Critical Design Review

Smart Pill Box

Oklahoma State University

Senior Design Spring 2023

Overview

Introduction
Project Description
Constraints
Electrical Components
- Parts

Software Design
- Frontend & Backend

Hardware Design
- Design I, Design II, and Alternatives

Design Analysis & Decision Matrix
Testing and Experimentation
Project Plan
Risk Management
Hazard Analysis
Cost
Work Distribution
Questions

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2/2/2023

Team Introductions and Roles

Hardware Manager:
- Zarek Rooker
  E.E & C.E.

Assignment:
- Point of Contact
- Hardware
- Electronics

Circuit Designer:
- Zahra Alnahwi
  E.E

Assignment:
- Component Research
- Hardware
- Electronics

Backend Dev:
- Stephen Fransen
  E.E

Assignment:
- Software
- Server Building

UI Designer:
- Daniel Jacobs
  C.E.

Assignment:
- Software
- User Interface

Project Description

Project Vision:

The main vision of this project is to provide an efficient and safe way to manage medication for elderly patients, especially those with cognitive decline, memory loss, and visual impairments. The Smart Pill Box (SPB) can help them to take medication correctly and on time, reduce medication errors, and provide a better way for caregivers to monitor the medication adherence. The SPB can also provide a more convenient, user-friendly, and cost-effective solution compared to other existing solutions.

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Design Constraints

Specifications

1. Store medicine for 7 days and for morning, noon, and evening
2. Lock/Unlock mechanism for medication
3. User interface with a touch screen
4. Speaker to remind the user to take medication
5. Camera to capture images of the user taking medication
6. Send notifications to caregivers upon completion of medication-taking
7. Store medication data in a remote cloud server

Optional:

1. Recognize pill types and quantity through images taken by the camera (optional)
2. Support user authorization through face recognition or fingerprint (optional)Multiple Compartments to store medicine

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Consideration and Constraints

Statistics to Consider:

- Average Adult takes 4 prescription medication
- More than four in ten older adults take five or more prescription medications

Target Audience:

- Elderly Patients

Considerations:

- Ease of use: The design should be intuitive and easy to operate, allowing elderly users to quickly and easily access their medication
- Lower risk of medicine contamination
- Lower risk of accidental ingestion of medication
- Accommodating for all

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Consideration and Constraints

Environmental:

- Energy efficient.
- Recyclable/Compostable

Sustainability:

- Long life span
- Refurbish/Reusable

Global:

- Meets regulatory standards
- Meets safety and performance requirements

Health:

- Safe for Use
- Properly Locking
- List Medications

Social:

- Accessible and useable for all

Ethical:

- Ethically produced and sourced

Safety:

- Electrical shock or fire
- Sharp edges & hazards

Cultural:

- Appropriate for target audience

Professional:

- Meets industry standard

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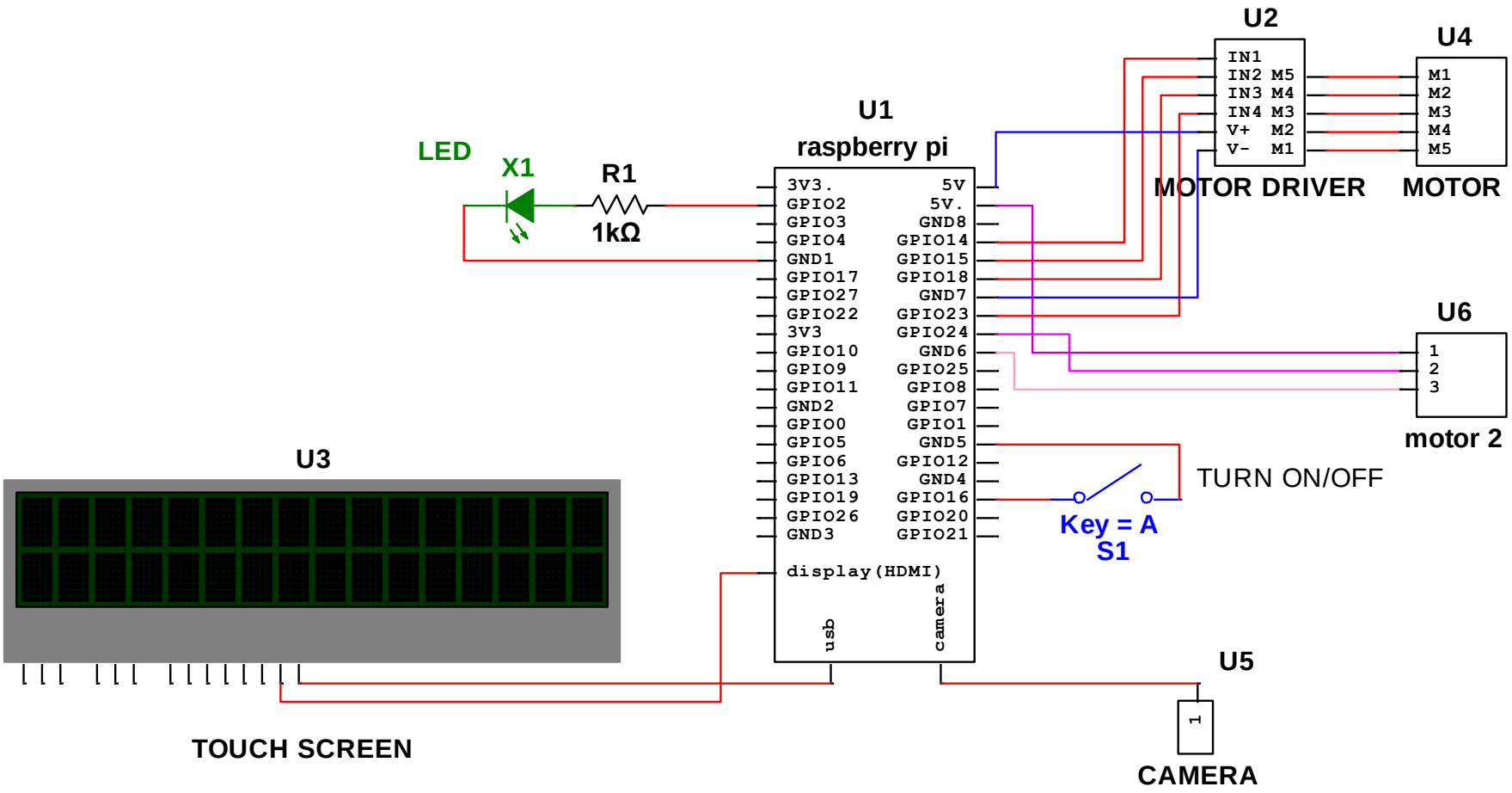
Schematic



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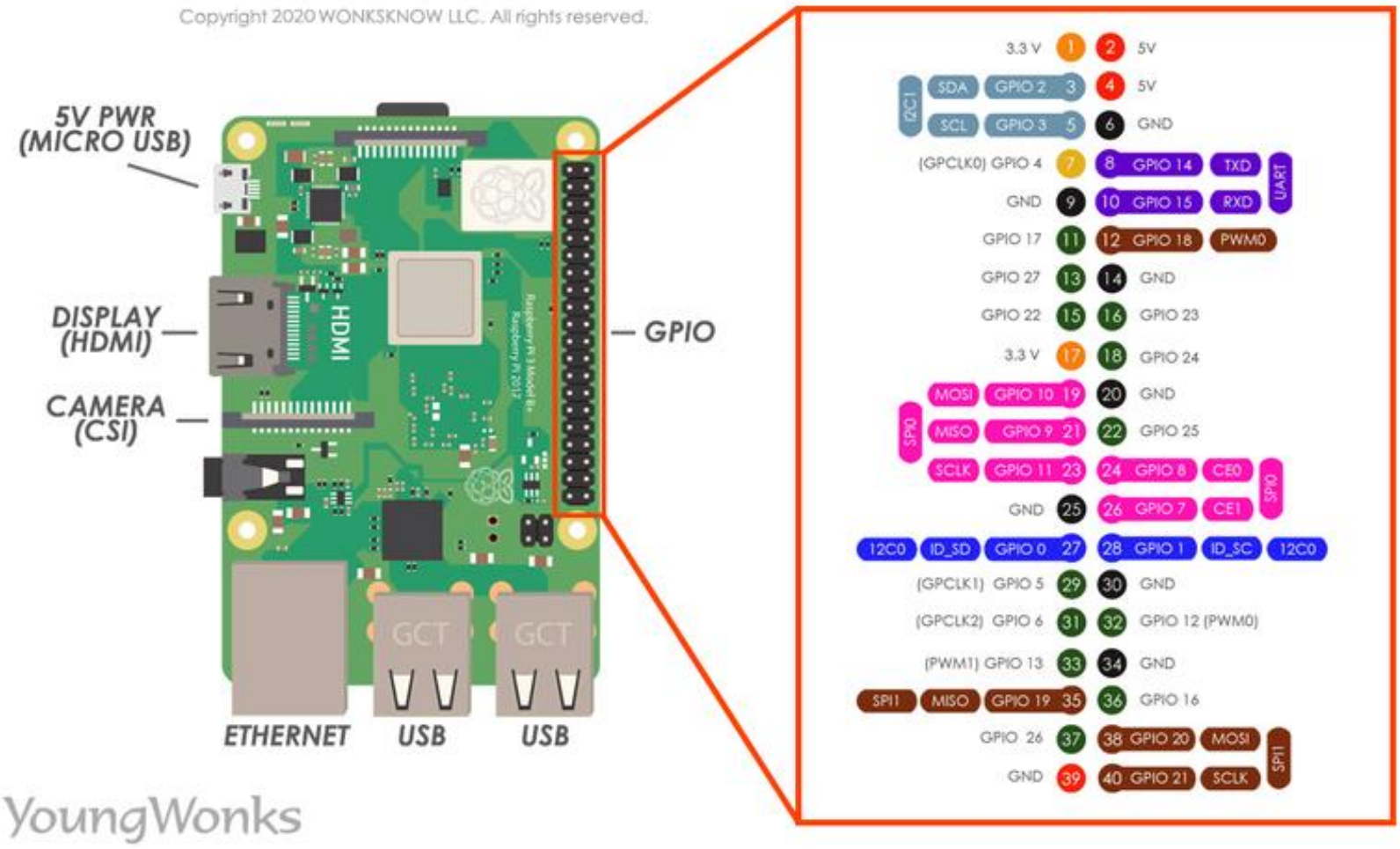
Pins Layout



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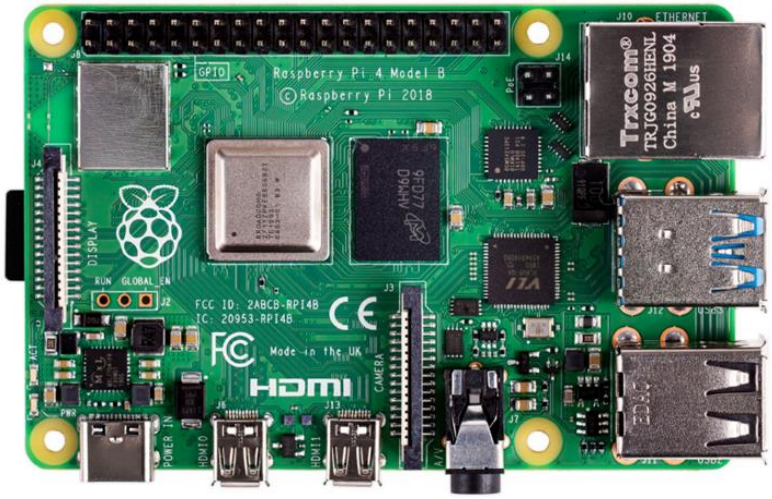
Microcontroller

RASPBERRY PI 4B/4GB

- Can run on 5V/3A DC or 5.1V/ 3A DC
- 40 Digital I/O Pins
- Each GPIO pin could output up to 16mA at 3.3 V
- All GPIO pins together should not exceed 50mA
- Programmed using python



$149

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Touch Screen and Speaker

5” Touch screen

- Touchscreen IPS Display 800x480 USB Powered HDMI Monitor
- Built-in Speaker & Stand for Raspberry Pi Jetson Nano Win PC
- Unite weight : 8.1 ounces

1 x HDMI to Micro HDMI Connector (for RPI 4B)

1 x USB to Micro USB Connector (for RPI 4B)

$61.99

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Camera

Raspberry Pi Camera Module 3

- Power consumption : 0.4 W – 1.4W
- The camera uses power supply from the Raspberry Pi
- Resolution: 11.9 megapixels

$25

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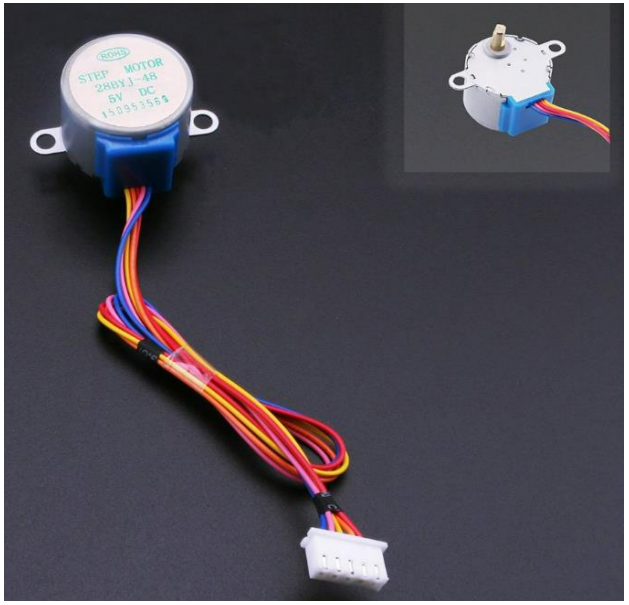
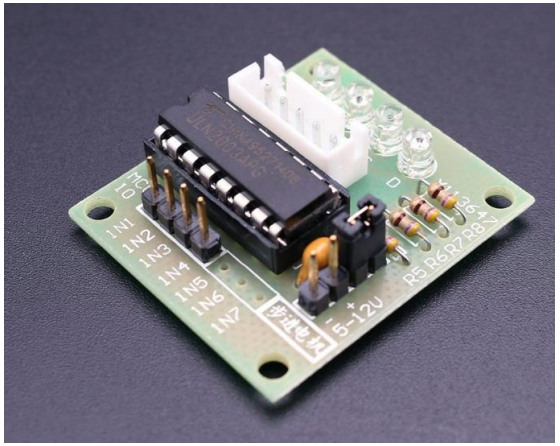
Motor 1

Stepper Motor

- The motor will connect to the driver motor
- The motor and the driver need 5V input
- Both draw 240mA
- Unite weight : 10.4 Ounces





$14.99

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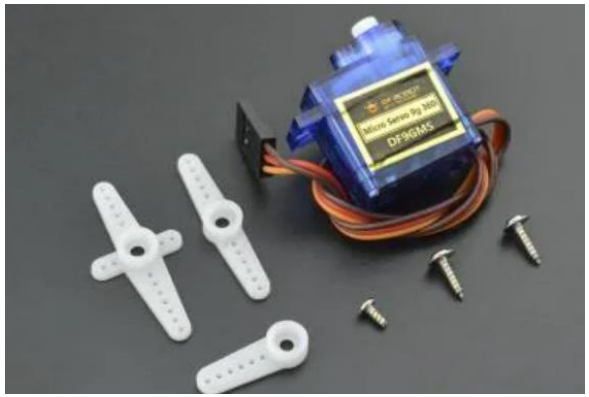
Motor 2

DFRobot Accessories TowerPro SG90C 360 Degree Micro Servo

- the motor need 5V input
- The motor draw 100 – 250mA
- Unite weight : 0.352740 oz



$4

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LDE

- 1K Ohm resistor
- LED

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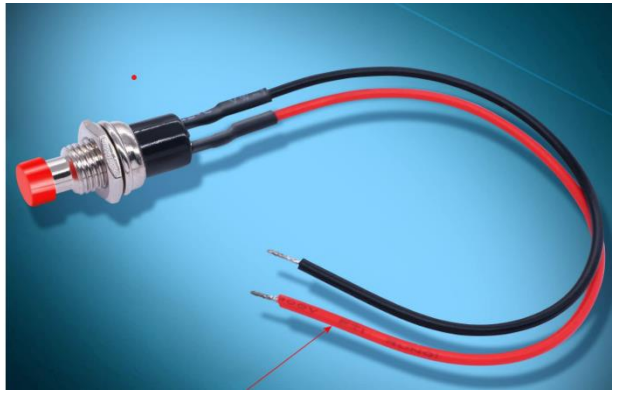
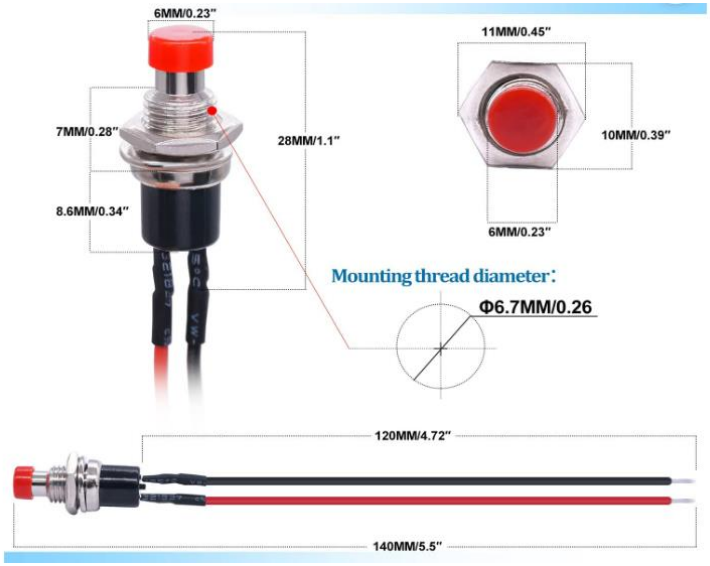
Button Turn on/off

Push Button Switch

- Current Rating : 1A
- Operating Voltage : 250V
- Contact : normally Open
- Brand : Push Button





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Power

Official Raspberry Pi Power Supply 5.1V 3A with USB C - 1.5 meter long

$7.98

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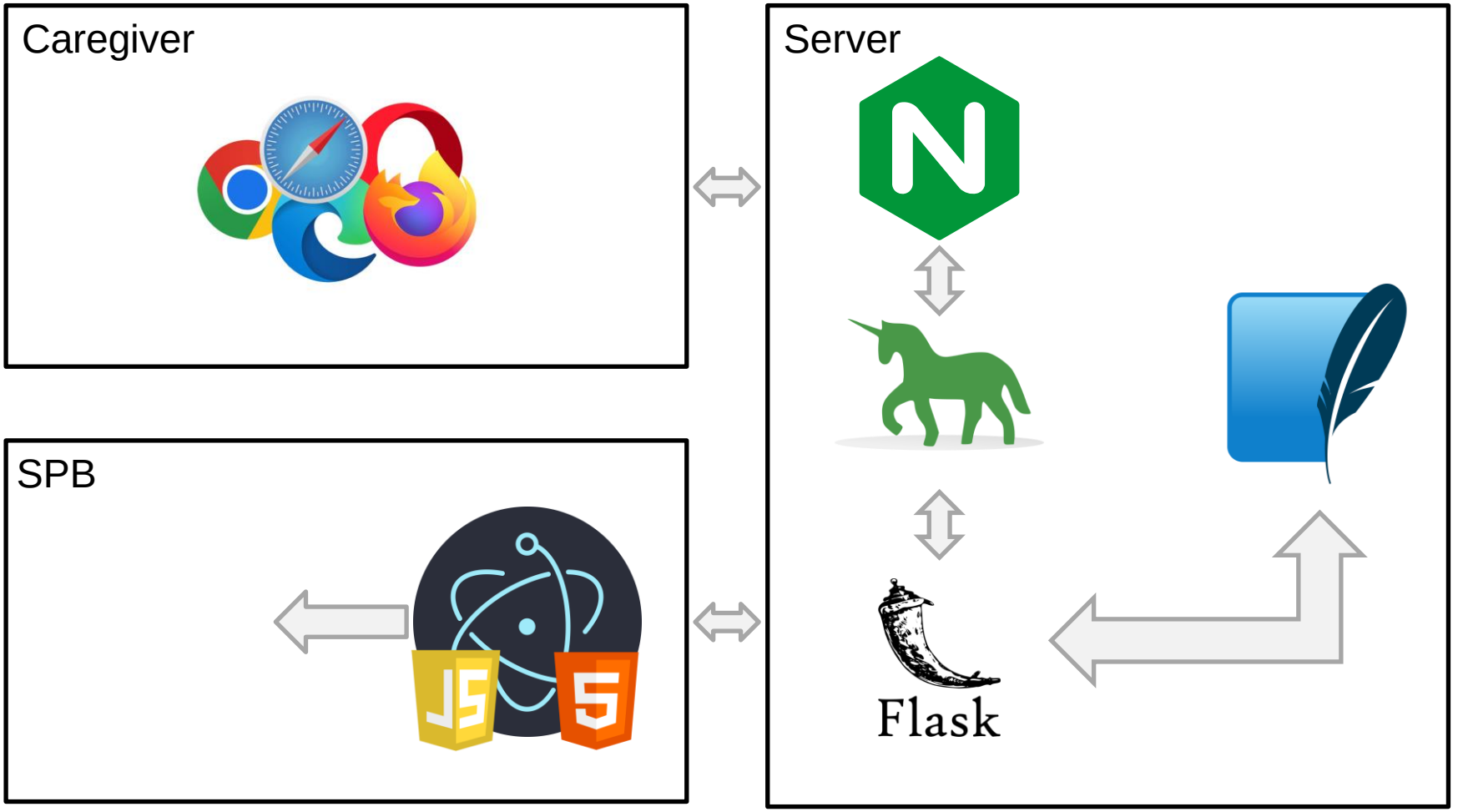
Software Design



User Interface Design

Desired Outcome:

- Simplicity
- Easy to Use

Required Features:

- Touch screen
  - Use it to unlock and access pills
- Take photos before and after
  - Saved in database (remote cloud server)
- Notification sent to caregiver after completion

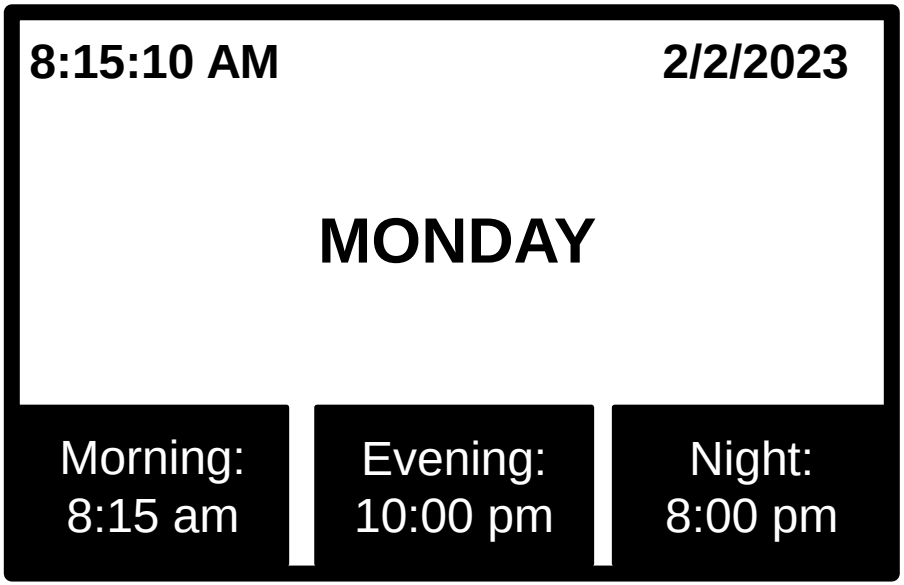
Concerns:

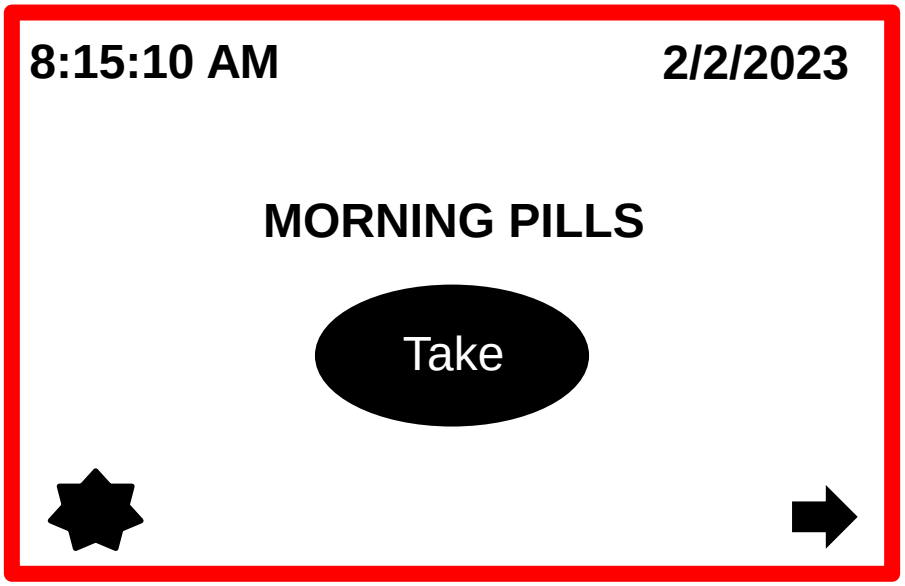
- Missed Medication
  - Beep for 20 Minutes
  - Notify Caregiver

User Interface Design

Always on Display:

- Date
- Time
- Schedule Time





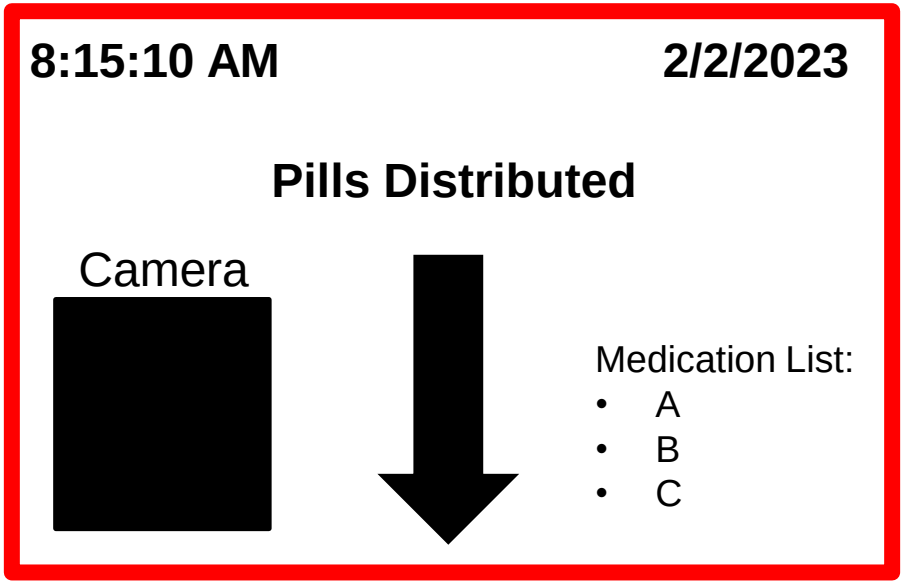
Alert Display:

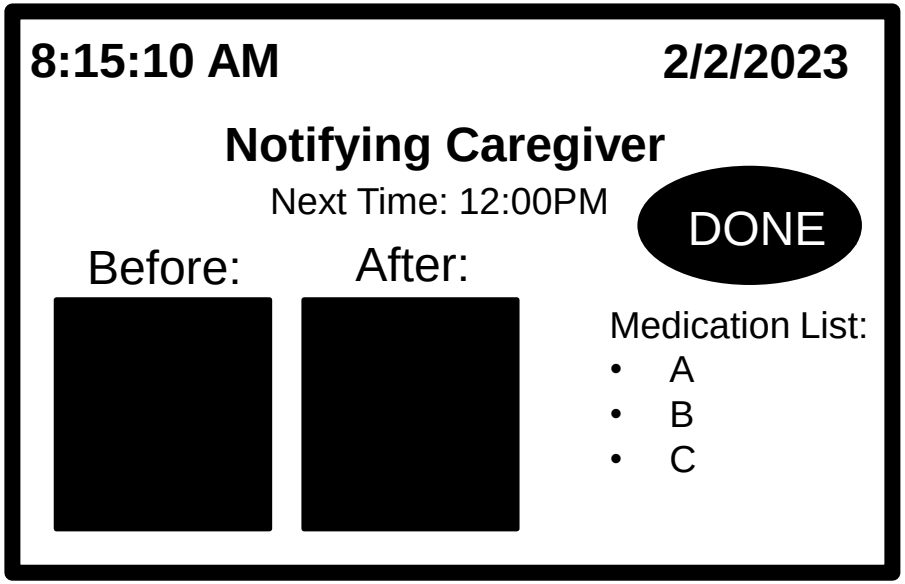
- Unlocks on Interaction
- Settings
- Snooze Alarm
- Time
- Schedule Time

User Interface Design

Distribution Display:

- Medication List
- Live Camera View
- Unlocks on Interaction





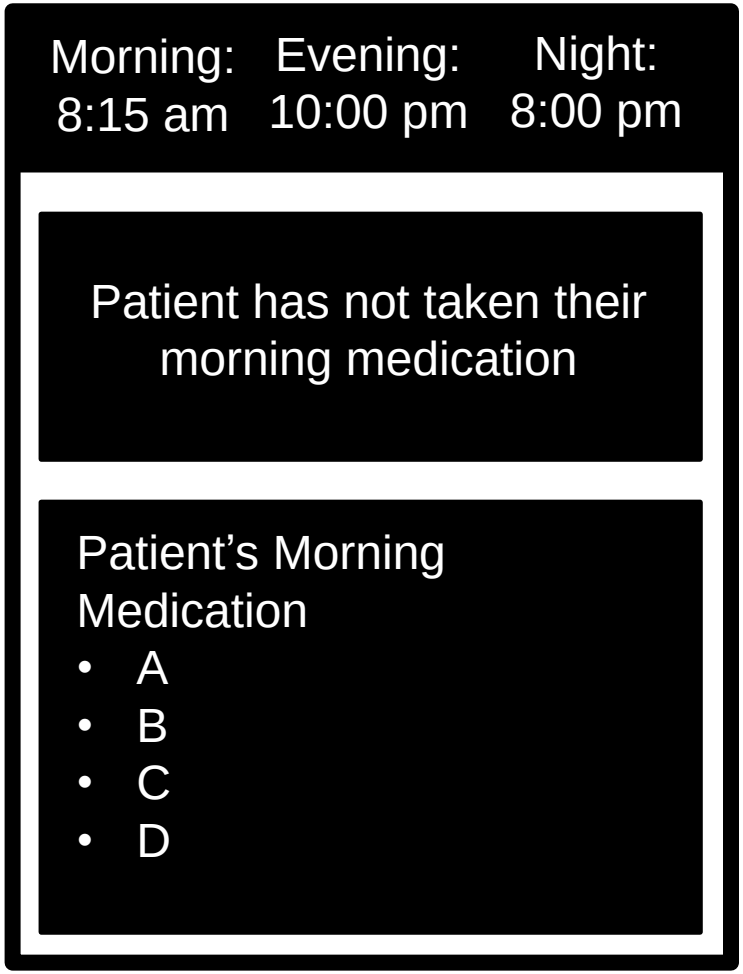
Acknowledgement Display:

- Confirmation Message
- Next Medication Time
- Medication List
- Before & After Picture

Web Application Features

Web/Phone Application

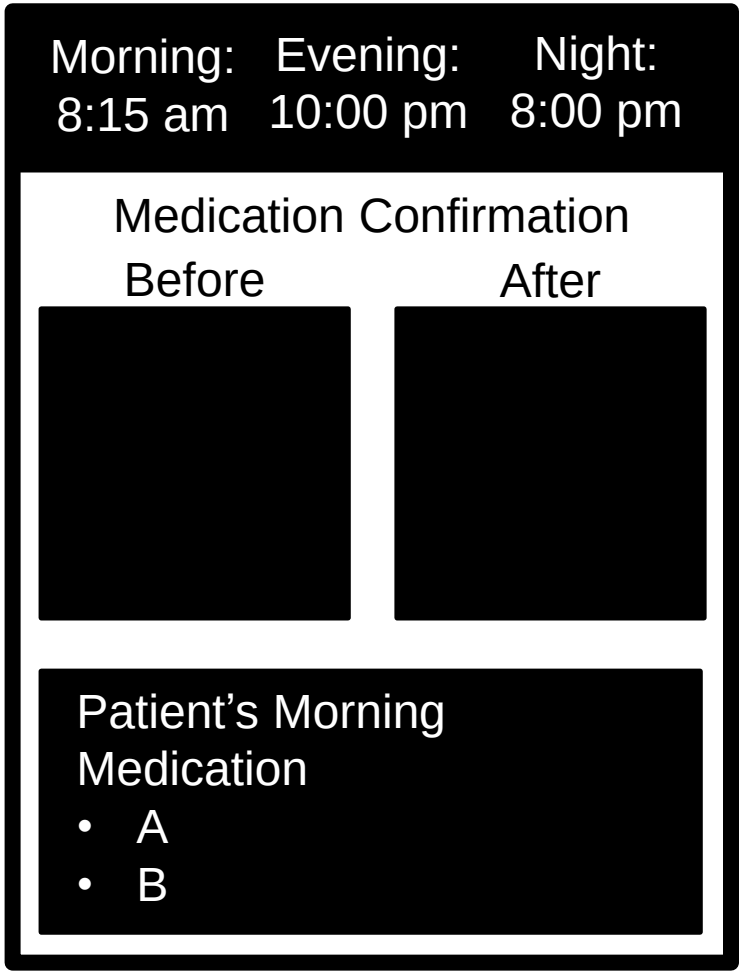
- Medication Notifications
  - Notified if patient has/has not taken their medication yet
  - List patient's medication for upcoming period



Web Application Features

Web/Phone Application

- Medication Notifications
  - Notified if patient has/has not taken their medication yet
  - List patient's medication for upcoming period
- Medication Confirmation
  - Confirm patient has taken medication
  - Check on patient's current condition



Final Design Expectation

Features:

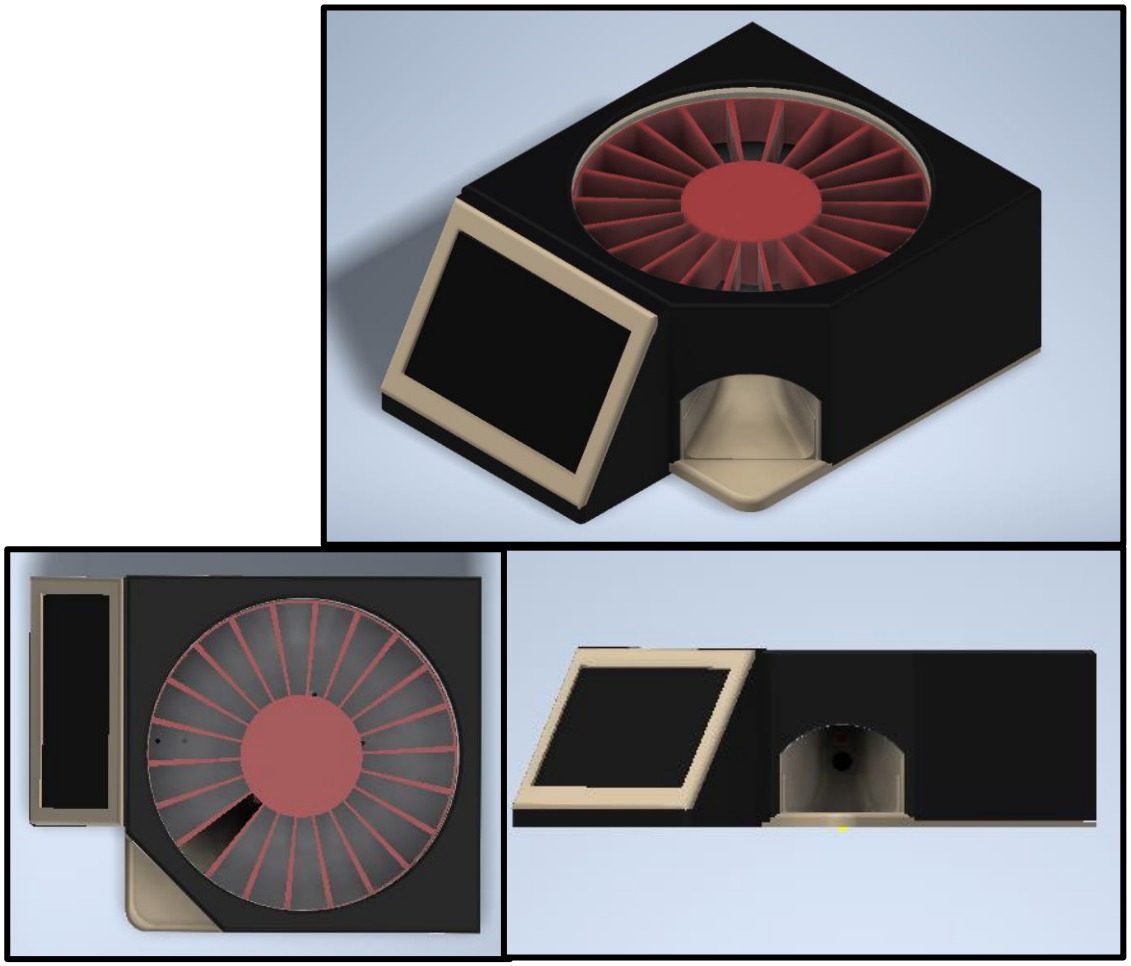
- Rotating Disk Capsules
- Clear Locking Lid
- Mass Loading
- Physical Labels
- 7 Day Supply

Size:

- 10” x 4” x 8”

Main Components:

- Capsule Piece
- Lid
- Dispenser
- Touchscreen Housing
- Overall Housing



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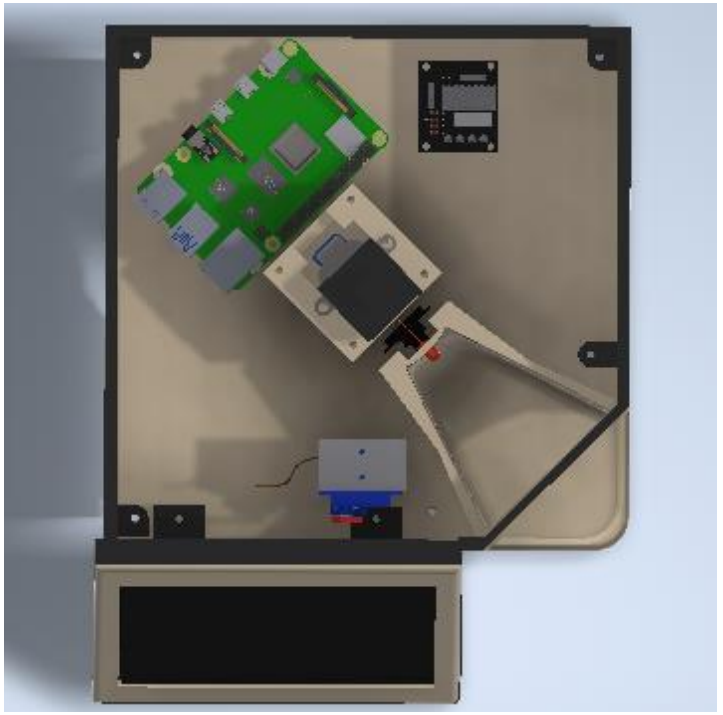
Electronics/Mechanics

Features:

- Camera in Dispenser
- Secured Raspberry Pi
- Stepper Motor & Servo Motor
- LED in Dispenser
- Touch Screen

Parts Not Shown:

- Wires
- Pi Fan
- Power button/Reset Switch
- Power Cord
- Screws (#4-40)



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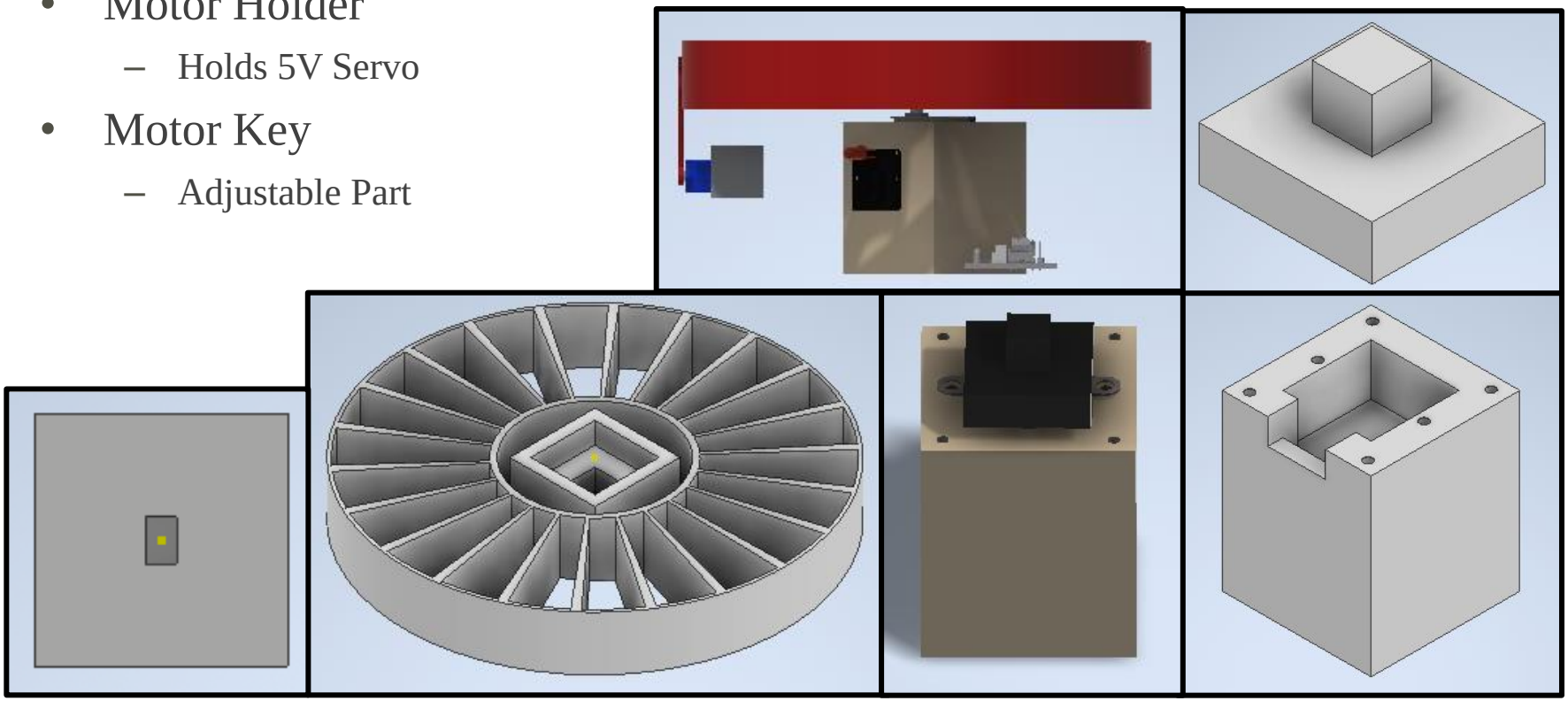
Rotating Capsule

Features:

- Rotating Capsule
  - 22 Compartments
- Motor Holder
  - Holds 5V Servo
- Motor Key
  - Adjustable Part



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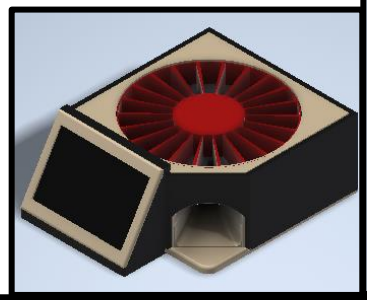
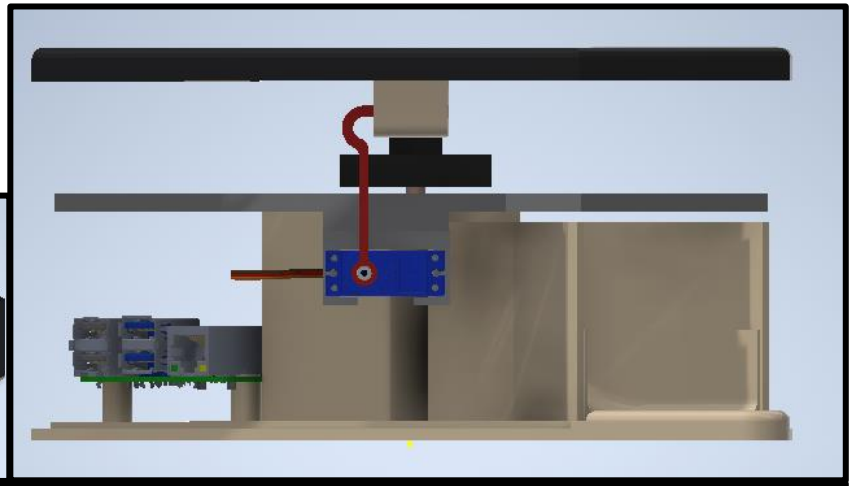
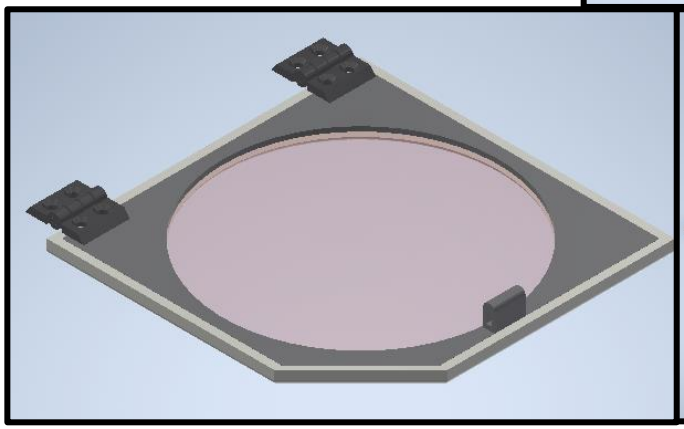
Lid & Locking Mechanism

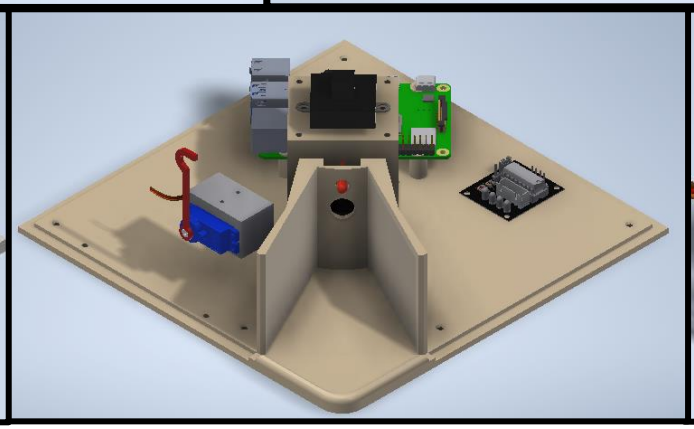
Features:

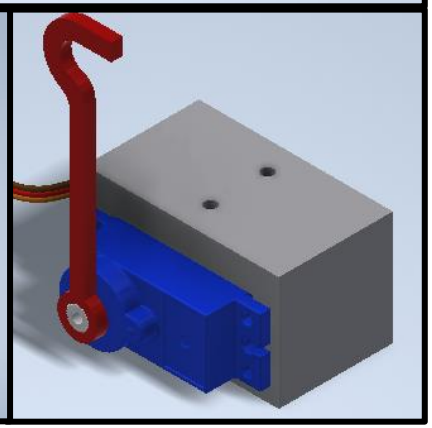
- Locking Mechanism
  - Simple Hook Design
  - Touchscreen Control
- Three Separate Parts
  - Clear Portion
  - Top Lid
  - Lid Support











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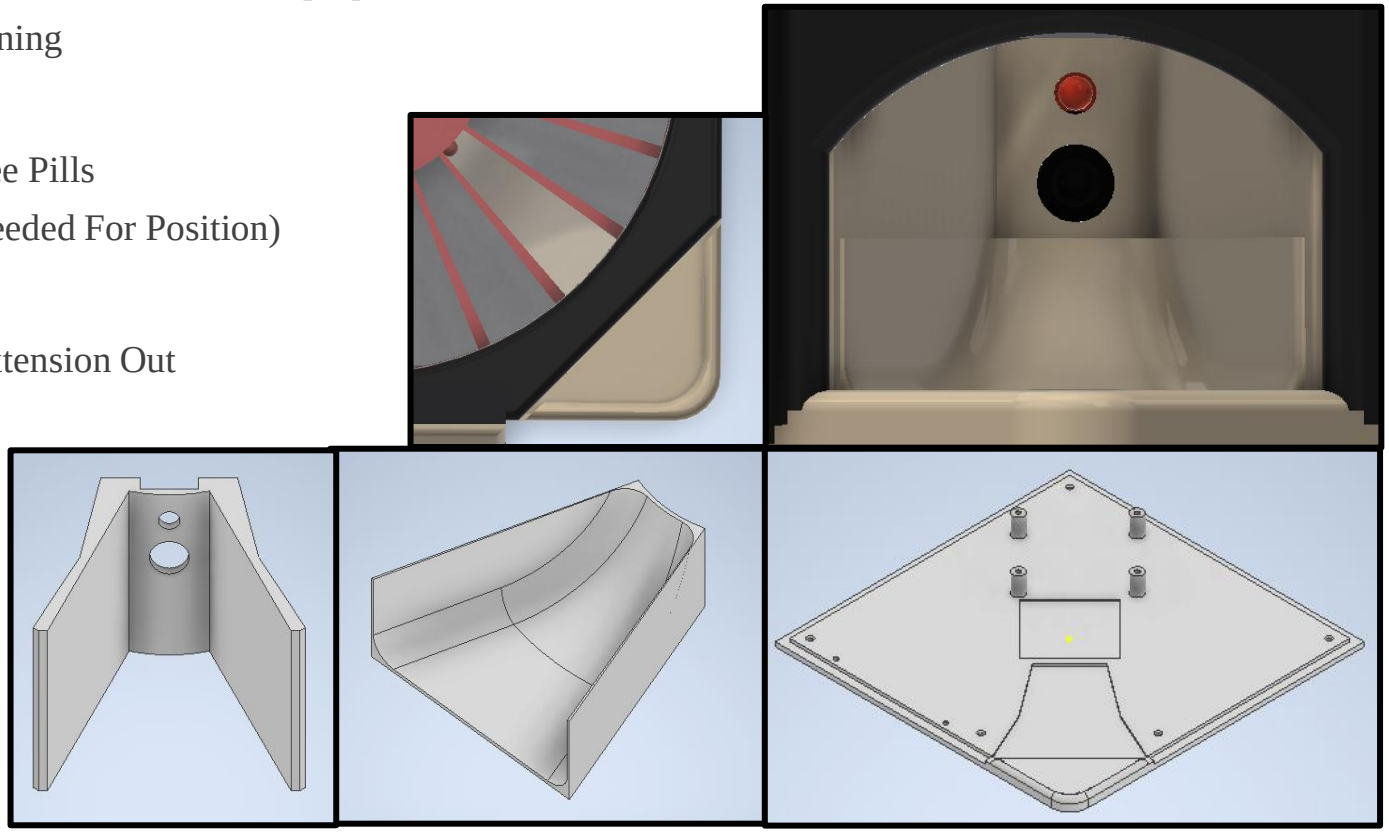
Dispenser/Tray

Features:

- Dispenser
  - Baseplate, Camera Holder (Drop Spot)
  - 3 Inch Opening
- Camera
  - Tilted to See Pills
  - (Testing Needed For Position)
- Slide/Tray
  - 1.5 Inch Extension Out
- LED



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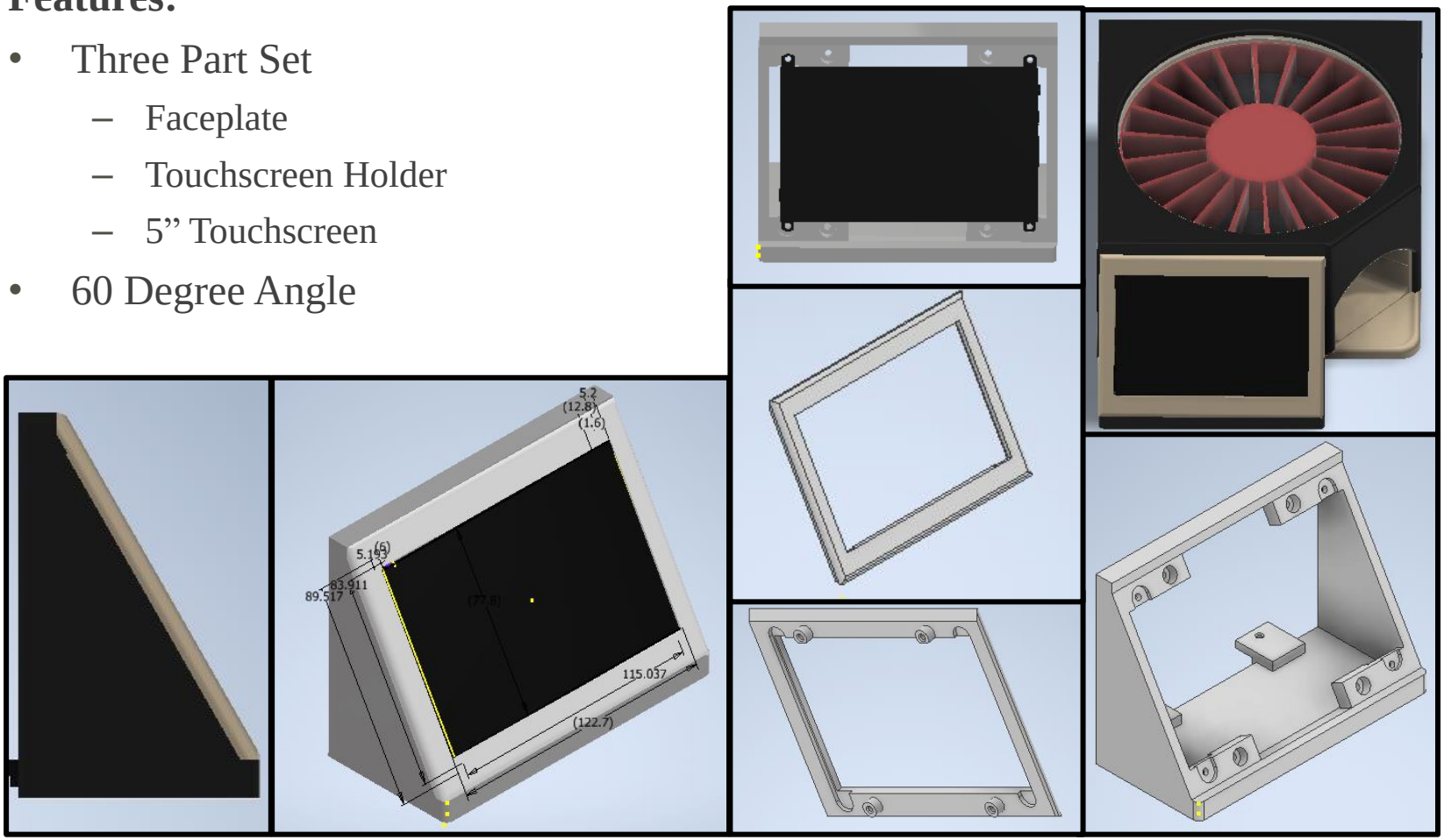
Touchscreen Housing

Features:

- Three Part Set
  - Faceplate
  - Touchscreen Holder
  - 5” Touchscreen
- 60 Degree Angle



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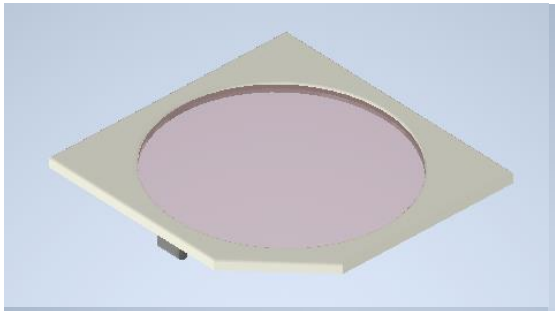
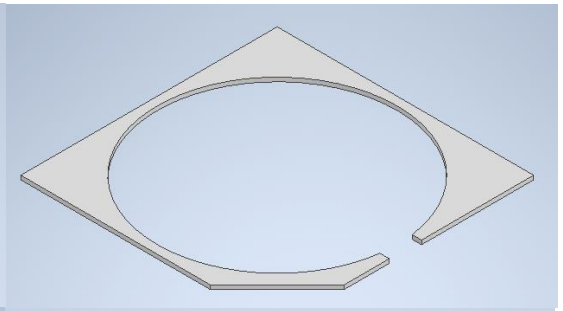
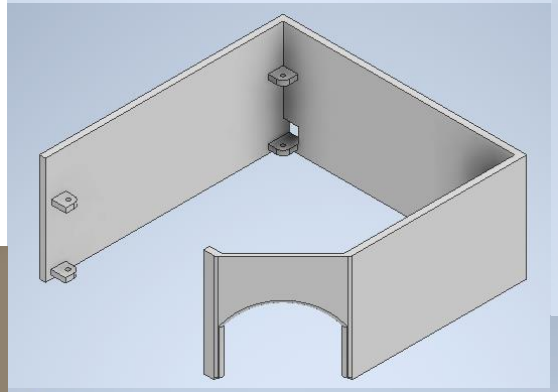
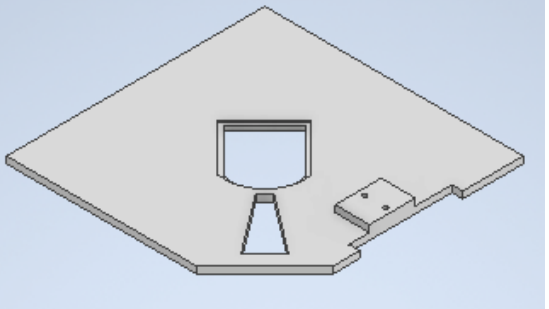
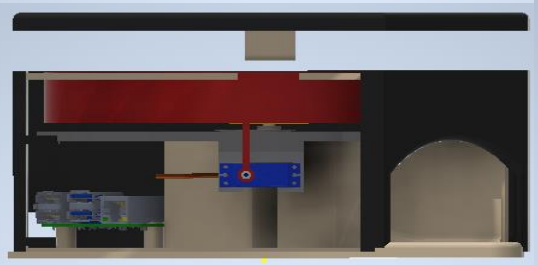
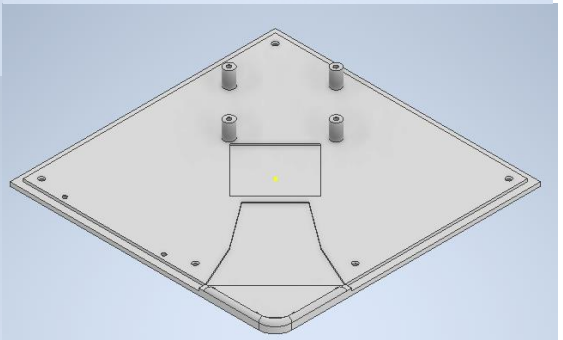
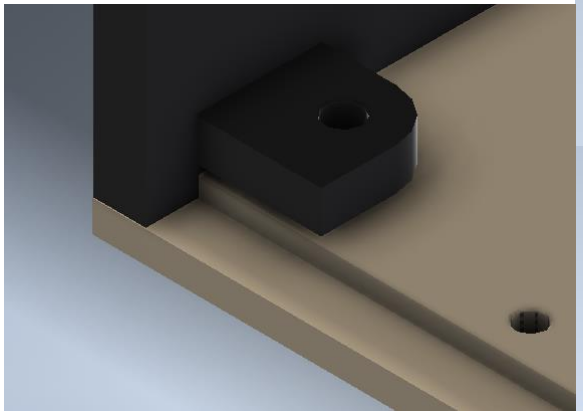
Overall Housing

Features:

- Walls
- Baseplates (3)
  - Top Plate
  - Drop Plate
  - Base Plate
    - Rubber Feet
- Connection Points

Hardware Overview

Components:

- Total Parts ~16

Hardware Testing Done:

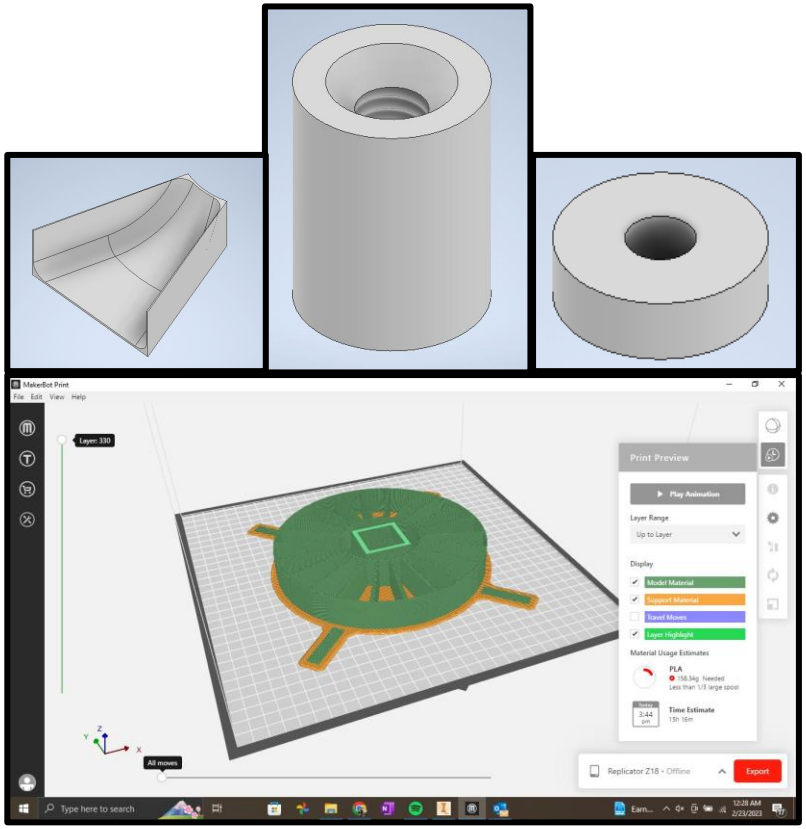
- Tested Motor Torque
- Motor Key Fitting, Screw Fitting, Bolt Fitting
- Parts Printed:
  - Rotating Capsule
  - Motor Holder

In Progress:

- Fabrication
- Alignment For Models
- Fixing Small Model Errors
- Supports Lid Base

To Do:

- Camera Position, Tray Piece Testing



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Design Cost Analysis

Parts:	**Cost:**	**Parts:**	**Cost:**
Raspberry Pi 4B	$200	Screws/Bolts/Nuts	$7.8
Pi Cord	$8	Cable USB	$6.12
Touchscreen	$100	Cable HDMI	$3.00
Camera	$25	Hinge(2)	$4.53
Stepper Motors	$22	SD Card	$10.81
Servo Motor	$4		
Ball Bearings (4)	$1	**Total Cost:**	$399.26

Future Contingency Costs: >$50

Contingencies: 30-50%

Testing and Experimentation

Hardware Testing:

- Unit testing
  - What does each part do? Does it accomplish that function?
  - What are some design constraints?
- Integration testing
  - Do parts fit together?
  - How does the system as a whole function?

Electrical testing:

- Unit testing
  - Are individual components functional?
  - Can we make the components behave as desired?
  - Are the components a good fit to accomplish the task?
- Integration testing
  - Do the parts work well together?

Software Testing:

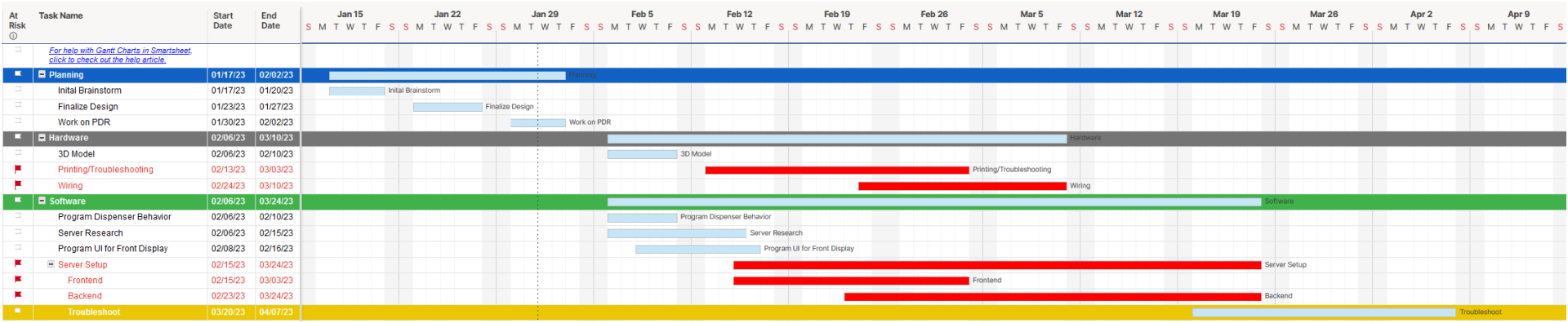
- Unit testing
  - Server communication?
  - UI?
  - Backend?
- Integration Testing
  - Does the backend handle inputs from the front end correct?
  - Does the information transfer between the server and the smart pillbox correctly?

Daniel Jacobs
2/2/2023

Project Plan

	Planning	**01/17/23**	**02/02/23**
	Inital Brainstorm	01/17/23	01/20/23
	Finalize Design	01/23/23	01/27/23
	Work on PDR	01/30/23	02/02/23
	Hardware	**02/06/23**	**03/10/23**
	3D Model	02/06/23	02/10/23
	Printing/Troubleshooting	02/13/23	03/03/23
	Wiring	02/24/23	03/10/23
	Software	**02/06/23**	**03/24/23**
	Program Dispenser Behavior	02/06/23	02/10/23
	Server Research	02/06/23	02/15/23
	Program UI for Front Display	02/08/23	02/16/23
	Server Setup	02/15/23	03/24/23
	Frontend	02/15/23	03/03/23
	Backend	02/23/23	03/24/23
	Troubleshoot	**03/20/23**	**04/07/23**

Project Plan



At Risk	Task Name	Start Date	End Date
	For help with Gantt Charts in Smartsheet, click to check out the help article.		
	Planning	01/17/23	02/02/23
	Inital Brainstorm	01/17/23	01/20/23
	Finalize Design	01/23/23	01/27/23
	Work on PDR	01/30/23	02/02/23
	Hardware	02/06/23	03/10/23
	3D Model	02/06/23	02/10/23
	Printing/Troubleshooting	02/13/23	03/03/23
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	Software	02/06/23	03/24/23
	Program Dispenser Behavior	02/06/23	02/10/23
	Server Research	02/06/23	02/15/23
	Program UI for Front Display	02/08/23	02/16/23
	Server Setup	02/15/23	03/24/23
	Frontend	02/15/23	03/03/23
	Backend	02/23/23	03/24/23
	Troubleshoot	03/20/23	04/07/23

Stephen Fransen
2/2/2023

Risk Management

Impact

Likelihood	Negligible	Minor	Moderate	Significant	Severe
Very Likely	3D Printer Failure				
Likely				Server/Networking Issues	
Possible	Motor Failure	Selected Parts are Unavailable	Broken Parts/Screens		
Unlikely				Design Does Not Meet Specification	
Very Unlikely					

Hazard Analysis

Wrong Drug Dosage: Smart pill boxes may have inaccurate dosages if users forget to double-check their input or if the machine malfunctions

Mitigation Strategy:

Keep and display a record of all medications taken and dosages.

Malfunctioning: The smart pill box may malfunction due to programming errors, hardware issues, or power outages, leading to incorrect prescriptions being dispensed.

Mitigation Strategy:

Regularly check and maintain the device to ensure it is functioning properly. Implement a redundancy system that can detect any errors and alert the user.

Zarek Rooker
2/2/2023

Hazard Analysis

Accidental Overdose: Overdose of medication due to incorrect dosage settings or incorrect usage of the device.

Mitigation Strategy: Educate users on how to use the device correctly, including instructions on how to set the dosage, and provide an emergency contact number in case of accidental overdose. The smart pill box should be programmed to alert the user if too many doses are taken in a day.

Security and privacy risks: Data stored on the device may be accessed by unauthorized users.

Mitigation Strategy: Utilize encryption technology to protect user data from being accessed by unauthorized users and to prevent data tampering. Additionally, provide a secure login system with password protection.

Zarek Rooker
2/2/2023

Presentation Work Disbursement

Zarek- Description**,** Design Constraints, Considerations, Hardware Design (I & II), Hazard Analysis

Zahra- Parts Research, Price Research , and Schematic

Stephen- Risk Management, Software Design, Project Plan, Web Application Features

Daniel – Testing, Decision Matrix, and Experimentation

Questions?

References:

Prescription drug statistics 2022 (singlecare.com)

Medication overload and older Americans - Lown Institute