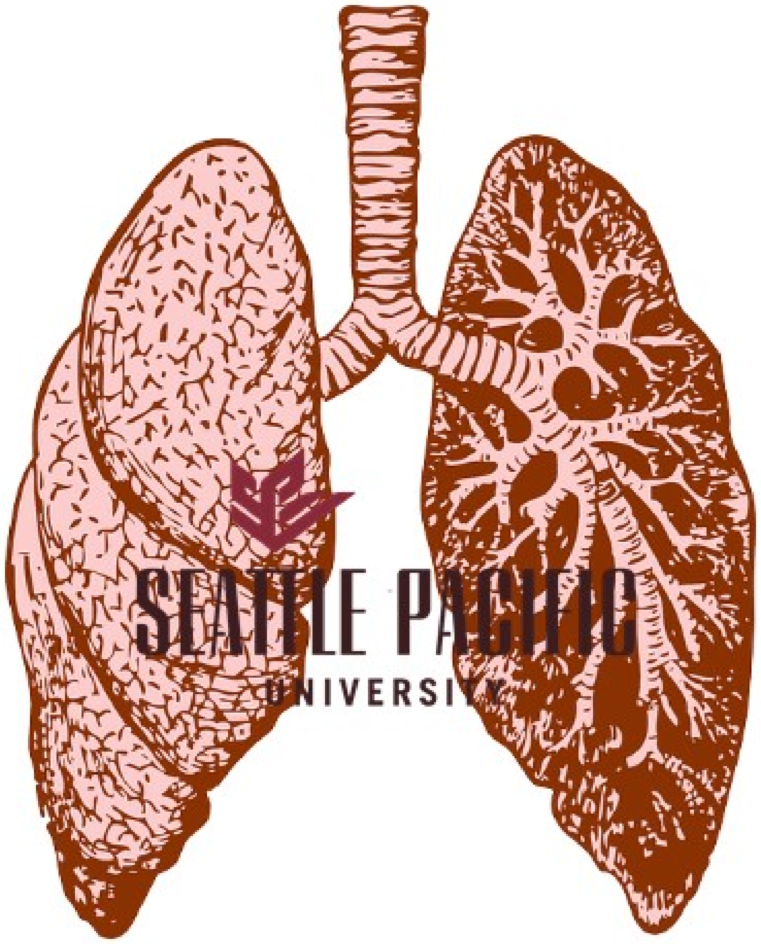


Incentive Spirometer 2.0: Breathing New Life into the Incentive Spirometer

Team Second Wind:

- Jason Smith
- Makana Dang
- Saihou Jobe
- Nathaniel Geller
- Omar Garibay

Restoring Lung Capacity

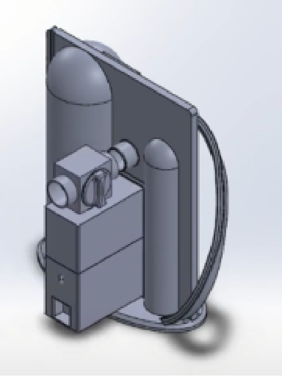
Team Second Wind: Jason Smith (ME), Saihou Jobe (CPE), Makana Dang (EE), Nathaniel Geller (ME), Omar Garibay (ME)

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 competitive.**



Approach:

- **Redesign aesthetic features to improve the look**
- **Study existing OPEP technology and integrate into system**
- **Create a valve that directs air flow between the OPEP and incentive spirometer**

RRP and Analyses

RRP

- **Use existing incentive spirometers as a basis for your product**
- **Build and test electrical components that are detachable and reusable.**
- **Experiment with oscillating air pressure measurements**

Analyses:

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

Proposed critical path device: ME

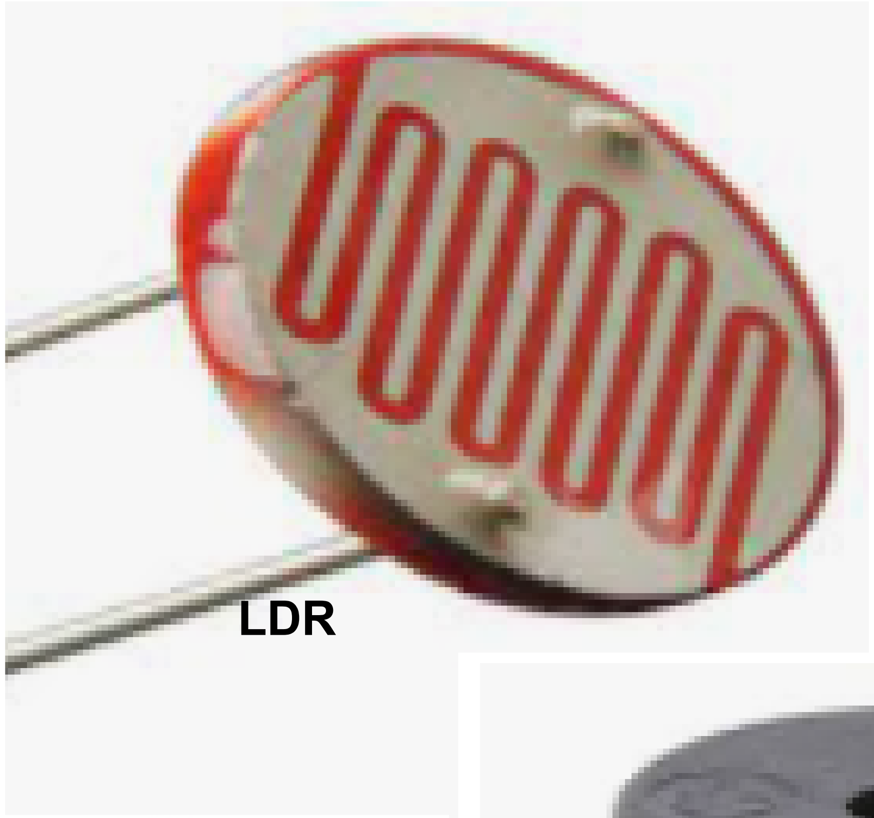
- We set out to update the overall design of the Spirometer in order to improve the aesthetic, and to allow for an OPEP device to be integrated. Using research papers, existing products on the market, we intend to find the optimal selection of devices and integrate them into a singular device that serves the function of an incentive spirometer and an OPEP device.

SimFlow CFD Simulation Software

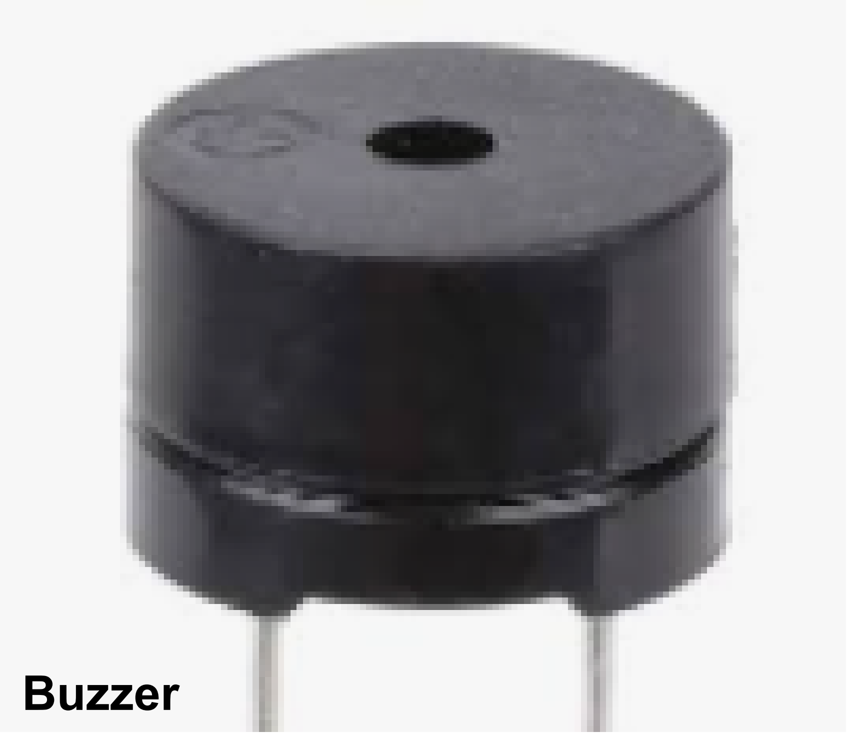
Compressible Flows	✔
Incompressible Flows	✔
Steady State Flows	✔
Transient Flows	✔
Multiphase Flows	✔
Turbulence	✔
Radiation	✔
Heat Transfer	✔
Combustion	✔
Discrete Phase Model	✔
Dynamic Mesh	✔

Proposed critical path device:
EE/CPE

Electrical: Built circuit and tested with raspberry Pi Pico. Integrated a buzzer and light dependent resistor (LDR) in the circuit.



APDS-9960

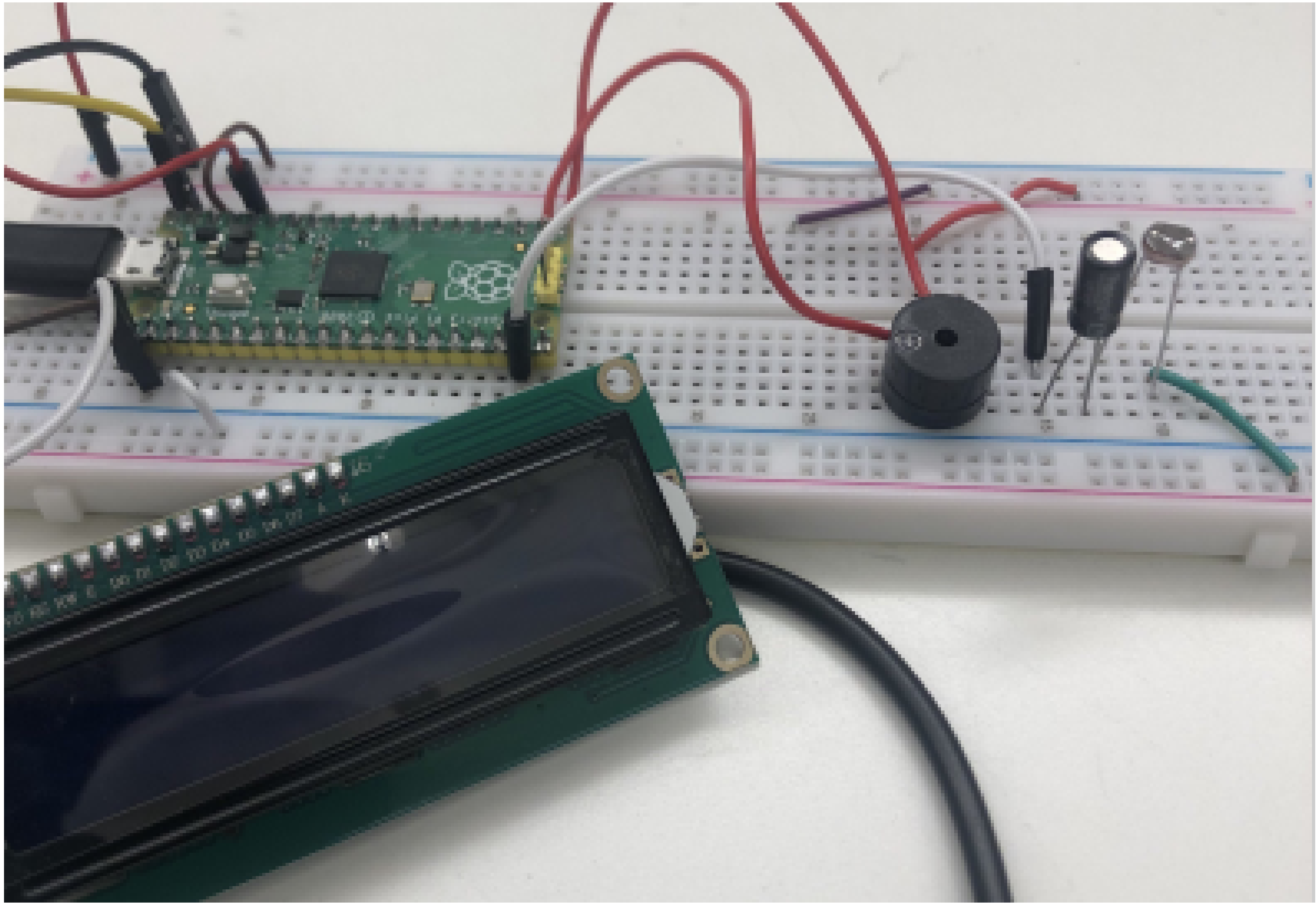


Buzzer

Proposed critical path device: EE/CPE (cont.)

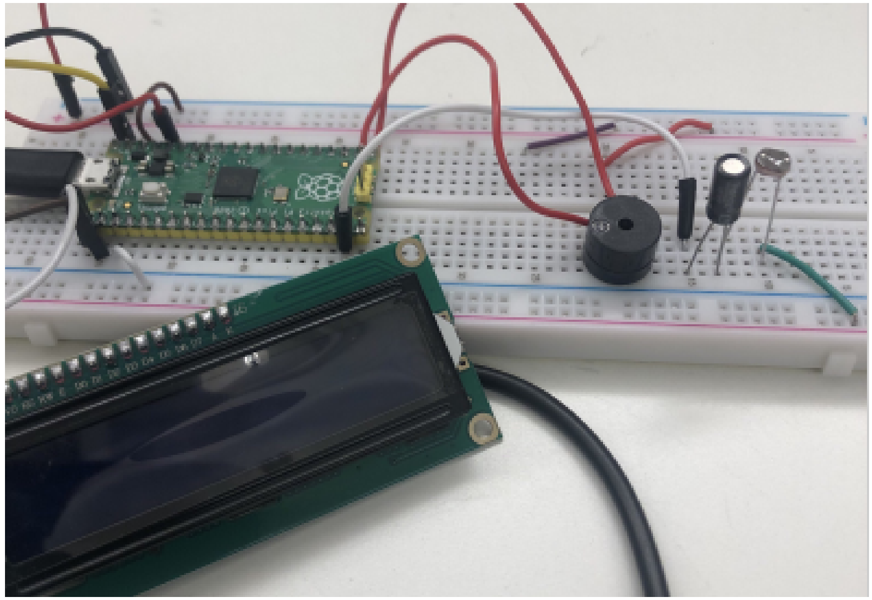
Using raspberry Pico GPIO pins, we integrated the buzzer and LDR with the Pico to capture date.

Code optimization for quicker response and output to LCD display during winter quarter.

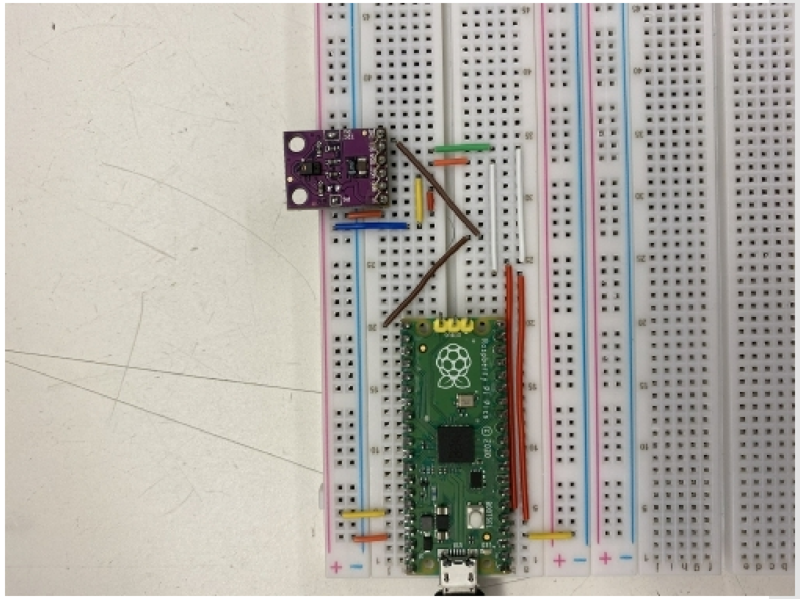


Diaphragm Sensor Specification Demonstration

ID	Requirement	Threshold	Objective	Observed
RRP001	Laser Sensor	N/A	Code Output	Pass
RRP001	Gesture Sensor	N/A	Code Output	Pass

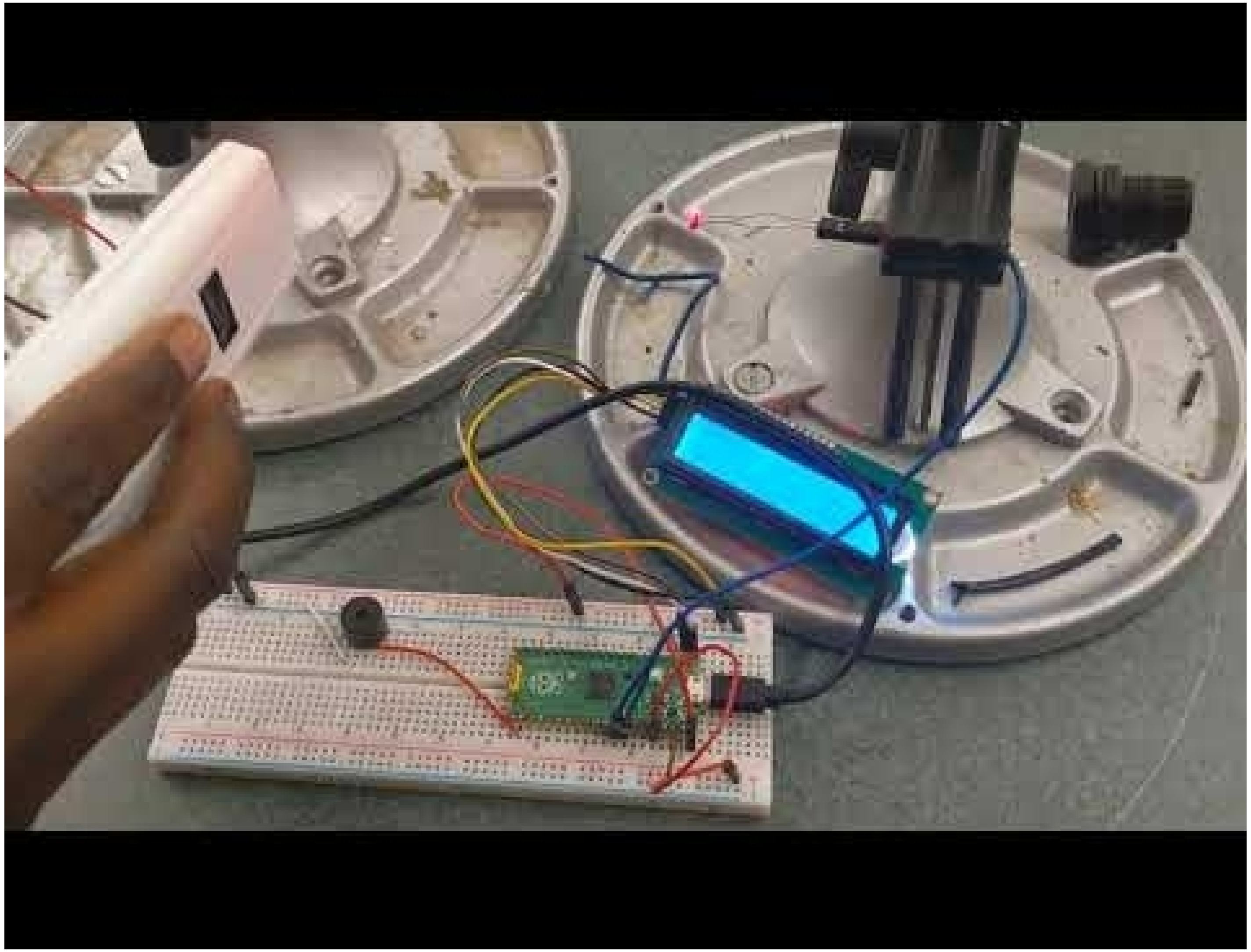


Circuit of Laser Sensor

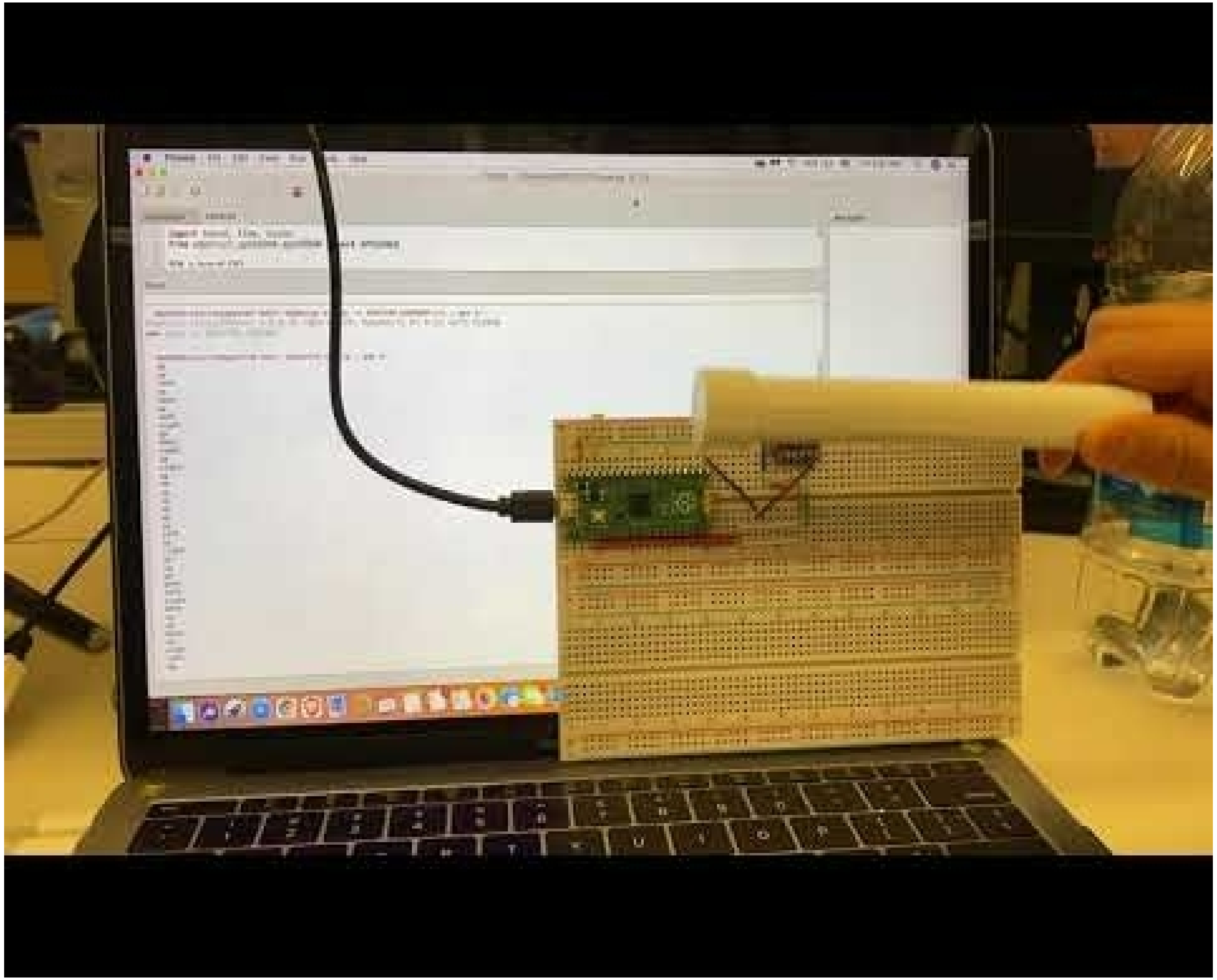


Gesture Sensor Module w/ Pico

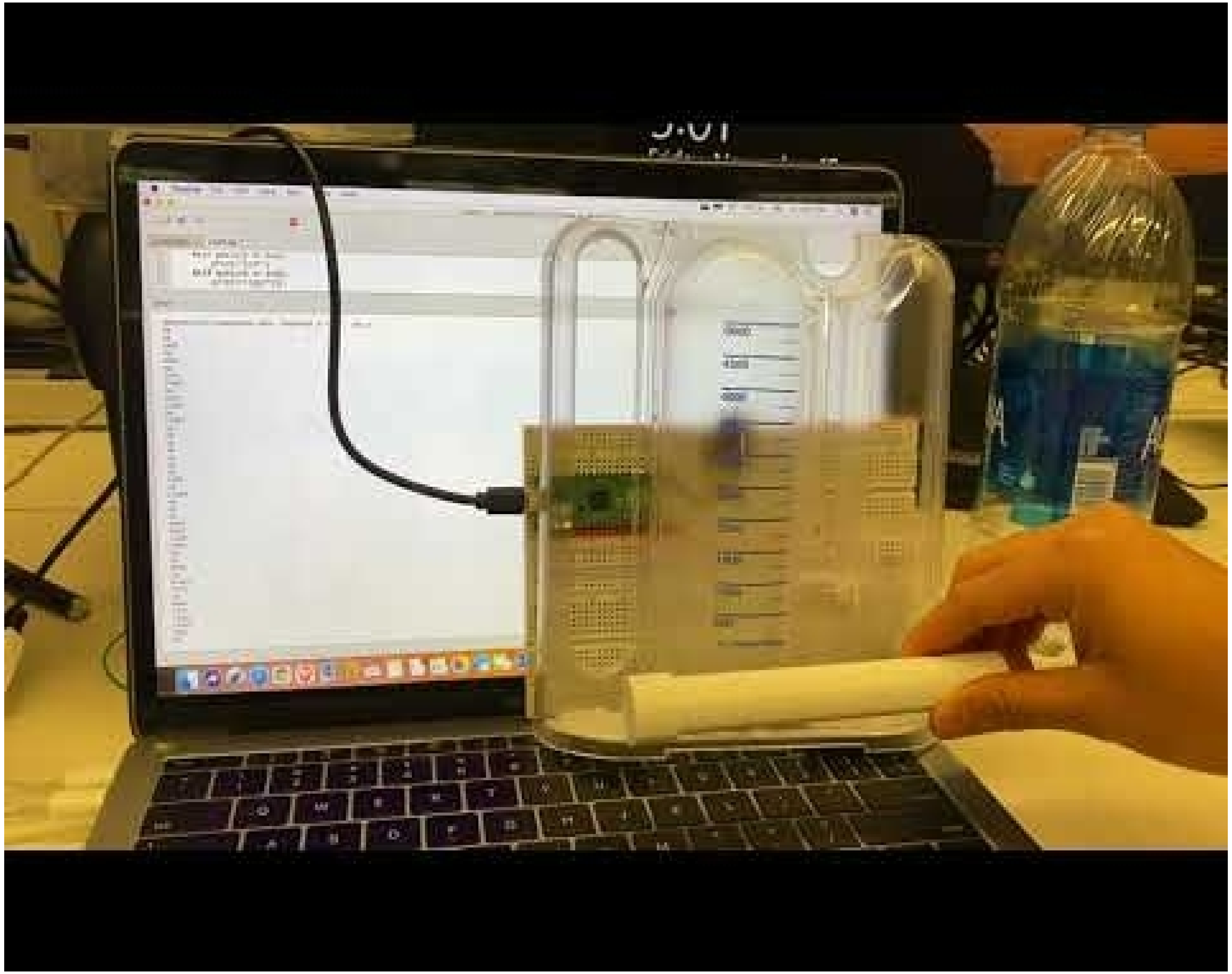
RRP Specification Demonstrations



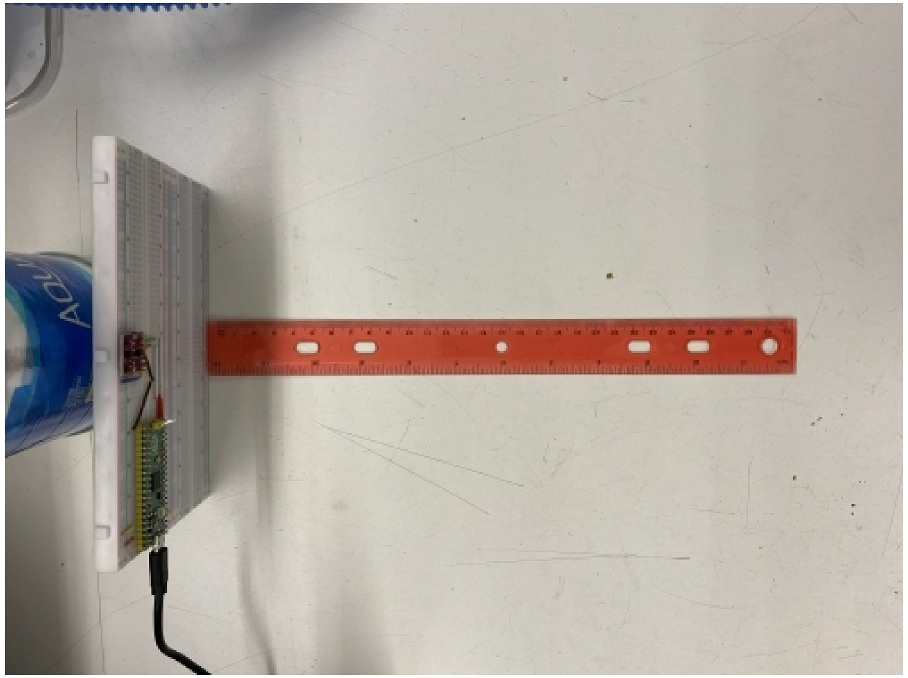
RRP Specification Demonstrations

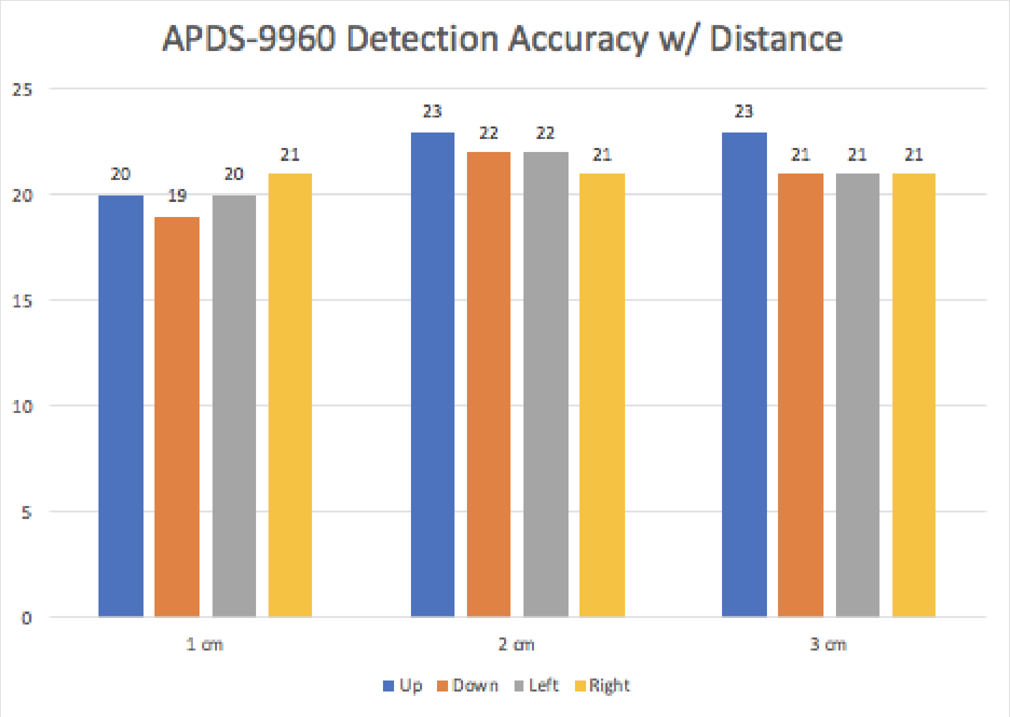


RRP Specification Demonstrations



Gesture Sensor Testing Analysis

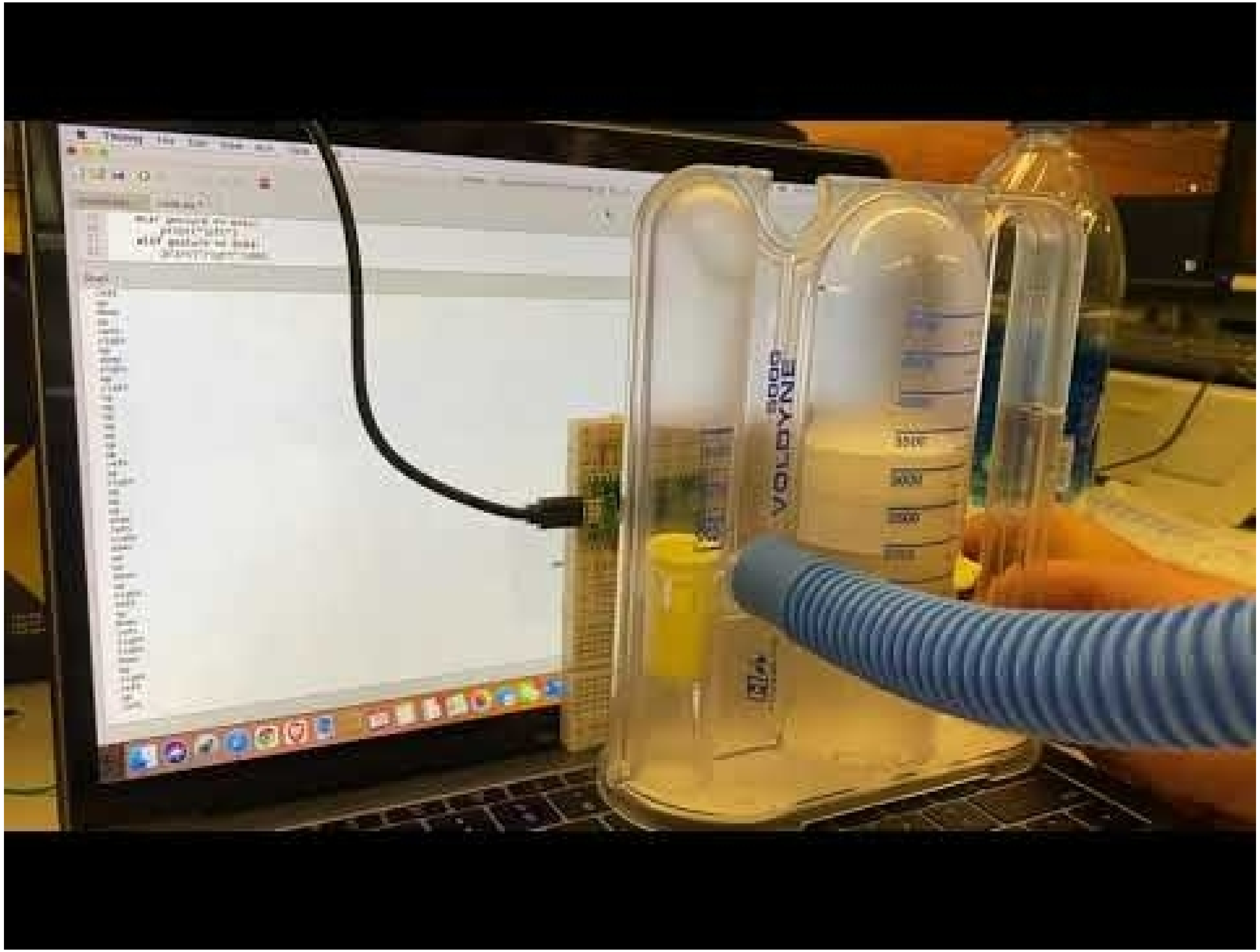




We tested the distance at which the APDS-9960 reads the movement best. Since we are planning on the sensor being very close to the diaphragm of the spirometer, we tested distances smaller than 3 cm.

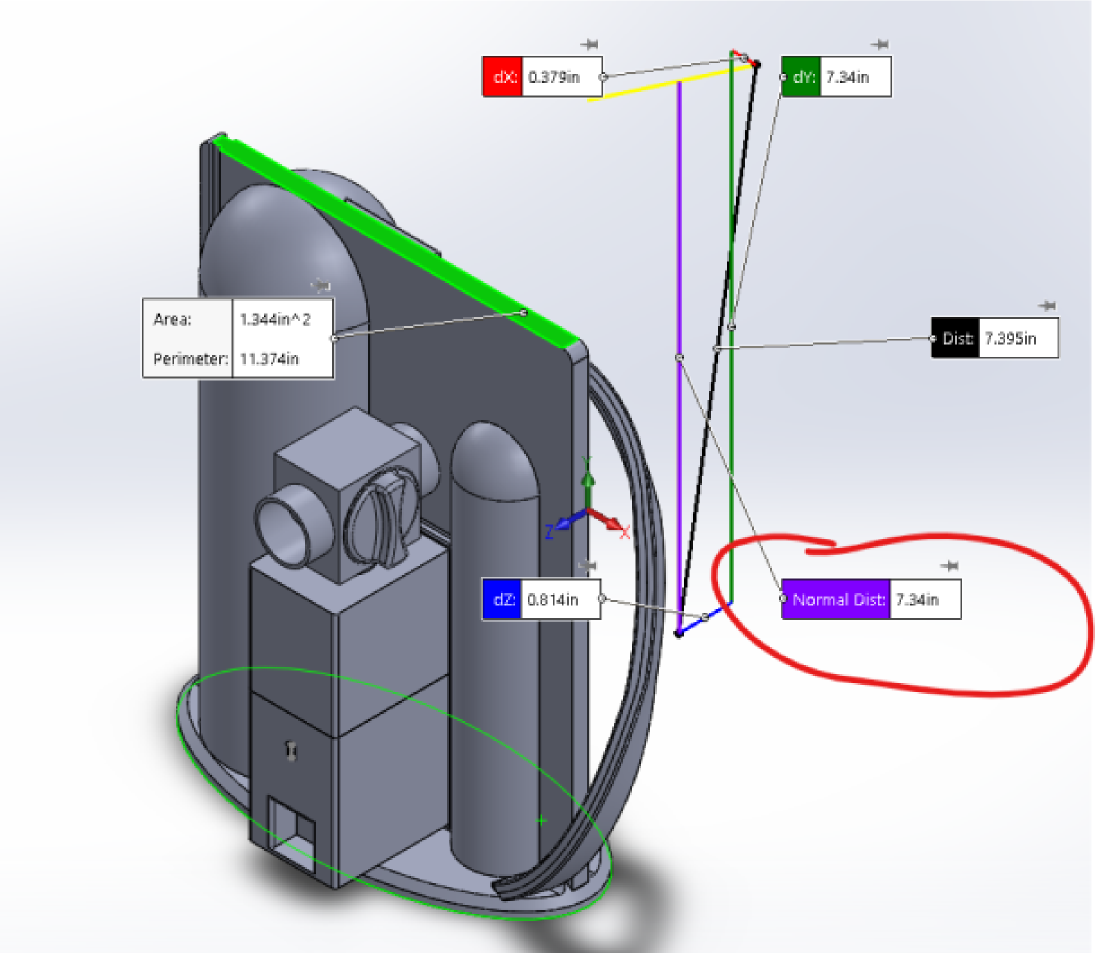
Here we see that the spirometer worked best 2 cm away when it is reading a motion in the upwards direction.

RRP Specification Demonstrations



ID	Threshold	Objective	Observed
RRP 004	Width: no longer than 3.5 in Height: no taller than 10in	Minimal size changes to Incentive Spirometer	Met

RRP Spirometer Specifications Demonstrations

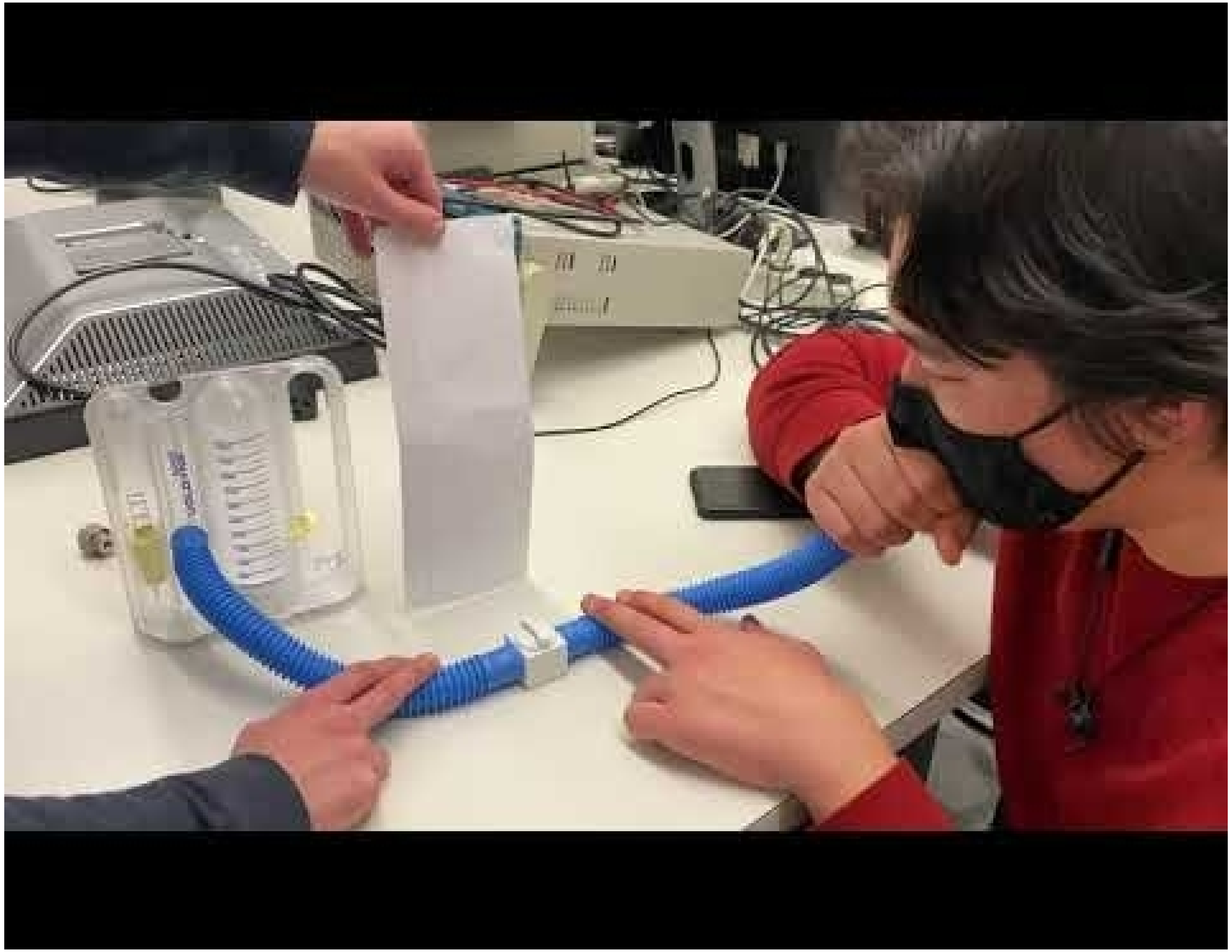


OPEP Valve Specification Demonstration

ID	Threshold	Objective	Observed
RRP003	N/A	Simple transition from spirometer to OPEP	Pass

- Modeled using SOLIDWORKS
- SOLIDWORKS incapable of flow simulation
  - Oscillation parts
  - Transient Flow
- We were able to validate this RRP through experimentation

RRP Specification Demonstrations



Audible System Specification Demonstration

ID	Threshold	Objective	Observed
RRP 004	Adjustable audio reminder to perfor m inhalation therapie s	Adjustable audio and visual reminder on the LCD screen to perform inhalation therapies	Buzzer goes off when laser is interrupted. Successful readings displays on LCD screen.

Critical Design Specifications

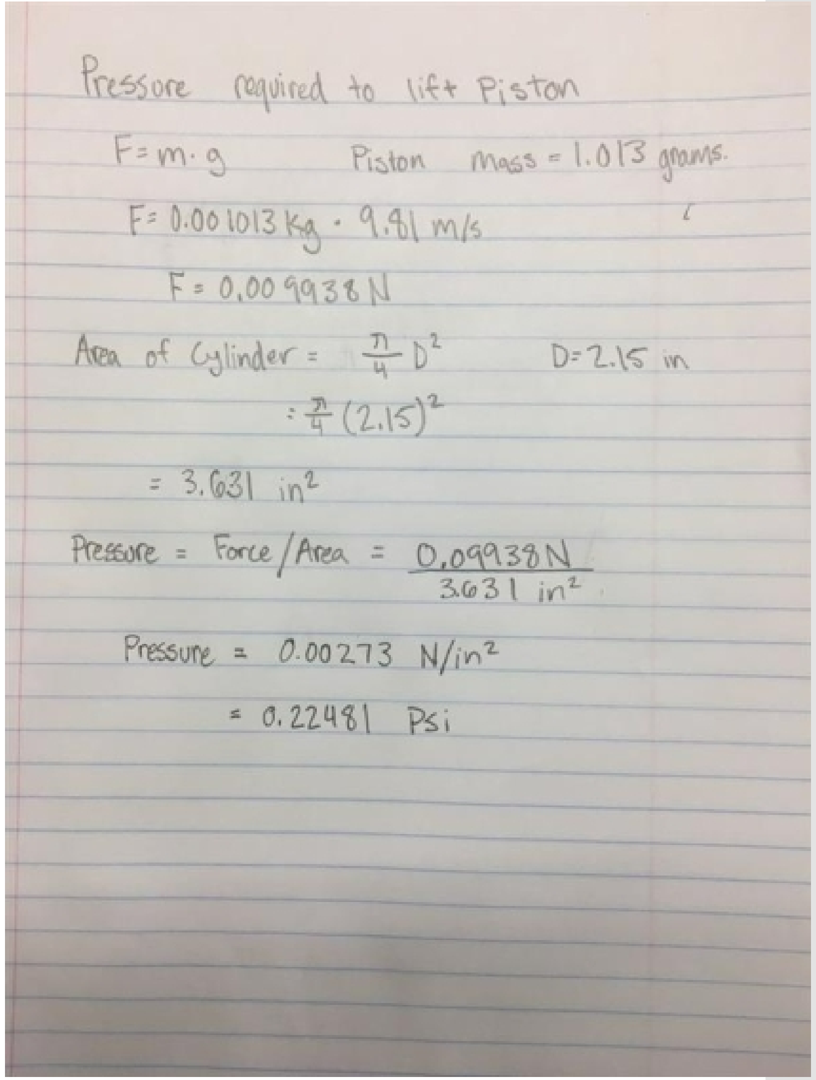
Spec ID	Requirement	Threshold	Objective	Validation Method	Why this threshold value
RRP 001	Proximity Sensor	N/A	Accurately record successful inhalation	Code output	Demonstrates ability to record when diaphragm crosses the target
RRP 002	OPEP valve	N/A	Simple transition from spirometer to OPEP	Simulation and Experimentation	Demonstrates ability to switch direction air flow within the device
RRP 003	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.
RRP 004	Spirometer dimensions	Height: less than 10 in Width: less than 3.5 in	Minimize footprint size for overall integrated device	Simulation	Per Mr. Currans request the device should have a similar size footprint to minimize the space needed for storage in the hospitals.

Engineering Analyses

- Range of sensors
- Battery Size
- Power Consumption
- OPEP oscillation pattern and magnitude
- Spirometer Analysis
- OPEP Integration
- Device and Housing Design

Mechanical Engineering Analysis

- Since we are changing the layout of the spirometer, we have calculated the pressure needed to lift the piston within the diaphragm
- We plan to use manometer next quarter to find more specific data of air flow pressure throughout the spirometer


Pressure required to lift Piston

$F = m \cdot g$ Piston mass = 1.013 grams.

$F = 0.001013 \text{ kg} \cdot 9.81 \text{ m/s}^2$

$F = 0.009938 \text{ N}$

Area of Cylinder $= \frac{\pi}{4} D^2$ D = 2.15 in

$= \frac{\pi}{4} (2.15)^2$

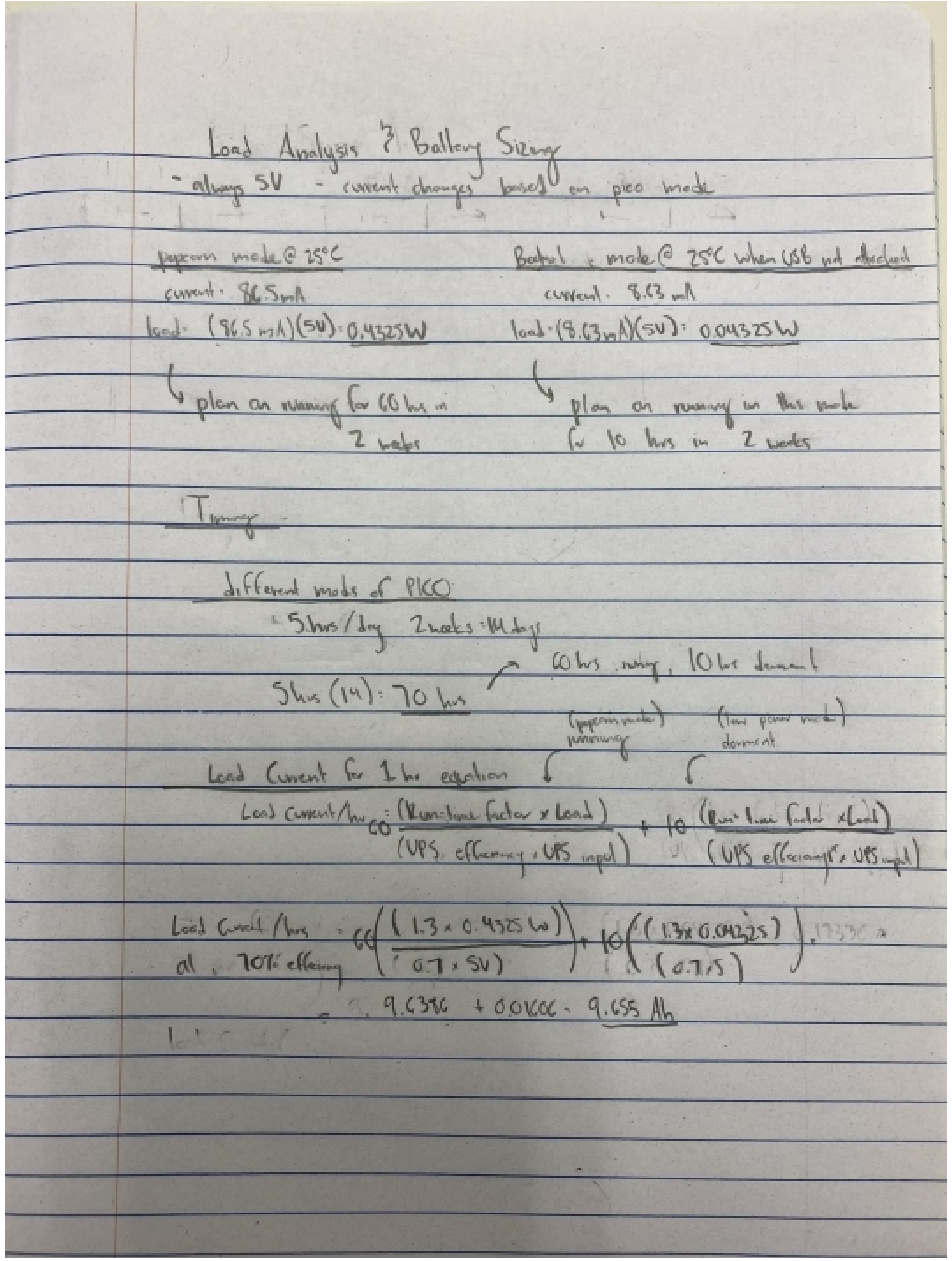
$= 3.631 \text{ in}^2$

Pressure = Force/Area $= \frac{0.09938 \text{ N}}{3.631 \text{ in}^2}$

Pressure $= 0.00273 \text{ N/in}^2$

$= 0.22481$ Psi

Electrical Engineering Analysis: Load Analysis and Battery Sizing



- Raspberry Pi Pico runs on different modes: Popcorn, Bootsel, dormant, and sleep
- We want the electrical system to last for at least 2 weeks
- Through load analysis and battery sizing, we believe the Pico will require 10 Ah

Battery Options Decided from Analysis

CR2032 –WR–SUB
- 3.6V Lithium Battery
- 220 mAh
- great for desired electrical housing size
-Might not provide enough current to power Pico for desired life cycle

USB Li-Ion Power Bank with 2 x 5V Outputs @ 2.1A - 5000mAh
-Might be too big for the electrical housing
-Provides user with long-lasting spirometer that is rechargeable

Analysis Discussed

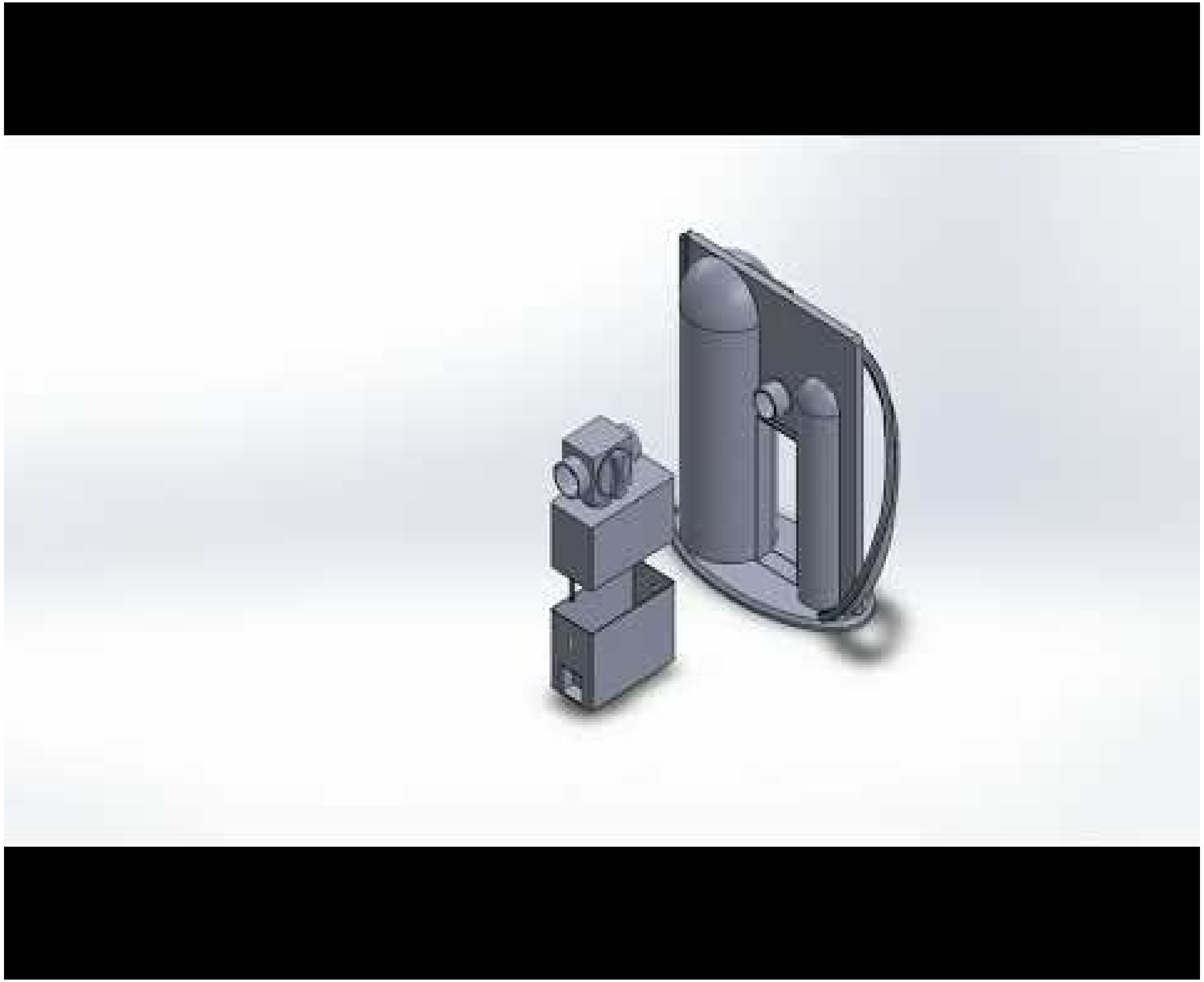
Raspberry Pi Pico Capabilities:

- Research is required for microcontroller to compile and execute code faster.

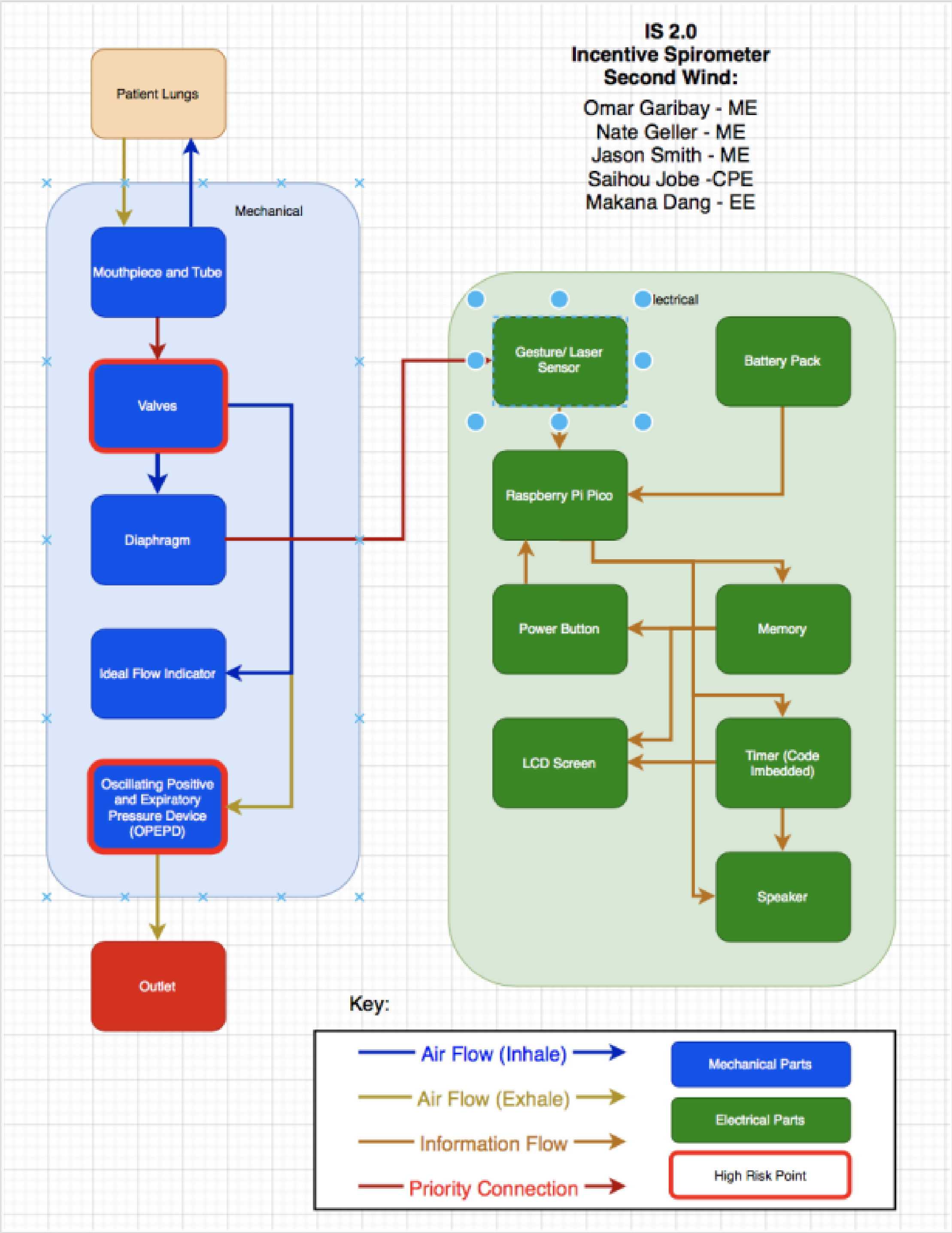
Audible Reminder:

- Audible patient reminder to execute inhalation exercise, approximately every 5 to 10 minutes, in not yet integrated in our code thus far. How to implement reminder is still being determined.

Analysis Discussed



Block Diagram



Winter Break Schedule

- Saihou Jobe – Research how to speed up micro-python code on thonny IDE.
- Nate Geller – Research flow analysis methods (flow simulation Software/flow measuring instruments)
- Omar Garibay – Will research potential options for producing/ molding plastic to produce our design
- Jason Smith – Will compose an SLS purchasing proposal with Kinnon McPeak
- Makana Dang – Research calibration specs and settings for APDS-9960 (gesture sensor) and start making website

Questions