ENGINEERING IN MEDICINE AND BIOLOGY

BIOM1010

PROJECT AUTOMATIC PILL DISPENSER

TEAM 5 GROUP REPORT

Name	zID	Email
Eidels, Shahar	z5366523	z5366523@ad.unsw.edu.au
Cook, Angus	z5587807	z5587807@ad.unsw.edu.au
Carrick, Jaxon	z5587992	z5587992@ad.unsw.edu.au
Nguyen, Steven	z5592999	z5592999@ad.unsw.edu.au
Nguyen, Quang	z5416177	z5416177@ad.unsw.edu.au

Abstract

This report details the design, development and evaluation of our innovative and cost-effective solution for the Automatic Pill Dispenser Project. This project centres on creating an automatic pill dispenser that is capable of dispensing the correct number of pills for a client at a specified day and time, providing affordable health technology to patients who are elderly or cognitively impaired. Widespread use of the automatic pill dispenser will have a range of implications including improving autonomy and quality of life for patients, cutting client expenditure, alleviating the burden on caretakers and reducing strain on the health care sector.

The design specifications emphasise functionality, accuracy, simplicity, aesthetics, safety and affordability and the ability to correctly dispense from five pill types. The design description section of this report details the electronic, programming and mechanical aspects of the device, including diagrams facilitating a comprehensive operational understanding and replication. The structure of our design consists of an ELEGOO circuit and mega board, with five motors. A rotating disk dispenses the required number and type of pills from various cups, depending on the day and time inputted. Unique features of our design include a display LCD screen and keypad, for a user-friendly interface, as well as key-card access for added safety.

Ethical considerations are crucial to the project including patient safety and compliance with regulatory standards. Safety features such as keycard access restrictions prevent error and enhance user protection. The report details the requirement for registration with the Therapeutic Goods Administration, as well as the ethical obligation for consistent device performance and accuracy, for the safety of clients who are entirely dependent on the device for their health.

The device was manufactured using computer aided design (CAD) software fusion 360, and 3D printed using quality PLA plastic, as well as utilising recycled materials for their affordability. Precise engineering techniques and detailed descriptions are included below to enhance reproducibility. Device performance assessments proved the device to be successful in meeting required outcomes, including delivering accurate dosages and a simple user-interface.

The Failure Modes Effects Analysis (FMEA) section of this report discusses the various ways in which the device can fail, including mechanical jamming, programming errors and electrical short-circuiting, and the mitigation strategies implemented to address these, for greater reliability and safety. Further considerations include registering the device as Intellectual property under a stakeholder group and obtaining a patent under IP Australia, as well as ensuring the device complies with all relevant regulations and standards. The device is priced at $100, allowing competitive marketing, client affordability and sufficient company profit margins.

Future work will focus on adapting the device to fit various pill shapes, introducing it into clinical use and hospitals, manufacturing on an industrial scale and developing a compatible phone application platform. In conclusion, we have created an affordable device meeting all objectives with the potential to greatly impact a variety of stakeholders.

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Introduction

With Australia's ageing population and patient's increasingly complex medication regimes, ensuring accurate and timely dosage administration is crucial. The purpose of this report is to present our final design and reflect upon the development and testing of our solution to the Pill Dispenser Project. The task involves the design and production of a dispenser which serves various functions: dispensing a certain amount of different unique pills required, having the ability to dispense on the current time and date inputted, have minimal ease to refill and should be password controlled to protect against misuse. The overall cost regarding the research and development of the dispenser must not exceed $80 AUD.

Pill dispensers are becoming more apparent within the world of medical technology, where they can be found within many households/hospitals due to their affordability and reliability . These medical devices serve as reminders when they dispense allocated medication at specified/specific times, which create multiple solutions to aiding in medical adherence, reducing human error and simplifying the medical management process.

Usually upheld by predetermined times, pill dispensers have evolved to create easier access for the client to track their management and customisation of schedules, reminders and connectivity by implementing the usage of application usage and electronic health records.

Regardless of how they operate and what mechanism they use to dispense medication, all pill dispensers must meet the standard based on important prompts to ensure they do not create issues within dosages and allocations for the client:

These can be classified into 4 different criteria: Setup, Dispensing, Notification and Maintenance. The setup of the pill dispenser must ensure that the loading and refilling of medication can be accessed and achievable within a constant period of time while creating a program that allows the user to set their schedule based on their prescribed/preferred regime. When dispensing an allocated amount of medication, it must be accessible for the client to take while ensuring that is the only amount they intake within that allocated period of time. A notification should be available to alert the user when their medication is ready and can be achieved either virtually or physically. The maintenance of the pill dispenser should be minimal and components should be secured to ensure there are no malfunctions within the dispenser itself.

Existing pill dispensers in the market commonly have features such as locking mechanisms, in built wifi reception, and time tracking capabilities, as well as satisfying the criteria described above. The aim of our project was to create a device that is able to deliver medication correctly and thus meet the basic requirements of a pill dispenser, while also being affordable and containing unique features that differentiate our design from existing products. The use of an RFID scanner card as the locking mechanism removes the necessity for a password, which is a weakness in many pill dispensers as medically incompetent individuals may be unable to remember a password, potentially rendering the device useless or ineffective and denying

critical medication to those who need it. Moreover, the lack of an easy access keypad on many commercial pill dispensers limits the autonomy of individuals as they cannot be expected to reprogram the dispenser themselves, increasing the burden on caretakers, nurses and relatives in a way that is mitigated by our design.

With initial sketches and further prototyping, the design of the pill dispenser was limited by the apparent costs of electronics and materials, while developing unique solutions was restricted by the complexity in the addition of extras features being incorporated in our final design. At most, practical solutions to each component in terms of materials, design and mechanics must ensure that the patient will have full medical compatibility with the dispenser.

Our problem statement has been discussed as such:

“The client has commissioned the design and manufacture of an Automatic Pill Dispenser that can dispense the correct dosage and type of pill depending on the time and day as input by the patient. The dispenser should be user-friendly for an elderly or cognitively impaired patient, easily refillable and be access restricted to protect against misuse. Research and development are capped at $80 across a two-month period.”

This report will discuss the design solution itself, detailing its design specifications and description, used to connect how the final design matches our initial prototyping, as well as the ethics of the design to prevent any errors that may lead to the decline of the patient’s wellbeing. This report also details the design manufacturing and performance processes, evaluated through our objectives determined by the problem statement. To continue on, the failure modes and effects analysis, the regulation and standards, as well as the health technology assessment all serve as a major reflection towards the team’s final design and model of the pill dispenser, while the intellectual property ensures the final design of the project stays innovative through its key functions and interactions between the device and client.

As such, the structure of this report is as follows: Introduction, followed by Design Specifications and Design Specifications which will reflect our final design and virtual model broken down into the different components of the pill dispenser, which then will be followed by Ethics. The Device Manufacture and Device Performance are essentially the building and testing stages within our design and serve to document our solution to the problem statement that our team willingly proposed. This report also accounts for the Failure Modes and Effects Analysis, Intellectual Property, Regulations and Standards and Health Technology Assessment as a set reevaulation and reflection on both the design and the processes of our team in the project. Lastly, the report will end with Future Directions as a way to conclude our submission for this project, and allow the team to summarise the prevalent effectiveness and key major issues in the final model showcase. The Referencing and Appendix are held to keep track of our budget and designs that have led to our final design during the period of this project.

Design Specifications

The automatic pill dispenser was required to meet a variety of criteria to be considered a successful product. These criteria included functionality, ergonomics, aesthetics, safety and the prerequisites set in the initial project brief.

The project brief required an automatic pill dispenser that met the following specifications; password protected, able to dispense a set number of each pill for three time intervals over a seven day period and that five pills could be held at a time. The most crucial specification set in the brief was that the dispenser was able to accurately deliver the correct number of pills upon a manual input. This input would replicate a user requiring pills up to 3 times a day, over a 7 day interval, and required a keypad for the user. Moreover, this keypad was used for another specification of the brief, being that the pill dispenser was password protected. This specification later evolved into a keycard being used to unlock the mechanism which still fulfilled the requirement of password protection. These two specifications necessitated both mechanical and software components thus were the two most important requirements from the brief. The final criteria in the brief was that the pill dispenser held 5 pill types, and while significant, was purely a mechanical constraint hence less essential.

Functionality includes the ability for the pill dispenser to correctly dispense the required number of pills from the given input. The pill dispenser was designed so that a user could input a day of the week and a time, from morning, midday or evening, and pills would be delivered based on pre-programmed amounts of pills for the corresponding time interval. This criteria requires the arduino to be coded correctly so that the motors for each pill hopper rotate the correct number of times, as well as the mechanical components not inadvertently allocating multiple pills in one rotation. This criteria is equally as important as safety, as receiving the incorrect number of pills could have negative health effects on the user.

Ergonomics is the ease of use to the average consumer of the pill dispenser. This design is targeted towards the elderly or patients of neurological diseases who have memory issues, as the design delivers pills for them and reduces the chance of them unknowingly ingesting the incorrect number of pills. Moreover, the keycard system further improved the ergonomics and made it easier for the technologically inept users to access this device. Ergonomics is a significant criteria due to the use base of this design although not as important as functionality.

Affordability is a significant criteria, as this device would be greatly impactful to the lives of those suffering neurological diseases. Market research has shown that similar products range in price from $50-$300, thus this product should be in the lower end of this price range. This specification is far less important than functionality although still a significant consideration in this design.

The least crucial design specification was the overall aesthetics of the pill dispenser. This was accomplished through creating an overall simple and compact casing for the pill dispensing mechanism. While important, this criteria was not a priority, as it required the least effort, especially compared to meeting specifications such as functionality.

Overall, the specifications set by the brief were the most significant, followed by functionality and safety, ergonomics, affordability then aesthetics.

Design Description

The pill dispenser featured significant electrical, programming and mechanical components designed to work cohesively to effectively deliver pills in the finished product.

Electrical Components

The coding language used for the pill dispenser was C++, and used an arduino mega board to control the components of the pill dispenser, the circuit diagram is pictured below in figure 1. The coding language C++ was used as this is the most compatible with arduino components.

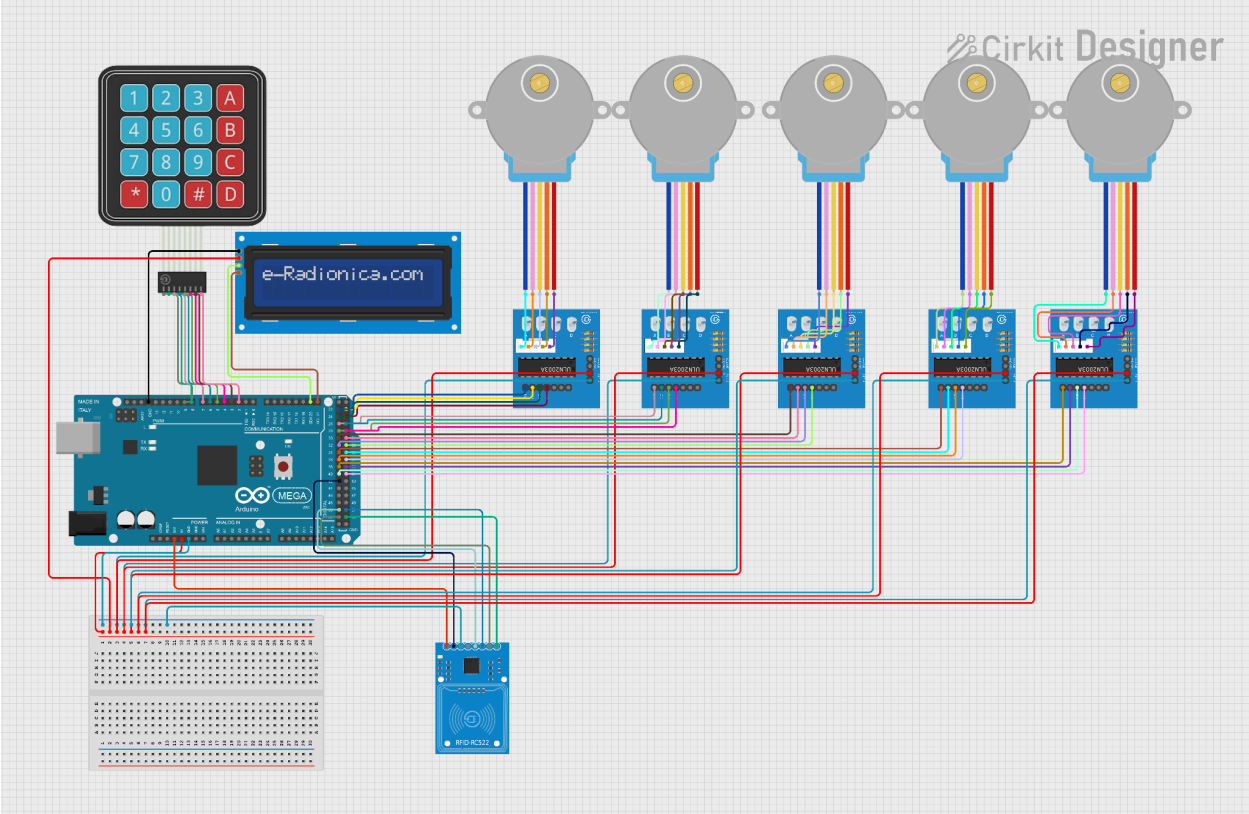

Figure 1, circuit diagram

The electrical component of the project is centred around an Arduino Mega. The different sections of the device are connected by a breadboard, and wires (jumping and female-to-male and male-to-male). The motion that dispenses the pills is created by 5 stepper motors, while the device is accessible via an RFID module and associated keycard. In order to improve the ability of elderly and medically incompetent people to access the dispenser, it also contains an LCD and a keypad . The system is coded to dispense a specific number of pills based on user input and protects access using an RFID card. The user can input the day (1-7) and time (1-3) for dispensing, and the number of pills for each type (Red, Green, Yellow, White and Purple).

Programming Components

Programming was a crucial step in the process of device manufacture. Screenshots of all the code used are included in the appendix and the commands are explained below in further detail.

Libraries included (refer to screenshot A):

- Wire.h: I2C communication library.
- LiquidCrystal_I2C.h: Library to control the LCD with I2C.
- Stepper.h: Library to control the stepper motors.
- SPI.h: SPI communication library.
- MFRC522.h: Library to interface with the RFID module.
- Keypad.h: Library to handle keypad input.

Constants and Objects Initialisation (refer to screenshot B):

- stepsPerRevolution: Defines the number of steps for a full revolution of the stepper motors.
- motorSpeed: Defines the speed of the motors in RPM.
- Stepper Objects: Initialises the stepper motors with their respective pin numbers.
- LiquidCrystal_I2C Object: Initialises the LCD with its I2C address.
- Keypad Configuration: Defines the keypad layout and pins.
- RFID Configuration: Defines the RFID module pins and initialises the MFRC522 object.

Variables and stores the selected day/time and pills count (refer to screenshot C):

- accessGranted: Boolean to check if access is granted.
- selectedDay: Stores the selected day input by the user.
- selectedTime: Stores the selected time input by the user.
- pillCounts: Array to store the number of pills to be dispensed for each motor.

Setup Function (refer to screenshot D):

- Serial.begin(9600): Initialises serial communication at 9600 baud (unit of transmission speed).
- LCD Initialization: Initializes and sets up the LCD.
- Stepper Motors Setup: Sets the speed for each motor.
- SPI and RFID Setup: Initializes SPI communication and the RFID module.

Main Loop (refer to screenshot E):

- handleRFID(): Checks RFID for access.
- selectDay(): Prompts the user to select the day.
- selectTime(): Prompts the user to select the time.
- getPillCounts(): Prompts users to input the number of pills for each type.
- dispensePills(): Dispenses the pills and performs the motor vibration logic.

RFID Handling (refer to screenshot F):

- handleRFID(): Reads the RFID card UID and compares it with the authorised UID. If matched, grants access. If false, prints “Unauthorised”.

User Input for Day and Time (refer to screenshot G):

- selectDay(): Prompts the user to select the day using the keypad (4x4).
- selectTime(): Prompts the user to select the time using the keypad (4x4).

User Input for Pill Counts (refer to screenshot H):

- getPillCounts(): Prompts the user to enter the number of pills for each type. The number is entered using the keypad and confirmed with the (#) key.

Dispense Pills and Motor frequency (refer to screenshot I):

- dispensePills(): Dispenses the specified number of pills for each type based on user input. It also includes a motor vibration sequence to ensure pills are properly dispensed, some motors require more than 1 rotation due friction of base plate and rotating disc.

Mechanical Components

The Automatic Pill Dispenser comprises of three mechanical components within each cup as shown in the figures below; the base plate (figure 2), the sweeper arm (figure 3) and the rotating disk (figure 4). There are five cups, where each cup contains a motor and one type of pill.

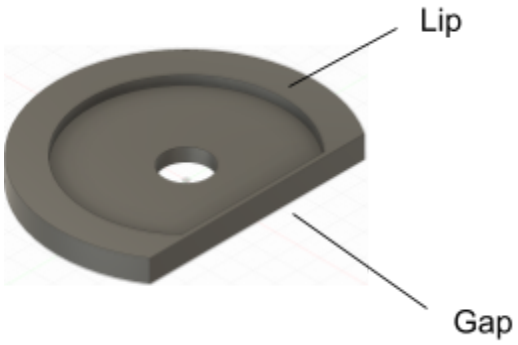

Figure 2, Labelled Diagram of base plate

Figure 3, Sweeper arm

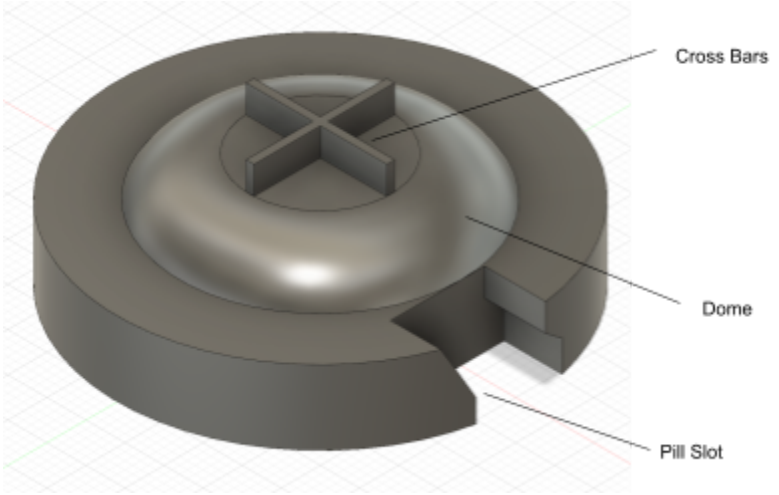

Figure 4, Labelled diagram of rotating disc

The base plate sat below the paper cup, while the rotating disc was placed inside the cup, resting on the base plate and the sweeper arm was glued to the wall of the cup above the rotating disc.

The pin from each motor passed through the base plate and was glued onto a slot in the bottom of the rotating disc, and the pieces were aligned so that the sweeper arm was positioned directly above the gap in the base plate and the pill slot in the disc. When a single pill is required, the motor will rotate for a full rotation. This will cause the disc to rotate, and the pill slot will move from under the sweeper arm to allow a single pill to fall into the pill slot. The slot will continue to rotate back under the sweeper arm, which allows the pill to fall through the gap in the base plate and thus be collected by the user. It was crucial for the sweeper arm and base plate to be properly aligned, so that when the slot is above the gap in the base plate only a single pill can fall through.This occurs as the sweeper arm prevents the other pills from entering the slot. The sweeper arm being aligned and misaligned is shown in figures 5 and 6. Moreover, the pill slot must begin the process positioned under the sweeper arm, otherwise multiple pills could potentially be dispensed in a single rotation.

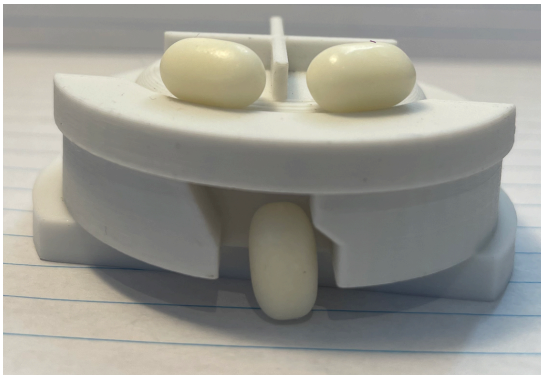

Figure 5, Correctly aligned

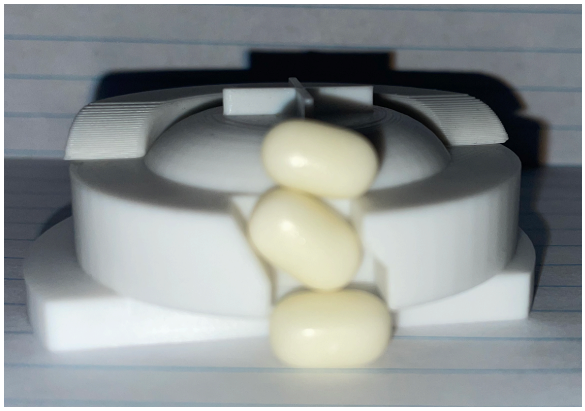

Figure 6, Incorrectly aligned

The fully constructed pill dispenser, pictured below in figure 7, shows the 5 pill hoppers glued to the sides of the box, with a ramp glued in place below them to allow the pills to fall then roll out of a slit in the side of the box.

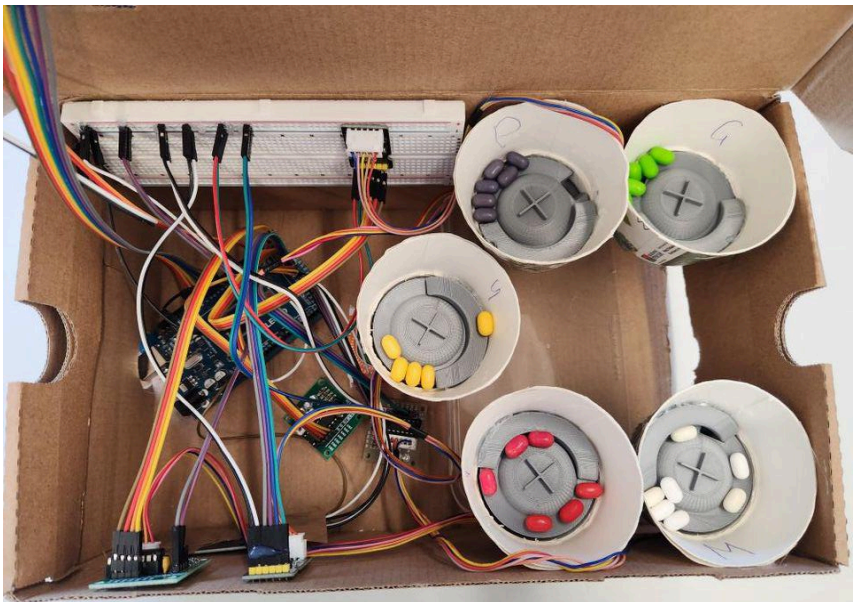

Figure 7, interior of pill dispenser

The electrical components of the design were kept in a separate section of the box too the pill hoppers, to prevent wires being caught in the rotating mechanism, and the breadboard and RFID scanner were glued to the sides of the box to allow easier access when making modifications to the dispenser.

The exterior of the box, shown below in figures 8 and 9, demonstrate the simplistic design. This design improved accessibility through clearly marking the RFID scanner, the slot that the pills fell out of and the use of a keypad to allow users to input the pills they require at that time.

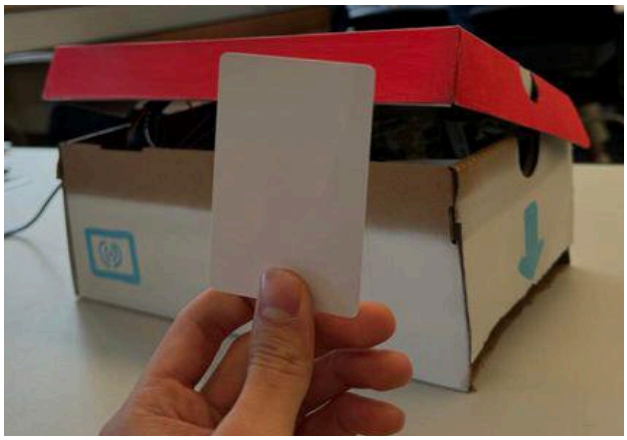

Figure 8, exterior of pill dispenser

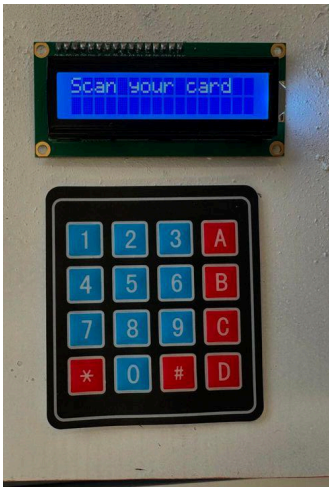

Figure 9 , keypad and LCD screen

Ethics

The pill dispenser is designed to be able to aid individuals who have consistent medical dependencies in the form of medication. It allows for people to access the correct amount of pills at certain times, even if they otherwise would not be competent to do so. Thus, as these people are dependent on the pill dispenser, there is a major ethical responsibility to consistently function exactly as required.

Our target demographic includes individuals such as the elderly and medically incompetent people, thus the pill dispenser has a necessity to be consistent and accurate. Due to issues such as fading sight, blindness, dementia and other potential medical problems, it is likely that users of the pill dispenser may be unable to accurately determine how many of a certain pill type they need at a given time. Therefore it is the ethical responsibility of the pill dispenser to deliver exactly the precise amount of medication at given times and days. Moreover, we are obligated to design the pill dispenser in a way that counteracts issues such as clients attempting to get more pills than they are meant to, or clients not being aware of exactly what their required dosage of certain medications at certain times is. Thus, we have a strong ethical responsibility to ensure that the pill dispenser works exactly as intended every time, without fail.

As the pills that are dispensed by the product would include those that are registered with the Therapeutic Goods Administration (TGA) under the Department of Health and Aged Care, the pill dispenser must also be registered with the TGA. The dispenser would be classified as a “medicine kit” by the TGA as it “includes at least one medicine that is on the ARTG” (Therapeutic Goods Administration, 2021), with the ARTG being the Australian Register of Therapeutic Goods.

To get a product placed on the ARTG, the designers of said product must apply to the TGA. Before the dispenser can be lawfully and ethically sold in Australia, it must pass the TGA’s internal risk assessment. Once the product has been proven to be safe and ethical, it can be placed on the ARTG, and is clear for sale in the Australian market.

A wide variety of design specifications have been implemented to ensure the pill dispenser is as safe as possible for users. All circuitry is enclosed within the design of the pill dispenser, meaning there is no risk associated with shocks or other electrical problems. Moreover, the dispenser is only accessible once a passcode is inputted, meaning that individuals suffering from issues such as dementia cannot accidently take a potentially dangerous dosage of their medication. Having specific dispensations of medication at given times of day ensures that clients who have memory issues and cannot regulate their own medicine intake cannot take either too many or too few pills. All of the pills in the dispenser are enclosed in separate compartments that are not easily accessible from the outside, meaning clients cannot access pills when it is not the correct time to do so, preventing potentially harmful side effects such as overdosing.

Device Manufacture

The pill dispenser underwent an extensive prototyping process with several prototypes and ideas created and tested before the finalised design. This process involved thorough research of existing pill dispenser products and comprehensive testing of each design.

Initial ideas were judged and rejected based on the ease of designing them, as well as predicted effectiveness and ergonomics of that design. Research was conducted during this phase of the design to further generate ideas, allowing us to refine our initial ideas into our first design.

Our preliminary prototype ideas contained 2 parts as described above in the ‘design description’ section, the rotating disc and the sweeper arm. The initial design was flawed in that the slot that pills were dispensed from was not properly aligned, the rotating disc had no means to be attached to a motor, and pills would become stuck on top of the disc, with no design features to force them to rotate, as shown below in figure 10. Moreover this design featured the sweeper arm attached to the rotating disc, which would be ineffective at forcing the pills through the slot.

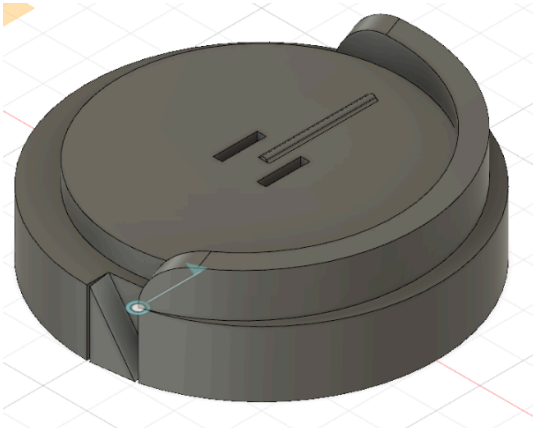

Figure 10, Initial Design of pill dispenser rotating disc

The second design introduced 2 new ideas; locking mechanism and a better design for the pill slot, as shown in figures 11 and 12.

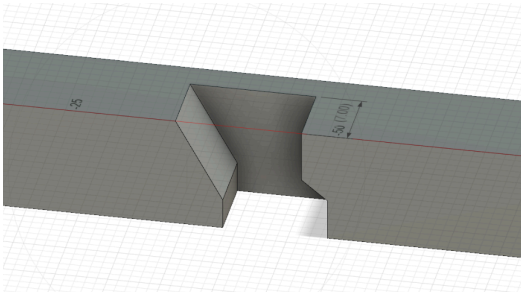

Figure 11, Pill Slot

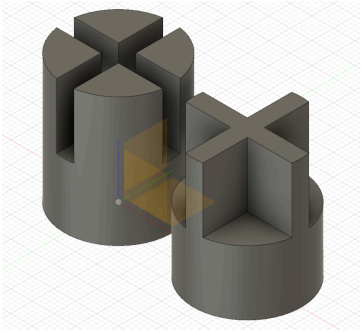

Figure 12, Locking mechanism

This iteration of the pill slot was designed to house only one pill, thus ensuring that a single pill was dispensed every rotation. Additionally, the locking mechanism was designed to allow the

rotating disc to be removed from the motor, although this idea was rejected in favour of the rotating disc being permanently attached to the motor.

The second design, fully pictured below in figure 13, greatly improved over the original draft, as it was able to force pills into the slot as well as featured an opening for the rotating pin of the motor to be inserted into, shown in figure 14.

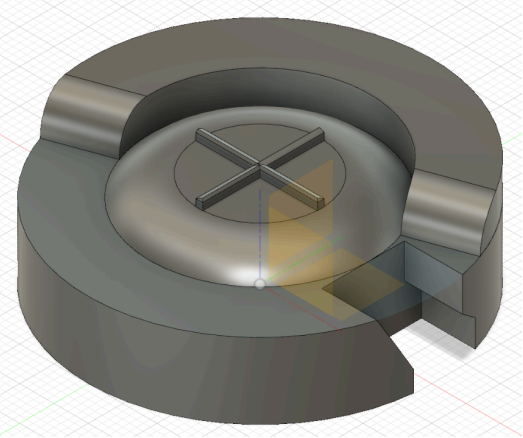

Figure 13, Second Design

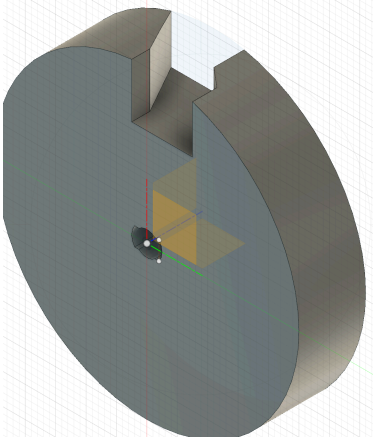

Figure 14, Second Design bottom view

This design was printed to become our first prototype, as shown in figure 15, but did not fit into the cup we had selected to hold the pill dispenser mechanism and the pills could also become stuck on top of the dome and sweeper arm, thus would not be forced into the slot. Moreover, the pill slot was too large causing multiple pills to fall at once, as shown below in figure 16.

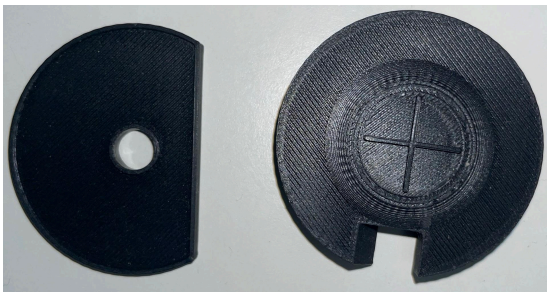

Figure 15, Second design printed

Figure 16, Flaw in second design

These issues were rectified in the third design, where the dome height was increased, along with the height of the rotating disc and pill slot being reduced, hence preventing multiple pills from falling through the slot, shown below in figure 17. Additionally, the sweeper arm was changed to have a more gentle curve, pictured in figure 18 which better forced pills through the slot, and the lip of the base plate was expanded to prevent pills from falling below the disc, demonstrated below in figure 19.

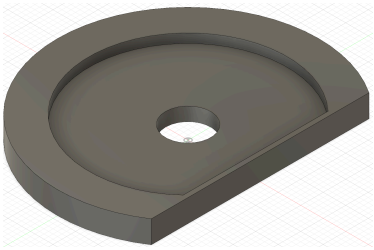

Figure 17, Third design for base plate

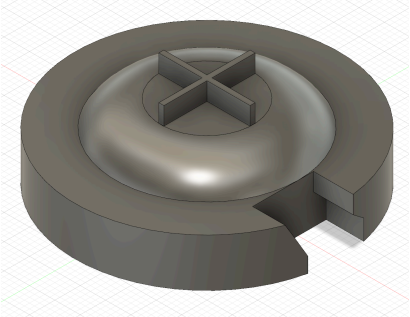

Figure 18, Third design of rotating disc

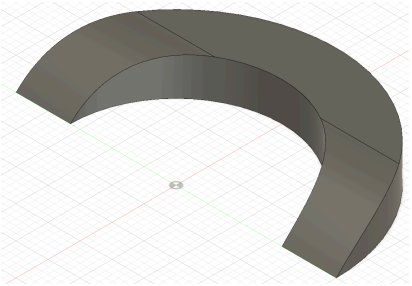

Figure 19, Third design for sweeper arm

This prototype was much more successful, as it could have a motor attached and successfully dispense pills, although occasionally pills would become trapped on the outer channel and fail to fall through the slot. This was due to two pills being able to lie horizontally next to each other by resting on the edge of the dome, rather than the dome edge forcing pills into the outer channel, as shown in figure 20. Furthermore, the sweeper arm did not fit against the edges of the cup causing a large gap between the edge of the dome and the sweeper arm, shown in figure 21, thus allowing pills to become stuck.

Figure 20, Two pills laying against the pill slot

Figure 21, Sweeper arm misaligned

The issues in the sweeper arm were amended by first enlarging the sweeper arm then creating a curve on the edge facing the pills, shown below in figure 22. This allowed the sweeper arm to better fit against the cup as well as preventing pills from resting atop the component, as shown in figure 20 above. The height of the dome on the rotating disc was increased, and the curve was altered to be steeper to prevent two pills from lying horizontally in the outer channel, as shown in figure 23. Additionally, the crossbars on the top of the dome were made taller to further force pills into the outer channel. The base plate remained the same from its third design as it perfectly fit the dimensions of the cup and motor pin.

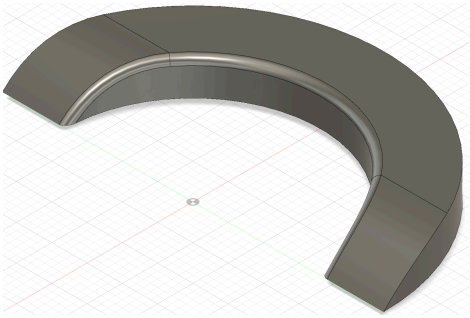

Figure 22, Sweeper arm in fourth design

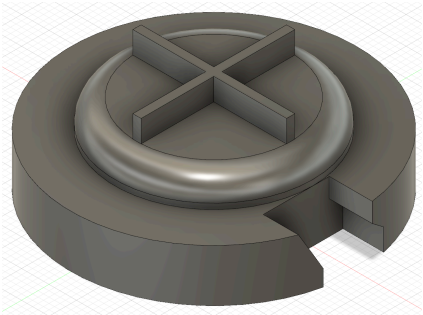

Figure 23, Fourth design of the rotating disc

The heightened dome of the fourth design, pictured below in figure 24 created excessive friction between the sweeper arm and the disc, which prevented the motor from spinning at a consistent rate thus increasing the possibility for a pill to fail to be dispensed. The contact between the two components is displayed in figure 25, and as a result this idea was denounced and the previous design of the rotating disc was used in the final design.

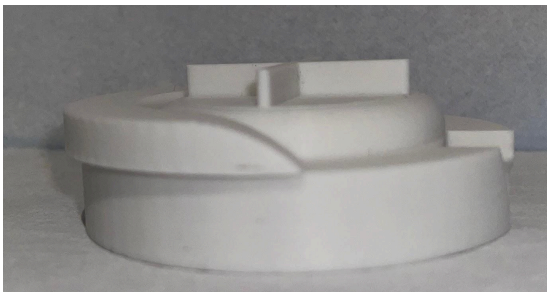

Figure 24, Side view of design four

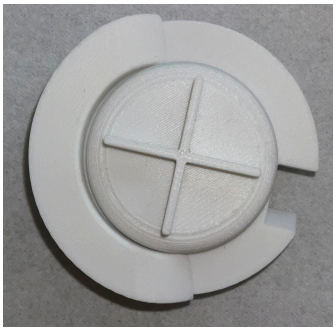

Figure 25, top view of design four

The fourth design had finalised the prototyping phase of the pill dispenser, using the rotating disc and base plate of the third design and the sweeper arm of the fourth design, as all components were able to work effectively and efficiently. All of these prototypes were initially designed using the computer aided design(CAD) software fusion 360, then printed using resources provided by the UNSW makerspace. The draft sheets to recreate the final designs can be found in appendix section B.

Device Performance

This section will evaluate the performance and results of the pill dispenser as well as providing a further detailed breakdown of how the device performed during the day of the showcase.

When showcasing our pill dispenser device on the 31st of July 2024, the device met expectations as it performed as required under the main criteria within the demonstration. The password protected interaction involved a keycard reader, which worked when demonstrated that the keycard reader would only read the id of the card and grant access when presented with the card with the right id. After being granted access, the dispenser displayed the period of time based on the numerical values that the user input , where for days, the numbers 1-7 corresponded with Monday to Sunday, while the period of day was split into three different time zones. These time zones were morning, afternoon and night, where the numerical values 1-3 aligned with these time periods.

The dispenser consistently delivered the exact quantity of pills as set in its programming, where the input of the number of pills required is aligned with the amount dispensed out, proving that our device worked as intended. The ability to input values was only possible with a keypad, which worked as we could input all numbers from 1-9, as well as having the ability to use the hashtag key as an Enter function. This was paired with the LCD, which created the digital printing and visuals for the inputs for each interaction, which had no issues displaying the content for each coded program and did not flicker or have visual bugs. When dispensing, the input of the user aligned with the motors of the Arduino circuit, which rotated accordingly where one pill meant one revolution within the motor and the disc. When the pills left the motor and disc, a ramp ensured they were dispensed and bundled up together into one section.

The following table summarises the device performance on testing day, including a mark that our group has allocated to each criteria, assessing our device effectiveness.

Table 1: Overall results of the pill dispenser test against the general requirements for the device performance:

Criteria	**Allocated Mark (Marked out of 2)**	**Justification**
Overall device function	2	Device is effective and user-friendly
Device is self-contained (including battery power, and consists of one or more units that house all required components). The device should not require being tethered to a computer to function.	0	Device requires a computer as a power source, however this can be improved in the future to be battery powered.

Remains intact throughout testing	2	Device is consistently durable and sturdy.
User-centric design	2	Utilises a simple and user-friendly interface.

Table 2: Overall results of the pill dispenser test measured against the main pill dispenser criteria required:

Criteria	**Allocated Mark (Marked out of 10)**	**Justification**
Can dispense specific number of pills depending on time	7	Device was highly effective when tested however experienced mechanical jamming on rare occasions, where a tic tac became lodged between the rotating disks.
Can reprogram the pill dispenser to change number and type of pill per time period	10	The pill dispenser features a keypad to easily reprogram the number of pills for a given time slot, as well as a LCD screen to display the number of pills entered.
Pill dispenser is password protected	10	A RFID scanner was used to negate the need for a password while still fulfilling this requirement
Aesthetics	8	The dispenser had a simple design, with all wires and electrical components encased in a painted box for aesthetics and protection. Further aesthetics could be improved by using wood or 3D printing in future to create the external casing.
Ease of use (how easily can I input time and password, how easily can I reload pills, etc)	10	The LCD screen and keypad resulted in this design being very user accessible. Moreover, pills were easily reloaded through opening the box.

In conclusion, the device is assessed to have performed effectively to a high standard, meeting all required criteria, and within the time and budgetary constraints.

Failure Modes and Effects Analysis (FMEA)

Failure Modes and Effects Analysis is a tool used for quantitative analysis of a product's risks, useful to "identify where and how it might fail and to assess the relative impact of different failures, in order to identify the parts of the process that are most in need of change", according to Institute for Healthcare Improvement (n.d.).

The following table includes a comprehensive Failure Modes and Effects Analysis, including discussion of mitigation strategies. Note; the following number ranking system uses 1-10 for severity, occurrence and detection where 10 is the most dangerous outcome for each.

Table 3: Failure Modes and Effects Analysis:

Failure Modes and Effects Analysis (FMEA)					
Function or Component	**Dispensing mechanism**	**Dispensing mechanism**	**Electronic control system**	**Electrical circuit**	**User interface**
Failure Type/Mode	**Pills jammed in dispenser**	**Incorrect number of pills dispensed**	**Incorrect dosage calculation due to software glitch**	**Electrical arduino components fail**	**Incorrect user input handling**
Potential Impact	Pills are not dispensed and dosages missed	Incorrect medication dosage, adverse health impacts	Incorrect medication dosage, adverse health impacts	Dispenser becomes entirely non-operational, dosages missed until replacement	Incorrect commands processed, incorrect dispensing
Severity (S)	8	7	7	9	6
Potential Root Causes	Mechanical blockages, misaligned parts, friction between disks	Two pills lodged in rotating disk compartment, incorrect number of rotations of disk	Programming errors, software bugs, incorrect algorithms	Wires damaged, overheating, electrical short circuits, defects, water damage	Software bugs, user errors, incorrect assignment of prescribed pills, incorrect selection of day/time
Occurrence (O)	4	5	6	3	8

Detection Mode	Client will notice no pill dispensed, easily detectable	Client may notice incorrect numbers or colours of pills dispensed, however may struggle to distinguish due to medical condition	Client may notice incorrect number or colours of pills dispensed, but will be unable to diagnose software issues	Client will notice system shutdowns and display malfunction, but will be unable to diagnose electrical issues	Client may notice incorrect number or colours of pills dispensed, however may struggle to distinguish due to medical condition
Detectability (D)	2	6	8	4	6
Risk Priority (S*O*D)	64	210	336	108	288
Criticality (S*O)	32	35	42	27	48
Action taken, mitigation strategies & recommendations	Repeated testing was conducted to ensure one pill was dispensed every time and thickness of the rotating disk was adjusted to fit pill dimensions. Regular cleaning is recommended for maintenance and spare rotating disks of different thicknesses are included to accommodate various pill sizes. Future improvement and development will focus on adding a sensor to detect if no pills are dispensed.	The thickness of the rotating disk was adjusted to fit pill dimensions, after repeated trialling for correct dispensing. The pill dispenser is set to begin and finish one revolution in the default closed mode to allow control and prevent unintentional dispensing. Routine calibration checks should be conducted. The LCD screen added allows clients to verify pills dispensed against the correct count displayed. Future recommendations include adding an audio cue to indicate that pills are correct.	Comprehensive software testing and repeated trialling with various scenarios has been conducted. The display screen allows increased detectability, as clients can cross check that the colour and number of pills dispensed correctly match the screen display. Routine checks are to be conducted by the client/caretaker to ensure correct dispensing and calibration. Caretakers are to be trained to detect and recognize software anomalies	Reliable quality electrical components were used in device manufacture and the device is used for short time intervals to prevent overheating. The device is encased in a container ensuring that circuitry is protected and wiring does not become moved and displaced. Care should be taken to store the device in a dry, controlled environment to avoid moisture damage. The device manufacturer is to provide a three-year warranty, covering electrical malfunction.	The number keypad allows the client to assign the pills required to each day and time, rather than changing the code itself, hence reducing the chance of errors. Access to medication is key-card access protected for safety and to prevent misuse. The LCD screen display allows clients to cross check that the pills dispensed are correct. Training should be offered for the correct set up and use. Future improvements will implement user-friendly error messages and prompts for verification.

Intellectual Property

Pill dispensers generally are devices that exist in the Australian market, with many individual designs having patents registered with IP Australia. However, as there is a large variety of different ways in which the dispensers are designed and physically operate, our device would be eligible for its own patent and thus legal protection.

In order to achieve a patent for this device, a careful intellectual property strategy would need to be followed. Under the intellectual property guidelines established by the University of New South Wales (University of New South Wales, 2023), intellectual property developed by students is owned by students unless it consists of teaching materials, or is separately agreed to be assigned to the university. As a result, the manufacturing group would have ownership of the intellectual property that is the pill dispenser. The intellectual property would need to be registered under a stakeholder group consisting of the members of the manufacturing team, in order to ensure that ownership and executive decision making is maintained. Once ownership of the intellectual property is firmly secured and distributed, the patenting process can begin.

In Australia, a device that is patentable must be new, useful and innovative. The pill dispenser fulfils these requirements as it has a unique mechanism of dispensation that is efficient, cheap and environmentally friendly due to its low resource requirement. Moreover, it is useful as it allows for greater independence for senior citizens who are reliant on medications but do not have the medical competence to monitor their own consumption of these medicines. It is then critical to determine what type of patent is required for a given device. In the case of the pill dispenser, a complete patent application is the correct choice, as this gives legally enforceable protection to the device. A provisional patent is not required as the device has been completed, and thus would be able to be submitted in a patent application. Moreover, the rotating disc within the pill dispenser is a novel and inventive idea, meaning it could be eligible for its own patent in conjunction with the pill dispenser as a whole. This design could be employed in other situations such as locking mechanisms and fluid flows, making it potentially desirable and therefore important to protect under a patent.

Another key element in the intellectual property strategy is ensuring that no other devices exist with a similar idea that our device would be infringing on the patents of. In order to ensure this, the IP Australia database must be consulted (IP Australia, 2024). On this database, there are 31 registered devices under the name “pill dispenser”. Of these, only 2 have currently been granted a patent. These two devices are a form of packaging and a dispenser with a completely different mechanism to ours (spring loaded), and thus would not be infringed upon by our design in any way. There are 3 more devices that have filed patents that have not yet been accepted or rejected. These devices use methods such as a trap door, a vertically stacked tower, and individualised compartments in order to dispense pills, none of which would be infringed upon by the rotating disc mechanism used in our pill dispenser.

As the rotating disc is a unique design and is pivotal to our dispenser, it is integral to confirm that it is not already protected under a patent. In the IP Australia database there are 44 registered devices under the term “rotating disc”. Only one of these devices has been granted a patent, and it is used to reduce friction in machinery manufacturing using an entirely different principle to the one in the pill dispenser. There is also a device that has filed for a patent for a rotating disc that has not yet been granted, but it is specifically for energy recovery on a moving vehicle wheel. None of their devices are used in a context such as dispensing pills, or operate using the same principle. As a result, the pill dispenser would be patentable as it does not infringe on any existing intellectual property in Australia.

As both the pill dispenser as a whole and rotating disc as a component are eligible to be patented by the manufacturing group, the patenting process can be begun. This requires collating information about the manufacturing group such as addresses, legal ownerships and payment methods. Moreover, it requires a design specification to be written. This is a document that accurately describes the device being presented for a patent in detail, encompassing what the invention is and how it works in detail. Once these relevant documents have been collected and prepared, a patent application can be filed with IP Australia, wherein it will be judged and either patented or rejected.

Regulations and Standards

In Australia, regulations and standards surrounding medical devices are coalesced under the rules of the Australian Regulatory Guidelines for Medical Devices (ARGMD). These rules operate around three key pillars, designing in accordance with risk mitigation and safety, developing solutions that are state of the art and ensuring that benefits outweigh the risks of medical procedures and devices. Thus, our pill dispenser needs to abide by all of these principles.

For any devices that wish to be placed on the Australian Register of Therapeutic Goods (ARTG) and thus be sold as medical devices in Australia, they must pass the ARGMD's conformity test. This requires manufacturers to have documented evidence that their devices pass the three key principles set by the ARGMD.

The pill dispenser has been carefully prototyped and redesigned in order to ensure that it is perfectly accurate in dispensing the exact right amount of pills at any given time and in any given situation. This means that it mitigates risk, as it cannot accidentally provide too many or too few pills that could potentially represent life saving medication for at risk individuals. The dispenser employs a novel dispensing mechanism as well as password encryption and time based pill commands, making it a state of the art and highly efficient device that effectively aids individuals that are reliant on medication and may not be medically competent to keep track of their dosages. Moreover, the benefits of the dispenser significantly outweigh the risks, as it is a potential lifeline to pivotal medication for individuals who would otherwise be at risk of issues such as overdosing due to being unable to track their consumption, while the dispenser provides little to no excess risks in comparison to an individual not having a dispenser and instead tracking their own medication consumption.

Once the device has been approved and placed on the ARTG, there are requirements for the device to be monitored and investigated if issues occurred. This will be done with the pill dispenser through having strong contact with all patrons of the device and a strong support team both digitally and in person, allowing us to receive constant feedback on the performance of the device as well as being able to efficiently investigate and solve any issues that may arise.

The primary obstacle in ensuring that the pill dispenser meets regulatory requirements would be proving its perfect, unwavering accuracy in dispensing the correct number of pills at the right time. Due to much of the use case of this device being for individuals who are not medically competent to track their own medication usage, it is pivotal that the device works to a consistently flawless standard, and this would be assessed under the conformity tests of the ARGMD. Moreover, the production of the dispenser would have to abide by ARTG manufacturing laws, which represents an obstacle as it requires consistent management of the production process and internal investigations to ensure that our design process is legally compliant, safe and efficient.

Health Technology Assessment

The following assessment evaluates the effectiveness, economic implications, and impacts of the pill dispenser, ensuring client access to affordable, effective and safe health technologies.

Technical properties, safety and effectiveness: The device adheres to design standards, including accurate dispensing mechanisms and durable, low-maintenance materials. The dispenser's safety and risks are assessed in the Failure Modes Effects Analysis (FMEA). Features including the keypad, clear display screen and automatic dispensing reduce the risk of human errors and facilitate user-friendly operation. It is essential for patients and caregivers to receive adequate training to operate the device effectively, and conduct routine checks. The device is suitable for use in home settings and healthcare facilities. Client monitoring and satisfaction surveys will be conducted to monitor product short and long term effectiveness.

Microeconomic impacts & product pricing: The cost of manufacturing a single prototype has totalled to $71.8, (see Budget table, appendix A). Additional direct costs will include materials, replacement parts, labour and manufacturing overhead as well as indirect costs of shipping, marketing, packaging and administrative expenses. These extra costs will be mostly offset by the reduced cost per unit as a result of large-scale bulk manufacturing.

The device's ability to reduce healthcare expenses related to medication non-compliance, such as hospitalisations, leads to significant savings by the consumer and hence increases the perceived financial value of the product. Market research has revealed that competitor pricing for similar products range from $50 to $300 (Safety and Mobility, n.d.).

The proposed retail price of the Automatic Pill Dispenser is $100, which is justified by the above considerations, ensuring that the company offsets manufacturing costs and aligns with medical device industry profit margins of 20-30% (Medicare Payment Advisory Commission, 2017), making the device affordable for clients and competitive in the market.

Macroeconomic and social impacts: Widespread adoption of automatic pill dispensers could reduce national healthcare costs by decreasing emergency care and hospitalisations, leading to more efficient resource allocation within the healthcare sector. Additionally, the automatic pill dispenser enhances patient autonomy and reduces the burden on caregivers, contributing positively to patient quality of life, particularly for those with complex medication needs or cognitive impairments.

Strategies for Stable Pricing: Bulk purchasing agreements with suppliers can utilise economies of scale to reduce production costs per unit. Ongoing investment into research and development and operational efficiency can further reduce production costs. Additionally, collaboration with healthcare providers, insurance companies and government agencies can facilitate funding, subsidies and insurance coverage to reduce consumer expenses and support stable market prices.

Future Directions

In order to facilitate implementation of the pill dispenser at a clinical level, further product testing, research and development must be conducted to ensure long-term device accuracy, efficiency and efficacy. This could be done using trial runs with current and future prototypes, until it is confirmed that the device works exactly as intended, and is thus ready to be put into the market and used on a wider clinical scale.

The current version of the prototype is designed to be able to dispense five different colours of pills of the same size. This can be improved by altering the design specifications of the rotating disc to allow for various pill types and wider clinical uses. The dispenser could be able to dispense pills of different sizes and shapes based on the dimensions of the gaps in the rotating disc, allowing for the device to be a more holistic aid to individuals who need help with medication intake. Moreover, changing the exact specifications of the dispenser and rotating disc could open it's capabilities to a wider clinical context of sorting and dispensing items, making it potentially useful in hospitals and other medical locations as a method of sorting and dispensing high use items such as pipettes, swabs or masks.

To be used at a clinical level, the prototype would need to be manufactured at an industrial level. This can be achieved through standardising the production of the dispenser. The rotating disc components are a unique design created on 3D modelling software, which can be universally accessed and created through 3D printing. Moreover, the electrical components are universal, meaning that a general design mould could be created to house the necessary internal components, allowing the device to be manufactured at a large scale.

In order to ensure clinical effectiveness, certain features could be added to the dispenser prototype to improve ease of use. For example, an LED light that changes colour corresponding to the coloured pill dispensed could improve clarity for individuals with weaker eyesight. Additionally, the implementation of a sound that plays whenever pills are ready to be taken would allow for patients that struggle with issues such as Alzheimers or Dementia to still be able to access their potentially life saving medication.

Pill dispensers are rapidly improving with a wide variety of effective pre-existing design ideas, however there are many further technological improvements which can still be made in addition to the mechanical aspect. Linking dispensers with digital apps on a phone would allow greater control over the dispenser, as well as improving its ease of use as it would allow carers and patients alike to have a clear representation and record of their medication consumption. Moreover, implementing generative AI into a pill dispenser could improve its efficacy. Analysing trends in when patients are most likely to miss medication using machine learning could allow for the dispenser to provide tailored prompts and notifications to remind individuals to take their medication. This would minimise the chance of individuals not receiving the correct dosage of their medications, and thus greatly improve the overall effectiveness of the device going forward into the future.

Referencing

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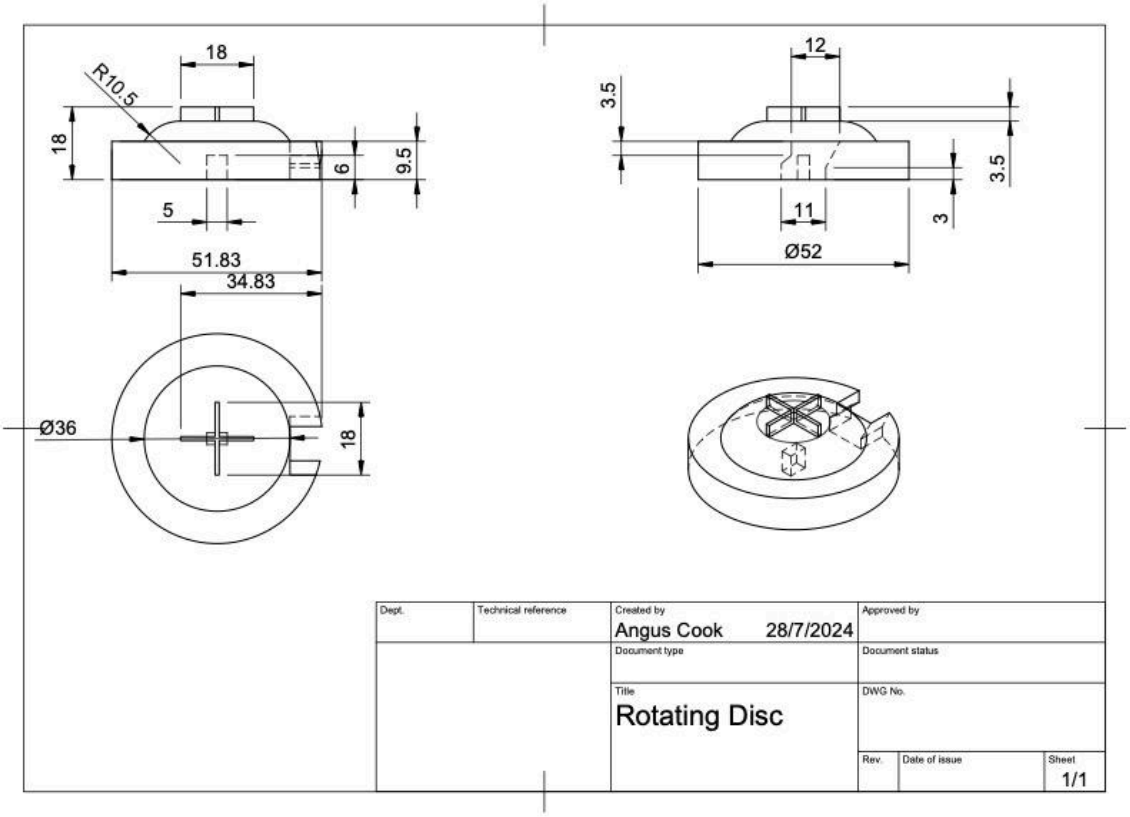
APPENDIX

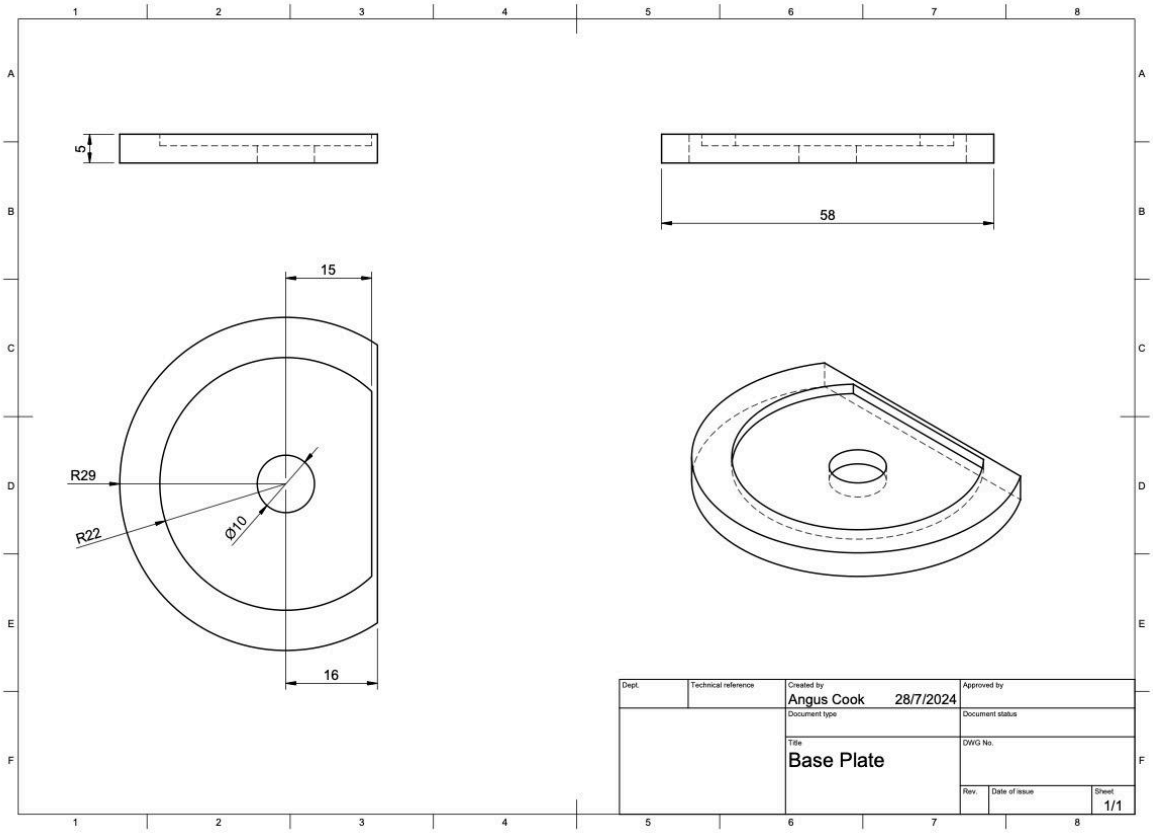
A. Budget Table:

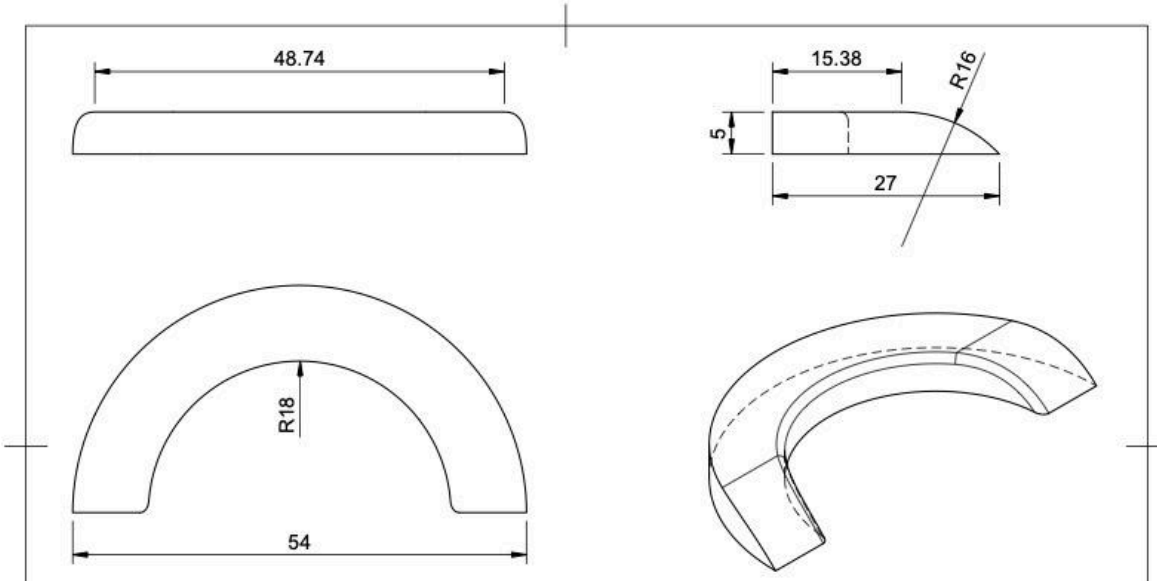
Material / Component	Quantity	Cost	Size / details / Specifications	URL (if purchased)
ELEGOO MEGA2560 R3 Board ATmega2560 ATMEGA16U2 with USB Cable Compatible with Arduino IDE	1	**$33.98**	Dimensions: 5.1L x 10.2W x 2.5H cm Memory storage capacity: 256 KB	https://www.amazon.com.au/Elegoo-Board-ATmega2560-ATMEGA16U2-Arduino/dp/B01H4ZLZLQ/ref=pd_lpo_sccl_1/357-3051176-1202050?pd_rd_w=V4HKP&content-id=amzn1.sym.7ef4c059-30c9-4984-b131-e38134d0b653&pf_rd_p=7ef4c059-30c9-4984-b131-e38134d0b653&pf_rd_r=3Y9MTWWBV3JJ219K18FX&pd_rd_wg=Ezm5a&pd_rd_r=2f306c6c-ef8b-4353-a43a-8f47aece2e60&pd_rd_i=B0772Q3LRD&th=1
Motors	4	**$27.83**		https://www.amazon.com.au/Dorhea-28BYJ-48-ULN2003-Stepper-Compatible/dp/B07Q4B5W4X/ref=sr_1_8?dib=eyJ2IjoiMSJ9.MzuyRTXRYeMokiVBcmnkXP7n1WZdPn--1yIcnE8b3BmeHqovTPDzg1-wPurBfpGId80uau69BMDRKwP8B5DI98vCtBXFrSKKF41SCiHQgGBIctJs7emJCQa78f7fsyYpy52TxFUFypZfxb1SwH5rjztyQbgQAV7Kl9qIaok97y5qDs9BJ2aBr_0AveHoVOyoHYwU_6R47fV79Bz08QiwcDJAv-a0DK1HoKF7x6DGp5aI7EUSmVTSawpkRULoVQCJT_fCgeZMzFQRXF-6VZTLpNNOP7kMw6DmrFjWR1MU3ds.x8HUZW5wx88n0lB5I9zGENSIfnDV7g1MNbPKj6r0uzM&dib_tag=se&keywords=5v+stepper+motor&qid=1722162468&refinements=p_36%3A-2800&rnid=5355409051&sr=8-8
Arduino Wire	1	**$9.99**		https://www.amazon.com.au/120pcs-Multicoloured-Dupont-Breadboard-arduino/dp/B01EV70C78/ref=asc_df_B01EV70C78/?tag=googleshopmob-22&linkCode=df0&hvadid=341743159395&hvpos=&hvnetw=g&hvrand=12070211024697086896&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9071723&hvtargid=pla-362913641420&psc=1&mcid=75bbd6ceb89f360baa147e90a2db692c
Paper cups	5	Nil	Base diameter 5.5 cm Height 8.5 cm	Obtained freely at UNSW
Paper plates	2	Nil	25 cm diameter	Obtained freely at UNSW

Shoe Box	1	Nil	35cm x 23.5cm x 13.5cm dimensions	Owned by group member
ELEGO kit	1	Nil	ELEGOO UNO R3 Starter Kit	Owned by group member
Spray paint	1	Nil	White	Owned by group member
Rotating component to dispense pills	5	Nil	PLA 3D Printed, White	3D Printed, UNSW MakerSpace
Flat base disk	5	Nil	PLA 3D Printed, White	3D Printed, UNSW MakerSpace
Total: $71.80			Budget limit: $80.00	

B. Draft Sheet for Final Prototype







Dept.	Technical reference	Created by	Approved by
		Angus Cook 28/7/2024	
		Document type	Document status
		Title: Sweeper Arm	DWG No.
			Rev. / Date of issue / Sheet: 1/1

C. Programming

Screenshot A

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Stepper.h>
#include <SPI.h>
#include <MFRC522.h>
#include <Keypad.h>
```

Screenshot B

```
// LCD
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Keypad
const byte numRows = 4;
const byte numCols = 4;
char keymap[numRows][numCols] = {
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'}
};
byte rowPins[numRows] = {9, 8, 7, 6};
byte colPins[numCols] = {5, 4, 3, 2};
Keypad myKeypad = Keypad(makeKeymap(keymap), rowPins, colPins, numRows, numCols);

// Stepper Motors
const int stepsPerRevolution = 2048;
int motorSpeed = 10; // RPM

Stepper redMotor(stepsPerRevolution, 22, 24, 23, 25);   // Motor for Red color
Stepper whiteMotor(stepsPerRevolution, 26, 28, 27, 29); // Motor for White color
Stepper greenMotor(stepsPerRevolution, 30, 32, 31, 33); // Motor for Green color
Stepper yellowMotor(stepsPerRevolution, 34, 36, 35, 37); // Motor for Yellow color
Stepper orangeMotor(stepsPerRevolution, 38, 40, 39, 41); // Motor for Orange color

// RFID
#define SS_PIN 53
#define RST_PIN 42
MFRC522 rfid(SS_PIN, RST_PIN);
MFRC522::MIFARE_Key key;
```

Screenshot C

```
// Variables
bool accessGranted = false;
int selectedDay = 0;
int selectedTime = 0;
int pillCounts[5] = {0, 0, 0, 0, 0}; // Array to store pill counts for each motor
```

Screenshot D

```
void setup() {
  Serial.begin(9600);
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Pill Dispenser");
  delay(2000);
  lcd.clear();

  redMotor.setSpeed(motorSpeed);
  whiteMotor.setSpeed(motorSpeed);
  greenMotor.setSpeed(motorSpeed);
  yellowMotor.setSpeed(motorSpeed);
  orangeMotor.setSpeed(motorSpeed);

  SPI.begin();    // Init SPI bus
  rfid.PCD_Init();// Init MFRC522

  lcd.setCursor(0, 0);

lcd.print("Scan your card");
}
```

Screenshot E

```
void loop() {
  if (!accessGranted) {
    handleRFID();
  } else if (selectedDay == 0) {
    selectDay();
  } else if (selectedTime == 0) {
    selectTime();
  } else {
    getPillCounts();
    dispensePills();
  }
}
```

Screenshot F

```
void handleRFID() {
  if (!rfid.PICC_IsNewCardPresent() || !rfid.PICC_ReadCardSerial()) {
    return;
  }

  // Print UID of the card
  Serial.print("UID tag: ");
  String content = "";
  for (byte i = 0; i < rfid.uid.size; i++) {
    content.concat(String(rfid.uid.uidByte[i] < 0x10 ? " 0" : " "));
    content.concat(String(rfid.uid.uidByte[i], HEX));
  }
  content.toUpperCase();
  Serial.println(content);
```

```
  // UID of a card
  String authorizedUID = " 03 98 D2 12";

  if (content.equals(authorizedUID)) {
    accessGranted = true;
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Access Granted");
    delay(2000);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Select Day (1-7)");
    lcd.setCursor(0, 1);
    lcd.print("1: Mon 2: Tue ... 7: Sun");
  } else {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Unauthorized");
    delay(2000);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Scan your card");
  }
}
```

Screenshot G

```
void selectDay() {
  char key = myKeypad.getKey();
  if (key >= '1' && key <= '7') {
    selectedDay = key - '0'; // Convert char to int
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Day selected: ");
    lcd.setCursor(0, 1);
    switch (selectedDay) {
    case 1: lcd.print("Monday"); break;
    case 2: lcd.print("Tuesday"); break;
    case 3: lcd.print("Wednesday"); break;
    case 4: lcd.print("Thursday"); break;
    case 5: lcd.print("Friday"); break;
    case 6: lcd.print("Saturday"); break;
    case 7: lcd.print("Sunday"); break;
    }
    delay(2000);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Select Time (1-3)");
    lcd.setCursor(0, 1);
    lcd.print("1: Morning 2: Lunch 3: Night");
  }
}
```

```
void selectTime() {
  char key = myKeypad.getKey();
  if (key >= '1' && key <= '3') {
    selectedTime = key - '0'; // Convert char to int
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Time selected: ");
    lcd.setCursor(0, 1);
    switch (selectedTime) {
      case 1: lcd.print("Morning"); break;
      case 2: lcd.print("Lunch"); break;
      case 3: lcd.print("Night"); break;
    }
    delay(2000);
  }
}
```

Screenshot H

```
void getPillCounts() {
  for (int i = 0; i < 5; i++) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("How many");
    switch (i) {
      case 0: lcd.print(" Red:"); break;
      case 1: lcd.print(" White:"); break;
      case 2: lcd.print(" Green:"); break;
      case 3: lcd.print(" Yellow:"); break;
      case 4: lcd.print(" Purple:"); break;
    }
    lcd.setCursor(0, 1);
    lcd.print("Enter count:");

    String countStr = "";
    char key;
    while (true) {
      key = myKeypad.getKey();
      if (key) {
        if (key == '#') {
          pillCounts[i] = countStr.toInt();
          break;
        } else if (key >= '0' && key <= '9') {
          countStr += key;
          lcd.setCursor(12, 1);
          lcd.print(countStr);
        }
      }
    }
  }
}
```

Screenshot I

```
void dispensePills() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Dispensing for: ");
  lcd.setCursor(0, 1);
  lcd.print("");
  switch (selectedDay) {
    case 1: lcd.print("Monday"); break;
    case 2: lcd.print("Tuesday"); break;
    case 3: lcd.print("Wednesday"); break;
    case 4: lcd.print("Thursday"); break;
    case 5: lcd.print("Friday"); break;
    case 6: lcd.print("Saturday"); break;
    case 7: lcd.print("Sunday"); break;
  }
switch (selectedTime) {
    case 1: lcd.print(" Morning"); break;
    case 2: lcd.print(" Lunch"); break;
    case 3: lcd.print(" Night"); break;
  }

  redMotor.step(pillCounts[0] * stepsPerRevolution);
  whiteMotor.step(pillCounts[1] * 2 * stepsPerRevolution);
  greenMotor.step(pillCounts[2] * stepsPerRevolution);
  yellowMotor.step(pillCounts[3] * stepsPerRevolution);
  orangeMotor.step(pillCounts[4] * 1.5 * stepsPerRevolution);
  // Stepping
  for (int i = 0; i < 5; i++) {
    redMotor.step(stepsPerRevolution / 8);
    delay(100);
    redMotor.step(-stepsPerRevolution / 8);
    delay(100);

    whiteMotor.step(stepsPerRevolution / 8);
    delay(100);
    whiteMotor.step(-stepsPerRevolution / 8);
    delay(100);

    greenMotor.step(stepsPerRevolution / 8);
    delay(100);
    greenMotor.step(-stepsPerRevolution / 8);
    delay(100);

    yellowMotor.step(stepsPerRevolution / 8);
    delay(100);
    yellowMotor.step(-stepsPerRevolution / 8);
    delay(100);

    orangeMotor.step(stepsPerRevolution / 8);
    delay(100);
    orangeMotor.step(-stepsPerRevolution / 8);
    delay(100);
  }

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Select Day (1-7)");
  lcd.setCursor(0, 1);
  lcd.print("1: Mon 2: Tue ... 7: Sun");

  selectedDay = 0;
  selectedTime = 0;
  accessGranted = false;
}
```