Design Project 3 – Sense of Independence

The MedMinder

IBEHS 1P10 – Health Solutions Design Projects

Tutorial 01

Team 3

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Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

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Executive Summary

Alzheimer's disease currently affects 36 million people and will reach 60 million in 2030 [1]. One of the largest challenges concerning Alzheimer's disease is medication administration. Current treatments are oral medications to be taken by the patient to reduce symptoms, however, the patient is required to independently administer the medication if they do not have a caregiver. The result is the patient underdosing or overdosing. Enhancing the current medication administration will reduce the progression rate of Alzheimer's, a heart shattering disease affecting millions worldwide. The implementation of a smart pill dispenser could increase the time a loved one has with a friend, parent, or grandparent suffering from this disease. Often in the early stage of Alzheimer's a caregiver is not required, the purpose of the automatic pill dispenser is to enhance the independence and dignity for patients living with Alzheimer's and reduce health care system pressures. 49% of individuals living with dementia forget the time and frequency medication should be taken [2]. Pressures in the healthcare system to reduce the effects of Alzheimer's induce a need for a dispenser to aid patients suffering from Alzheimer's to meet the market needs for this demographic. The MedMinder aims to enhance the quality of life for patients living with Alzheimer's in medication administration and independence. Incorporating distance sensors, visual and audio aids, patients will have the ability to independently take their own medications. Compartments contained within the solution provide the exact number of medications for an individual at a given dosing period. The activation of the system through elapsed time management and distance sensor, will release a given amount of medication at a specified time corresponding to the individual's schedule. After a given period, a summary of data collected from the course of the cycle can be obtained and shared with clinicians and caregivers to monitor their loved one and ensure their medication is being taken at correct times and on a consistent basis. Implementing these features for a challenge faced by not only individuals suffering from Mild Cognitive Impairment, but to other demographics will substantially enhance medication management worldwide.

Main Body

Summary of Design Objectives:

Need Statement: Design a device capable of delivering assisted care for Alzheimer's patients experiencing challenges with medication management, in turn improving daily life and enhancing independence.

Design Criteria:

- Must be monitored by caregivers (Constraint)
- Must include a timer aspect to act as a reminder (Constraint)

- Must be permanent or hard to move (Constraint)
- Easy to use (Objective)
- Low cognitive use (Objective)
- Low maintenance (Objective)
- Induce treatment option (Function)
- Output appropriate tasks (Function)

Background and Research Summary:

Advances in technology have developed innovative solutions in healthcare, including the integration of time-of-flight (TOF) sensors, light-emitting diodes (LEDs), and piezoelectric buzzers.

TOF sensors function by emitting an intense beam of light to measure an object's distance by reflecting off its surface and detecting the reflected light with pixels. These sensors typically consist of LEDs or vertical-cavity surface-emitting lasers (VCSELs) as a light source emitting near-infrared light and a CMOS sensor consisting of smart pixels [3]. The accuracy and range of the sensor depend on the type of components used, with VCSELs offering higher precision but at a higher cost compared to LEDs. Moreover, the sensor's functionality is also affected, which may struggle to capture high-sensitivity images under low light and reduce noise [4]. TOF sensors exist in various areas of healthcare, specifically with PET detectors. The integration of TOF sensors with PET detectors can produce better-quality imaging as images taken have a sharper contrast, and the sensors have minimal interference from other subsystems [5]. As a result, early diagnosis of neurodegenerative diseases, such as Alzheimer's disease, becomes simplified, as it can detect metabolic and biochemical alterations within the brain with greater detail [6].

LEDs work by emitting light through electroluminescence when current goes through its semiconductor materials. Electrical voltage drives the recombination of electrons and holes across a forward-biased p-n junction or diode, releasing a photon that emits light. Various materials can be found in LEDs, specifically for the type of semiconductor used. Examples of semiconductor materials are gallium nitride, zinc selenide, gallium arsenide phosphide and many other metal compounds. The types of materials used can affect the overall functionality as different semiconducting materials produce different coloured lights [7]. LEDs can be found in various fields of healthcare, including imaging, optogenetics and light therapies [8].

Piezoelectric buzzers generate sound using a piezoceramic disc or piezo crystal that changes shape when a voltage is applied. As a result, the piezoelectric material changes shape, pushing against the diaphragm of the buzzer. This action creates a pressure wave, which then transforms into sound [9].

Different types of piezoelectric materials, such as singular crystalline material, piezoceramics, piezoelectric semiconductors, polymers, composites, and glass ceramics, have different piezoelectric and mechanical properties. Certain types of piezoelectric materials are more effective than others due to differences in properties, such as their piezoelectric constants and elastic stiffness [10]. Piezoelectric buzzers are commonly utilized in patient monitoring systems and medical devices to relay notifications and messages.

Market Analysis:

Two products currently on the market that qualify as “Smart Pill Dispensers” on the market include the “e-Pill Voice” and the “Hero Automatic Dispenser”

The e-Pill Voice is a device made by e-pill Medication Reminders, a company famous for it’s line of electronic pill dispensers that come in all sorts of shapes and sizes [11]. The e-Pill Voice has a shape like a circular disc, a design choice that is reminiscent of traditional pill dispensers. The dispenser itself is electronically automated, with a clock in the middle that is set to dispense pills at certain times. The dispenser itself is locked by a key, preventing patients from taking medications before the allotted time. As the name suggests, the device is voice automated and notifies the patient with a voice recording when it is time for them to take their pill. The e-Pill Voice is able to hold up to 28 days of medication with a different compartment for each day. The e-Pill operates with either an AC adapter or 4AA batteries allowing it a great deal of versatility and portability.

The Hero Automatic Dispenser will seem like almost an entirely different device compared to the E-Pill Voice. Made by Hero Health, the Hero Automatic Dispenser is tall and shaped to fit on top of a kitchen counter, as opposed to a bedside table or drawer like the E-Pill Voice [12]. The Hero Automatic Dispenser is a technologically advanced device that not only features audible and visual reminders but also notifies the caretaker via their companion mobile app. Instead of having a lock and key mechanism for locking the pills, the Hero Automatic Dispenser has a PIN password system that ensures the medication is stored securely. Because of the upright structure of the Dispenser, it also has a plastic cup for the pills to dispense into. Unlike the E-Pill Voice, the Hero Automatic Dispenser only has 10 different compartments, however it can hold up to 90 days of medication compared to the E-Pill’s 28 days.

Both the E-Pill and Hero Automatic Dispenser share several similarities, such as how both of them are white in color which are often used to illicit patient and tranquil feelings for users, as well as how both feature notifications for the caretakers and patients. However, the Hero Automatic Dispenser is significantly more expensive and features a subscription service as well. [13]

Description of Proposed Solution:

The MedMinder is an automatic pill dispenser made to cater to Alzheimer's patients who are susceptible to underdosing or overdosing their recommended daily dosage of medication. The Med Minder is an upright device meant to be placed on a counter or table that dispenses a pill at a particular time upon receiving a motion signal detected by the distance sensor. It has 8 distinct compartments, with 7 for each day of the week and 1 being empty to rest on the empty pill lid (Figure 4). When a pill needs to be dispensed, the user put's their hand under the distance sensor and the green LED on the front of the dispenser lights up. The container rotates using a DC motor connected to it via a rod and the pill for the corresponding day enter into the empty space in the pill lid. The pill enters into the funnel and empty's out onto the pill catcher, where it will be taken by the patient. The distance sensor senses the presence of the pill on the pill catcher. If, after a certain duration, the pill has not been taken, the MedMinder will notify the patient and caretaker by flashing the red LED and producing a buzzing sound. This ensures that the pill is removed from the pill catcher and has been taken by the patient. After the pill has been removed, the LED's turn off. A big problem with Alzheimer's patients is that they forget they've taken their pill and can tend to overdose on their medication, the MedMinder will flash green if the patient tries to take a pill again within the same day.

Universal Design Considerations:

A primary concern in senior residents is their inability to take their medication at a given time without relying on a caregiver [14]. The MedMinder incorporates both an LED lighting system and a noise buzzer to notify patients when to take medication (Figure 1). Adults speaking a foreign language can utilize this device [15]. Blister packs and other medication containers have language that many individuals who speak a foreign language are challenged with health literacy, as a result they require a caregiver to administer their medication when they could independently take their own. For individuals with mobility challenges, The MedMinder device uses an automatic sensor to distribute their medication (Figure 2). MS patients who lose fine motor skills in their hands find it difficult to open medication blister packs and child lock bottles [16]. Sensory mechanisms prevent the need for excess strength in taking medications and eases the medication management process. One patient stated reducing the need for fine motor skills significantly increased their quality of life and reduced frustration. Long-term care homes utilize blister packs for medical administration, for patients with medication unsupported by the blister packs, increased pressure is placed on the healthcare workers to administer medication included in both the blister pack and other means of administration [17]. MedMinder implementation in long term and retirement homes will reduce health care system pressures. For medications requiring caregiver administration, that would be their sole priority, instead of managing 2 dosing periods. Diseases such as Parkinson's with multiple medications could utilize this device to manage when each medication should be taken to ensure the right number is taken at the correct time, with limited mobility they are able to access their medication easily and with the right dosage.

Accessibility challenges arise where caregivers are unable to monitor if their loved one took their medication and the perception of the device. Individuals suffering from cognitive impairment may not be able to perceive the intentions of the device due to the lack of symbolism to guide them how they receive their medication. Implementing arrows or an LCD screen would allow them to see the action required in order to successfully obtain their required medication. Additionally, caregivers continuously need to add medication to the dispenser in the correct order, similar to a blister pack. Depending on the length of a medication cycle and the number of dosages, this task could be tedious and reduce the appeal to users. Location of the MedMinder is flexible although portability reduces accessibility. The MedMinder could be placed on a small table, dresser or even be wall mounted depending on the location. While it is not a large device, if an individual were not home for the time of medication administration, they would be unable to access their dose which could alter their cycle. Patients would be required to bring additional medications if they were not expected to remain at The MedMinder location.

Design Verifications:

When implementing the concept for the MedMinder, various factors were considered to make the product successful and implement its function effectively. The goals of the overall design were to be simple, lightweight, and clear of its overall function due to the chosen demographic of Alzheimer's patients. An improved design was created to allow individuals with impaired cognition to take their scheduled medication by incorporating mechanisms that will remind and ensure that the pill is being taken. To accurately represent MedMinder, a prototype was constructed with the use of a DC motor, distance sensor, Raspberry Pi, LEDs, buzzer, plastic encasing, dowels, and Styrofoam. The choice of materials, such as plastic and Styrofoam, were used for their durability, reduced part weight, and flexibility for the multiple components within the dispenser. For the external casing that holds the internal components that execute the dispensing mechanisms, a hollow plastic container was used to be connected to a wooden stand. This was chosen as a support mechanism that has enough room for the internal components, whilst being resistant to stress or forces. Not only, but the front portion of the external case also had the LEDs attached to ensure that the lights were seen during dispensing time or off periods. The pill compartments that separate medications were built using Styrofoam as the dividers, which were glued to a plastic straw. The plastic straw was attached to a dowel, which connects to the DC motor to rotate the dividers when time to dispense the pill. An open plastic cylindrical case was placed over the dividers to ensure that the pills and DC motor were secured within the external casing. On the bottom of the external casing, where the pill container rested, an opening was made for the pill to dispense through a plastic funnel into a catcher. The distance sensor that notifies if the pill was taken was placed underneath the funnel to clearly detect the pill. In order to test the product, each part was trialed before being included within the design, specifically the motor portion. The rotating pill dividers were tested with the motor in terms of ensuring smooth movement and distinguishing the right amount of rotation that will provide the strength of dispensing the pill. This was done in increments with using trial-and-error to see what interval was perfect for the motor, which ideally was 0.5 seconds. Once the rotation was perfected, the internal components were fully assembled and tested as a whole mechanism. There were adjustments that needed to be made since there were unaccounted certainties such as friction, that impacted the overall function. The major challenge that the team faced was the motor's feasibility and the materials' resistance. To overcome this obstacle, the rotation had to be increased to 0.1 seconds for greater strength and small additional attachments including electrical tape, were used to decrease friction. In future, the pill dividers will be constructed with a material with a lower friction coefficient (nylon or PTFE) since Styrofoam's coefficient of friction increases with velocity. All in all, the MedMinder prototype was created in similarity to the CAD model using resourceful materials and tested accordingly.

Strengths and Limitations:

Medication management is a major challenge for seniors, nearly 55% are non-compliant with prescription drugs [14]. The MedMinder was designed to incorporate reminders to enhance medication management for individuals suffering from cognitive impairment. Reminders and scheduling are proven to aid Alzheimer's patients, based on a study conducted by the University of Missouri [18]. Utilization of technical devices for patients with Alzheimer's can enhance their memory by providing them with reminders for daily tasks and upcoming events. Each day, at a specific time, patients will be notified to take their medication. Caregivers will input the number of hours between dosages and the length of the dosing cycle. Once the time between dosing periods is reached, a green LED and a buzzer will turn on to notify adults to take their medication. Remaining active, the output devices will only shut off once the patient has successfully activated the motor component of the device. This encourages patients to take their medication at the correct time. Delaying the progression of cognitive decline and increasing the quality of life of a patient facing Alzheimer's disease, is the aim of the output device component, absent in various current pill dispensers, reducing their effectiveness. Overdoses are the leading cause of concern in medication errors, with 40% of errors being administration [19]. Seniors living with Alzheimer's or Mild Cognitive Impairment are unable to administer their medication correctly and at the proper dosage without a caregiver. Implementing a compartmentalized rotational system containing the desired medication amount per compartment ensures patients are taking the appropriate amount of medication on a controlled basis. To prevent the patient from continuously taking medication, there is a locking system in place ensuring individuals only take their medication at a given time, declining patients the ability to take medication if it is outside the given dosing period.

One limitation with the design is its ability to have multiple dosage cycles based on the rotation and compartment design. Incorporating only 8 compartments, represented in figure 3, increases the need for caregivers to restock the dispenser for the patient. Continuous replenishing of the design reduces its overall ability for low maintenance, nearly twice a week requiring an individual to restock the device. Producing a greater amount of rotation cycles would allow patients to go for extended periods of time without the need to be concerned with their medication management and enhance the efficiency of the design. Finally, the proposed device does not have the ability to measure if a patient took their medication. The MedMinder incorporates a feature relaying information to caregivers when the medication was dispensed and the time it was picked up through a data summary file. The program does not outline and cannot control whether the medication was directly administered to the patient following the notification the patient obtained their medication.

Following advancements, The MedMinder could be a life changing device for patients not only suffering from Alzheimer's disease, while also aiding various cohorts in their ability to manage medications.

Summary of Contributions:

Name:	**Contributions:**
Kristina Siiman	Administrator, coding sub-team (sensor testing, function production, general code layout, planning, and implementation of processes and their functions), prototype production (compartments, wooden stand, dispenser mechanism including the funnel and container molding), slideshow creation for expo, Design report (Strengths and Limitations, Executive Summary, Universal Design Considerations)
Krystal Kwok	Manager, modelling sub-team (constructing the general design, more specifically the internal

	components and assembling the pill container), prototype production (stand, pill compartments, external casing, and dispensing mechanism), and Design Report (Design Verification, Executive Summary and Description of Proposed Solution).
Ryan Junejo	Subject Matter Expert, modelling sub-team (general design and modelling layout, constructing the exteriors of the model, assembling the model and ensuring it's fully constrained), prototype production (compartments, motor 3D printing, recording and editing the video), Design Report (Market Analysis, Executive Summary, and Design Verification)
Tharshigan Vithiyananthan	Coordinator, computing sub team (Planning, overall while loop structure, commented sections of code, planned and implement functions, wired sensors and output devices to breadboard), prototype production (raspberry pi, sensors, motor, and breadboard integration, motor attachment, 3D printing for pill dish and motor brackets), Design Report (Research and Background Summary, Executive Summary, Design Verification)

Reference List

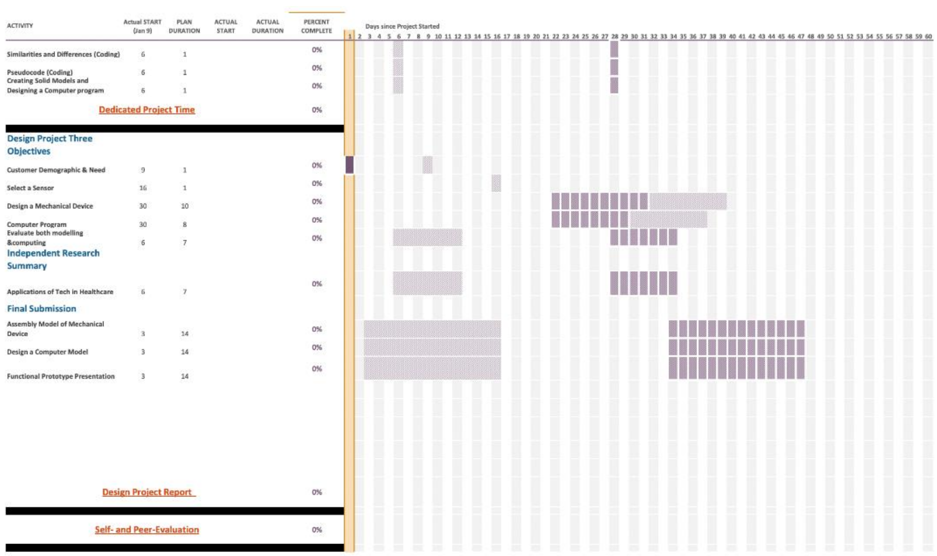
1. L. C. Brazaca, I. Sampaio, V. Zucolotto, and B. C. Janegitz, "Applications of biosensors in Alzheimer's disease diagnosis," *Talanta*, vol. 210, p. 120644, 2020, doi: 10.1016/j.talanta.2019.120644.
2. R. H. Lim and T. Sharmeen, "Medicines management issues in dementia and coping strategies used by people living with dementia and family carers: A systematic review," International Journal of Geriatric Psychiatry, vol. 33, no. 12, pp. 1562–1581, Sep. 2018, doi: https://doi.org/10.1002/gps.4985.

3. M. Lindner, I. Schiller, A. Kolb, and R. Koch, "Time-of-Flight sensor calibration for accurate range sensing," Computer Vision and Image Understanding, vol. 114, no. 12, pp. 1318–1328, Dec. 2010, doi: 10.1016/J.CVIU.2009.11.002
4. M. Mori *et al.*, "An APD-CMOS image sensor toward high sensitivity and wide dynamic range," in *2016 IEEE International Electron Devices Meeting (IEDM)*, Dec. 2016, pp. 8.3.1-8.3.4. doi: 10.1109/IEDM.2016.7838374.
5. C. S. Levin, S. H. Maramraju, M. M. Khalighi, T. W. Deller, G. Delso, and F. Jansen, "Design Features and Mutual Compatibility Studies of the Time-of-Flight PET Capable GE SIGNA PET/MR System," IEEE Trans Med Imaging, vol. 35, no. 8, pp. 1907–1914, Aug. 2016, doi: 10.1109/TMI.2016.2537811.
6. V. Valotassiou et al., "SPECT and PET imaging in Alzheimer's disease," Ann Nucl Med, vol. 32, no. 9, pp. 583–593, Nov. 2018, doi: 10.1007/s12149-018-1292-6
7. K. Sask. IBEHS 1P10. Class Lecture, Topic: "Materials for Sensors and Devices." Integrated Biomedical Engineering & Health Sciences, McMaster University, Hamilton, ON, Jan. 30, 2023.
8. J. Dong and D. Xiong, "Applications of Light Emitting Diodes in Health Care," *Ann Biomed Eng*, vol. 45, no. 11, pp. 2509–2523, Nov. 2017, doi: 10.1007/s10439-017-1930-5.
9. K.-T. Chang, "Design and Implementation of a Piezoelectric Clutch Mechanism Using Piezoelectric Buzzers," in *2007 2nd IEEE Conference on Industrial Electronics and Applications*, May 2007, pp. 2178–2183. doi: 10.1109/ICIEA.2007.4318796.
10. A. Aabid *et al.*, "A Systematic Review of Piezoelectric Materials and Energy Harvesters for Industrial Applications," *Sensors*, vol. 21, no. 12, p. 4145, Jun. 2021, doi: 10.3390/s21124145.
11. E.-P. Medication Reminders, "E-Pill Voice Product Information," *E-Pill Voice Product*. [Online]. Available: https://www.epill.com/medsmart-voice.html. [Accessed: 08-Mar-2023].
12. A. Clark, "Hero pill dispenser review: Is the hero medication dispenser the best?," *The Senior List*, 14-Feb-2023. [Online]. Available: https://www.theseniorlist.com/medication/dispensers/hero/#:~:text=In%20a%20nutshell%2C%20Hero%20can,made%20me%20healthier%20and%20stronger. [Accessed: 08-Mar-2023].
13. C. Crider, "Having trouble keeping your medication in order? here are some great organizers that might help," *Healthline*, 21-Apr-2022. [Online]. Available: https://www.healthline.com/health/pill-dispenser#our-picks. [Accessed: 08-Mar-2023].
14. "Top 6 Problems with Medication Adherence in Seniors," *www.agingcare.com*. https://www.agingcare.com/articles/medication-problems-elderly-people-have-146111.htm#:~:text=According%20to%20the%20Department%20of
15. "Drug Packaging: Could They Make It More Difficult?," *EverydayHealth.com*. https://www.everydayhealth.com/columns/trevis-gleason-life-with-multiple-sclerosis/from-childproof-caps-to-blister-packs-could-they-make-it-more-difficult/ (accessed Mar. 08, 2023).
16. "Health literacy: A silent barrier for newcomers in Canada," *The Sheaf - The University of Saskatchewan Newspaper Since 1912*, Feb. 04, 2017. https://thesheaf.com/2017/02/04/health-literacy-a-silent-barrier-for-newcomers-in-canada/ (accessed Mar. 08, 2023).
17. "Study examines potential advantages and disadvantages of blister packaging for nursing homes," News-Medical.net, May 20, 2019. https://www.news-medical.net/news/20190520/Study-examines-potential-advantages-and-disadvantages-of-blister-packaging-for-nursing-homes.aspx
18. "Smartphone reminders can improve memory for older adults with dementia // Show Me Mizzou // University of Missouri," *showme.missouri.edu*. https://showme.missouri.edu/2022/smartphone-reminders-can-improve-memory-for-older-adults-with-dementia/#:~:text=In%20a%20recent%20study%20involving (accessed Mar. 08, 2023).
19. K. Arora, "Smart pill Dispenser using Internet of Things." [Online]. Available: https://www.ijert.org/research/smart-pill-dispenser-using-internet-of-things-IJERTV7IS070155.pdf

Appendices

Appendix A: Project Schedule

Preliminary Gantt Chart:



Final Gantt Chart:

Design Project Three

Period Highlight: 1

Plan Duration · Actual Start · % Complete · Actual (beyond plan) · % Complete (beyond plan)

Days since Project Started (Beginning January 9th 2023 (9th Column))

ACTIVITY	Actual START (Jan 9)	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestones					100%
Milestone 0 - Team					
Review Administrative Responsibilites (milestone 0 worksheet)	9	1	9	1	100%
Team Charter	9	1	9	1	100%
Milestone 1 (Team)					
Define Customer Demographic	9	7	12	4	100%
Formulat Statements of fact	9	7	12	4	100%
Creating a Need Statement	9	7	12	4	100%
Milestone 2 (Individual)					
Premliminary Concept Solutions (min.2)	16	1	16	1	100%
Input & Output Devices	16	1	16	1	100%
Milestone 2 (Team)					
Concept Evaluation & Discussion	16	3	17	2	100%
Complete Pugh Matrix	16	3	17	2	100%
Proposal of Design Requirements	16	3	17	2	100%
Milestone 3 (Sub-Teams & Individual)					
Preliminary Sketch (CAD team)	23	7	25	5	100%
Processing Input and Output (Computing team)	23	7	26	4	100%
Milestone 3 (Team)					
Appearance of device	23	1	23	1	100%
Communication of the device	23	1	23	1	100%
Function of the device	23	1	23	1	100%
Milestone 4 (Individual)					
Detailed Sketch (CAD team)	30	7	33	4	100%
Workflow/Chart (Computing team)	30	7	33	4	100%
Milestone 4 (Team)					
Preliminary Modelling (CAD team)	6	1	6	1	100%
Similarities and Differences (CAD)	6	1	6	1	100%
Outcome of Design (CAD)	6	1	6	1	100%
Preliminary Program (Coding)	6	1	6	1	100%

Days since Project Started (Beginning January 9th 2023 (9th Column))

ACTIVITY	Actual START (Jan 9)	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Similarities and Differences (Coding)	6	1	6	1	100%
Pseudocode (Coding)	6	1	6	1	100%
Creating Solid Models and Designing a Computer program	6	1	6	1	100%
Dedicated Project Time					100%
Design Project Three Objectives					
Customer Demographic & Need	9	1	9	1	100%
Select a Sensor	16	1	16	1	100%
Design a Mechanical Device	30	10	30	10	100%
Computer Program	30	8	30	7	100%
Evaluate both modelling &computing	6	7	7	6	100%
Independent Research Summary					
Applications of Tech in Healthcare	6	7	6	7	100%
Final Submission					
Assembly Model of Mechanical Device	3	14	1	14	100%
Design a Computer Model	3	14	1	14	100%
Functional Prototype Presentation	3	14	5	12	100%
Design Project Report					100%
Self- and Peer-Evaluation					100%

Appendix B: Scheduled Weekly Meetings

Date: Jan 16th, 2023

Milestone 2 (Team)

Attendance

Krystal	Ryan	Tharshigan	Kristina
X	X	X	X

Agenda Items:

- Present concept sketches that were completed prior (individual)
- Discuss each preliminary sketch and the innovation behind it
- Complete the Pugh matrix worksheet and justify each personal sketch
- Discuss pros and cons of each sketch
- Select one design that will be used for further testing

Meeting Notes:

- Including a moving mechanism in concepts and discuss how important this should be for the demographic.
- Consider how to make the concept portable with each project objective
- Alzheimer's is a difficult demographic since the patients will be unaware of the therapies that are being induced.
- Prioritizing Form and Function

Future Action Items:

- Discuss a moving mechanism
- Improving selected concept

- Discuss future problems with concepts

Date: Jan 23rd 2023

Milestone 3 (Team)

Attendance

Krystal	Ryan	Tharshigan	Kristina
X	X	X	X

Agenda Items:

- Discuss preliminary designs that were created by the modelling team. Talk about the different components and what the area of focus will be.
- Give feedback on each preliminary items (Stage One and Two)
- Coding team discusses how the sensor and design will interact (flow chart).
- Continue discussing the moving mechanism from last week and talk about what materials could possibly be used.
- Start a detailed sketch and plan out the program.

Meeting Notes: (Free Time)

- Discussed how to make our idea feasible and customizable within the demographic
- Adjusted on the design so that the sensor can be interacting with the patient
- Talked about how the design will be assembled and prototypes (future ideas)
- Discussed with TA about the availability of parts available, what 2 separate functions and discussed feasibility of prototype

Future Action Items:

- Discuss which sensor (motion or force) which will be more benefitting for the patient
- Create detailed sketch and start CADing
- Create program

Date: Jan 30th, 2023

Milestone 4 (Team)

Attendance

Krystal	Ryan	Tharshigan	Kristina
X	X	X	X

Agenda Items:

- Modelling Team: Present detailed sketches and go over specific mechanisms that are key to the assembly of the product.
- Computing Team: Present pseudocode chart of device-user interaction and processes that will help with the feedback of the product.
- Compare with other team members to fill in the loose gaps.

Meeting Notes:

- Spoke to the TA about the feasibility of the design and concerns about the dispensing mechanisms.
- Discussed if the pseudocode has two clear mechanisms that are meaningful to the patient.
- Adjusted the mechanisms based on TA feedback that the two mechanisms need to be related to the sensor directly.
- Discussed as a team to remove the push button and use the distance sensor instead

- Reviewed and changed the 2 processes to meet requirements
-

Future Action Items:

- Modelling Team: Improve the detailed sketch that the team agreed upon and begin CADing difficult parts.
- Coding Team: Create a new pseudocode that is adjusted to the new mechanisms and inquire about the time functions that would be needed.
- Meet as a group over Teams this week.

Date: Feb 6th, 2023

Dedicated Project Time

Attendance

Krystal	Ryan	Tharshigan	Kristina
X	X	X	X

Agenda Items:

- Begin to start CADing and coding the prototype.
- Discuss prototype materials that can be used for the dispensing mechanism.
- Work on IRH summary.
- Modelling team: Dimension the prototype and discuss steps of the assembly due to the challenge of connecting the dispenser.

Meeting Notes:

- Spoke with the TA about the new design proposal after being advised that Dr. Mcdonald is lenient with the mechanisms not being direct feedback from the sensor.

- The two mechanisms that were hard decided on were using the LEDs to notify the patient to take their pill with the buzzer and using the distance sensor to ensure if the pill was taken from the catcher.
- Asked about coding questions with the time function since there was confusion about if there was a function that used hours rather than seconds.

Future Action Items:

- Continue to model and code aiming to finish by next week.
- Meet this week on Teams to follow up.

Date: Feb. 13th 2023

Dedicated Project Time

Attendance

Krystal	Ryan	Tharshigan	Kristina
X	X	X	X

Agenda Items:

- Modelling Team: Discuss the pill compartments and how different medication will be stored. Also, discuss how to CAD the dispensing mechanism that allows the pill to fall into the catcher.
- Coding Team: Discuss how the code will rotate the pill compartments and continue to familiarize with the Raspberry Pi.
- Create a schedule after reading week to allow for the prototype to be built on time and decide what materials everyone is bringing.

Meeting Notes:

- Short meeting with the TA about our progress and asked questions about the presentation.
- Discussed the prototyping expectations.

Future Action Items:

- Bring materials for the prototype
- Complete the CAD and code
- Decide what to 3D print
- Practice for the presentation and what points need to be emphasized
- Video progress from the prototype once constructed
- Meet on Teams

Additional Meetings:

Date: Jan. 12, 2023

Members Present: Tharshigan, Kristina, Krystal

Notes:

- Discussed progress with the individual section for Milestone 2
    - Discussed potential demographics we could target and our individual research on the market for each demographic: elderly patients with tremors, patients with communication difficulties, deaf and blind patients
        - Made the decision to target Alzheimer's patients, specifically targeting sundowning
    - Discussed potential solutions that everyone created:
        - Device that controls household appliances for Alzhiemer’s patients
        - Glove that interprets sign language
        - Pill dispenser

Date: Jan. 21, 2023

Members Present: Tharshigan, Kristina, Krystal, Ryan

Notes:

- Online meeting
- Discussed refinements of our pill container design
  - Introduced the canister design with the separate components
  - Searched and discussed the current market of pill dispensers
    - What aspect or feature would be useful for Alzhiemer's patients that don't exist?
    - Discussed images of existing containers to see if we could take any design features as inspirations for our own design
    - Discussed the overall function of the pill dispenser
      - Will it dispense weekly? Biweekly? One dose per day?
- Delegated tasks for next meeting
  - Modelling subteam: create preliminary sketches with detail about how compartments would look like
  - Computing subteam: research about what sensor and output devices we could use

Date: Jan. 22, 2023

Members Present: Tharshigan, Kristina

Notes:

- Online meeting
- Discussed refinements of our design from last meeting with entire team
  - Introduced the canister design with the separate components with holes
  - Worked on pseudocode together
    - Planned out how to approach structure of the program: by using a while loop
- Delegated tasks for next meeting:

  - Brainstorm processes that we could implement into our program

Date: Jan. 25, 2023

Members Present: Tharshigan, Kristina, Krystal, Ryan

Notes:

- Online meeting
- Discussed what sensors to include
- Overview of the design so far
- Decided to use the distance sensor and push button
  - Sensor to detect if any pills are left
  - Push button to dispense
- Discussed progress of the modelling sub team
- Discussed about the Design Review for next Design Studio session
  - Discussed what aspects of the design should be done by then
  - Discussed about potential questions we could ask
- Discussed CAD prototypes and possible features that could be included

Date: Jan. 30, 2023

Members Present: Tharshigan, Kristina, Krystal, Ryan

Notes:

- Discussed design changes from previous design studio
- Went over the 2 distinct processes
- Went over IRH summary and who is doing what topic
- Went over prototyping and potential materials that we could use
- Set deadlines to finish our respective roles for modeling and computation subteam

Date: Feb. 02, 2023

Members Present: Tharshigan, Kristina

Notes:

- Went over discussion in previous design studio session
  - When time to take pill, LED blinks, buzzer goes off
  - When hand under sensor, motor rotates, pill dispenses
  - LED blinks red when not time to take pill
  - When pill still under sensor, buzzer goes off to notify patient
- Reviewed modelling sub team design
  - Discussed where raspberry pi and breadboard could be placed
    - Decided that LEDs would be placed right under the dispensing zone
- Discussed how the time function would work
  - Decided that using elapsed time would be the best approach
- Delegated tasks and discussed team-made deadlines for the code and CAD to be completed by

Date: Feb. 23, 2023

Members Present: Tharshigan, Kristina

Notes:

- Computing sub team meeting
- Discussed progress with the code
  - Restructuring while loop by controlling it with a variable
  - Discussed the implementation of time function
  - Discussed what sections need their own function
    - Controlling output devices

    - Rolling average
    - Distance sensor measurements
    - Text file
- Discussed overall mechanism
  - Does any component need to be changed?
- Discussed progress with raspberry pi and breadboard wiring
- Discussed materials that can be brought from home
- Delegated tasks and section of codes to complete during the rest of reading week

Date: Feb. 27, 2023

Members Present: Tharshigan, Kristina, Ryan

Notes:

- Discussed progress over reading week
  - Rough draft of code was completed
  - Majority of the CAD file was completed
- Discussed materials everyone brought and decided which materials can be used
  - Small cylindrical container for housing the compartments
  - A large, clear biscuit box to house the entire device
- Fully wired the raspberry pi, breadboards, output devices and sensor
  - Tested each component to ensure that it works
  - Realized that the DC motor would best accommodate how we wanted the prototype to function instead of Servo motor
- Delegated tasks
  - CAD model must be done by the next day
  - Begin to construct physical prototype

Date: Feb. 28, 2023

Members Present: Tharshigan, Kristina, Ryan, Krystal

<u>Notes:</u>

- Discussed about yesterday's meeting with Krystal as she was absent for that meeting
- Discussed progress with CAD model
- Discussed design changes for prototype
  - LEDs should be placed right in front of the device
  - Breadboard could lean against the inside of the large container
  - Discussed about 3D printing a pill dish that is concave to catch all dispensed pills to one place
  - Discussed about the need for a funnel
    - Funnel could be made from a top portion of a pop bottle
- Discussed the use of popsicle sticks to hold motor in placed
- Made modifications to CAD model
  - Modelling team finished the CAD model
- Realized that DC motor would need a bracket to mount it on the device
  - Designed a rough 3D model of what the bracket could look like

Date: Mar. 01, 2023

Members Present: Tharshigan, Kristina, Ryan, Krystal

<u>Notes:</u>

- Meeting at Thode MakerSpace
- Began to construct the compartments using a straw, hot glue, and foam board cutouts
- Began to make cuts within compartment housing container at the top for access to the compartments
- Tested code with the sensors to see if program works as planned
  - Decided that for process 2, it should measure container distance and time
  - LED and buzzer should blink faster

- Began to make a hole cutout to the large container to feed the rotating axis through

Date: Mar. 02, 2023

Members Present: Tharshigan, Kristina, Ryan, Krystal

Notes:

- 3D printed motor brackets
- Assembled a wooden stand
- Trimmed compartments down and secured compartments and compartment housing to the large container
- Wooden dowel was filed down and drilled a hole in the dowel to attach dowel to motor and to attach motor to straw (rotating axis)
- Tested computer program with the assembled prototype
  - Discovered that the amount of time the motor needs to rotate for each compartment should increase to 1 second
  - Compartments weren't moving well due to friction and other errors
  - Needed to secure motor at the top of the device
  - Needed a proper pill dish

Date: Mar. 03, 2023

Members Present: Tharshigan, Kristina, Ryan, Krystal

Notes:

- Used a pop bottle cutout to make the funnel
- Fixed the compartment rotation by adding a washer and electrical tape near the ends
- Constructed 2 cardboard bars that were attached near the top of the device for where the motor can rest
- Attached the motor brackets and DC motor together

- Used a new dowel and filed it down, drilled a hole as the old one became defective
- Extended wiring of output devices and DC motor
- Raspberry pi housing was constructed
- Did more testing with the prototype as a whole
    - Pill was dispensing
    - Compartments still had problems rotating smoothly
    - Realized that certain part of the compartments has more weight due to the dowel hole not being perfectly centered
- Expo was extended to Mar. 06 therefore, we decided to add final touches later

Appendix C: Comprehensive List of Sources

Materials	R. Pope, "The basics of shock & vibration absorbers," *Sorbothane*, 08-Nov-2022. [Online]. Available: https://www.sorbothane.com/technical-data/articles/the-basics-of-shock-vibration-absorbers/#:~:text=Sorbothane%20is%20a%20thermoset%20that,acoustic%20damping%20and%20shock%20attenuation. [Accessed: 08-Mar-2023].
ResearchSummary: Scientific Principles Of Sensor Technology	M. Lindner, I. Schiller, A. Kolb, and R. Koch, "Time-of-Flight sensor calibration for accurate range sensing," Computer Vision and Image Understanding, vol. 114, no. 12, pp. 1318–1328, Dec. 2010, doi: 10.1016/J.CVIU.2009.11.002.
	C. S. Levin, S. H. Maramraju, M. M. Khalighi, T. W. Deller, G. Delso, and F. Jansen, "Design Features and Mutual Compatibility Studies of the Time-of-Flight PET Capable GE SIGNA PET/MR System," IEEE Trans Med Imaging, vol. 35, no. 8, pp. 1907–1914, Aug. 2016, doi: 10.1109/TMI.2016.2537811.
	V. Valotassiou et al., "SPECT and PET imaging in Alzheimer's disease," Ann Nucl Med, vol. 32, no. 9, pp. 583–593, Nov. 2018, doi: 10.1007/s12149-018-1292-6.
	X. Zeng, H.-T. Deng, D.-L. Wen, Y.-Y. Li, L. Xu, and X.-S. Zhang, "Wearable Multi-Functional Sensing Technology for Healthcare Smart Detection," Micromachines (Basel), vol. 13, no. 2, p. 254, Feb. 2022, doi: 10.3390/mi13020254
Research Summary: Applications of Mechanisms to Improve Accessibility For IRH	"How to engineer for inclusion," Stanford University School of Engineering. [Online]. Available: https://engineering.stanford.edu/magazine/article/how-engineer-inclusion. [Accessed: 07-Feb-2023].
	"Disability," World Health Organization. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/disability-andhealth#:~:text=An%20estimated%201.3%20billion%20people%20%E2%80%93%20or% 2016%25%20of%20the%20global,diseases%20and%20people%20living%20longer. [Accessed: 07-Feb-2023].
	A. Al-Heeti, "Accessibility Tech is still lacking for people with disabilities," CNET. [Online]. Available: https://www.cnet.com/tech/computing/for-people-with-disabilitiesaccessibility-techs-still-not-all-it-could-be/. [Accessed: 07-Feb-2023].

	Independent Redress Mechanism | Green Climate Fund, “Inclusion and accessibility within Accountability Mechanisms: Ensuring Persons with disabilities are not left behind,” Independent Redress Mechanism | Green Climate Fund, 21-Sep-2022. [Online]. Available: https://irm.greenclimate.fund/blog/inclusion-and-accessibility-withinaccountability-mechanisms-ensuring-persons-disabilities-are. [Accessed: 07-Feb-2023].
	A. S. Gillis, “What is a web server and how does it work?,” WhatIs.com, 22-Jul-2020.[Online].Available: https://www.techtarget.com/whatis/definition/Web-server. [Accessed: 07-Feb-2023].
	F. J. García-Peñalvo and M. Franco-Martín, “Sensor Technologies for caring people with disabilities,” Sensors, vol. 19, no. 22, p. 4914, 2019.
	B. Shubankar, M. Chowdhary, and M. Priyaadharshini, “IOT device for disabled people,” Procedia Computer Science, vol. 165, pp. 189–195, 2019.
Research Summary: Applications of Sensor Technology	L. C. Brazaca, I. Sampaio, V. Zucolotto, and B. C. Janegitz, “Applications of biosensors in Alzheimer’s disease diagnosis,” *Talanta*, vol. 210, p. 120644, 2020, doi: 10.1016/j.talanta.2019.120644.
	N. Gillani and T. Arslan, “Intelligent Sensing Technologies for the Diagnosis, Monitoring and Therapy of Alzheimer’s Disease: A Systematic Review,” *Sensors*, vol. 21, no. 12, p. 4249, 2021, doi: 10.3390/s21124249.
	K. Arora, “Smart pill Dispenser using Internet of Things.” [Online]. Available: https://www.ijert.org/research/smart-pill-dispenser-using-internet-of-things-IJERTV7IS070155.pdf
	R. Das, S. Paul, G. K. Mourya, N. Kumar, and M. Hussain, “Recent Trends and Practices Toward Assessment and Rehabilitation of Neurodegenerative Disorders: Insights From Human Gait,” *Front Neurosci*, vol. 16, 2022, doi: 10.3389/fnins.2022.859298.
Research Summary:	“Comparison: Automated medication dispensers,” The Senior List, 06-Dec-2022. [Online]. Available: https://www.theseniorlist.com/medication/dispensers/. [Accessed: 07-Feb-2023].

Universal design: Recent advancements and existing gaps	“Wagner Pill Dispenser Patent Model,” National Museum of American History. [Online]. Available: https://americanhistory.si.edu/collections/search/object/nmah_332970#:~:text=David%20 P.,had%20taken%20her%20daily%20pill. [Accessed: 07-Feb-2023].
	“Smart medication dispenser: Smart Pill Dispenser,” Wellness Pharmacy, 23-Jan-2023. [Online]. Available: https://www.wellpharmacy.com/smart-dispenser/. [Accessed: 07- Feb-2023].
	“Hero pill dispenser review,” Forbes, 28-Dec-2022. [Online]. Available: https://www.forbes.com/health/healthy-aging/hero-pill-dispenser-review/. [Accessed: 07- Feb-2023].
	S. Faisal, J. Ivo, and T. Patel, “A review of features and characteristics of smart medication adherence products,” Canadian Pharmacists Journal / Revue des Pharmaciens du Canada, vol. 154, no. 5, pp. 312–323, 2021.
	“Do automated dispensing machines improve patient safety?,” The Canadian journal of hospital pharmacy, Nov-2009. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2827025/. [Accessed: 07-Feb-2023].
Alzheimer’s Information	M. C. Staff, “How alzheimer's drugs help manage symptoms,” *Mayo Clinic*, 12-Oct-2022. [Online]. Available: https://www.mayoclinic.org/diseases-conditions/alzheimers-disease/in-depth/alzheimers/art-20048103. [Accessed: 08-Mar-2023].
	J. E. Gaugler, H. Ascher-Svanum, D. L. Roth, T. Fafowora, A. Siderowf, and T. G. Beach, “Characteristics of patients misdiagnosed with alzheimer’s disease and their medication use: An analysis of the NACC-uds database,” *BMC Geriatrics*, vol. 13, no. 1, 2013.
Coding Resources:	https://docs.python.org/3/library/datetime.html
	https://docs.python.org/3/tutorial/errors.html

Appendix D: Additional Documentation

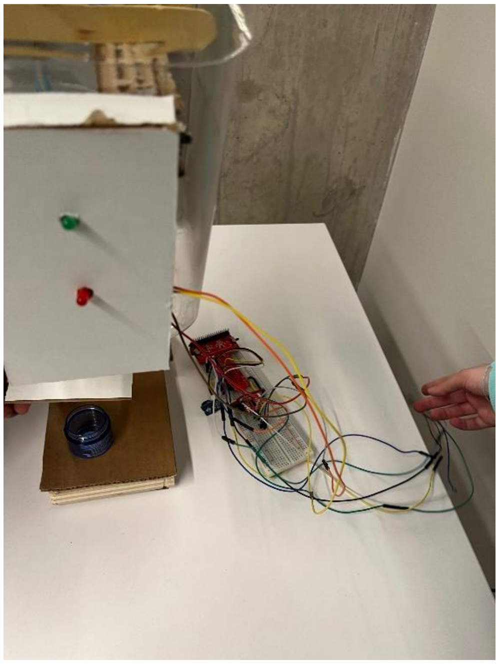


Figure 1: Demonstration of the LED's and the raspberry pi setup.

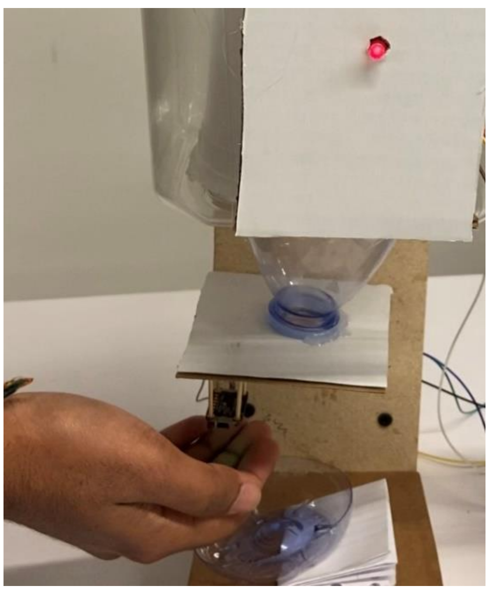


Figure 2: Distance sensor to activate the pill dispenser, LED is red since it is not time to take medication.

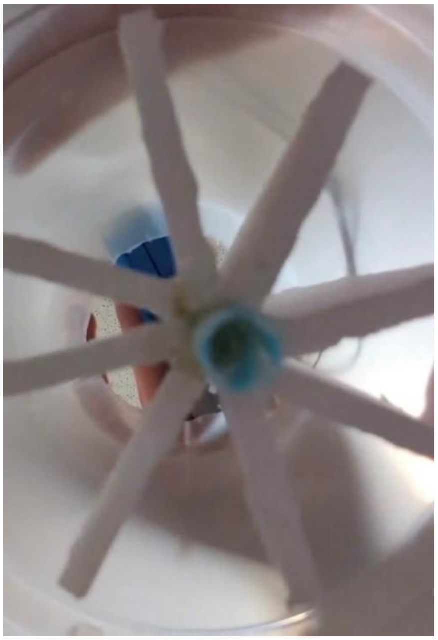


Figure 3: Compartments for medication placement. The axis will rotate with the dowel connected to the motor which causes the release of the prescription medication.

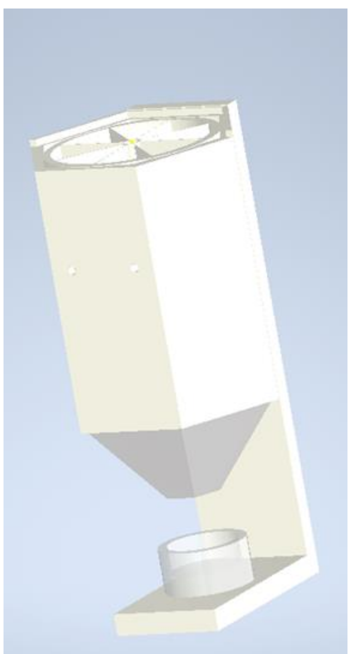


Figure 4: CAD model of The MedMinder. Hexagon shaped component contains 8 compartments for the medication and the funnel located at the bottom of the mechanism will direct the prescription to the pill catcher located on the stand.

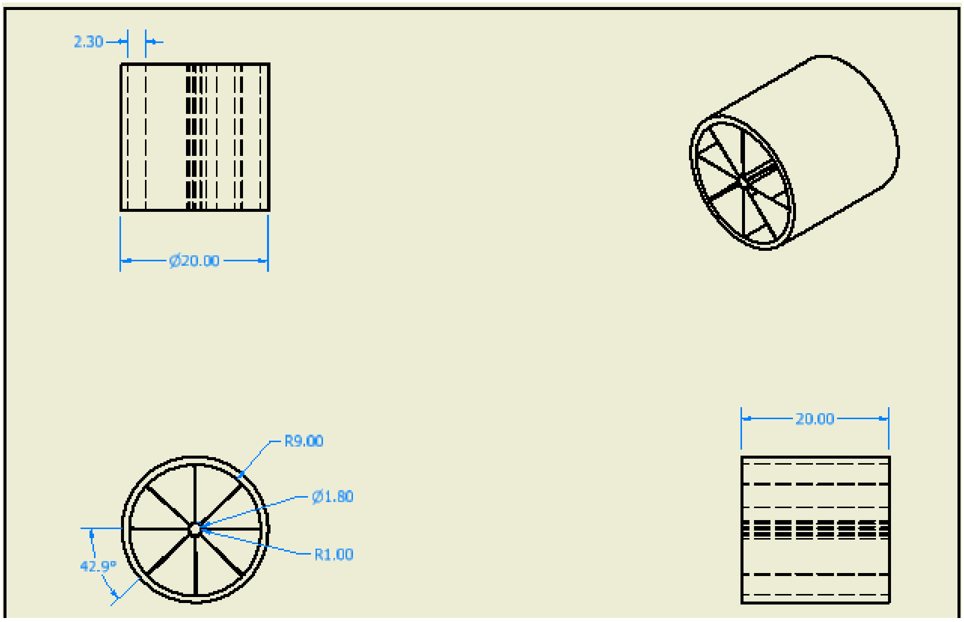


Figure 5: Engineering Drawing of the pill compartment that is divided into 8 sections, 7 for different medications and one for an opening to dispense. All the dimensions highlighted were crucial to the overall design and assembly.

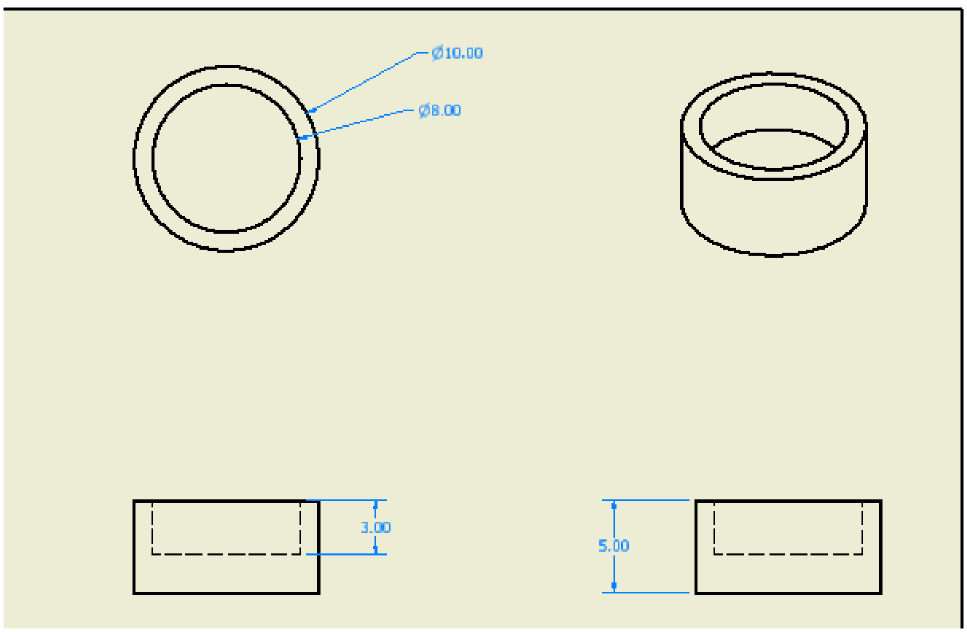


Figure 6: Engineering Drawing of the pill catcher that was placed underneath the funnel and directed in view of the distance sensor.

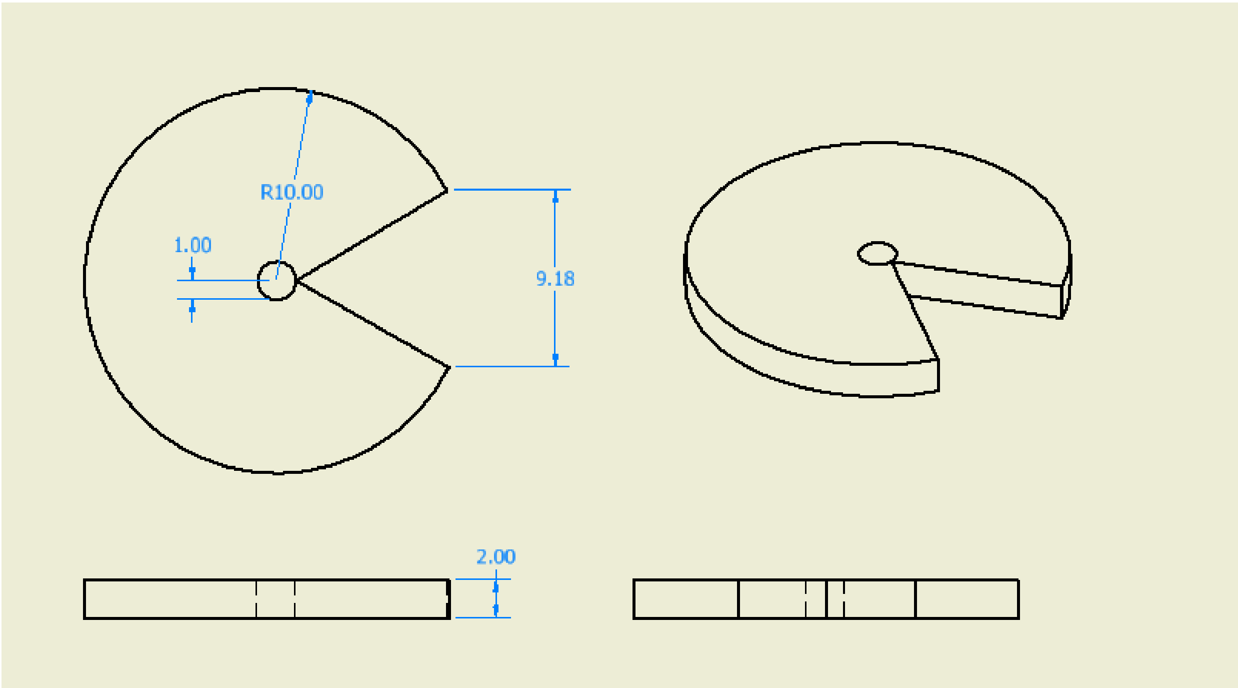


Figure 7: Engineering Drawing of the pill lid which the pill fell through.

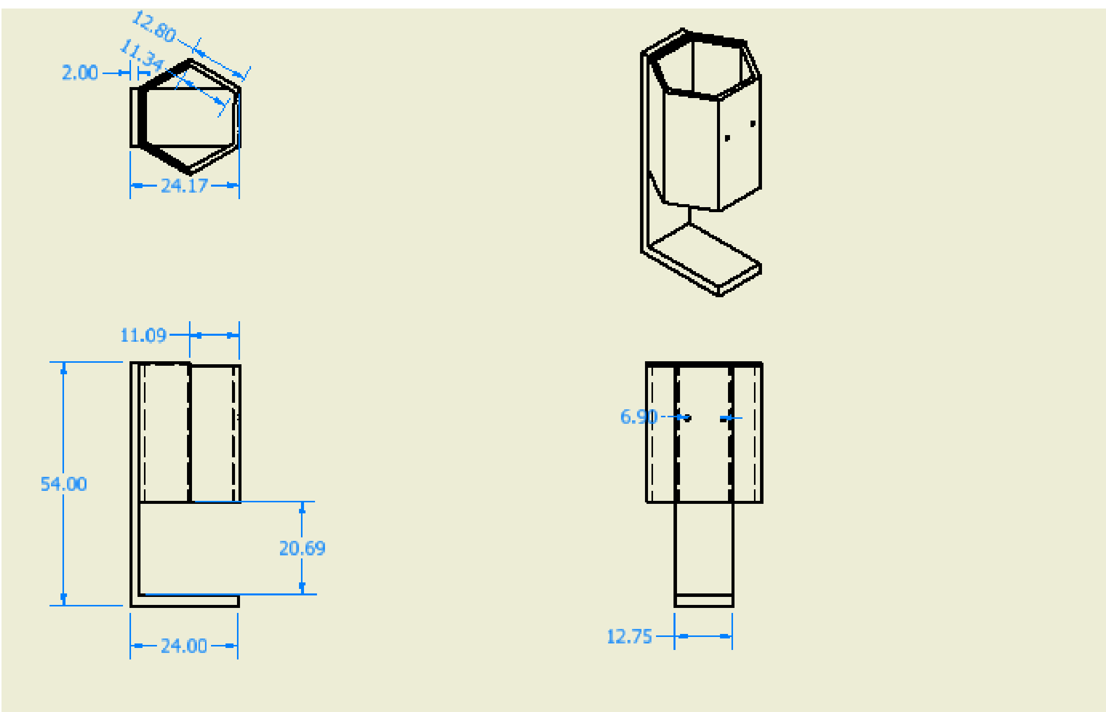


Figure 8: Engineering Drawing of the outer casing of the pill dispenser as well as the stand that held up the structure

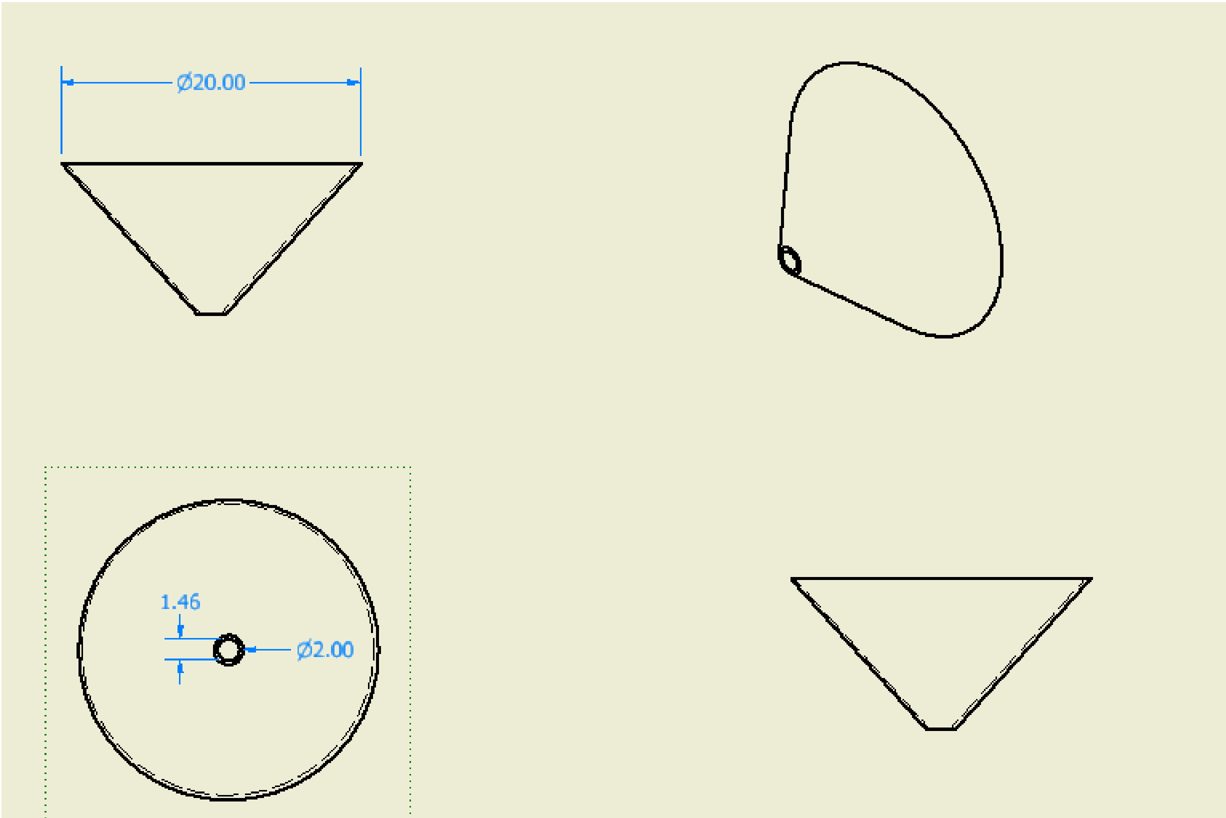


Figure 9: Engineering Drawing of the funnel

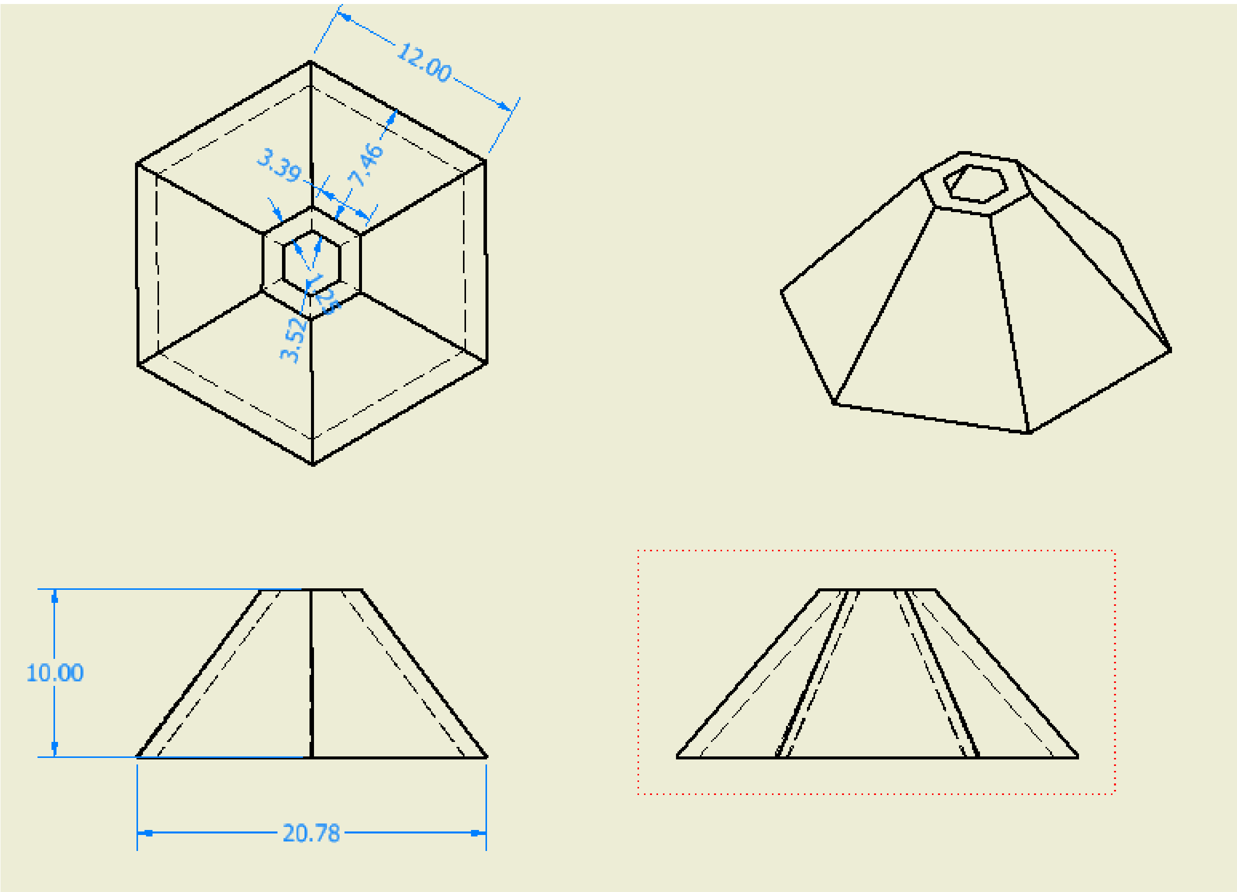


Figure 10: Engineering Drawing of the Base of the Pill Dispenser

Appendix E: Design Studio Worksheets