UNIVERSITI TEKNOLOGI PETRONAS

MEB2063 ENGINEERING TEAM PROJECT

MAY 2023 SEMESTER

FINAL REPORT

GROUP 30

PROJECT TITLE: **ANTI-THEFT DONATION BOX**

TEAM MEMBERS

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ABSTRACT

For the MEB2063 Engineering Team Project, our team consisted of 6 students from various engineering background has created a working prototype of Anti-Theft Donation Box with implementation of security features such as keypad lock and solenoid lock as well as anti-theft detection system with sensor and alarm. Nowadays, many theft cases involving donation box occur due to no additional security measures such as alarm systems to alert the surroundings in case of theft. Thus, the importance of this project is to reduce and prevent the risk of theft of donation box. For the making of the prototype, detailed research is conducted beforehand to obtain idea for the prototype design. Then, the anti-theft donation box is made out by cutting and combining plywood by referring to the dimensional drawing that has been sketched using AutoCAD software. The electrical circuit for the anti-theft detection system is assembled accordingly with proper coding and calculation. The built donation box is then combined with the electrical circuit for the final working prototype. Our project prototype works with 2 functional modes which are mode A and mode B. For Mode A. the keypad lock system is activated while the theft detection system is deactivated, which is suitable to be used during the day when many people are around while for Mode B, the keypad lock system is deactivated and the theft detection system is activated which is suitable to be used at night when the risk of theft is high. Hence, our project prototype is functioning well according to what has been planned and also, all of the objectives of our project prototype are achieved with compliance to the 9th Sustainable Development Goals (SDG) by the United Nations which is Industry, Innovation, and Infrastructure.

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1.0 INTRODUCTION

1.1 Project Background

Donation boxes can be commonly noticed in many public places such as schools as well as religious and community centres (Idral et al., 2018). It is a convenient way to collect money from the public for various purposes and organizations.

In ancient times, the donation boxes were used to collect offerings for religious rituals and practices while the churches community used wooden donation boxes to collect money for the poor people (Britain Express, n.d.). As the time passes, donation boxes have slowly evolved to fulfil the needs of the society. Nowadays, donation boxes made of metal and plastic are used for various purposes such as supporting local charities and political campaigns which can be found in many places such as shopping centres and bus stations.

However, the presence of donation boxes in public is vulnerable to the possibility for theft because some irresponsible individuals will steal the donations intended for those in need for their self-use (Idral et al., 2018). Thus, various security measures have been taken into implementation to protect donation boxes from risk of theft.

The concept of an anti-theft donation box is nothing new. In fact, several organisations have been using them to safeguard their donations for many years. The usage of locks and keys is one of the most prevalent security techniques which prohibits unauthorised access to the box and guarantees that donations may only be collected by authorised personnel. With the advancement of technology and the growing demand for security, there has been a renewed interest in designing more advanced anti-theft donation boxes in recent years. For example, some boxes now implemented sensors or alarms that can notify authorities if someone attempts to break into the box.

The purpose of anti-theft donation box is to prevent theft and ensure that all donations are used for the intended cause which will provide donors and organisations with peace of mind (Idral et al., 2018). Donors will be certain that their contributions will be used for the intended purpose while organisations can be reassured that their hard-earned money will be safeguarded. Overall, donation boxes are important in supporting charitable causes and organizations. Although the risk of theft is the main issue of donation boxes, the implementation of security measures has helped to protect these boxes and ensure that donations go to those who need them most.

For our project, we are designing a donation box known as “Anti-Theft Donation Box” with few additional security measures to reduce the risk of theft which include the implementation of keypad lock along with sensors and alarm system to alert the surrounding in case of theft. By applying the knowledge of engineering in project designing and circuit system, the prototype design can be accomplished accordingly to ensure an effective and working prototype. This engineering project is fully aligned with the 9th Sustainable Development Goals (SDG) by the United Nations which is **Industry, Innovation, and Infrastructure**. Our group strongly believed that this engineering project of Anti-Theft Donation Box will benefit the society in terms of innovation for security purpose to reduce donation theft cases as well as knowledge of modern technology that can be implemented in daily life application.

1.2 Problem Statements

1. The main issue related to donation box is the risk of donation theft especially left unattended in public place.
2. Many donation boxes only use keys and locks system to safeguard the donation box with no additional security measures such as alarm systems to alert the surroundings in case of theft.
3. Usage of keys and locks system in donation box is not easily accessed and difficult to be unlocked in case of missing keys.

1.3 Project Objectives

1. To design a concept of anti-theft donation box to reduce the possibility of donation theft from the donation box with additional security implementation such as keypad lock and alarm system.
2. To apply engineering knowledge of technical project design and circuit system to create a working prototype design for the benefits of society.
3. To ensure a successful and efficient working prototype design by making proper research and discussions among group members.

2.0 DESIGN THINKING

2.1 Literature Review

Donation box refers to a box that is used to collect money or fund from individuals for a specific cause or purpose. These boxes may come in different design, shape and size. For instance, traditional collecting boxes with a slot for inserting money. Moreover, with the rise of digital technology, there are modernized donation boxes, whereby the boxes are equipped with digital payment options such as QR codes for mobile donations or contactless card readers.

Nowadays, donation boxes are often seen in various locations, especially locations with many visitors, ranging from public spaces to religious institutions and non-profit organizations. Donation boxes have long served as a mean of collecting and raising funds for charities, community initiatives as well as disaster relief programs. In fact, it is important to have donation boxes placed in public spaces as it promotes charitable giving, raising awareness as well as acting as a mean to support the non-profit organizations' operations. In addition, these boxes serve as the accessible platforms for individuals to contribute to the society without the need for complex paperwork as they can donate their spare change or small amount of money.

Since donation boxes in public spaces often left unattended, these boxes have become the target of thieves due to its accessibility (Idral et al., 2018). There are various cunning methods employed by individuals to steal from the donation boxes. One of the most common ways involved the utilization of wire to extract money from the box. By skilfully manoeuvring the wire, these thieves can bypass the traditional donation box's safety features. Besides, another daring method used is by severing the padlock securing the donation box. This is usually done by cutting the padlock using the bolt cutters. Hence, this allows the thieves to gain unrestricted access to the donation box's contents. Over and above that, an even more egregious act done by the thieves are by stealing the entire donation box, which is the worst case as it deprives the intended beneficiaries of the donations.

In Malaysia, there have been several stolen donation box cases throughout the years. According to the Deputy Comm Datuk Wira Abdul Majid Mohd Ali (2022), the cases of stolen donation boxes has recorded a spike of 163% for the first two months of this year, which is 2023. To strengthen this statistic, recently in Kuala Lumpur, on 4th March 2023, Kelana Jaya mosque's donation box was stolen by two men. The incident was caught on camera, whereby the men broke the chain by using bolt cutters and later taking away the donation box.

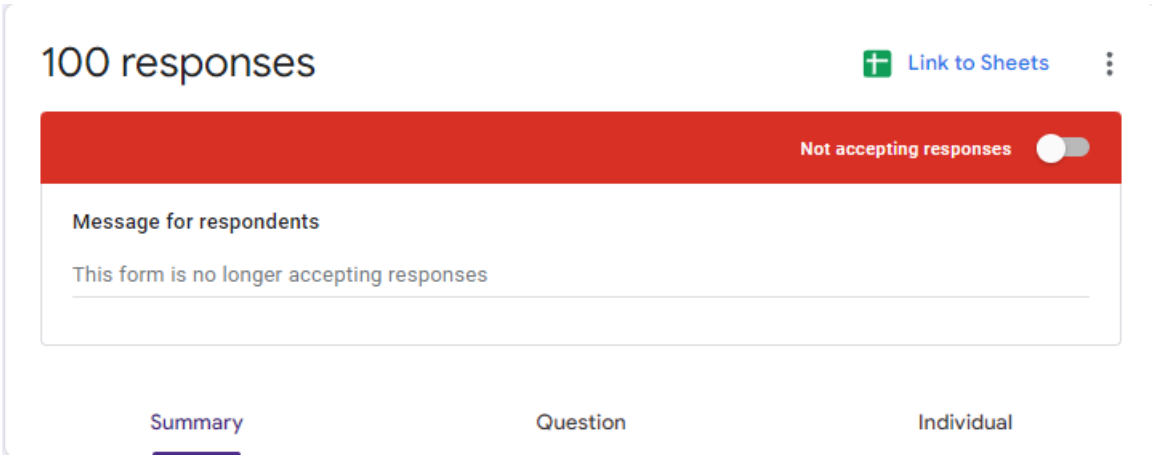
Meanwhile, on 8th January 2022, a 19-year-old man was caught for his attempt to steal mosque donation box in Rawang. Not only that, back in 2017, three friends were sentence to six months in jail and fined RM 1000 for stealing from donation box.

It is undeniably disheartening to acknowledge the exploitation of individuals' generosity towards the community. The cases of stolen donation boxes occurred due to the poor design of the donation box. The current donation box design is lacking important safety features, letting it susceptible to theft. In addition, the current donation box design mostly relies only on a simple padlock to keep it locked, which unable to prevent determined thieves to break into the donation box (Idral et al., 2018).

Hence, to prevent more stealing cases, it is crucial to design an improved donation box that includes extra safety features and adapting the features according to the specific needs and circumstances of each donation box. Our team aspires to design an improved anti-theft donation box which would have sufficient space for money storing, keypad lock system as well as theft detection system. By incorporating these two additional systems, it may help to reduce the risk of theft and increase the overall security of the collected funds as well as to ensure the donations will be utilized for their intended purposes.

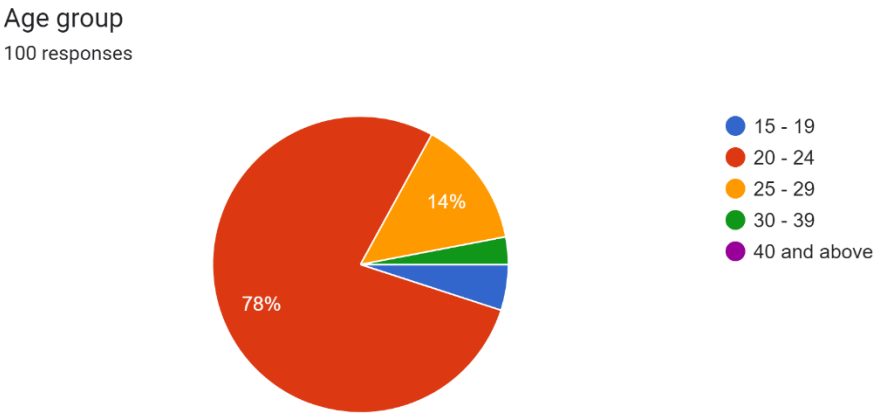
2.2 Design Thinking Tools

Our group has conducted an online survey via google form to collect data from individuals as well as their opinion towards our innovation. We managed to collect data from 100 respondents from different age groups. These data are essential for our project since we need respondents' opinion to ensure that our concern is valid and relevant to the community as well.



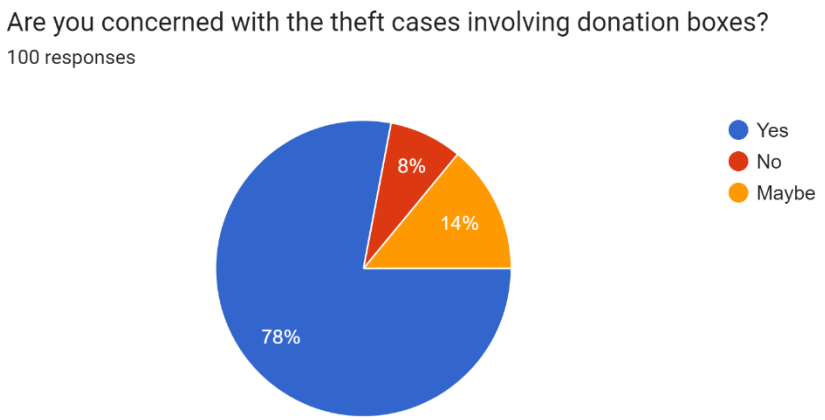
The following data was gathered through the online survey:

Question 1:



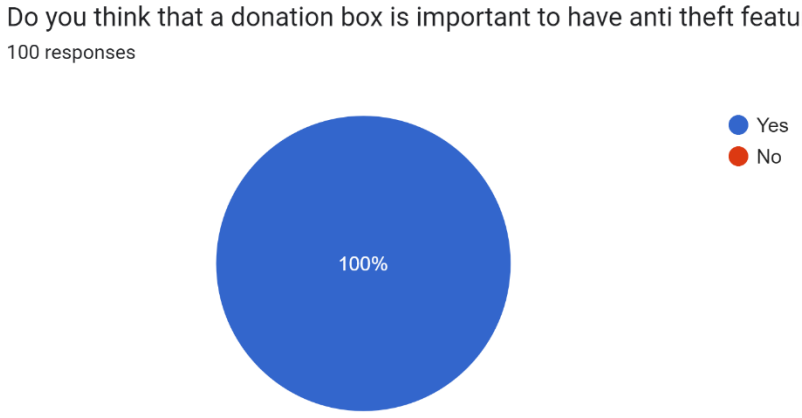
78% of respondents are in the age group of 20-24 while 14% are in the age group of 25-29 and above. 5% are in the age group of 15-19 while the remaining are between 30-39.

Question 2:



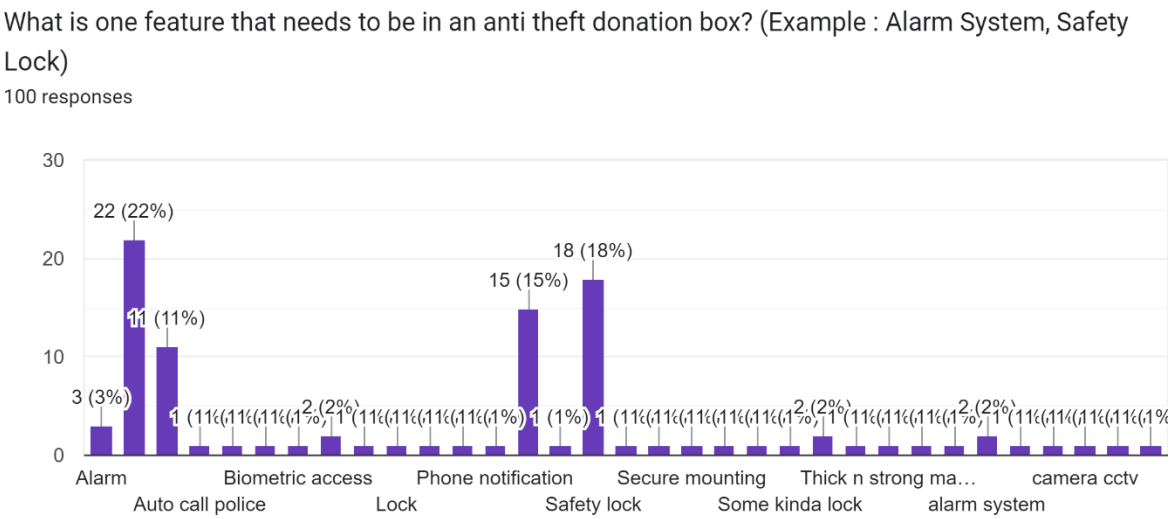
There are 78% of respondents answered 'Yes', 14% answered 'Maybe' and 8% of the respondents answered 'No'. We could say that majority of the respondents are concern about the theft cases involving donation box. Therefore, our concern and this project can be considered relevant.

Question 3:



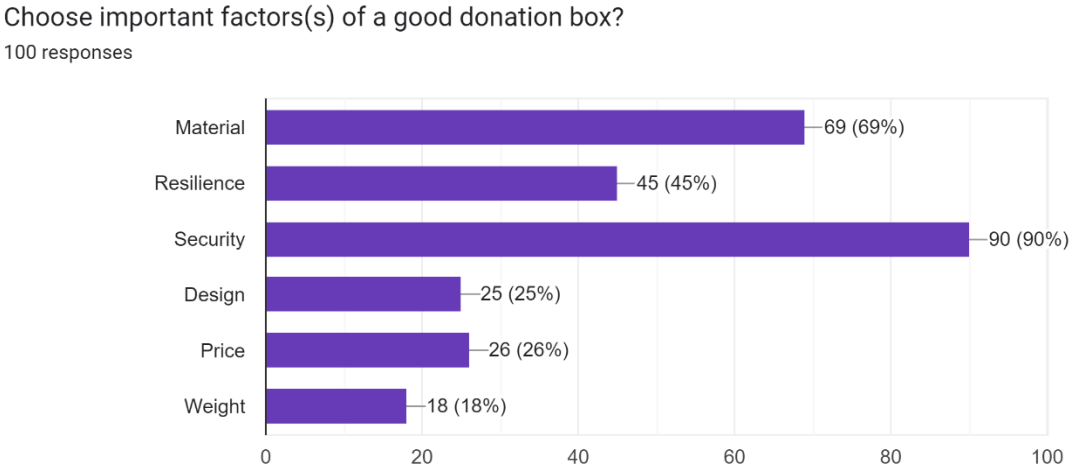
Based on the pie chart shown, all respondents answered 'Yes' and they agree that a donation box should have anti-theft feature.

Question 4:



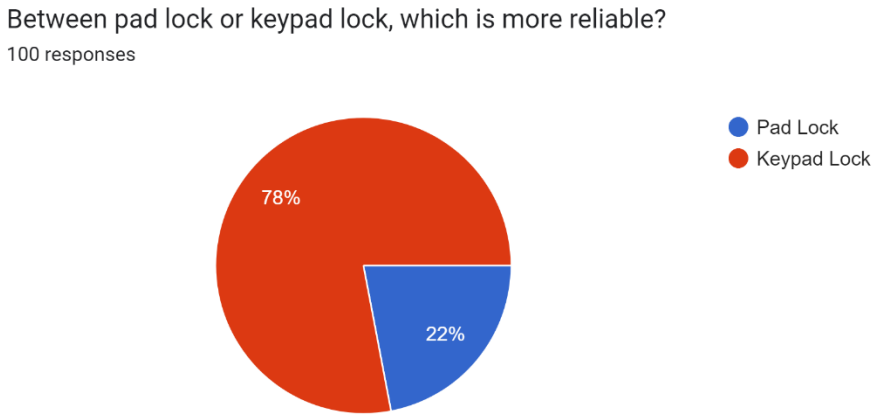
From the data collected, 38% of the respondents agreed that a donation box should have an alarm system. Another 36% of the respondents thought that safety lock should be implemented in donation boxes. While 4% and 3% of respondents respectively thought that donation boxes should be made from a strong and thick material and there should be a CCTV attached to it. The others have suggested that donation boxes need biometric access, auto-call police and owner system, money tracker and movement sensor.

Question 5:



For this question, we have asked the respondents to choose multiple factors. 90 and 69 respondents chose security and material, respectively, to be the important factor of a donation box. 45 respondents chose resilience, 26 respondents chose price, and 25 respondents chose design to be the important factor of a donation box. Meanwhile, 18 respondents chose weight as an important factor of a good donation box.

Question 6:



For this question, 78% of respondents chose keypad lock as a more reliable security while 225 of respondents chose pad lock to be more reliable.

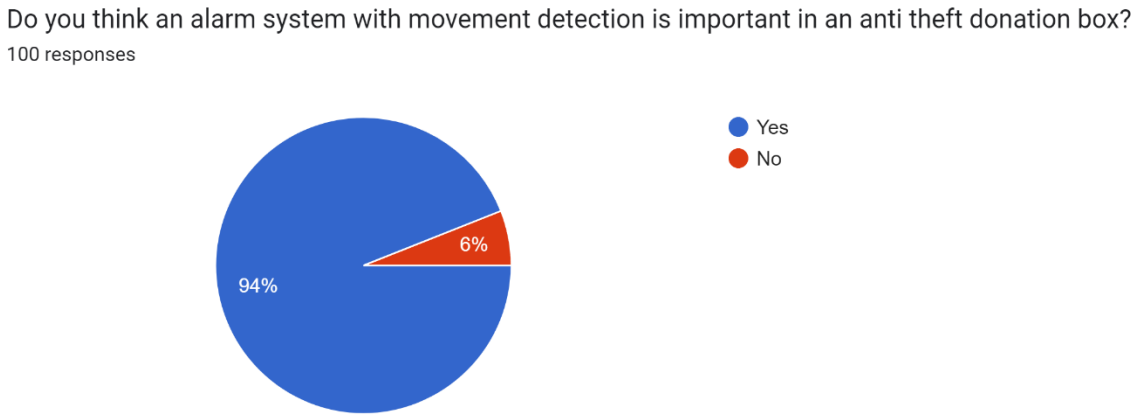
Question 7: **Why?**

Answers	Number of Respondent
Better security	29
Pad lock can be easily broken and opened	22
More reliable because of high technology	16
Key will not be lost	11

Meanwhile, there are a few reasons why some respondent chose pad lock to be more reliable. First, pad lock cannot be hacked. A few respondents agree that using keypad lock will increase the risk of the donation box getting hacked by thieves as it can be opened using passcode. Using keypad lock also comes with the risk of the passcode to get leaked. Other than that, a few others stated that with pad lock, not everyone has the access to it since not everyone has the key to

open the lock. Some also agreed that keypad lock is not needed since pad lock has been used as a reliable medium of security for a long time, and high-quality pad locks can offer excellent resistance to tampering and physical attacks.

Question 8:



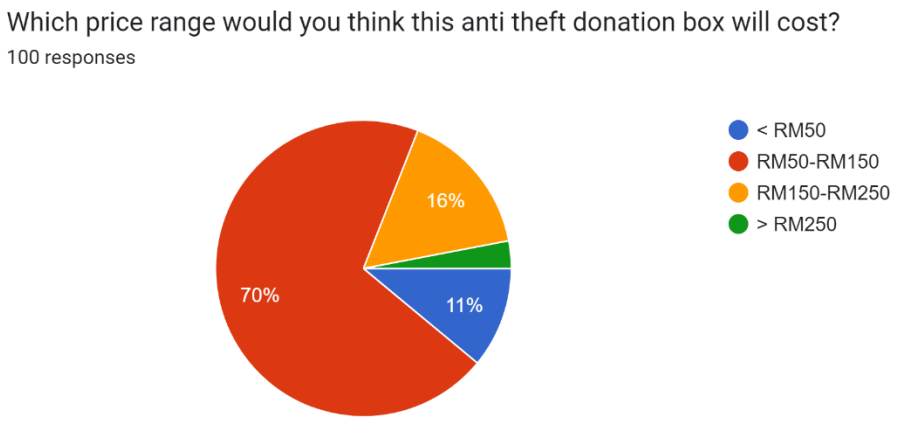
Majority of the respondents thought that an alarm system with movement detection is important in anti-theft donation box.

Question 9: **Why?**

Answers	Number of Respondent
Safer & more secure	25
Alertness	22
Prevent theft	20
Detection	13
Increase efficiency	9
Protection in unattended areas	7

For the respondents that disagree with the alarm system with movement detection, the reasons are because the costing. The price of the donation box could be really expensive as it is completed with security system. Other than that, some of the respondents thought that someone could be accused of theft when they accidentally bumped into the box, or the animals could be playing around which will create unnecessary panic and commotion.

Question 10:



70% of the respondents thought that the price of the donation box most likely to be around RM 50-150 while 16% and 11% of the respondents thought that it would cost around RM 150-250 and less than RM50 respectively. However, only 3% of the respondents thought that the price would be over RM250. Most of the respondents thought that donation box price should range from RM 50-150 as the price is considered as affordable, and not too expensive. Therefore, we do think that the product price is one of the most important aspect that should be considered in creating a product.

Question 11: **Do you think anti-theft donation box would benefit the community?**

Based on the opinions given by the respondents, majority of them though that having anti-theft donation box would benefit the community. A few of the respondents said that anti-theft donation box should be implemented especially at community buildings like mosques, churches, and temples to avoid the donators' monetary support going to thieves. This way, the fund could be used to benefit the worthy and receivers in need. Therefore, the donations could be used for good cause. Other than that, some thought that the current donation boxes lack of safety features, that contributed to the rising theft cases. However, there is only a very minority percent of the respondents thought that it would not benefit the community, but there is no explanation given as to why they thought that.

3.0 PROJECT MANAGEMENT PLANNING

3.1 Task Listing and Distribution

No.	Name and ID	Position	Tasks
1	**Tang Jin Hang** 20001336 (Electrical Engineering Department)	Project Manager	• Organize and coordinate meetings with group members. • Distribute tasks among group members. • Supervise members' work. • Communicate with supervisor for further project update. • Compile and proofread the reports before submission. • Design a complete electrical circuit for anti-theft detection system with proper theory and calculation. • Purchase electrical components for the electrical circuit of anti-theft detection system.
2	**Muhammad Khairul Hilmi bin Mohd Zaki** 20001244 (Chemical Engineering Department)	Secretary	• Prepare agenda for meetings according to Project Manager. • Prepare Gantt Chart and task listing and distribution for project planning to ensure smooth flow of work. • Mark attendance during the meeting and keep track of the deadlines. • Perform background research on the problem statement and objectives of the project as well as overall overview of the project prototype. • Create a video of e-poster presentation.

3	**Muneesh Nachiappa** 20001267 (Mechanical Engineering Department)	Treasurer	• Conduct research on price of the materials required to ensure cost-effectiveness of the materials. • Evaluate capital and operational costs of the project. • Create invoice of purchase for claim purpose. • Analyse the cost required for a single project prototype. • Propose the price of prototype based on the price and cost research. • Build the donation box by referring the dimensional drawing from AutoCAD software. • Purchase the material required for the prototype making.
4	**Muhamad Fareez Che Idris** 20001251 (Mechanical Engineering Department)	Designer	• Propose concept designs and evaluate the most suitable prototype design. • Sketch the project prototype using AutoCAD software. • Analyse advantages and disadvantages of the prototype design. • Communicate with Research Officer for improvement of prototype design based on the survey data and research conducted. • Justify the prototype design and structure. • Ensure the prototype to function accordingly. • Build the donation box by referring to the dimensional drawing from the Auto CAD software. • Creating video of working prototype demonstration.

5	**Nurin Faqihah Binti Nor Azmi** 20001189 (Chemical Engineering Department)	Research Officer I	• Create survey in Google Form to collect data and distribute the form. • Analyse survey result and provide idea based on the survey to improve the project prototype design. • Prepare a written report on the data collected from the survey. • Design an e-poster for the project that includes the working prototype
6	**Presca Shila Anak Kemban** 20001078 (Petroleum Engineering Department)	Research Officer II	• Conduct research to gather information on the project such as materials required for the prototype design. • Prepare a written report on the research conducted for analysis. • Conduct further research for any improvement and solution if there is any problem on the prototype design such as alternative materials. • Choose suitable tools and software to build the prototype. • Creating a video for working prototype demonstration. • Collect feedback from users by creating a survey for discussion.

3.2 Gantt Chart

Tasks	W1 8/5 14/5	W2 15/5 21/5	W3 22/5 28/5	W4 29/5 4/6	W5 5/6 11/6	W6 12/6 18/6	W7 19/6 25/6	W8 26/6 2/7	W9 3/7 9/7	W10 10/7 16/7	W11 17/7 23/7	W12 24/7 30/7
Seminar 1												
Task distribution												
Individual Reflection												
Seminar 2												
Brainstorming ideas												
Consultation with supervisor on the ideas												
Seminar 3												
Finalize design idea												
Research on the finalized design idea												
Conduct survey												
Seminar 4												
First draft of product design												
Extended Proposal preparation												
Finalize methodology of design idea												
Seminar 5												
Extended Proposal submission												
Seminar 6												
Discuss the final design of product												
Drawing the product design using AutoCAD												
Seminar 7												
Product simulation and prototype making												
Final report preparation												
Presentation of Prototype Progress												
Seminar 8												
Preparation of Video Presentation for Working Prototype												
Preparation of E-Poster												
Submission of Video and E-Poster												
Finalize final report												
Assessor Evaluation												
Submission of Peer Evaluation Form												
Submission of Final Report												

3.3 Feasibility of Plan

Few factors need to be taken into consideration to determine the feasibility of the design idea of Anti-Theft Donation Box including the security, economical and operation aspects.

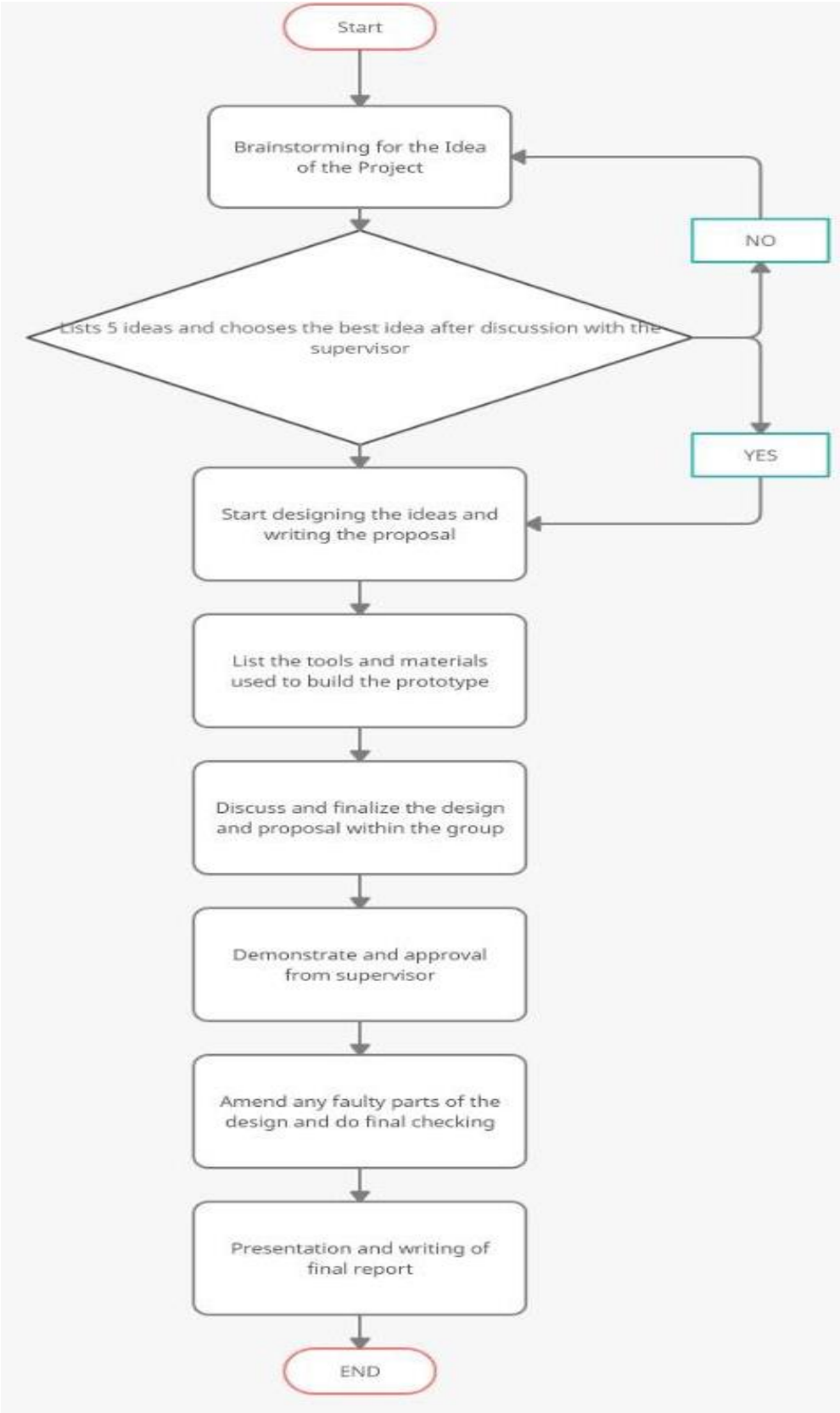
The main purpose of Anti-Theft Donation Box is to protect the donations from the risk of theft especially when the donation box is placed in the public. For the security design, the donation box is made of wood and instead of using locks and keys, we implement the use of keypad lock at which only the authorised personnel of the donation box can access the donation box with initially set PIN number. In addition, sensors and security alarms are also applied to the donation box at which the sound alarms will activate to alert the surroundings if the sensors detect any suspicious movement, or someone tries to break it. It is a feasible plan because the sensors and alarms system as well as the keypad lock can be implemented and operated efficiently by a simple circuit design with certain electronic components such as Arduino UNO and a pressure sensor. Hence, the security measures of the Anti-Theft Donation Box are important to be considered to ensure the feasibility of the donation box.

Another important aspect for the plan feasibility of the Anti-Theft Donation Box is the economical aspect which includes the price of the materials used and the operational cost to build the Anti-Theft Donation Box prototype. It is important to reduce the cost of the operation and materials in order to create an affordable selling price for the users. With a proper planning of capital and operational cost around RM288, the plan to build the Anti-Theft Donation Box is feasible. The cost spent for the prototype can also be reduced by using reused or recycled materials which will make the plan to be more feasible in terms of economical aspect. Since the budget allocated for the prototype design is limited to RM300, it is significant to reduce the spending by considering cheaper but good quality materials so that the prototype design becomes more feasible and operates efficiently.

Lastly, the operation aspect also needs to be considered at which the prototype design should be working effectively based on its functions without any failure or error. By considering this aspect, the plan is feasible since the design and operation system of the Anti-Theft Donation Box is design and planned precisely as well as tested accordingly to ensure successful operation. In addition, the knowledge learnt in the engineering field can also be applied in the designing of the Anti-Theft Donation Box which makes the plan to be more feasible. The prototype also should be user-friendly in terms of operation aspect and easy to be accessed such as the implementation of keypad lock for security.

4.0 METHODOLOGY

4.1 Project Workflow



4.2 Identification of Suitable Tools and Software

Designing:

1. AutoCAD 2023: Used by the designers to design the possible designs for the prototype. The designs were proposed with explanation and the best design was obtained.

Fabrication:

List of tools in the chosen prototype design was:

1. LED Weight Indicator: To indicate the accurate weight of money in the donation box.
2. Solenoid Lock: To be the latch for locking and unlocking the donation box and make sure the donation box is safe to be used.
3. Weight Sensor: To accurately read the weight of the money inside the donation box.
4. Alarm: To ring and notify the owner in any case of forced opening or theft.

4.3 Justification of Fabrication Choices

The main material for our chosen prototype is wood. Since this is an anti-theft donation box, safety is one of the main factors that we considered, and we wanted to make sure the final product is safe to be used even in real life. That's exactly why we chose wood, specifically plywood. This is because plywood by its nature is strong and durable. At the same time, it is also cheap and for students it is easier to obtain compared to other types of wood in today's market. As one of our goals is to use sustainable materials for our prototype, plywood is one of the best choices for us.

The main process in our prototype for an efficient donation box is the Arduino system and the weight sensor to ensure the system works. The keypad lock connected with the solenoid locker is one of the best solutions for us to make sure the donation box is not easily breakable. At the same time, the Arduino with the weight censor makes it more efficient by sensing any slight changes in the weight to notify the user about it in any case of possible theft occurring.

Moreover, the prototype will be built with more recycled things such as the supporting base and the interior of the donation box to make sure that this system is good for the environment and also could contribute to reducing the total cost to make the working prototype. At the same time it is easier to use plywood to build things at low cost because to shape, or build it is easy compared to any other metal objects. Hence, we can ensure that the sustainable resources have a great shape according to the prototype design that was chosen for the built up.

4.4 Experimental Procedure

Material and Apparatus

- Plywood
- Screws and nails
- Wood sheet wallpaper
- Jigsaw
- Chisel
- Hammer
- Arduino controller
- Force sensor
- 10k ohm resistor
- 16 x 2 LCD display with I2C adapter
- Tactile push button
- Buzzer
- Connecting wires
- Breadboard
- Keypad
- Relay
- Solenoid lock
- 12V power adapter
- Power jack

Procedure

1. All the listed materials and apparatus was prepared. Some of the materials were bought and some of them were borrowed from the lab.

- 5 x 5 feet plywood
- Small screws and nails.
- Wood cutter
- Hammer
- Arduino controller

- Force sensor
- 10k ohm resistor
- 16 x 2 LCD display with I2C adapter
- Tactile push button
- Buzzer
- Connecting wires
- Breadboard
- Keypad
- Relay
- Solenoid lock
- 12V power adapter
- Power jack.

2. The dimensions of the box were finalised and the cutting procedures were started.
3. The wood cutter machine was used to ensure the accuracy of the cutting of the wood, with the tolerance of 0.2mm each piece. The tolerance was allowed because this is a 100% handmade prototype from scratch. No auto-cutting machines were used.
4. Once all the wood pieces were cut according to the proposed design, it was combined using nails and screws.
5. The electrical components were all built separately before fixing it inside the prepared box design.
6. The prototype box was softened and cleaned using sandpaper and sprayed on top to ensure the cleanliness of the prototype and also the safety of the user. The wallpaper was stick on top of the box to ensure its cleaner and neat to be used by the user.
7. Once the prototype exterior(box) was done, all the electrical components were carefully inserted to ensure all the electrical components were in good condition and still usable for the users.
8. The whole function of the prototype was tested again and explained to the teammates with a few modifications made to ensure the efficiency of its usage.

5.0 ENGINEERING ANALYSIS

5.1 Theory

There are two main systems in the anti-theft donation box, which are keypad lock system and theft detection system. The keypad lock system is responsible for the change of mode of the systems involved and input of password to open the compartment below that contains money while the theft detection system mainly compromised of a pressure sensor and an alarm, which the alarm will trigger when the pressure sensor detects there is a huge change of pressure that is originally act by the money on the sensor. Both systems can be controlled by a microcontroller, named Arduino UNO through coding.

For the keypad lock system, a 4x4 matrix membrane is connected to Arduino UNO to receive any inputs from the keypad membrane. The keypad has 16 switches, which are related to their circuit respectively. Each switch has their own unique output when pressed or not pressed. Then, the switches for a keypad's keys are open by default, which the switch circuits are not connected / open when the switch is not pressed because the switch will not touch the conductive contacts underneath them. Thus, when a key is pressed, the circuit is closed and completed. By releasing your finger from the key, the switch circuit will break and go back to its open position. The functionality of a keypad can be programmed well to pair with a solenoid lock to build a keypad lock system.

First, the Arduino UNO is coded to store strings as password to lock or unlock the donation box. The lock or unlock mechanism is conducted by a solenoid lock, while the relay is used to control the open or close of solenoid lock. If the password inserted to the keypad is wrong, the door is locked by the solenoid lock. If the password inserted to the keypad is correct, the door is unlocked by the solenoid lock. The LCD can show whether the user has typed the correct or wrong password by displaying a message to the user. Next, the keypad system is involved in swapping of mode of the systems involved, which we will discuss it later. The overall concept are the keypad lock system and theft detection system can be activated or deactivated through input of keypad membrane and coding in Arduino UNO.

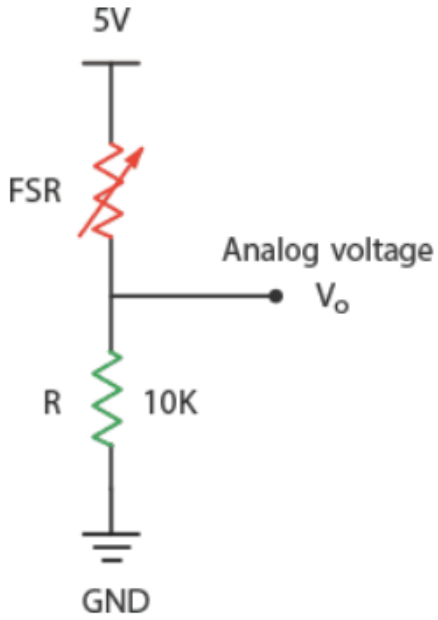
For the theft detection system, it consists of a pressure sensor, an alarm that are connected to an Arduino UNO. A pressure sensor, also known as a force sensing resistor, is a sensor designed to measure physical pressure, squeeze, and weight. It is simply a variable resistor that will change resistance based on the pressure applied to the sensing area. When

squeezed, the carbon elements in the pressure sensor will come into contact with the conductive traces, which will lower the resistance.

Next, the electronics components used for the theft detection system involve Arduino UNO, Force sensor, 1kΩ & 10kΩ resistors, tactile push button, buzzer and jumper wires. In the whole system, the Arduino UNO is coded to detect change of force applied on the force sensor. If there is a change of force acting on it, which is a possible theft action, the buzzer will ring and alert the surroundings nearby. If the alarm is activated, the buzzer will not go off even the item is placed back again, so that the thief cannot replace the money in the donation box with other items. To reset the whole system, the tactile push button is pressed.

5.2 Calculation of Pressure Sensor Value

Before the pressure sensor is used to retrieve values for the Arduino UNO to perform any output for the buzzer, the pressure sensor needs to be set up by combining the pressure sensor with a fixed-value resistor to form a voltage divider, which the voltage produced can be read by Arduino UNO, and will be converted to 'values' in coding to trigger buzzer/ alarm.



In our prototype, the fixed-value resistor that is used is a 10kΩ resistor and voltage supplied is 5V. The equation below can be used to calculate the output voltage (V_0):

$$V_o = V_{CC} \frac{R}{R + R_{pressure\ sensor}}$$

When there is no pressure, the pressure sensor will emit a high resistance at 10MΩ and it will produce a low output voltage.

$$V_o = 5V \frac{10kW}{10kW + 10MW} = 0.005V» \ 0V$$

When a significant force is applied to the pressure sensor, and we expect a drop of resistance by the pressure sensor to $250W$, the output voltage will increase.

$$V_o = 5V \frac{10kW}{10kW + 250W} = 4.9V» \ 5V$$

From the equations above, it explains that why output voltage or the value shown in Arduino UNO will increase, when there is more force applied to the pressure sensor. The table below shows a rough idea about how the voltage will vary based on the applied forces.

Force (N)	Pressure sensor Resistance	Output Voltage (V)
0.0	10MΩ	0.0
0.2	30kΩ	1.3
1.0	6kΩ	3.1
100	250Ω	4.9

5.3 Coding

```
#include <Keypad.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // LCD I2C address 0x27

// For the keypad and solenoid lock
const int RELAY_PIN  = A3; // connects to the IN pin of relay
const int ROW_NUM    = 4; // four rows
const int COLUMN_NUM = 4; // four columns

char keys[ROW_NUM][COLUMN_NUM] = { //Assign inputs values to list of strings
  {'1','2','3', 'A'},
  {'4','5','6', 'B'},
  {'7','8','9', 'C'},
  {'*','0','#', 'D'}
};

byte pin_rows[ROW_NUM] = {9, 8, 7, 6}; //connect to the row pinouts of the keypad
byte pin_column[COLUMN_NUM] = {5, 4, 3, 2}; //connect to the column pinouts of the keypad

Keypad keypad = Keypad( makeKeymap(keys), pin_rows, pin_column, ROW_NUM, COLUMN_NUM );

const String password = "1234"; // password to open safety box
const String Mode_A = "0A";  // Mode A
const String Mode_B = "0B";  // Mode B
String input_password;        //Assign this to contain the commands key-in by user

// For the pressure sensor and alarm
int weight = 0;               //variable to get values from pressure sensor
int temp = 0;                //variable to activate/deactivate alarm
int limit = 0;               //variable to set limit to activate alarm
int btn = 0;                //variable to restart whole program
int buzz = 11;              //pinOut to turn on/off alarm
int z = 0;                 //Counter for password
int k = 1;                  //counter for showing lcd
bool stopProgram = false;    //Counter to stop/ restart the whole program

//Switch Mode A and B
int mode = 0 ;         //variable to switch Modes

void setup() {
  // For the keypad and solenoid lock
  Serial.begin(9600);
  input_password.reserve(32); // maximum input characters is 33
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, LOW); // to set the solenoid lock to be locked at setup
```

```
  // For the pressure sensor and alarm
  pinMode(A0, INPUT);
  pinMode(12, INPUT);
  pinMode(buzz, OUTPUT);
  Serial.begin(9600);
  lcd.init();
  lcd.backlight();          //setup lcd screen
  digitalWrite(buzz, LOW);  //to set alarm to turn off at setup
}

void loop()
{
  //Start of two different Modes (A and B)
  //Mode A : Keypad system Online & Alarm System Offline
  //Description : This mode is ideally being used when user is around, which donators can donate money without triggering alarm and officers can retrieve money from donation box
  //              by inputing the correct password on keypad.

  while (mode == 0)
  {
  //For the keypad and solenoid lock
  char key = keypad.getKey();
  // For the pressure sensor and alarm
  weight = analogRead(A0);       //get input from pressure sensor
  btn = digitalRead(12);
  Serial.println(weight);        //Display input from pressure sensor
  limit = weight ;

  if (k=1) {
    lcd.setCursor(0,0);
    lcd.print("Enter Command"); }      //Ensure lcd always display this message at start of mode A


  if (key){
    k = 0;
    lcd.setCursor(0,0);
    lcd.print("Enter Command");
    lcd.setCursor(z,1);
    lcd.print(key);                  //Display inputs of keypad on LCD for users

    if(key == '*') {
      input_password = "";  //if '*' is inputed, the whole input of password/command is reset.
      z = 0;
      lcd.clear();
      k = 1;
    } else if(key == '#') {        //if '#' is inputed, the whole input of password/command is registered. (Act as "enter" function on PC)
      if(input_password == password ) {       // if password is correct, door will be unlocked to retrieve money
```

```
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Password correct");   //Display message to show that door is unlocked
        lcd.setCursor(0,1);
        lcd.print("Open for 20s");
        digitalWrite(RELAY_PIN, HIGH);  // unlock the door for 20 seconds
        delay(20000);
        digitalWrite(RELAY_PIN, LOW); // lock the door after 20 seconds
      }
      else if(input_password == Mode_A) {      //if command is correct, it will be switched to Mode A
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Switch to Mode A");         //Display message to show that system is switched to
Mode A
        delay(2000);
        lcd.clear();
        k = 1;
        mode = 0;
      }
      else if(input_password == Mode_B) {      //if command is correct, it will be switched to Mode B
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Switch to Mode B");         //Display message to show that system is switched to
Mode B
        delay(2000);
        lcd.clear();
        k = 1;
        mode = 1;
      }
      else {                             //if password/commmand is wrong, input will be reseted
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Password/Command");     // Display message to show that password/command is wrong
        lcd.setCursor(0,1);
        lcd.print("Is Wrong!");
        delay(2000);
        lcd.clear();
        k = 1;
      }
      z = 0;
      input_password = ""; // reset the input password
      lcd.clear();
      k = 1;
    } else {
      z += 1 ;
      input_password += key; // append new character to input password string
    }
  }
```

```
  }

  ////**********************************************************************************************
**********************************************************************************/////
  //Mode B : Keypad system Offline & Alarm System Online
  //Description : This mode is ideally being used when user is not around, which the alarm will be
triggered if there is a change of value of pressure acts on pressure sensor (suspicious
  //              theft activity) and the donation box cannot be opened through input of password (to
prevent thief from opening if they steal the password).

  while (mode == 1)
  {
  //For the keypad and solenoid lock
  char key = keypad.getKey();
  // For the pressure sensor and alarm
  weight = analogRead(A0);             //get input from pressure sensor
  btn = digitalRead(12);
  Serial.println(weight);              //Display input from pressure sensor



  if ((weight < limit - 50) || (weight > limit + 50))  //Detect sudden change of weight within 0.5s
  {
    temp=1;                     //variable will be 1 to activate alarm , if value of weight changes
beyond the range set.
  }
  delay(500);                   // to give a delay of time so that limit will not equal to weight
immediately
  limit = weight;               // to compare with weight so that it can detect sudden change of
weight

  if (temp == 1)
  {
    digitalWrite(buzz, HIGH);   //alarm is triggered
  }

  if (temp == 0)
  {
    digitalWrite(buzz, LOW);    //alarm is not triggered
  }

  if (btn == 1)
  {
    temp=0;
    stopProgram = true;        // variable to stop the alarm if pushbutton/reset button on Arduino is
pushed
  }
  delay(100);
```

```
  if (stopProgram) {
    while (true) {
      digitalWrite(buzz, LOW);
      // Empty loop to stop the program and stop the alarm
    }}

////////////////////////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////
  //Keypad input to switch mode.
  if (k=1);{
    lcd.setCursor(0,0);
    lcd.print("Enter Command");}       //Ensure lcd always display this message at start of mode B

  if (key){
    k = 0;
    lcd.setCursor(0,0);
    lcd.print("Enter Command");
    lcd.setCursor(z,1);
    lcd.print(key);                    //Display inputs of keypad on LCD for users

    if(key == '*') {                   //if '*' is inputed, the whole input of password/command is
reset.
      input_password = ""; // reset the input password
      z = 0;
      lcd.clear();
      k = 1;
    } else if(key == '#') {             //if '#' is inputed, the whole input of password/command is
registered. (Act as "enter" function on PC)
      if(input_password == Mode_A ) {    //if command is correct, it will be switched to Mode A
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Switch to Mode A");    //Display message to show that system is switched to Mode A
        delay(2000);
        lcd.clear();
        k = 1;
        mode = 0;
      }
      else if(input_password == Mode_B) {        //if command is correct, it will be switched to Mode
B
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Switch to Mode B");          //Display message to show that system is switched to
Mode B
        delay(2000);
        lcd.clear();
        k = 1;
        mode = 1;
      }
```

```
      else  {                                  //if password/commmand is wrong, input will be reseted
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print("Command is Wrong");         // Display message to show that password/command is
wrong
        delay(2000);
        lcd.clear();
        k = 1;
      }
      z = 0;
      input_password = ""; // reset the input password
      lcd.clear();
      k = 1;
    } else {
      z += 1 ;
      input_password += key; // append new character to input password string
    }
  }
  }
}
```

5.4 Final Design

Figure 5.1 Front View of Prototype

Figure 5.2 Top View of Prototype

Figure 5.3 Side View of Prototype

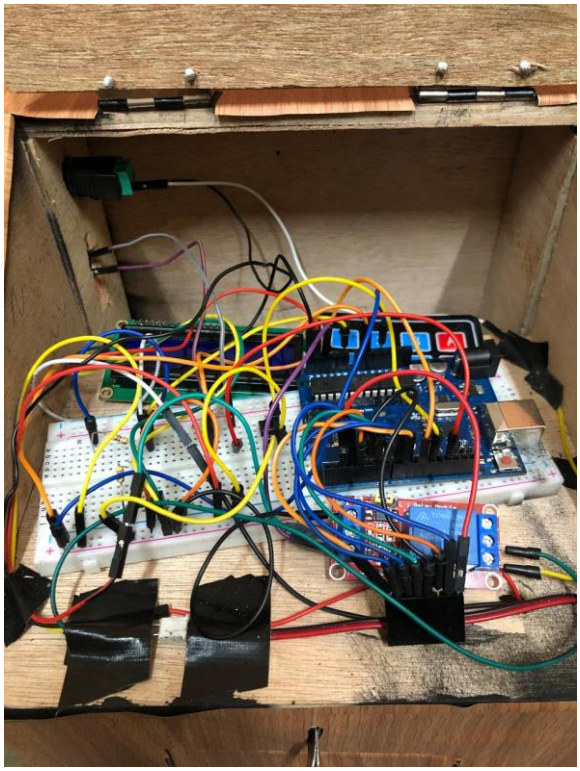


Figure 5.4 Electronics of Prototype

Figure 5.5 Safe Box and Solenoid Lock of Prototype

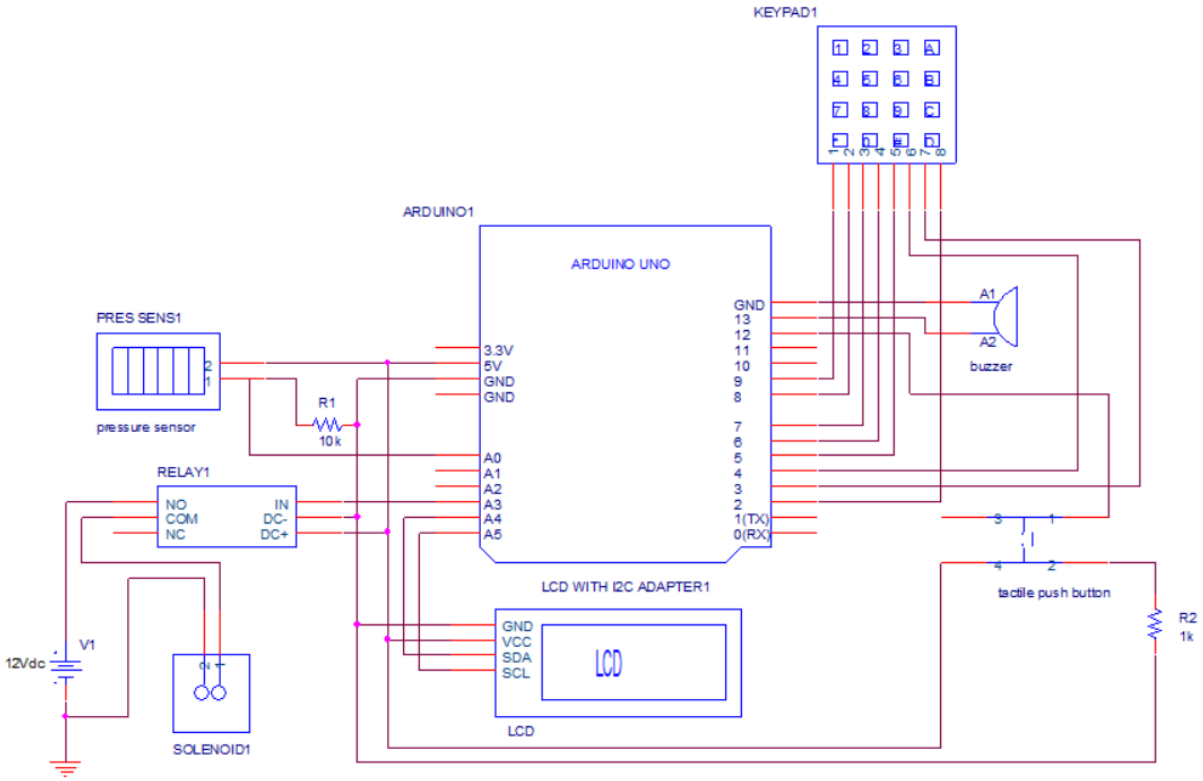


Figure 5.6 Circuit Design of Prototype

6.0 BUSINESS / ECONOMIC ANALYSIS

6.1 Capital Cost Considerations

No	Item	Quantity	Cost per Item (RM	Total cost (RM)
1.	Plywood	4	2ft x 4ft with 12 mm thickness = 25.13	100.52
2.	Arduino UNO	1	38.65	38.65
3.	LCD 1602 with 12C	1	14.90	14.90
4.	Breadboard	1	3.90	3.90
5.	Tactile push button	1	0.20	0.20
6.	Buzzer	1	1.50	1.50
7.	4x4 keypad membrane matrix	1	2.90	2.90
8.	DC 12V solenoid Door	1	19.50	19.50
9.	AC Power Adapter	1	8.40	8.40
10.	5V-1 Way Isolator Relay	1	18.40	18.40
11.	12V DC power connector adaptor	1	6.10	6.10
12.	Thin Film Pressure Sensor	1	23.23	23.23
TOTAL				137.68 + (100.52)

***The proposed capital cost would be decreased in the final report. Some of the stuff can be recycled or obtained from Equipment Prototype & Testing Center in UTP.**

6.2 Operational Cost Considerations

No	Item	Cost(RM)
1	Welding	20
2.	AC Circuit	30
Total		50

6.3 Alternatives in Materials

No.	Item	Alternative item
1.	Plywood	Solid Wood • Strongest Wood type to make. • Classy look • Very expensive type of wood Aluminium Metal • Very strong and durable for high safety. • Hard and costly to manufacture. • Very expensive to obtain
2.	Arduino UNO	Arduino Nano • Compact version of Arduino UNO • Offers the service in a very small form factor
3.	DC 12V solenoid Door	Magnetic Lock • Strong holding power magnetic door that can be used for high security purposes. • More expensive and hard to obtain compared to solenoid door.
4.	Thin Film Pressure Sensor	Optical Pressure Sensor • High sensitivity and accuracy • Reliable and long lasting • Expensive compared to other sensors.

6.4 Market Analysis

Based on our research, for the time being, there are no existing product that are similar to our anti-theft donation box. However, there are anti-theft parcel drop boxes from various companies that are sold in the market. From our findings, these parcels drop boxes are the closest comparison to our anti-theft donation box. Based on the article written by Harms, C. (2023), the best parcel drop box in the current market is from Architectural Mailboxes, which wins all the aspect from storing to security and durability. The box is equipped with three-point lock system, rotating drum design, outgoing partition and comes fully assembled. However, the drop box is not waterproof. The box is sold on the market with the price of RM 1,353. The price is a bit pricey and is not very affordable. There are other drop boxes from other companies as well with the same range of price.

6.5 Price & Feasibility

We are planning to sell our product at the price of RM500. Since the production of our product has cost us RM 288, selling it for RM500 is relevant. Other than the production cost, we must consider the time and workforce in determining the price of our product. In terms of the target market attractiveness:

Items	Potential
Number of competitors	High
Growth rate of product	High
Average of net income	High
Satisfaction of customers	High
Long term prospect	High

Since, our product is the only product that is available on market, we have high potential in succeeding since we have zero competitors. With zero competitors, we expect a high growth rate of our product in market since we are the only producer of anti-theft donation box. Other than that, since we are targeting public places especially mosque, the growth rate will potentially increase since there are a lot of mosques that may need our product. The selling price of our product is almost twice of the actual production cost; therefore, we can expect to have a high average of net income if we are to commercialize our product. Next, in terms of the satisfaction of our customer, since our product is equipped with double security system, we can ensure that the purpose of our product will be able to fulfil the customers' needs, hence customers' satisfaction is expected to be high. Last but not least, we have created a timeless product, which has no limit of time and can be used in many generations. Our products will still be relevant in 15 years time since mosque and donation will continue to exist in the future. Therefore, our product has a high potential in terms of the long-term prospect and hopefully will succeed in the future.

7.0 RESULTS & DISCUSSION

7.1 General Idea of Prototype

The anti-theft donation box is a donation box that contains double-lock security systems and ample space of money storage to ensure the user can ensure the safety of donation box. The anti-theft donation box contains of two modes to enhance the capability and versatility of the prototype. The first mode is activated when the user is around, and the keypad lock system is activated to enable user to retrieve money from the safe box, while the theft detection system is turned off to prevent the alarm from triggering, since donation by people normally occur in the morning till late evening. The second mode is activated when the user is not around, and the keypad lock system is deactivated, so that the solenoid lock cannot be opened if the thief breaks through the first padlock through brute force, while the theft detection system is activated to detect any sudden change of weight acts on the pressure sensor to trigger the ringing of alarm.

7.2 Project Results

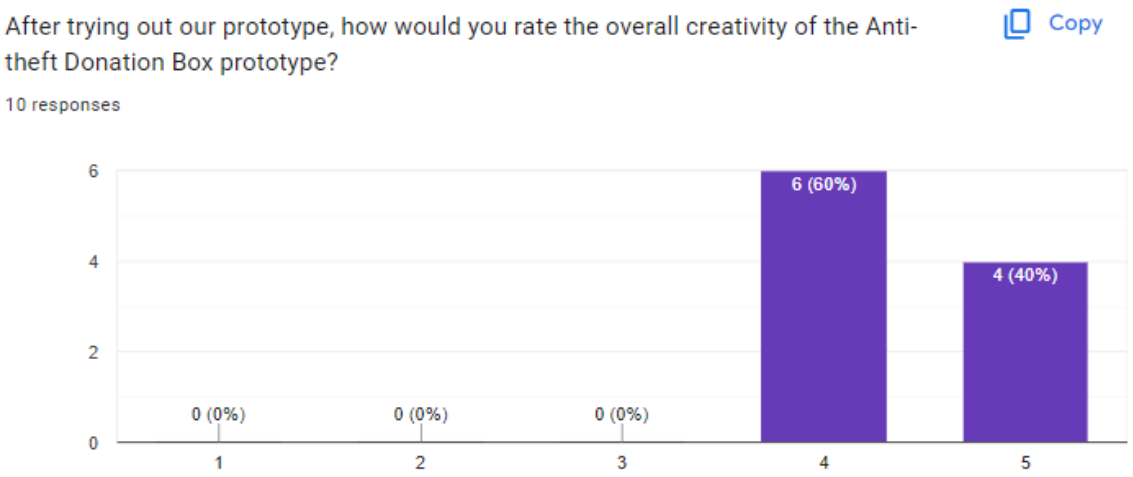
Mode	Keypad Lock System	Theft Detection System	Results
A	Activated	Deactivated	User can retrieve money from donation box through opening of solenoid lock. Donations by donors will not cause the triggering of alarm.
B	Deactivated	Activated	Thief cannot retrieve money from donation box due to lock of solenoid lock. Change of weight act on pressure sensor is detected and will cause triggering of alarm.

7.3 Project Output & Discussion (Users Feedback)

To get the output of our project, the Anti-theft Donation Box prototype, our group has approached 10 people to try out the prototype and give their feedback in terms of the creativity, security, and appearance of the prototype. The feedback has been collected via Google Form.

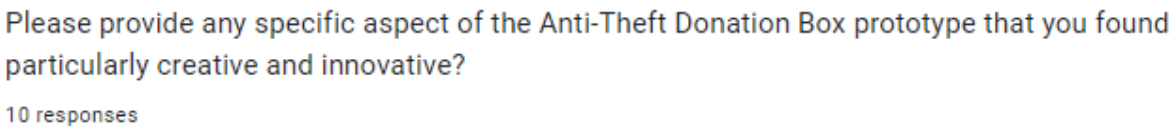
The questions and responses are as follow:

Question 1:



On the scale 1 (not creative) to 5 (very creative), six respondents have chosen scale 4, indicating that they find the prototype creative while another four respondents have chosen scale 5, stating that they find the prototype is very creative. Hence, it can be concluded that the idea of building an Anti-theft donation box is a creative idea.

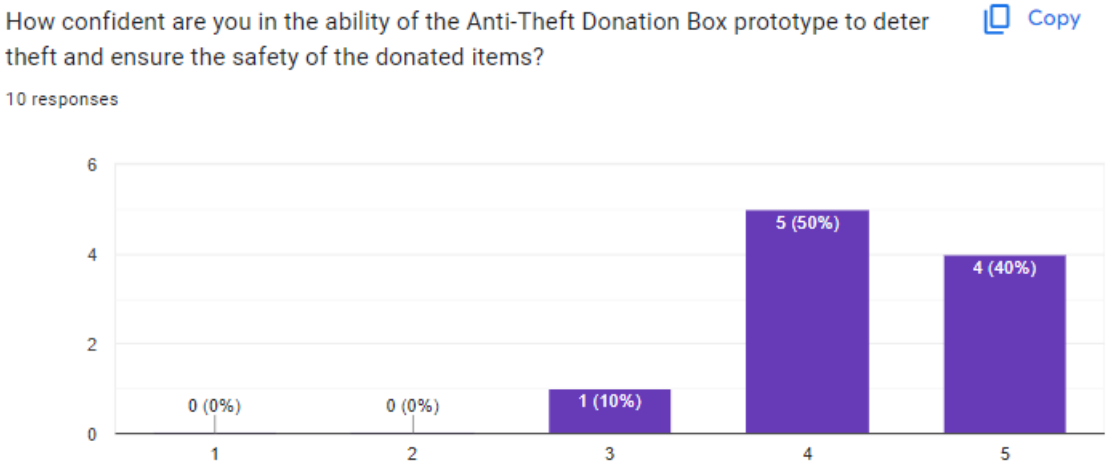
Question 2:



To understand users' perspectives of our prototype, we have asked the specific aspect that they found particularly creative and innovative. Of the 10 responses, five respondents found the two-stage locking mechanism creative as it increases the security of the donation box. This is because the prototype uses padlock as well as keypad lock mechanism. While two respondents

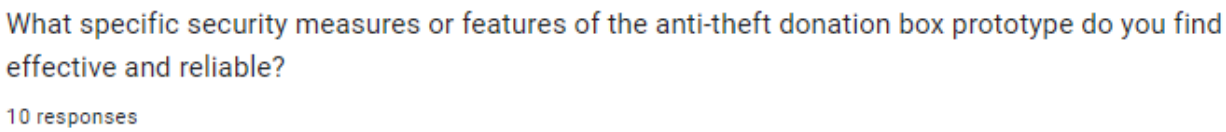
complimented the design of the donation box as the unconventional design stands out than the traditional donation box. Besides, another two respondents found that specific compartment of the electrical components creative while the last respondent found the alarm system of the prototype creative.

Question 3:



On the scale 1 (very doubtful) to 5 (very confident), four respondents are very confident on the ability of the prototype to deter theft and ensure the safety of the donated items. Besides, another five respondents have chosen scale 4, which indicates that they are confident in the security of the donation box while one last respondent has chosen to remain neutral.

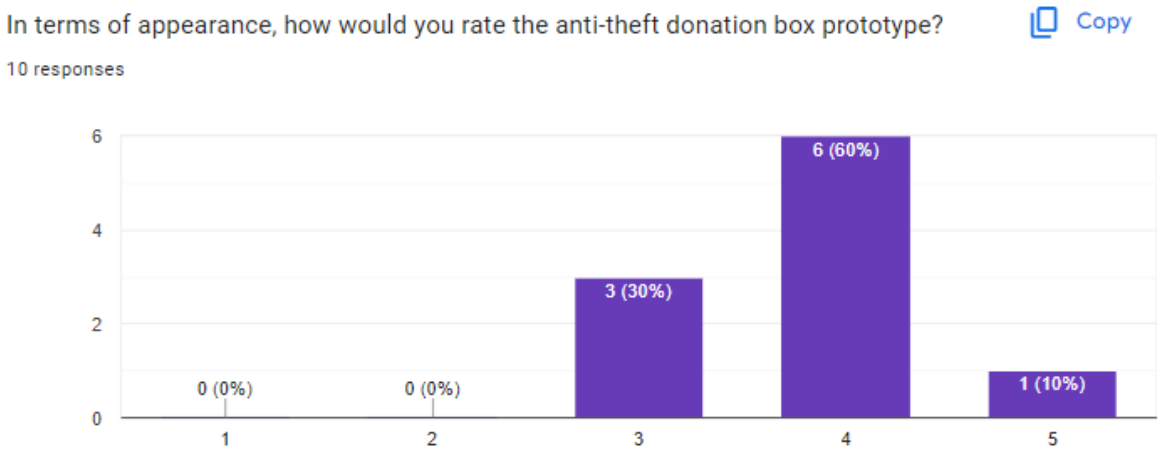
Question 4:



Of 10 responses, six respondents found that mode of the prototype is the effective feature of the anti-theft donation box. The modes are mode A whereby the keypad lock mechanism will be activated while the theft detection system will be deactivated, while in mode B, the keypad lock mechanism will be deactivated, and the theft detection system will be activated. Another three respondents complimented the two-stage locking mechanism, which are the padlock and

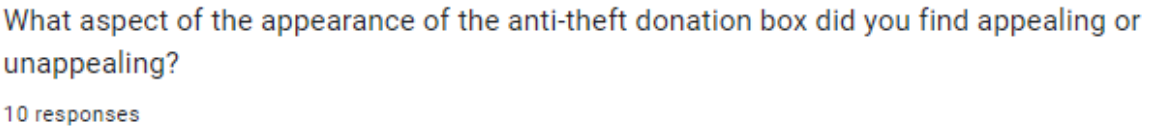
keypad lock mechanism. Lastly, one respondent commended on the sensitivity of the theft detection system that can detect the change of weight.

Question 5:



On the scale 1 (very unattractive) to 5 (very attractive), most of the respondents, which is six respondents out of 10 respondents have chosen scale 4, indicating that they found the donation box attractive. While another one respondent found that the donation box is very attractive and the remaining three respondents chose neutral.

Question 6:



Out of 10 responses, five respondents found the unique design and shape of the box appealing, as it is an unusual design as compared to the common cube-shape donation box. Besides, three respondents complimented the special compartment of the electrical components and another two respondents commented on that the finishing of the prototype can be further improved.

7.4 Justification of Structure

The strong, intelligently constructed trapezoidal prism shape of the anti-theft donation box has two different compartments: a triangular prism at the top and an L-shaped prism below. Both endurance and security are guaranteed by this distinctive design. A large input slot at the top of the box provides a secure and practical way to insert monetary gifts. An internal channel effectively directs the cash to a roomy container reserved only for safely storing the contributed money. A precise pressure sensor that is integrated into a sturdy platform within the storage area is placed strategically near the bottom of the money compartment for improved theft protection. The sensor continuously monitors weight distribution, and when it notices any substantial changes, it immediately activates an elaborate warning system outside the box. This system effectively alerts nearby individuals, discouraging any attempts at theft.

The donation box door has a high-tech keypad lock mechanism fitted to further protect the monies contributed. This mechanism is deftly incorporated onto the triangular prism compartment's surface and linked to a solenoid lock on the door of the fund storage compartment. By inputting the right password on the keypad, only authorized users can access the money compartment, offering an added layer of security. The electronic parts, including the electronic board, are safely stored in a separate compartment above the fund holding space to guarantee excellent performance and ease of maintenance. The risk of interference from the strain of the money on the electronic circuitry is reduced by this isolation. Additionally, in the event of any problems, the detachable electronics section makes straightforward maintenance and troubleshooting processes possible. These design components work together to create an anti-theft donation box that prioritizes security and usability while also offering a reliable and cutting-edge method of gathering and protecting funds.

7.5 Justification of Electrical Circuits

The electrical circuits consist of two main systems, which one system is the keypad system that gets input from keypad to perform actions such as activating/deactivating solenoid lock and switching operating modes of prototype. The second system is the theft detection system that relies on input of pressure sensor to determine the output of buzzer. A sudden change of weight will cause the buzzer to ring since it will be a suspected theft action. An additional tactile push button is designed in the system to ensure the buzzer will not turn off if the thief intends to stop the buzzer from ringing by replacing the weight of money with something else. Thus, the buzzer can only be turned off when the push button is pushed by the user after the theft occurs. In both systems, LCD display is a good medium to display the state of the working prototype. For example, LCD display will show the concurrent password or command that is entering by the user so that the input entered is correct. Lastly, the electrical circuit is placed and locked inside the compartment of the box, so that it is difficult to get accessed by random people from outside of the box.

7.6 Limitations of Prototype

The first limitation of the prototype is the prototype imposes security issue if the thief fully understands how the security system of the anti-theft donation box works. In this case, the thief can steal the money without triggering the alarm. However, this issue rarely occurs since it will require a lot of effort from the thief to learn the security system of the anti-theft donation box. To overcome this limitation, additional security measures can be added such as fingerprint sensor to ensure only chosen person in charge can open the safe box and retrieve the money.

The second limitation of the prototype is the pressure sensor that is used in this prototype is too small compared to the expected coverage area by the sensor. Since a pressure sensor is only effectively sensitive within the measure range of the sensor piece, the sensor should be large enough so that it can cover a larger area, thus has higher capabilities to carry more money. However, the manufacture of bigger surface area of pressure sensor requires higher costs and customization from the manufacturer. To overcome this limitation, higher cost is required to manufacture a customized size of pressure sensor.

8.0 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

In a conclusion, our project aims to design a concept of anti-theft donation box with implementation of security features such as keypad lock and solenoid lock as well as anti-theft detection system and our team are able to build a working prototype of an anti-theft donation box by applying engineering knowledge learnt. This means that all of the objectives of our project for Engineering Team Project to design a concept of anti-theft donation box to reduce the possibility of donation theft from the donation box with additional security implementation such as keypad lock and alarm system, to apply engineering knowledge of technical project design and circuit system to create a working prototype design for the benefits of society and to ensure a successful and efficient working prototype design by making proper research and discussions among group members are successfully achieved. From all of the research and discussions made on the materials, prototype design idea, financial consideration and the cooperation between team members, our project prototype is finally finished and completed with fully functioning system which is to prevent theft from donation box by implementation of anti-theft detection system with sensor and alarm system. By combining the donation box with the completed electrical circuit, the anti-theft donation box is functioning well and according to few users that tested our project prototype, it is stated as a great innovation for the community and it agrees with the 9th Sustainable Development Goals (SDG) by the United Nations which is Industry, Innovation, and Infrastructure. Furthermore, the adaption of 2 different modes of function which are mode A and mode B for the anti-theft donation box also enhances the security of the donation box which can be used according to the situation. In addition, the prototype design is very feasible and bring many benefits to the society to reduce the risk of donation theft from donation boxes. Although the idea of Anti-Theft donation box seems to be common, we believe that the improvements and additional security measures that our group implemented in the prototype design will surely be more efficient and more beneficial to the community.

8.2 Recommendations and Alternatives

For the improvement of our project prototype, there are few recommendations and alternatives that can be made to in the future to overcome the limitations in our project prototype. For the materials used to build the donation box, more sturdy and solid materials such as metal and solid wood can be utilized instead of the current use of plywood for the resilience and solidness of the donation box to increase its security. This will prevent the thief from breaking the donation box easily by using weapon such as hammer. Other than that, the pressure sensor that cover the bottom of the money storage in the donation box to detect any changes in the money weight can be improved by increasing the size of the pressure sensor film to cover bigger area of the donation box which will increase the sensitivity, reliability and the performance of the anti-theft detection system. The customized size of the pressure sensor can be made directly from its manufacturer to ensure the perfect coverage of the sensor in the donation box. However, to improve the material and size of the pressure sensor in the donation box, more cost is required to be spent on the improved material and electronic component. Thus, to reduce the cost of the production of the anti-theft donation box, a mass production should be implemented by making a big number of the donation box at the same time. This is because the mass production requires bulk purchase of the materials and electronic components which will reduce the cost spent on the materials due to the bulk purchase. In addition, the bulk purchase of materials can be done directly from its manufacturer and the price is much cheaper compared to buying one unit of material at the store.

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