Critical Design Review

ECEN 4024: Smart Pill Box Team

Spring 2023

Report Presented by:

Zarek Rooker

Daniel Jacobs

Zahra Alnahwi

Stephen Fransen

Advisors:

Dr. Weihua Sheng, Joel Quarnstrom (GA), Su Zhidong (GA)

Electrical and Computer Engineering

Oklahoma State University

Table of Contents

1. Team 4
1.1. Team Structure 4
1.2. Advisors 4
2. Problem Objective 4
3. Design Constraints 4
3.1. Performance Constraints 4
3.2. Economic Restraints 5
4. Ethical Responsibilities 5
4.1. Global 5
4.2. Economic 5
4.3. Societal 6
4.4. Environmental 6
5. Design Details 6
5.1. Electrical 6
5.1.1. Microcontroller/ Microprocessor 6
5.1.2. Motors 8
5.1.3. Camera 10
5.1.4. Touch Screen and Speaker 11
5.1.5. Power Supply 12
5.1.6. Power Button 13
5.1.7. Power Indicator: 13
5.1.8. Power Consumption: 14
5.1.9. Circuit Schematic Diagram: 15
5.2. Hardware 16
5.2.1. Introduction 16
5.2.2. Overall Design 16
5.2.3. Rotating Capsule 17
5.2.4. Lid & Locking Mechanism 18
5.2.5. Dispenser & Tray 18
5.2.6. Touchscreen Housing 19
5.2.7. Overall Housing 20
5.3. Software 20
5.3.1. Front-End 20
5.3.2. Back-End 21

6. Testing Strategy and Results 21
   6.1. Electrical 21
   6.2. Hardware 21
   6.3. Software 22
      6.3.1. Front-end 22
      6.3.2. Back-End 22
7. Cost 22
   7.1. Cost Breakdown 22
   7.2. Parts List 23
      7.2.1. Electrical Parts 23
      7.2.2. Hardware Parts 23
8. Scheduling 24
   8.1. Initial Schedule 24
   8.2. Current Schedule 24
9. Risk Management 24
10. Report Contributions 25
11. References 25

1. Team

1.1. Team Structure

- Zarek Rooker
  - Role: Hardware Manager & POC
  - Assignment: Hardware Design, Electronic Testing
- Zahra Alnahwi
  - Role: Circuit Designer:
  - Assignment: Electronic Design & Testing
- Stephen Fransen
  - Role: Backend Dev
  - Assignment: Software, Server Building
- Daniel Jacobs
  - Role: UI Designer:
  - Assignment: Software, User Interface

1.2. Advisors

The project is advised by Dr. Weihua Sheng and Graduate Assistants Joel Quarnstrom and Su Zhidong. Both graduate assistants offer advice and explanation. Joel offers advice in hardware design and testing while Su assists in electronic and software advice.

2. Problem Objective

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.

3. Design Constraints

3.1. Performance Constraints

The following specifications are the main driving point for our design throughout this document. Optional specifications are also listed below.

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)

3.2. Economic Restraints

The design of the smart pill box should be cost-effective and accessible for customers. A hard budget of $1000 has been allocated to research and development for our project. To keep research and development within budget, our team aims to reduce the cost to around $500 to allow for potential contingency costs.

4. Ethical Responsibilities

4.1. Global

Global responsibilities for a smart pill box include meeting regulatory standards, safety requirements, and performance requirements. The pill box must ensure that it is compliant with all applicable laws and regulations and must be certified as meeting the applicable safety and performance requirements.

4.2. Economic

The economic responsibilities associated with a smart pill box are significant. It is important that the device is affordable for those who need it. This means that the device must have a low development cost to allow for appropriate production cost. Additionally, the device must be made with high-quality materials that will last for a long time.

4.3. Societal

The ethical responsibility for using these statistics is to ensure that elderly patients have access to their medications, are aware of how to use and manage them, and can take them safely. Additionally, the design should be intuitive and tailored to the elderly user to reduce the risk of medicine contamination and accidental ingestion. Lastly, it is important to provide education on how to use and manage medications, as well as the potential side effects, so that elderly patients can make the best decisions for their health.

4.4. Environmental

The user should also be aware of the materials used to make their Smart Pill Box. Our Smart Pill Boxes will be made with PLA, which is a biodegradable material. To protect the environment, the other materials used should be either biodegradable or recyclable. In addition, the Smart Pill Box should reduce the amount of energy used. The device should strive to utilize the lowest amount of energy possible. This will help to reduce energy waste and protect the environment.

5. Design Details

5.1. Electrical

5.1.1. Microcontroller/ Microprocessor

When it comes to the microcontroller/ microprocessor choice, two options were considered: Arduino and Raspberry Pi. While both are great for such projects, the Raspberry Pi would be more suitable for this one for some reasons. Firstly, the Raspberry Pi has a superb processing power (~16 GHz) than the Arduino (~16MHz). Secondly, when it comes to data transfer, the Raspberry Pi can transfer the data via SD Card, USB, or FTP whereas the Arduino can only do so via the flash of the microcontroller. Thirdly, the Raspberry Pi can connect easily to the Internet with Ethernet or WiFi while most Arduino boards do not support the Internet without extra modules. Lastly, unlike the Arduino, the Raspberry Pi can run multiple applications at the same time. For those reasons, the Pi would be the best choice.

Furthermore, the Raspberry Pi has many models, and each model has its pros and cons. The chosen model is Raspberry Pi 4 Model B 2019 Quad Core 64 Bit WiFi Bluetooth (4GB)**(Figure 5.1.1)**. Its specifications are:

1. Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1. 5GHz---4GB LPDDR4-2400 SDRAM
2. 2.4 GHz and 5. 0 GHz IEEE 802. 11B/g/n/ac Wireless LAN, Bluetooth 5. 0, double-true Gigabit Ethernet
3. 2 × USB 3. 0 ports, 2 x USB 2. 0 Ports---2 × micro HDMI ports supporting up to 4Kp60 video resolution
4. 2-lane MIPI DSI/CSI ports for camera and display--4-pole stereo audio and composite video port--Micro SD card slot for loading operating system and data storage

What distinguishes this model from others is the fast processor, more and faster RAM, dual micro HDMI ports and the 4k output. As shown in the Circuit Schematic Diagram section, the raspberry pi will be controlling the camera, motors, touch screen, power switch, and power indicator.

Figur.5.1.1. Raspberry Pi 4 Model B

5.1.2. Motors

When it comes to the motors selection, this is actually one of the challenging parts. The main goal is to choose a strong motor that can withstand the load of the rotating capsule disk. The Stepper motor - NEMA-17 was chosen at first **(Figure 5.1.2)** with its HAT **(Figure 5.1.2)** . A major challenge was faced and that is the motor needs a separate power supply. To solve that, 4 solutions were considered.

1. to use 2 separate wall plugs (1 for the Pi, the other for the motor). This was not a suitable solution for it is not convenient to have 2 wall plugs for the same machine.
2. to use 1 wall plug and battery pack. Although this solution is better than the first, it was still not a desired option because the goal is to use only 1 power supply to make it more convenient for the user.
3. to use 1 AC to DC converter that has 2 outputs (1 for the Pi and the other for the motor). Similarly to the previous solutions, this was not a desired option for the converter has a huge size and adds more cost.
4. after more research, it was finally found that motors with low drawn current, strong enough to handle the rotating capsule disk, and does not require a separate power supply exist. This motor shown in **(Figure 5.1.3)** comes with a motor driver board that gets connected to the Pi (does not require another power supply). Furthermore, another servo motor **(Figure 5.1.4)** will be used for the locking mechanism. The servo motor does not need a separate power supply nor a motor driver board. Both motors will be powered by the Pi. The power consumption of both motos is shown in the Power Consumption Section below.

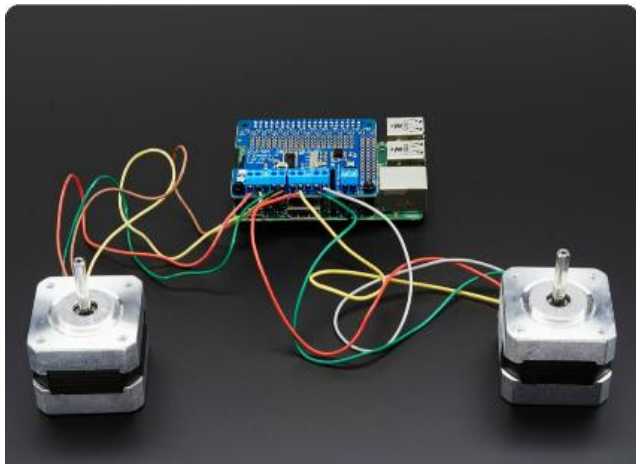


Figure 5.1.2. Stepper Motor NEMA with Hat

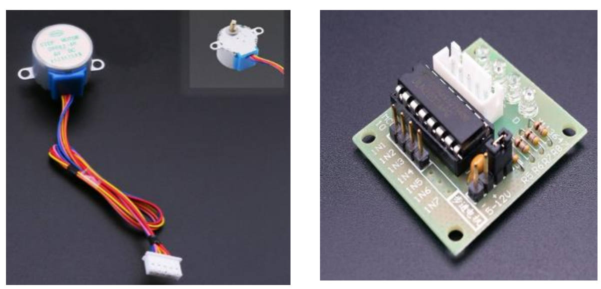


Figure 5.1.3. Stepper Motor with Driver

Figure 5.1.4. Servo Motor

5.1.3. Camera

One of the requirements of the project is to capture images of the user taking the medication. To achieve that, the Raspberry Pi Camera Module 3 **(Figure 5.1.5)** is used. It is the latest compact camera for the Raspberry Pi. Some of its features are:

1. Back-illuminated and stacked CMOS 12-megapixel image sensor (Sony IMX708)
2. High signal-to-noise ratio (SNR)
3. Phase Detection Autofocus (PDAF) for rapid autofocus
4. Resolution: 11.9 megapixels
5. HDR mode (up to 3 megapixel output)
6. Low power consumption (1.25W max)

Figure 5.1.5. Raspberry Pi Camera Module 3

5.1.4. Touch Screen and Speaker

Another requirement is to have a user interface with a touch screen and to have a speaker to remind the user to take the medication. To achieve this, two options were considered. The first option is to have a separate touch screen and a speaker connected to the Pi. Another option is to use a touch screen with a built-in speaker. The second option is the chosen one for it's more convenient and more organized. The ELECROW Raspberry Pi Monitor 5 Inch Touchscreen, which has a built-in speaker **(Figure 5.1.6)** , is the chosen solution. The features that make this a great fit are:

1. Mini Screen for Raspberry Pi: 5 inch monitor
2. Support 800*480 resolution
3. Capacitive USB Touchscreen: simply power the USB touch port to achieve touch function and no need to install the driver
4. Support Speaker, Brightness & Volume Adjustment
5. Neat and Organized: all wires and connectors are hidden behind the screen

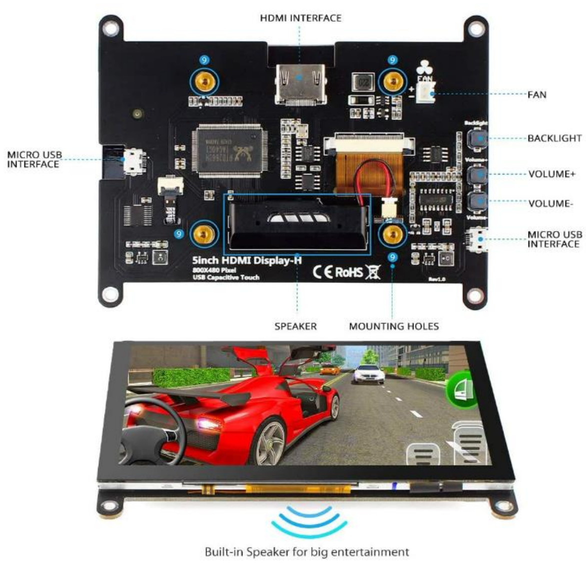


Figure 5.1.6. ELECROW Raspberry Pi Monitor 5 Inch Touchscreen with built-in speaker

5.1.5. Power Supply

For this project, it is necessary to choose a proper power supply that would be able to withstand the loads connected to the Raspberry Pi. Two options were considered. The first is using a battery and the other is using Official Raspberry Pi Power Supply **(Figure 5.1.7).** As far as using the battery, a Battery Management System (BMS) is needed which adds more complexity and cost to the design. Therefore, it was decided to use the Official Raspberry Pi 4 USB-C Power Supply. Its specifications are as below:

1. 5.1 Vdc
2. 3A
3. 15.3 W

As the power consumption calculations shown below in **Power Consumption Section**, the chosen power supply would be suitable.

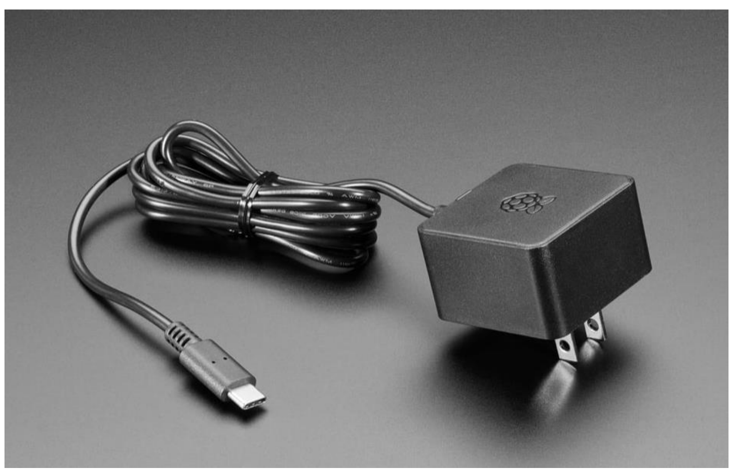


Figure 5.1.7. Official Raspberry Pi Power Supply 5.1V 3A with USB C

5.1.6. Power Button

The Raspberry Pi does not come with a built-in power switch. It is not recommended to just pull the power supply plug for the Pi because that might cause the SD card and the file system to be corrupted. The Raspberry Pi could be safely shut down via a software command. But to make it easier for the user, a power button will be used. By shutting down the Raspberry Pi, it is meant to put it in "Halt State" in which the Pi still uses very little power. The purpose of the power button is to put the Pi in the halt state and to wake the Pi from it. Moreover, the power supply could be safely disconnected once the Pi is on the Halt State. What is needed to make the power button work are: SPST NO switch, wires, and writing the code. To understand how the wake function works, simply by shorting pin 5 (SCL) pin with any GND pin wakes the Pi from the Halt State. The same pins will be used to shut it down. A script is written to listen for a button press to shut down the Pi. Edge detection method is used for this process. Basically, the Pi listens for an interrupt, which is the change in state from LOW to HIGH or HIGH to LOW. A method called "wait_for_edge" is used to block the execution of the script until an interrupt is detected. The GPIO pin is set up to shutdown the Pi once a Falling edge is detected. The power Switch shown in **(Figure 5.1.8).**

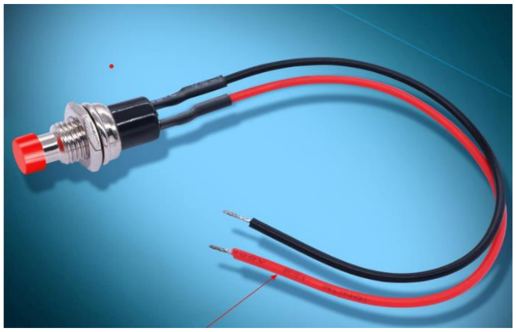


Figure 5.1.8. Push Button Switch

5.1.7. Power Indicator:

An LED in series with a resistor is connected to 1 GPIO pin and 1 GND pin that will indicate whether or not the Pi is on.

5.1.8. Power Consumption:

In this section, the power consumption for each part is calculated based on the data from datasheets of the parts. The table below shows the summary for that. As mentioned above in the **Component Section** The Official Raspberry Pi 4 USB-C Power Supply has an input of 5.1V, rated current of 3A, and max power consumption of 15.3W. It can be seen in the below table that the sum of the max drawn current and power consumption of each component did not exceed the limits.

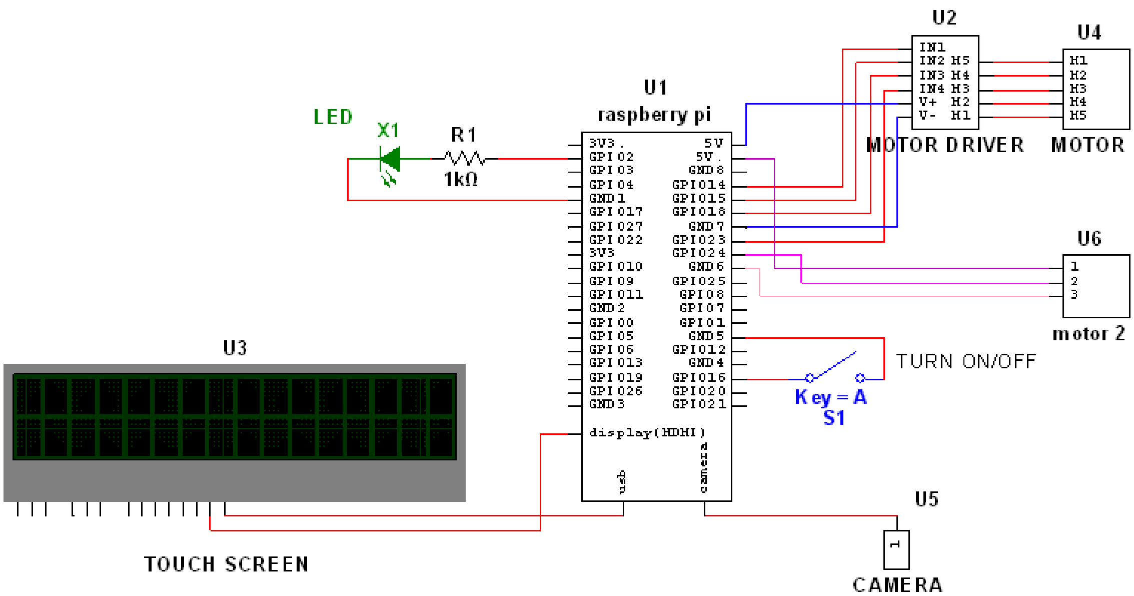
Part	**Voltage**	**Voltage Source**	**Max Drawn Current**	**Max Power Consumption**
1- Raspberry Pi	5.1 V	Official USB-C power supply	0.6A - 1.2 A	3.06W - 6.375 W
2- Camera	3.3 V	Raspberry Pi (Camera Connectors available)	0.2A - 0.25A	0.66W - 0.825 W
3- Touch Screen	5 V	Raspberry Pi (USB)	0.5A	2.5 W
4- Motor (Stepper Motor + Driver)	5 V	Motor Driver *Driver is power by Raspberry Pi (GPIO pins)*	0.24 A	1.2 W
5- Motor (Servo Motor)	5 V	Raspberry Pi	0.1A - 0.36A	0.5W - 1.8W
6- LED + Resistor	3.3 V	Raspberry Pi GPIO pins	0.002A - 0.01A	0.0066W - 0.033W

Total Estimated Max Power Consumption	**12.733W**

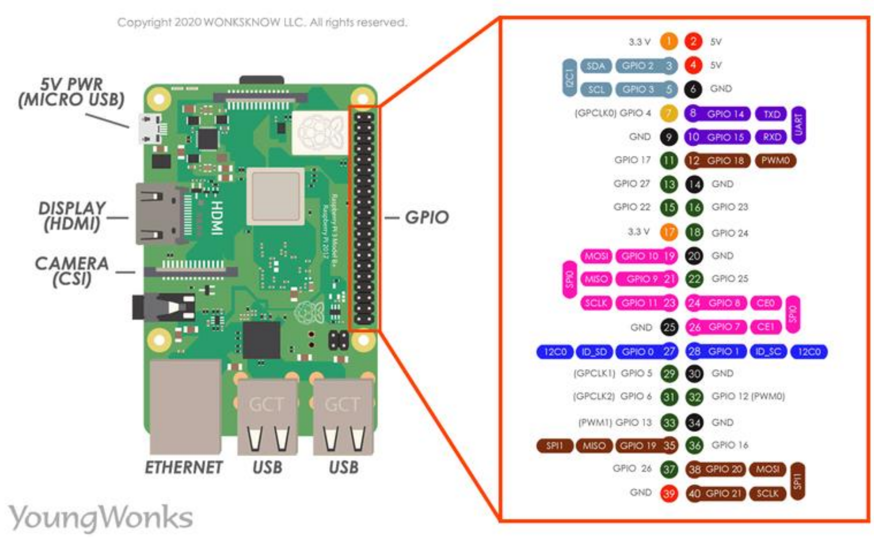
Total Estimated Max Drawn Current	**2.56A**

5.1.9. Circuit Schematic Diagram:

To make the circuit schematic diagram, Multisim software is used. Most of the parts in this project (Raspberry Pi, Motors, Touch Screen, Camera) cannot be found in Multisim. Therefore, using the Component Wizard tool in Multisim, a model for each component is created.



Pins Layout:



5.2. Hardware

5.2.1. Introduction

The hardware components have multiple different sections that make up its design. We must consider the compartments that hold the pills, the locking mechanism, the overall housing design, and how to properly secure the device. This section will be broken down into five main sections: the Rotating Capsule Piece, Lid, Dispenser, Touchscreen Housing, and overall Housing. Each component is designed to be intuitive and user-friendly, utilizing materials that are both aesthetically pleasing and durable to ensure that the device is secure and stable. Furthermore, the design of the Smart Pill Box ensures that the medication is easily accessible and can be quickly refilled when necessary.

5.2.2. Overall Design

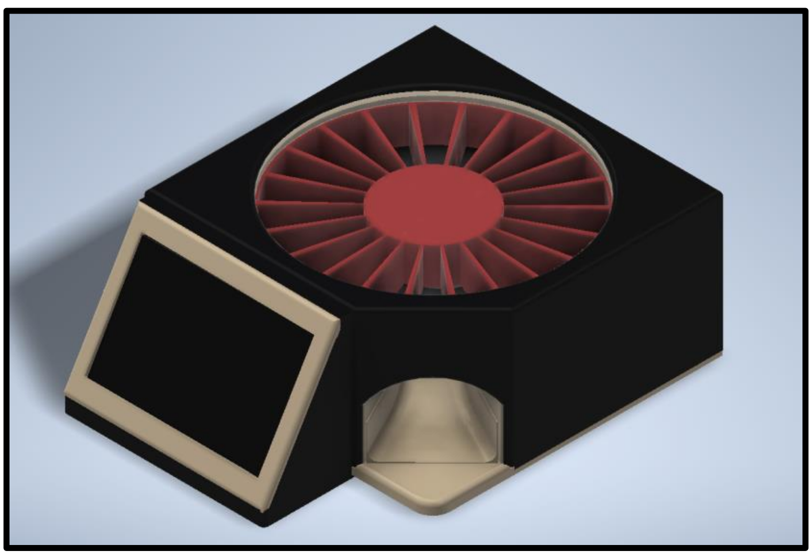


Figure 5.2.1: Overall Design

The overall design of the device can be seen in Figure 5.2.1. We will break down all the major components that make up the overall design, with a focus on visibility, easy loading, accessibility, and a 7-day supply. The dimensions of the design are 10" x 4" x 8" and the estimated weight is 3.283 lb. With this size, we can store more than 5 pills in one compartment, and loading is made easy with a lid that opens for mass loading. A touchscreen is featured on the front for user friendliness and the dispenser is clearly shown with an intuitive tray for the user to get pills from.

5.2.3. Rotating Capsule

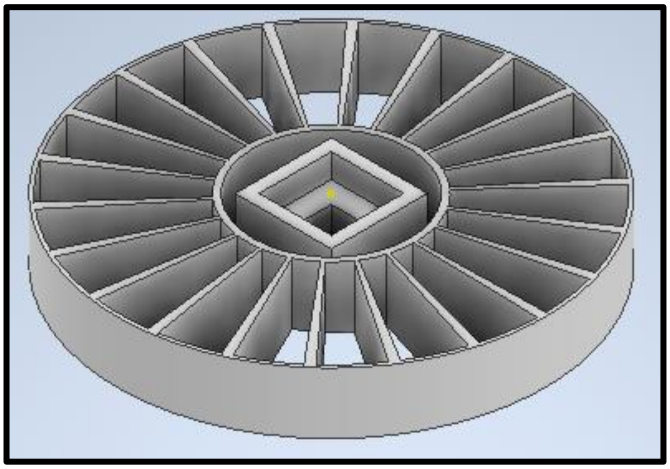


Figure 5.2.3: Rotating Capsule Piece (Bottom View)

The requirement for a locking mechanism pushed us to a design like the rotating capsule (Figure 5.2.2). The rotating capsule piece has 22 compartments for a 7-day supply to be held. The piece will sit on a stepper motor that will provide enough torque to rotate the device. The each cut out on the piece holds one time for taking medication (ex. Monday at 8 am). The device will also include a physical display of the day that it is on.

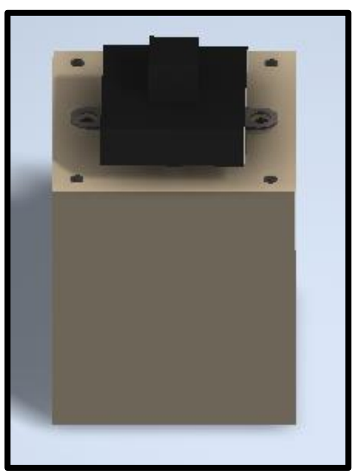


Figure 5.2.4: Motor Holder and Key

To allow for adjustments we are including a motor holder and motor key. Both pieces allow us to verify the fit of the motor and the fit of the axle. This allows for easy adjustment and reduces 3D print times. As we can see in Figure 6.2.4 the motor holder is the gray piece and will include cutouts for the wires of the stepper motor to come out. It also has 4 screw holes to allow the drop plate to connect. The motor key is the black piece and fits into the rotating capsule piece (Figure 6.2.3). These pieces have already been printed but are already subject to change. Specifically, they will be adjusted to host ball bearings.

5.2.4. Lid & Locking Mechanism

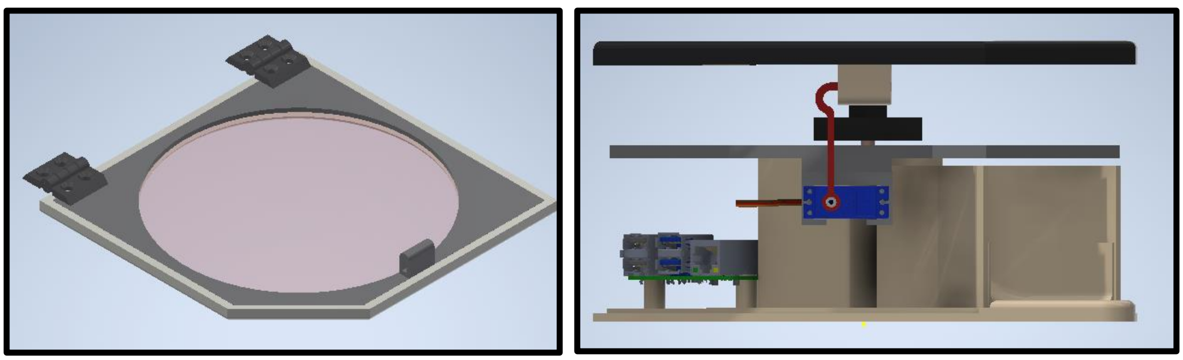


Figure 5.2.4: Lid and Locking Mechanism

This lid mechanism is designed with a three-part system (Figure 5.2.4, Left). The first part is the top piece which is the outside of the box. The second part is a clear portion, which provides a clear view of the contents inside smart pill box. The third part is at the bottom plate of the lid and will allow for a flush finish that keeps all the components of the lid secured. The top lid is made of durable material and the lid support ensures that the lid remains in place. The locking mechanism is a simple hook design, which allows the user to easily lock and unlock the mechanism (Figure 5.2.4, Right). This will be controlled by the touchscreen, which allows for easy access to the locking mechanism. This locking mechanism is the perfect solution for securing the pills and keeping them safe.

5.2.5. Dispenser & Tray

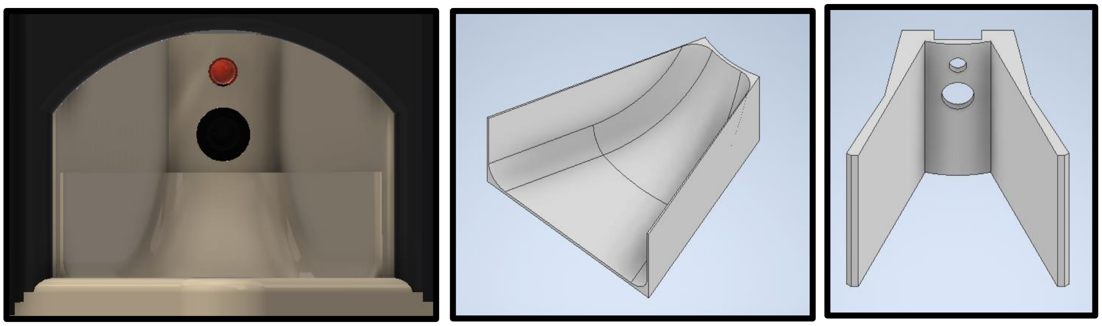


Figure 5.2.5: Dispenser & Tray

The dispenser of the Smart Pill Box will have multiple features (Figure 5.2.5, Left). It will be made of a baseplate and camera holder, and the opening will be 3 inches wide, big enough for most hand sizes to fit into. There will also be a tray that allows for the medicine to be removed and cleaned more easily (Figure 5.2.5, Middle). Inside the dispenser, a camera will be housed to take before and after pictures of the medicine being taken from the compartment. The camera will be held and secured in the camera holder (Figure 5.2.5, Right), and an LED will provide better visibility and clarity of where the medicine is dispensed.

5.2.6. Touchscreen Housing

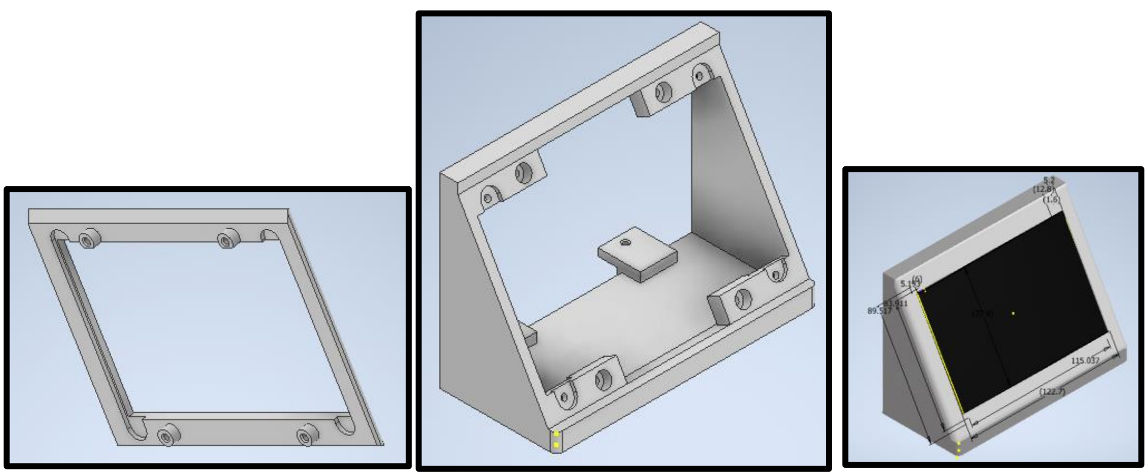


Figure 5.2.6: Touchscreen Housing Parts

The touchscreen housing (Right) also has three components: a faceplate (Left), a touchscreen holder (Middle), and a 5” touchscreen. The design was created to introduce a finishing touch to the holder. The faceplate will be placed on the front of the holder to present a flush finish with no screw holes visible. The 5” touchscreen will be securely inserted into the holder and will support all the necessary connectivity. The connections will all be hidden at the back and out of view from the user. The touchscreen will be set at a 60-degree angle to enable the user to clearly see the device even if it is at waist height. The overall holder design will connect to the overall housing to provide a finished look.

5.2.7. Overall Housing

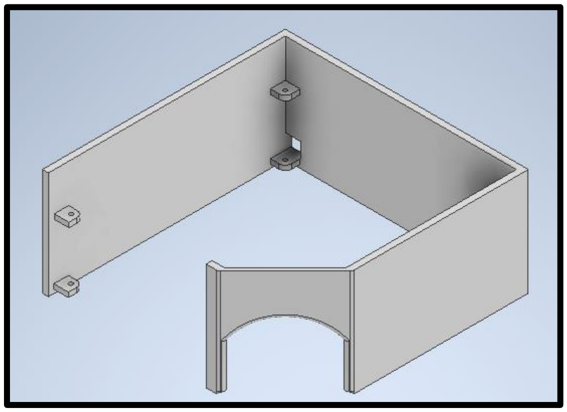


Figure 5.2.7: Housing Walls

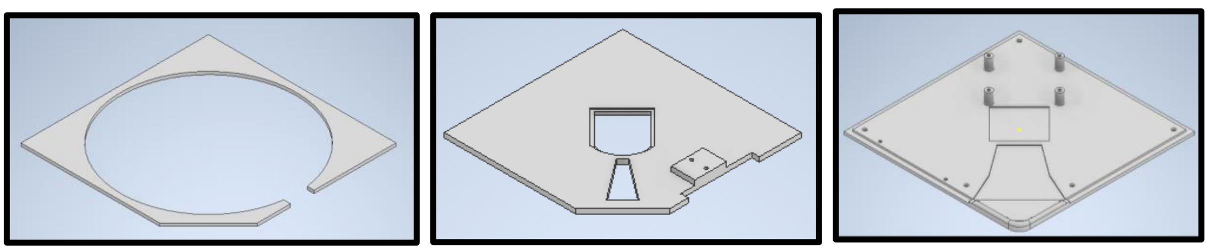


Figure 5.2.8: Top Plate, Drop Plate, and Bottom Plate

The overall housing consists of the walls (Figure 5.2.7) and baseplates (Figure 5.2.8). The wall of the design is very simple and will have a cutout to allow for power to connect to the system. The baseplates will have three components the top plate, drop plate, and baseplate. The top plate will be flush with the rotating capsule and will be visible when the lid is open. The drop plate is where the pills will be dispensed and will hold all the pills on it. It will also hold the place the servo will be used to lock the device. Finally, the baseplate is the bottom of the project and will have rubber feet to secure the device onto any surface. The two components will be connected by screws, bolts, and nuts to allow for an accurate finish.

5.3. Software

5.3.1. Front-End

The front-end will consist of two access points. The first is the screen on the smart pillbox accessed by the user. The second is through a webserver accessed by the user's caregiver. We are designing these interfaces using HTML, CSS, and Javascript. Then, for the GUI on the smart pillbox, we will use Electron to package the code into an offline portable app that runs on the raspberry pi. For the webserver, we will host it on a remote server that will serve the webpage to the caregivers.

The functionality available to the on the pillbox includes dispensing medications at set times, refilling medications, taking pictures of dispensed medications, alerting the user that it is time to take medications, and alerting the caregiver of missed doses. All of this will be done through the raspberry pi within the box. There will be a touch screen for the user to see a list of medications, see times that are scheduled, and input a code to receive medicine.

On the caregiver side of the front-end, the website will have a secure login. On the main page, there will be a list of patients under their care. Once they click on a patient, they will have a list of medications and times similar to what will be displayed on the user's pillbox. One important feature will be receiving an image of all the pills dispense recently and an alert if there were none dispensed. The caregivers will also have access to set up medications and times to take them.

5.3.2. Back-End

For the backend, we decided to move to a remote server as this will allow us to send notifications easier and serve as a more unified experience if the smart pillbox is produced en masse. The backend will consist of a webapp made using Flask that will be hosted on a server using a combination of Gunicorn and NGINX. We chose Flask primarily because we had used previously in Embedded Systems and are confident we can deliver on all of the requirements. The Flask will be accompanied by the various HTML, CSS, and JS files that are required to get the webapp functioning. We chose Gunicorn and NGINX primarily because the Flask documentation heavily recommends using this combination. Gunicorn is a WSGI server for the Flask application, and we are using NGINX to serve the HTTP calls for increased security and efficiency.

Additionally, we will be using PostgreSQL as our database. This will store usernames, passwords, medication lists, user roles (caregiver/patient), and any camera captures. This will be secured using hash maps to ensure confidential information is leaked.

6. Testing Strategy and Results

6.1. Electrical

To test the parts on the Pi, a code is needed to be written to it. The parts have not arrived yet except the camera module. Luckily, one of the team members has a Raspberry Pi and a stepper motor which allowed the team to test them. The first test of the Raspberry Pi, stepper, and camera was successful. The plan is to test each component separately with the Pi, and then to connect them together. After connecting each part separately, the drawn current from the part and the power consumption will be measured to compare it with the power consumption calculations done to make sure the Pi does not get overloaded.

6.2. Hardware

Testing the hardware for a smart pill box is an important part of the manufacturing process. The hardware must meet certain standards to ensure the device is safe and reliable. This usually involves testing the connections of the components, checking for any potential malfunctions, and testing the overall design of the device. Additionally, the hardware must be tested for its durability and ability to withstand any potential external forces. Through these tests, we can ensure that the smart pill box is safe and reliable for its intended purpose.

Figure 6.2.1: 3D Printed Rotary Capsule

With 3D Printed parts connections always seem to be a problem. We have already tested the screw fittings, bolt fittings, and the size of the overall model. Figure 6.2.1 shows the size of the rotating capsule. The image depicts the number of pills that can fit in each slot, and it is easily over 5 pills.

Initial hardware testing we have already conducted include testing the motor torque to see if it can support the rotating capsule piece. The test was successful, and we have already learned how to increase performance. The biggest solution is to reduce the friction coefficient. This can be done by having a lighter model, ball bearings or ball rollers, and potentially a different material with a lower friction coefficient.

6.3. Software

6.3.1. Front-end

Front-end testing will consist of making sure the flow of the program is consistent with intended design and is also responsive. For example, ensuring the touch screen works with the interface is important because that is our main way of interacting with the device. Other parts we will test are the speakers going off at the correct times and user logins being accessible.

6.3.2. Back-End

Back-end testing will ensure that data flows properly and consistently between the raspberry pi, the webserver, and the caregiver. Some tests we will implement are database entries showing up after sent from the pi and image receiving on the caregiver's end.

7. Cost

7.1. Cost Breakdown

The device has parts cost of $399. The break down is shown in the table below:

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

Touchscreen and Pi make up 75% of cost

Production cost given purchases in bulk and utilizing any vendor. ~$250

7.2. Parts List

7.2.1. Electrical Parts

Part Description	Part Name	Price	Supplier
Microcontroller	Raspberry pi 4 Model B	$ 149	Amazon
Touchscreen	ELECROW Raspberry Pi Monitor 5 Inch touchscreen	$61.99	Amazon
Camera	Raspberry Pi Camera Module 3	$25	Cana kit
Motor + Driver	Stepper Motor + ULN2003 Driver Board	$14.99	Amazon
Motor	SG90C 360 Degree Micro Servo	$4.00	Mouser
Power Supply	Raspberry Pi 4 Model B Official PSU, USB-C	$7.98	Amazon
Memory	Memory Cards 8GB UHS Class 4 MicroSD Card WD/SD	$9.56	Mouser
Power Switch	Push Button Switch	$0	-
Power Indicator	LED	$0	-
Resistor	Resistor	$0	-

7.2.2. Hardware Parts

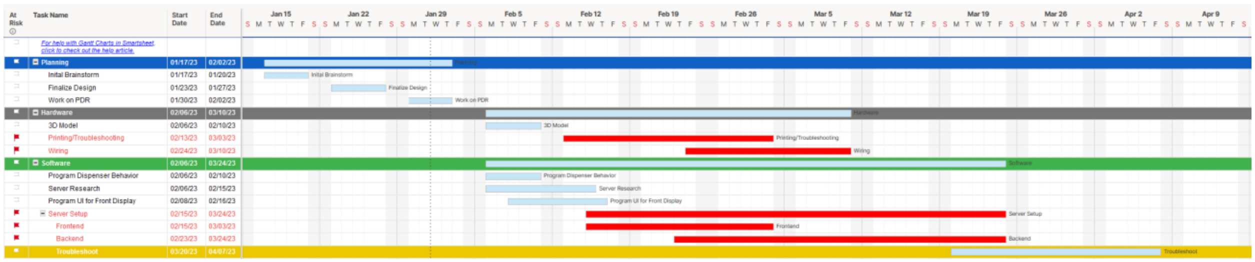
Part Description	Part Name	Price	Supplier
Ball Bearings	608-2RS-W/CHEVRONSRI2	$1.00	Digi-key
Screws	36-9900-ND	$0.12	Digi-key
Screws	36-9901-ND	$0.12	Digi-key
Bolts	7235-3-ND	$0.10	Digi-key
Hdmi-Micro	2648-RPIHDMIADAPTER-ND	$3.00	Digi-key
USB	2671-USB3.0AMF-1FT-ND	$6.12	Digi-key

Hinges	2419-237.1-30-30-A-ND	$4.53	Digi-key

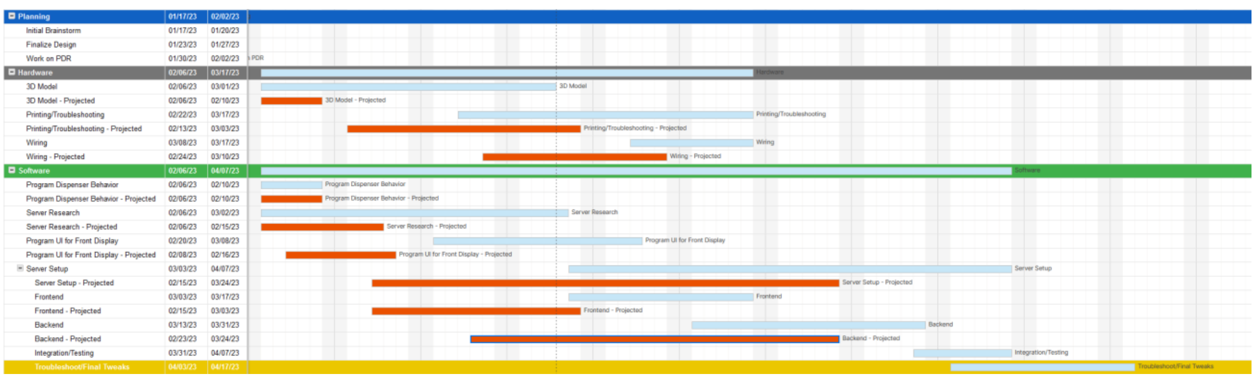
8. Scheduling

Attached below are the initial and current schedules for the project. We were backed up by server researching problems and copious printing problems, but now that our design is close to finalization, the remainder of our time will predominantly testing the final design fitting and software.

8.1. Initial Schedule



8.2. Current Schedule



9. Risk Management

The table below shows our risk matrix, which tracks the likelihood and impact that potential problems might have along the course of this project. The most problematic circumstance that we foresee is general server/networking issues. We could have difficulty accessing the webpage remotely during our demonstration or otherwise. Hosting public webpages is a topic that we have not done before this project. We could also run into problems with the campus networking as we have had difficulties using it in the past.

Design Does Not Meet Specification: at this point in the project, we have every required part of the SPB covered. However, there is still room for plans to fall through leaving us without some of the required functionality that was asked of the team.

Selected Parts are Unavailable: This event is possible because some of the parts needed are niche or in high demand. However, in electronics, there are usually several alternatives, so it would not pose a significant risk to the project.

Broken Parts: Broken parts would delay the implementation and testing of the affected parts until we can get replacements. The impact is moderate because it would only delay us, and the likelihood is "possible" because shipping can be rough on components sometimes.

Parts Arrive Late: This would have a similar impact to broken parts because it would delay our progress. However, it is unlikely because shipping methods are generally predictable and tracking can keep us updated on expected arrival times.

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			Parts Arrive Late	Design Does Not Meet Specification	
Very Unlikely					

10. Report Contributions

Zarek: Problem Objective**,** Constraints & Ethics, Hardware Design, Hardware Testing

Daniel: Software design, Software testing, Risk Management

Zahra: Electrical, Electrical test, Power Consumption, Circuit Schematic, Parts Price

Stephen: Scheduling, Risk Management, Back-End Software, Formatting

11. References

Raspberry pi or Arduino – when to choose which? Leo Rover Blog. (n.d.). Retrieved March 10, 2023, from https://www.leorover.tech/post/raspberry-pi-or-arduino-when-to-choose-which#:~:text=Arduino%20is%20an%20electronic%20board,monitoring%20weather%20and%20many%20others

Cdaviddav. (2021, May 7). *Raspberry Pi vs Arduino comparison*. DIYI0T. Retrieved March 10, 2023, from https://diyi0t.com/raspberry-pi-vs-arduino-comparison/

Piltch, A. (2020, June 2). *Raspberry pi 4: Review, buying guide and how to use*. Tom's Hardware. Retrieved March 10, 2023, from https://www.tomshardware.com/reviews/raspberry-pi-4

Raspberry pi camera module 3. CanaKit. (n.d.). Retrieved March 10, 2023, from https://www.canakit.com/raspberry-pi-camera-module-3.html?defpid=4836

Raspberry pi documentation. Raspberry Pi hardware. (n.d.). Retrieved March 10, 2023, from https://www.raspberrypi.com/documentation/computers/raspberry-pi.html#power-supply

Galt, J. (2020, November 25). *How to add a power button to your Raspberry Pi*. Howchoo. Retrieved March 10, 2023, from https://howchoo.com/g/mwnlytk3zmm/how-to-add-a-power-button-to-your-raspberry-pi?utm_source=youtube&utm_medium=referral&utm_campaign=power-button-video&utm_content=description

Amazon.com: Raspberry Pi 4 Model B official PSU, USB-C, 5.1V, 3A, US ... (n.d.). Retrieved March 11, 2023, from https://www.amazon.com/Raspberry-Model-Official-SC0218-Accessory/dp/B07W8XHMJZ

Raspberry pi documentation. Raspberry Pi hardware. (n.d.). Retrieved March 10, 2023, from https://www.raspberrypi.com/documentation/computers/raspberry-pi.html#power-supply

Servo Motor Micro SG90. ProtoSupplies. (2023, January 24). Retrieved March 10, 2023, from https://protosupplies.com/product/servo-motor-micro-sg90/

SAVAGE, A. R. T. H. U. R. D. E. K. K. E. R. (2016). *DP*. Amazon. Retrieved March 10, 2023, from https://www.amazon.com/dp/B08343QX67/ref=emc_b_5_t