

## Incentive Spirometer 2.0: Modernize the Incentive Spirometer and add an OPEP function

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# Restoring Lung Capacity

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## Objective:

- To create a more incentivized and engaging device that allows doctors to track a patient's progress while also providing a secondary function that eliminates the need for a second device.
- Provide Lung Technologies in collaboration with Northwest Orthopedics in Spokane with a new, improved incentive spirometers.

## Concept:

Find optimized arrangement of components and features so that the product can be more beneficial and reliable, while also being cost competitive.

## Approach:

- Redesign aesthetic features to improve the look
- Study existing OPEP technology and integrate into system
- Create a system of self-regulating valves that open/close based on the direction of air flow.

## RRP and Analyses

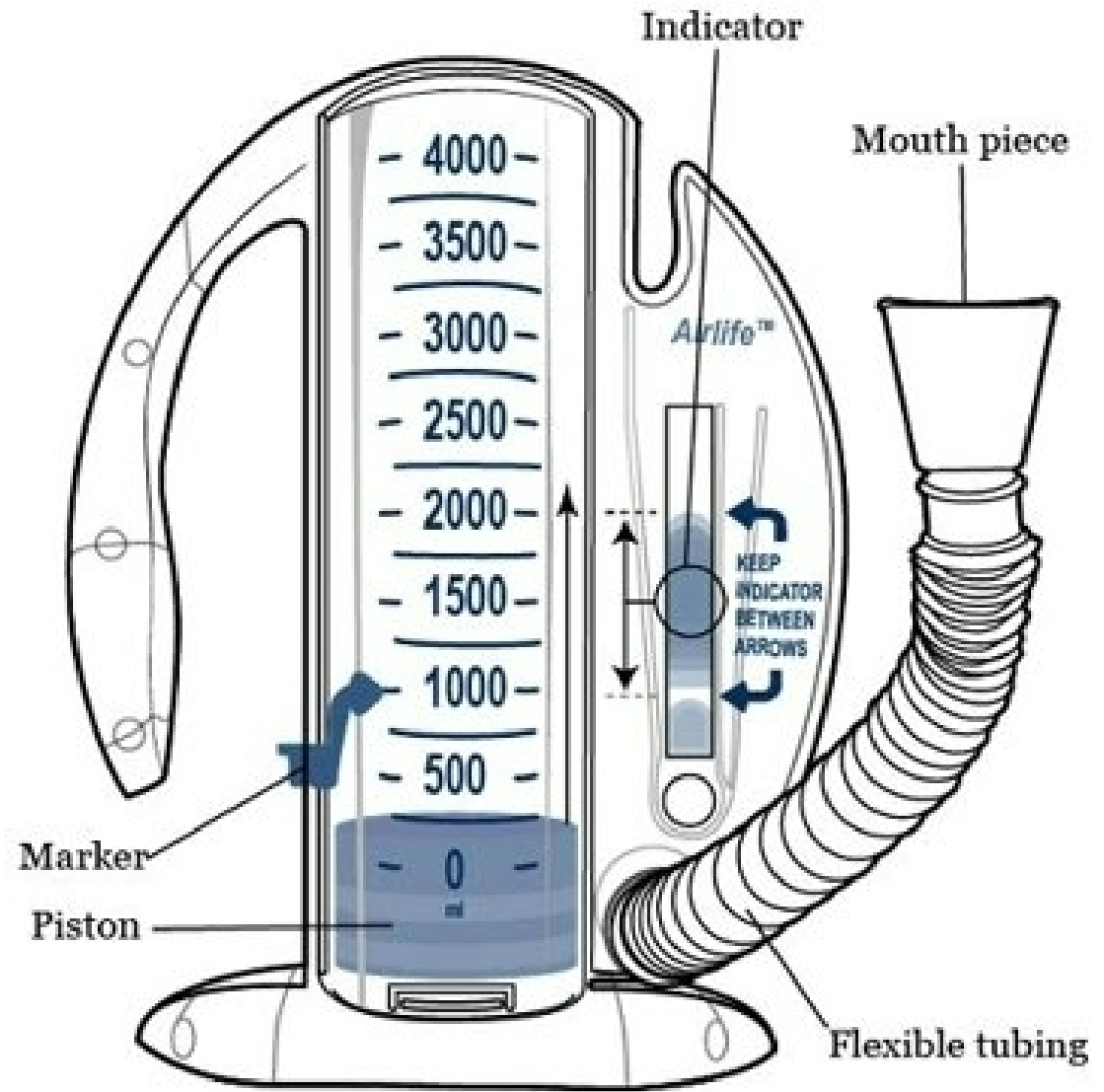
### RRP

- Use existing incentive spirometers as a basis for your product
- Build and test electrical components that are detachable and reusable.

### Analyses:

- Perform SOLIDWORKS simulations for air flow. This will apply to the incentive spirometer and the OPEP components of the device.

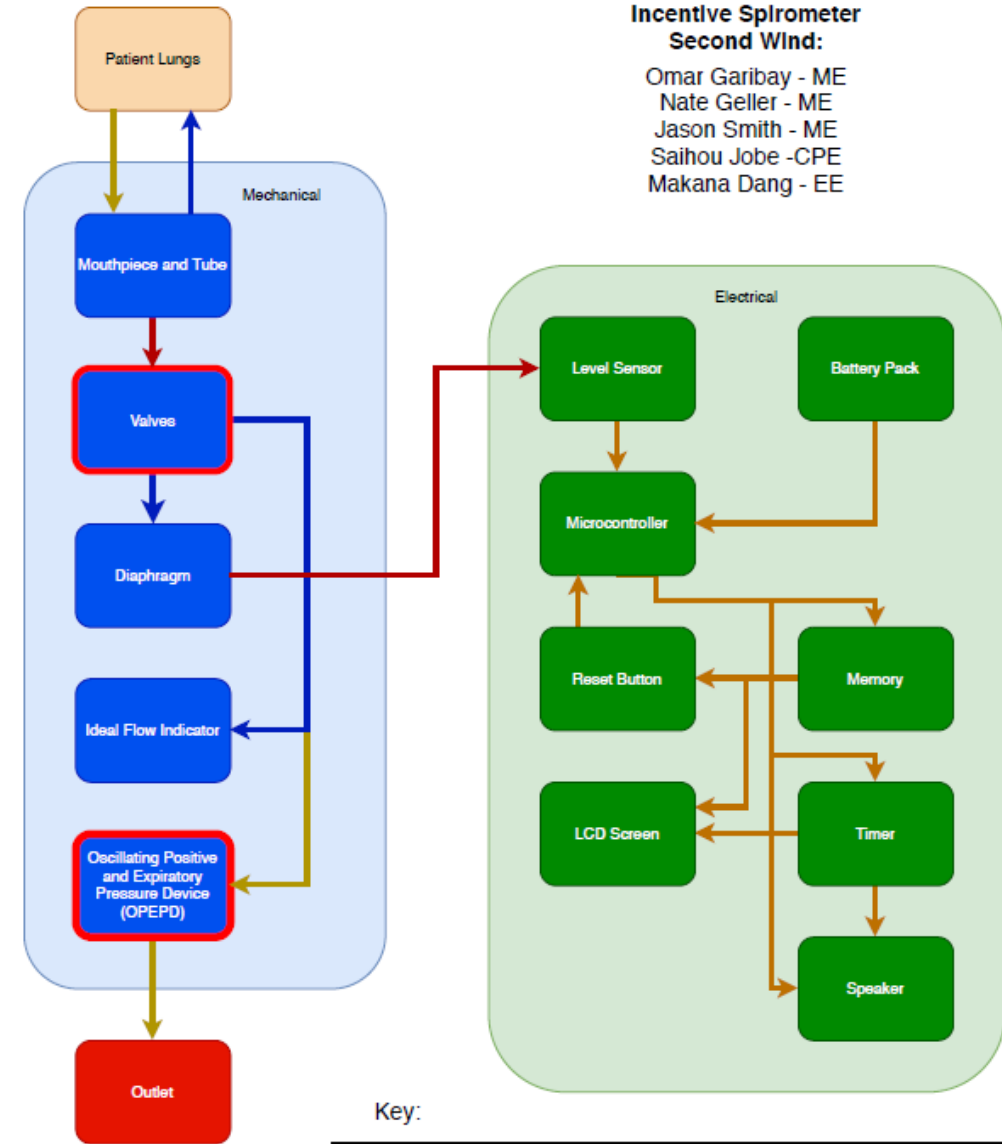
# Spirometer Design



- We need to reduce the cost on the healthcare system that results from post-surgical complications.
- Pulmonologist require reliable patient data obtained from the spirometer for high quality patient care.
- Integrated exhalation device to the spirometer reduces required real estate for medical devices in patient rooms.

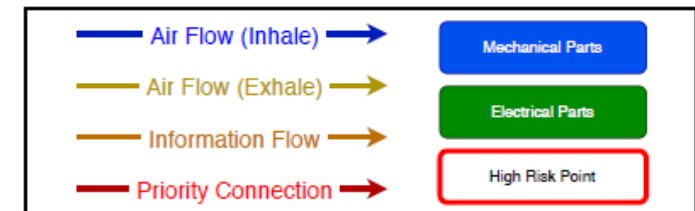
Problem  
Space and  
supporting  
research

# Block Diagram



IS 2.0  
Incentive Spirometer  
Second Wind:  
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Jason Smith - ME  
Saihou Jobe -CPE  
Makana Dang - EE

Key:





THE INTEGRATION OF THE ELECTRICAL COMPONENTS WITH THE DIAPHRAGM.



VALVES TO DIRECT AND REGULATE AIR FLOW. (VALVES TO SWITCH BETWEEN SPIROMETER AND OPEPD)



THE SYSTEM TO VIEW RECORDED TESTS AND SUCCESSFUL INHALATIONS

Critical path

# Q1 Specifications

- How will we know if we were successful?

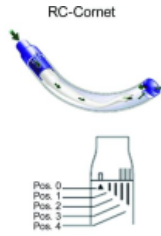
Spec ID	Requirement	Threshold (Shall)	Objective (Should)	Validation Method	Why this threshold value	Relates to critical feature(s)
RRP001	Proximity Sensor	N/A	Accurately record successful inhalation	Code output	Demonstrates ability to record when diaphragm crosses the target	1
RRP002	OPEP valve	N/A	Simple transition from spirometer to OPEP	Simulation and Experimentation	Demonstrates ability to switch direction air flow within the device	3
RRP003	Alarm system	Adjustable audio reminder to perform inhalation therapies	Adjustable audio and visual reminder on the LCD screen to perform inhalation therapies	Code Output and Testing	Demonstrates that the electronics can keep an internal timer on when the patient needs to perform their exercise.	2

# Engineering Analysis

- We can use SOLIDWORKS's integrated flow simulators to study the effects of air flow in the system.
  - Valves
  - Air Pressure
  - Vents and Outlets
- Information storage
  - Data viewing
  - Data reset
  - Sensor interpretation
- Load Analysis
  - Battery Sizing
  - Load of each component

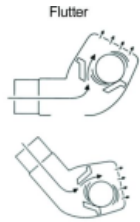






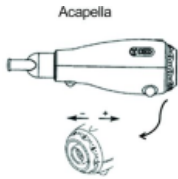
Exhaled gas passes through a curved plastic tube containing a flexible, latex free hose and sound damper. During exhalation, the latex free hose erratically strikes the top and bottom of the curved plastic tube, intermittently occluding flow, creating oscillations and PEP.

Settings on the mouthpiece can be adjusted to twist the tube and change the size of the expiratory resistor, which adjusts the frequency, amplitude and mean pressure.



Exhaled air passes through the hollow tube, by the metal ball, then vertically within the housing, cone and perforated cap to create the airflow oscillations.

This device is gravity dependent. Therefore, the angle at which it is held by the patient affects the amount of effort needed to cause the metal ball to vibrate, influencing the frequency and amplitude of the oscillations and PEP.



High-frequency oscillations and PEP are created as exhaled gas passes through a cone, which is intermittently occluded by a plug attached to the lever.

A knob located at the distal end of the device adjusts the proximity of the magnet and counterweighted plug, thereby adjusting the frequency, amplitude and mean pressure.

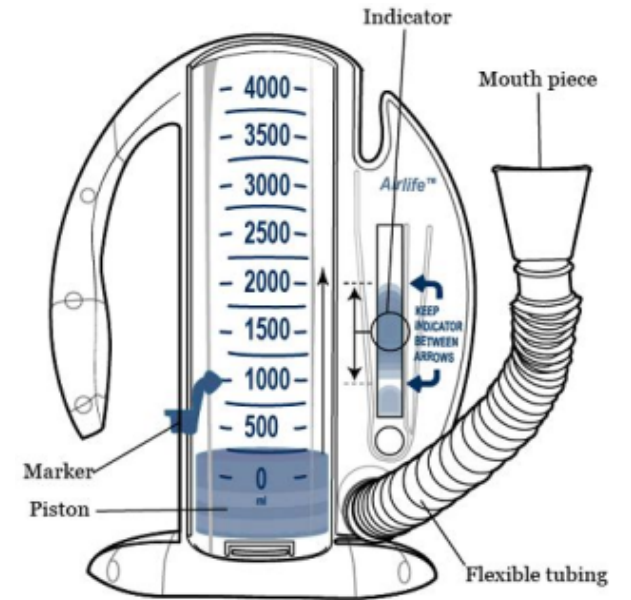
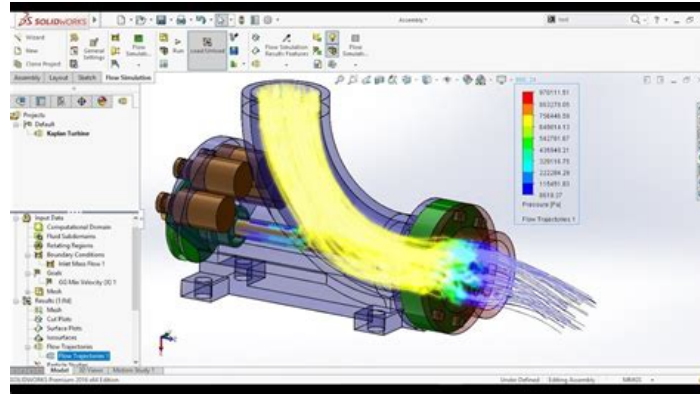
The closer the magnet is to the plug the more expiratory resistance, PEP and amplitude are generated.

The Blue and Green versions differ by manufacturer limitations with respect to the patient's expiratory flow.



Exhaled gas passes through a one-way valve housed within a chamber, creating airflow oscillations and PEP as the valve chatters.

A dial on the chamber adjusts the resistance setting, or the ease with which the one-way valve opens and closes.

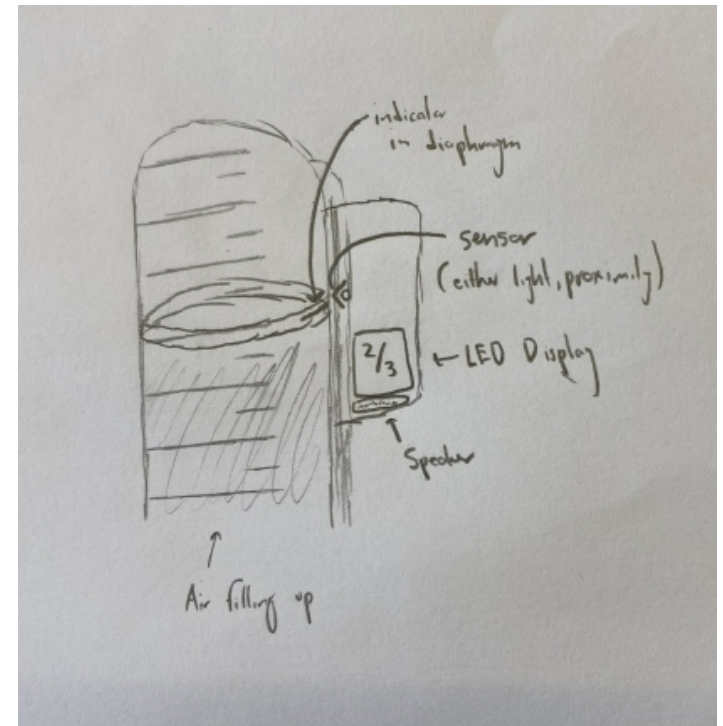
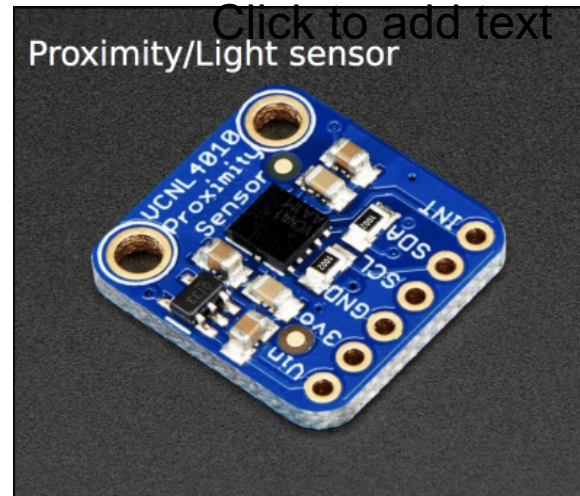


# Proposed Critical Path: Mechanical

We will be relying on previous discoveries and inventions for the fundamental function of the device and its features. We seek to update the overall design. Using research papers, existing products on the market, and simulated 3D computer models, we will find the optimal selection of devices and integrate them into a singular device that serves the function of an incentive spirometer and an OPEP device.

# Proposed Critical Path: Electrical and CPE

- Testing different sensors for the diaphragm position for recording SMIs
- Testing component loads to determine battery sizing
- Integration with microcontroller



The image features a white background with two teal-colored geometric shapes. On the left, there is a large teal trapezoid that tapers towards the right. On the right side, there is a smaller teal triangle that tapers towards the left. The word "Questions?" is centered in the white space between these two shapes.

Questions?