An automated, continuous counting inventory module for medication

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PharmAccount — Accurate. Efficient. Accountable.

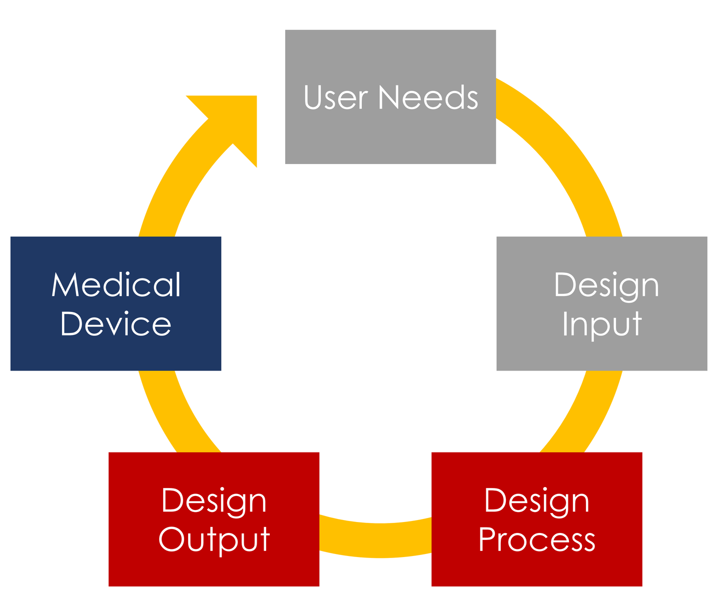
Mission Statement

To develop innovative solutions that address drug diversion, enhance security, and improve medication management accountability—ensuring safer practices, better patient outcomes, and streamlined healthcare processes.

Introduction/Background

- Medication reconciled weekly to find discrepancies from human error/drug diversion
- Manual count performed by two registered nurses
  - Time-consuming
  - Diverts attention from patient care
  - Contributes to provider fatigue
  - Human error → unnecessary investigations
- **This project aims to tackle the limitations of current counting processes by implementing an automated, continuous solution.**


Project Planning



Gantt Chart:

Final Prototype Specifications

Rated Capacity	424 g
Weight Sensitivity	392 mg
Precision at 392 mg	32% Max, 3% Avg
Accuracy at 392 mg	97.34% ± 5.79%
Count Time	1.245 seconds
Power Voltage	3.3 V DC
Service Life	7 years
Operating Temperature	-40°C to 85°C
Storage Capacity	313 cm^3
Cost	$20

Final Technical Model

Technical model of how signal voltage of load cell translates to weight, which was verified with three different linear regression models, displayed on the right.

$$G = (U_{sig}/U_{ref}) * (L_{R.C.}/L_{R.O})$$

G = estimated weight (kg)

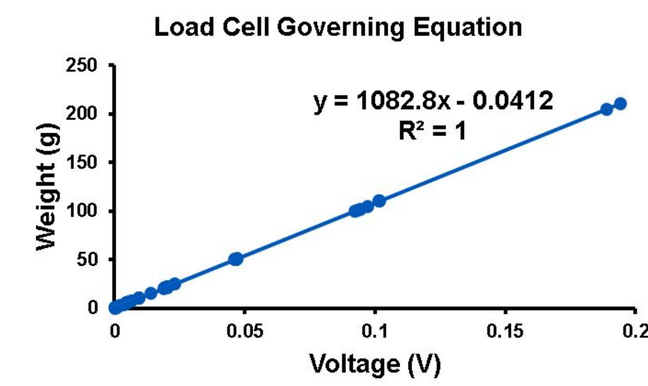
U_{sig} = signal voltage of load cell (mV)

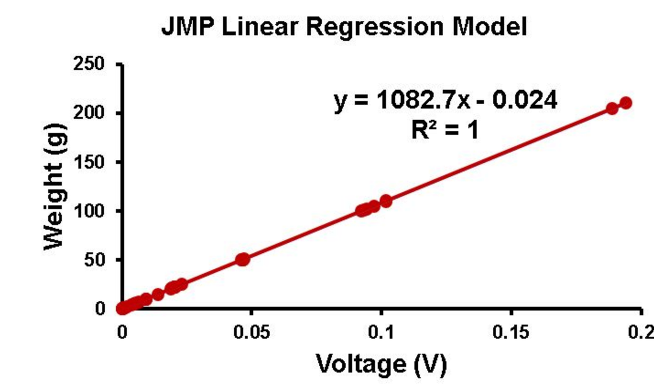
U_{ref} = reference voltage from the load cell (V)

$L_{R.C}$ = rated capacity of load cell (maximum allowable weight) (kg)

$L_{R.O}$ = rated output of the load cell (1 mV/V)

Figure 1 (right): Wheatstone Circuit - measures the electrical resistance between two nodes of a bridge circuit → provide signal voltage





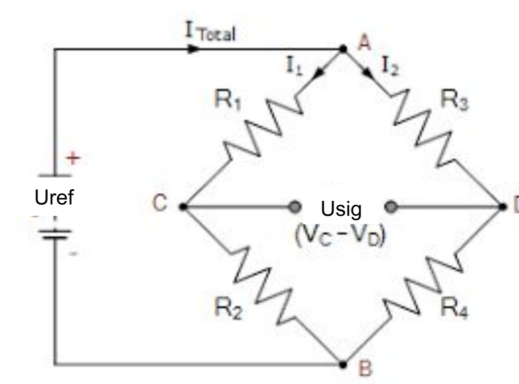
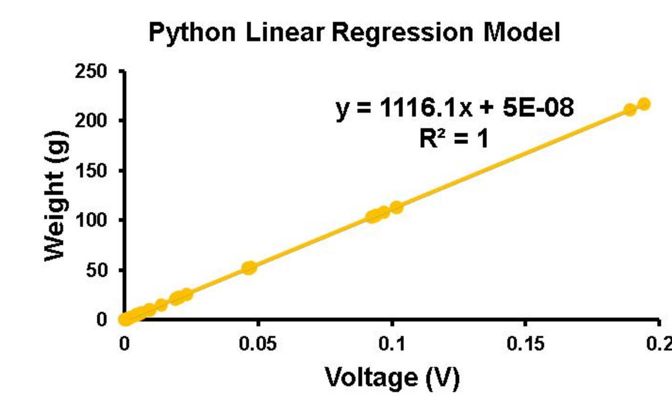


Fig. 1



Prototype

Fig. 2

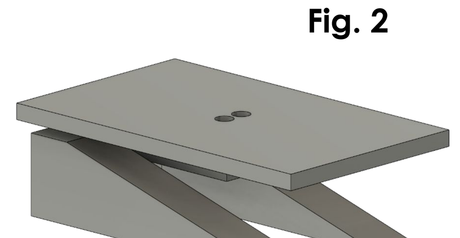


Fig. 3

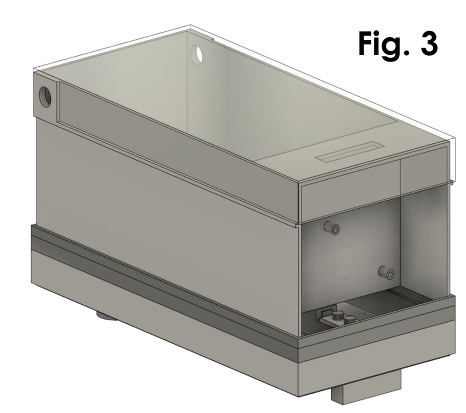


Fig. 4

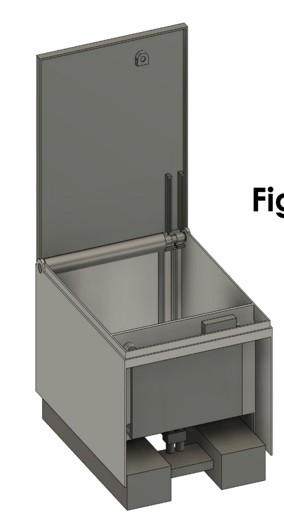


Fig. 5

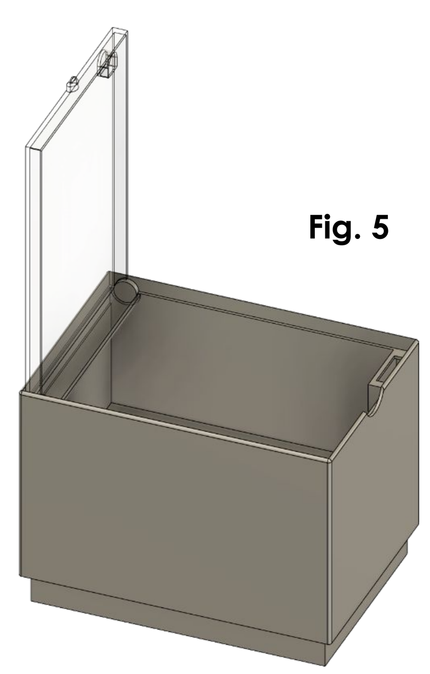
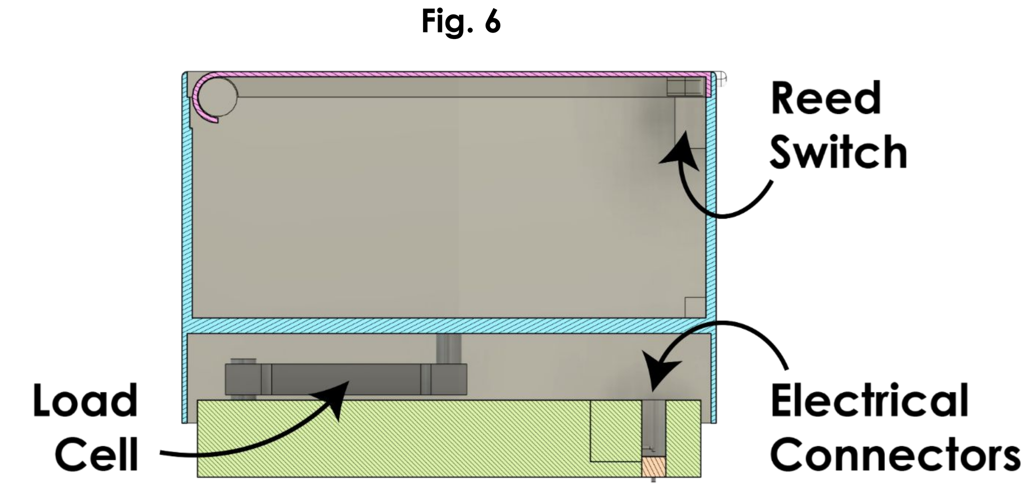


Fig. 6



Figures 2, 3, 4, 5, 6 (left): Iterative design progression of a drug cabinet.

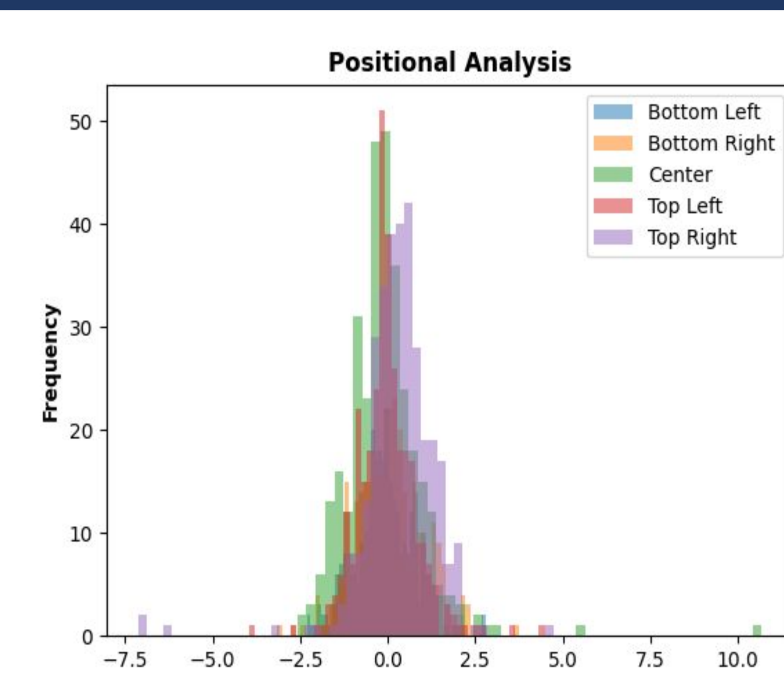
- **(Fig. 2)** Initial mount for load cell.
- **(Fig. 3)** Initial model with frontal cabinet for actuator.
- **(Fig. 4)** Iteration with different locking mechanism and connection to electrical components.
- **(Fig. 5)** Final iteration.
- **(Fig. 6)** Labeled sagittal view of final iteration.

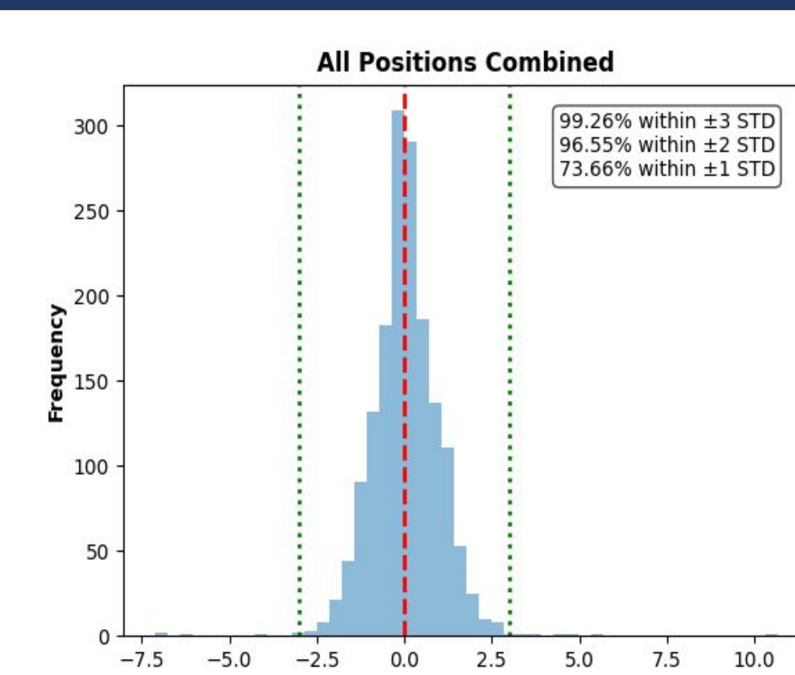
Verification Results

Positional Analysis:

Figure 7 (right): Histograms depicting the distribution of normalized data points:

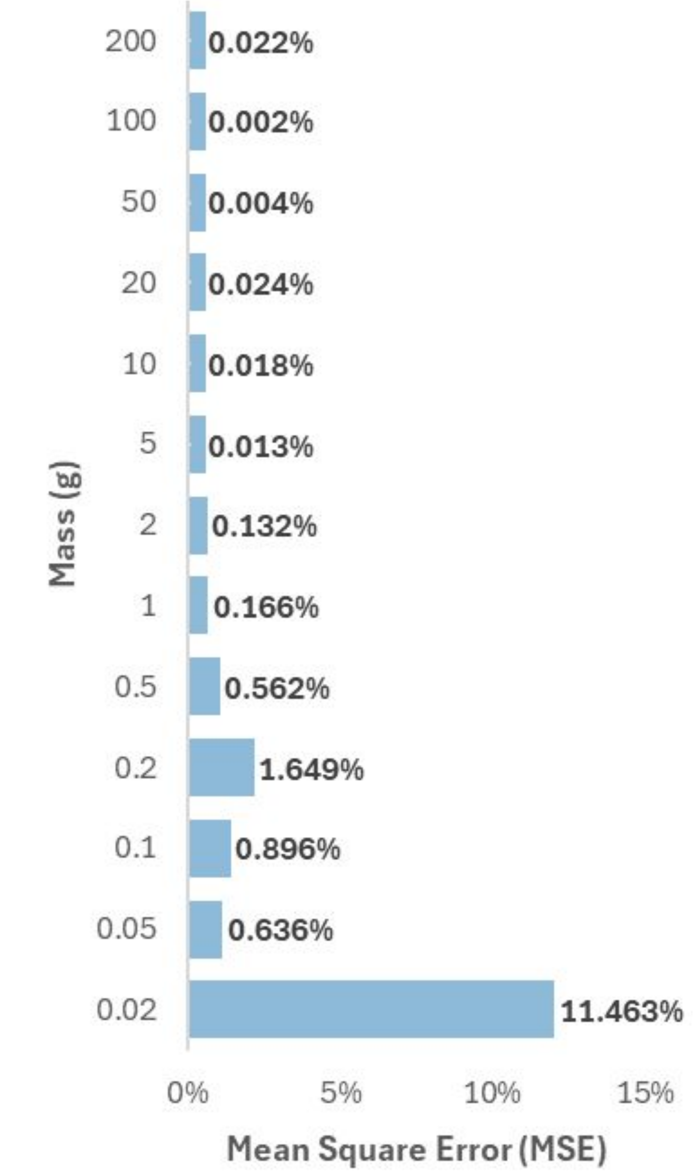
$$\frac{\text{(weight - median)}}{\text{standard deviation}}$$





Verification Results (Cont.)

Mean Square Error Analysis:



Transactional Testing:

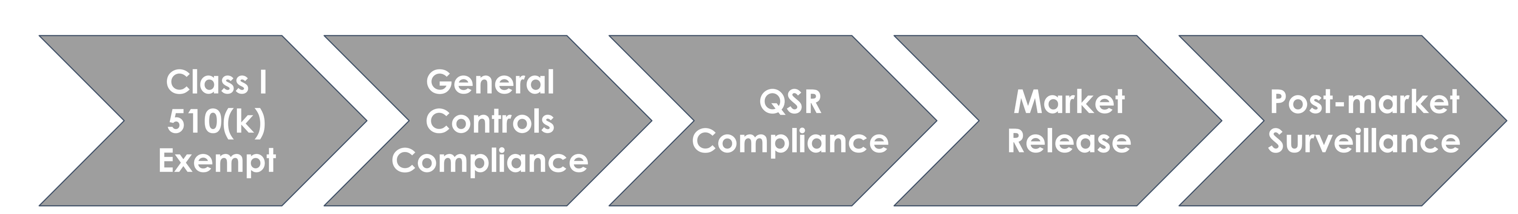
No.	Quantity Change	Calculated Quantity (Rounded)	Error
1	+48	44	4.04
1*		48	-0.10
2	-4	44	-0.12
3	-13	27	3.90
3*		31	-0.07
4	-19	8	3.79
4*		12	0.01
5	+30	38	3.95
5*		42	-0.13
6	+6	48	-0.15

Limitations

- Inconsistencies in sensor output due to prototype structure quality
- Interference due to external forces (vibrations)
- Inability to test custom microcontroller circuit prior to PCB design
- Imprecise and inaccurate at detecting weights <200 mg

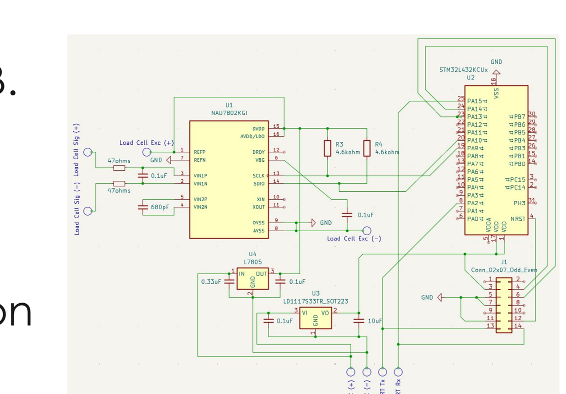
Design Status and Future Work

Regulatory Requirements:



Future Work:

- Design, order, and validate custom PCB.
- Increase sensor reliability and sensitivity.
- Translate design to alternative applications: automated pharmacy systems, pharmacy-at-home, medication management and compliance



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f'{percent_within_3std:.2f}% within ±3 STD\n'
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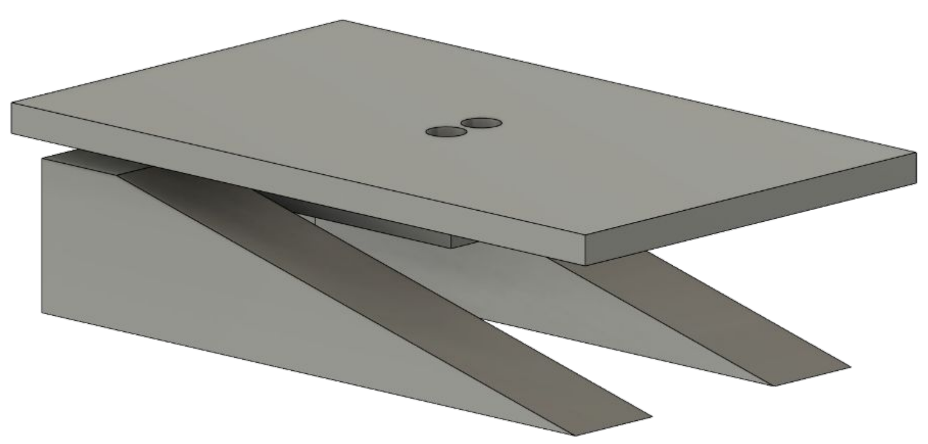

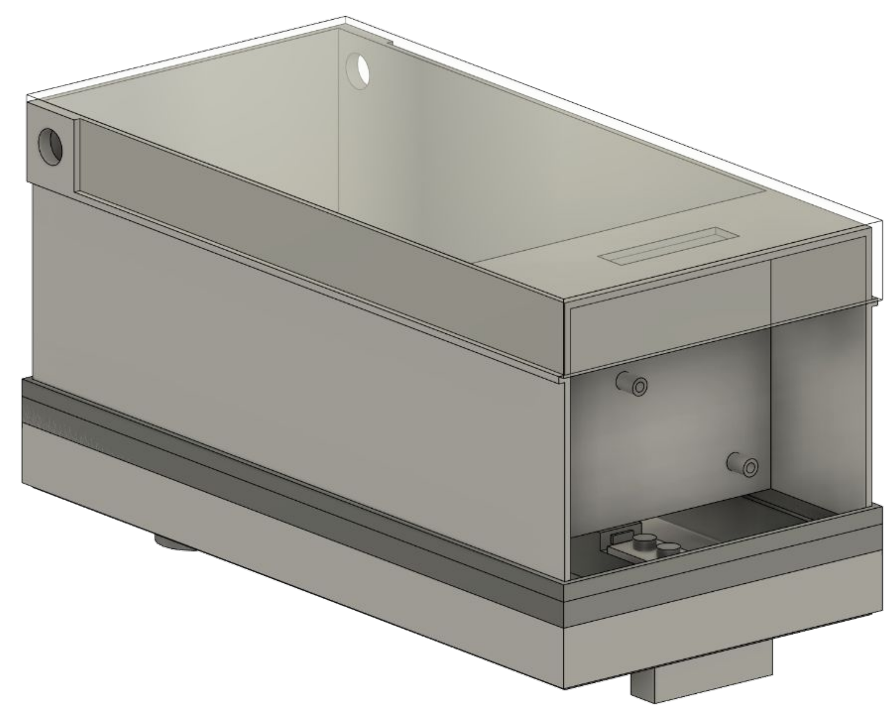

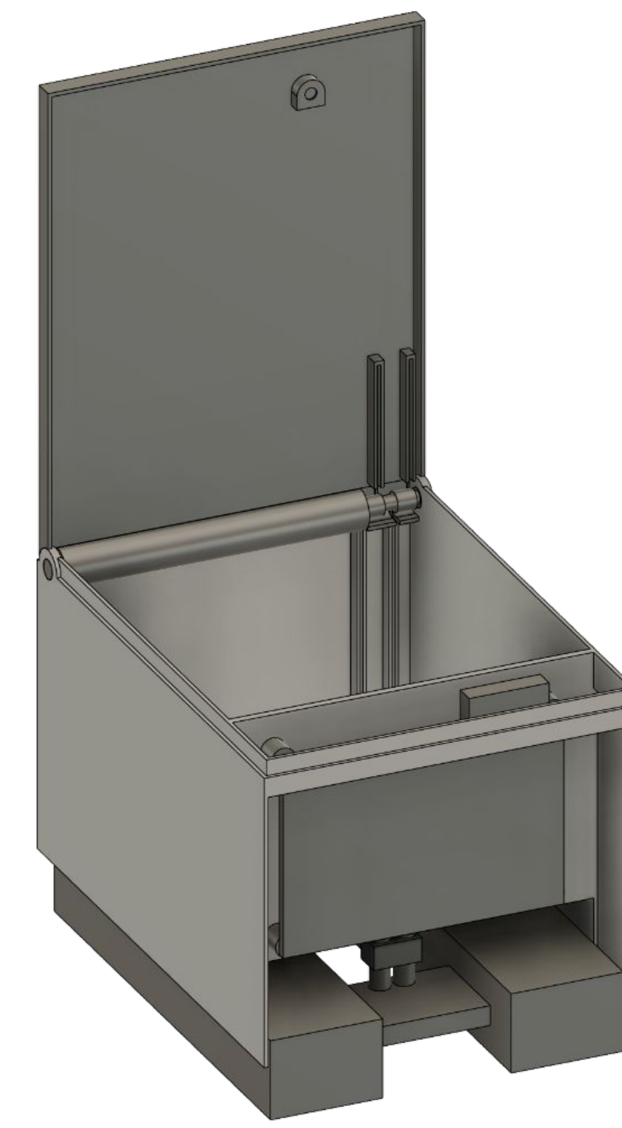

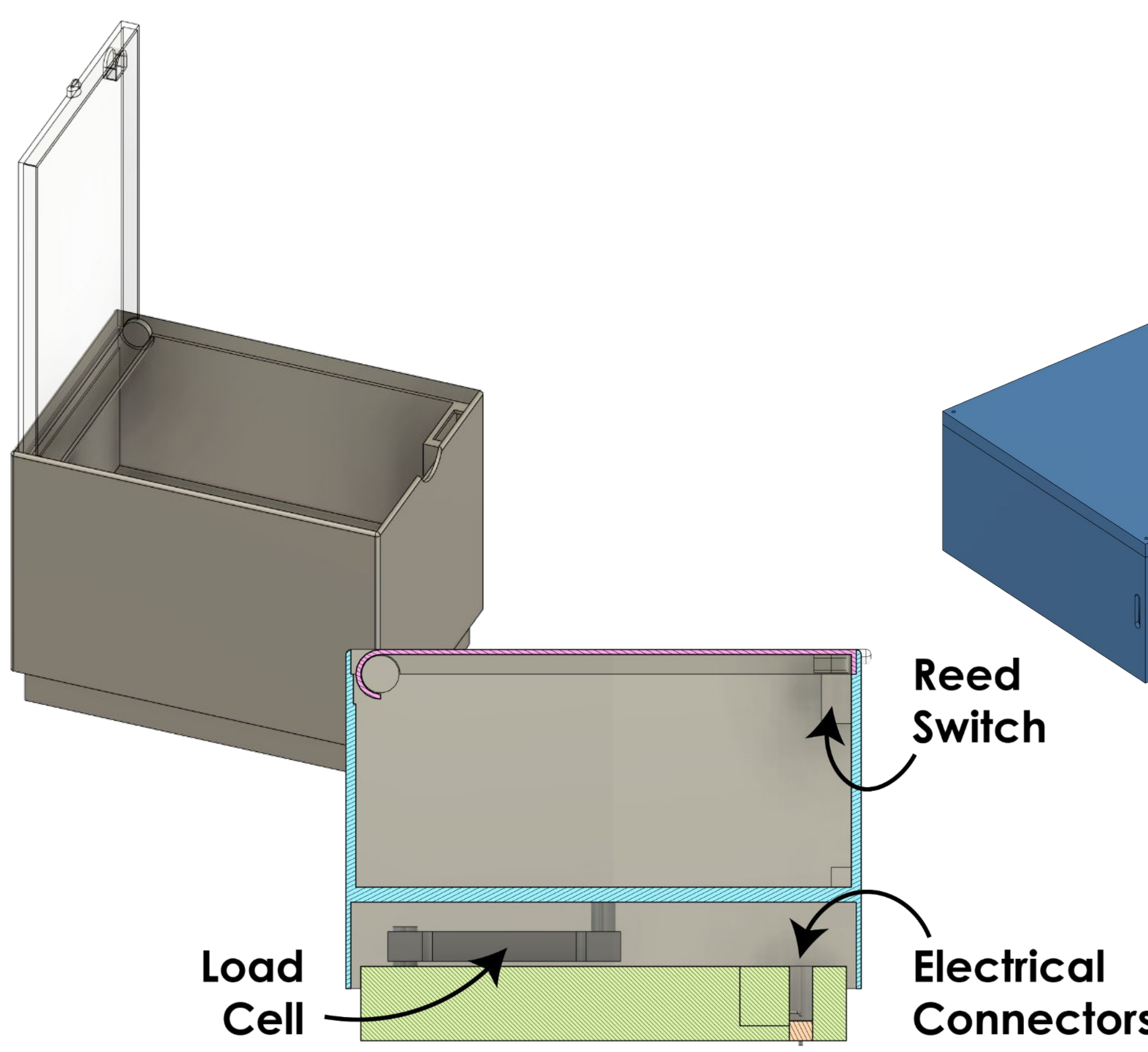

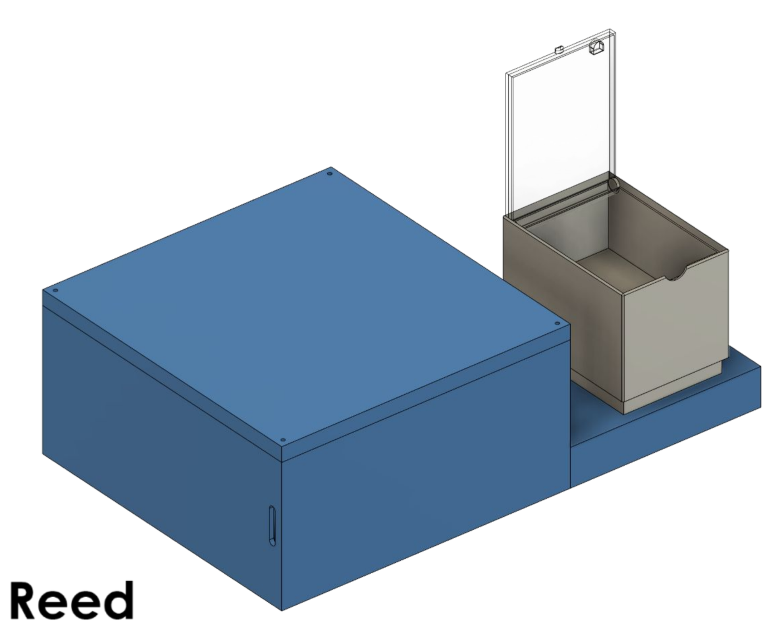

Limitations:

- Inconsistencies in sensor output due to prototype structure quality.
- Sensitivities to external forces.
- Inability to test custom microcontroller circuit prior to PCV development.

Transaction	Quanity Change	Calculated Quantity (Rounded)	Error
1	+48	44	4.04
1*		48	-0.10
2	-4	44	-0.12
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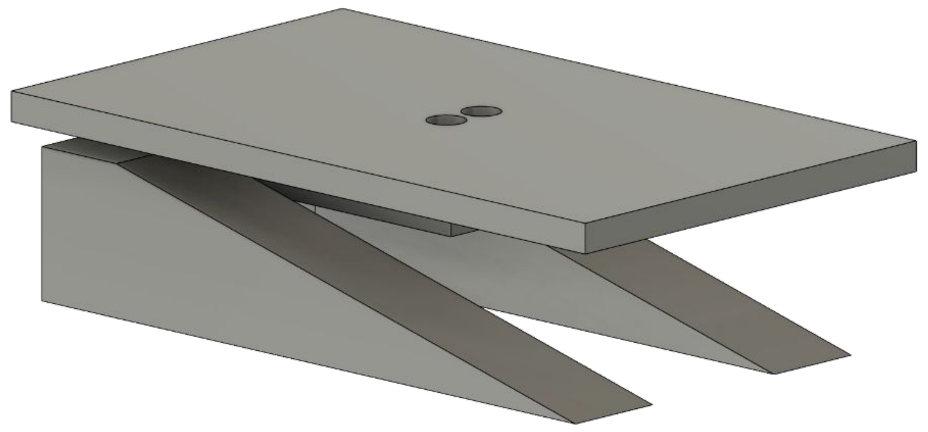
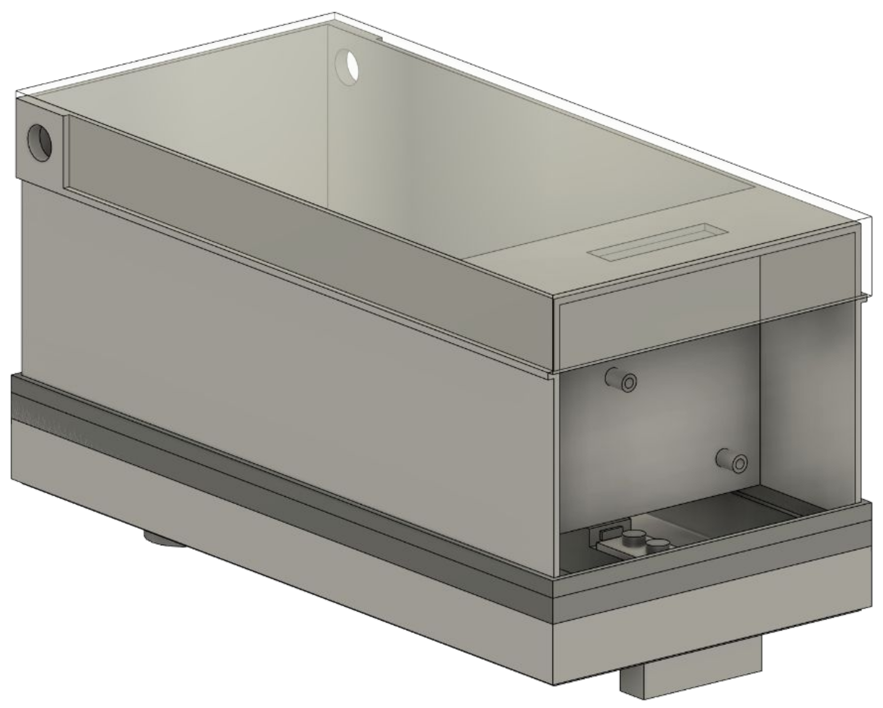
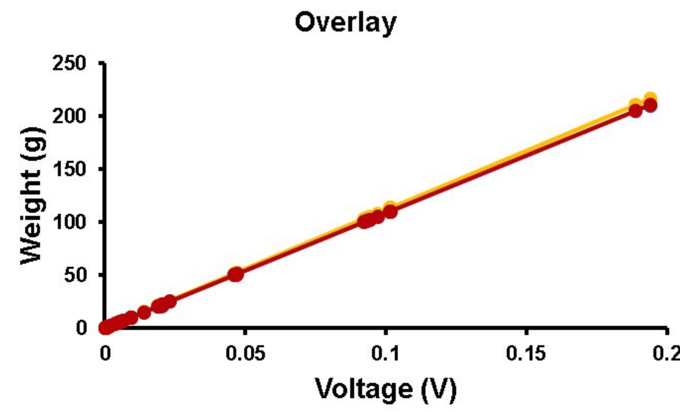
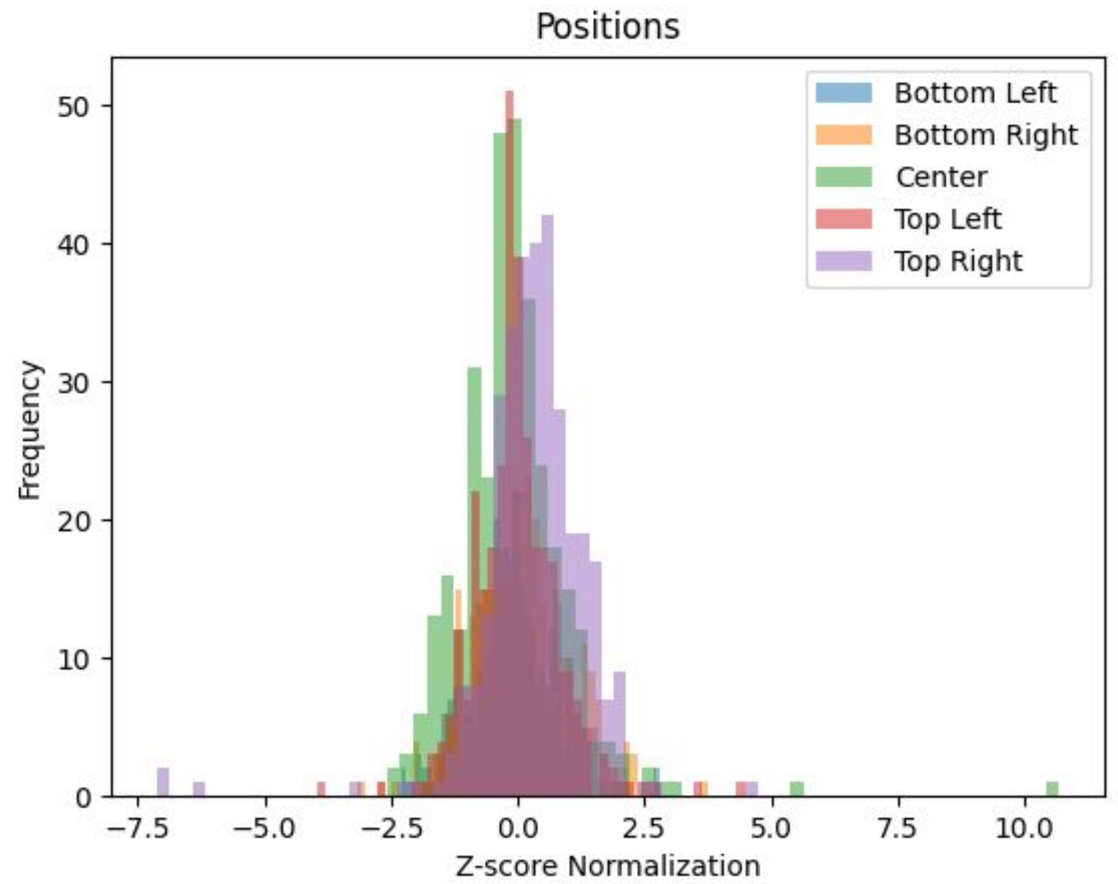
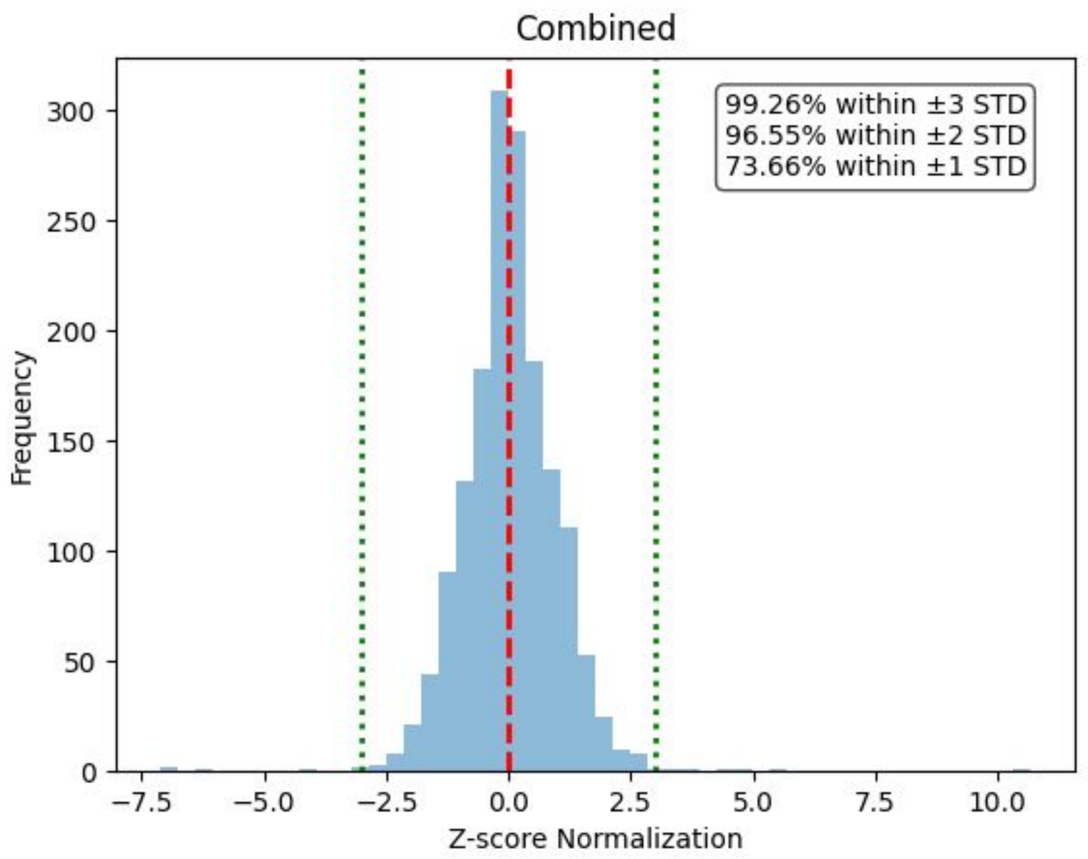
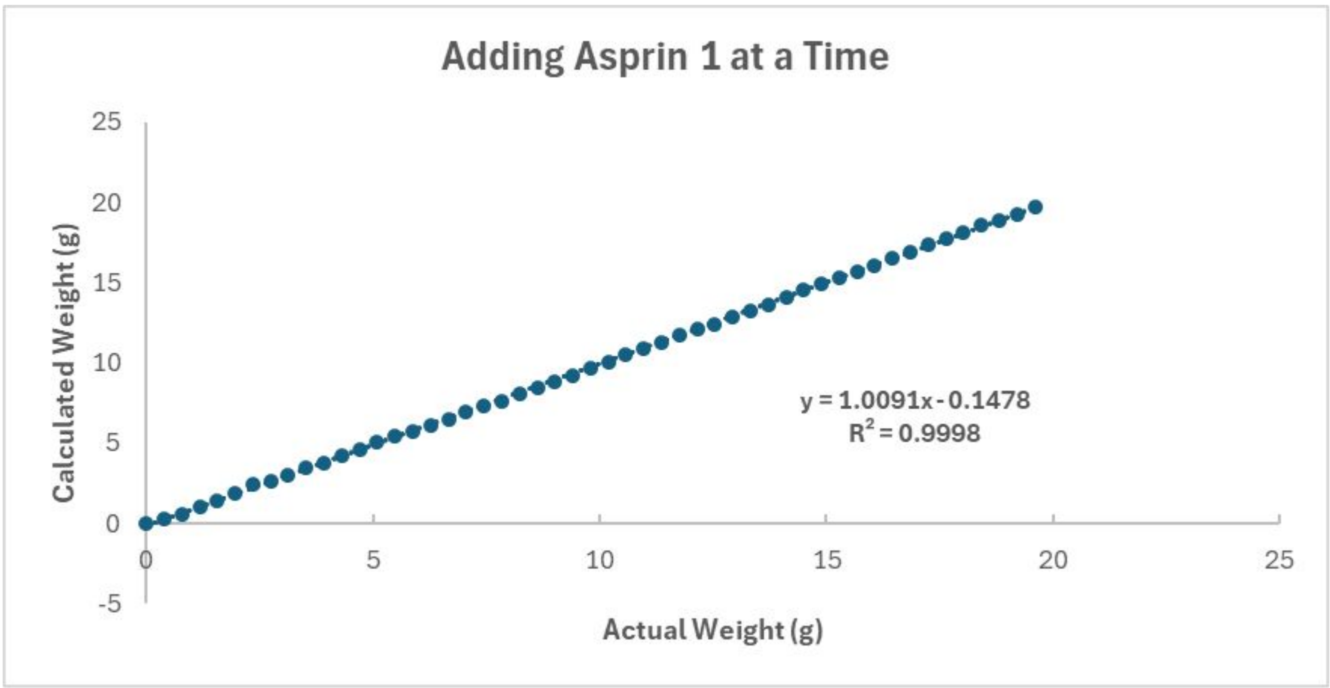


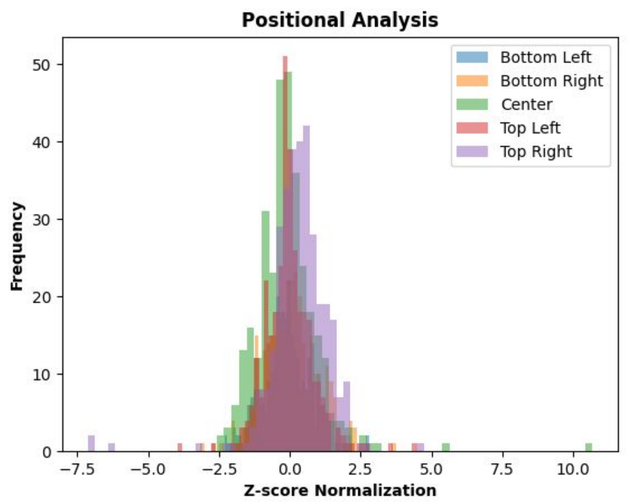


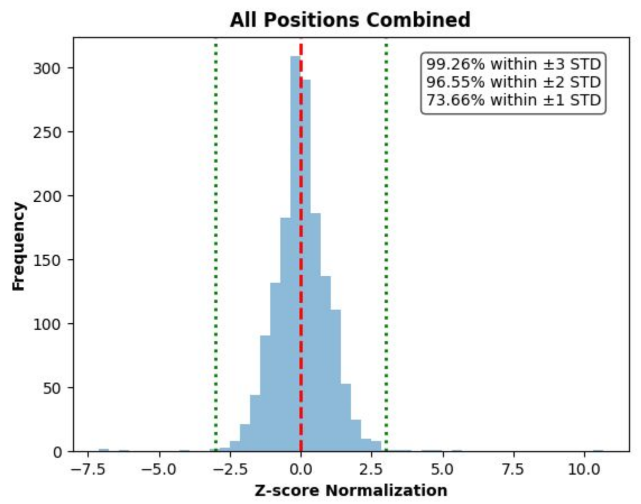


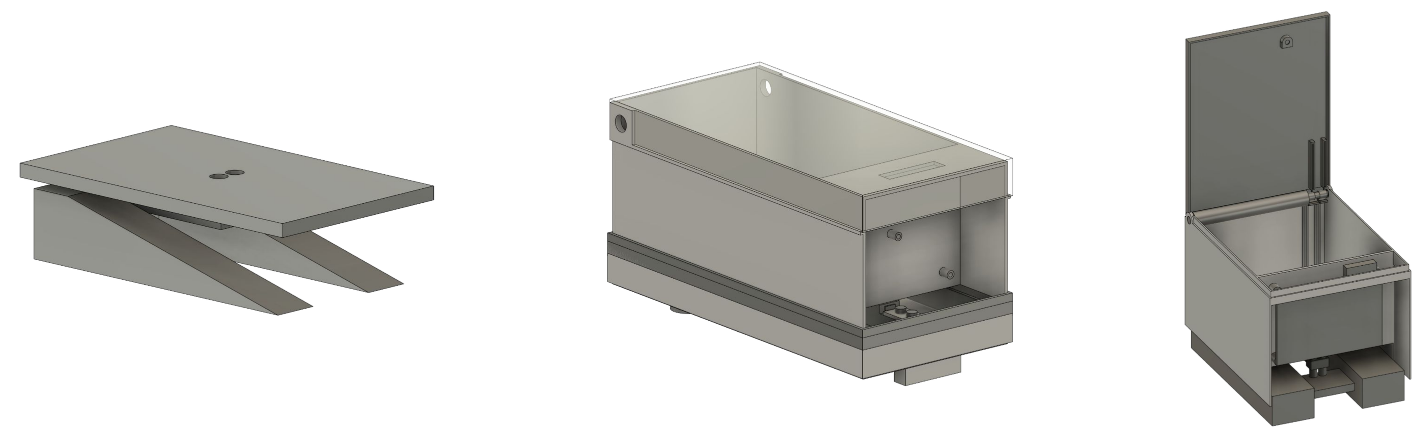












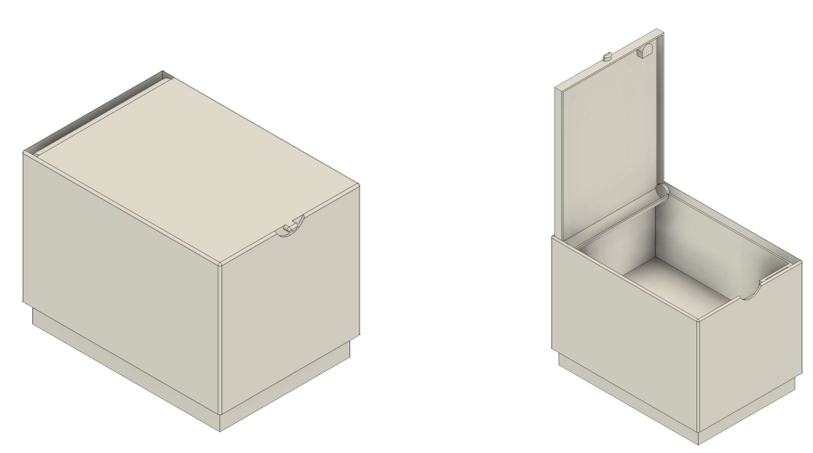


Figure 2: Labeled Fusion model of closed and opened drug cabinet

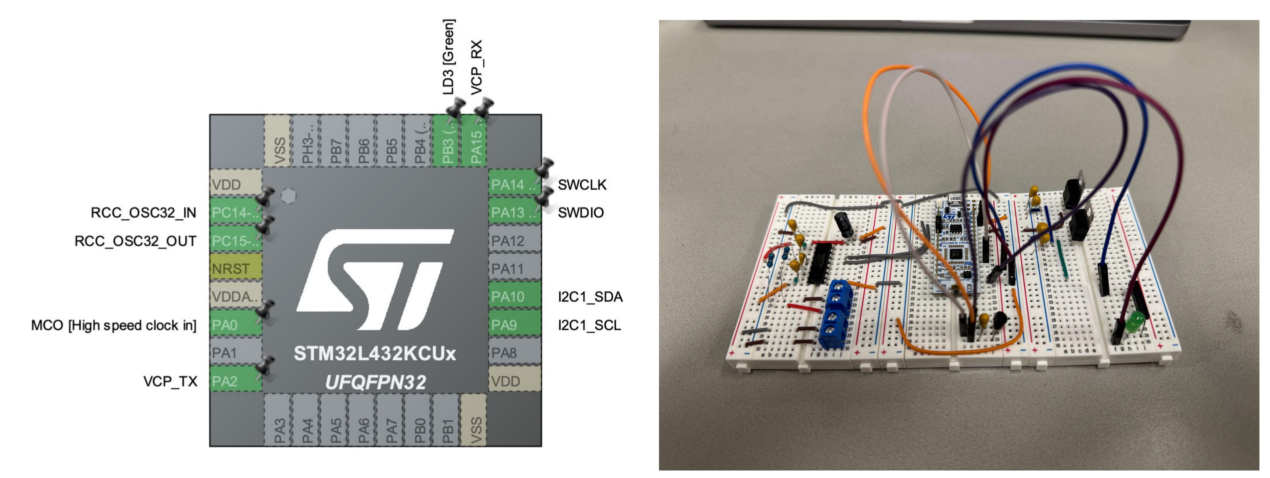
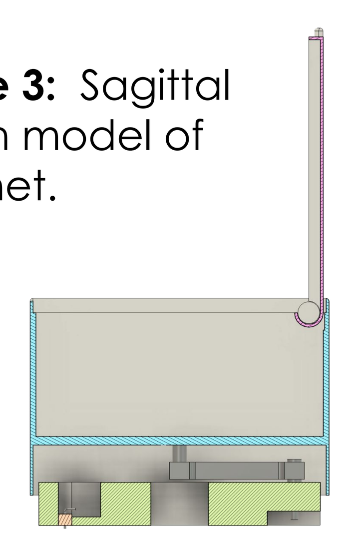


Figure 5: Microcontroller schematic and physical prototype

Figure 3: Sagittal Fusion model of cabinet.



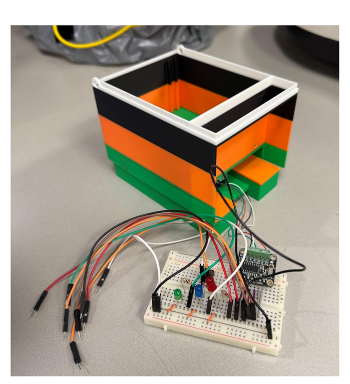


Figure 4: Physical prototype of cabinet

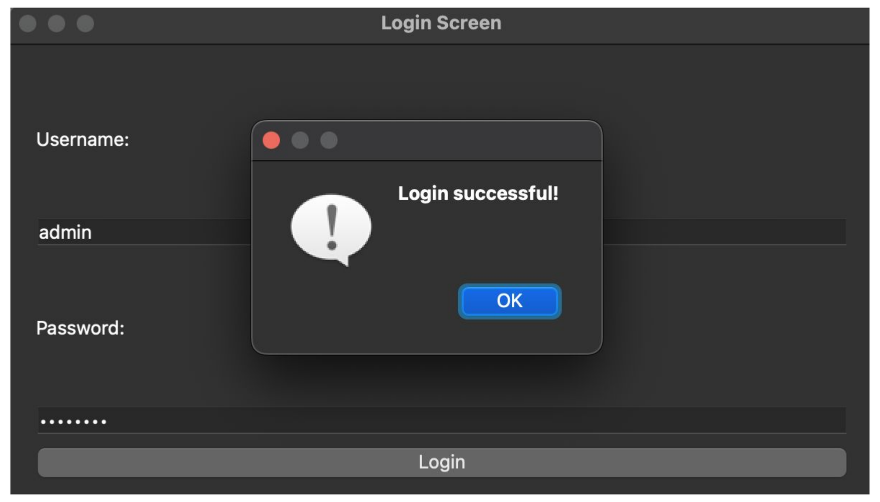


Figure 6: Medication management software GUI