameter | 1) Measure the orifice plate diameter and confirm or disprove its diameter is within tolerance of nominal 2)Run a second series of tests and determine/ refine correction coefficients to determine adjusted diameter. | Measure the orifice plate diameter. If diameter assumption is incorrect, run calculations to see if results match new theory calcuation. | Measured the diameter of the orifice plate. Found that the diameter was not as assumed after cutting. Re-calculated the theoretical pressure drop across the plate. | Found that with the measured diameter, the theorestical calculations matched the intial testing. |

# AIRWAY RESISTANCE TEST SETUP



# AIRWAY RESISTANCE RESULTS R=5

**Round 1 of Testing**

| | For Nominal critical diameter of 4.955 mm | | | | | | | | For actual critical diameter of 4.674 mm | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured Q (averaged) [Lpm] | Experimental Values ΔP (cmH2O) | | | | | Expected Value | Percent Difference | Measured Q (averaged) [Lpm] | Expected Value (cmH2O) | Measured Value (cmH2O) | Percent Difference |
| | | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Avg | | | | | | |
| Upper Bound Flow Rate | 26.08 | 5.00 | 5.20 | 5.00 | 5.00 | 5.05 | 2.17 | 132.718894 | 26.08 | 2.27 | 5.05 | 122.4669604 |
| Lower Bound Flow Rate | 11.04 | 0.50 | 0.33 | 0.50 | 0.33 | 0.42 | 0.92 | 54.71014493 | 11.04 | 0.67 | 0.42 | 36.84210526 |
| Median Flow Rate* | 18.50 | 2.25 | 2.00 | 2.00 | 2.00 | 2.06 | 1.55 | 33.06451613 | 18.50 | 1.87 | 2.06 | 10.21936865 |

Equivalent Resistance value for median flow rate = 6.75

Design Point

* This was the flow rate used for the design of the orifice plate(s): designed for 21LPM and actual median flow rate is approximately 18.5 LPM

This number is expected to be improved after the second round of testing with the improved test procedure.Then orifice diameter can be altered with a predictable outcome.

**Round 2 of testing**

| | Measured Q [Lpm] | | | Experimental Values ΔP (cmH2O) | | | Expected Values | | | Percent Difference | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 |
| Upper Bound Flow Rate | 25.5 | 25.6 | 26.05 | 4.5 | 4.5 | 4.75 | 3.55223219 | 3.580147464 | 3.707118254 | 26.6809082 | 25.6931 | 28.1319 |
| Lower Bound Flow Rate | 12.28 | 12.26 | 12.38 | 0.25 | 0.25 | 0.50 | 0.823792281 | 0.821111104 | 0.837263722 | 69.652544 | 69.5535 | 40.2817 |
| Median Flow Rate* | 18.6 | 18.65 | 18.6 | 2 | 2 | 2 | 1.889935023 | 1.900109621 | 1.889935023 | 5.823743983 | 5.25709 | 5.82374 |

| Equivalent Resistances | |
|---|---|
| Upper Bound Flow Rate | 10.5882 |
| Lower Bound Flow Rate | 1.22349 |
| Median Flow Rate* | 6.45161 |
| Average Upper / Lower | 5.90586 |

# AIRWAY RESISTANCE RESULTS R=50

| Measured Q [Lpm] | | | Experimental Values ΔP (cmH2O) | | | Expected Values | | | Percent Difference | | | Avg % difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 | |
| 23.2 | 23.33 | 23.3 | 27 | 27.5 | 28 | 14.47236 | 14.635 | 14.59739 | 86.56254 | 87.90566 | 91.81512 | 88.76110377 |
| 10.35 | 10.44 | 10.38 | 2.40 | 2.50 | 2.40 | 2.880342 | 2.930653 | 2.897064 | 16.67656 | 14.69477 | 17.1575 | 16.17627873 |
| 19.8 | 19.82 | 19.77 | 18 | 18.3 | 18.4 | 17.4134 | 17.44859 | 17.36067 | 3.368699 | 4.879526 | 5.98671 | 4.744978455 |

| | Avg R |
|---|---|
| Upper Bound Flow Rate | 70.88499323 |
| Lower Bound Flow Rate | 14.05123065 |
| Median Flow Rate* | 55.26207565 |

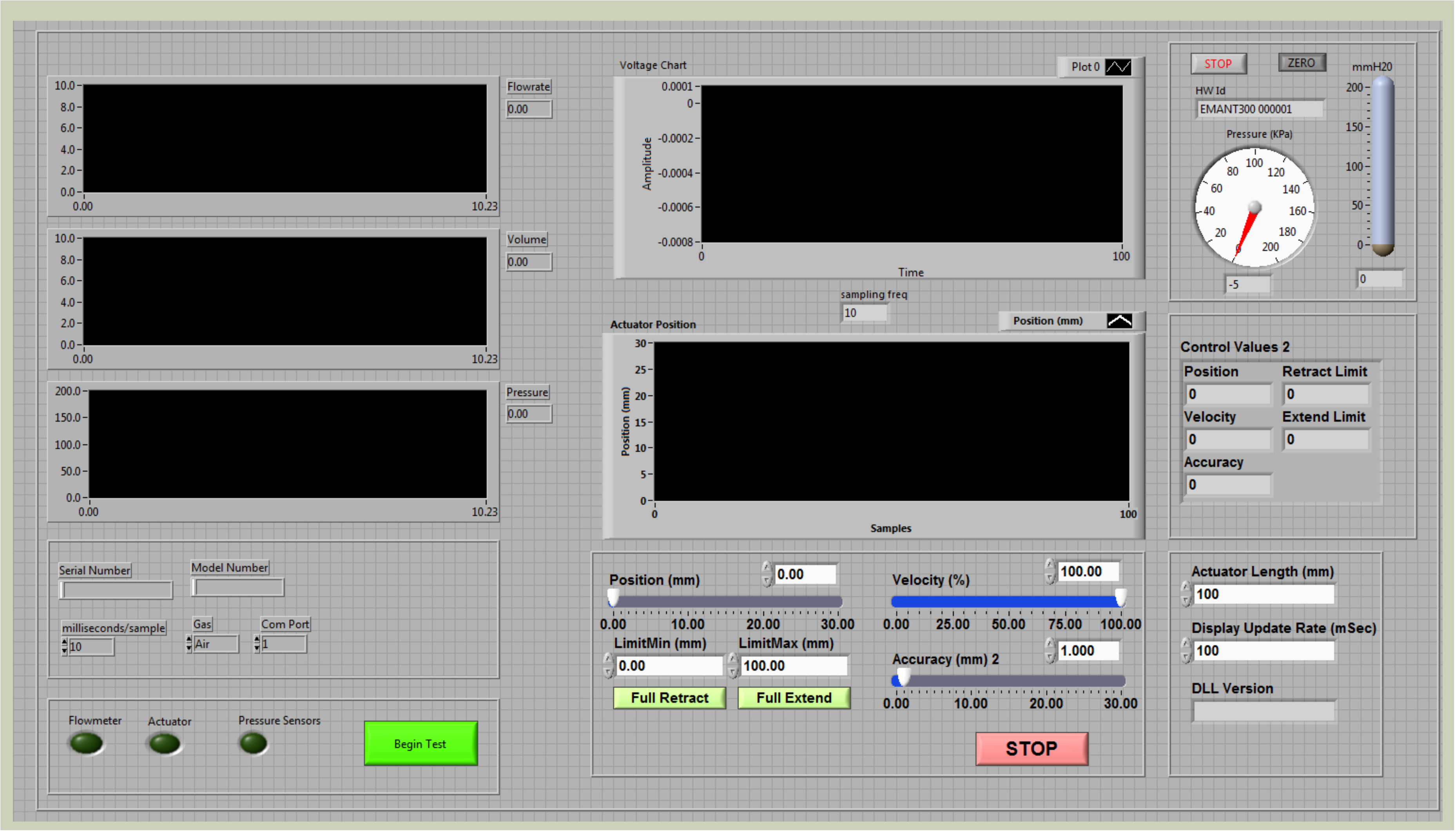
# ACTUATION

# SYRINGE SIZE VALIDATION

- Using a 10 mL syringe
  - A breath was not triggered by pulling on the syringe
- Using a 60 mL syringe
  - A breath was triggered by pulling on the syringe
- Conclusions
  - The team plans to test the range of negative pressure that the PEV can detect. This will then be compared to our own gasps of breath.

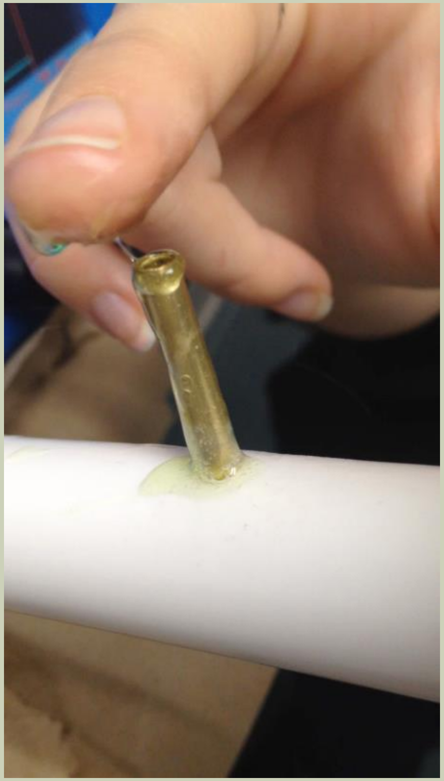
# SYRINGE SIZE VALIDATION

# LABVIEW PROGRAM



# LEAK TESTS WITH DISH SOAP

Testing theory:



Connection Test:

# LEAK TESTS CONFIGURATION 2

Test Theory:

Leak Test:

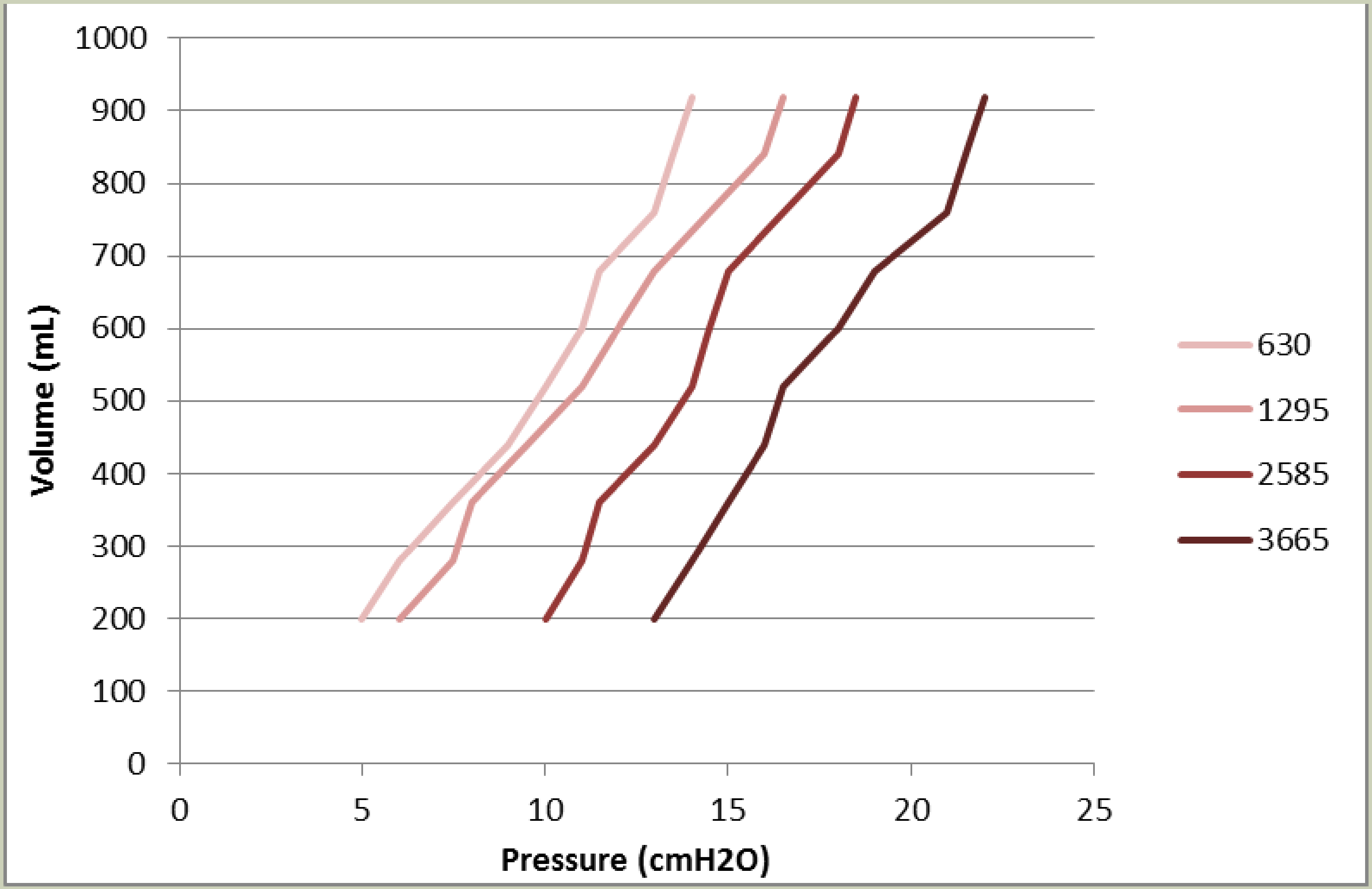
# FLOW METER VALIDATION

- During the last demo, the customer was satisfied with just assuming the flow meter was correct to the manufacturing specs.
- Flow Measurements:
  - Measurement Range: 0 to 300.0 Std L/min
  - Accuracy: 2% of readings 0.05 Std L/min, whichever is greater, at standard conditions (21.1°C and 101.3 kPa)
  - Response Time: less than 4 msec, 63% of final value at full scale flow

# LUNG COMPLIANCE

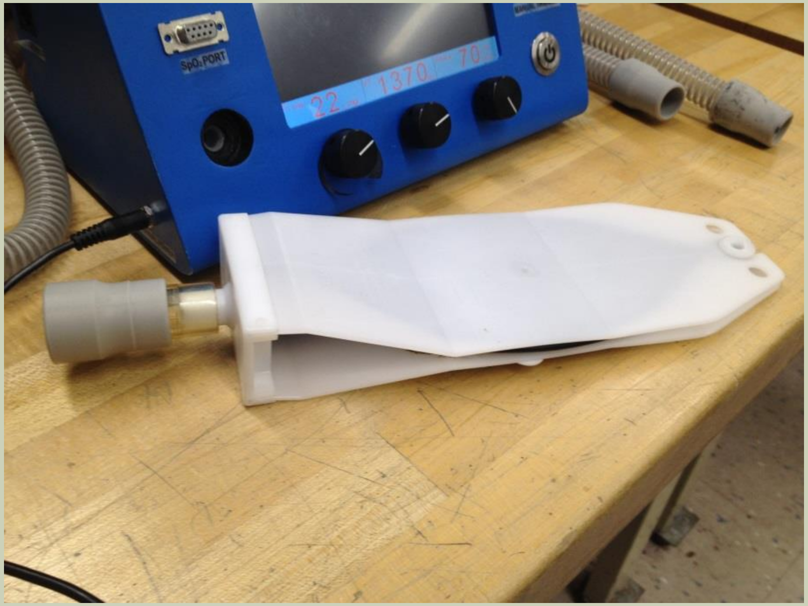
- Box sits on lung as lung inflates
- Weights are measured in grams
- Box weighs 65g

# LUNG COMPLIANCE



# MAXIMUM LUNG VOLUME

- The lung was slightly more than 1 L
- Team will not have to worry about the nominal value as limit to be avoided to protect instrumentation.



# DEMOS OF PROTOTYPE

- Show that it can be hooked up to various PEV's

# TEAM VISION WEEKS 9-11

At the end of MSD II phase 4 the team will have a demonstration of our project's progress. Our expectations for our demonstration are:

- Demonstrate that our prototype can collect and store data for the four modes of the MediResp IV.
- Complete test plans S1-S12
  - Be able to show the customer our test results for tests S1-S12.
  - Be prepared to describe how we tested each requirement.
  - Be prepared to show how we tested each requirement.
- Create a database to display reports of the data collected for each mode.
- Set expectations for the next phase review:
  - Complete all test plans
  - Prepare and run our Imagine RIT exhibit.
  - Complete our project poster and write-up.
  - Submit application for poster contest.
  - Begin project close out.

# TEAM ROLES WEEKS 9-11

| **Week 9-11 Planned Tasks** | |
|---|---|
| Test S1: Breath Rate | **Danielle** |
| Test S2: Inspiration Time | **Stephanie** |
| Test S3: Rise Time | **Kristeen** |
| Test S4: Tidal Volume | **Leslie** |
| Test S5: Inhale:Exhale Ratio | **Soham** |
| Test S6: Pressure Provided | **Mike** |
| Test S7: Weight | **Leslie** |
| Test S8: PEV-Human Connection | **Soham** |
| Test S9: Extrinsic Peak End-Expiratory | **Andrew** |
| Test S10: Mean Airway Pressure | **Danielle** |
| Test S11: Intrinsic Peak End-Expiratory Pressure (AKA Auto-PEEP) | **Danielle** |
| Create database to display reports of the data collected for each mode | **Kristeen** |
| Develop elevator speech for Imagine RIT | **All** |

# QUESTIONS?