Low-cost, Open-source Spirometer

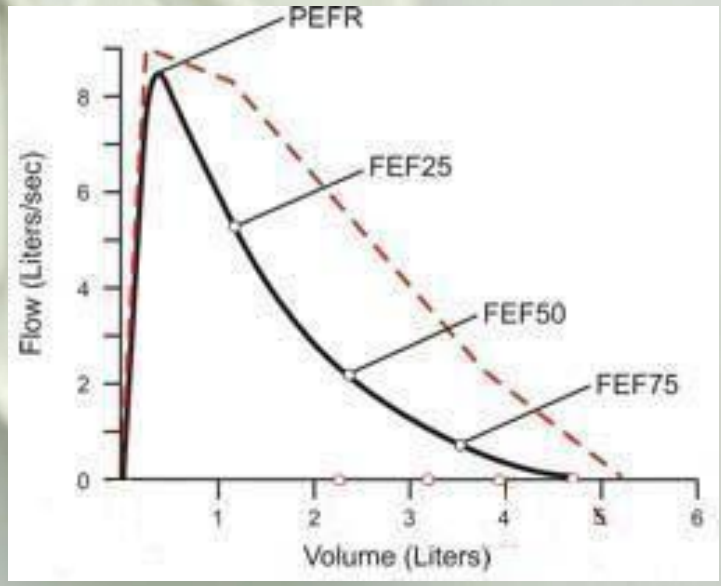
Jeremy Glynn, Andrew Dias, Jeremy Schaefer, Andrew Bremer

Advisor: Prof. Mitch Tyler

Client: David Van Sickle, Ph.D.

Spirometry Background

- Measures pulmonary function
  - Air flow and volume
- Test parameters
  - Peak Expiratory Flow
  - Forced Vital Capacity
  - Forced Expiratory Flow



[1]

Motivation

- Diagnostic tool for respiratory diseases
  - Chronic Obstructive Pulmonary Disease (COPD), including emphysema
  - Asthma
- COPD is 4th leading cause of death worldwide
  - Estimated to be 3rd by 2020[2]
- Over 500 million with these diseases [2,3,4]

Problem Statement

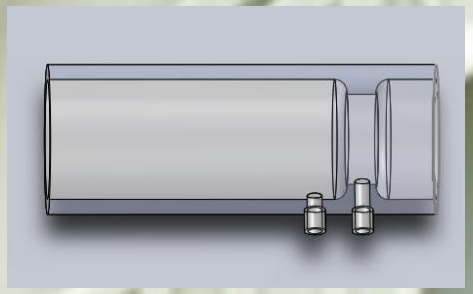
- Develop a low-cost, reliable spirometer
  - Affordable in developing nations
  - Standardized A/V coaching for patient
  - Connect to computer via USB
  - Evaluate quality of maneuver

Design Specifications

- Measure air volumes up to 8 L, flows to 14 L/s
- Durable and portable
- Only factory-set calibration
- Easy to disinfect
- Universal interface
- Cost under $50

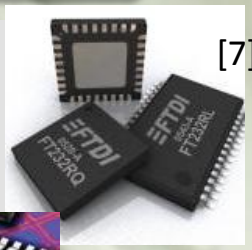
Spring 2009

Air Flow → **Pressure Sensor** → **Circuitry** → **Computer**



[5]

[7]

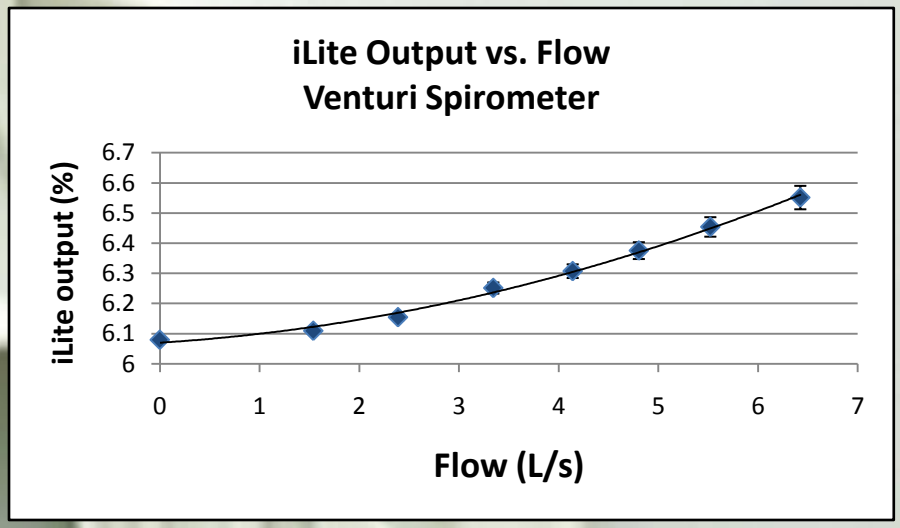


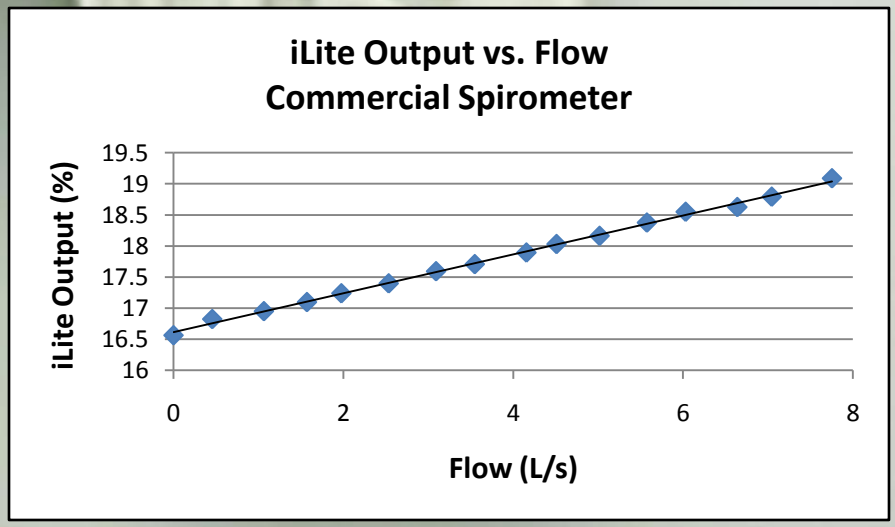
[6]

- Forcefully Exhale
- Analog voltage output
- Amplification
- A/D conversion
- Output via USB
- Calculate test results
- Display spirogram

Focus of Summer Work

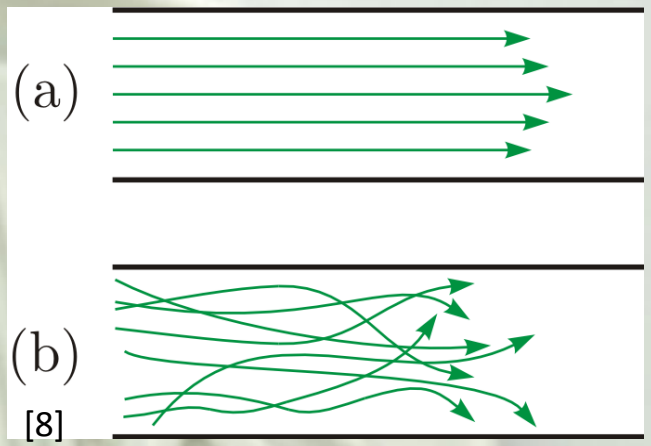
- Improve low-flow sensitivity
  - Linear flow-pressure relationship
- Not possible with Spring design



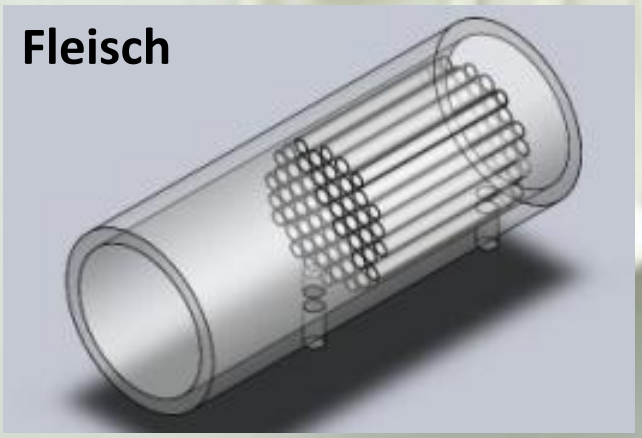


Hardware Development

- In search of laminar air flow
  - Produces linear flow-pressure relationship



[8]



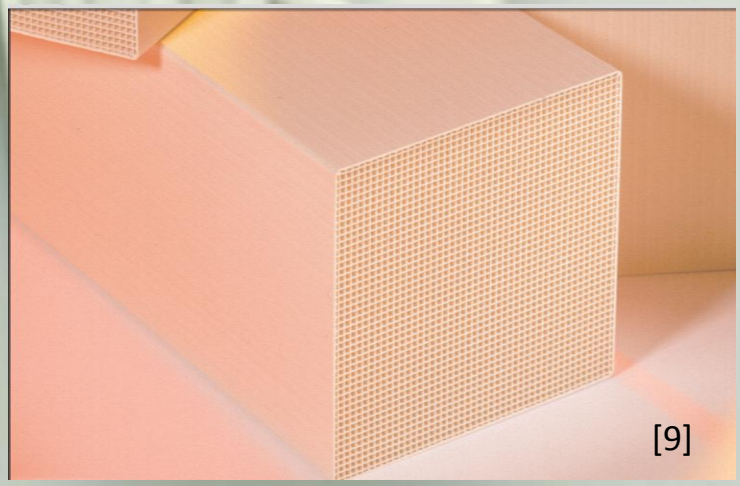
Vs.

Design Matrix: Body Type

	Weight	Fleisch	Lilly	Constriction
Low resistance	25	15	20	23
Material cost	5	4	3	2
Ease of cleaning	20	15	10	18
Ease of manufacture	15	12	7	5
Pressure vs. flow linearity	25	20	20	5
Pressure vs. flow SNR	10	8	2	9
Total	**100**	**74**	**62**	**62**

Hardware Refinements

- Optimize body diameter
  - Linear flow/pressure curve
  - Low flow impedance
- Alternative materials
  - Corning Celcor®
  - Other custom ceramics



Design Matrix: Software Platform

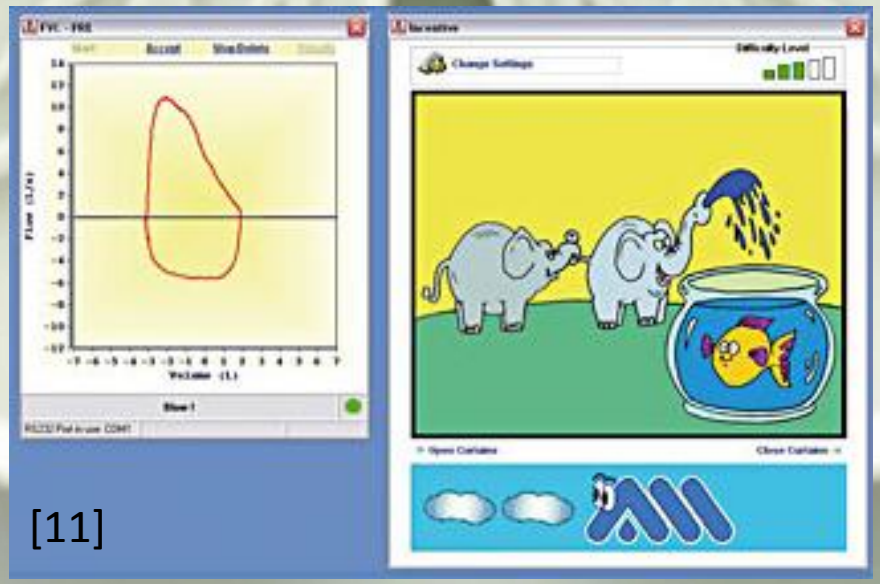
	Weight	Adobe AIR	Microsoft Silverlight	Java
Supports USB	25	17	6	23
Supports different operating systems	20	17	10	15
Graphics capabilities and ease of implementation	15	13	13	5
Data processing speed	15	9	9	13
Smoothness in interface	10	9	9	3
RAM usage	15	5	5	8
Total	**100**	**70**	**52**	**67**

Graphical User Interface

- Using Adobe AIR because of graphics
- Links to video tutorials
- Real-time
  - Flow/volume and volume/time graphs
  - Animation incentive to encourage user
  - Major focus for this semester

Coaching

- Audio will accompany incentive screen
- User must exhale for full 6 seconds
- Must be standard – same for all patients

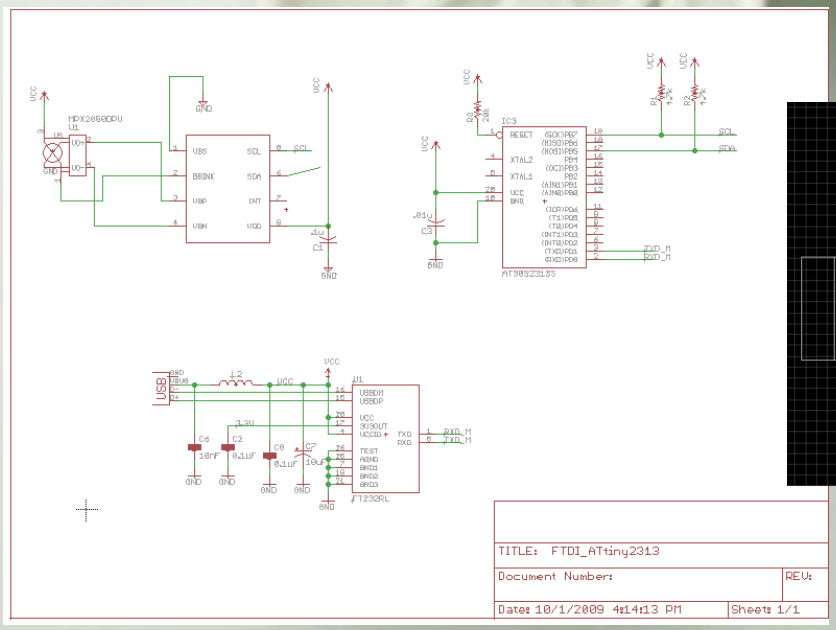


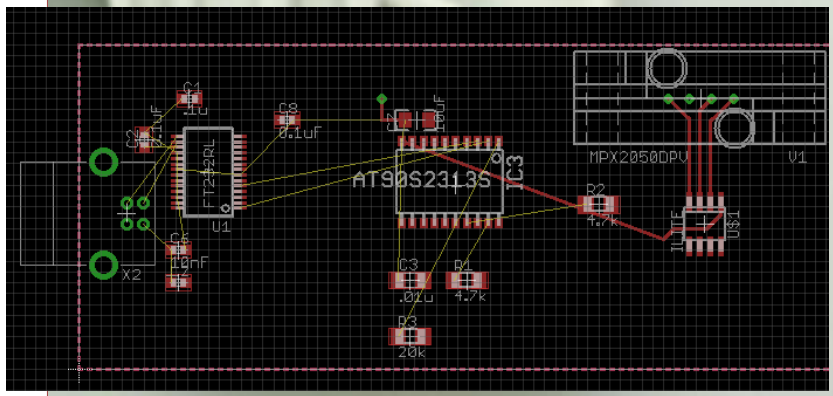
[11]

http://www.spirometry.com/ENG/Products/PopUp.asp?nome=WP_screen_incentive.jpg&Txt=WinspiroPRO%20Paediatric%20Incentive%20screenshot

Fall Goals

- GUI work
- PCB Layout and microcontroller programming
- Documentation – IRB and WARF for testing





Questions?

References

1. Morgan Scientific. What is a Pulmonary Function Test. <http://www.morgansci.com/customer-resource-center/pulmonary-info-for-doctors/what-is-a-pft-test-2.php>.
2. AARC (American Association for Respiratory Care). <http://www.aarc.org/headlines/08/11/copd_month/>.
3. World Health Organization. Chronic respiratory diseases. <http://www.who.int/respiratory/en/>.
4. American Academy of Allergy Asthma and immunology. Asthma statistics. <http://aaaai.org/media/statistics/asthma-statistics.asp>.
5. ZMDI . ZMD31014 Sensor Signal Conditioner. <http://www.zmd.biz/signal_conditioner.php?content=sensor&product=zmd31014&prod_cont=brief>.
6. Embedded Systems News. Microchip PIC18F1XK50. <http://embeddedsystemnews.com/microchip-announces-pic18f13k50-and-pic18f14k50-lowest-cost-usb-microcontrollers.html>.
7. FTDI Chip. FT232R. <http://www.ftdichip.com/Products/FT232R.htm>.
8. Wikipedia Commons. Laminar Flow. <http://commons.wikimedia.org/wiki/File:Toky.png>.
9. Corning Environmental Technologies. Standalone Substrates. <http://www.corning.com/environmentaltechnologies/products_services/corning_celcor_substrates_stationary_applications.aspx>.
10. http://blog.lib.umn.edu/gray0239/architecture/
11. <http://www.spirometry.com/ENG/Products/PopUp.asp?nome=WP_screen_incentive.jpg&Txt=WinspiroPRO%20Paediatric%20Incentive%20screenshot>.