Team Second Wind: Incentive Spirometer 2.0
DR 2.2 Presentation

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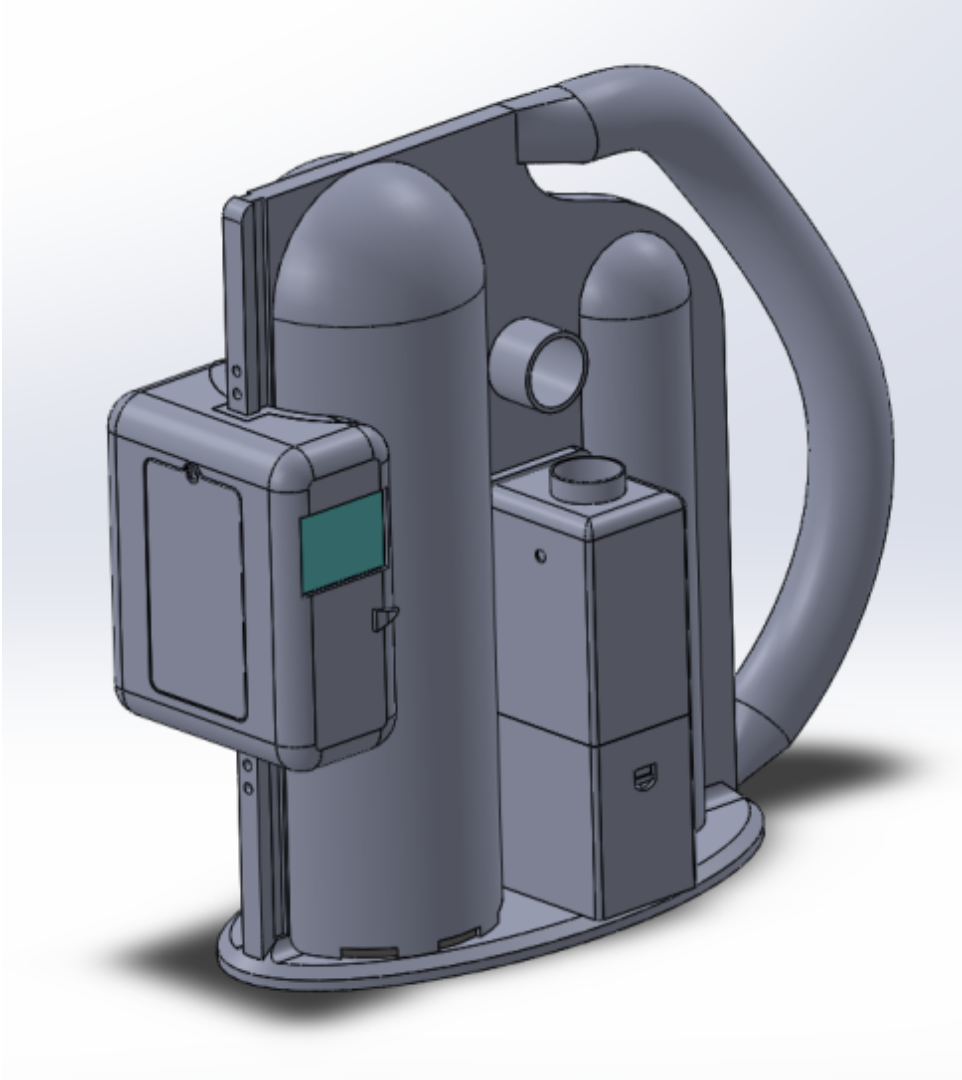
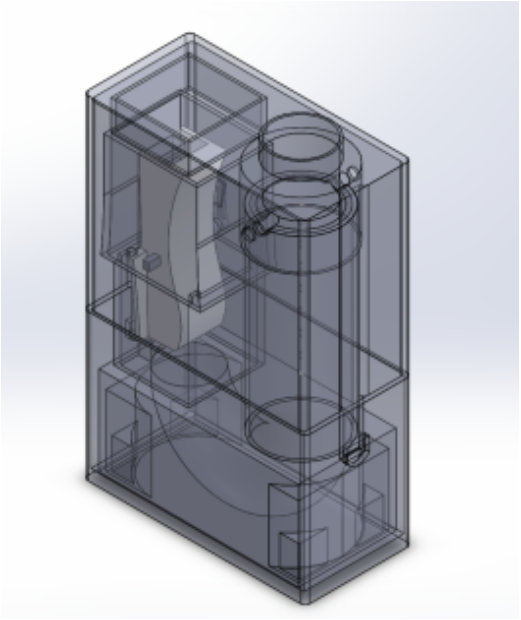
Original Project Plan

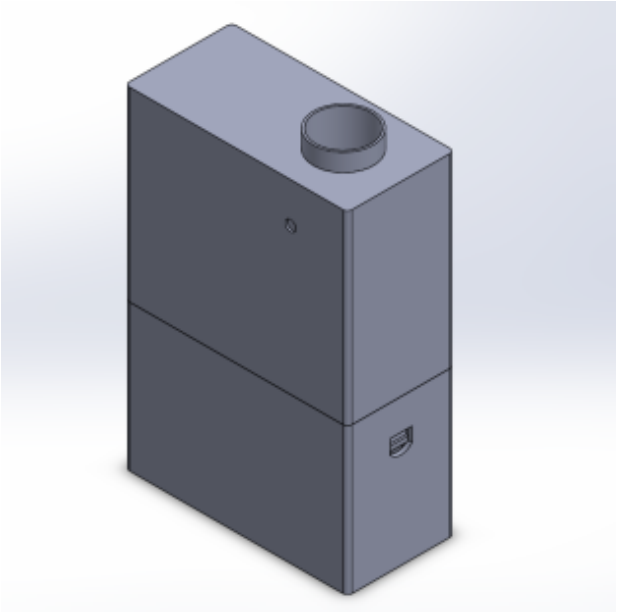
- Updated aesthetic and ergonomic redesign of Spirometer without changing function
- Design fully functional OPEP device with similar pressure resistances to industry standards
- Electrical System capable of recording when piston passes prescribed volume
- Adjustable Electrical Housing capable of being moved to prescribed volume.

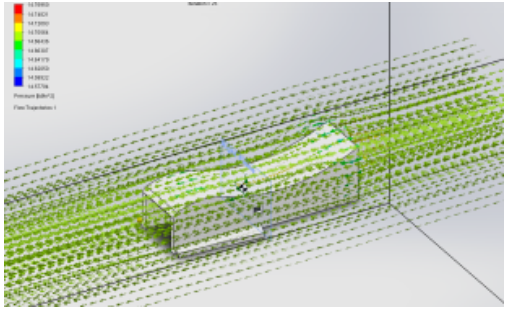
Updated aesthetic and ergonomic redesign of Spirometer

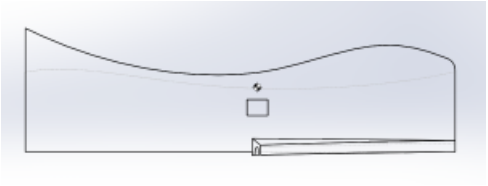
- Electrical Housing updated and integrated
- OPEP integrated and resized to fit spirometer body
- Spirometer updated to accurately match reference model











OPEP

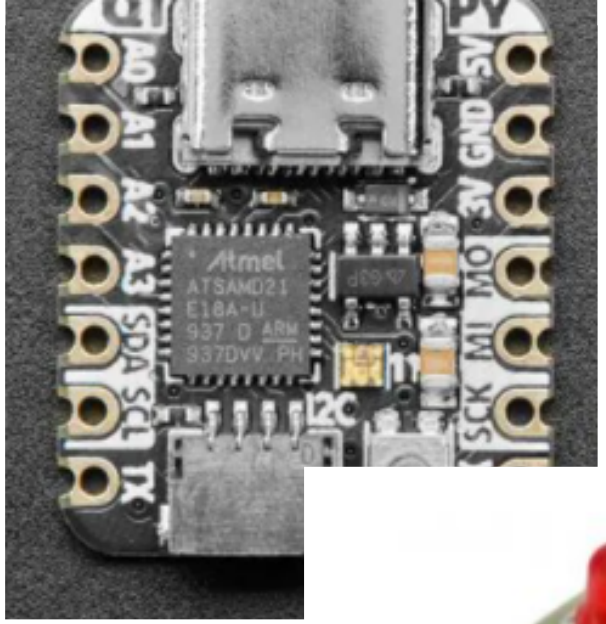
- Revised internals to fit our oscillating mechanism
- Design compact housing to fit within spirometer

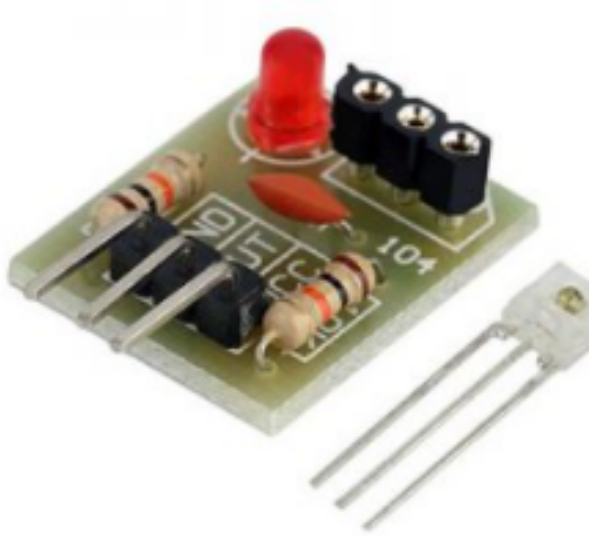
Electrical System Recording and Displaying Successful Inhalations

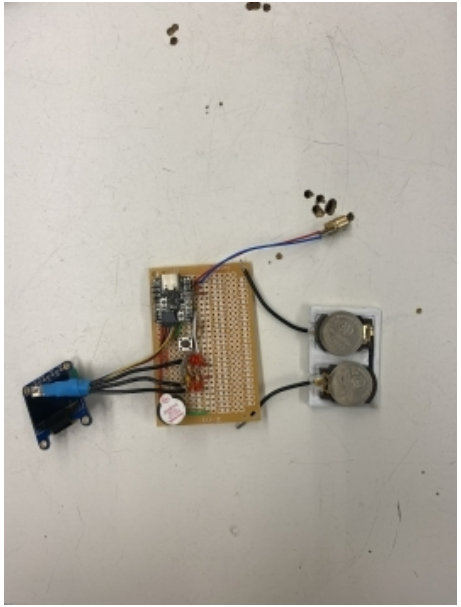
- Laser sensor system consisting of laser emitter and receiver are soldered on board and are capable of recording inhalations
- When a successful inhalation is achieved, the buzzer is currently able to alert the user of that success; currently working on inhalation alert system every 5-10 minutes
- The new OLED display can connect to electrical system, but the code to utilize it is still being implemented
- Batteries selected and wiring to microcontroller will be implemented next quarter

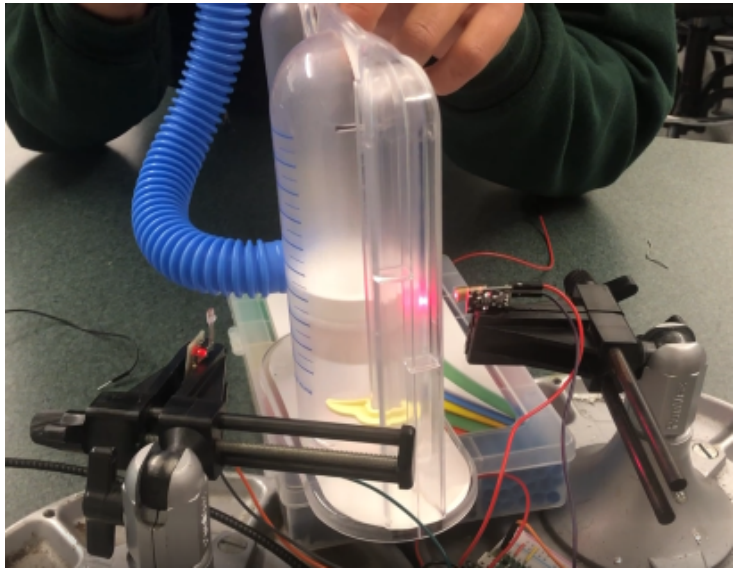
Sensor

And Microcontroller

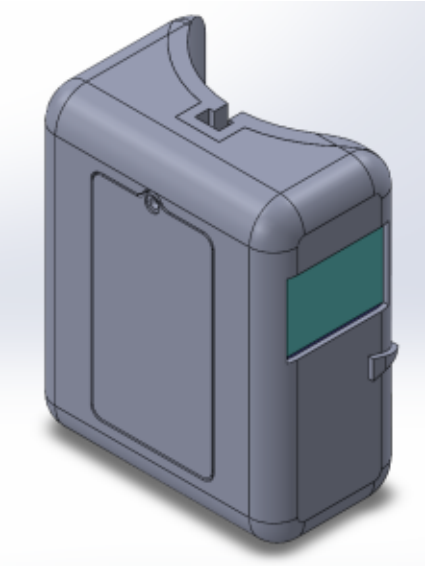


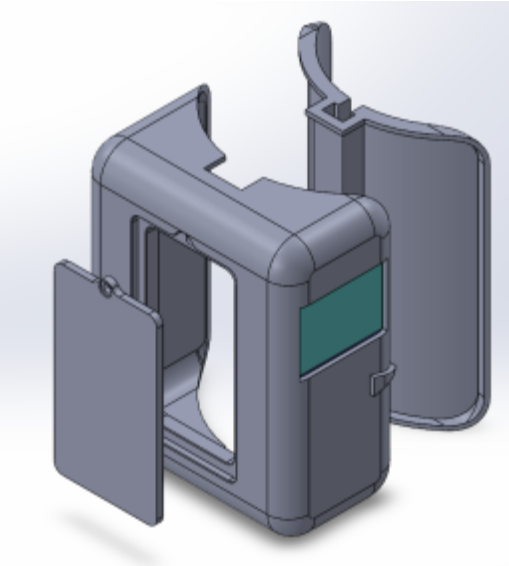






Electrical System Prototype





Adjustable Electrical Housing Unit

- Capable of housing 2x CR2023 coin batteries
- Contains: screen, circuit board, microcontroller, batteries, laser diode, laser sensor
- Designed with low profile to prevent tipping

Functional Specifications - Effectiveness

Incentive Spirometer 2.0 needs to be designed such that exhalations therapies performed by patient per doctor's prescription are digitally recorded and displayed for the doctor and patient. Our device will also be designed to be able to accommodate exhalation therapy if necessary.

ID	Specification	Status	DR 2.2 Justification	Plans to meet full specs
E001	Should record inhalation in less than 0.5 s and shall record in less than 1 s	Device records inhalation in less than 1 second	Successful LCD output and buzzer goes off in less than 1 second, when inhalation level is reached.	Specification E001 is met.
E002	The sensor will accurately count the number of repetitions with 100% accuracy.	The sensor has a 98% confidence level.	Conducted 100 tests, and only 2 failed.	Specification E001 is met. We surpassed our 95% confidence level.

Functional Specifications - Design

Incentive Spirometer 2.0 will be designed to accommodate an OPEP device, as well as remind the patient of when to use the device

ID	Specification	Status	DR 2.2 Justification	Plans to meet full specs
D001	Amplitude of OPEP resistance should be within 5% of max resistance of Aerobika and shall be within 10%	We still plan on meeting this specification, but our design is still in the development process	We have designed and printed a prototype, but we haven't been able to test it due to printing limitations.	Print and test a further developed design. And make slight adjustments using information gained form said tests to redesign.
D002	OPEP should have 5 levels of resistance and shall have 3 level	We have designed a way to adjust resistance but not yet tested	We have designed a Pressure Resitance component to control the amount of air flow entering the second chamber	3D print our design for testing. Make adjustments to increase the functionality
D003	Spirometer can function w/o electrical component	We have kept the functional design of our spirometer 1 to 1 with competing designs.	Once we will be able to have a smoother print, capable of being tested.	Analyze the air channels in current spirometers and match function.
D004	Audible reminder for patients every 6 min.	Designed to meet this, but in spring quarter	Since we are using the same buzzer as the inhalation alert, analysis shows this will work once we integrate the reminder into our software.	Send a signal from a GPIO pin to the buzzer every 6 minutes.

Functional Specifications - Efficiency

The incentive spirometer will read user inhalation volumes and display successful maximum inhalations to the user via OLED display. The device will be functional over 60 hours.

ID	Specification	Status	DR 2.2Justification	Plans to meet full specs
EF 001	Battery should last 30 hours and shall last 25 hours	The battery life shall last 25 hours	The battery life should last 30 hours	We will conduct 2 trials, as well as verifying through calculations

Functional Specifications - Data Retention

The incentive spirometer will only retain data for a single patient at a time and delete it after the patient has completed their breathing exercises. Information will be displayed on a screen for the patient and attending physician to verify the patient's performance.

ID	Specification	Status	DR 2.2Justification	Plans to meet full specs
DR 001	Display the number of successful inhalation repetitions over the period of 1 hour will be recorded	LCD displays the number of all successful inhalations.	LCD accurately and consistently display the number of successful inhalations.	Specification DR001 is met.
DR002	Display different messages input from the microcontroller	The LCD displays different messages depending on its state.	This specification is not fully met because we will transition to a smaller display unit.	We need to integrate a smaller LCD and conduct more testing.

Functional Specifications - Physical Characteristics

This device is likely to be handle by a large variety of people and therefore needs to be simple to use and aesthetically pleasing. The design of the spirometer also needs to be as compact as possible as it will be in a hospital setting where space is a limited resource.

ID	Specification	Status	DR 2.2Justification	Plans to meet full specs
PC001	Height: 10-11 in Width: 6-7 in Depth: 3-4 in	The Dimensions are: H: 7.25 in W: 6 in D: 3 in	We have kept similar dimensions to previous spirometers and want to keep as compact as possible	Our customer Kerry Curran requested that the new spirometer design remain similar in size to the original design.
PC002	Preserve battery life while not in use with ON/OFF switch	We have power calculations to determine battery life.	We have not met this specification thus far because it will interfere with code testing frequency.	During spring quarter, we will add a “sleep” feature in our code until the reminder goes off again for the next inhalation therapy.

Functional Specifications - Cost

Given that our product incorporates multiple devices the cost will be greater than other spirometers on the market. We aim to be competitive by increasing the functionality and lifetime of each subsystem on our device.

ID	Specification	Status	DR 2.2Justification	Plans to meet full specs
C001	Cost of the electrical components should not exceed $40 and shall not exceed $75	Our current estimate using the bill of materials for the electrical components show that we are under $75	The electrical housing is not fully complete and cannot give a definite estimate, but we are confident we can meet this specification	Continue working on the laser circuit and finalize a layout. Use this layout to give an estimate on the cost.

Functional Specifications - Safety

Since the device will be used for rehabilitation, it is essential for the electrical parts to stay hidden to account for overall safety. The device must not harm the user at all, be that from electrical shock or from other events.

ID	Specification	Status	DR 2.2Justification	Plans to meet full specs
S001	No exposed wires	Wires are not concealed thus far.	Conducting tests that require access to wires.	Once all testing is completed, electronic housing will get built in a manner such that there will be no exposed wires.
S002	No user access to electrical components	Electrical components not fully integrated into a housing.	Conducting tests that require access to individual electronic components.	The user will not be able to access the internals of the electrical housing. Housing will be secured with hardware that require tools to take apart.

Summary of Analyses

Updated analyses in red, unchanged analyses in green

Mechanical Analyses:

- Spirometer Dimensioning and Modeling
- OPEP Pressure Data
  - Collected max and min pressure data on Aerobika
  - Min pressure of 1.59 kpa and Max pressure of 2.04 kpa
- Flow Analysis of Oscillating Mechanism

Electrical and Software Analyses:

- Sensor Selection
  - Laser emitter and receiver
- Power Consumption
  - Expectation: 5 hrs/day for 5 days
  - Max Load: 2.046 Wh; Min Load: 0.6138 Wh
- Battery Size
  - 2 CR2032 watch batteries: 6 V; 235 mAh; 1.41 Wh
- Wiring and Component Layout
  - Stemma QT; 20 pr 22 gauge wire
- APDS 9960 Module
- Sensor Distance and Orientation
- GPIO Pins
- Software IDE
- Microcontroller Selection
  - QT Py RP2040
- Data Retention

Schedule – Mechanical

Over break:

- Nate: Begin website design.
- Omar: Continues to run flow simulations on OPEP internals
- Jason: Collaborate with Makana on PCB design and fit within electrical housing.

Week 1:

- OPEP Team: T valve integration with OPEP and spirometer
- OPEP Team: Axis of rotation and center of mass adjustments given values from the flow simulations
- Electrical Housing: Add stand-offs and screw holes for manufacturing and assembly

Week 2:

- OPEP Team: Refine adjustability of Resistance Pressure component
- Electrical Housing: Design positioning mechanism and choose security screws for assembly

Week 3:

- Team OPEP: Complete function OPEP assembly
- Electrical Housing: Print components and practice assembly. Take note of issues and assembly steps.

Week 4:

- Team OPEP: Adjust OPEP in all areas to match performance of Aerobika
- Electrical Housing: Test fit the PCB and electrical components within the electrical housing

Schedule – Mechanical

Week 5:

- OPEP Team: T valve integration with OPEP and spirometer
- OPEP Team: Axis of rotation and center of mass adjustments given values from the flow simulations
- Electrical Housing: Test assembly of the electrical housing and make note of changes needed.

Week 6:

- OPEP Team: Refine adjustability of Resistance Pressure component
- Electrical Housing: Make changes based off assembly notes and any issues that have risen from test fitting last week

Week 7:

- Team OPEP: Complete function OPEP assembly
- Electrical Housing: Make final necessary changes to facilitate excellent performance

Week 8:

- Electrical Housing: Print and assemble final version

Schedule - Electrical

Over break:

- Design PCB for electrical circuit in order to improve the size of our system
- Research methods of implementing OLED display and battery with microcontroller

Week 1:

- Order PCB after confirmation from Dr. Liu
- Complete interface of microcontroller and the battery through code and schematic manipulation

Week 2:

- Implement code for inhalation reminder every 5 to 10 minutes
- Completely integrate OLED display in electrical circuit; configure code to implement OLED display

Schedule - Electrical

Week 3:

- Order any additional components needed for PCB coming in the next week
- Record current load of electrical system while in different modes such as popcorn and sleep mode

Week 4:

- Receive, populate, and test new PCB
- Interface new PCB circuit with switch and battery
- Record load and current draw of circuit to finalize power consumption and battery life calculations
- Start user interface code for electrical system; including recording and displaying inhalation attempts, reminding user of inhalation, reset button, on and off switch

Week 5:

- Finalize user interface code for electrical system
- Complete full battery test of the electrical system; two trials

Schedule - Electrical

Week 6:

- Configure electrical system with housing in unison with Jason for internal wiring assembly
- Completely test system again with spirometer; troubleshoot any problems

Week 7:

- Finalize integration of electrical system in housing unit
- Test electrical system in housing with the spirometer
- Final electrical housing inspection; looking for exposed wires or access to electrical components

Week 8:

- Complete final presentations and documents
- Complete team website

Questions?