# IOT BASED MEDICINE DISPENSER FOR IMPROVING MEDICATION ADHERENCE

By

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
BRAC University
June 2023

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June 2023

## Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at BRAC University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

**Student's Full Name & Signature:**

| | |
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## Approval

The Final Year Design Project (FYDP) titled "IoT based Medicine Dispenser for Improving Medication Adherence" submitted by

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of Spring 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 27th April, 2023.

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## Ethics Statement:

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## Abstract/ Executive Summary

Some people, particularly older adults, struggle to remember when to take their medications. One suggestion for resolving this issue is a medicine dispensing device. This project is about an IoT medicine dispenser for solid drugs (pills, capsules, antibiotics etc.) and a website application for keeping a track and managing it. The major goal is to provide a solution that will enable individuals, particularly elderly people, to prevent taking medications incorrectly. This device's objectives are to dispense medicines at the designated times and also to monitor medication consumption. A literature review was done to obtain and evaluate data about the numerous medication dispensers available on the market in order to establish the most suitable system

**Keywords:** IoT; Medication; Dispenser; Adherence; Elderly; Website Application.

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## List of Acronyms

| | |
|---|---|
| IoT | Internet of Things |
| NodeMCU | Node Micro Controller Unit |
| LCD | Liquid-crystal display |
| LiPo | Lithium-polymer battery |
| PVC | Polyvinyl chloride |
| ISO | International Organization for Standardization. |
| IEC | International Electro technical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |

## Glossary

| | |
|---|---|
| IoT | The internet of things, or IoT, is an interconnected network information processing system, mechanical and key machine, things, animals, or people who are given unique identifiers and the capacity to transfer data over a network without the need for human-to-human or human-to-computer interaction. |
| Medicine dispenser | Medicine dispensers are devices that deliver medication at predetermined intervals to help patients follow their recommended medication schedule. Additionally, they could let the patient know when it's time to take their prescription |
| Adherence | The term adherence refers to how closely a person behaves in relation to health-related instructions or suggestions made by a healthcare professional in the context of a particular condition or ailment. |
| Gantt Chart | A Gantt chart is a graphical depiction of activities versus time that aids project managers in keeping track of development. Project management timelines and tasks are turned into Gantt charts to create bar charts, which are basically task scheduling tools. |

# Chapter 1: Introduction

### 1.1 Introduction

Families today find it challenging to care for the elderly on a 24/7 basis. The elderly must receive their medications on schedule. It can be challenging for older persons to manage and take several medications as directed. Chronic morbidity is more common as people get older, necessitating complicated prescription schedules. It might be difficult for seniors and older adults to follow complicated pharmaceutical regimens. Medication adherence refers to how closely individuals follow their doctors' orders and take their meds. According to a review, between 26% and 59% of people 60 and older do not follow their prescribed medication schedules [1]. Poor medication adherence is caused by a variety of causes, including an increase in the quantity and frequency of medications used, as well as a lengthy course of pharmacological therapy. Non-compliance has negative effects; many chronic illnesses can result in complications, lower patients' quality of life, and higher mortality.

Users who take drugs without family assistance can benefit from an automatic medicine dispenser. The user is relieved of the error-prone task of giving the wrong medication at the wrong time. People are increasingly being forced to choose a device that efficiently manages their medications as the cost of in-home medical care increases [2]. The main objective of the proposed device of this project is to provide an IoT based medicine dispenser for people of all age groups which will help them maintain their hectic medicine schedule smoothly. In order to make things simpler for everyone, the product is made to ensure that the quantity and timing of the tablets to be dispensed may be regulated and tracked using a web app. Additionally, it allows for clear communication between the patient and the caregiver or doctor since they can monitor the patient's medication intake and determine whether any pills have been missed [3].

#### 1.1.1 Problem Statement

People around us use prescribed drugs on a regular basis nowadays. Many of them require taking the medicines on a regular basis. Among them, there is often a complex medicine regimen. With some research we got to learn that every day, over 15 lakh people use antibiotics [4]. When it comes to people aged 65 and older, the median number of prescription drugs they use has doubled from 2 to 4, and the percentage who take more than 5 drugs climbed from 12.8% to 39.0% between 1988 and 2010 [5]. Taking correct medicines at the correct time can be tricky. We human beings tend to forget. We tend to be reluctant about doing things on time. Some people have medical conditions like dementia and forgetting is a real issue for them. A study found that despite having clear prescription information provided, 40% to 75% of older adults do not correctly take their medications [6].

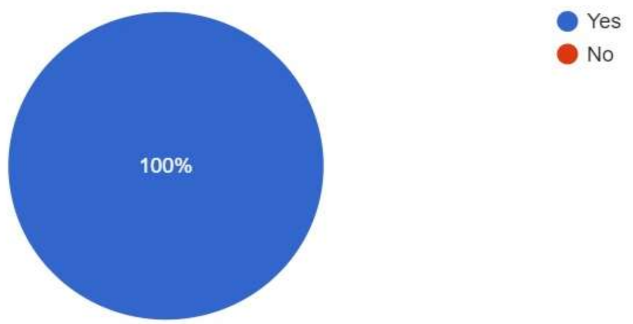
Conventionally, there is no reliable way of monitoring if the patient is taking the medicines according to the prescription without on-spot human supervision. The estimated 34.8 billion defined daily doses of antibiotics consumed globally in 2015, or an average of 5 days of antibiotic use per person [7]. As a result, it has become necessary for the patients to take their prescribed medicines timely. Negligence of taking medicines timely can lead to severe health damage for the consumers. In a study, 187 children from a group of 1322 patients received daily medicine for the full duration of the study [8]. Therefore, patients of all age groups have to maintain a complex medicine regimen. Many companies have already designed several medicine dispensing manual devices to organize the medicines according to their prescribed times. Manual devices still require possibilities of error which has to be reduced with more advanced technological improvements.

### 1.1.2 Background Study

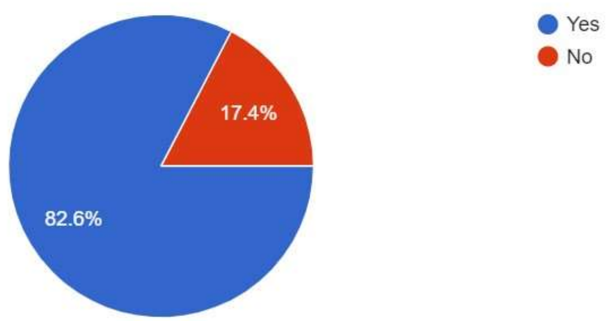
In the modern age, as the number of patients increases, the usage of prescribed medications is also increasing alongside [9]. For an effective treatment of the patient, medication adherence is a must [10]. Clinical trial report shows that 80-90% adherence rate is required for the treatment to be adequate [10]. Non-adherence to prescribed medications increases the health risk, increases the expenditure on healthcare treatment and, to the extreme, and increases the risk of mortality [11]. Unfortunately, the average adherence rate is only 43-78% [11]. Many reasons are responsible for which the patients are being unable to take their medications properly. Complex medication regimen including polypharmacy is one of the major reasons behind medication non-adherence [4]. A report from Italy shows that among 100 people, 49 people became non-adherent in the first follow up and 55 people became non-adherent after three months upon their release from the hospital [12] . It can become difficult for a patient who has multiple medication pills to take, several times a day. By making a mistake, taking the wrong medications or taking wrong doses of medications can cause serious health issues [13]. Again, patients who are on long term condition treatment like asthma, diabetes, hypertension, arthritis, epilepsy, heart failure, angina etc. are to follow their medication regimen properly throughout their treatment duration for a proper treatment. But unfortunately, according to the statistics, medication adherence decreases with time among the patients who are on long term treatment [13]. Furthermore, forgetfulness is another big issue in terms of taking medications on time. Especially, people with forgetting tendencies or with medical conditions like Dementia can cause interruptions in the medication taking regimen [14].Some patients have also been reported for skipping their medications after feeling a little better but without completing the course of the medications. Skipping some kind of medications e.g., antibiotics can cause serious health risks. Not completing the full course of antibiotics can cause the creation of antibiotic resistance in the patient’s body, which makes it difficult to treat the infections [15]. Moreover, elderly people face difficulty in taking medicines correctly due to different reasons. A study stated that 40% up to 75% of elderly people fail to consume their medication properly despite the provided clear prescription details [16]. Conventionally, to monitor if a patient is taking his/her medications properly, human intervention on the spot is required. In this fashion, the caregiver monitors the patient’s medication taking activities by being with the patient. But, in the modern busy world, people are not getting much of a facility to be with their loved ones all the time and look after them. The scenario is common in case of children or elderly people. A survey conducted on Bangladeshi people shows that 72.8% of the people took at least one medicine one month prior to the research [17]. The survey shows that anti-ulcerant usage was 23.35%, antibiotics usage was 4.45% [17]. That is a considerable number for such kinds of medications. And so, the importance of medication adherence should be spread among people. With the aforementioned points in mind, a survey has been conducted among the people living in Dhaka. Following are the respective outcomes:

### 1.1.2.1 Survey on IoT Based Medicine Dispenser

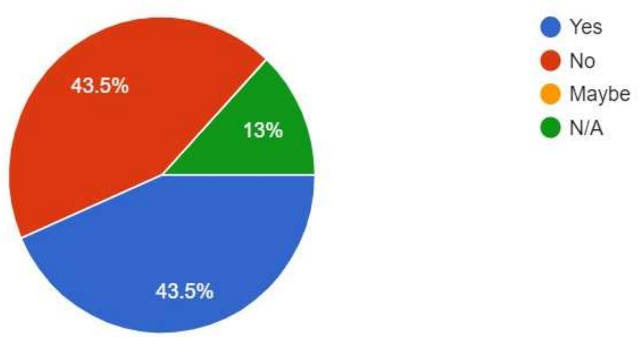
a. Do you or any of your family member(s) take medications regularly?



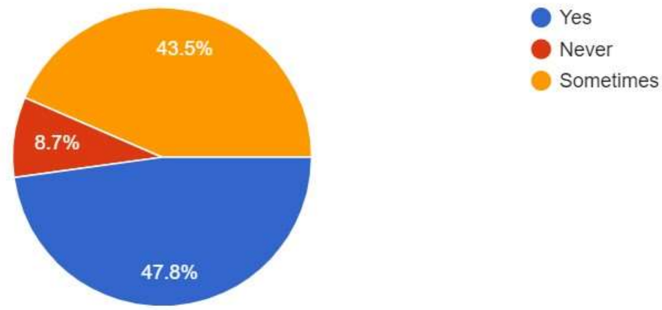

b. Do you have elderly parents?



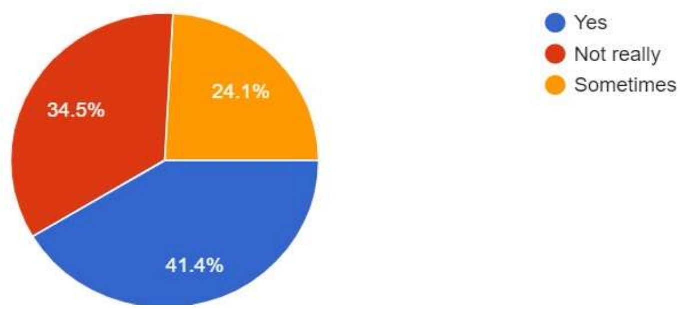

c. If yes, do they live alone most of the time?



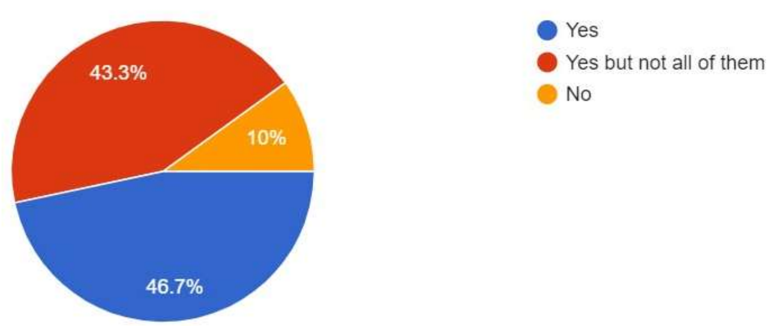
d. Do you or any other member(s) of your family forget to take their medicine on



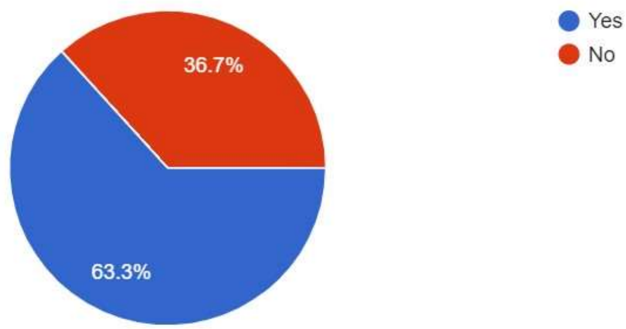

e. Does anyone in your family need your assistance in their medication (ex. your elderly parent , someone with dementia or some disability)



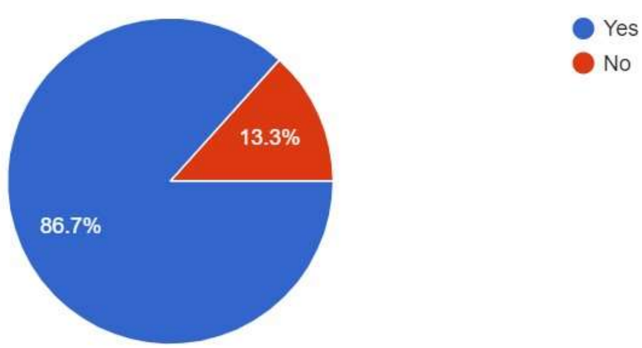

f. Are the prescribed medicines strictly time bounded?(Must be taken at the specified time)



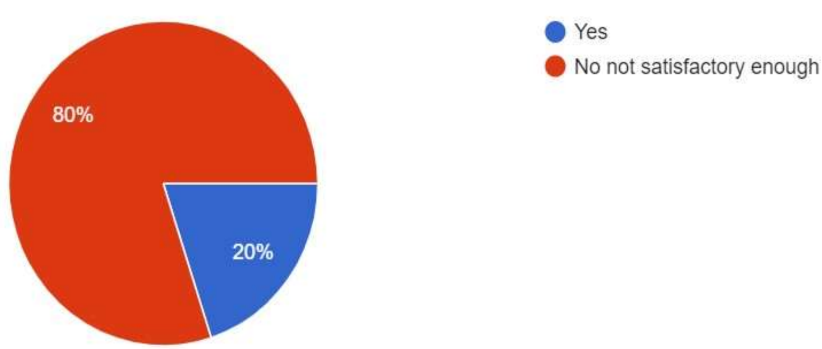
g. Did any of your family member(s) suffer due to missing a dose?



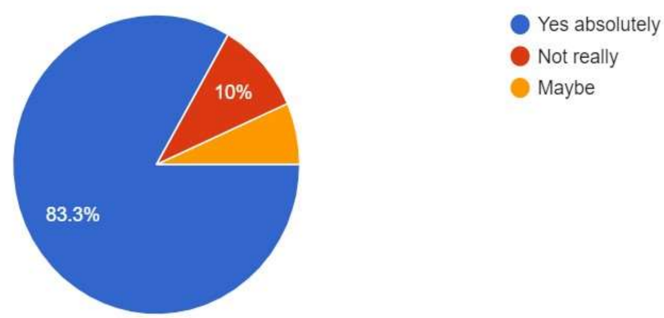

h. Do you want a device that assists in taking medicine in time?




i. Do you think the medicine dispensers available in the current market are enough



j. Do you prefer a medicine dispenser which will alert the user to take their medication and keep track of their medicine consumption?

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Survey shows that at least one member of every family takes medication which reflects the growing use of prescription medications. It also illustrates the possibility that elderly parents may be patients who live alone. This raises concern for the elderly parents' or other family members' adherence to their medicine as non-adherence poses health concerns and in the worst situations, can result in fatalities. Furthermore, the survey depicts the scenario of people forgetting to take their medications, sometimes due to medical conditions like dementia. It illustrates the situation of taking strictly time-limited medications which can be a must for patients having conditions such as arthritis, epilepsy, heart failure, angina etc. The survey also depicts the typical scenario of individuals forgetting to take their medication doses which could also lead to health risks. Furthermore, we can understand from the survey that the public's desire for a proper medication dispenser and the absence of one on the current market. Finally the last survey depicts individuals supporting a medication dispenser with an alert and tracking system.

### 1.1.3 Literature Gap

The area that hasn't been fully examined or is only partially explored is referred to as literature gap [18]. This could refer to a population or sample (size, kind, location, etc.), research methodology, data collecting and/or analysis, or other study variables or conditions [18].

- ❖ It is well established that medication dispensers, especially IoT-based ones, increase medication adherence. However, additional research is required to determine its clinical effectiveness. RCTs, or randomized controlled trials, can be used to assess the veracity of these assertions [19]. RCTs are a crucial technique for assessing health technology because they correct the biases that are present in retrospective research [19].

- ❖ IoT-based medicine dispensers simplify activities for the user, but their applicability may be in doubt because older individuals sometimes might face difficulty adjusting to new technology. There is no known study being done to identify an alternative solution for this.

- The dependability and durability of the suggested devices must be assessed because IoT-based medicine dispensers are continuously used and monitored. There has to be more thorough research done on the suggested medicine dispensers to determine whether or not they would be effective over the long term.
- IoT-based medicine dispensing systems are susceptible to cyber-attacks that employ IoT devices to access consumers' private information. Attackers may typically damage the device by implanting malware on it, or gain access to additional personal information belonging to the firm [20].
- IoT-based drug delivery systems could conflict with disabled people's electronic hearing aids or movability devices. There hasn't yet been a study done on incorporating solutions to this issue.
- More research needs to be done to enhance the capabilities of IoT based medicine dispensers with artificial intelligence and machine learning algorithms.

### 1.1.4 Relevance to Current and Future Industry

#### 1.1.4.1 Current Industry

The suggested IoT-based medication dispenser for this project delivers medications in accordance with the user's prescription, prompts the user with an alarm system, automatically dispense medicines and allows the doctor or caregiver to monitor and access remotely by using the website we established. Currently, businesses like Philips, Med Minder, Hero Health and Omnicell have launched IoT-based drug dispensers on the market. The iot based medicine dispenser by Philips, named RxPense, loads two weeks' worth of prepackaged medications that have been approved by the user's pharmacist, robotically opens each dose packet, and gives the patient their medication at the appropriate moment after patient authentication [21]. Although it can be used at home, it is primarily made for industrial use in senior living facilities, managed care facilities, and assisted living facilities [21].

Med Minder is a 28 slot medicine dispensing device where the powered pillbox is equipped with a secure M2M Bluetooth module made by Gemalto that provides a 24/7 automated wireless link from the pill box to the patient, doctor, family member and Med Minders medical alert monitoring center [22]. Hero health can store a 90-day supply of 10 different prescriptions. It cannot, however, dispense liquids, soft gummies, such as chewy children's vitamins, injectable, or half-pills [23]. Liquids and drugs that aren't room temperature cannot be stored by it [23]. The Omnicell medication dispenser includes barcoded labels, a medication label printer built-in, and metal locking lid drawers [24]. It is adaptable, expandable, and a nurse-friendly invention that more effectively controls inventory and eliminates repetitive processes [24].

### 1.1.4.2: Future Industry

With the increasing importance of technologies like artificial intelligence (AI), the internet of things (IoT), augmented reality (AR), robotics, and data management techniques, the healthcare sector continues to be a beehive of innovation [25]. However, not all innovations are created equally, nor do they always advance. Instead, their evolution resembles an S-shaped curve that depicts their usual lifetime of early emergence, accelerated acceptance, stabilization, and maturation [25]. There are more than 200 innovation areas that will influence the direction of the industry, according to Global Data's Technology Foresights, which uses innovation intensity models based on over 443,000 patents to create the S-curve for the healthcare sector [25]. Smart helmets, body temperature sensors, wearable interfaces with AI, and AI-assisted medical reporting are some of the characteristics that are anticipated to appear in the IoT healthcare sector in the future [25]. We need to improve a few aspects of our suggested device in order to be competitive in the future market, such as creating mechanisms to store liquid medications and automating the filling and refilling process utilizing a robotic arm, adding facial recognition features and improving cyber security. Additionally, we need to develop a system that will let multiple people use a single dispenser.

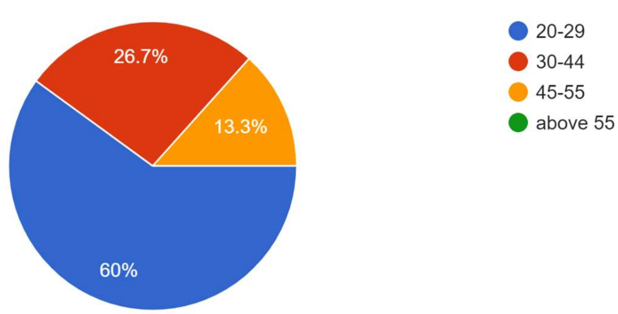
## 1.2 Objectives, Requirements, Specification and Constraints

### 1.2.1. Objectives

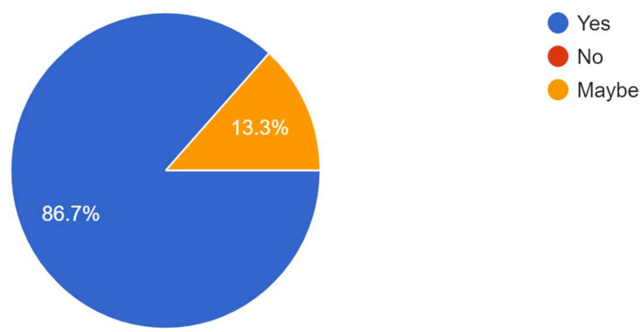
Since it is a modern technology, it is required to acknowledge the people about it. Technical training may be needed to be offered so that the technology is utilized to its full potential. Once the people are familiar with it, the scope of this project is extensive. Manual labor decreases with the help of this device and the technology. People can put their time on work while making sure that their cared ones are being taken care of properly. Implementing the project will help the patients to get the necessary treatment that they deserve and will bring a sigh of relief to the caregivers.

### 1.2.1.1 Survey Conducted Based on the Objectives of Device

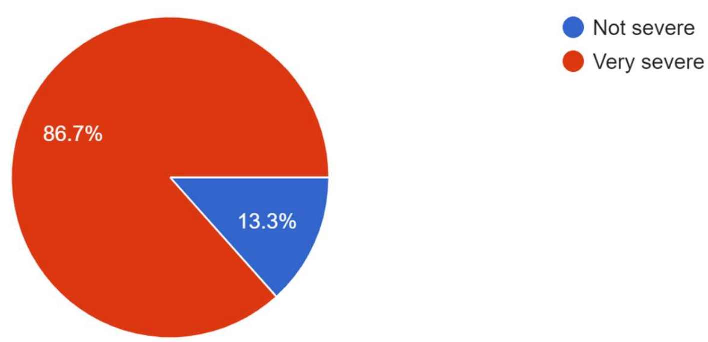
a) What is your age?



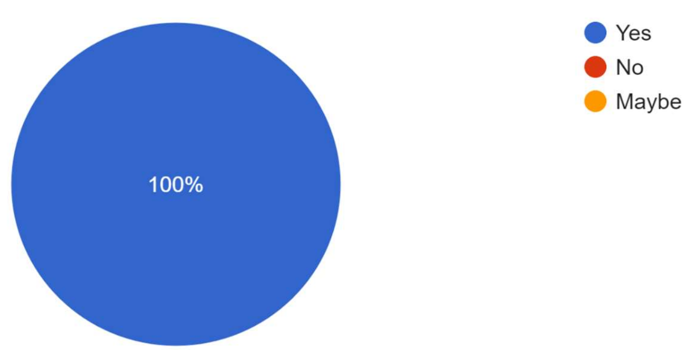
b) Do you believe that missing/taking prescribed medications late can have serious health consequences?



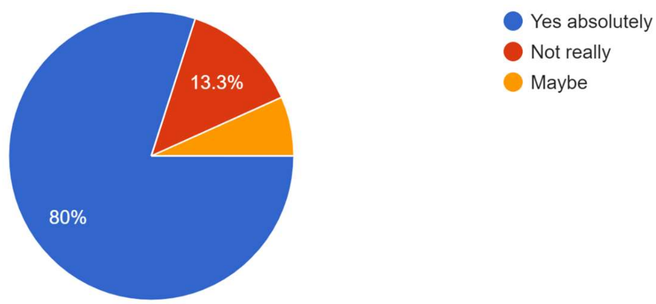

c) How severe effects can missing prescribed medicines have? (according to your knowledge/experience)



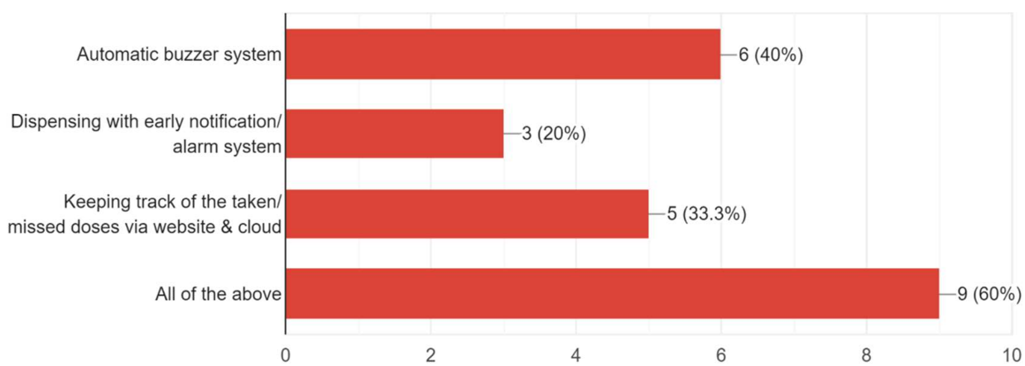

d) Do you feel the need for a device that can automatically dispense medicine from time to time?



e) Do you wish to control and monitor your medicine dispenser and keep track of the daily doses online?




f) If yes, what features can be useful?




However, our country doesn't have the availability of devices to dispense medicine automatically, there are some objectives to use the spaces that we have in our country.

**Objectives**

Our objective is to construct an IoT based device that will do the following-

- Alerting the user when it is time to take medications:
    - ➢ To prevent forgetfulness.,
    - ➢ Keeping the patient informed of the medicine schedule.

- Giving the patient the right medicine at the right dose for a particular time:
    - Automatically dispensing the medicines.
- Keeping data of medicine taken/missed on the cloud:
    - Data can be monitored by the caregiver remotely.
    - Doctors can use the data for better treatment.
    - The patient himself/herself can go through the data if needed (in case he/she forgets whether he/she has taken a particular dose).

### 1.2.2 Functional and Nonfunctional Requirement

#### 1.2.2.1 Functional Requirements

- **Alerting system:** The device will send notification to the user to take medicine in the exact time to maintain strict medicine adherence.

- **On device display:** On the display, the necessary information for filling the device with prescribed pills, other information will be displayed.

- **Input button:** An input button on the device is required to take dispensing confirmation from its user.
- **Medicine storing/dispensing mechanism:** Mechanisms that will allow to store the medicine doses, have refill ability, mechanisms for dispensing the medicines to the user of the device. The device should be able to store medicine supplies for a couple of days.

- **Computing unit**: The brain of the device that controls the mechanisms inside the machine, shows data on the display, has connectivity with the internet and communicates with the cloud to sync data e.g., medicine schedule, analytics. There should be enough pins to be able to connect with the motors, display and other peripherals. Processing power, memory storage etc. characteristics should be met to operate the device properly.

- **Web application**: A web application that is capable of taking medicine prescription data, sending it to the device. The app should also be able to show analytics of medicine taking data received from the device. The web app connects with the device through IoT technology.

- **Medicine safety**: Because it is a device that keeps medications, it is necessary to ensure the security of such sensitive items. Blister packaging of the medication pills should be included while storing the pills in the device. Utilizing suitable material in the storage compartments that won't rip or pierce the medicine blister pack is required.

- **Power supply**: To provide 24/7 power to the device, a rechargeable battery along with an AC adapter is required.

#### 1.2.2.2 Non-Functional Requirements

- **Indoor friendly design:** It will be simpler for the user to utilize it inside the home because it is a medication dispensing aid. This device's design goal is to be indoor-friendly so that users may conveniently utilize it in their rooms**.**

- **Sleek design:** The device has been made to look sleek and modern, so that the device looks aesthetically pleasing to the user.

- **Providing safety:** It is rational to keep all medications out of the hands of children or people who have tendencies to take overdose of medications for recreational or even worse, self-harming purposes [26]. Our device can help with it by keeping the medications locked and only releasing the necessary amount at the designated time.

- **Time saver:** For people with tight schedules, having to search through the medication, reading labels, opening the lids consumes time that could be used for something else [26].

### 1.2.3 Specifications

An overview of the components required for the three design approaches are provided here along with their specifications.

Table 1.1: Component specifications for design approach 1

| **Sub-system** | **Components** | **Specification** |
|---|---|---|
| Computing Unit | NodeMCU (ESP8266) | • 80MHz CPU<br>• 4MB Flash Memory<br>• 9 GPIOs with I2C, SPI<br>• WiFi 802.11 b/g/n<br>• Operating Voltage 3.3V<br>• Max Input Voltage 10V<br>• Sleep Current draw 9mA (at 5V)<br>• Operation Mean Current draw 200mA (at 5V)<br>• Weight 20g |
| Multiplexer | IC 74LS138 | • 3 line to 8 line Decoding<br>• Operating Voltage 5V<br>• Max supply voltage 7V<br>• Current draw 8mA |

| | | |
|---|---|---|
| Real Time Clock (RTC) | DS107, Crystal | • Crystal Frequency 32.768 kHz<br>• Operating Voltage 5 V<br>• Max Supply Voltage 5.5 V<br>• Idle Current draw 200 uA<br>• Mean Current draw 5 mA<br>• Weight 10 g |
| Display | 16x2 LCD Display, IC PCF8574 | • Operating Voltage 5 V<br>• Operation Mean Current draw 120 mA<br>• Idle Current 5.5 mA<br>• Weight 45 g |
| Conveyor | IC L298, Resistor, DC Geared Motor | • Motor Speed 30 RPM<br>• Motor Operating Voltage 6 V<br>• Motor Max Torque 0.95 Nm<br>• Motor Operation Mean Current draw 240 mA<br>• Motor Max Operating Voltage 24 V<br>• Motor Max Current draw 260 mA<br>• IC Operating Voltage 5 V<br>• Weight 200 gm |
| Dispensing Mechanism | Servo Motor | • Operating Voltage 5 V<br>• Stall Torque 1.6 kg/cm<br>• Operation Mean Current draw 500 mA<br>• Idle Current 5 mA<br>• Weight 9 gm |
| Battery | LiPo Battery | • Supply Voltage 7.4 V<br>• Electric Charge 3300 mAh<br>• Weight 400 gm |
| DC to DC Converter | Buck Converter LM2587 | • Input Voltage 3 V – 35 V<br>• Output Voltage 1.25 V – 30 V<br>• Output, Input Current Ratio 0.9<br>• Weight 31 gm |
| Medicine Boxes | Dimensions 50mm*40mm*30mm | • Material – Thin cardboard sheet<br>• Weight 25 gm |
| Device Case | Dimensions 20 cm * 23 cm * 29 cm | • Material – PVC<br>• Density 0.34 g/cm^3<br>• Thickness 0.5 mm<br>• Weight 52.734 gm |
| Dose Capacity | - | 42 doses |

Table 1.2: Component specifications for design approach 2

| **Sub-system** | **Components** | **Specification** |
|---|---|---|
| Arduino Mega | 2560 CH340 | • Operating Voltage 5V<br>• Input Voltage (recommended) 7-12V<br>• Input Voltage (limits) 6-20V<br>• Digital I/O Pins 54 (of which 14 provide PWM output)<br>• Analog Input Pins 16<br>• DC Current per I/O<br>• 50 mA Flash Memory Clock Speed 16 MHz |
| Wi-Fi module | ESP8266 | • 80MHz CPU<br>• 4MB Flash Memory<br>• 9 GPIOs with I2C,SPI<br>• WiFi 802.11 b/g/n<br>• Power input: 4.5 to 9V<br>• Length,Width,Height(mm): 49*24.5*13<br>• Operating temperature: -40 to 125°C<br>• Operating Voltage 3.3V<br>• Max Input Voltage 10V<br>• Sleep current draw: 9mA(at 5V)<br>• Operation mean current draw 200mA (at 5V) |
| Real Time Clock (RTC) | DS1307 | • Minimum Supply Voltage (V): 4.5<br>• Maximum Supply Voltage (V) : 5.5<br>• Operating Temperature Range (°C) : 0 to 70<br>• Communication : I2C |
| Display, I2C connected | 16x2 LCD Display, IC PCF8574 | • Operating Voltage 5V<br>• Max Operating Voltage 6V<br>• Operation mean current draw 120mA<br>• Idle current 5.5mA<br>• Length,Width,Height(mm):36*80*10 |

| | | |
|---|---|---|
| | | • Weight: 35gm<br>• Shipment weight: 0.033kg<br>• Shipment dimensions: 9*5*1cm. |
| Motor | NEMA 17 Stepper Motor 17HS4401S | • Size: 42.3 mm square × 48 mm, not including the shaft (NEMA 17)<br>• Weight: 350 g (13 oz)<br>• Shaft diameter: 5 mm “D”<br>• Steps per revolution: 200<br>• Current rating: 1.2 A per coil<br>• Voltage rating: 4 V<br>• Resistance: 3.3 Ω per coil<br>• Holding torque: 3.2 kg-cm (44 oz-in)<br>• Inductance: 2.8 mH per coil<br>• Lead length: 30 cm (12″)<br>• Output shaft supported by two ball bearings |
| Conveyor | 6V DC Geared Motor | • Overall Dimensions: 24.6 mm,<br>• Diameter x 35.2 mm Long.<br>• Voltage Range: DC 6V-1.1V<br>• Rated Voltage: DC 9.6V |
| Battery | LiPo Battery(3300mAh) | • Battery type : 3S Lithium polymer battery (LiPo)<br>• Charge capacity : 3300mAh<br>• Output voltage : 11.1V<br>• Continuous discharge rate : 30C<br>• Charge rate : 1C to 3C |

| | | |
|---|---|---|
| Alarm system | Buzzer | ● Power supply voltage: 4.5 V<br>● Power consumption: 190 mA (max. 250 mA)<br>● Gearbox: 48:1<br>● Speed: 90 ± 10 rpm<br>● Torque: 0.8 kg*cm (0.078 Nm) |
| Dispensing mechanism | Push button | ● Operating voltage: 12V DC<br>● Operating current: 50mA<br>● Dimensions in mm (LxWxH): 12*12*8<br>● Weight:1gm(31pprox.) |
| Medicine Boxes | Dimensions 4cm x 3cm x 5cm | ● Material – Plastic (PET)<br>● Density 1.38g/cm^3<br>● Thickness 2mm<br>● Weight 25.9gm |
| Device Case | Dimensions 30cm * 45cm * 20cm | ● Material - PVC<br>● Density 0.34g/cm^3<br>● Thickness 0.5mm<br>● Weight 402gm |
| Medicine Dose Capacity | - | 45 doses |

Table 1.3: Component specifications for design approach 3

| **Sub-system** | **Components** | **Specification** |
|---|---|---|
| Arduino Mega | 2560 CH340 | ● Operating Voltage 5V<br>● Input Voltage (recommended) 7-12V<br>● Input Voltage (limits) 6-20V<br>● Digital I/O Pins 54 (of which 14 provide PWM output)<br>● Analog Input Pins 16<br>● DC Current per I/O<br>● 50 mA Flash Memory Clock Speed 16 MHz |
| Motor | Stepper Motor(NEMA 17) | ● Size: 42.3 mm square × 48 mm, not including the shaft (NEMA 17)<br>● Weight: 350 g (13 oz)<br>● Shaft diameter: 5 mm "D"<br>● Steps per revolution: 200<br>● Current rating: 1.2 A per coil<br>● Voltage rating: 4 V<br>● Resistance: 3.3 Ω per coil<br>● Holding torque: 3.2 kg-cm (44 oz-in)<br>● Inductance: 2.8 mH per coil<br>● Lead length: 30 cm (12″)<br>● Output shaft supported by two ball bearings |
| Real Time Clock (RTC) | DS107, Crystal | ● Crystal Frequency 32.768 kHz<br>● Operating Voltage 5 V<br>● Max Supply Voltage 5.5 V<br>● Idle Current draw 200 uA<br>● Mean Current draw 5 mA<br>● Weight 10 g |
| Display | 16x2 LCD Display, IC PCF8574 | ● Operating Voltage 5 V<br>● Operation Mean Current draw 120 mA<br>● Idle Current 5.5 mA<br>● Weight 45 g |
| Conveyor | IC L298, Resistor, DC Geared Motor | ● Motor Speed 30 RPM<br>● Motor Operating Voltage 6 V<br>● Motor Max Torque 0.95 Nm<br>● Motor Operation Mean Current draw 240 mA<br>● Motor Max Operating Voltage 24 V<br>● Motor Max Current draw 260 mA |

| | | |
|---|---|---|
| | | ● IC Operating Voltage 5 V<br>● IC Max Operating Voltage 7 V<br>● IC Operation Mean Current draw 50 mA<br>● IC Max Current draw 70 mA<br>● IC Idle Current 12 mA<br>● Weight 200 gm |
| Dispensing Mechanism | Servo Motor | ● Operating Voltage 5 V<br>● Stall Torque 1.6 kg/cm<br>● Operation Mean Current draw 500 mA<br>● Idle Current 5 mA<br>● Weight 9 gm |
| Battery | LiPo Battery | ● Supply Voltage 7.4 V<br>● Electric Charge 3300 mAh<br>● Weight 400 gm |
| DC to DC Converter | Buck Converter LM2587 | ● Input Voltage 3 V - 35 V<br>● Output Voltage 1.25 V - 30 V<br>● Output, Input Current Ratio 0.9<br>● Weight 31 gm |
| Medicine Boxes | Dimensions 5cm * 4cm * 3cm | ● Material - Plastic (PET)<br>● Density 1.38 g/cm^3<br>● Thickness 2 mm<br>● Weight 25.9 gm |
| Device Case | Dimensions 45cm*75cm*12cm | ● Material - PVC<br>● Density 0.34 g/cm^3<br>● Thickness 0.5 mm<br>● Weight 52.734 gm |
| Medicine Dose Capacity | - | 42 doses |

### 1.2.4 Technical and Non-Technical Consideration and Constraint in Design Process

#### 1.2.4.1 Technical Considerations

The technical considerations in our project are-

- ➢ Alerting system
- ➢ On device display
- ➢ Input button
- ➢ Medicine storing/dispensing mechanism
- ➢ Computing Unit
- ➢ Web application
- ➢ Medicine Safety

- ➢ Power Supply

#### 1.2.4.2 Non-Technical Considerations

The non-technical considerations are:

- ➢ Indoor friendly design
- ➢ Sleek design
- ➢ Providing safety
- ➢ Time saver

#### 1.2.4.3 Constraints

**Budget:**
The cost of the chosen optimal design of this project is not viable for everyone. Approximately 6158/- BDT is spent on this project, depending on our working location, the designing process, and other elements. Because of this, people of lower income might not be able to get their hands on it. However, this technology is more affordable than previous projects that were comparable to this one such as Hero Health where the monthly subscriptions cost around 45 dollars a month.

**Device maintenance:**
The system will include a range of parts and services. One or more pieces may need to be changed in order to keep the system operating properly. For instance, we have used LiPo battery in all three of our designs, which is a DC battery. Therefore, DC voltage cannot be directly increased or decreased for high-voltage power transmission or distributed for low-voltage use. It demands extra hardware, such as an inverter and a rectifier, etc., which drives up the cost of transmission. Furthermore, there's always a chance of a short circuit or inner system failure happening in any electrical device so up keeping is crucial to getting optimal results.

**Cyber security concern:**
Security is a major concern in the emerging IoT technology and has a lot of room for work. As the medicine usage data (whether the patient has taken/missed the dosage) will be uploaded to the cloud for the sake of monitoring by the doctor/caregiver, there is always a chance of the cloud system getting hacked which can manipulate the data unethically and endanger the life of the patient if the notification for the wrong medicine is given.

**Refilling inconvenience:**
The medicines will be manually refilled by the caregiver or through any assistance as the provision of automatic sorting is not possible to implement at the current times due to budget which can be a matter of inconvenience by the customer. It is one of the constraints that will be fixed in the near future.

**Medicine type:**
This device only can store pills that are solid and blister packaged. Liquid or other forms of medications cannot be stored in this device. Also pills that do not come with blister packaging should not be kept in this device for medicine safety purposes.

**Storage issue:**
As the medicines are stored in different chambers as per the mechanism of this device therefore to increase the storing capacity it will require to increase the chambers. Adding more chambers can make the device more bulky.

**Dose intake skepticism:**
It will be assumed that the pills have been consumed after they are dispensed. The system is unable to monitor whether the patient actually took the medication or whether they skipped the dose after the dose is dispensed.

**Pill unpacking inconvenience**:
For the safety of the drug, blister-packaged pills should be placed in the device. While consuming the medication, the patient needs to take the pill out from blister packaging, which can be a bit intimidating for some users.

**Requires caution while filling**:
Erroneous filing of pills will cause erroneous dispense, which is not traceable through this device.

**Temperature:**
There are different medicines that must be stored at certain temperatures in order to keep them safe and usable. This device only can store medicines that require room temperature to be stored in. Therefore, this device is unable to keep medication that needs to be stored at lower temperatures.

### 1.2.4 Applicable Compliance, Standards and Codes

Table 1.4: Standard applicable codes and compliances.

| **Device** | **Applicable Standard/Coded** | **Explanation** | **How it dictates the solution** |
|---|---|---|---|
| Battery | IEC 60086 | It is an International standard that promotes interchangeability of batteries based on standardized form, fit and function for battery producers [27]. | The interchangeability feature means that it can be used in a wide range of products, so it can be suitable for our device too [27]. |

| | | | |
|---|---|---|---|
| Cloud Data | ISO/IEC 17826:2012 | This standard defines the interface for managing and accessing data stored in cloud storage [28]. It is applicable to developers who use or implement cloud storage. | This standard documents on how to get access to the cloud storage and how to manage it [28]. We can use this standard for managing the device's cloud storage system. |
| Motors | IEC 60034-2-1 | This is the standard for electric motors. Electric motors include stepper and servo motors. | This standard is about establishing a procedure for testing a product's effectiveness [29]. This standard can be used to measure the effectiveness of our device. |
| Internet of Things (IoT) | IEEE P2413 | This standard outlines an IoT architecture framework that meets the requirements for several IoT application domains [30]. For many current and upcoming "smart" applications and technological developments in many technology areas, the Internet of Things (IoT) is a critical enabler [30]. | The IoT architectural framework offers a reference model that establishes connections between numerous IoT verticals (such as transportation, healthcare, etc.) and basic architectural components [30]. We can take help from this framework to dictate the solution. |
| Power Supply | IEC 60950 | It is a safety standard that is applicable to technology devices that are powered by batteries or by the mains, as well as electrical office equipment and related devices, and whose rated voltage does not exceed 600 V [31]. | Application of this standard is designed to lower the risk of electric shock, energy-related hazards, and mechanical-related hazards [31]. So, we can apply this standard while designing our device. |
| Alarm System(Buzzer) | EN 50134-2:2017 | This European Standard outlines the specifications for trigger devices that transmit triggering signals both manually and automatically [32]. This standard is applicable to all trigger devices that send triggering signals via wired or wireless | This standard outlines the specifications and tests for trigger devices that are a part of an alarm system [32]. This standard can dictate the requirements needed for our device’s alarm system. |

| | | | |
|---|---|---|---|
| | | links to a local unit or controller [32]. | |
| WiFi | IEEE 802.11ax | This standard is a 2.4GHz and 5GHz frequency band-based IoT enabling technology that is superior to its predecessor [33]. Additionally, it works better for local range IoT | Since our project is an IoT based project, internet connection is crucial. Since internet connection is provided by the WiFi, this standard meets the most with our device. |

### 1.3 Systematic Overview/Summary of the Proposed Project

According to studies, many people, regardless of age, forget to take their medications. This increases a lot of additional life hazards and is especially common in the elderly. Dispensers for medications can be useful in this situation. Dispensers come in a variety of forms, the majority of them are merely straightforward, lacking any reminders or other details. This project suggests an alarm-setting dispenser that can follow a strict medicine schedule of the user to dispense medications and is connected to a website. Studies regarding adherence and non-adherence rate among the general population, different types of medicines taken by the public are shown. We also conducted a survey regarding the number of people having elderly parents living alone, people in the family having a complex medicine regimen and in need of supervision, percentage of people forgetting to take their medications and later on suffering for it etc. We also asked the general public about their thoughts on the medicine dispensers available on the market and whether they need a dispenser like the one we proposed. The objectives of this project, along with functional and non-functional requirements, specifications and constraints we faced are discussed. The applicable standards and codes related to this project are also discussed.

### 1.4 Conclusion

This project proposes an IoT based medicine dispenser. The main goal of our project is to make individuals more reliant on IoT based medical devices that have simple, easy-to-follow regimens to ensure medication adherence where the main target market being older individuals who frequently forget and endanger their lives as a result. The Internet of Things (IoT) is an architecture that makes it possible for people, systems, and gadgets of any kind to connect with one another [34].

# Chapter 2: Project Design Approach

### 2.1 Introduction

For building this project, three approaches have been considered according to the objectives of the project. For each of the approaches - circuit design, model design, program code etc. have been planned. After that, the electronic circuits have been designed and simulated in Proteus. For the graphical simulation, Fusion 360 software has been used. Proper programming code was written to make the circuits work. Since it is an embedded system related project, coding has major significance. As for the errors or bugs in the design or the code, they were debugged and solved till the desired result was achieved. Since it is an IoT based project, an important part of this project is the online platform through which we will communicate with the device. For this reason, we designed a website that fulfilled our necessities. A flowchart of the process of project implementation is given below:

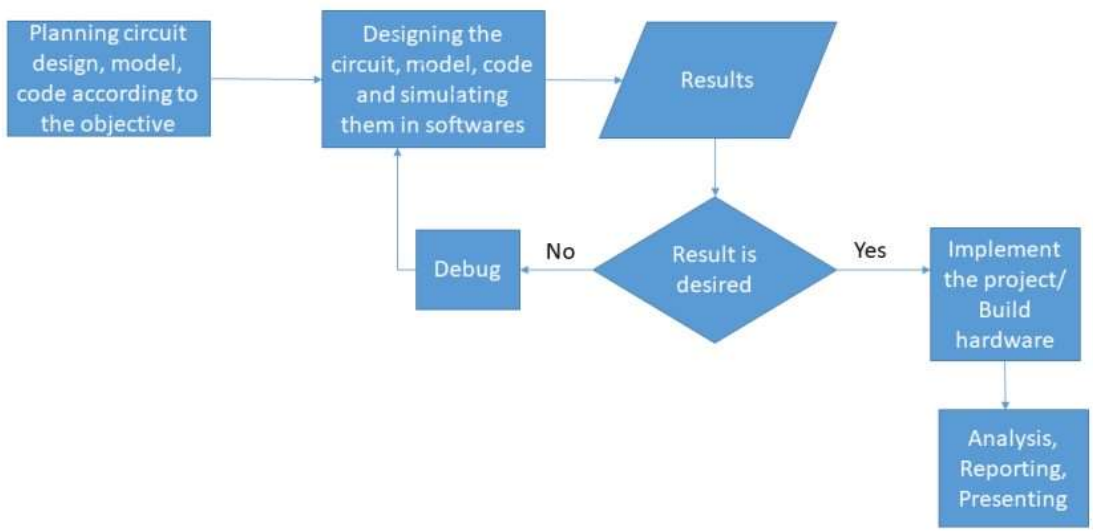



Fig 2.1: Flowchart for constructing the project.

### 2.2 Identify Multiple Design Approach

For this project, three different design approaches are-
(i) Design approach 1- Stack Box Model
(ii) Design approach 2- Vending Machine Model
(iii)Design approach 3- Tray Model

(i) Design approach 1- Stack Box Model:

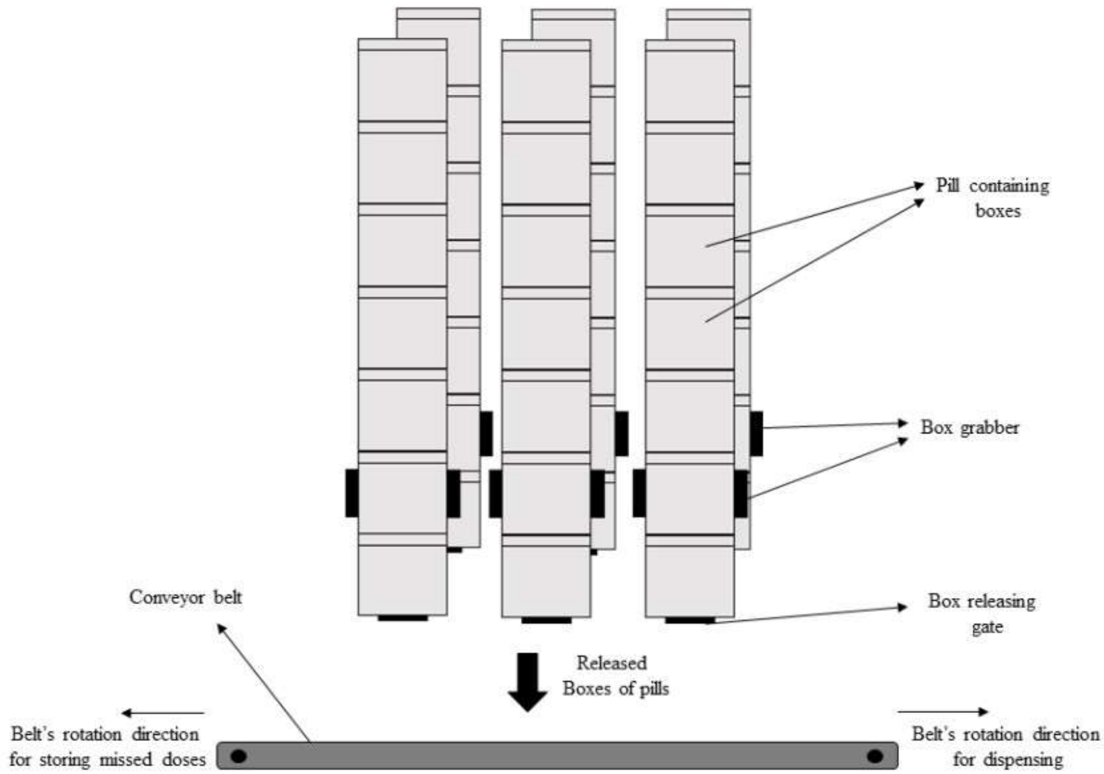



Fig 2.2: Stack Box Model

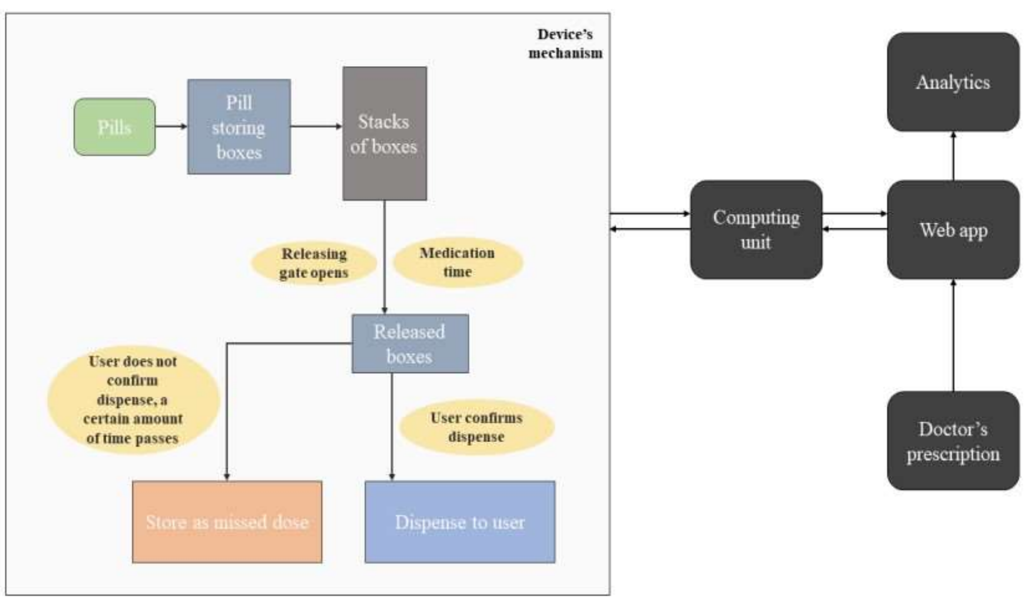



Fig 2.3: Block diagram of Stack Box Model

(i) Design approach 2- Vending Machine Model

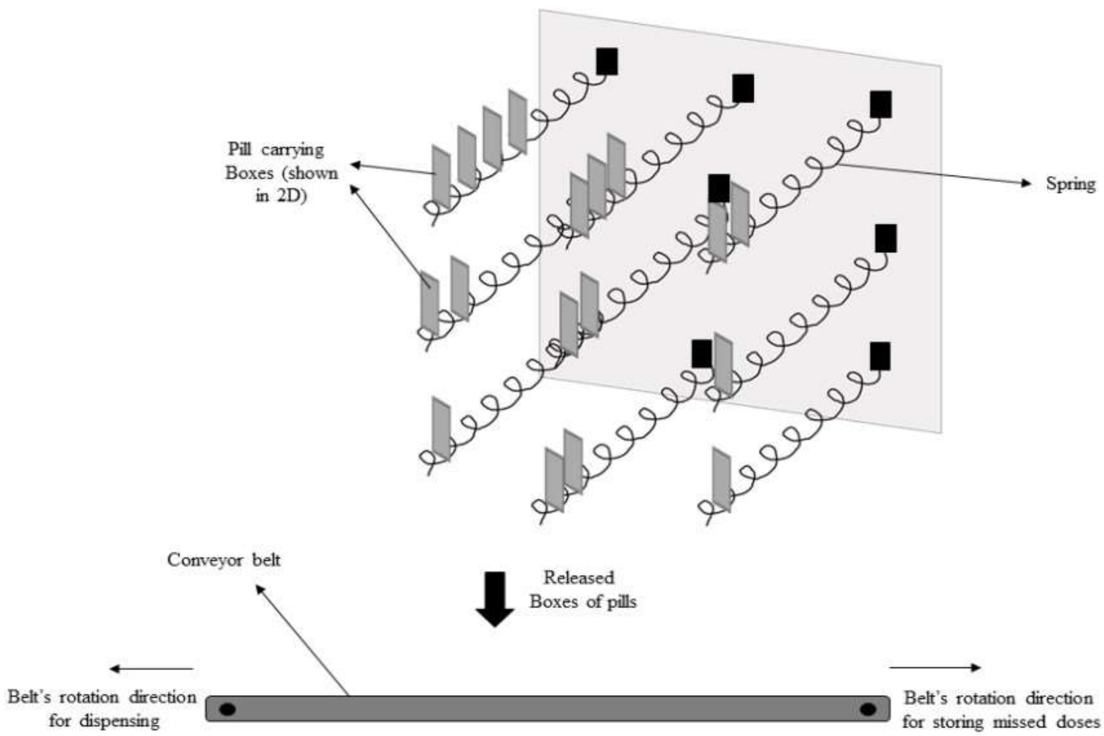



Fig 2.4: Vending Machine Model

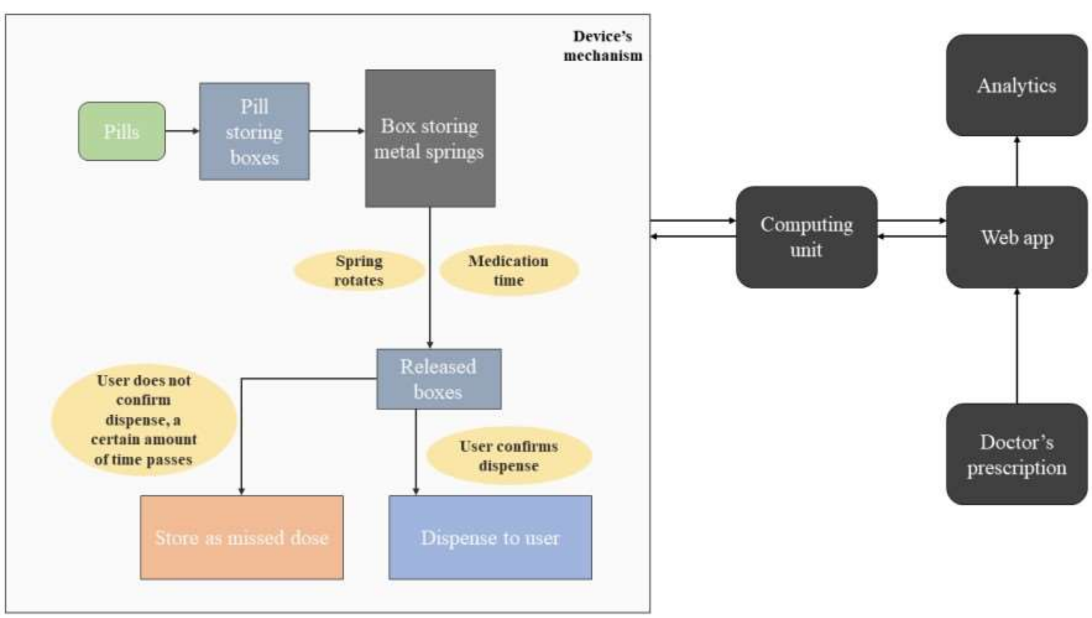



Fig 2.5: Block diagram of Vending Machine Model

(i) Design approach 3- Tray Model

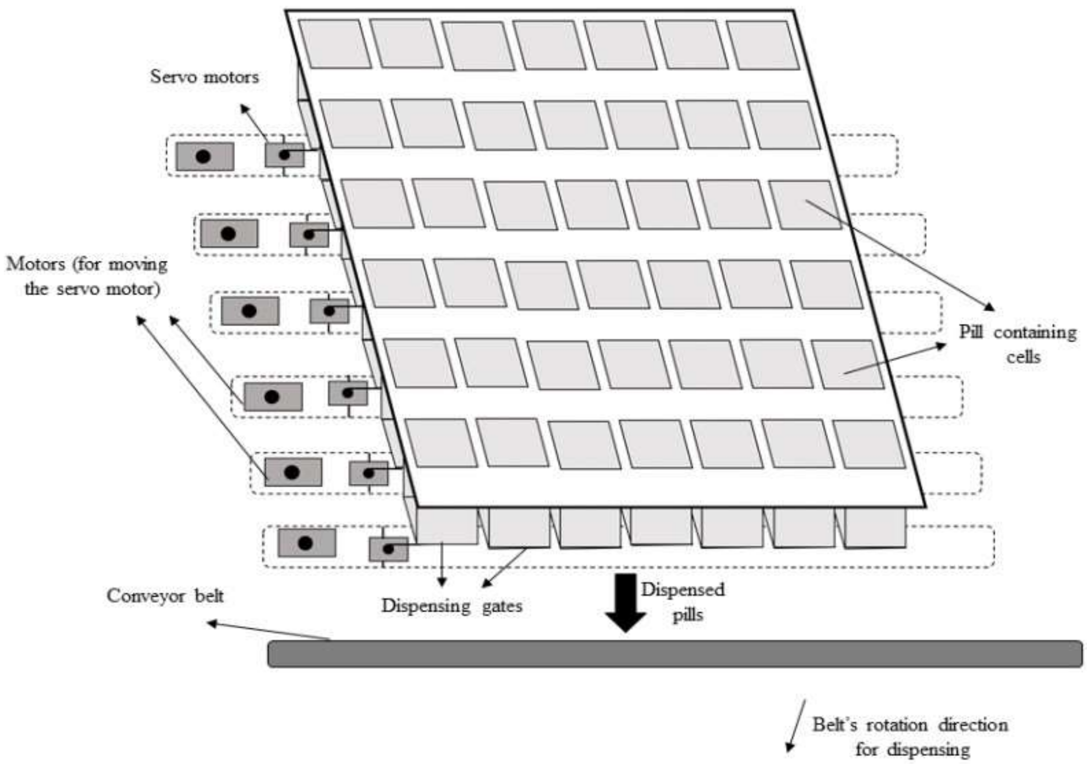



Fig 2.6: Tray Model

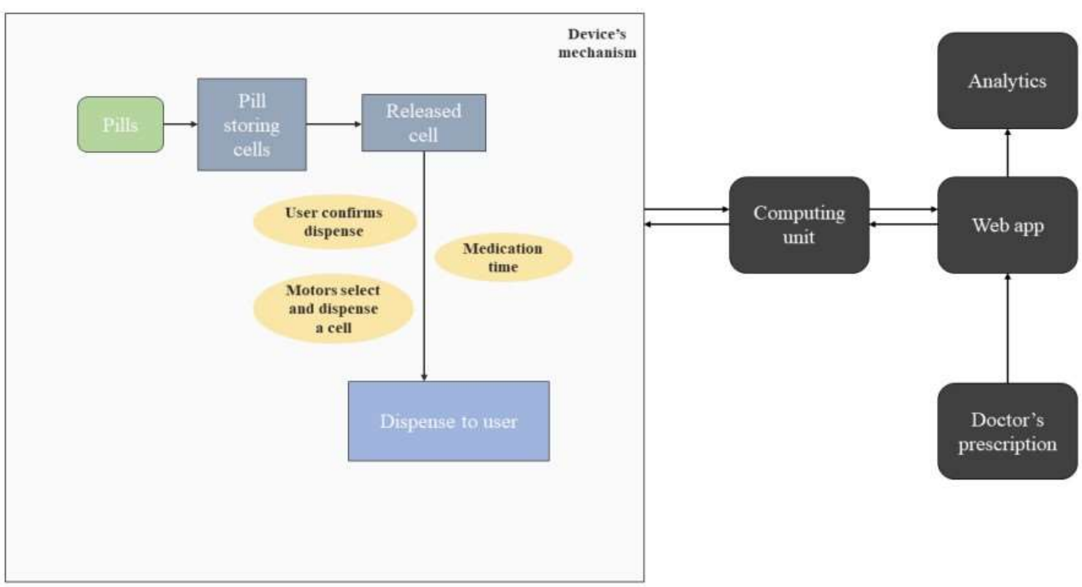



Fig 2.7: Block diagram of Tray Model

Updated budget of design 1:

Table 2.1: Updated budget for design approach 1.

| **Component** | **Unit** | **Per Unit price** | **Total price** |
|---|---|---|---|
| NodeMCU (ESP8266) | 1 | 420 | 420 |
| 74138 decoder | 1 | 25 | 25 |
| Mini Servo Motor SG90 | 12 | 150.98 | 1811.76 |
| Lipo Battery 1000mAh 11.1V 3S | 1 | 1,250 | 1,250 |
| Battery charger B3 compact | 1 | 480 | 480 |
| IC 74LS138 | 2 | 3 | 6 |
| Socket for NodeMCU | 2 | 18 | 36 |
| 16x2 LCD Display | 1 | 418.46 | 418.46 |
| DC Geared Motor (6V,30rpm) | 1 | 345.57 | 345.57 |
| L298N Motor Driver | 1 | 302.10 | 302.10 |
| Real Time clock Module DS3231 | 1 | 340 | 340 |
| DC to DC Buck Converter | 1 | 99 | 99 |
| Vero board | 1 | 25 | 25 |
| Device case, box material | - | 600 | 600 |
| **Total** | | | **BDT 6,158/-** |

Table 2.2: Budget for design approach 2.

| Component | Unit | Per Unit price | Total price |
|---|---|---|---|
| Arduino Mega(2560 CH340) | 1 | 1,498 | 1,498 |
| Wifi module (ESP8266) | 1 | 420 | 420 |
| DS1307(RTC module) | 1 | 30 | 30 |
| Display(I2C connected) | 1 | 250 | 250 |
| Stepper motor (NEMA 17) | 9 | 1232 | 11,088 |
| 6V DC Geared Motor | 1 | 79 | 79 |
| LiPo Battery(3300mAh) | 1 | 1,927 | 1,927 |
| Buck Converter | 1 | 353 | 353 |
| Buzzer | 1 | 40 | 40 |
| Push button | 1 | 5 | 5 |
| Wires, misc. components | - | 300 | 300 |
| Device case, box material | - | 1000 | 1000 |
| **Total** | | | **16,990/-** |

Table 2.3: Budget for design approach 3.

| Component | Unit | Per Unit price | Total price |
|---|---|---|---|
| Arduino Mega | 1,498 | 1 | 1,498 |
| Servo motor | 150 | 6 | 900 |
| Stepper motor (NEMA17) | 1,232 | 6 | 7,392 |
| RTC module | 340 | 1 | 340 |
| 6V DC Geared Motor | 346 | 1 | 346 |
| Wifi module (ESP8266) | 220 | 1 | 220 |

| | | | |
|---|---|---|---|
| 12x2 LCD Display | 300 | 1 | 300 |
| Battery LiPo | 1,927 | 1 | 1,927 |
| Push Button and switch and buzzer | 56.35 | 1 | 56.35 |
| ULN2003 motor driver | 108 | 1 | 108 |
| Wires, others | 500 | 1 | 500 |
| Hardware material | 3,000 | 1 | 3,000 |
| **Total (BDT)** | | | **Total (BDT) 16,587/-** |

### 2.3 Describe Multiple Design Approach

#### 2.3.1 Design Approach 1 – Stack Box Model

In the first design approach, we will be using a medicine storing and dispensing mechanism that looks similar to Figure 2.9. In the mechanism design, there are stacks of boxes. The boxes contain doses of medicine pills. The boxes will have individual identity numbers, to be traced. Medications will be filled in the boxes manually, with the help of instructions displayed on the device's display, by the caregiver. At the bottom of each stack, there is a releasing gate, which will open at the time of releasing the box. The box grabber mechanism will make sure that one box is being released at a time. After a box is released, there is a conveyor belt that will take the box to the dispensing channel where the user can get it. If the user misses the dose, the conveyor belt will move the box in the opposite direction to a chamber that stores the missed medication boxes, to prevent medication overdose. The mechanism will be controlled by the computing unit, which is connected to the internet. Medication scheduling is done on the web app, which syncs with the device and provides correct medication at the correct time. Figure 2.8 shows the flowchart of the design. For software simulation purposes, we have used Arduino UNO in the simulation since there is no simulation model available for NodeMCU. But in real implementation there will be NodeMCU for design 1. All the calculations are done keeping this matter in mind. The model of the stack of medication boxes in the medicine dispenser machine is inspired by a design used by Philips [35].

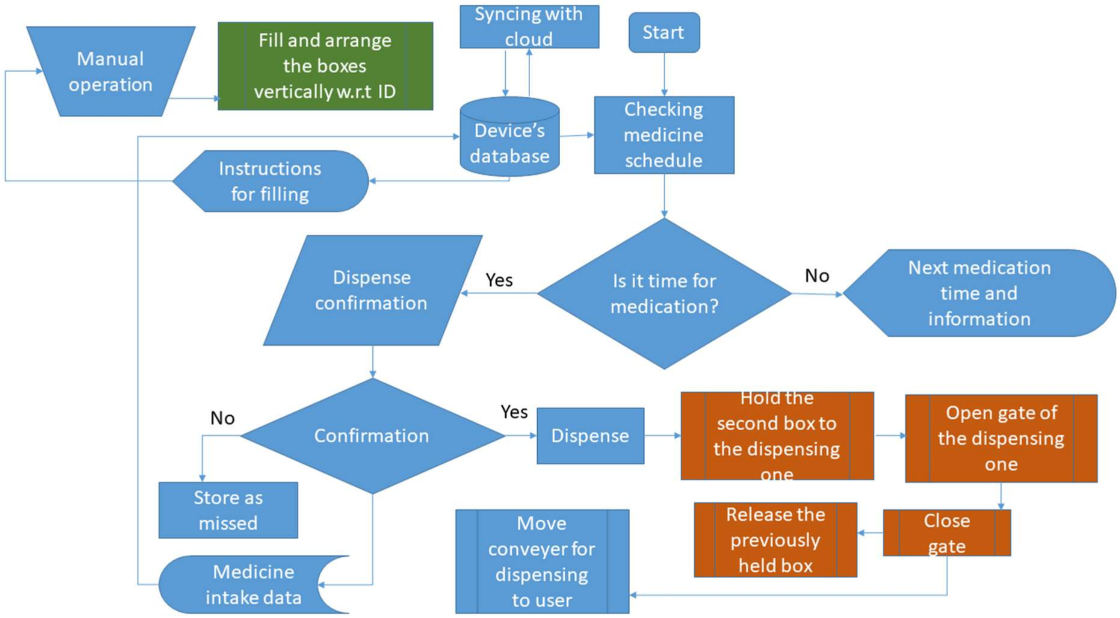



Fig. 2.8: Flowchart of design approach 1

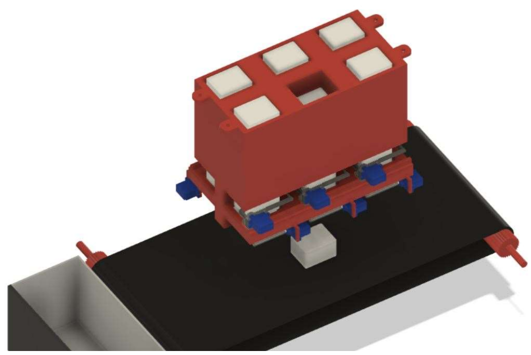


Fig. 2.9: Medicine storing and dispensing mechanism of design approach 1

### 2.3.2 Design Approach 2 - The Vending Machine Model

This strategy is known as the "vending machine model," and it employs a mechanism that is quite similar to a vending machine mechanism [36]. There are metal springs that are attached to a vertical plane. The medicines are kept in boxes. Within the springs, the medicine boxes are stored in order. Each spring is estimated to hold at least 5 boxes of medicine pills. Motors attached to the end of each spring will rotate the springs at the time of releasing a box. Each box has a unique identification number in order to be tracked. Medications will be filled in the boxes according to the doctor's prescription, by the caregiver. Filling the boxes with proper medications will be assisted by the information that is shown on on-device display. After a box is released, there is a conveyor belt that will take the box to the dispensing channel where the user can get it. If the user misses the dose, the conveyor belt moves the box in the opposite direction to a chamber that stores the missed medication boxes, to prevent medication overdose. The mechanism will be controlled by the computing unit (ESP8266), which is connected to the internet. Medication scheduling will be done on the web app, which syncs with the device and provides the correct medication at the correct time.

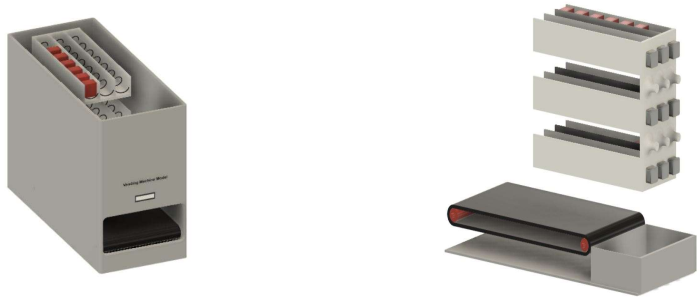


Fig 2.10: 3D Model of Vending Machine Model

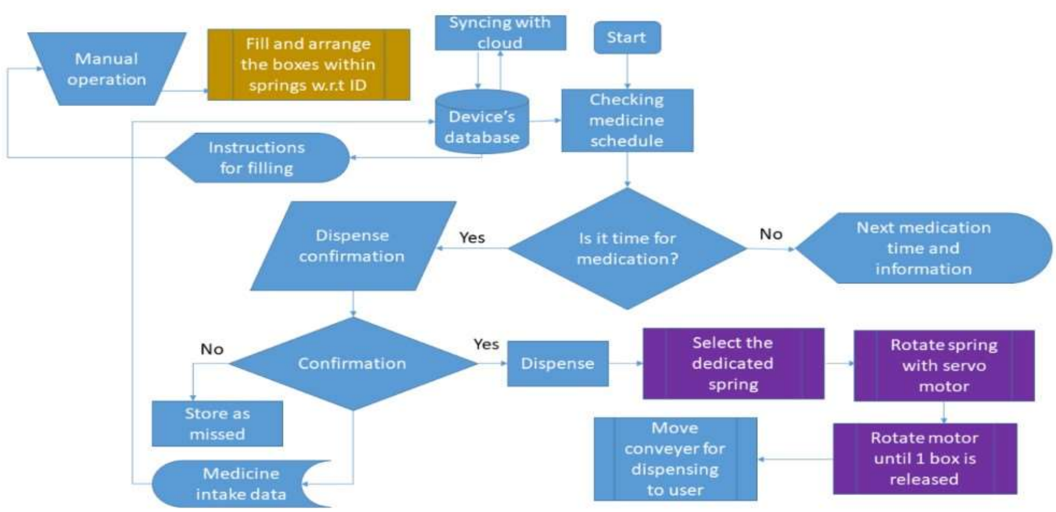



Fig 2.11: Flowchart of design approach 2

### 2.3.3 Design Approach 3 - Tray Model

The design approach used in this one uses a medicine storage and dispensing mechanism that has a tray-like single horizontal plane. The plane has cells, which are to be filled with medication doses. The cells have individual identity numbers, to be traced. Medications are stored in the cells according to the doctor's prescription, by the caregiver. Filling the boxes with proper medications will be assisted by the information that is shown on on-device display. When a particular cell is dispensed, the medications are collected on the conveyor belt, which is then provided to the user by movement of the belt. For this 6x7 cell design, 6 servo motors are used for each row. The servo motor for a row can move along the x-axis and select a particular cell within that row to make that cell dispense. The movement of the servo motor is controlled by a continuous servo motor, there are 6 of these continuous servo motors for 6 rows. Normally, a cell’s gate is closed, which is placed at the bottom of the cell, using a spring. After selecting a particular cell, the servo can make the cell’s gate open to dispense the stored medications. The mechanism is controlled by the computing unit, which is connected to the internet. Medication scheduling is done on the web app, which syncs with the device and provides correct medication at the correct time. Figure 2.12 and figure 2.13 shows the storage and dispensing mechanism. Figure 2.14 shows the flow chart of the design.


Fig 2.12: 3D model of Tray Model

Fig 2.13: Tray and conveyor belt 3D concept

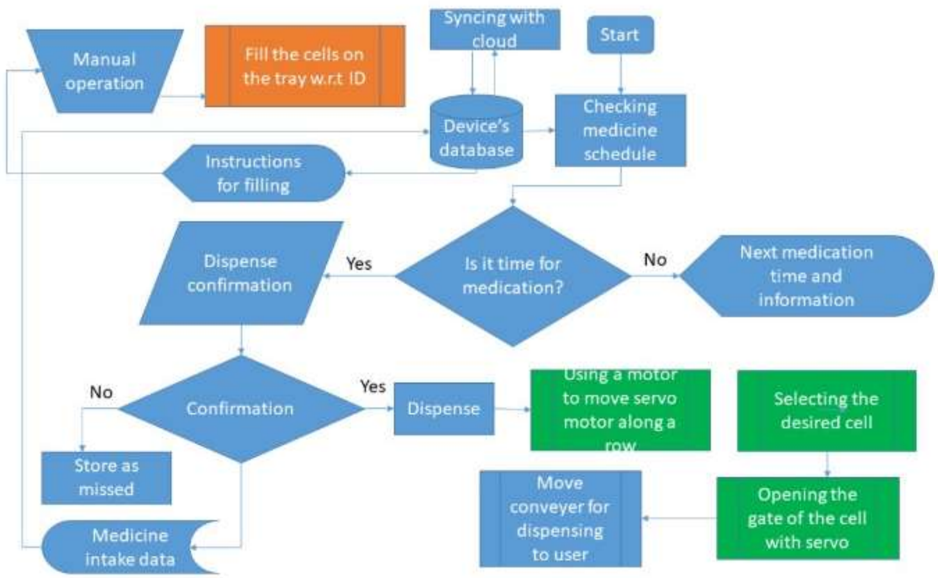



Fig 2.14: Flowchart of design approach 3

The web application we have constructed is used to schedule medicine doses to the device, see all the scheduled medicine details and see analytics of the device over the internet. Analytics will allow the caregiver or the doctor to see whether the patient/user has taken or missed a particular dose. The homepage is shown in Fig 2.15.. Medicine schedule can be seen by clicking on the VIEW SCHEDULE, shown in Fig 2.16. Analytics can be seen by clicking on the ANALYTICS.


Fig 2.15: Homepage of the website.

**Medicine Schedule**

| Box/Dose No. | Medication Names | Time |
|---|---|---|
| 1 | Napa x1, Esonix 1 | 2022-12-25T07:30 |
| 2 | Napa x1, Vitamin x1 | 2022-12-25T13:30 |
| 3 | Cal D x1, Vitamin x1 | 2022-12-25T20:30 |

Fig 2.16: Medicine schedule of the use/patient.

**Dispenser Analytics**

| Box/Dose No. | Medication Names | Time | Status |
|---|---|---|---|
| 1 | Napa x1, Esonix 1 | 2022-12-25T07:30 | |
| 2 | Napa x1, Vitamin x1 | 2022-12-25T13:30 | |
| 3 | Cal D x1, Vitamin x1 | 2022-12-25T20:30 | |

Fig 2.17: Analytics section of the website

Table 2.4: Comparison between the three design approaches.

| **Criteria** | **Design Approach 1** | **Design Approach 2** | **Design Approach 3** |
|---|---|---|---|
| **Medicine Refilling Convenience** | Putting pills in correct boxes, stack up the boxes in correct order. Requires the person to be cautious in 2 of these steps. | Putting pills in correct boxes, put the boxes in correct order within the springs. Requires the person to be cautious in 2 of these steps | For refilling, putting pills in the correct cell will be enough. Less chance of making mistakes for the person who will refill. |
| **Medicine Dose Changing Facility** | For changing a particular dose, more than one box might be needed to bring out. This might be inconvenient and includes risks of making mistakes. | Any particular dose can easily be changed by picking up the desired box from the spring. | Any particular dose can easily be changed if needed. |
| **Resistance to Trembling** | The stacks are firmly placed within the structure. External shake should not cause much of a negative effect. | The boxes are not attached to the string firmly, they are loosely placed. External shake can cause a box to fall down. | External shake should not cause much of a negative effect to the device. |

| | | | |
|---|---|---|---|
| **Dispensing Jam** | Box is released by opening the gate. Since the dispensing channel is simple, there should be less chance of dispense jam. | Boxes can get jammed within springs and can cause dispensing jam. We can tell it by seeing the jams in the vending machine in the real world. | If the motors or slider in a particular row somehow dislocate, the cell to be dispensed might not be correctly selected. That can cause dispense jam. |
| **Indoor Space Requirement** | The medicine boxes are stacked vertically, 6 of these stacks together take comparatively less area on the ground than other designs. | The box contains springs that are parallel to the ground. Since a single spring holds at-least 5 springs, that will require more area on the ground for the device to be stored | Since all the medicine boxes are placed on a single plane, this design will take the most area on the ground for the device to be stored. |
| **Dispense Mechanism Complexity** | A releasing gate and a grabber is used for each stack. Grabber holds a box when another box is being released by the releasing gate. Comparatively simpler operation. | Selecting the desired spring and running the continuous servo attached to the spring is the only operation for releasing a box. Simplest of all the approaches. | For releasing a specific cell, first the row is located. Then two motors for that row need to be in action. Servo motor is slide to the dedicated cell by a continuous servo. Most complexity among other approaches |

## 2.4 Analysis of Multiple Design Approach

### 2.4.1 Analysis of Design Approach 1

Electronic circuit schematic for the design is shown in Figure 2.18. Here, 2 servo motors work together for each stack. After a box is dispensed from the stack, the conveyor motor rotates in either - in the user's direction or in the direction where the dose is stored as a missed dose inside the device.

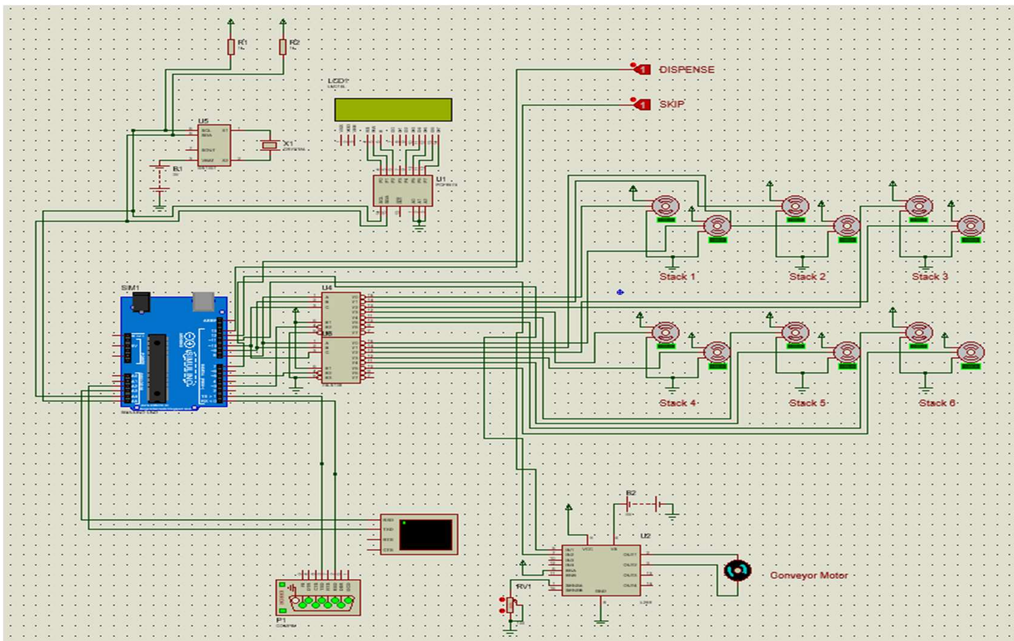



Fig 2.18: Electronic Circuit Schematic for design approach 1

Test cases

1. Inputting medicine data - box number, dose details, time - in the web app
2. Receiving the data from web app to the device
3. Prompting to take medicine at the time of dose taking
4. Dispensing the dose using appropriate mechanism
5. If a dose is missed sending the data to web app

Verification - simulation video for circuit
https://youtu.be/zveDA9F2FLE
Verification - simulation video for 3D graphics
https://youtu.be/4JsVGUP9hCM

Result: The device was able to perform all the desired tasks passing the test cases from 1-5.

### 2.4.2 Analysis of Design Approach 2

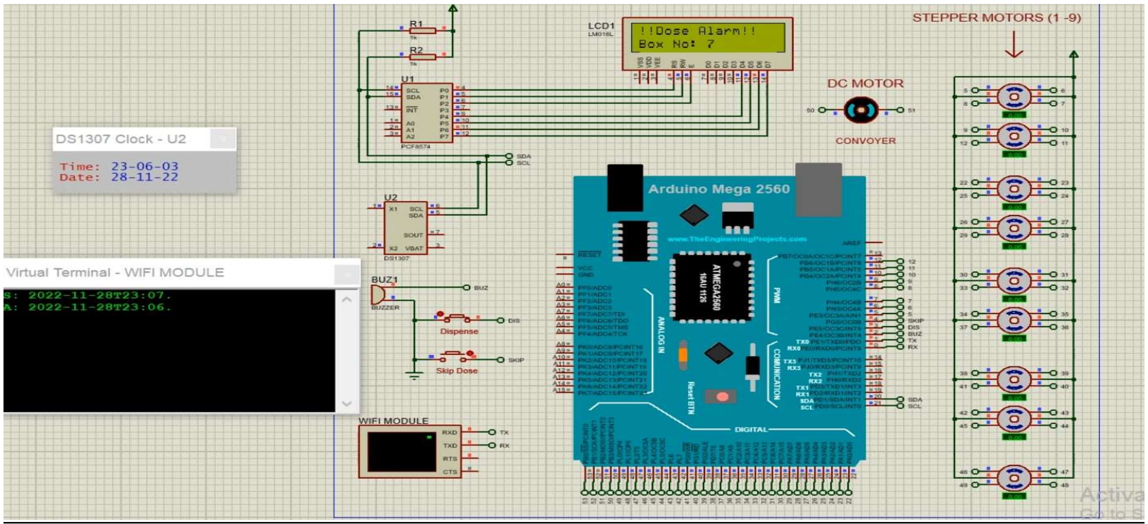



Fig 2.19: Electronic Circuit Schematic for design approach 2

Verification - simulation video for circuit:
https://youtu.be/I8zUBioM618
Verification - simulation video for 3D graphics
https://youtu.be/Vd38Lic6qso

Result: The device was able to perform all the desired tasks passing the test cases from 1-5.

### 2.4.3 Analysis of Design Approach 3

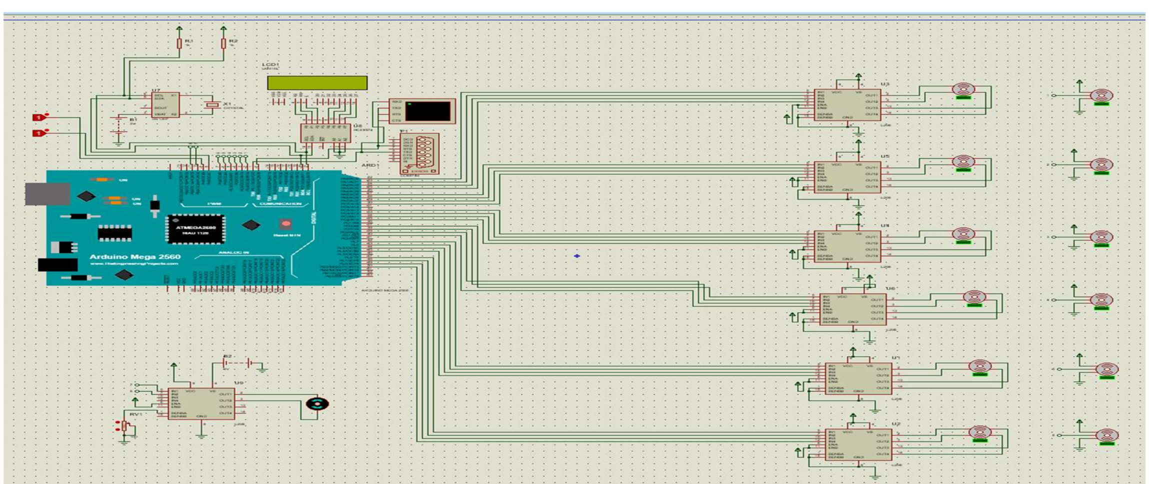



Fig 2.20: Electronic Circuit Schematic for design approach 3

Verification - simulation video for circuit:
https://youtu.be/RMmsgLbUQpU
Verification - simulation video for 3D graphics
https://youtu.be/tanu0X-5sc8

Result: The device was able to perform all the desired tasks passing the test cases from 1-5.

### 2.5 Conclusion

The mechanisms of the three design approaches are displayed alongside graphical depictions of the designs. Additionally displayed is the web application that monitors and stores all the data. The three designs were simulated using the Proteus software, and test cases were run based on specific criteria, including entering medication data, receiving data from a web app to the device, prompting the user to take their medication at the appropriate time, dispensing the dose using the proper mechanism, and sending data to a web app if a dose was missed.

# Chapter 3: Use of Modern Engineering and IT Tool

### 3.1 Introduction

The term "modern engineering IT tools" refers to all architectural designs for products and subsystems, electrical schematics, printed circuit board designs, mechanical design drawings, fabrication drawings, binary images and source files for all programmable parts, software tools, including those for compiling programmable part source files, test jigs (including electrical, mechanical, and software design files used to create the test jigs), test procedures, and test software (including source files, build documentation, and test data) [37]. For designing our iot based medicine dispenser, we applied some software tools for coding, schematics and animation and some hardware tools for the device implementation.

### 3.2 Select Appropriate Engineering and IT Tools

Appropriate software and hardware tools for the implementation of this device is shown below:

**Software tools:**

- **Coding software:**
  - Visual Studio Code
  - Arduino IDE

- **Languages:**
  - **J**avaScript
  - CSS
  - C, C++.

- **Graphical simulation:**
  - Fusion 360

**Hardware tools:**

- Vero board.
- 74128 decoder IC.
- I2C LCD display 16 x 2
- 1100 mAh 3S LiPo battery

### 3.3 Use of Modern Engineering and IT Tools

#### 3.3.1 Software

**Proteus:**
It is a software mainly used for developing PCB layouts, modeling embedded circuits and making schematics. This tool has been chosen for simulation for certain reasons. The library of Proteus is well equipped with microcontrollers like Raspberry PI, PIC, and Arduino which

can be an issue with other simulation software's. Programming code must be designed for microcontrollers in embedded projects and designing such codes require extensive testing that includes uploading code to microcontroller [38].Proteus makes this process easier. Once a circuit is designed in Proteus, the code can be tested in the simulation, if it runs properly then it can be tested with the hardware part also [38]. Other softwares like Eagle and MuliSim cannot provide such facilities since Eagle does not support microcontroller simulation and some microcontrollers are unavailable in MultiSim which can create problems for the users.

**Arduino IDE:**

The open-source Arduino IDE program is primarily used for writing, compiling, and uploading code to virtually all Arduino modules and boards. It operates on the Java Platform, which has built-in functions and commands that are essential for debugging, modifying, and compiling the code, and is compatible with all operating systems, including MAC, Windows, and Linux [39]. Several Arduino modules are available, including the Uno, Mega, Leonardo, Micro, and many others [39]. Each of them has an embedded microprocessor that can be programmed and accepts data in the form of code.

**Fusion 360:**

For professional product design and manufacturing, Fusion 360 is a cloud-based 3D modeling, CAD, CAM, CAE, and PCB software platform [40]. It creates an engineers items based on our desired standards in terms of appearance, form, fit, and functionality. With extensive electronics and PCB design tools, it engineers, designs, and produces anything.

**Visual Studio Code:**

Visual Studio Code is a free, compact, yet capable source code editor for Windows, macOS, Linux, and Raspberry Pi OS. It includes built-in support for JavaScript, TypeScript, and Node.js and has a robust ecosystem of extensions for more programming languages such as C++, C#, Java, Python, PHP, and Go, runtimes, environments and clouds [41].

**JavaScript:**

Programmers all over the world use JavaScript to make effective and interactive online apps and browsers. JavaScript can be used for a wide range of applications, including software, hardware controls, and servers. Because it is built into web browsers, JavaScript is most recognized for being a language used on the web. JavaScript enables programmers to add features such as displaying and masking menus or information, zoom in or zoom out an image's size, playing audio or video on a website, including animations and so on [42]. For any web developer, JavaScript is an essential programming language.

**CSS:**

CSS, or Cascading Style Sheets, is a markup language that is used to style elements in markup languages like HTML [43]. It divides the website's visual design from its content. Since HTML serves as a site's very foundation and CSS handles all of the looks for a whole website, the two are closely related. CSS has a straightforward English-based syntax that is governed by a set of rules.

Table 3.1: Software comparison for modern engineering IT tools.

| Software name | Portability | Library Resources | Component Availability | Import Facilities | User Complexity | User Popularity |
|---|---|---|---|---|---|---|
| Circuit simulation | | | | | | |
| **Proteus** | ✓ | High | High | ✓ | Low | High |
| **Autodesk Eagle** | ✓ | Moderate | Low | ✓ | High | Low |
| Web app development | | | | | | |
| **VS Code** | ✓ | High | High | ✓ | Low | High |
| **Atom** | ✓ | Moderate | Moderate | ✓ | Moderate | Low |
| Programming language | | | | | | |
| **Javascript** | ✓ | High | High | ✓ | Low | High |
| **Python** | ✓ | High | Moderate | ✓ | High | Moderate |
| 3D Model | | | | | | |
| **Fusion 360** | ✓ | High | High | ✓ | Moderate | High |
| **Blender** | ✓ | Moderate | Moderate | ✓ | High | Moderate |

### 3.2.2 Hardware

**Vero board:**

One of the most popular kinds of prototyping boards is vero board/stripboard. These boards are designed to permanently assemble prototype on-off circuits [44]. The board is constructed from an insulating substance, typically fiberglass or a resin-bonded plastic [44]. Parallel copper strips spaced 2.54 mm apart are seen on one side and these strips have holes that are also spaced 2.54 mm apart [44]. On the opposite side of the board, components are positioned with their wires bent to fit through the holes [44]. To make the assembly neater, the projecting ends of the wires are chopped off before they are soldered to the copper strips [44].

No specific equipment or chemical processing is necessary for vero board. Copper tracks are used to link the components, which are arranged in strips on an insulating board with pinholes spaced 0.1 inches apart [44].

**74128 decoder IC:**

The IC 74LS138 is a 3 to 8 line decoder integrated circuit from the 74xx family of transistor-transistor-logic-gates and is mostly utilized in applications like memory decoding with high performance, otherwise data routing, etc [45]. Modern technology, such as silicon (Si) gate TTL technology, is used in the decoder 74LS138 IC [45]. These are appropriate for a variety of applications, such as data routing or memory address decoding. These applications will likely use TTL circuitry and have strong noise resistance and low power consumption. These ICs can be utilized to reduce the effects of system decoding in memory systems with high performance.

**I2C LCD display 16 x 2:**

An HD44780-based character LCD display plus an I2C LCD adaptor make up a standard I2C LCD display [46]. 32 ASCII characters can be shown over two rows on a 16 x 2 character LCD [46]. A regular LCD is substantially more difficult to connect than an I2C LCD. Only four pins must be connected. In our proposed device, an LCD display is used to show the time, date, time of next medicine dispensed, medicine taken or missed confirmations.

**1100 mAh 3S LiPo battery:**

Rechargeable lithium batteries made of lithium polymer are small, light, and extremely high-powered [47]. Lithium polymer batteries have polymer gel electrolytes and a Lithium cobalt oxide ($LiCoO_2$) or other comparable material as the anode and cathode [47]. The nominal voltage of the 3S LiPo battery is 11.1 volts, the maximum charging voltage is 12.6 volts, and the cutoff voltage is approximately 9 volts [47].

### 3.4 Conclusion

After confirmation of the design approaches, we used platforms VS code, Arduino IDE and JavaScript, CSS languages for coding. For implementation of the circuit, we used Proteus software. For graphical representation of the designs, we used fusion 360 software. A comparison table is included to demonstrate why we selected these particular softwares above others. As for the hardware part, we constructed the circuit on a vero board and components such as 74138 decoder, LCD display, 1100 mAh LiPo battery, servo motor SG90 etc. were used.

# Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution

### 4.1 Introduction

After software implementation of the three design approaches, we tested them on certain parameters and compared to know which one performed best. Given that the project is a medication dispenser, aspects like power consumption are crucial in assessing whether or not the design is optimized. Since the device will always be operational, variables like how much backup the battery we're using can supply are also crucial. Since it is meant to be a domestic medicine dispenser, we have to test the factors like cost, weight, ground area taken by the device, usability and sustainability. We tested the three design approaches from multiple perspectives to attain the optimal one.

### 4.2 Optimization of Multiple Design Approach

Table 4.1: Power consumption calculation of design approach 1.

| **Component** | **Operating** | **Idle** | **Rated Max** |
|---|---|---|---|
| Computing Unit | 5 V * 200 mA = 1 W | 5 V * 9 mA = 0.045 W | 10 V * 200 mA = 2 W |
| Multiplexer | 5 V * 8 mA = 0.04 W<br>0.04 * 2 = 0.08 W | 5 V * 2 mA = 0.01 W<br>0.01 * 2 = 0.02 W | 7V * 8 mA = 0.056 W<br>0.056 * 2 = 0.112 W |
| Real Time Clock (RTC) | 5 V * 5 mA = 0.025 W | 5 V * 200 uA = 0.001 W | 5.5 V * 5 mA = 0.027 W |
| Display | 5 V * 120 mA = 0.6 W | 5 V * 5.5 mA = 0.027 W | 5 V * 120 mA = 0.6 W |
| Conveyor | (7.4 V * 250 mA = 1.85 W) + (5 V * 50 mA = 0.25 W) = 2.1 W | 5 V * 12 mA = 0.06 W | (24 V * 260 mA = 6.24 W) + (7 V * 70 mA = 0.49 W) = 6.73 W |
| Dispensing Mechanism | 5 V * 500 mA = 2.5 W<br>2.5 * 2 = 5 W | 5 V * 5 mA = 0.025 W<br>0.025 * 2 = 0.05 W | 5 V * 500 mA = 2.5 W<br>2.5 * 2 = 5 W |
| DC to DC Converter | (1.11 * output current) - output current = (1.11 * 1391 mA) - 1391 mA = 153.01 mA<br>7.4 V * 153.01 mA = 1.13 W | (1.11 * output current) - output current = (1.11 * 40.7 mA) - 40.7 mA = 4.48 mA<br>7.4 V * 4.48 mA = 0.03 W | - |
| **Total** | 1.13W + 2.1W + 6.955 W = 10.185 W | 0.03 W+ 0.203 W = 0.233 W | 14.469 W |
| **Battery Backup (7.4 V, 3300 mAh)** | 3300/((10.185/7.4) * 1000) = 2.4 hrs. | 3300/((0.203/7.4) * 1000) = 120.3 hrs. | - |

Table 4.2: Power consumption calculation of design approach 2.

| Component | Operating | Idle | Rated Max |
|---|---|---|---|
| Arduino Mega | 5.5V*50mA=0.275W | 3.9V*40mA=0.156 W | 12V*500mA=6W |
| Wifi Module (ESP8266) | 5 V * 200 mA = 1 W | 5 V * 9 mA = 0.045 W | 10 V * 200 mA = 2 W |
| Real Time Clock (RTC) (DS1307) | 5 V * 5 mA = 0.025 W | 5 V * 200 uA = 0.001 W | 5.5 V * 5 mA = 0.027 W |
| Display,I2C connected | 5 V * 120 mA = 0.6 W | 5 V * 5.5 mA = 0.027 W | 5 V * 120 mA = 0.6 W |
| Stepper Motor (NEMA 17) 17HS4401S | 3.6V*1.7A=6.12W (one motor) | 2.2V*0.5A=1.1W (one motor) | 24V*1.8A=43.2W (one motor) |
| DC to DC Converter | 7.4 V * 153.01 mA = 1.13 W | 7.4 V * 4.48 mA = 0.03 W | - |
| Conveyor ( 6V Geared DC Motor) | 6V*0.33A=1.98W | 3V*170mA=0.51W | 7.5V*800mA=6W |
| **Total(without battery)** | 11.13W(operating) | 1.869W(idle) | 57.827(rated max) |
| **Battery Backup (7.4 V, 3300 mAh)** | 3300 / ((11.13 / 7.4) * 1000) = 2.1 hrs. | 3300 / ((1.869 / 7.4) * 1000) =13.07 hrs. | - |

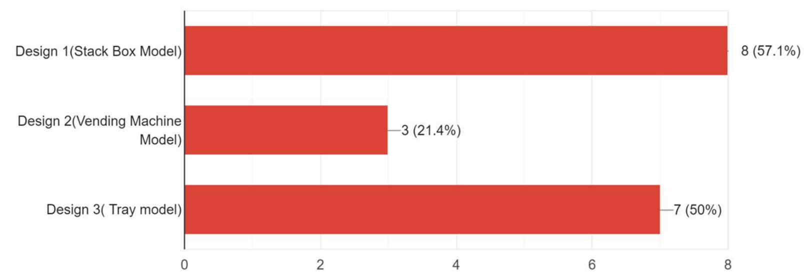
Table 4.3: Power consumption calculation of design approach 3.

| Component | Operating | Idle | Rated Max |
|---|---|---|---|
| Arduino Mega | 5.5V*50mA=0.275W | 3.9V*40mA=0.156 W | 12V*500mA=6W |
| Wifi Module (ESP8266) | 5 V * 200 mA = 1 W | 5 V * 9 mA = 0.045 W | 10 V * 200 mA = 2 W |
| Real Time Clock (RTC) (DS1307) | 5 V * 5 mA = 0.025 W | 5 V * 200 uA = 0.001 W | 5.5 V * 5 mA = 0.027 W |
| Display,I2C connected | 5 V * 120 mA = 0.6 W | 5 V * 5.5 mA = 0.027 W | 5 V * 120 mA = 0.6 W |
| Stepper Motor (NEMA 17) | 12V*1.5A=18W (one motor) | 3.2V*1.2A=3.84W (one motor) | 24V*1.8A=43.2W |
| Dispensing mechanism (Servo motor) | 5 V * 500 mA = 2.5 W (One motor) | 5 V * 5 mA = 0.025 W 0.025 * 2 = 0.05 W | 5 V * 500 mA = 2.5 W 2.5 * 2 = 5 W |
| Motor driver (ULN2003) | 5V*0.5A = 2.5 W (One driver) | 5V*0.05A = 0.25 W 0.25 W*6= 1.5 W | 5V*0.5A = 2.5 W 6*2.5W = 15W |
| DC to DC Converter | 7.4 V * 153.01 mA = 1.13 W | 7.4 V * 4.48 mA = 0.03 W | - |
| Conveyor (6V DC Geared Motor) | 6V*70mA=0.42W | 3V*170mA=0.51W | 7.5V*800mA=6W |

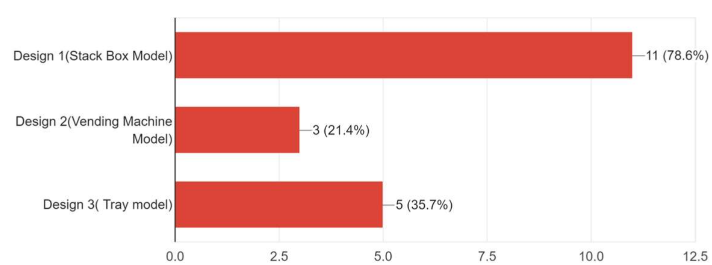
| | | | |
|---|---|---|---|
| **Total(without battery)** | 26.45W(operating) | 4.884W(idle) | 77.827(rated max) |
| **Battery Backup (7.4 V, 3300 mAh)** | 3300 / ((26.45 / 7.4) * 1000) = 0.92 hrs. | 3300 / ((4.884 / 7.4) * 1000) =5 hrs. | - |

**Survey report for user preference**

a. Among these 3 designs, which design/ device do you prefer on the basis of medicine refilling procedure?




b. Among these 3 designs, personally, which design/device would you choose?



Sustainability test: Trembling the device

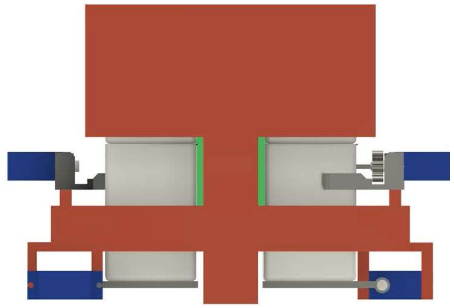


Fig 4.3: Design 1 mechanism

Mechanism for design 1 - the servo motors (one at the bottom of the stack, one grabbing a box of the stack) hold the boxes firmly. Without any PWM signal provided, the servo motor will not change its position. Again the stack is firmly secured in a holding structure that is colored red in the model shown above. So, moderate external trembling should not cause any serious issue.

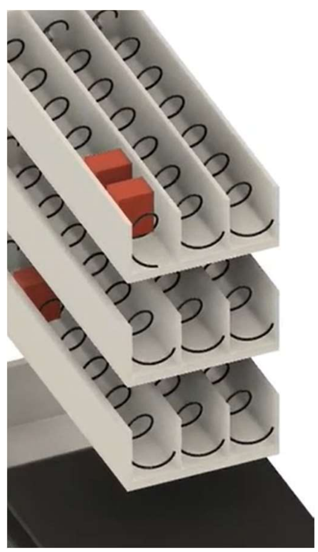


Fig 4.4: Design 2 mechanism

The boxes containing medicines are loosely placed on the springs for design-2. Upon the springs' rotation, the boxes are dispensed. And so, if anyone shakes the device or if the device faces external trembling, boxes might fall off the springs. This can cause wrong medication due to the wrong dose.

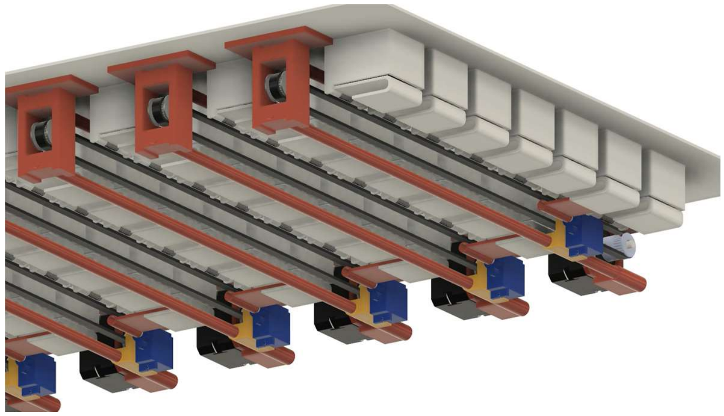


Fig 4.5: Design 3 mechanism

In this design, all the boxes are closed by default with the help of springs (Normally Closed or NC). In order to make a dispense, stepper motor and servo motor need to work together and pull out the dispensing gate of any particular cell. So without any signal given to the motors, the mechanism is a firm system. Moderate external trembling should not cause any major issue here.

Table 4.4: Parameter analysis of the three design approaches.

| **Criterion** | **Design 1** | **Design 2** | **Design 3** |
|---|---|---|---|
| Cost | 6,848/- | 16,990/- | 16,587/- |
| Power Consumption (Operating) | 10.185 W | 11.13W | 26.45W |
| Power Consumption (Idle) | 0.233 W | 1.869W | 4.884 W |
| Power Consumption (Rated Max) | 14.469 W | 57.827W | 77.827 W |
| Battery Backup (Normal Operation - e.g. 3 dispenses per day, 3300 mAh) | 95.9 hrs | 40 hrs | 37 hrs |
| Battery Backup (Continuous Operation, 3300 mAh) | 2.4 hrs | 2.1 hrs | 0.92 hrs |

| | | | |
|---|---|---|---|
| Battery Backup (Idle, 3300 mAh) | 120.3 hrs | 13.07 hrs | 88 hrs |
| Execution Time (Dispensing Time) | 25 seconds | 30 seconds | 23 seconds |
| Device Weight | 805.6 gm (without medicines) | 3.8892 kgs | 2.544Kgs (Without medicine) |
| Device Dimensions | 20 cm * 23 cm * 29 cm | 30cm * 45cm * 20cm | 45cm*75cm*12cm |
| Ground Area Requirement (For storing the device) | 0.49 sq. feet | 1.77 sq. feet | 3.6 sq. feet |
| Medicine Dose Storage Capacity | 42 doses | 45 doses | 42 doses |
| Usability (From survey) - Medicine refilling<br>- Medicine dose changing<br>- Model preference | 57.1% | 21.4% | 50% |
| Sustainability: Trembling the device (From graphical representation) | No risk | Risky | No risk |

### 4.3 Identify Optimal Design Approach

After evaluating the three design approached based on power consumption, survey on model preference, tests on trembling of the devices, parameter analysis based on cost, power consumption, battery backup, device weight, dimensions, ground area, medicine storage capacity, usability and sustainability, we came to the conclusion that design approach 1 i.e. the Stack Box Model is the optimal design approach.

### 4.4 Performance Evaluation of Developed Solution

Obtaining best design solution
Based on -

- Cost (less is better)
- Power Consumption (less is better)
- Ground (for storage) area requirement (less is better)
- Usability (more is better)
- Device weight (less is better)

Design 1 (Stack Box Model) is the best design to be implemented.

Optimization on selected design:

Modifying the firmware code, the execution time of design 1 is put down to 19 seconds from 25 seconds. Which means, the device is working ((25-19)/25) * 100 = 24% faster than before.

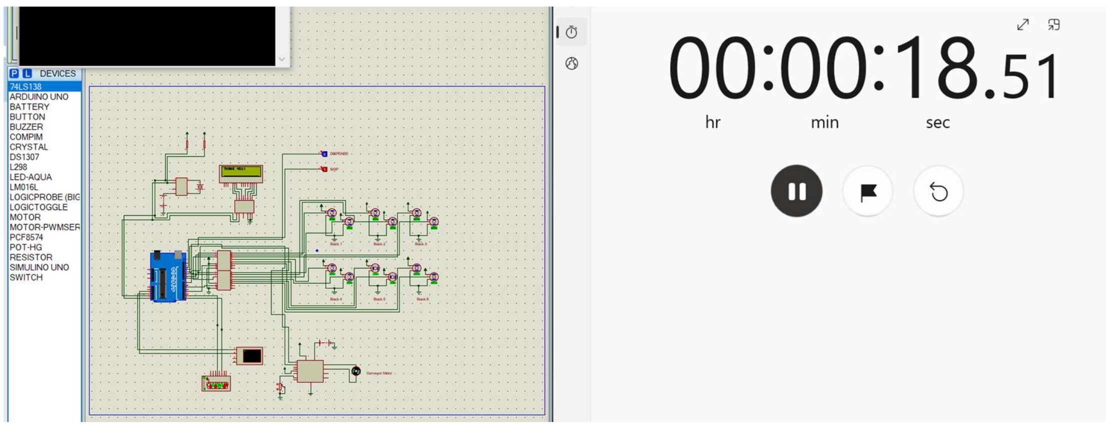



Fig 4.6: Optimization of design approach 1

### 4.5 Conclusion

We have covered a variety of mathematical reasoning, analytical thinking and complex engineering problem difficulties. We covered the functionality phases of the 3 distinct design approaches we came up with after finishing the tasks in order to select the optimal design strategy for our project. In addition to calculating the power consumption of the three designs, a survey was also done about general public preferences regarding the three designs. To determine which of the three designs performed the best, test cases of trembling were conducted. The designs were evaluated on the basis of certain parameters like cost, power consumption in idle mode, operating mode and maximum power consumption, battery backup for normal operation, continuous operation as well as during idle operation, dispensing time. Also comparison of device weight, dimensions, ground area requirement for storing the device and medicine dose storage capacity of the three designs. The parameter usability which includes medicine refilling, medicine dose changing and model preference were determined through a survey. Also the sustainability of the designs were tested to determine which design poses no risk. Optimization on the selected optimal design is done by modifying the firmware code, which enhanced its speed by 24% than before.

# Chapter 5: Completion of Final Design and Validation

### 5.1 Introduction

Among the three design approaches, design approach 1 i.e. the Stack Box Model is considered to be the optimal design. For hardware implementation of the design, we used PVC sheets to construct the structure, for the outer casing, a thick PVC of 5mm has been used. Overboard has been used to make the circuit. As for the internal components, mini servo motor has been used to operate the grabbers. A grabber will hold the upper medicine chambers whenever a pill will be dispensed. An I2C 16X2 LCD display has been used to display the time, date and to give visual updates to the user. A geared DC motor has been used to run the conveyor belt. An 1100 mAh LiPo battery has been used to power the device. An elaborate description of the final design is provided below.

### 5.2 Completion of Final Design

The chosen final design among the 3 design approaches is design approach 1-Stack Box Model. Fig 5.1 shows the main board of the circuit. It consists of NodeMCU as the microcontroller which contains the C, C++ code. It also has 2 demultiplexer ICs to provide PWM signal to the servos. Furthermore, it has an RTC module to keep real-time and a buzzer.

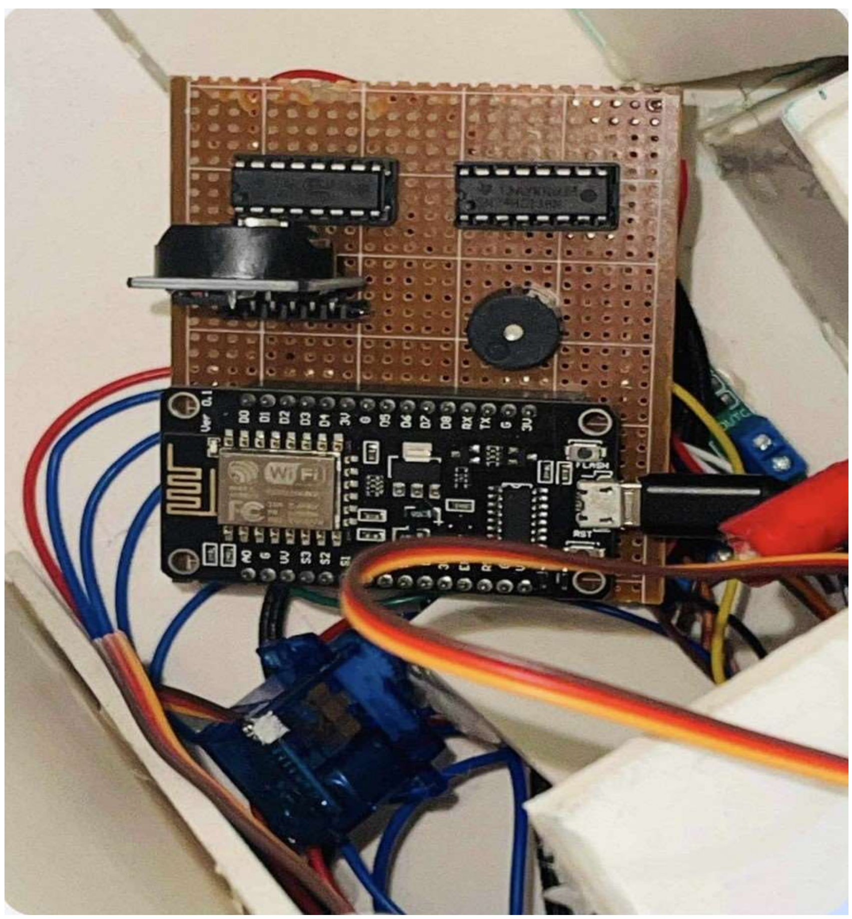


Fig 5.1: Main board of the circuit

In Fig 5.2, the internal structure of the Stack Box Model is shown. There are in total 6 stacks as shown which will contain the medicine boxes. In each stack, there will be 7 medicine boxes, so in total, the device can hold 42 medicine boxes. The boxes will be numbered sequentially. Medicine will be filled in the boxes according to the user's prescription. For example, if the user has to take Omep 20mg along with Napa 500mg at the same time, the designated medicine box would contain both the medicines and they would be dispensed together. At the time of dispense, there is a releasing gate which will release the medicine box on the conveyor belt. And a grabber will hold the upper medicine chambers. Mini servo motors have been used to control this mechanism.

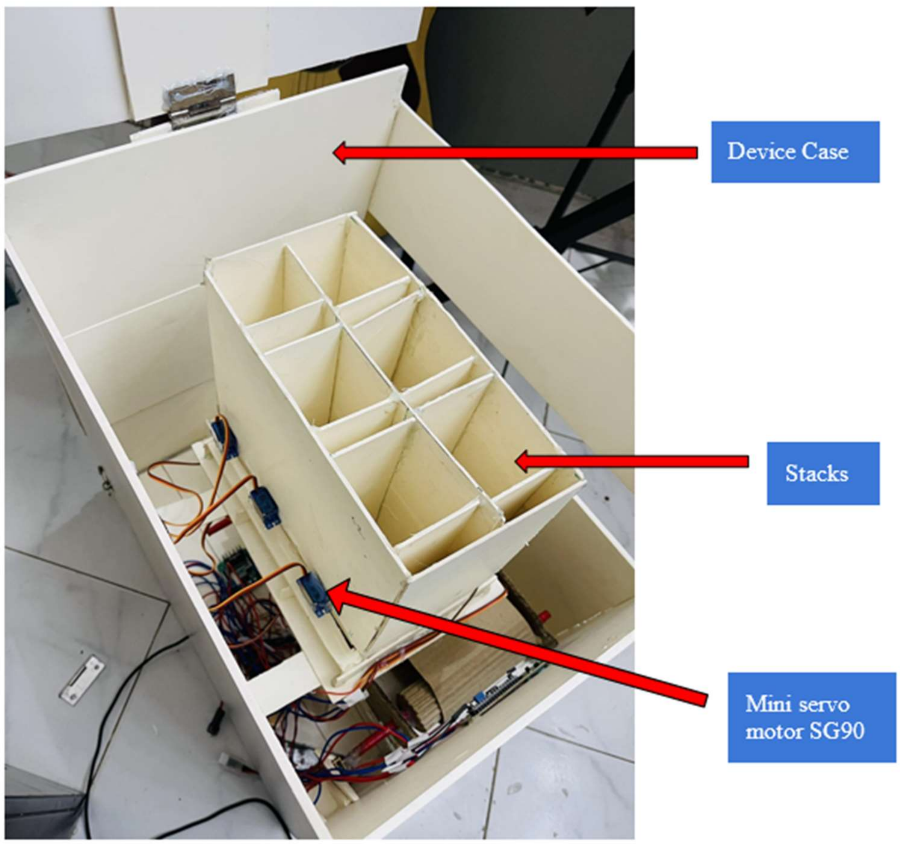



Fig 5.2: Internal structure of Stack Box Model

In Fig 5.3, the chamber at the rear part of the device is shown. Before the designated time of a medication, an alarm will go off alerting the user to take the pill. The display will show "Press and Hold to Dispense". If the user presses the button, the medicine box will be dispensed at the designated time. The release gate will open and the medicine box will fall, while the grabber will hold the upper medicine boxes. It will fall on the conveyor belt and the belt will take it to the dispensed section which is at the front part of the device. But if, for some reason, the user forgets to press the button within time, after a certain window of time, let's say after 1 hour, the medicine box will fall on the conveyor belt and the belt would move backwards and take the box at the missed dose section which is a chamber located at the rear part of the device.

Now comes the issue of the user taking the missed dose from the missed chamber after several hours of missing the dose. Some medicines are time sensitive and it could cause health risks for the user. As shown in the figure, there is a small door behind the missed chamber, it will be locked and the caregiver of the patient will have the key for safety purposes.


Fig 5.3: Chamber to store missed doses.

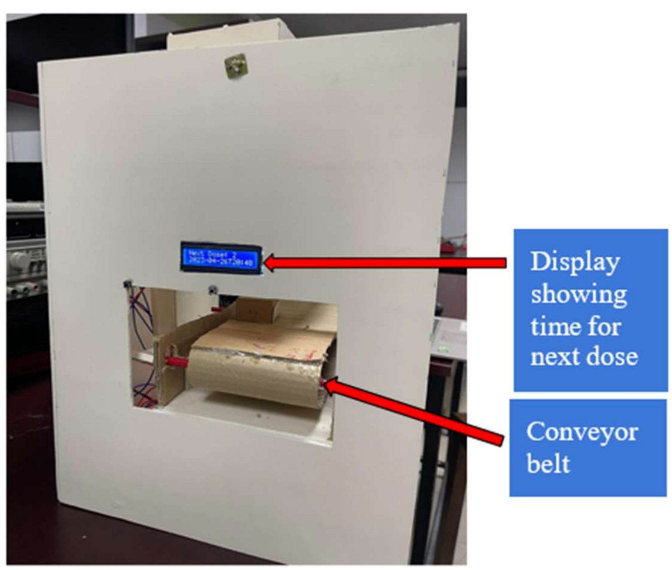



Fig 5.4: External look of Stack Box Model

The overall look of the device is shown in Fig 5.4. The display is showing the time for the next dose after the previous dose has been dispensed.

### 5.3 Evaluate the Solution to Meet Desired Need

The objectives of this device is to-

- Alert the user before the time of their medication according to their schedule.
- Providing accurate doses of medicines according to users' prescription from time to time.
- Tracking the data on our developed website.
- Storing the medicines if it is missed or not taken by the user in time.
- Controlling the whole system using the user interface which will be our developed website.
- Reducing risk of missing medicines on time.
  - The whole operation of the device is demonstrated below: https://youtu.be/LY3Up2LzZBU
  - The dispensing mechanism is demonstrated below: https://youtu.be/4tIHnRerklQ

The operation of the device can be evaluated based on some test cases.

**Test cases:**

- Updating the user’s medications according to the prescription and other necessary data into the code.
- Manually filling and refilling the medicine boxes sequentially.
- Uninterruptible connection of the device with the internet.
- Display showing the necessary information throughout the operation.
- Opening of releaser gate during dispense and operation of grabber holding the upper boxes.
- Operation of releasing and storing the missed doses to the missed section.
- Running of conveyor belt to take the box to the designated section.

**Results:**

- All the information was successfully updated into the code.
- The device was successfully connected to the mobile data. However, sudden drop of network bar or drop of mobile data could hamper the process.
- The manual refilling brought a bit of inconvenience as it is a time consuming process and the sequence must be maintained while filling.
- Throughout the operation, the LCD display successfully showed all the information that was designed.
- At the time of dispense, the releaser gate successfully opened and the grabber of the respective stack was successful in holding the upper medicine boxes.

- The operation of releasing the missed dose after the certain time window frame and the conveyor belt carrying it to the missed section was done successfully.
- Slight problem occurred during running of the conveyor belt during the test cases. The belt was made with cardboard and glued together. It was falling apart during the first test cases, but later on the issue was solved and it performed properly.

### 5.4 Conclusion

The completion of final design and validation are shown in this part. Among the three proposed design approaches, design approach 1 is chosen as the final design. The parts of the device are explained with figures and video demonstration of the working device is also provided. Test cases were done to test the overall operation of the device. We faced a little difficulty in some cases but the rest were operated successfully.

# Chapter 6: Impact Analysis and Project Sustainability

## 6.1 Introduction

Automated systems in medical care are gaining popularity recently as caregivers want to treat a maximum number of people within minimum time with leaving little to no room left for error. Nowadays, the number of nuclear families is increasing, leaving the elderly people unattended and leaving them in care of caregivers with no scope of monitoring. Drug overdose continues to be the leading cause of accident-related deaths, despite the implementation and monitoring of prevention initiatives. Indeed, between 2014 and 2017, the number of people killed by a drug overdose increased by an average of 16% per year in the United States [48, 49]. According to the National Office for Statistics in the United Kingdom, the mortality rate from drug abuse has been increasing since 1993 and is expected to reach 50.4 fatalities per million people in 2019 [50,51]. Due to this, an IoT based medicine dispensing system will make sure to monitor the data/ prescriptions given by the doctor that will be uploaded to the webpage and ensure proper medicine intake of the patient. This device has some features such as, automatically dispensing scheduled medicine to reduce hassle for the caregiver and as well as the medicine taker since everything is already preprogrammed and preset, the medicines are already packed in blister packs to ensure the safety of the medicines [52], being able to monitor the improvement/ decline of patients health through the remote data viewing by the doctor to decide whether to bring upon change on the medicine or not are just some of the highlights.

## 6.2 Assess the Impact of Solution

The primary goal of IoT based medicine dispensing devices is to create a user-friendly automated system with a simple tool of application that can administer medicine according to the user's specified schedule and keep track of whether or not the user took medicine.

### 6.2.1 Health Impact

An Internet of Things (IoT) enabled smart medicine dispenser can help patients take their pills on time and without error, making it easier for them to keep track of their medication regimen and for their caregiver and doctor to monitor it as well. Furthermore, people with the following restrictions can use this medicine dispensing device. For example, negligence, a lack of adequate medication mindfulness, a lack of family support, etc [53]. Alzheimer's disease awareness is quite low in Bangladesh [54]. As a result, the required care for such a patient— such as scheduling doctor appointments and keeping track of prescription medicines is neglected. Therefore, using this device will not only maintain the prescribed medicine schedule of the consumer but also assist the user to schedule doctor's appointments at ease. It will remind the caregiver to monitor the patient's drug intake and health by monitoring their adherence to prescribed medication in addition to keeping track of the prescriptions. By taking medications on time, the medications can have a proper impact on the patients and help the user live a healthier, more fulfilling life.

### 6.2.2 Societal Impact

As this device will be automatically dispensing medicine, therefore, it will solve the issue of complex regimen of every society as the residents can use it on their own. Also, as it will be transferring health information to the caregiver of the user therefore if there is any risk for the patient they will be able to take care of the patient on an immediate basis. Recently, the world experienced a pandemic that halted daily life [55], even going to doctors for life-threatening diseases became impossible because the virus was airborne and usually spread by mere human contact within 3 feet. A simple medication upgrade or dosage reduction would have necessitated a visit to the doctor, endangering not only the user's life but also that of the caregiver and other members of society. Furthermore, another societal impact of our selected designed device is that the dependency upon a caregiver will be reduced and the user will be self-sufficient to a certain extent. Using this device will immensely improve the condition of patients that are suffering from chronic diseases such as Alzheimer’s, Diabetes, etc. It will also reduce frequent visits to the pharmacy as the device has a capacity of storing medicines for weeks. Industrial Impact The number of existing pill dispenser devices on the market is currently on the low side. There are only a few devices on the market, such as the Lifeline Automated Medication Dispensing Device, the Hero Health Device, and others. According to Data Bridge (2021), the smart pill dispenser market is expected to grow significantly during the forecast period, owing to an increase in the need for medication intake, an increase in the geriatric population, and diseases associated with old age. Due to the increased prevalence of infectious and chronic diseases, the rising elderly population, and the expansion of the healthcare industry, North America now holds a monopoly on the smart pill dispenser market. This will create scopes for this device market to expand in Bangladesh. The automatic pill dispenser industry had effects in 2020 as a result of this pandemic. Major changes in the healthcare industry were brought about by the coronavirus pandemic, which also hindered routine medical staff activities and reduced hospital admissions. These were referred to as non-emergent hospital visits for a range of medical conditions. Because it was believed that the majority of outpatient appointments were voluntary, it was recommended that all casual stopovers be canceled owing to the danger of transmission. [56].

### 6.2.3 Economic Impact

IoT based Medicine Dispensers are going to provide solutions to the people who have complex regimens so it will decrease the mismanagement and the overdose of medicines that will definitely help the user from becoming severely sick. Therefore, the extra medical expense can be prevented. Also different stakeholders can use this device for business purposes to play a role in their own and national economy. When compared to the expected costs of the currently available devices, we came to the conclusion that our suggested Internet of Things-based medical equipment will be less expensive and more affordable for the majority of the middle class in our country. From the cloud data of each patient, the doctors can analyze their situation and predict chronic illnesses in the early stage and this will reduce the treatment cost for the patient. Digitalization Impact As our project is based on IoT, therefore, people can get their medicine solutions in a digital platform. Our device will redirect the health track of the user to its caregiver automatically without any sort of complications that can simplify the hassle of the user. By the health track caregiver can provide proper medical support that can prevent several risks. As the process will complete without any manual support, therefore, the device can take part in many modern updates in near future.

### 6.3 Evaluate the Sustainability

The IoT based medicine dispenser is expected to be sustainable in the long run, at least for a good 7 years and maintenance will be required every two years to ensure that the system is providing correct information and the correct medicine is being dispensed to avoid being overdosed on them, and strengthening the security system of the website to avoid cyber-attacks. We have conducted surveys on the impact and sustainability of the device and the sustainable aspects of the device are:

#### 6.3.1 Environmental Sustainability:

Rechargeable Battery: In our project, we're employing a rechargeable battery. Disposable batteries also pollute the environment. Rechargeable batteries, on the other hand, are superior to standard batteries and, if used properly, may be better for the environment. According to Mario Grosso, a professor and authority on the environmental effects of batteries, we can easily reuse batteries after they have completed their life cycle, which will reduce the demand for more battery production. As a result, we do not require more raw materials and do not require mining to obtain raw resources. It will improve the atmosphere around us [56]. Furthermore, the material we have chosen to make our devices with is PVC (Polyvinyl chloride) due to its sustainability, affordability, easy to process, can be manipulated in any shape etc. In addition to that, PVC is desired compared to other plastics for low primary energy demand and resource consumptions during the production process [57].

#### 6.3.2 Economic Sustainability

The International Labor Organization (ILO) reported that the youth unemployment rate in Bangladesh is at 10.6%, more than double the 4.2% national average. According to the report, youth unemployment drastically rose during the Covid-19 pandemic [58]. The Bangladeshi government strives to ensure that youth talent is used to the fullest extent possible [59]. Our IoT based medicine device will help sustain the economy of Bangladesh by creating a scope for jobs which will help with the alleviation of poverty and create jobs for the youth interested to work in the tech industry, moving Bangladesh towards digitalization. Furthermore, the device won't be replacing the need for caregivers for elderly people as they assist them through other means such as cleaning after them, assisting them in moving etc. By taking the burden of monitoring the medication timeline, they can focus on assisting the elderly in other ways which require attention. In addition to it, caregivers can save some time and focus on other important tasks that will benefit their organization. The device that our technology offers, other stakeholders will be interested in investing in this sector as well. If our device sponsors can successfully promote their usable technology to other nations, they will be more credible when it comes to medication management and the advantages of following a schedule, which will increase their foreign trade earnings. Since this initiative would create a new region for the management of medicines in Bangladesh, its economic viability is long-term.

### 6.4 Conclusion

We have examined how the environment, society, user safety, and their health may be impacted by our initiative in this area. We have also talked about the economic and environmental facets of sustainability. By assessing the project's sustainability in light of several circumstances, we can increase its lifespan, advance society, and so look toward a better future for our nation.

# Chapter 7: Engineering Project Management

## 7.1 Introduction

Someone must oversee the process of promptly, cost-effectively completing organizational requirements in order for projects to be properly completed. Project management, according to the Project Management Institute, is the process of applying tools, techniques, knowledge, and skills to a project's operations in order to meet requirements. Project management is broken down into five stages by the Project Management Institute: initiation, planning, execution, monitoring and control, and closure. Integration, scope, time, money, quality, procurement, human resources, communications, risk management, and stakeholder management are some of the categories of expertise that project managers must use throughout the process [60]. In this project, the entire group analyzed the project and organized it in order to efficiently execute the project and created a Gantt chart to track the progress accordingly. It is the duty of engineers to carefully plan out a project and communicate with a team as effectively as possible. One of the main aspects of project management is having the final project thought out clearly and precisely. Any engineering team that ignores this phase runs the danger of having the unanticipated derail the efforts of dozens or even hundreds of workers. Project managers in the engineering industry must be adaptable and educated about all the most recent best practices because engineering is a challenging and constantly evolving sector. This includes both general managerial skills and engineering practices relevant to the current project.

## 7.2 Define, Plan and Manage Engineering Project

Project management is the application of techniques, methods, skills, knowledge, and experience to achieve particular project objectives within agreed-upon constraints. Project management has final outputs that are limited in time and budget. A significant distinction between project management and management is that project management has a final result and a time frame, whereas management is an ongoing process. As a result, a project professional must possess a diverse set of talents, including often technical abilities, as well as people management abilities and business acumen [61].

Table 7.1: Project management during 400P, 400D and 400C.

| **EEE400P** | | | |
|---|---|---|---|
| **Task** | **Start Date** | **End Date** | **Duration (Days)** |
| **Problem Identification** | **15/06/22** | **23/06/22** | **9** |
| **Topic Review and Finalization** | **23/06/22** | **05/07/22** | **13** |

| | | | |
|---|---|---|---|
| **Concept Note Preparation** | **05/07/22** | **13/08/22** | **40** |
| **Project Proposal Report** | **13/08/22** | **01/09/22** | **20** |

**EEE400D**

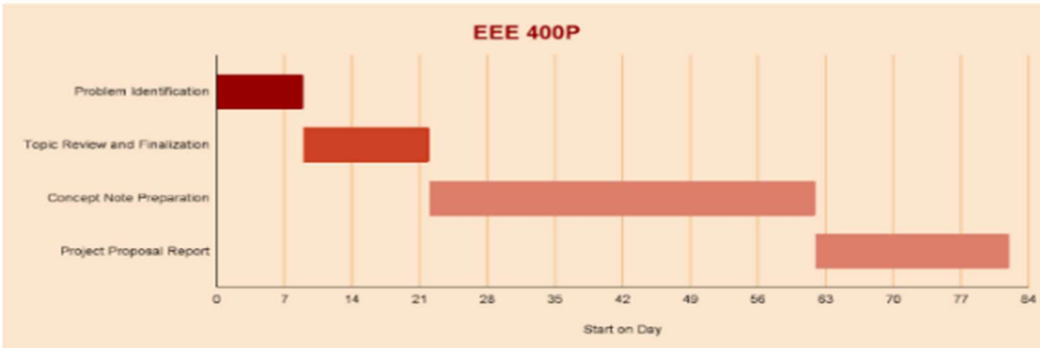
| **Task** | **Start Date** | **End Date** | **Duration (Days)** |
|---|---|---|---|
| **Implementation Of Selected Design** | **01/01/23** | **28/01/23** | **28** |
| **Testing The Simulation** | **29/01/23** | **22/02/23** | **24** |
| **Development and Validation** | **23/02/23** | **25/03/23** | **31** |
| **Project Final Report Submission** | **26/03/23** | **29/04/23** | **35** |

**EEE400C**

| **Task** | **Start Date** | **End Date** | **Duration (Days)** |
|---|---|---|---|
| **Ordering The Components** | **26/01/23** | **25/02/23** | **30** |
| **Completion Of Device** | **01/03/23** | **15/04/23** | **45** |
| **Poster Presentation** | **18/04/23** | **26/04/23** | **8** |
| **Report Writing** | **15/04/23** | **11/05/23** | **26** |

## Gantt chart:

Table 7.2: Gantt chart for 400P.

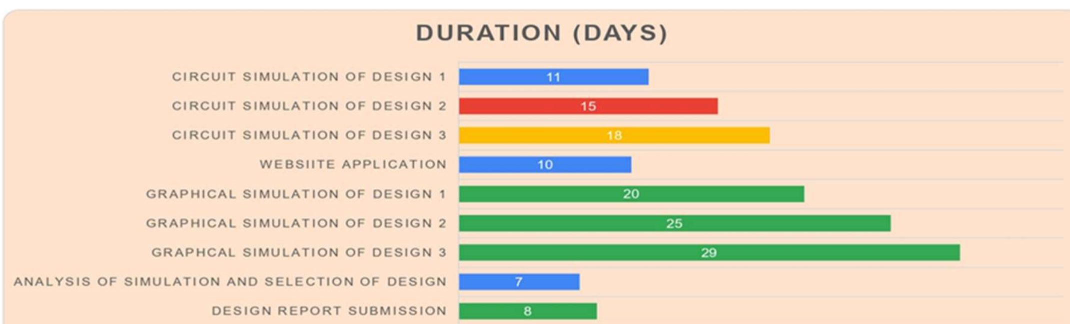



Faysal, Nibir

Raisa, Nishat

Faysal, Nibir, Raisa, Nishat

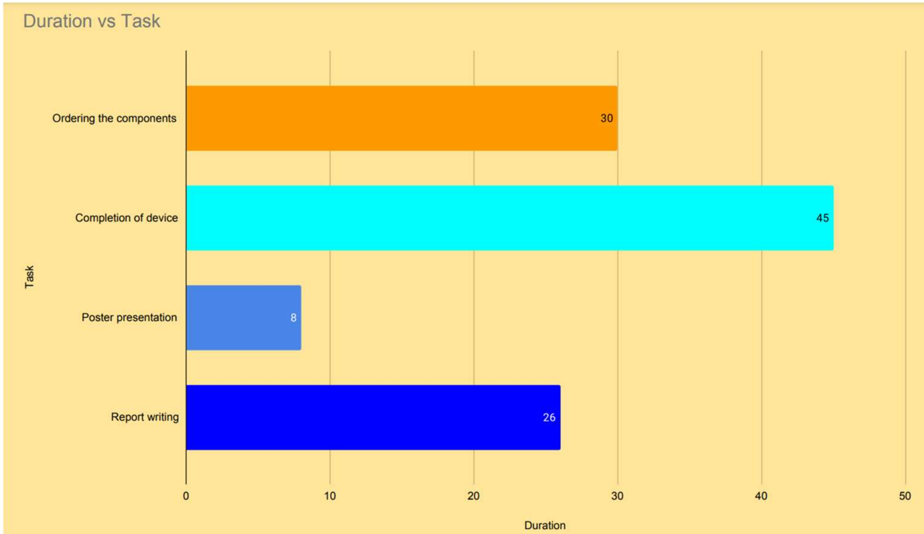
Table 7.3: Gantt chart for 400D.




| | Design report submission | Analysis of simulation and selection of design | Graphcal simulation of design 3 | Graphical simulation of design 2 | Graphical simulation of design 1 | Websiite application | Circuit simulation of design 3 | Circuit simulation of design 2 | Circuit simulation of design 1 |
|---|---|---|---|---|---|---|---|---|---|
| Duration | 8 | 7 | 29 | 25 | 20 | 10 | 18 | 15 | 11 |

- Faysal
- Nishat & Fatima
- Nibir
- Faysal
- Faysal, Nibir, Fatima & Nishat
- Faysal, Nibir, Fatima & Nishat
- Faysal, Nibir, Fatima & Nishat
- Faysal
- Faysal, Nibir, Fatima & Nishat

Table 7.4: Gantt chart for 400C.




### 7.3 Evaluate Project Progress

As per our requirements, the whole group started brainstorming for ideas on 15th of June, 2022. We have kept our respected ATC members and Chair updated about our idea and settled with an automated medicine dispenser. We wanted to make this device as we could see that our device will be helpful to the masses of people. Each and every step was planned meticulously as there were some doubts whether we could implement our vision for the device in real life. Finally our respected ATC group approved of our proposed project and we started to research various journal papers, conference papers to increase our understanding of the project and getting various ideas on the procedure of making the device. A work plan was created and we have divided tasks among group mates to ensure maximum efficiency can be gotten as an outcome. Furthermore, we have maintained a logbook to track the progress of the group members and arranged weekly meetings among ourselves and demonstrated progress to our respected ATC members. Our assignment for the first semester of the FYDP-P was to create the project plans. As a result, we talked about the project's design, methods, specifications, and budget. Additionally, we highlighted the sustainability, legal, and risk considerations. We began the simulation portion of our project during the following semester (400D). Here, we also provide a brief description of the other alternative solutions to our project's problems, along with a simulation of each one, and we explained why we chose ours.

We were unable to stick to our earlier work plan because of the strain from our courses. So, we created a new strategy. Due to the rising costs of most of the components, we also needed to adjust the budget. We demonstrated how and why our idea will be advantageous for both people and the environment. Finally, we successfully used the equipment and carried out our monitoring over the last semester of our research. During the beginning of each semester, we began developing both the hardware and software components. In order to track and monitor the medicine intakes of patients, we have created a webpage where all the information will be stored and the caregiver can monitor it from anywhere anytime. During the assembly of the device, we came across various constraints like filling the medicine onto the device, conveyor belt malfunction, overheating etc. We tackled such issues as a united group and finally made the device ready for showcase and impressed other faculties as they came to evaluate us.

### 7.4 Conclusion

The aforementioned procedures and work schedules should be followed in order to successfully execute an engineering project. Failure to do so could result in the project failing. An engineering project benefits from effective teamwork, careful planning, communication, and study. Here, we attempted to adhere to them appropriately in our project. Without effective project management, we are unable to create a work schedule, manage our time effectively, and we also run into financial difficulties. Therefore, an engineering project requires careful planning and supervision.

# Chapter 8: Economical Analysis

## 8.1 Introduction

Economic analysis assesses the profitability or bad repercussions of initiatives, scenarios, activities, themes, or actions. It has a connection with the subject of calculating the opportunity cost of any endeavor or task. Management use it in a variety of situations in business [62].

## 8.2 Economic Analysis

A medicine dispenser is a device that stores and administers drugs at specified intervals making it easier for patients to manage their prescription schedules. Using a drug dispenser can have various economic advantages, including improved health outcomes, lower healthcare expenses, and enhanced productivity. One of a drug dispenser's most significant economic benefits is the possibility of enhanced health outcomes. A medicine dispenser can assist in avoiding problems and lower the risk of hospitalization by ensuring that patients take their drugs as directed. This can result in cheaper healthcare expenses and higher productivity owing to fewer lost days of work. A drug dispenser can both improve health outcomes and save healthcare expenditures. A medication dispenser can help patients and insurers save money on healthcare by lowering the likelihood of hospitalization and other costly medical procedures. A drug dispenser can also assist in reducing medication mistakes and decreasing healthcare expenses. Another economic advantage of a medication dispenser is the possibility of greater production. A medicine dispenser can free up time and energy for other activities, such as work and recreation, by minimizing the time and effort necessary to handle prescriptions. This can lead to higher productivity and economic prosperity for people and society. Using a drug dispenser can have considerable economic benefits, such as improved health outcomes, lower healthcare expenses, and enhanced productivity. While the initial expenditure in a drug dispenser may be significant, the long-term economic benefits might make it profitable for patients and healthcare professionals.

## 8.3 Cost Benefit Analysis

### 8.3.1 Cost-Benefit Analysis for a Medicine Dispenser

The IoT-based medicine dispenser can dispense the precise prescription dosage at the correct time that was booked through our website, avoiding overdosing or skipping doses. The IoT-based medicine dispensers can dispense the precise prescription dosage at the correct time that was scheduled through our website, avoiding overdosing or skipping doses, which is critical for patients who need to take multiple medications or have memory or mobility issues. The costs of adopting our suggested system include acquiring the dispensers themselves, educating staff on how to operate them, and any necessary maintenance or upgrades. Any required software or hardware updates to support the system may incur additional charges. Furthermore, any necessary hardware or software changes to support the system may involve additional costs. Depending on its features and quality, the medicine dispenser might be quite expensive.

The Iot based medicine dispenser, depending on its nature, may require frequent maintenance, such as cleaning or replacing parts, such as short circuits, fuse damage etc can happen which might raise the device's ongoing cost. If the user requires training to operate the device, additional fees may be incurred. Medicine dispensers can help users take the correct drug at the precise dosage and time, improving medication adherence and overall health results. Medication adherence can lower healthcare costs by minimizing hospitalizations, emergency department visits, and complications. A medicine dispenser can help people with mobility or cognitive impairments maintain their independence and quality of life by allowing them to manage their medications on their own. Our device can assure the close ones or caregivers of the patient that the medicines are being monitored so that misdoing or overdosing can be avoided. It can also help people who need help managing their prescriptions. While there are costs associated with obtaining and maintaining the device, the long-term benefits of improved drug adherence, fewer healthcare costs, increased flexibility, and peace of mind may outweigh the costs. The benefits of using a medicine dispenser system include enhanced patient safety, fewer drug errors, and more efficient medication distribution. These benefits may cut healthcare costs over time by reducing medication errors and improving patient outcomes. The socio economic condition of the average person should also be considered while setting up the price of the device.

### 8.3.2 Cost Analysis of Multiple Designs

Several considerations need to be taken into account when performing a cost analysis of different medication dispenser designs. Such as the cost of materials, labor, and equipment necessary to create the dispenser. The production cost is affected by the intricacy of the design and the materials utilized. The expense of the dispenser's research and development. The more sophisticated the dispenser, the greater the development cost. The cost of securing patents, trademarks, or other types of intellectual property protection for the dispenser's design. The expense of promoting and advertising the dispenser, including the creation of marketing materials such as brochures, product films, and online content. Then there is the cost of delivering and distributing the dispenser to merchants or customers directly. Also, the expense of providing customer service, technical assistance, and dispenser maintenance. Once these cost factors have been identified, an analysis can be done for the cost of multiple designs of medicine dispensers by comparing the costs associated with each design. This can be done by creating a spreadsheet or cost comparison table that includes all of the relevant cost factors and associated costs for each design. A sensitivity analysis can be conducted to determine how changes in factors such as manufacturing costs or sales volume could affect the overall cost of each design. This will aid in determining the best cost-effective design for your requirements. It is critical to evaluate the possible income generated by each design, as well as any potential regulatory or legal difficulties that may affect the dispenser's cost or profitability. Weighing in each of these factors, one may decide which design is the best practical and affordable response to their demands.

Table 8.1: Cost analysis for the three design approaches.

| **Design Approach** | **Functionality** | **Time** | **Budget** |
|---|---|---|---|
| Stack Box Model | • Pill stored in a stack form | 25 Seconds | • 6950 BDT (Device cost)<br>• 7500 BDT (Buying cost) |
| Vending Machine Model | • Medicine Dispensed in Vending Machine form | 1-1.5 minutes | • 16990 BDT (Device Cost)<br>• 17600 BDT (Buying cost) |
| Tray Model | • Pill stored in a tray model | 2 minutes | • 16587 BDT (Device Cost)<br>• 17500 BDT (buying cost) |

From the above table, it can be speculated that the stack box model is more cost effective compared to our other designs. Furthermore, we can see that the execution time for the stack box model can be more appealing to the customers due to its faster response time. Currently to rival the stack box device, there is Hero pill dispenser device where the cost is $44.99 per month [63]. Our device is far cheaper therefore having greater possibility to attract a lot of customers.

### 8.4 Evaluate Economic and Financial Aspects

Medicine dispensers can have significant economic and financial impacts, both on individual patients and healthcare systems as a whole. Medicine dispensers can also improve medication adherence, reducing healthcare costs and improving health outcomes. They assist patients in taking their prescriptions on schedule and at the appropriate dose. They can be utilized in hospitals, clinics, and private residences. The economic and financial elements of medicine dispensers are influenced by various factors such as manufacture, distribution, and marketing. The cost of manufacturing comprises raw materials, labor, and overhead expenses. Transportation, inventory, and warehousing costs are all included in the distribution cost. Advertising and promotional charges are included in the marketing cost. In addition to these expenses, medication dispensers can minimize hospital readmissions and emergency department visits, saving money on healthcare. This can save healthcare providers and Insurance companies a lot of money. These dispensers can assist to decrease waste by ensuring that patients take the appropriate amount at the appropriate time, lowering the probability of throwing expired drugs. This can save money for both patients and healthcare systems. Medicine dispensers can increase efficiency by reducing the time and resources required to manage patients' prescription regimens. This can save healthcare providers money while improving patient outcomes by lowering the chance of pharmaceutical mistakes. These dispensers may also be expensive to buy and install for some people, which can be a barrier for some patients and healthcare systems. However, the long-term cost savings and improved health outcomes may offset the upfront expense. Continuous technological expenditures for maintenance, upgrades, and support may be incurred depending on the type of medication dispenser utilized. This should be taken into account in any cost-benefit analysis.

### 8.5 Conclusion

To summarize, we developed an engineering project that takes into account service providers, stakeholders, and the country's economic and financial issues. Furthermore, due to the lack of any medicine management devices in our country, our initiative will have a favorable impact on consumer lifestyle and behavior surrounding medicine management and it will save lives, assisting in the stabilization of the country's economic condition.

# Chapter 9: Ethics and Professional Responsibilities

### 9.1 Introduction

Ethical responsibility is the capacity to perceive, interpret, and act in accordance with a variety of moral precepts and norms within a certain industry or situation. This involves a responsibility to perform with care, diligence, and skill. It also implies duties like honesty and secrecy, even if they aren't stated explicitly in the contract [64]. Professional ethics are values that guide how an individual or group behaves in a professional setting [64]. While designing the device, we should take ethical design into consideration. Designing products/devices while keeping our values, ideals and business practices in mind is called ethical design [59]. We should take usability, accessibility, privacy, transparency, user involvement etc. into accounts while designing the device [65].

### 9.2 Identify Ethical Issues and Professional Responsibility

These are the ethical considerations that we considered while designing the device:

- **Transparency:**
  Transparency is a part of ethical design and it is necessary to maintain it with the customers so they can fully know whether or not they need the device. We need to be transparent about the cost, advantages and also about the difficulties that might occur or the user might face with this device. We must provide detailed instructions of the product through pamphlets, tutorials and other ways to the customers instead of just selling it to them. This will also ensure the extent of user involvement with the device.

- **Survey from general people:**
  We conducted a survey among the people in Dhaka about the current medicine intake and the need for a suitable medicine dispenser. A survey was also conducted among potential stakeholders and general people about the features of the multiple designs and were given an option to choose their preferred one. This assisted us in designing our product with the primary goal of our project i.e. what users need and want.

- **Range of usability:**
  Since this is an IoT based medicine dispenser, the mechanism might be difficult for people who have a hard time with technology, especially older people. Also, people with disabilities might also find it difficult to operate the device and it might interfere with their electronic hearing aid machine. We need to be straightforward with these limitations while proposing this device to potential investors or customers in the future.

- **Environment friendly device:**
  We have to consider the possibility of whether this proposed device is environmentally friendly or not. We need to choose rechargeable batteries for the device. Since rechargeable batteries reduce carbon footprint and are durable than single use batteries.

- **Cyber security concern:**
  IoT interfaced devices run the danger of compromising user data. Users and businesses are continually plagued by vulnerabilities, which is a significant challenge. IoT devices lack the processing power necessary for built-in security, which is one of the key reasons they are insecure [66]. The limited funding for creating and testing safe firmware, which is driven by the cost of devices and their incredibly quick development cycles, is another factor in the widespread nature of vulnerabilities [66]. Malware can nonetheless infect IoT devices despite their generally limited computing power [66]. We have to check for potential cyber failures and test the firmware before launching the product. We have to be open about any possibility about security concerns.

### 9.3 Apply Ethical Issues and Professional Responsibility

- **Maintaining ethics while writing report:**
  Ethical writing indicates writing that adheres to ethical standards and makes it obvious through documentation, when it has been influenced by other sources [67]. When writing, ethics can be maintained by properly attributing sources, referencing all ideas that are not our own, and quoting both direct quotes and paraphrases [67]. While writing the report, all the information taken from journals, articles, and websites have been cited properly. All the methods, their implementation, and result data are authentic and have been cited in respective places.

- **Ensuring confidentiality:**
  All the information of the user including their prescription, medicine intake, missed doses will be stored via website and backed up by cloud. Outsiders would not be able to access these information except the patient and their doctor/caregiver.

- **Public safety:**
  Thorough testing must be done on the device regarding safety issues like short circuit occurrence, motor/sensor failure, effect of high temperature etc. As this device is solely for the purpose of human aid, this must be one of the top priorities.

- **Review of applicable standards, professional codes and practice:**

- **Internet of Things (IoT) (IEEE P2413) :**
  This standard establishes an architectural framework for the Internet of Things (IoT), which includes descriptions of various IoT domains, definitions of IoT domain abstractions, and identification of commonalities between various IoT domains. It also provides a reference model that builds connections between common architecture components and other IoT matters (like transport, medical management etc.) [30]. Since this project is an IoT based one, we have applied this standard into our system.

- **Cloud data (ISO/IEC 17826:2012) :**
  The interface for managing and accessing cloud storage is defined by ISO/IEC 17826:2012 [28]. It applies to programmers who use or implement cloud storage. This standard is applicable for our device as we have developed a website to keep track of the patient's information and is backed up by cloud.

- **Wifi (IEEE 802.11ax):**
  The 802.11ax Wi-Fi standard, sometimes referred to as Wi-Fi 6, is the most recent development in a line of never-ending innovation [33]. The 802.11ax standard was suggested by the Institute of Electrical and Electronics Engineers in order to combine the flexibility and high speed of Gigabit Ethernet wireless with the dependability and predictability found in licensed radio [33].

- **Alarm system (Buzzer) (EN 50134-2:2017):**
  The specifications and tests for trigger devices that are a part of a social alarm system are laid forth in this European Standard. This European Standard is applicable to all trigger devices that send triggering signals via wired or wireless links to a local unit or controller [32]. Our device has an alarm system which alerts the user before the designated time of a medication.

### 9.4 Conclusion

Everyday decisions we make are guided by an ethical framework that helps us avoid unjust results and helps us make decisions that have good effects on the world. Through our decisions, ethics teaches us how to improve the world [68]. Business leaders have a special responsibility and tremendous power in establishing the ethical culture of their organizations, which has an impact on their larger communities as well. As a result, business ethics are just as important as personal ethics in everyday life [68]. The concept of professional responsibility holds that each person (or organization) has a duty to behave in the interests of society as a whole [68].

The ethical and professional responsibilities that may arise have been discussed. The issues include transparency, range of usability, environment friendly device, cyber security, user confidentiality, public safety and maintaining ethics while preparing the report. We also included the applicable codes that go in compliance with our device to prove that we were transparent about the inclusion of those principles.

# Chapter 10: Conclusion and Future Work

### 10.1 Project Summary/Conclusion

We have suggested a medicine dispenser in this project to address the issues with current medication dispensers. The proposed dispenser has three advantages over existing medication dispensers- (i) medicine schedules can easily be maintained by the patient as all the information is synced with the cloud. (ii) dispensing medicines strictly on scheduled time can help in avoiding medicine overdose.(iii)the device can be remotely controlled. WE derived three design approaches i.e. three designs of medicine dispensers. After simulating the designs and running multiple tests, we concluded the first design as the final one. We implemented the device in real life and ran more test cases to prove its credibility.

### 10.2 Future Work

There are some constraints we faced in our project which opens up the responsibilities of further future work.

- After the medicine is dispensed, if the user throws away the medicine or doesn’t take the medicine willingly, it cannot be detected by our device.
- Some mechanism needs to be added to make the device easy to use for disabled people.
- It cannot store medicines that require to be stored at low temperatures such as insulin. In future, we need to work on a mechanism that can store liquid medicines too.
- Refilling the medicines can be a hassle for the user as it needs to be done manually. In future, more work needs to be done to make the experience of the user of refilling the medicines more comfortable. Work can be done for implementing the filling and refilling mechanism via robotic arm.
- Facial recognition features could be added in the future so that people except the user or their caregiver would not be able to access the device.
- More storage space needs to be added in the future for further convenience of the user.

# Chapter 11: Identification of Complex Engineering Problems and Activities

### 11.1 Identify the Attribute of Complex Engineering Problem (EP)

#### 11.1.1 Attributes of Complex Engineering Problems (EP)

| | **Attributes** | **Put tick (√) as appropriate** |
|---|---|---|
| P1 | Depth of knowledge required | ✓ |
| P2 | Range of conflicting requirements | ✓ |
| P3 | Depth of analysis required | ✓ |
| P4 | Familiarity of issues | ✓ |
| P5 | Extent of applicable codes | |
| P6 | Extent of stakeholder involvement and needs | |
| P7 | Interdependence | ✓ |

### 11.2 Provide Reasoning How the Project Address Selected Attribute (EP)

**P1: Depth of knowledge required:**

In order to run the features that will be introduced to the system, this project's electrical circuits, web application, and medicine-carrying champers must be constructed with the appropriate understanding and delivering command through code. Therefore, this project cannot be carried out without understanding of the devices and sensors as well as competence in these soft wares like Fusion 360 and Proteus. In the hardware part, we had to learn about implementing the circuit on Vero board and assembling all the components together.

**P2: Range of conflicting requirements:**

There were difficulties building the web application as we needed expertise to build on and also maintaining multiple motors in this design was also a challenge.

**P3: Depth of analysis required:**

As several kinds of medicine dispensers are already available in the market, we went through lots of research papers to find out the shortcoming of the currently available medicine dispensers and try to add those features into our device. A lot of technical knowledge was also required to implement the device. We had to develop our own website and also implement the hardware part. All this took a lot of research.

**P4: Familiarity of issues:**

Medicine is a sector which has been upgrading every day. This project focuses on the purpose to elevate this sector in an automated way so that people in our country can be benefited from getting an automated medicine dispensing device and get touched with the technologies that would solve their issues of missing medicines on time..

**P7: Interdependence:**
People who have a habit of missing medicines can use this project to be more comfortable with his medication. However, users will be able to use this device in an indoor atmosphere and schedule their medicine timing by themselves. Which will create a connection with the users as well as the stakeholders once this device is on the market.

## 11.3 Identify the Attribute of Complex Engineering Activities (EA)

### 11.3.1 Attributes of Complex Engineering Activities (EA)

| | **Attributes** | **Put tick (√) as appropriate** |
|---|---|---|
| A1 | Range of resource | ✓ |
| A2 | Level of interaction | ✓ |
| A3 | Innovation | ✓ |
| A4 | Consequences for society and the environment | ✓ |
| A5 | Familiarity | ✓ |

## 11.4 Provide Reasoning How the Project Address Selected Attribute (EA)

**A1: Range of resource:**
Research has been done to get as many concepts as possible about this project and to gather information that will enable us to choose the specific range of components we need to utilize and how to make the project cost-effective. Additionally, it has broadened our perspective so that we may consider several operating strategies and pick the optimal one in terms of parts, technology, and software.

**A2: Level of interaction:**
Due to the fact that users will become aware of the system's advantages when they utilize this module, it is also essential to its usability. To run this project on a wide scale and efficiently, a lot of manufacturing is required. As a result, the project's benefits must be shared among all parties. This will encourage the people who make up our target audience to carry out this activity locally. People with enthusiasm would always learn about new technologies like this.

**A3: Innovation:**
The concept for this project was created with the assumption that a certain number of modern conveniences, such as automated dispensing systems, cloud data storage for online applications, missed medication storing systems, etc., required timely medication to be administered in a modern manner.

**A4: Consequences for society and the environment:**

The consumer will be able to take prescribed medications on time thanks to this project. As a result, taking medication is simple, and the patient will experience no hazards. In addition to improving patient care, it will reduce the prevalence of diseases. Since practically everyone uses medications, this can forge bonds amongst doctors and persuade others to adopt similar technologies. As a result, it has an impact on both society and technology.

**A5: Familiarity:**

One of Bangladesh's most promising sectors is medicine therapy, which is periodically being developed with contemporary technologies. This project intends to grow this industry in our nation so that individuals can benefit, avoid skipping their medications on time, and learn about technologies that can assist them in resolving their issues with fewer missed prescription appointments.

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# Appendix

## Logbook

| Final Year Design Project (C) Spring 2023 | | | |
|---|---|---|---|
| **Student Details** | **NAME & ID** | **EMAIL ADDRESS** | **PHONE (+880)** |
| **Member 1** | Fatima Fairuz Raisa,16321033 | fatima.fairuz.raisa@g.bracu.ac.bd | 1748272143 |
| **Member 2** | Nishat Tasneem Orthy,18121073 | nishat.tasneem.orthy@g.bracu.ac.bd | 1883067401 |
| **Member 3** | Hossain Muhammad Faysal,19121142 | hossain.muhammad.faysal@g.bracu.ac.bd | 1785389808 |
| **Member 4** | MD Imran Sarder Nibir,19121116 | md.imran.sarder.nibir@g.bracu.ac.bd | 1866989850 |
| **ATC Details:** | | | |
| **ATC-06** | | | |
| Chair | Dr. A.S. Nazmul Huda | nazmul.huda@bracu.ac.bd | |
| Member 1 | Nahid Hossain Taz | nahid.hossain@bracu.ac.bd | |
| Member 2 | Raihana Shams Islam Antara | raihanashams.antara@bracu.ac.bd | |

| **Date/Time/Place** | **Attendee** | **Summary of Meeting Minutes** | **Responsible** | **Comment by ATC** |
|---|---|---|---|---|
| January 26,2023. 11.00am | 1. Nishat Tasneem Orthy<br>2. Hossain Muhammad Faysal | Task1- Attending FYDP 400C class | Task 1 done by-<br>1. Nishat Tasneem Orthy<br>2. Hossain Muhammad Faysal | N/A |
| January 31,2023. Group meeting | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Ordering all the components.<br>Task2- Payment for the purchase. | Task 1 done by-<br>1. Hossain Muhammad Faysal<br>Task2 done by- All. | N/A. |
| February 15,2023. | 1. Hossain Muhammad Faysal | Task1- Receiving the ordered components. | Task 1 done by-<br>1. Hossain Muhammad Faysal | N/A. |

| | | | | |
|---|---|---|---|---|
| February 16,3:40p.m Google meet. | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Dividing work on pcb design, box making, schematic etc. | Task1 done by- All | N/A |
| February 23,3:30p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Consultation with ATC on some queries and problems . | Task1 done by- All | Sir advised us to start working on the hardware implementation asap. |
| March 1, 11:30p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Completion of 400C progress presentation slide. | Task1 done by- All | N/A |
| March 2,12:15 p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task 1- Attending 400C progress presentation | Task1 done by- All | Sir asked us some questions regarding our project. |
| March 2,3:30p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Consultation with Huda sir showing progress presentation slide. | Task1 done by- All | Sir told us to keep working. |
| March 9, 2.p.m Group meeting | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1- Discussion on work progress on campus. | Task1 done by- All | N/A. |

| | | | | |
|---|---|---|---|---|
| March 15,3:30p.m Group meeting. | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Participating on solving some hardware related issues. | Task1 done by-<br>All | N/A |
| March 20, 9:50p.m Google meet | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Division of writing parts of 400C report. | Task1 done by-<br>All | N/A |
| March 23,4:48p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Mailing ATC our work progress doc. | Task1 done by-<br>1. Nishat Tasneem Orthy. | N/A |
| March 25,11:00p.m Group meeting | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Completion of schematic.<br>Task1-<br>Further discussion on pcb. | Task1 done by-<br>1. Hossain Muhammad Faysal<br>Task2 done by-<br>All | N/A |
| 27 March,3:30p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Consultation with Huda sir regarding work progress. | Task1 done by-<br>All | Sir approved our work so far. |
| March 28,3:27p.m Group meeting | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Discussion on ordering rest of the components. | Task1 done by-<br>All | N/A |

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| April 2,10:30p.m<br>Google meet | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Discussion on work progress and further work division. | Task1 done by-<br>All | N/A |
| April 8, 11:47p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task1-<br>Updating work progress<br>on the structure of the device. | Task1 done by-<br>1. Imran Sarder Nibir | N/A |
| April 17, 11:13p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task 1-<br>Ordering components<br>for making circuit in veroboard. | Task 1 done by-<br>1. Nishat Tasneem Orthy | N/A |
| April 20, 12.00p.m | 1.Hossain Muhammad Faysal<br>2. MD. Imran Sarder Nibir | Task1-<br>Working on the<br>completion of the device. | Task 1 done by-<br>1. Hussain Muhammad Faysal<br>2. Imran Sarder Nibir | N/A |
| April 26,1:00p.m | 1. Fatima Fairuz Raisa<br>2. Hossain Muhammad Faysal<br>3. MD. Imran Sarder Nibir | Task 1-<br>Finishing work on completion of<br>final device. | Task 1 done by-<br>1. Hossain Muhammad Faysal<br>2. MD. Imran Sarder Nibir | N/A |
| April 26,11p.m | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Task 1-<br>Completion of poster presentation slide. | Task 1 done by-<br>1. Nishat Tasneem Orthy | N/A |
| April 27,2:00-6:00p.m. | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy | Task 1-<br>Poster presentation and | Task1 done by-<br>All | ATCs from different groups<br>along with our ATC asked |

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| | 3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | device demonstration . | | questions and we demonstrated our device to them. |
| May 10 | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy | 400C report writing. | Task 1 done by<br>1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy | N/A. |
| May 14,2023 | 1. Nishat Tasneem Orthy | Mailing ATC 400C report for feedback. | Task 1 done by<br>1. Nishat Tasneem Orthy | Sir told us to provide the plagiarism report along with the main report. |
| May 15,2023 | 1. Fatima Fairuz Raisa<br>2. Nishat Tasneem Orthy<br>3. Hossain Muhammad Faysal<br>4. MD. Imran Sarder Nibir | Submission of 400C report in google classroom | Task 1 done by<br>1. Nishat Tasneem Orthy | N/A |

**Related Code:**

Source code for NodeMCU

```
#include <ESP8266WiFi.h>
#include <FirebaseESP8266.h>
#include <Wire.h>
#include <RtcDS3231.h>
#include <LiquidCrystal_I2C.h>
#include <Servo.h>
const char* ssid = "***";
const char* password = "***";
const char* firebaseHost = "***";
const char* firebaseAuth = "***";
const char* locatF;
char dose[17];
char doseAll[42][17];
char currTime[17];
int n, i, k, t, x, stackno, btnC, pos;
byte dT = 0;
byte address = 0x0010;
LiquidCrystal_I2C lcd(0x3F, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
RtcDS3231<TwoWire> rtcObject(Wire);
Servo grabber;
Servo releaser;
FirebaseData fbdo;
void setup()
{
 Wire.begin();
 rtcObject.Begin();
 lcd.begin (16,2);
 WiFi.begin(ssid, password);
 lcd.backlight();
 lcd.clear();
 lcd.setCursor(1 , 0);
 lcd.print ("W E L C O M E");
 delay(2000);
RtcDateTime currentTime = RtcDateTime(23, 04, 26, 23, 40, 00); //yy, mm, dd, hh, mm, ss
rtcObject.SetDateTime(currentTime);
 while (WiFi.status() != WL_CONNECTED)
 {
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Connecting to");
 lcd.setCursor(0, 1);
 lcd.print("WiFi...");
 delay (1000);
 }
 pinMode (3, INPUT_PULLUP);  // rx pin button
 pinMode (1, OUTPUT);  // tx pin buzzer
```

```
pinMode (0, OUTPUT);  //A0 demux
pinMode (14, OUTPUT);  //A1 demux
pinMode (12, OUTPUT);  //A2 demux
pinMode (16, OUTPUT);  //IN1
pinMode (2, OUTPUT);  //IN2
grabber.attach(13, 1500, 3500);
releaser.attach(15, 1500, 3500);
Firebase.begin(firebaseHost, firebaseAuth);
dataFetch();
}
void dataFetch()
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Fetching data");
lcd.setCursor(0, 1);
lcd.print("from database..");
for(n=1; n<43; n++)
{
switch (n)
{
case 1:
locatF = "MedicineDoses/1/Time";
break;
case 2:
locatF = "MedicineDoses/2/Time";
break;
case 3:
locatF = "MedicineDoses/3/Time";
break;
case 4:
locatF = "MedicineDoses/4/Time";
break;
case 5:
locatF = "MedicineDoses/5/Time";
break;
case 6:
locatF = "MedicineDoses/6/Time";
break;
case 7:
locatF = "MedicineDoses/7/Time";
break;
case 8:
locatF = "MedicineDoses/8/Time";
break;
case 9:
locatF = "MedicineDoses/9/Time";
break;
case 10:
locatF = "MedicineDoses/10/Time";
```

```
break;
case 11:
locatF = "MedicineDoses/11/Time";
break;
case 12:
locatF = "MedicineDoses/12/Time";
break;
case 13:
locatF = "MedicineDoses/13/Time";
break;
case 14:
locatF = "MedicineDoses/14/Time";
break;
case 15:
locatF = "MedicineDoses/15/Time";
break;
case 16:
locatF = "MedicineDoses/16/Time";
break;
case 17:
locatF = "MedicineDoses/17/Time";
break;
case 18:
locatF = "MedicineDoses/18/Time";
break;
case 19:
locatF = "MedicineDoses/19/Time";
break;
case 20:
locatF = "MedicineDoses/20/Time";
break;
case 21:
locatF = "MedicineDoses/21/Time";
break;
case 22:
locatF = "MedicineDoses/22/Time";
break;
case 23:
locatF = "MedicineDoses/23/Time";
break;
case 24:
locatF = "MedicineDoses/24/Time";
break;
case 25:
locatF = "MedicineDoses/25/Time";
break;
case 26:
locatF = "MedicineDoses/26/Time";
break;
case 27:
```

```
locatF = "MedicineDoses/27/Time";
break;
case 28:
locatF = "MedicineDoses/28/Time";
break;
case 29:
locatF = "MedicineDoses/29/Time";
break;
case 30:
locatF = "MedicineDoses/30/Time";
break;
case 31:
locatF = "MedicineDoses/31/Time";
break;
case 32:
locatF = "MedicineDoses/32/Time";
break;
case 33:
locatF = "MedicineDoses/33/Time";
break;
case 34:
locatF = "MedicineDoses/34/Time";
break;
case 35:
locatF = "MedicineDoses/35/Time";
break;
case 36:
locatF = "MedicineDoses/36/Time";
break;
case 37:
locatF = "MedicineDoses/37/Time";
break;
case 38:
locatF = "MedicineDoses/38/Time";
break;
case 39:
locatF = "MedicineDoses/39/Time";
break;
case 40:
locatF = "MedicineDoses/40/Time";
break;
case 41:
locatF = "MedicineDoses/41/Time";
break;
case 42:
locatF = "MedicineDoses/42/Time";
break;
}
Firebase.getString(fbdo, locatF);
String doseTime = fbdo.stringData();
```

```
doseTime.toCharArray(dose, 17);
for(i=0; i<17; i++)
{
doseAll[n-1][i] = dose[i];
}
}
}
void idleAct2()
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Next Dose:");
lcd.setCursor(11, 0);
lcd.print(dT+1);
lcd.setCursor(0, 1);
lcd.print(doseAll[dT]);
delay(60000);
}
void takenDose()
{
t=dT+1;
switch(t)
{
case 1:
Firebase.setString(fbdo, "MedicineDoses/1/mStatus", "TAKEN");
break;
case 2:
Firebase.setString(fbdo, "MedicineDoses/2/mStatus", "TAKEN");
break;
case 3:
Firebase.setString(fbdo, "MedicineDoses/3/mStatus", "TAKEN");
break;
case 4:
Firebase.setString(fbdo, "MedicineDoses/4/mStatus", "TAKEN");
break;
case 5:
Firebase.setString(fbdo, "MedicineDoses/5/mStatus", "TAKEN");
break;
case 6:
Firebase.setString(fbdo, "MedicineDoses/6/mStatus", "TAKEN");
break;
case 7:
Firebase.setString(fbdo, "MedicineDoses/7/mStatus", "TAKEN");
break;
case 8:
Firebase.setString(fbdo, "MedicineDoses/8/mStatus", "TAKEN");
break;
case 9:
Firebase.setString(fbdo, "MedicineDoses/9/mStatus", "TAKEN");
break;
```

```
case 10:
Firebase.setString(fbdo, "MedicineDoses/10/mStatus", "TAKEN");
break;
case 11:
Firebase.setString(fbdo, "MedicineDoses/11/mStatus", "TAKEN");
break;
case 12:
Firebase.setString(fbdo, "MedicineDoses/12/mStatus", "TAKEN");
break;
case 13:
Firebase.setString(fbdo, "MedicineDoses/13/mStatus", "TAKEN");
break;
case 14:
Firebase.setString(fbdo, "MedicineDoses/14/mStatus", "TAKEN");
break;
case 15:
Firebase.setString(fbdo, "MedicineDoses/15/mStatus", "TAKEN");
break;
case 16:
Firebase.setString(fbdo, "MedicineDoses/16/mStatus", "TAKEN");
break;
case 17:
Firebase.setString(fbdo, "MedicineDoses/17/mStatus", "TAKEN");
break;
case 18:
Firebase.setString(fbdo, "MedicineDoses/18/mStatus", "TAKEN");
break;
case 19:
Firebase.setString(fbdo, "MedicineDoses/19/mStatus", "TAKEN");
break;
case 20:
Firebase.setString(fbdo, "MedicineDoses/20/mStatus", "TAKEN");
break;
case 21:
Firebase.setString(fbdo, "MedicineDoses/21/mStatus", "TAKEN");
break;
case 22:
Firebase.setString(fbdo, "MedicineDoses/22/mStatus", "TAKEN");
break;
case 23:
Firebase.setString(fbdo, "MedicineDoses/23/mStatus", "TAKEN");
break;
case 24:
Firebase.setString(fbdo, "MedicineDoses/24/mStatus", "TAKEN");
break;
case 25:
Firebase.setString(fbdo, "MedicineDoses/25/mStatus", "TAKEN");
break;
case 26:
Firebase.setString(fbdo, "MedicineDoses/26/mStatus", "TAKEN");
```

```
break;
case 27:
Firebase.setString(fbdo, "MedicineDoses/27/mStatus", "TAKEN");
break;
case 28:
Firebase.setString(fbdo, "MedicineDoses/28/mStatus", "TAKEN");
break;
case 29:
Firebase.setString(fbdo, "MedicineDoses/29/mStatus", "TAKEN");
break;
case 30:
Firebase.setString(fbdo, "MedicineDoses/30/mStatus", "TAKEN");
break;
case 31:
Firebase.setString(fbdo, "MedicineDoses/31/mStatus", "TAKEN");
break;
case 32:
Firebase.setString(fbdo, "MedicineDoses/32/mStatus", "TAKEN");
break;
case 33:
Firebase.setString(fbdo, "MedicineDoses/33/mStatus", "TAKEN");
break;
case 34:
Firebase.setString(fbdo, "MedicineDoses/34/mStatus", "TAKEN");
break;
case 35:
Firebase.setString(fbdo, "MedicineDoses/35/mStatus", "TAKEN");
break;
case 36:
Firebase.setString(fbdo, "MedicineDoses/36/mStatus", "TAKEN");
break;
case 37:
Firebase.setString(fbdo, "MedicineDoses/37/mStatus", "TAKEN");
break;
case 38:
Firebase.setString(fbdo, "MedicineDoses/38/mStatus", "TAKEN");
break;
case 39:
Firebase.setString(fbdo, "MedicineDoses/39/mStatus", "TAKEN");
break;
case 40:
Firebase.setString(fbdo, "MedicineDoses/40/mStatus", "TAKEN");
break;
case 41:
Firebase.setString(fbdo, "MedicineDoses/41/mStatus", "TAKEN");
break;
case 42:
Firebase.setString(fbdo, "MedicineDoses/42/mStatus", "TAKEN");
break;
}
```

```
 dT++;
 Wire.beginTransmission(0x57);
 Wire.write(highByte(address));
 Wire.write(lowByte(address));
 Wire.write(dT);
 Wire.endTransmission();
 idleAct2();
 }
 void dispense()
{
if (dT>=0 && dT<=6)
stackno = 1;
else if (dT>=7 && dT<=13)
stackno = 2;
else if (dT>=14 && dT<=20)
stackno = 3;
else if (dT>=21 && dT<=27)
stackno = 4;
else if (dT>=28 && dT<=34)
stackno = 5;
else if (dT>=35 && dT<=41)
stackno = 6;
switch (stackno)
{
 case 1:
 digitalWrite(0, LOW); //A0, D3
 digitalWrite(14, LOW); //A1, D5
 digitalWrite(12, LOW); //A2, D6
 break;
 case 2:
 digitalWrite(0, HIGH);
 digitalWrite(14, LOW);
 digitalWrite(12, LOW);
 break;
 case 3:
 digitalWrite(0, LOW);
 digitalWrite(14, HIGH);
 digitalWrite(12, LOW);
 break;
 case 4:
 digitalWrite(0, HIGH);
 digitalWrite(14, HIGH);
 digitalWrite(12, LOW);
 break;
 case 5:
 digitalWrite(0, LOW);
 digitalWrite(14, LOW);
 digitalWrite(12, HIGH);
 break;
 case 6:
```

```
 digitalWrite(0, HIGH);
 digitalWrite(14, LOW);
 digitalWrite(12, HIGH);
 break;
 }
 for(pos=0; pos<=40; pos+=5)
 {
 grabber.write(pos);
 delay(15);
 }
delay(500);
for (pos=0; pos<=120; pos+=5)
{
 releaser.write(pos);
 delay(15);
 }
 delay(500);
for (pos=120; pos>=0; pos-=5)
{
 releaser.write(pos);
 delay(15);
 }
 delay(500);
 for (pos=40; pos>=0; pos-=5)
{
 grabber.write(pos);
 delay(15);
 }
digitalWrite(16, HIGH);
digitalWrite(2, LOW);
delay(10000);
digitalWrite(16, LOW);
digitalWrite(2, LOW);
delay(10);
takenDose();
}
void missedDose()
{
k=dT+1;
switch(k)
{
case 1:
Firebase.setString(fbdo, "MedicineDoses/1/mStatus", "MISSED");
break;
case 2:
Firebase.setString(fbdo, "MedicineDoses/2/mStatus", "MISSED");
break;
case 3:
Firebase.setString(fbdo, "MedicineDoses/3/mStatus", "MISSED");
break;
```

```
case 4:
 Firebase.setString(fbdo, "MedicineDoses/4/mStatus", "MISSED");
 break;
 case 5:
 Firebase.setString(fbdo, "MedicineDoses/5/mStatus", "MISSED");
 break;
 case 6:
 Firebase.setString(fbdo, "MedicineDoses/6/mStatus", "MISSED");
 break;
 case 7:
 Firebase.setString(fbdo, "MedicineDoses/7/mStatus", "MISSED");
 break;
 case 8:
 Firebase.setString(fbdo, "MedicineDoses/8/mStatus", "MISSED");
 break;
 case 9:
 Firebase.setString(fbdo, "MedicineDoses/9/mStatus", "MISSED");
 break;
 case 10:
 Firebase.setString(fbdo, "MedicineDoses/10/mStatus", "MISSED");
 break;
 case 11:
 Firebase.setString(fbdo, "MedicineDoses/11/mStatus", "MISSED");
 break;
 case 12:
 Firebase.setString(fbdo, "MedicineDoses/12/mStatus", "MISSED");
 break;
 case 13:
 Firebase.setString(fbdo, "MedicineDoses/13/mStatus", "MISSED");
 break;
 case 14:
 Firebase.setString(fbdo, "MedicineDoses/14/mStatus", "MISSED");
 break;
 case 15:
 Firebase.setString(fbdo, "MedicineDoses/15/mStatus", "MISSED");
 break;
 case 16:
 Firebase.setString(fbdo, "MedicineDoses/16/mStatus", "MISSED");
 break;
 case 17:
 Firebase.setString(fbdo, "MedicineDoses/17/mStatus", "MISSED");
 break;
 case 18:
 Firebase.setString(fbdo, "MedicineDoses/18/mStatus", "MISSED");
 break;
 case 19:
 Firebase.setString(fbdo, "MedicineDoses/19/mStatus", "MISSED");
 break;
 case 20:
 Firebase.setString(fbdo, "MedicineDoses/20/mStatus", "MISSED");
```

```
break;
case 21:
Firebase.setString(fbdo, "MedicineDoses/21/mStatus", "MISSED");
break;
case 22:
Firebase.setString(fbdo, "MedicineDoses/22/mStatus", "MISSED");
break;
case 23:
Firebase.setString(fbdo, "MedicineDoses/23/mStatus", "MISSED");
break;
case 24:
Firebase.setString(fbdo, "MedicineDoses/24/mStatus", "MISSED");
break;
case 25:
Firebase.setString(fbdo, "MedicineDoses/25/mStatus", "MISSED");
break;
case 26:
Firebase.setString(fbdo, "MedicineDoses/26/mStatus", "MISSED");
break;
case 27:
Firebase.setString(fbdo, "MedicineDoses/27/mStatus", "MISSED");
break;
case 28:
Firebase.setString(fbdo, "MedicineDoses/28/mStatus", "MISSED");
break;
case 29:
Firebase.setString(fbdo, "MedicineDoses/29/mStatus", "MISSED");
break;
case 30:
Firebase.setString(fbdo, "MedicineDoses/30/mStatus", "MISSED");
break;
case 31:
Firebase.setString(fbdo, "MedicineDoses/31/mStatus", "MISSED");
break;
case 32:
Firebase.setString(fbdo, "MedicineDoses/32/mStatus", "MISSED");
break;
case 33:
Firebase.setString(fbdo, "MedicineDoses/33/mStatus", "MISSED");
break;
case 34:
Firebase.setString(fbdo, "MedicineDoses/34/mStatus", "MISSED");
break;
case 35:
Firebase.setString(fbdo, "MedicineDoses/35/mStatus", "MISSED");
break;
case 36:
Firebase.setString(fbdo, "MedicineDoses/36/mStatus", "MISSED");
break;
case 37:
```

```
 Firebase.setString(fbdo, "MedicineDoses/37/mStatus", "MISSED");
 break;
 case 38:
 Firebase.setString(fbdo, "MedicineDoses/38/mStatus", "MISSED");
 break;
 case 39:
 Firebase.setString(fbdo, "MedicineDoses/39/mStatus", "MISSED");
 break;
 case 40:
 Firebase.setString(fbdo, "MedicineDoses/40/mStatus", "MISSED");
 break;
 case 41:
 Firebase.setString(fbdo, "MedicineDoses/41/mStatus", "MISSED");
 break;
 case 42:
 Firebase.setString(fbdo, "MedicineDoses/42/mStatus", "MISSED");
 break;
 }
dT++;
Wire.beginTransmission(0x57);
Wire.write(highByte(address));
Wire.write(lowByte(address));
Wire.write(dT);
Wire.endTransmission();
}
void missedAct()
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Dose");
lcd.setCursor(5, 0);
lcd.print(dT+1);
lcd.setCursor(8, 0);
lcd.print("Missed!");
delay(1000);
if (dT>=0 && dT<=6)
stackno = 1;
else if (dT>=7 && dT<=13)
stackno = 2;
else if (dT>=14 && dT<=20)
stackno = 3;
else if (dT>=21 && dT<=27)
stackno = 4;
else if (dT>=28 && dT<=34)
stackno = 5;
else if (dT>=35 && dT<=41)
stackno = 6;
switch (stackno)
{
```

```
 case 1:
 digitalWrite(0, LOW); //A0, D3
 digitalWrite(14, LOW); //A1, D5
 digitalWrite(12, LOW); //A2, D6
 break;
 case 2:
 digitalWrite(0, HIGH);
 digitalWrite(14, LOW);
 digitalWrite(12, LOW);
 break;
 case 3:
 digitalWrite(0, LOW);
 digitalWrite(14, HIGH);
 digitalWrite(12, LOW);
 break;
 case 4:
 digitalWrite(0, HIGH);
 digitalWrite(14, HIGH);
 digitalWrite(12, LOW);
 break;
 case 5:
 digitalWrite(0, LOW);
 digitalWrite(14, LOW);
 digitalWrite(12, HIGH);
 break;
 case 6:
 digitalWrite(0, HIGH);
 digitalWrite(14, LOW);
 digitalWrite(12, HIGH);
 break;
 }
for(pos=0; pos<=40; pos+=5)
{
grabber.write(pos);
delay(15);
}
delay(500);
for(pos=0; pos<=120; pos+=5)
{
 releaser.write(pos);
 delay(15);
 }
 delay(500);
 for(pos=120; pos>=0; pos-=5)
 {
 releaser.write(pos);
 delay(15);
 }
 delay(500);
 for(pos=40; pos>=0; pos-=5)
```

```
 {
 grabber.write(pos);
 delay(15);
 }
 digitalWrite(16, LOW);
 digitalWrite(2, HIGH);
 delay(10000);
 digitalWrite(16, LOW);
 digitalWrite(2, LOW);
 delay(10);
 missedDose();
 }
 void dispenseAct()
{
unsigned long timerBegin = millis();
while(millis()-timerBegin <= 60000)
{
 tone(1, 2351.97); //  G
 delay(200);
 tone(1, 1977.768); //  E
 delay(200);
 tone(1, 1569.78); //  C
 delay(200);
 noTone(1);
 delay(50);
 tone(1, 1569.78); // C
 delay(200);
 tone(1, 1977.768); // E
 delay(200);
 tone(1, 2351.97); // G
 delay(200);
 noTone(1);
 lcd.clear();
 lcd.setCursor(1, 0);
 lcd.print("MEDICINE TIME!");
 delay(2000);
 lcd.clear();
 delay(500);
 lcd.setCursor(0, 0);
 lcd.print("PRESS & HOLD to");
 lcd.setCursor(4, 1);
 lcd.print("DISPENSE..");
 delay(2000);
 if (!digitalRead(3))
 {
 lcd.clear();
 lcd.setCursor(3, 0);
 lcd.print("DISPENSING..");
 lcd.setCursor(3, 1);
 lcd.print("Box:");
```

```
 lcd.setCursor(8, 1);
 lcd.print(dT+1);
delay(1000);
dispense();
btnC=1;
}
}
if ((millis()-timerBegin > 60000) && btnC == 0)
{
missedAct();
}
btnC=0;
}
void idleAct()
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Next Dose:");
lcd.setCursor(11, 0);
lcd.print(dT+1);
lcd.setCursor(0, 1);
lcd.print(doseAll[dT]);
delay(1000);
}
void loop()
{
for(i=1; i<43; i++)
{
 RtcDateTime currentTime = rtcObject.GetDateTime();
 int min = currentTime.Minute();
 char minC[3];
 if (min<10)
 sprintf(minC, "0%d", min);
 else
 sprintf(minC, "%d", min);
 int hh = currentTime.Hour();
 char hhC[3];
 if (hh<10)
 sprintf(hhC, "0%d", hh);
 else
 sprintf(hhC, "%d", hh);
 int mm = currentTime.Month();
 char mmC[3];
 if (mm<10)
 sprintf(mmC, "0%d", mm);
 else
 sprintf(mmC, "%d", mm);
 int dd = currentTime.Day();
 char ddC[3];
 if (dd<10)
```

```
sprintf(ddC, "0%d", dd);
else
sprintf(ddC, "%d", dd);
int yy = currentTime.Year();
char yyC[5];
sprintf(yyC, "%d", yy);
sprintf(currTime, "%s-%s-%sT%s:%s", yyC, mmC, ddC, hhC, minC);
Wire.beginTransmission(0x57);
Wire.write(highByte(address));
Wire.write(lowByte(address));
Wire.endTransmission();
Wire.requestFrom(0x57, 1);
if (Wire.available()) {
dT = Wire.read();
}
x = strcmp(doseAll[i-1], currTime);
if(x == 0)
{
dispenseAct();
}
else
{
 idleAct();
}
if (!digitalRead(3))
{
 lcd.clear();
 lcd.setCursor(2, 0);
 lcd.print("Device REFILL");
 delay(1000);
 dT=0;
 Wire.beginTransmission(0x57);
 Wire.write(highByte(address));
 Wire.write(lowByte(address));
 Wire.write(dT);
 Wire.endTransmission();
 }
 const char* blnk = "";
 int y = strcmp(doseAll[dT], blnk);
 while (y == 0)
{
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Cartrige Empty");
 lcd.setCursor(0, 1);
 lcd.print("Please REFILL");
 delay(1000);
 if (!digitalRead(3))
 {
 lcd.clear();
```

```
lcd.setCursor(2, 0);
lcd.print("Device REFILL");
delay(1000);
dT=0;
Wire.beginTransmission(0x57);
Wire.write(highByte(address));
Wire.write(lowByte(address));
Wire.write(dT);
Wire.endTransmission();
}
}
while(dT>41)
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Cartrige Empty");
lcd.setCursor(0, 1);
lcd.print("Please REFILL");
delay(1000);
if (!digitalRead(3))
{
lcd.clear();
lcd.setCursor(2, 0);
lcd.print("Device REFILL");
delay(1000);
dT=0;
Wire.beginTransmission(0x57);
Wire.write(highByte(address));
Wire.write(lowByte(address));
Wire.write(dT);
Wire.endTransmission();
}
}
}
}
```