PRODUCT DESIGN AND ANALYSIS OF AUTOMATIC MOTORIZED CAT FEEDER FOR LARGE CAGE SIZES

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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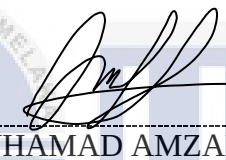
DECLARATION

I declare that this Choose an item. entitled " Product Design And Analysis Of Automatic Motorized Cat Feeder For Large Cat Cage" is the result of my research except as cited in the references. has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : 

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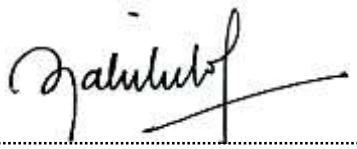
APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

Signature : 

Supervisor Name : *TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS*

Date : 12/1/2023

DEDICATION

I dedicate this project to the Almighty God, Allah SWT, the Creator of all entire beings in the universe. He has been this project's main source, strength, and inspiration. “He has given everything from Him as the pay for what the people have done their work”. I also dedicate this project to my family, especially my parents. My father, Md Noor bin Chik. Thank you for the great support you have given me for this entire life. My mother, Mrs Nuran Murni binti Ahmad. Thank you for being the best mother I have ever had. Thank you for being the greatest parent, raising me from when I was a child until to how big I am ke it is nothing. Not to forget, I dedicate this project to my supervisor, Ts. Dr Syahibudil Ikhwan Bin Abdul Kudus, my siblings, and my friends. Thank you for all the words, the motivation, the inspiration, and everything. Without their support and prayers, I may not be able to do this as far as I could.

ABSTRACT

This study aims to design and analyze a suiTable an automatic motorized cat feeder for large cage sizes. Using the Internet of Things (IoT) based cat feeder, can be enhanced with monitoring and controlling functions. The Internet of Things (IoT) develops a vast network of devices that exchange data regularly. Therefore, Consumers are increasingly interested in smart home devices and gadgets, which allow them to connect all of their devices for increased convenience, comfort, energy efficiency, and, most importantly, practicality, which is one of the project's main goals. The cat feeder system developed in this research is separated into two primary sectors which are measurements and control while the design structure is focused on the structure inappropriate position to be placed on a large cage size. To create an automatic cat feeder for large cage size, design research is conducted to comprehend the design structures, functions, materials, and applications of the cat feeder, and then design improvement and design for prototyping are implemented using SolidWork software. Secondary data were gathered and used as benchmarks to satisfy the intended functions of the cat feeder. Material selection and plateform design have been made as part of design modification and improvement. Furthermore, finite element analysis is carried out to analyse the cat feeder mounter and to ensure the fabrication of a cat feeder that can withstand maximum loads of up to 10 kilograms. Static analysis is used, and the result is a factor of safety of 28.57. Furthermore, prototype design verification is verified according to factor of safety and benchmarks from secondary data interpretation to fulfill project objectives. This shows the value of 28.57 factor of safety is safe under the design load. Polyamide-12 nylon powder are selected as material except mounter knobs and arduino components. Thus, the main prototype fabrication method is conducted by using SLS 3D printing machine. Arduino system code is writted by using Arduino software. Moreover, measuring instruments are used for dimensional inspection by manual method. Cat feeder is assembled and tested after fabrication. A usability test is conducted in order to gather user feedback, confirm the cat feeder's intended uses, and spot any unknown design flaws. Overall, the cat feeder is an alpha prototype, meaning that ongoing design improvement is required to satisfy the demands of the specific requirent. In the end, cat owners don't have to worry about feeding their pets and can watch over their caged cats from a distance.

ABSTRAK

Kajian ini bertujuan untuk merekabentuk dan menganalisis penyuap kucing bermotor automatik yang sesuai digunakan untuk sangkar kucing yang besar. Menggunakan penyuap kucing berasaskan Internet of Things (IoT), ia boleh dipertingkatkan dengan fungsi pemantauan dan kawalan. Internet of Things (IoT) membangunkan rangkaian peranti yang luas yang bertukar-tukar data secara tetap. Oleh itu, Pengguna semakin berminat dengan peranti dan alat rumah pintar, yang membolehkan mereka menyambungkan semua peranti mereka untuk meningkatkan kemudahan, keselesaan, kecekapan tenaga dan, yang paling penting, praktikal, yang merupakan salah satu matlamat utama projek. Sistem penyuap kucing yang dibangunkan dalam penyelidikan ini diasingkan kepada dua sektor utama iaitu pengukuran dan kawalan manakala bagi reka bentuk luaran tertumpu kepada struktur dalam kedudukan yang sesuai untuk diletakkan pada sangkar kucing yang besar. Untuk mencipta penyuap kucing automatik untuk saiz sangkar yang besar, penyelidikan reka bentuk dijalankan untuk memahami struktur reka bentuk, fungsi, bahan dan aplikasi penyuap kucing, dan kemudian penambahbaikan reka bentuk dan reka bentuk untuk prototaip dilaksanakan menggunakan perisian SolidWork. Data sekunder dikumpul dan digunakan sebagai penanda aras untuk memenuhi fungsi penyuap kucing yang dimaksudkan. Pemilihan bahan dan reka bentuk plat telah dibuat sebagai sebahagian daripada pengubahsuaian dan penambahbaikan reka bentuk. Tambahan pula, analisis unsur terhingga dijalankan untuk menganalisis pelekap penyuap kucing dan untuk memastikan fabrikasi penyuap kucing yang boleh menahan beban maksimum sehingga 10 kilogram. Analisis statik digunakan, dan hasilnya adalah faktor keselamatan 28.57. Tambahan pula, pengesahan reka bentuk prototaip disahkan mengikut faktor keselamatan dan tanda aras daripada tafsiran data sekunder untuk memenuhi objektif projek. Ini menunjukkan nilai 28.57 faktor keselamatan selamat di bawah beban reka bentuk. Serbuk nilon poliamida-12 dipilih sebagai bahan kecuali tombol pelekap dan komponen arduino. Oleh itu, kaedah fabrikasi prototaip utama dijalankan dengan menggunakan mesin pencetak SLS 3D. Kod sistem Arduino ditulis dengan menggunakan perisian Arduino. Selain itu, alat pengukur digunakan untuk pemeriksaan dimensi dengan kaedah manual. Penyumpan kucing dipasang dan diuji selepas fabrikasi. Ujian kebolehgunaan dijalankan untuk mengumpul maklum balas pengguna, mengesahkan kegunaan yang dimaksudkan oleh pemakan kucing dan mengesan sebarang kecacatan reka bentuk yang tidak diketahui. Secara keseluruhannya, penyuap kucing ialah prototaip alfa, bermakna penambahbaikan reka bentuk yang berterusan diperlukan untuk memenuhi permintaan keperluan khusus. Akhirnya, pemilik kucing tidak perlu risau untuk memberi makan kepada haiwan peliharaan mereka dan boleh mengawasi kucing sangkar mereka dari jauh.

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	-	Centimetres
kg	-	Kilograms
N	-	Newton
MPa	-	Mega-pascal
CAD	-	Computer aided design
SLS	-	Selective laser sintering
BOM	-	Bill of materials
3D	-	3-Dimensional
STL	-	Stereolithography
HOQ	-	House of Quality
QFD	-	Quality Function Deployment
PDS	-	Product Design Specification
R	-	Respondents

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CHAPTER 1

INTRODUCTION

1.1 Background

Raising animals is one of the long-standing human behaviors, according to Estep and Hetts in 1992 human-animal interactions can be defined as the degree of relatedness or distance between animals and humans(Anggraini et al., 2020). The relationship requires mutual individual recognition. Tactile, visual, olfactory, gustatory, and auditory stimuli from humans may be emphasized in animals. Whether or not the influence on an animal's behavior and physiology is good depends on the quality of human-animal relationships.

Cats are one of the world's most popular pets, and Malaysia is no exception. This animal has been a part of human life for around 6000 to 10000 years (Anggraini et al., 2020) . Humans and cats had a relationship approximately 4000 years ago in ancient Egypt. The Egyptians even considered the cat to be a sacred animal at the time. Cats have unique characteristics in Islam.

Cats are, in fact, animals that we usually see and are near."(HR. Abu Daud, An Nasa'i, Ibnu Majah, Ad Darimi, Ahmad, Malik at Tirmidzi.) This hadith is Saheeh, according to Syaikh Al Albani in Irwa'ul Gholil Number 173. The hadith says that because the cat is a clean animal devoid of najis, keeping one is accepTable and beneficial, if the cat is nurtured so that it loves its own family.

Feeding is one of the most vital aspects of cat ownership. Keeping a cat at home, on the other hand, takes time and effort. According to the results of the distributed questionnaires, 66.2 percent of the 77 respondents had forgotten to feed their pet cats on

occasion, due to forgetfulness and busyness. Under other circumstances, 76 percent of the 79 respondents with homecoming activities just leave the cat at home, either entrusted or abandoned, with the value of care to meet the cat's demands 63.1 percent above 5 (1 to 10 scale) of 65 respondents. Data from additional polls revealed that 87.3 percent of 79 respondents need a tool to assist cat keepers in solving the problem (Anggraini et al., 2020).

Singhania (2015) Has described how to create an autonomous pet monitoring and feeding system using the Internet of Things in "Automatic Pet Monitoring and Feeding System Using IoT." The goal of using the term in its current form is to provide a global answer to the issues that everyone in the world is currently experiencing. The system's goal is to minimize human interference with caring for pets in their busy lives. Only by automating the pet-care process is this feasible. This pet care system is an all-in-one piece of equipment for keeping an eye on your pet's activity. It also makes the pet feel free.

1.2 Problem Statement

Based on background research, cat owners may not be able to see their cats regularly due to work or travel. Despite their busy schedules, almost every Malaysian family owns a cat or more than one. Nowadays, owning a cat is difficult since the cat must be cared for while the owner is not around, especially when the owner has more than one cat. When feeding their cat and needing to feed their cat every day, time constraints become a burden on cat owners due to rushing for work and other preferences. Consider the fact that the owner must want to ensure that their cat gets fed at the same time every day, even if they are not at home. Cats are used to following a routine, whether their owners are aware of it. Another individual cannot be expected to follow the owner's schedule. Here are some problem statements from the background research:

1. Keeping a cat at home, on the other hand, takes time and effort
2. Cat owners always forget to feed their pet cats on occasion, due to forgetfulness and busyness.
3. Homecoming activities just leave the cat at home, either entrusted or abandoned.

As a result, a new product, the Automatic Motorized Cat Feeder for Large Cage Sizes, has been developed as a solution to this problem. Instead of asking neighbors or friends to feed the cats, the owner may now feed their cat whenever and wherever they want without having to leave the house by just clicking on a smartphone application. This could assist cat owners in providing proper diet management for their pets and assisting cats in living healthy lives.

1.3 Research Objective

From the problem statement explained above, several objectives need to be completed at the end of this project. The main objectives of this project are:

1. To design and develop automatic motorized cat feeder that matches a large cage size.
2. To develop and test the feeding mechanism of an automatic motorized cat feeder by using the Arduino system.
3. Analyze the design and system of an automatic motorized cat feeder through usability test for target users.

1.4 Scope of Research

This study focuses on a home cat that is inside a large cat cage that only receives food and does not receive water. In this project, Node MCU ESP8266 as the main controller works together with the Wi-fi module. Using this machine, the owner can feed their cats by Google Assistant from anywhere. However, the owner can feed their cats by using the IFTTT application. Both software and hardware will be used in the implementation of this design.

Moreover, the scope of this study describes the extent to which the research field will be investigated in the work and the parameters that will be used through the process. The automatic motorized cat feeder should be of high quality to maintain the product's durability and the appearance of it should be good looking.

The other main scope of this project is to examine the importance of automatic motorized cat feeders to ensure criteria based on user requirement by using Product Design Specification (PDS), Quality Functional Deployment (QFD), Pugh's method, and weighted rating method.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will cover definitions, information, past research related to the motorized cat feeder for a large cat cage, product design, Product Design Specification (PDS), Market positioning analysis, customer requirement analysis, and cat feeder system with IoT based. In addition, the research steps of this project will be covered in this chapter. This section will provide a summary of the prior research projects that have been completed. The references came from a variety of reputable and authorized sources, including books, journals, articles, and websites. Aside from that, this section discusses the advantages and disadvantages of past projects over this project.

2.2 Definition of automatic motorize cat feeder.

Working pet owners are busy with their jobs and assignments, thereby leaving the pet care duty unfinished. When pets are left alone for long periods during the day, it can cause a lot of anxiety. Owners are unable to provide constant attention to their pets due to the issue. Furthermore, pets accompanied by owners are not permitted to visit places where the owner is permitted. As a result, they are compelled to remain at home alone. This causes mental illness in pets, such as separation anxiety disorder and autism, as well as bad behavior and attacks on other animals. Furthermore, no one is responsible for caring for or feeding the pet on time. When a pet is left alone, it may go far away from home and be unable to return(Rao Kotekar et al., 2019).

Utilizing the pet implementation of the capability of location-awareness and helping pet owners easily teach their pets about behavior and feeding management, several works have discussed the enhancement. The investigation revealed that the pet monitor gadget, which was interested in Internet of Things (IoT) principles, had made major development, and met the requirements of pet owners looking for work without issue. The idea was to make it possible for pet owners to automate routine tasks such as feeding and monitoring(Liyanage et al., 2021).

New wireless-based inventions have emerged in the twenty-first century. Such advancements have begun to impact our lives in every aspect. The most significant alteration was brought about by the invention of the mobile phone. We've been able to get more intelligent devices with diverse features since then. Since most people nowadays bring mobile phones with them, they behave by engaging with smartphones(Liyanage et al., 2021). Since then, we have been able to obtain more intelligent equipment with a wider range of capabilities. Because most people nowadays carry mobile phones with them, they interact with them through their smartphones. The Internet of Things (IoT) is a new technology that is presently being catalyzed by mobile phones (IoT) (Liyanage et al., 2021) .

Product features are the characteristics or features that describe the product and define it from similar products on the market. Product features may help brands become more easily recognized in the market by highlighting the product and making it different and unique. Product analysis is examining a product's features, cost, availability, quality, appearance, and other aspects. As part of the product design process, product analysis can also be used to include a high-level product description into the final product and requirements. It includes all product-related information, such as the product's purpose,

operation, and characteristics. The sample features of the automatic motorized cat feeder for a large cat cage are shown in Figure 1 and Figure 2 below.

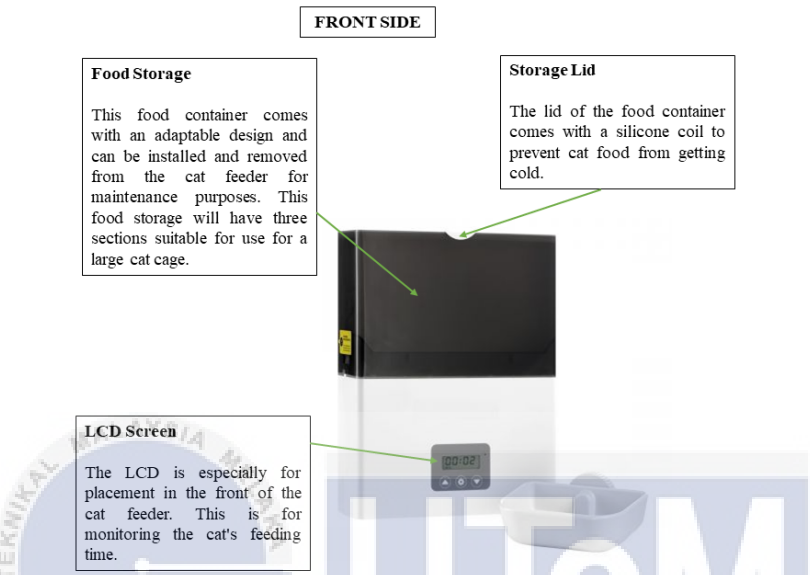


Figure 1 Feature Analysis front side of Motorized Cat Feeder

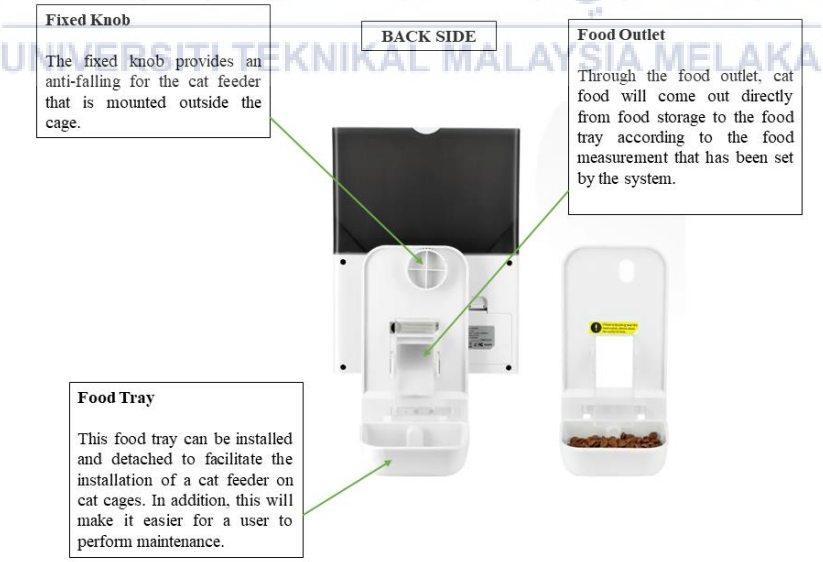


Figure 2 Feature Analysis back side of Motorized Cat Feeder

The concept of this kind of motorized car feeder is compact and convenient that will help cat's owner feed their cats from the cage easily and save space in the cage. Figures 1 and 2 show the motorized cat feeder for large cat cage feature analysis 1 where it has the food storage, storage lid, LCD screen, fixed knob, foot outlet, and food tray. The motorized cat feeder comes with an assembly and disassembles feature that will provide convenience for the user when they organize it. This feature will boost volume efficiency and make it easier to store and portable.

2.3 Specification Analysis of Cat Feeder

A product specification is a document that integrates useful information about a product by combining design, standards, technical requirements, and end-user requirements. Product specification analysis is a model that regulates product dimensions, parameters, manufacturing processes, and resources to manage standard product specifications to end application values. This sub-topic will look at the specifications and characteristics of 20 different motorized cat feeders currently on the market. This analysis could be useful during the concept design and development stages. The motorized cat feeder is described and evaluated based on important details such as size, features, material, style, function, and more.

Table 1 Shows the result of the specification analysis of the existing product

No.	Product	About the product
1	 New 2.3L Automatic Pet Feeder Cat Dog Food Dispenser for Cage or Kennel (www.bestdeals.co.nz) **Brand:** BestDeals.co **Price:** RM837.00 **Material:** ABS + PP **System:** Built-in infrared sensor and anti-jam system **Weight:** 1.7kg **Storage:** 2.3L **Dimensions (LxWxH):** 27 x 35 x 12cm	**Target Species:** Cat and Dog **Function**: Pet feeding **Number of Pets:** 1 pet **Dry Kibbles Diameter:** 2-10mm **Feeding Meals:** 4 Meals per day **Feeding Portions:** Up to 20 Portions Per Meal **Operation Mode:** Automatic **Structure:** • Easily Mounted onto the side of your pet cage • Square shape **Features:** • Recyclable • Digital timer programs up to 4 meals a day • built-in infrared sensor and anti-jam system to prevent food blocking **Potential Problems:** • Thin case • Low durability
2	 Smart WiFi Cage Feeder (Amazon.com) **Brand:** Dr. Feeder **Price:** RM230.00 **Material:** Acrylonitrile Butadiene Styrene **System:** APP Controlled by Phone **Weight:** 1.65kg **Storage:** 2.5L **Dimensions (LxWxH):** 14 x 10.5 x 4.4 inches	**Target Species:** Cat, dog, and hamster **Function**: Pet feeding **Number of Pets:** 1 pet **Dry Kibbles Diameter:** 2-10mm **Feeding Meals:** 8 Meals per day **Feeding Portions:** Up to 25 Portions Per Meal **Operation Mode:** Manual & Automatic **Structure:** • Easily Mounted onto the side of your pet cage • Square shape **Features:** • Simple and Convenient • Easy to clean • For various pets **Potential Problems:** Low-quality material

3	 500g Auto HANGING Pet Feeder (Shopee.com) **Brand:** No brand **Price:** RM19.00- RM19.00 **Material:** ABS **System:** • Natural gravity supply system • No electronic system **Power Source:** None **Weight:** 0.4kg **Storage:** 2L **Dimensions (LxWxH):** 24 x 12x 12cm	**Target Species:** Cat and dog **Function**: Pet feeding **Number of Pets:** 1 pet **Dry Kibbles Diameter:** 5-12mm **Feeding Meals: 3** Meals per day **Feeding Portions:** Up to 5 Portions Per Meal **Operation Mode:** Automatic **Structure:** • Compact design • Easy install **Features:** • Careful slope design, two-grain outlets, refuse to block grain • Open the top cover to add grain, convenient and quick • Built-in a safety box, strong lock fresh **Potential Problems:** • Just for 1 pet • For the short term
4	 PETLIBRO Automatic Cat Feeder (Shopee.com) **Brand:** PETLIBRO **Price:** RM290 **Material:** Stainless Steel **System:** Programmable **Power Source:** 3x alkaline D batteries **Weight:** 2.15kg **Storage:** 4L **Dimensions (LxWxH):** 7.5 x 7.5 x 12 inches	**Target Species:** Cat and dog up to 20kg **Function**: Pet food feeding **Number of Pets:** 1 or 2 pets **Dry Kibbles Diameter:** 5-10mm **Feeding Meals:** 1-4 Meals per day **Feeding Portions:** Up to 10 Portions Per Meal **Operation Mode:** Automatic and manual **Structure:** • Humanized Design • Easy Monitoring & Control **Features:** • Flexible Timed Feeding • Easy to Use & Maintain • Voice Recorder **Potential Problems:** • Programming buttons are too dark to see very well • The lid does not have a latch or anything to keep it on

5	 WellToBe auto pet feeder (Amazon.com) **Brand:** WellToBe **Price:** RM416 **Material:** Silicone, ABS **System:** • Programmable • Voice Recorder **Power Source:** Battery and Plug-in Power **Weight:** 2.68kg **Storage:** 4L **Dimensions (LxWxH):** 16.9 x 11.4 x 7.1 inches	**Target Species:** Cat and dog **Function**: Pet food feeding **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 2-12mm **Feeding Meals:** 6 Meals per day **Feeding Portions:** (about 1/16 cup) per meal for 1 portion **Operation Mode:** Automatic **Structure:** • Anti-blocking design • Anti-Clog Design **Features:** • Divides Meals Equally • Smart Program Panel • Feed Multiple Pets & Easy to Clean **Potential Problems:** • Set up was difficult and calculating the correct portions was a challenge • The bowls were flimsy and easily kicked around by my very food enthused cats
6	 Automatic Pet Feeder with 2 Splitters (Amazon.com) **Brand:** HoneyGuaridan **Price:** RM378.86 **Material:** Stainless Steel, ABS **System:** • Programmable • Premium Customizable Message Speaker **Power Source:** Battery and Plug-in Power **Weight:** 2.72kg **Storage:** 7L **Dimensions (LxWxH):** 10.63 x 8.66 x 16.34 inches	**Target Species:** Cat and dog **Number of Pets:** 1-3 pets **Function**: Pet food feeding **Dry Kibbles Diameter:** 5-20mm **Feeding Meals:** 6 Meals per day **Feeding Portions:** 1 to 48 portions of 12g/ 0.5 oz unit size (about 1/10cup) **Operation Mode:** Manual & Automatic **Structure:** • Ergonomic Operation Panel • Bulky Design **Features:** • Feed Multiple Pets & Transparent 7L Hopper • Unique Infrared Detection Design **Potential Problems:** • Product is made of extremely thin and cheap plastic • Bulky and ugly

7	 Automatic Pet Feeder with 2 Splitters (Amazon.com) **Brand:** U.S Solid **Price:** RM416.82 **Material:** Stainless Steel 304, ABS **System:** • Programmable • Sound record design **Power Source:** Battery and Plug-in Power **Weight:** 1.85kg **Storage:** 4.5L **Dimensions (LxWxH):** 14.65 x 7.6 x 7.56 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 5-15mm **Function**: Pet food feeding **Feeding Meals:** 1-40 portions according to your pet **Feeding Portions:** 5g per portion **Operation Mode:** Manual & Automatic **Structure:** • Visible Container • Flexible Portions **Features:** • Feed multiple pets in & a large visible food storage container • Simple to operate & thoughtful sound record **Potential Problems:** • One bowl always had way more than the other
8	 Automatic Pet Feeder with 2 Splitters (Amazon.com) **Brand:** HoneyGuaridan **Price:** RM416.82 **Material:** Polyethylene Terephthalate **System:** • Programmable • 10s Customized Meal's Calling **Power Source:** Battery and Plug-in Power **Weight:** 2.24kg **Storage:** 6L **Dimensions (LxWxH):** 11.81 x 7.48 x 13.58 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 5-12mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** About 6g/ 0.21 oz per portion **Operation Mode:** Automatic & Manual feeding option **Structure:** • Anti-Clog Design & Infrared Detection Design • Ergonomic Operation Panel **Features:** • Desiccant Bag Included • Smart Program Panel • 2-way splitter • Reversal mechanism and key locking lid to prevent the feeder from blocking and spillage. **Potential Problems:**

		One bowl always had way more than the other
9	 Automatic Cat Feeder for Two Cats (Amazon.com) **Brand:** PETLIBRO **Price:** RM404.09 **Material:** Polyethylene Terephthalate **System:** • Programmable • 10s Meal Call and Timer Setting **Power Source:** Battery and Plug-in Power **Weight:** 2.26kg **Storage:** 5L **Dimensions (LxWxH):** 7.7 x 10.2 x 14.2 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 2-15mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** About 1-50 portions per meal **Operation Mode:** Automatic & Manual feeding option **Structure:** • Secure Twist-Lock Lid • Patent rotor design **Features:** • AdjusTable Portions • Easy to Observe • Personalized Meal Call • Easy-to-read LED Display **Potential Problems:** • Too many steps to set the time • Portion sizes are very inconsistent and do not equally divide it
10	 ALUKE 7L Pet Feeder Food Dispenser for Two Cats (Amazon.com) **Brand:** ALUKE **Price:** RM357.73 **Material:** Polyethylene Terephthalate **System:** • Programmable timer • Voice Control & speaker **Power Source:** Battery and Plug-in Power **Weight:** 2.26kg **Storage:** 7L	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 4.8-19.8mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** 1 to 48 portions of 0.28 oz (about 1/16 cup)per meal **Operation Mode:** Automatic & Manual feeding option **Structure:** • Two-way Splitter • Anti-Clog Design **Features:** • Flexible meal scheduling • Infrared detection design & easy to clean **Potential Problems:**

	Dimensions (LxWxH): 16 x 8.86 x 11 inches	• The bin, if filled, gets too heavy and the gears do not work
11	 HoneyGuaridan Automatic Cat Feeder (Amazon.com) **Brand:** HoneyGuaridan **Price:** RM 333.19 **Material:** Stainless Steel & ABS **System:** • Voice Recording Dual Power Apply Food Alarm **Power Source:** Battery and Plug-in Power **Weight:** 2.68kg **Storage:** 4L **Dimensions (LxWxH):** 13.66 x 10.87 x 8.86 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 2-12mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** 1 to 80 portions of 0.28 oz (about 1/16 cup)per meal **Operation Mode:** Automatic & Manual feeding option **Structure:** • Two-way Splitter • Anti-Clog Design • Unique Infrared Detection Design • Ergonomic Operation Panel **Features:** • Easy to clean • Low Food Alarm • Customizable Message Speaker **Potential Problems:** • The dispenser didn't always dispense at the time it was set
12	 PetSafe Smart Feed Automatic Pet Feeder (Amazon.com) **Brand:** Petsafe **Price:** RM 253.19 **Material:** Stainless Steel & ABS **System:** • Smart Feed App (IoT) • Portion Control • Programmable Timer **Power Source:** Battery and Plug-in Power **Weight:** 2.55kg **Storage:** 4L	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 2-12mm **Function**: Pet food feeding **Feeding Meals:** 1-12 meals per day **Feeding Portions:** 1/8 cup to 4 cups per meal **Operation Mode:** Automatic **Structure:** • Two-way Splitter • Top-rack dishwasher safe **Features:** • Easy to clean • Monitors Food Level **Potential Problems:** • Does not work with 5G in house, only 2.4G

	Dimensions (LxWxH): 11.66 x 9.87 x 7.86 inches	• Motor-driven sprocket is very weak and no longer turns sprocket on conveyor
13	 HUICOCY Automatic Cat Feeders (Amazon.com) **Brand:** HUICOCY **Price:** RM 459.76 **Material:** 304 Stainless Steel and ABS **System:** • Programmable Timer • Voice Recorder **Power Source:** Battery and Plug-in Power **Weight:** 1.76kg **Storage:** 4.5L **Dimensions (LxWxH):** 14.68 x 7.64 x 7.64 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 1-10mm **Function**: Pet food feeding **Feeding Meals:** 1-4 meals per day **Feeding Portions:** 1-40 portions per meal (5g per portion) **Operation Mode:** Automatic & Manual **Structure:** • Prevent Tipping Over Design • 2-way Splitter • Clog-Free Design **Features:** • Easy & Friendly Operation • Monitors Food Level • 10s Voice Recorder **Potential Problems:** • The mechanism did not give out but 5-10 pieces of food per time even hitting the manual function
14	 XAOLAI Automatic Cat Feeders (Amazon.com) **Brand:** XAOLAI **Price:** RM 413.33 **Material:** 304 Stainless Steel and ABS **System:** • Phone APP Feeding & Support 2.4GHz Network • Voice Recorder **Power Source:** Battery and Plug-in Power **Weight:** 3.08kg **Storage:** 7L **Dimensions (LxWxH):** 18 x 9 x 9 inches	**Target Species:** Cat and dog (small and medium-size pets) **Dry Kibbles Diameter:** 2-15mm **Number of Pets:** 1-3 pets **Food Type:** Dry Food **Function**: Pet food feeding **Feeding Meals:** 1-10 meals per day **Feeding Portions:** 1-50 Portions Per Meal (Each Portion is about 6g) **Operation Mode:** Automatic **Structure:** • Inbuilt Desiccant Box • 2-way Splitter • Large Capacity Hopper **Features:** • Easy & Friendly Operation • Infrared Induction & Pet-Proof **Potential Problems:**

		• Bit hard to set up, and the instructions weren't very clear
15	  HBN Smart Pet Feeder (Amazon.com) **Brand:** HBN **Price:** RM 315.93 **Material:** Acrylonitrile Butadiene Styrene **System:** • APP control • Voice record **Power Source:** Battery and Plug-in Power **Weight:** 2.26kg **Storage:** 6L **Dimensions (LxWxH):** 9.7 x 13.8 x 9 Inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1 pet **Dry Kibbles Diameter:** 5-10mm **Function**: Pet food feeding **Feeding Meals:** 1-30 meals per day **Feeding Portions:** 10 Portions Per Meal (Each Portion is about 10) **Operation Mode:** Automatic **Structure:** • Removable Feed Container • Compact Design **Features:** • Easy & Friendly Operation • Offline Working And Backup Battery **Potential Problems:** • The type is extremely small as well and doesn't seem to match the specific product
16	 WellToBe Automatic Cat Feeder (Ubuy.com) **Brand:** WellToBe **Price:** RM 315.93 **Material:** Stainless Steel & ABS **System:** • Programmable Timer • Voice record **Power Source:** Battery and Plug-in Power **Weight:** 2.7kg **Storage:** 7L **Dimensions (LxWxH):** 15.75 x 10.63 x 9.06 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1-3 pets **Dry Kibbles Diameter:** 5-20mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** 1 to 48 portions of 12g/0.5 oz unit size (about 1/10cup) **Operation Mode:** Automatic & Manual **Structure:** • Anti-Clog Design • Ergonomic Operation Panel • 2-Way Splitter **Features:** • Easy & Friendly Operation • Customizable Voice Record **Potential Problems:** • Programming is less than intuitive • Dumps a portion out repeatedly and overfeeds the cats

17	 NPET Automatic Cat Feeder (Amazon.com) **Brand:** NPET **Price:** RM 248.62 **Material:** Stainless Steel & ABS **System:** • Programmable Timer • Voice record **Power Source:** Battery and Plug-in Power **Weight:** 2.69kg **Storage:** 6. L **Dimensions (LxWxH):** 16.06 x 8.9 x 8.11 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1 or 2 pets **Dry Kibbles Diameter:** 2-15mm **Function**: Pet food feeding **Feeding Meals:** 1-4 meals per day **Feeding Portions:** 1 to 39 portions of 12g/0.5 oz unit size (about 1/10cup) **Operation Mode:** Automatic **Structure:** • Anti-Clog Design • Press-lock Design • Removable food container **Features:** • User-Friendly Design • Desiccant Bag **Potential Problems:** • The portion sizes are incredibly small • There's not a lot of power in dispensing the food itself
18	 PETLIBRO Automatic Cat Feeder(Amazon.com) **Brand:** PETLIBRO **Price:** RM 235.85 **Material:** Stainless Steel & ABS **System:** • Programmable Timer • Voice record **Power Source:** Battery and Plug-in Power **Weight:** 1.9kg **Storage:** 3L **Dimensions (LxWxH):** 11.5 x 7.7 x 7.7 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1 or 2 pets **Dry Kibbles Diameter:** 2-15mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** 1 to 50 portions per meal **Operation Mode:** Automatic **Structure:** • Twist-lock Lid • Pet Poaching Proof • Detachable for Clean **Features:** • BPA-free Machine • Easy-to-read LED Display • Easy to Observe **Potential Problems:** • Poor quality • The molded plastic pieces have countless hard-to-reach spaces that are hard to clean and dry

19	 BLUE RISE Automatic Cat Feeder (Amazon.com) **Brand:** BLUERISE **Price:** RM 273.50 **Material:** Stainless Steel & ABS **System:** • APP control • Voice record **Power Source:** Battery and Plug-in Power **Weight:** 1.75kg **Storage:** 4L **Dimensions (LxWxH):** 13.74 x 7.95 x 7.76 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1 or 2 pets **Dry Kibbles Diameter:** 2-12mm **Function**: Pet food feeding **Feeding Meals:** 10 meals per day **Feeding Portions:** 12 portions per meal **Operation Mode:** Automatic & Manual **Structure:** • Secured Locking Lid • New Concept Food Bowl • Inbuilt Desiccant Box **Features:** • 10s Voice Recorder • Easy to Disassemble & Clean • Easy to Observe **Potential Problems:** • Poor quality • Storage design make the cat claw until getting scratch on it.
20	 WOPET Automatic Cat Feeder (Amazon.com) **Brand:** WOPET **Price:** RM 273.50 **Material:** Stainless Steel & ABS **System:** • APP control • Voice record • Camera **Power Source:** Battery and Plug-in Power **Weight:** 2.81kg **Storage:** 7L **Dimensions (LxWxH):** 13.7 x 9.8 x 15.3 inches	**Target Species:** Cat and dog (small and medium-size pets) **Number of Pets:** 1 or 2 pets **Dry Kibbles Diameter:** 2-15mm **Function**: Pet food feeding **Feeding Meals:** 1-6 meals per day **Feeding Portions:** 20 portions per meal **Operation Mode:** Automatic & Manual **Structure:** • Secured Locking Lid • Tough Structure **Features:** • 10s Customized Messages • HD Camera **Potential Problems:** • The wifi range is terrible • Difficult to set up

Based on Table 1, there is a variety of existing motorized cat feeders in the market. Before any product can be made, product analysis allows us to understand the necessary sizes, materials, styles, product characteristics, and functionalities. Identifying these decisions aids helped in the design and production of these project prototypes. From Table 2.1, A motorized cat feeder that can be used indoors or outdoors and is ideal for any environment was discovered., but the other suitability depends on the specific design such as special for a cat cage and not for a cat cage. Generally, the designers will choose an anti-clog design or two-way splitter features as the main feature of the design to make it easier for cat owners to feed more than 1 of their pets. Besides, the materials used are stainless steel or ABS as the main structure so the cat feeder will be lightweight and easier to do maintenance. In conclusion, motorized cat feeders offer advantages not only focusing on the design but can also be used as a substitute feeder device that will match any environment whether it is an indoor or outdoor concept.

2.4 Market Positioning Analysis of Cat Feeders

2.4.1 Market Segmentation-Positioning Map

1. **1st PM CHART: WIRE BOWL STRUCTURE VS APPEARANCE**

The first things that this project focused on in position mapping are bowl structure and appearance. The reason behind this decision is based on the appearance and the functionality of the product. It is because user tends to choose the multi-bowl feature that is convenient and easy to use. Based on our survey, there is a variety of sizes of products that single bowl or vice versa. So, decided to investigate which of these features were chosen by other companies and also users. Which bowl structure and appearance design that lead in the market.

Table 2 Bowl structure vs appearance

Position Map 1: Structure VS Appearance													
Bowl Structure **Single bowl** ⟷ **Multiple Bowl**							**Appearance** **Simple** ⟷ **Complex**						
-3	-2	-1	0	1	2	3	-3	-2	-1	0	1	2	3

2. 2nd PM CHART: PORTABILITY VS SPACES

The second things that these project would be focused on in position map are size and consolidation. This is the way to investigate whether products created by companies are usually easy to carry and organize. This is because many products in the market especially motorized cat feeders are commonly portable, washable, and detachable food storage. So, by using a position map, It can be varified whether that statement are right or wrong, and automatically it shows us the direction taken by companies to create motorized cat feeders.

Table 1 Size VS Consolidation

Position Map 2: Size VS Consolidation													
Size **Compact** ⟷ **Big-Size**							**Consolidation** **Easily fastened** ⟷ **Removal parts**						
-3	-2	-1	0	1	2	3	-3	-2	-1	0	1	2	3

Table 2 Rate-setting of existing product

 2.3L Automatic Pet Feeder	 2.5L Smart WiFi Cage Feeder	 500g Auto HANGING Pet Feeder	 PETLIBRO Automatic Cat Feeder
Structure: -3 Appearance: -3 Size: -2 Consolidation: -1	Structure: -3 Appearance: -3 Size: -2 Consolidation: -1	Structure: -3 Appearance: 1 Size: -3 Consolidation: 1	Structure: -3 Appearance: -2 Size: -1 Consolidation: 1
 WellToBe auto pet feeder	 Automatic Pet Feeder with 2 Splitters	 U.S Solid Automatic Pet Feeder with	 HoneyGuaridan Automatic Pet Feeder
Structure: 2 Appearance: 2 Size: 1 Consolidation: 2	Structure: 2 Appearance: 2 Size: 3 Consolidation: 2	Structure: 2 Appearance: 2 Size: 1 Consolidation: 1	Structure: 2 Appearance: -1 Size: 3 Consolidation: 2
 PETLIBRO Automatic Cat Feeder	 ALUKE 7L Pet Feeder Food Dispenser	 HoneyGuaridan Automatic Cat Feeder	 PetSafe Smart Feed Automatic Pet Feeder
Structure: 2 Appearance: 2 Size: 2 Consolidation: 1	Structure: 2 Appearance: 2 Size: 3 Consolidation: 3	Structure: 2 Appearance: 1 Size: 1 Consolidation: 2	Structure: 2 Appearance: 1 Size: 1 Consolidation: 2

 HUICOCY Automatic Cat Feeders	 XAOLAI Automatic Cat Feeders	 HBN Smart Pet Feeder	 WellToBe Automatic Cat Feeder
Structure: 2 Appearance: 2 Size: 1 Consolidation: 2	Structure: 2 Appearance: -2 Size: 3 Consolidation: -1	Structure: -3 Appearance: -1 Size: 2 Consolidation: -1	Structure: 2 Appearance: 1 Size: 3 Consolidation: 2
 NPET Automatic Cat Feeder	 PETLIBRO Automatic Cat Feeder	 BLUE RISE Automatic Cat Feeder	 WOPET Automatic Cat Feeder
Structure: -2 Appearance: 2 Size: 2 Consolidation: -1	Structure: -2 Appearance: 2 Size: -2 Consolidation: 1	Structure: -2 Appearance: 1 Size: 1 Consolidation: 1	Structure: -2 Appearance: -2 Size: 3 Consolidation: -2

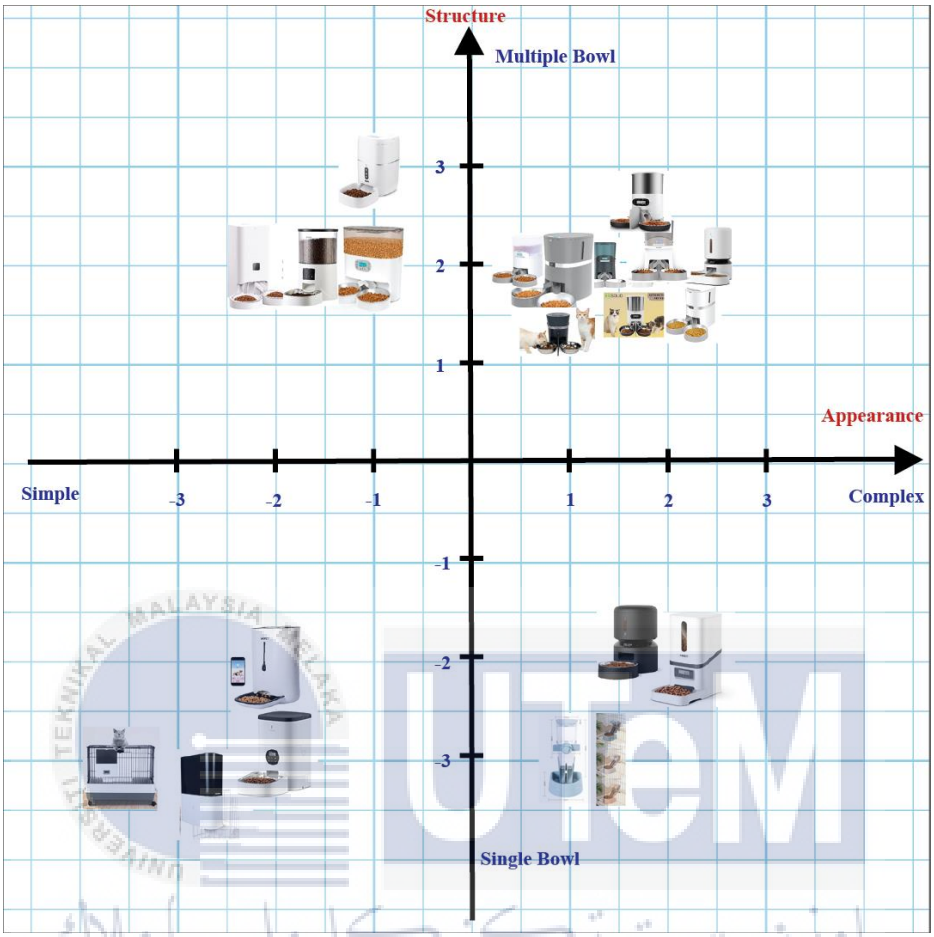


Figure 3 Position Map of Structure vs Appearance

Based on the result in the position map of structure vs appearance, we can conclude that many companies produce products with a complex appearance. Besides, it also has multiple bowls to feed more than 1 pet. This kind of product leads in the market more than other products because users prefer things that can feed their 2 or 3 pets at the same time. Besides, there are a few companies that make complex designs is due to ensure that the design is compatible with the system and features provided. There are several products specially designed for cages but just only have a simple appearance and one bowl structure which is it's just only suiTable for one pet in a small cage.

Table of Groups

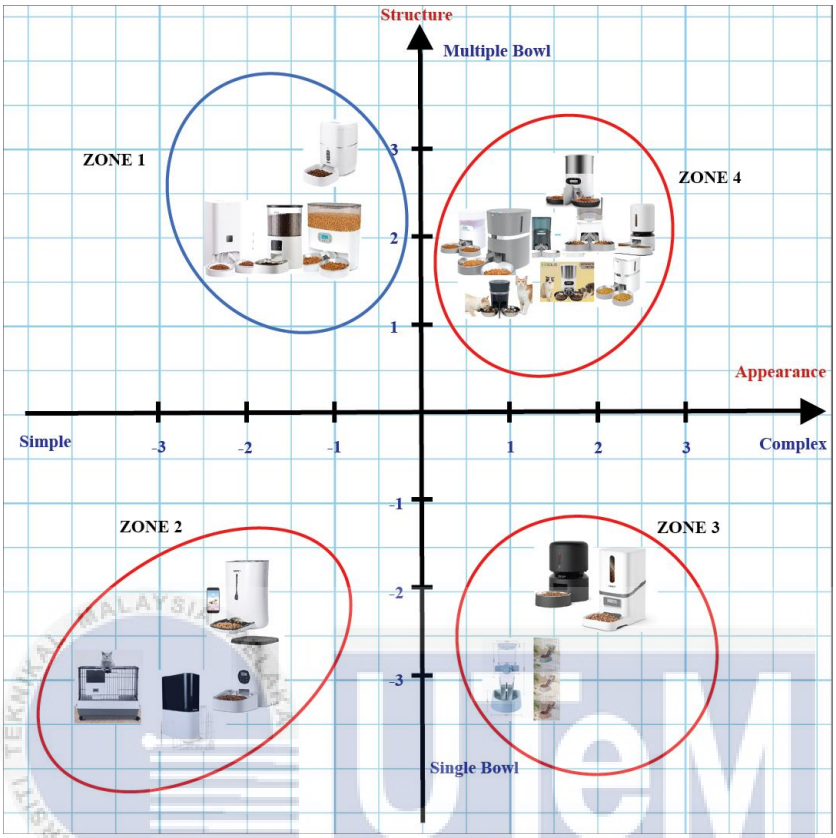


Figure 4 Sample Table of group

Table 5 Generates the Table for structure vs appearance

Zone	Description
1	Style: More towards geometric modelling (square and cylinder) Function: Can feed for 1-3 pets Appearance: Simple Design: Food storage on top and have one and two splitter food dispenser
2	Style: More towards geometric modelling (square and cylinder) Function: Can feed 1-2 pets inside the cat cage Appearance: Simple Design: Food storage on top and just only can dispense food from one way
3	Style: More towards modern style Function: Can feed for 1-3 pets exclude cat cage Appearance: Complex Design: Food storage on top and have one way food dispenser

4	Style: More towards modern style Function: Can feed for 2-3 pets Appearance: Complex Design: Food storage on top and have two splitter food dispenser

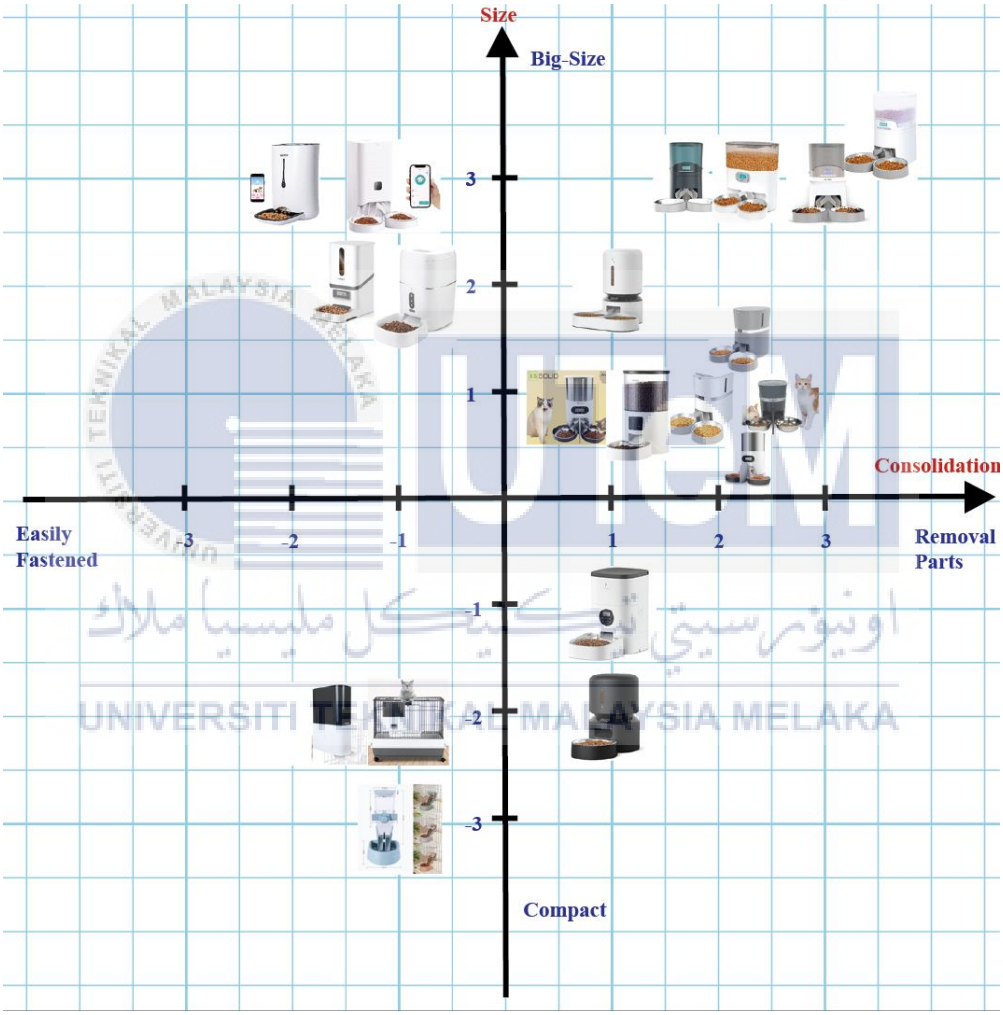


Figure 5 Position Map of Size vs Consolidation

Based on the result in the position map of size vs consolidation, it can be conclude that many companies produce products with a big size that focused on feeding more than 2 pets that can last for a few days because dry food can be filled for more than 5 liters. Besides, the consolidation shows a scale from 1 to 3 which is the products are removed parts because

users get easier to install and maintenance matters. This kind of product leads in the market more than other products because users prefer things that can save their time. Besides, there are a few companies that choose to make the products in an average size that focused on small and medium-sized pets.

Table of Groups

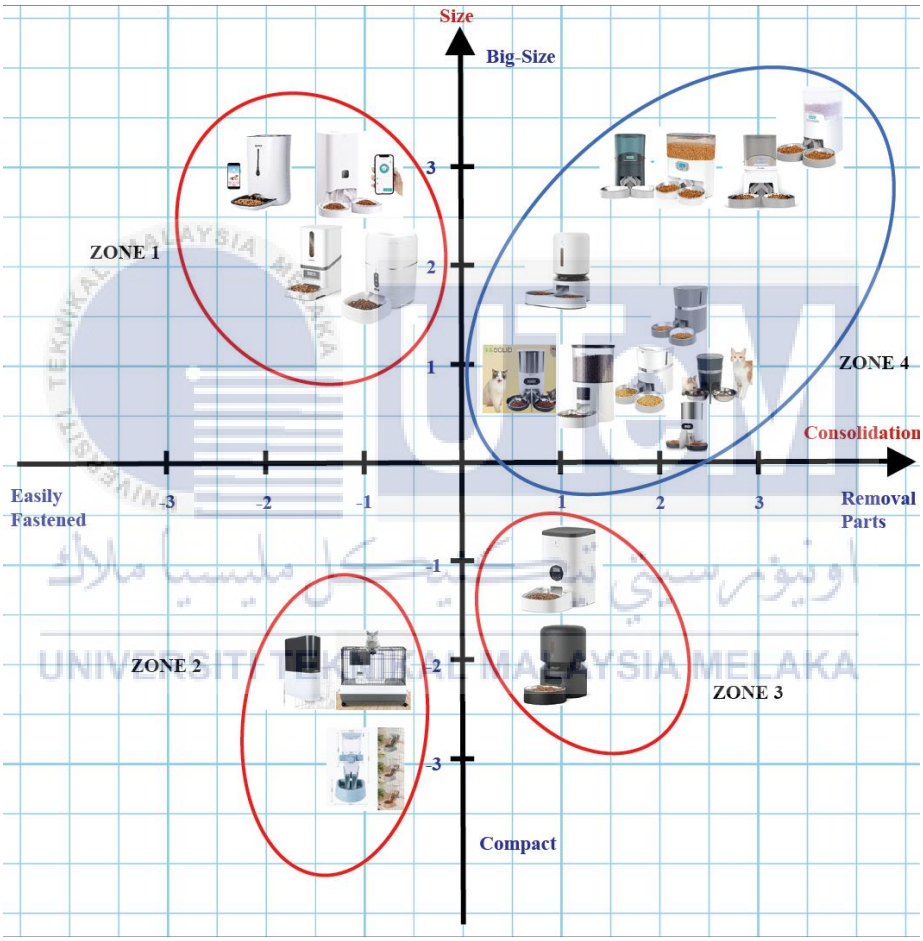


Figure 6 Sample table of group

Table 3 Generates the Table for size vs consolidation

Zone	Description
1	Style: More towards geometric modeling (square and cylinder) Function: Can feed 1-2 pets Size: Big Consolidation: Don't have many removable parts and have one food dispenser
2	Style: More towards geometric modeling (square) Function: Can feed 1-2 pets inside the cat cage Size: Compact Consolidation: A few parts can be removed
3	Style: More toward modern style Function: Can feed for 1-2 pets excluding cat cage Size: Compact Consolidation: A few parts can be removed
4	Style: More toward modern style Function: Can feed 2-3 pets Appearance: Complex Consolidation: A few parts can be removed

2.7 Internet of Things (IoT) Ecosystem

An IoT ecosystem consists of web-enabled smart data from a site to run on another. Cloud computing model is devices that use embedded systems, such as processors, attractive since it frees the business owner from the need to sensors and communication hardware, to collect, send and invest in the infrastructure, renting resources according to act on data they acquire from their environments (Sharma & Parveen Kantha, 2020).

The Internet of Things, or IoT, is a network of connected computing devices, mechanical and digital machinery, items, animals, or people that may exchange data across

a network without the need for human-to-human or human-to-computer interaction (Sharma & Parveen Kantha, 2020).

These web-enabled devices' connectivity, networking, and communication protocols are heavily influenced by the particular IoT applications that have been implemented. IoT can also employ machine learning and artificial intelligence (AI) to help make data collection processes simpler and more dynamic (Sharma & Parveen Kantha, 2020).

IoT is crucial to business in addition to providing smart home automation devices. Businesses may automate procedures and save money on labour thanks to IoT. However, it has also found use cases for organisations within the agriculture, infrastructure, and home automation industries, leading some organisations toward digital transformation. In general, IoT is most prevalent in manufacturing, transportation, and utility organisations, using sensors and other IoT devices (Sharma & Parveen Kantha, 2020).

Anyone who says that the Internet has fundamentally changed society may be right, but at the same time, the greatest transformation still lies ahead of us. Author identifies several new technologies are converging in such a way that the Internet is on the frontlines of a huge expansion as large and small objects become connected and take on their own web identity,(Sawane & Ekunde, 2019).This project aims to create a smartphone controlled home automation system that uses WI-FI and IoT and can be controlled and monitored remotely from any Android OS or IOS phone. The system is implemented using ordinary household appliances,(Irjet, 2019) .

The main controller in this project is a NodeMCU ESP8266, with a Servo motor to open and close the feeding storage and a 16x2 LCD to display the time. The time will be obtained from NTP servers. Instead of using the RTC module for Time and Date, the NTP

server used to save on hardware. NTP servers are a better solution for getting time than RTC because they are more accurate and can provide time for any location in the world.

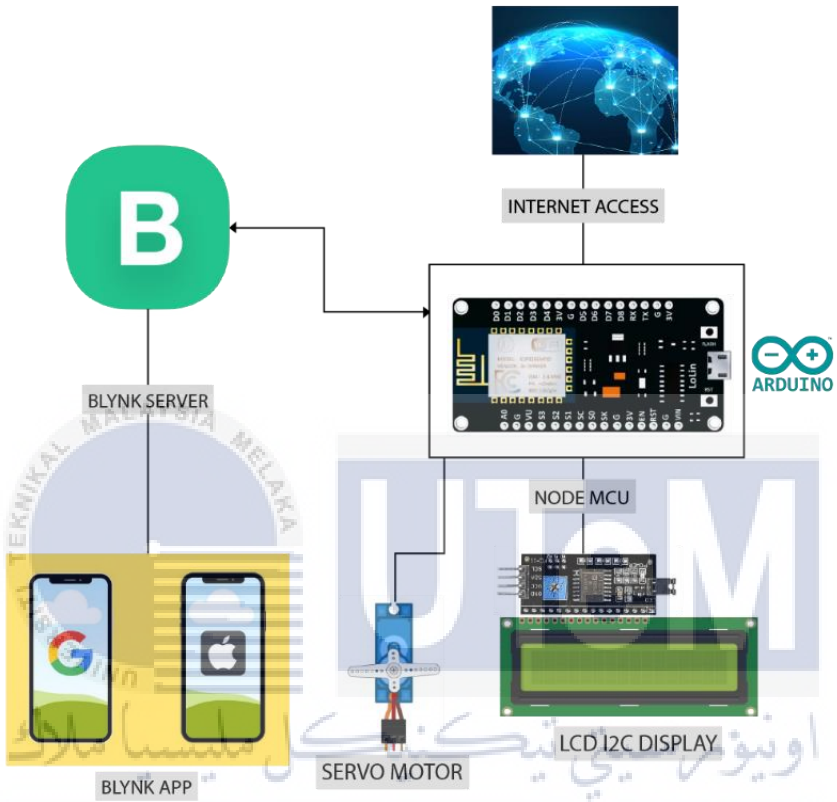


Figure 7 Diagram of the project

The microcontroller of NodeMCU will be programme using Arduino IDE by add the name of SSID and password of the internet access. The Blynk app eventually will be connected with the NodeMCU through the project authentication ID when the project at Blynk was create. Figure 2.27 show the connection of this project.

2.7.1 Components

i. NodeMCU ESP8266

Figure 8 NodeMCU ESP8266

NodeMCU is open source platform, it's hardware design is open for edit/modify/build. NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. Author describes The ESP8266 is a low-cost Wi-Fi chip with TCP/IP protocol developed by Espressif Systems (Parihar, 2019). The ESP8266 chip in NodeMCU is a highly integrated chip designed for the needs of the new connected world. It provides a complete and self-contained Wi-Fi networking solution, allowing it to host or offload all Wi-Fi networking functions from another application processor.

The ESP8266 NodeMCU has powerful on-board processing and storage capabilities, allowing it to be integrated with sensor-specific devices via its GPIOs with minimal development and runtime loading. Explain the significance of the work or make suggestions for applications and extensions (Parihar, 2019).

ii. 16x2 LCD Module

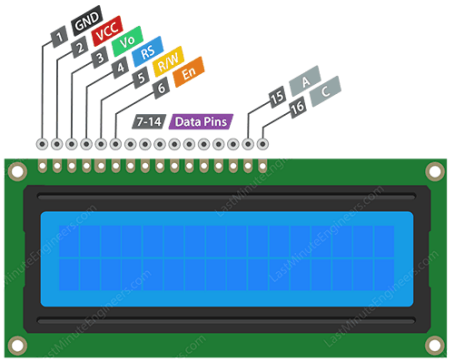


Figure 9 16x2 LCD Module

The name 'Character LCD' comes from the fact that these LCDs are ideal for displaying only text/characters. The display has an LED backlight and can show 32 ASCII characters in two rows of 16, each with 16 characters.

iii. LCD I2C Module

Figure 10 I2C Serial interface Adapter

Controlling an LCD panel can be difficult due to a microcontroller's/limited microprocessor's pin resources. With just two pins, serial to parallel adapters like the I2C serial interface adapter module with PCF8574 chip make work simple. A 16x2 LCD can be connected to the serial interface adapter, which has two signal output pins (SDA and SCL) that can be used to communicate with an MCU/MPU

iv. Servo Motor

Figure 11 Micro Servo gg SG90

A servomotor is a closed-loop servomechanism that controls its motion and final position using position feedback. The signal (analogue or digital) representing the position commanded for the output shaft is fed into the control. The SG90 Micro Servo Motor is a small and light server motor with a high output power. The servo can rotate 180 degrees (90 degrees in each direction) and works in the same way as the standard types but is smaller. To control these servos, you can use any servo code, hardware, or library.

Table 7 Micro Servo gg SG90 specification

Features	
Weight	9g
Dimension	22.2 x 11.8 x 31 mm approx.
Stall torque	1.8 kgf·cm
Operating speed	0.1 s/60 degree
Operating voltage	4.8 V (~5V)
Dead band width	10 µs
Temperature range	0 ºC – 55 ºC

2.7.2 Blynk App

Blynk is a mobile platform for iOS or Android that allows users to read or write bits wirelessly over the internet to control numerous microcontroller platforms including Arduino, Raspberry Pi, NodeMCU, and others. By just dragging and dropping the available widgets from this software, users may easily design the graphical user interfaces for their projects. It is a white-label mobile app IoT platform with private clouds, device administration, data analytics, and machine learning that is independent of hardware (Sharma & Parveen Kantha, 2020).

Blynk introduced End-user mode which is both makers and end users employ this mode. With the support of widgets and other panels that include detailed information about data that is set/sent/received to/from Blynk.Cloud and devices, it is focused on devices, automations, and notifications view and administration.

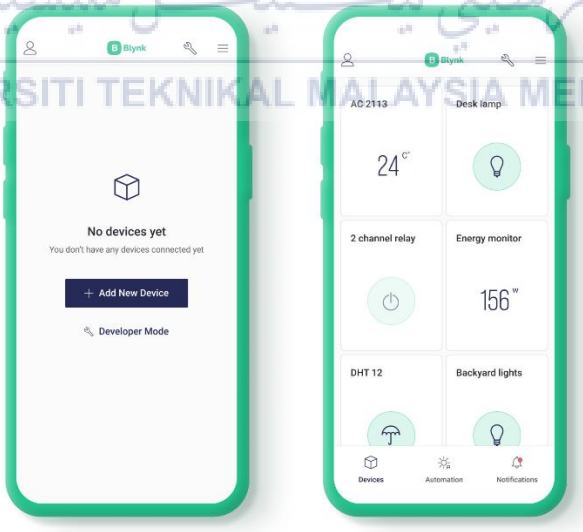


Figure 12 Devices tab (www.blynk.io)

When users open the app, this part is already open. Here, all newly created devices will be listed, and their interface will display in accordance with the type of template used.

Tap the top-right button in the navigation bar to access the Right menu and add a new device. There are also possibilities to rearrange the order of the devices. The middle button, labelled "Add new device," will take you directly to the device provisioning process if there are no devices present yet.

2.7.3 Arduino

Arduino is an open-source hardware and software platform created for computer programmers, industrial artists, professionals, and people interested in designing interactive devices and applications specifically for an interactive development environment (Zait Anat, 2018).

Figure 13 Arduino logo (www.Arduino.cc)

Various sensors and inputs can send signals to Arduino for processing. Arduino may modify the surroundings by manipulating light sources, motors, or other actuators. The Arduino development environment (based on "Processing" - an open source programming language and integrated development environment) and the Arduino programming language (based on "Wiring" - an open source framework for microcontrollers) are used to create and execute programmes for the microcontroller on the Arduino board (Zait Anat, 2018).

2.8 Selective Laser Sintering 3D printed

Selective Laser Sintering (SLS) is a rapid prototyping technique for creating complicated 3D parts by solidifying successive layers of powder material on top of one another(Wang & Laoui, 2006). Solidification is achieved by employing heat energy delivered through a laser beam to fuse or sinter specified portions of consecutive powder layers.

Selective Laser Sintering (SLS) is one of the most advanced powder bed fusion additive manufacturing processes for polymeric component fabrication. On the top surface, the SLS-printed specimens had a better finish than Multi Jet Fusion (MJF),(Cai et al., 2021). Before each layer is laser sintered, a powder deposition device is utilized to deposit consecutive thin layers of powders (usually 0.1-0.3 mm thickness) in a building container,(Wang & Laoui, 2006).

2.8.1 Material

Because of the wide range of temperatures between the onset melting temperature (during heating) and the onset crystallization temperature, polyamide 12 (PA12) is the most widely used polymer for both PBF processes (during cooling)(Cai et al., 2021). Adjusting the laser power, hatch spacing, and scanning speed for SLS investigated the effect of energy density on the density and mechanical characteristics of printed PA12 specimens. According to the findings of the experiments, a nonlinear equation was developed to characterize the relationship between energy density and tensile property to forecast the tensile characteristics of SLS-printed PA12 components.

Figure 14 Polyamide-12 powder

Table 8 Material specification (Polyamide-12 powder)

Type of Characteristic	**Material characteristic**
Part Density	0.95 g/cm3
Color	White
Melting Point(10℃ /min)	183 °C
Tensile Strength	46 MPa
Flexural Strength	46.3 MPa
Izod Impact Strength	4.9 KJ/m2

Table 9 Material Strength

Composition(CP)	(%) Virgin	(%) Reheat	(%) Recycled
1	100	0	0
2	400	20	40
3	0	0	100

- Virgin: material refers to a new manufacturer's material
- Reheat: material heating in the powder feeder chamber but never exposed to the laser beam (overflow powder)
- Recycled: un-sintering material and exposed to laser beam

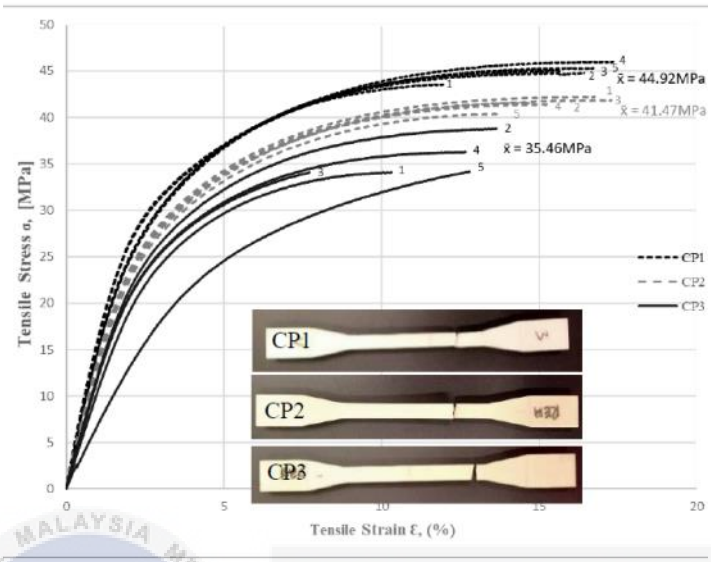


Figure 15 Testing result

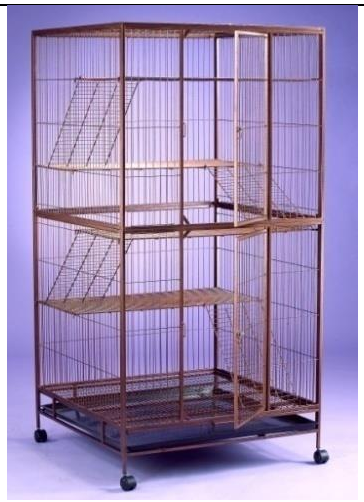
2.9 Type of Cat cage

Table 2.10 show a list of cat cages that are available in the Malaysian market. Each cat cage has different in terms of height, width, and length. The cat cage that has been listed is an excellent type that is suitable for the project.

Table 10 Type of large cat cage

No.	Cages	Specification
1	 (a) Collapsible Steel Cat Cage 6366 (www.pet.my)	**Measurement LxWxH:** 91.4 x 58.4 x 73.6 cm **Features:** Solid Platform & Double Doors

2	 (b) Steel Cat Cage C234 (www.pet.my)	**Measurement LxWxH :** 933 x 603 x 1283 mm **Features:** 2 front doors, knock down version cage **Accesories:** 1 plastic tray, 3 wire ladders, 3 metal shelves, castor wheels c/w brake
3	 (c) Steel Cat Cage C377RI (www.pet.my)	**Measurement LxWxH:** 107 x 69.3 x 151 cm **Features:** 2 front doors **Accesories:** 1 plastic tray

4	 (d) Steel Cat Cage 6335s (www.pet.my)	**Measurement LxWxH:** 89 x 89 x 175 cm **Features:** Two Doors & 4 Extra Large Platforms **Accesories:** 1 plastic tray
5	 (e) Steel Cat Cage 6358 (Economical Model) (www.pet.my)	**Measurement LxWxH:** 30 x 20.5 x 45 inches **Features:** 3 Two Doors **Accesories:** Come with 1 tray and wheels
6	 (f) Steel Cat Cage D670 (Economical Model) (www.pet.my)	**Measurement LxWxH:** 1778 x 889 x 1676 Height **Features:** Central Net (Can Split Into Two Cages) **Accesories:** Come with 1 tray and wheels

2.10 Summary

In brief, this chapter consists of a future analysis of automatic motorized cat feeders about product features are the characteristics or features that describe the product and define it from similar products on the market. Product specification analysis is a model that regulates product dimensions, parameters, manufacturing processes, and resources to manage standard product specifications to end application values. Depending on the outcome, the target market is determined for the automatic motorized cat feeder. Moreover, the cat feeder system uses the Blynk app that can be controlled and monitored remotely from any IOS and Android OS phone. Furthermore, 3d printed Selective Laser Sintering (SLS) and Polyamide-12 (PA12) powder were studied for prototype purposes.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter focuses on the progress flow of this project. A progress flow chart and project planning chart are used to illustrate the sequences of the tasks of the project. At the same time, the methods used, and the implementation steps of the methods will also be introduced.

3.2 Project Planning

The project planning is a guideline for planning project progress to guarantee the project runs smoothly and that all tasks and deadlines are achieved. It aids in the improvement of project time management. The status and progress of the project may also be easily checked using the Gantt Chart. As a result, the efficiency of this project will increase if the tasks are proceeding according to the timeframe planned at the beginning. A Gantt chart may be used for any sort of project or to improve our work. Creating and executing a project correctly will make a significant impact on us.

Moreover, Gantt charts are widely used to track project timelines. It is helpful to be able to provide extra information about the project's different tasks or stages, such as how the activities connect, how far each task has progressed, what resources are being utilized for each work, and so on.

To build a Gantt chart, First, identify high-level activities and then break them down into smaller actionable subtasks. It also can determine the effort and duration 82 necessary for those smaller groups of activities, as well as link and sequence project tasks. Following

that, it is time to create a bar chart for each task. MS Excel is used to create Gantt charts since it is the simplest method for producing a Gantt chart. The interactive Gantt chart makes it even faster and easier. Finally, a Gantt chart will provide the designer with a clear knowledge of what must be done to complete a certain project and can aid in the development of a healthy scheduling process.

According to the Gantt chart shown in **Appendix A** which is associated with the progress flow chart shown in Figure 3.1, the project is planned to start from December 2020 until January 2022. The project starts with the topic discussion of the project and the project is divided into 4 stages, which are data collection, data analysis, product development, and result and testing. Each task in the stages is given a long period for completion to ensure the flexibility of the task and reduce future modifications. Besides, 4 important dates are marked on this Gantt chart as a reminder, which are the submission of the PSM 1 report, the PSM 1 presentation, the submission of the PSM 2 report, and the PSM 2 presentation.

The Gantt chart, on the other hand, is a visual representation of the project's timeline. The Gantt chart in this project shows that most of the tasks are scheduled to run simultaneously. As a result, task completion times might become longer and more flexible. Furthermore, running tasks concurrently speeds up the process of the project and saves time since some of the tasks in different stages are related to each other. As an example, the task "design sketch" can be started along with some tasks in the data analysis stage and the modification can be carried out concurrently to avoid a waste of time.

3.3 Identifying Customer Needs

3.3.1 Need Statement

Methods to Identify Customer Needs:

1. Questionnaire Analysis

Purpose of this survey using questionnaire is to know respondent's experience using automatic cat feeder, main problem and their opinion about possible improvement that can be made to the cat feeder product that existing in the market. Based on the position mapping result, user's interest can be indentified about the type of products. In turn, that will allow for a making good questionnaire. According to the Questionnaire shown in **Appendix B** The questionnaire started by testing the extent of respondent's knowledge of cat feeder, so that their interest about the product can be verified as well as make user understand the content that the project focused on.

After that, respondents were also asked about difficulties of existing products because the main purpose is to detect the main problem among existing products. So, idea to solve the problem will come out. Moreover, respondents were also asked about possible improvements to the existing product. The reason are to get their honest opinion, so that this questionnaire can follow their demands. Furthermore, respondents were asked about features that suiTable for automatic cat feeder because it will be apply to this project. This survey will help researcher to follow the right path to create automatic motorized cat feeder product that can fulfill user demand and standard.

3.4 Methods

To increase the quality of the product and the product design and development process, several quality tools, design aids, and planning tools are implemented in this project 83 for data collection, data analysis, and decision selection. For example, customers' requirements and opinions are collected using a user questionnaire survey. These questionnaire surveys are conducted early in the project to keep up with the continuously changing requirements, trends, and current market situation of the clients.

This project's questionnaire survey includes closed-ended questions, open-ended questions, and a Likert scale. A closed-ended question can only be answered with "yes" or "no," and it is designed to generate a quick response and a specific piece of information. The open-ended question, on the other hand, frequently gives a variety of solutions as well as a more in-depth response. It's beneficial to learn about someone's situation and opinions. The Likert scale, on the other hand, is a rating scale with five response alternatives that are meant to measure a respondent's sentiments or opinions about something directly.

Moreover, House of Quality (HOQ) is used by the product development team to get all the information from the customer requirement and tools for doing product planning. After the conducted HOQ, an analysis of existing products may be used to collect customer requirements. In the current market, there are many different types of automatic motorized cat feeders made by various designers, and those designs may be categorized based on their brand, appearance, function, material, mechanism, assembly, size, and component amounts. 20 Specification analysis and consumer image map analysis can be used to document and evaluate this data.

All product information will be investigated and documented on a Table for easy comparison during the specification analysis. The consumer image map analysis, on the

other hand, allows the user to highlight the features of existing products. Existing products will be rated based on specific criteria, and the results will be displayed in the form of a visual graph. The current products with the highest sales and popularity may be referred to as the products that have a specification that fulfills the customers' satisfaction and requirements by referring to these analyses.

The thesis, journal, articles, and books may all provide data and information regarding the multipurpose bookshelf. These resources may be used to develop the multipurpose bookshelf and enhance the design process by looking at the research background, purpose, methods used, and results.

The integration of the QFD method is used to define the customers' requirements since this QFD allows the user to translate the customers' voices into technical characteristics. Meanwhile, Pugh's method and Weighted Rating Method are concept comparisons and evaluation matrices applied to a hypothetical example. So, this method is used to filter all concepts to the final concept.

As indicated in Chapter 1 Background, owning a cat is difficult since the cat must be cared for while the owner is not around, especially when the owner has more than one cat. When feeding their cat and needing to feed their cat every day, time constraints become a burden on cat owners due to rushing for work and other preferences. To solve these issues, an automatic motorized cat feeder for large cat cages that may be created based on criteria like easy monitoring, minimalist, ease of cleaning, and ease of installation is chosen. These statements, however, will not be the ultimate decision because consumer requirements and the present market scenario are always changing. As a result, putting the methods discussed above into action is critical to ensuring 20 existing products of the automatic motorized cat

feeder meet consumer expectations while also enhancing the product design and development process.

3.5 Research implement

The research steps in this project involve the integrated QFD method with several steps. The first step is to start with designing and conducting the user questionnaire survey. The questionnaire survey is conducted to get the user's needs. Following the collection of these responses, the prioritized criteria may be determined using the integrated QFD.

Besides that, the final design can be verified according to the design direction and any other specifications related to it after selecting the final design. Then, we could sketch idea concepts through the Sketchbook Software before a CAD drawing was created. By using Pugh's Weighted Rating Method, the Design team would be able to get the final concept through these methods. The CAD design drawing will be created by using Solidworks software. Furthermore, the prototype-making is started right after the CAD drawing is completed where it starts with buying the material and printing the converted part from software to (.Stl). After that, the printed pieces of the material is been assembled using a screw driver. Lastly, the mission form and design validation questionnaire survey for this project are conducted where the mission form is conducted to test the prototype while the design validation is conducted after they have tested the prototype.

3.6 Prototype Test

At the end of Chapter 4, a usability test will be conducted to collect user feedback on the prototype to identify usability difficulties and present discovered problems for future study to develop the automatic motorized cat feeder for large cage size.

3.7 Summary

In a nutshell, the progress Gantt chart is used as a project planning tool in the early stages of a project to improve the project's efficiency and smoothness of progress without missing any tasks within the time given. Other than that, questionnaire analysis to determine the design direction, design needs, and design preferences of the automatic motorized cat feeder by analyzing each section of the questionnaire survey. There are numerous ways to data collecting and analysis, including questionnaire surveys, referring to resources, and existing product analysis. For data analysis, specification analysis, consumer position map analysis, and the QFD method are employed. For the final concept screening method, Pugh's and Weighted Rating Methods are employed.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter aims to describe the concept selection using the integrated QFD, along with the results step by step. Besides, this chapter also consists of the preliminary research and the result. This method's main tool is the House of Quality, where all the data will be analyzed and documented by using the House of Quality. Furthermore, this chapter also consists of Concept Design Development starting from explorative until explanatory sketches to obtain the final concept by using Pugh's Method and Weighted Rating Evaluation Method.

4.2 Survey of User Requirement

This questionnaire contains three part which is section A, section B and section C. Purpose of this questionnaire is to know respondents' experience using the existing product of automatic motorized cat feeder and users' demand to improve the existing product in the market. The questions were divided into 3 sections because it more organized and each section has a different purpose. The personal information of respondents was decided to focus in section A to identify a range of ages, gender, and occupation that commonly have experience with cat care and opinion of user's requirement for automatic motorized cat feeder products. Furthermore, section B contains 11 questions in total. This part is focused on respondents' experiences with cat care, their opinion as well as suiTable improvement for existing products in the market. Other than that, section C contained 17 questions and has 5 levels important

based on respondents' demands such as product preference, safety, ease of use, and convenience.

After the link of the questionnaire surveyhasbeen sent out, there are 45 respondents answered this questionnaire. Based on the results, the range of age is various from 19 to 60 years old, and this helps to know respondents' opinions for creating the best design based on user demand. Also, their demand will be applied to the design of this project.

4.2.1 Result of Survey

SECTION A

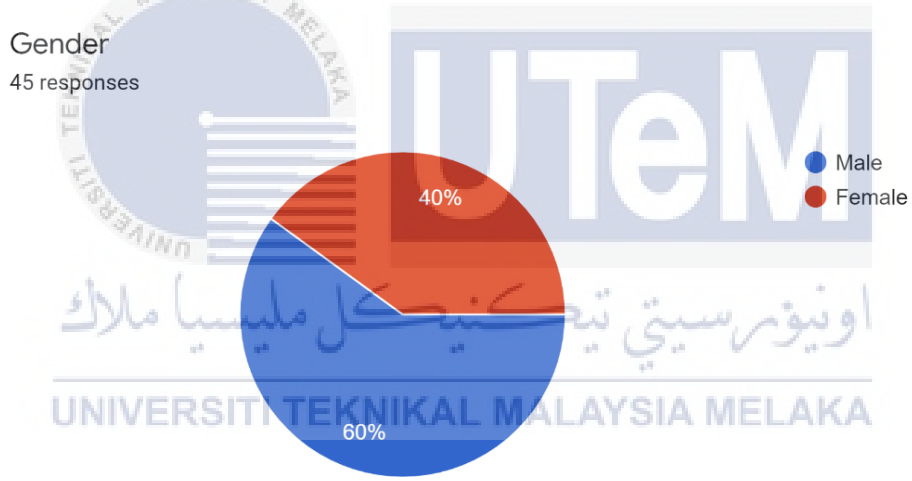


Figure 4.16 Analysis of gender

For question 1, percentage for female who answer this survey are 40% which is 18 responses and for male 60% which is 27 responses only. This show male answer more than female.

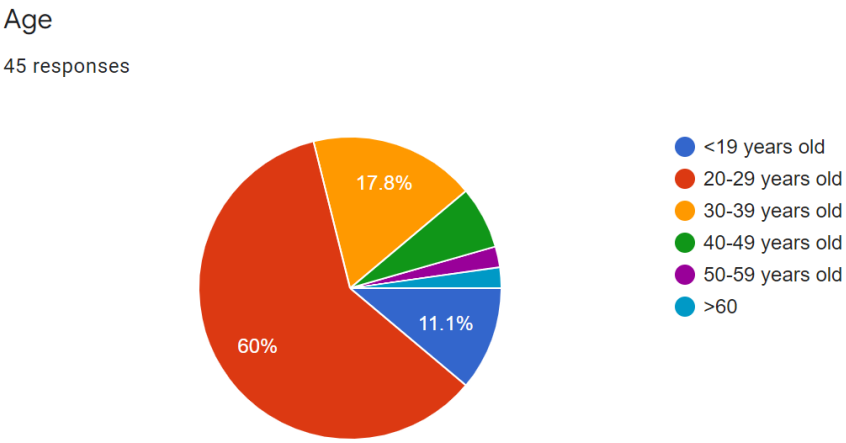


Figure 4.17 Analysis of age

For question 1, Majority age that answer this question is between 20 to 29 which made the percentage is 60%. Group of age such as 19 years and below received 11.1% and group of age 30 to 39 received 17.8%. While others group of ages only received 11.1%. This question show tat age from 21 to 29 are most commonly have experience with cat care scenario.

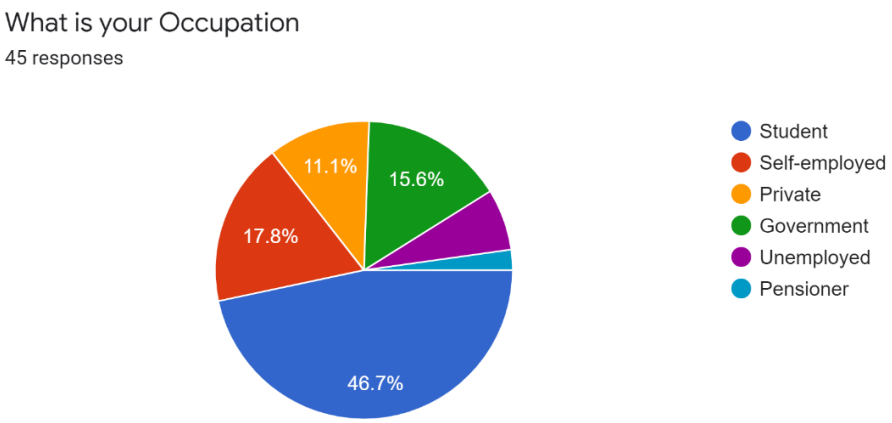


Figure 4.18 Analysis of occupation

Percentage the lead in this question are 46.7%, means 21 student are majority responses this question. Moreover, group of self-employed received 17.8% meanwhile group of private received 11.1% and government received 15.6%. Only 3 respondents are unemployed.

SECTION B

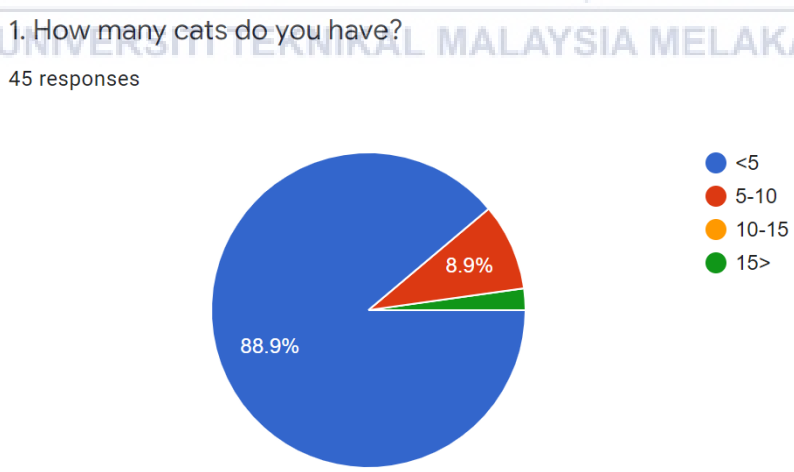


Figure 4.19 Analysis of the number of cats kept by the respondent

Based on this question, 88.9% respondents have less than 5 cats meanwhile 8.9% respondents have in range 5 to 10 cats. Only one respondent have 15 cats and above. This show that majority respondents only have less than 5 cats.

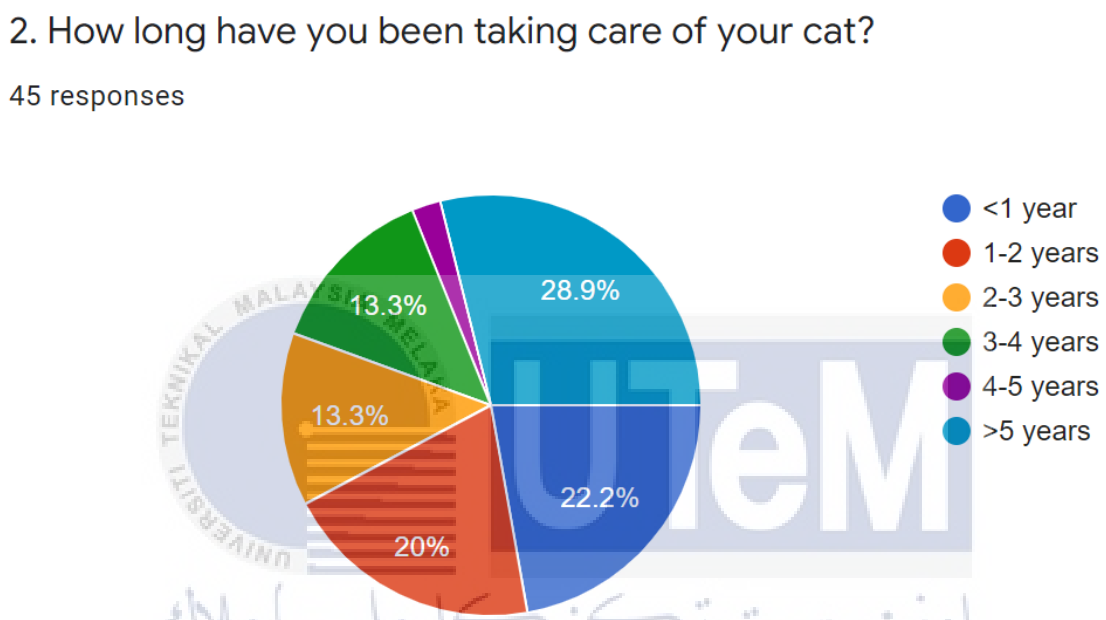


Figure 4.20 Analysis of how long respondents kept their cats

Based on this question, there are 22.2% kept cats for less than a year. 20% kept cats in range 1 to 2 years, 13.3% kept cats in range 2 to 3 years and 28.9% respondents kept cats in 5 years above. For group of range 4 to 5 years only received 2.2% . This show that majority respondents have experience keeping cats for over 5 years.

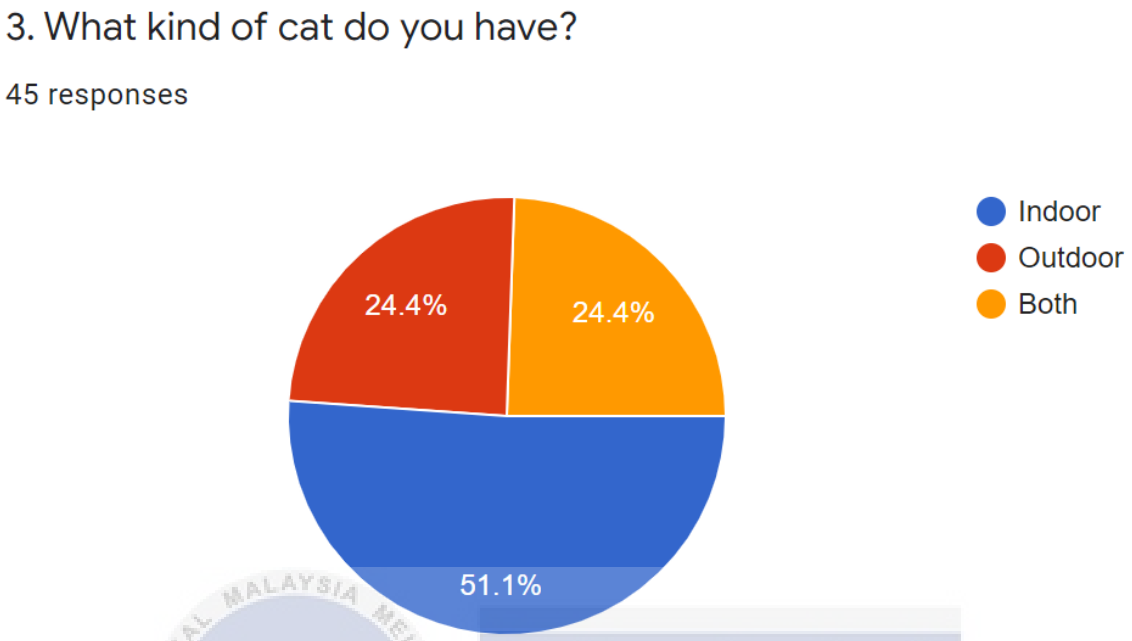


Figure 4.21 Analysis of kind of cat

The result show that group of indoor cats received 51.1% meanwhile outdoor cats only received 24.4%. Only 24.4% respondents have both kind of cats. This show that majority respondents own indoor cats compared to outdoor cats.

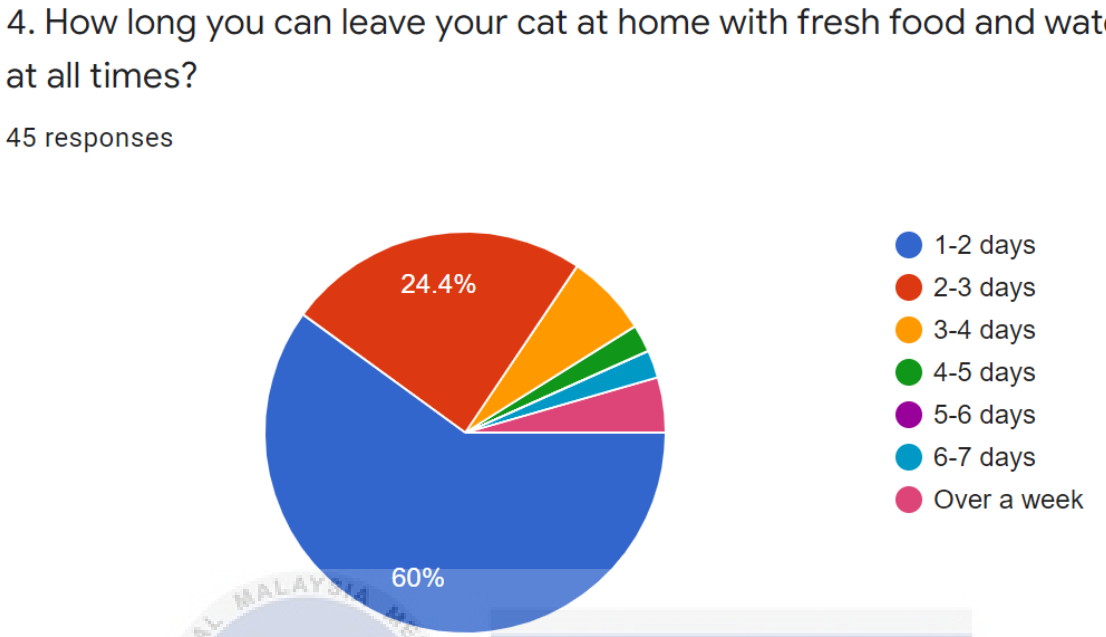


Figure 4.22 Analysis of range of days when leaving the cat at home with food and water

Based on the result, group of range 1 to 2 days received 60% meanwhile group of range 2 to 3 days only received 24.4%. Moreover, group of range 3 to 4, 5 to 6, 6 to 7 and over a week only received 17.7% for the overall total. This show that majority respondents were only confident to leave their cats at home for less than 2 days.

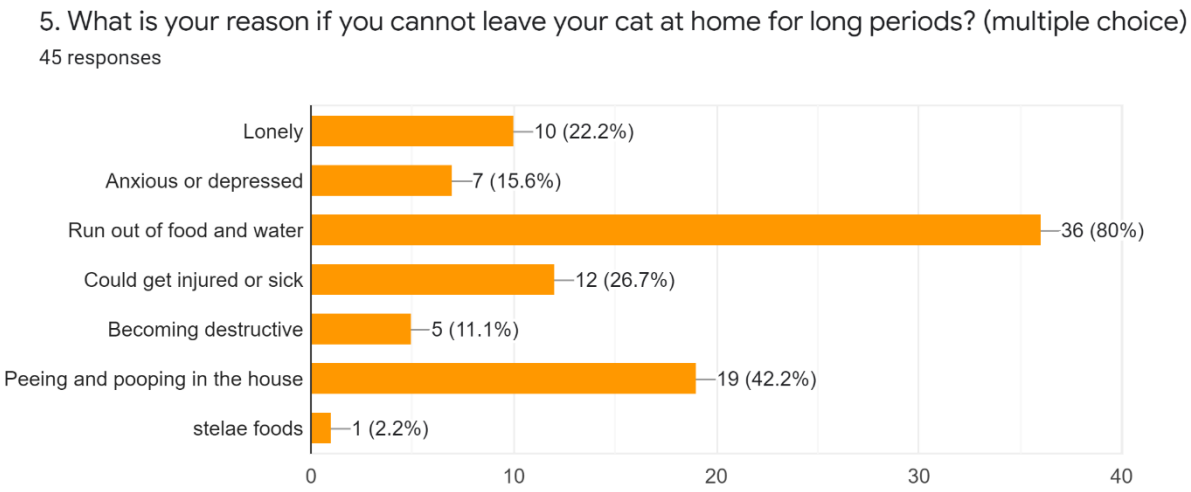


Figure 4.23 analysis of respondent's reason why they cannot leave their cat at home

Based on the result, 22.2% of respondents know that leaving their cats at home can make their cats lonely. 15.6% of respondents stated that their cats will be anxious and depressed when they leave their cats at home. 80% of respondents chose to run out of food and water. 16.7% of respondents agreed that their cats becoming destructive. 42.2% of respondents agreed that their cats will pee and poop in the house and only 2.2% thought that cat food would go stale over a long period. This shows that most respondents worried about running out of food and water when they leave their cats for a long period.

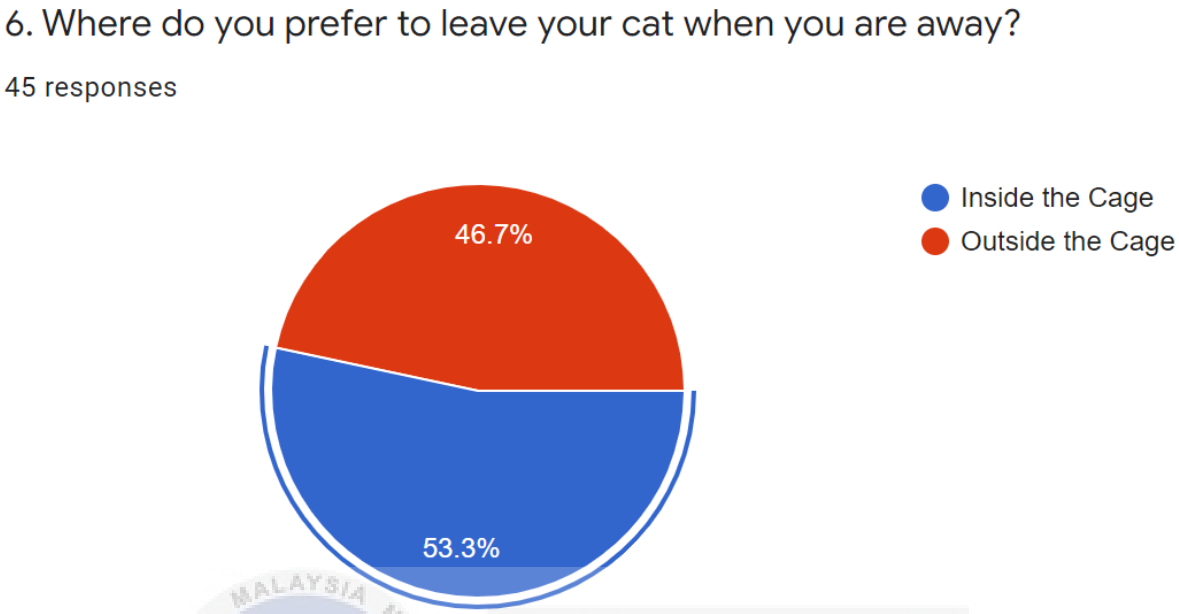


Figure 4.24 analysis of cat circumstance at home when owner are away

Based on the result, 53.3% of respondents preferred to leave their cats inside the cage meanwhile 46.7% preferred to leave their cats outside the cage when they are away. This show that the majority of respondents choose to leave their cat inside the cage compared to outside the cage.

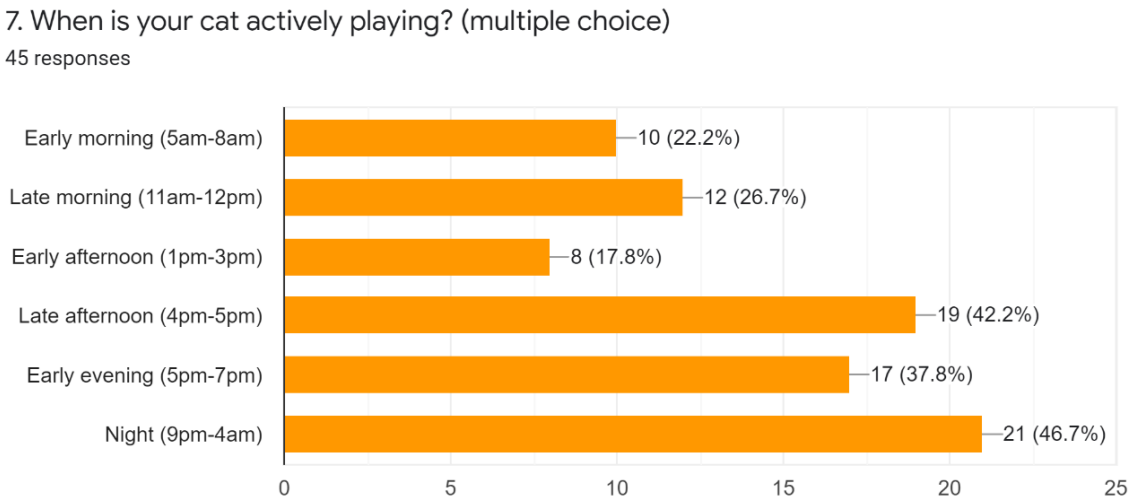


Figure 4.25 analysis of cat play time

The result shows that 51.1% which is 23 of the respondents have an active cat playing early morning in the time range 5am to 8am. Moreover, 26.7% which is 12 of the respondents have an active cat playing late morning in the time range 11am to 12pm. 17.8% which is 8 of the respondents have an active cat playing early afternoon in the time range 1pm to 3pm. 42.2% which is 19 of the respondents have an active cat playing late afternoon in the time range 4pm to 5pm. For group of early evening in the time range 5pm to 7pm received 37.8% which is 17 of the respondents and for group of night in the time range 9pm to 4am received 46.7% which is 21 respondents. This show that majority respondents have an active cat playing at night in time range 9pm to 4am.

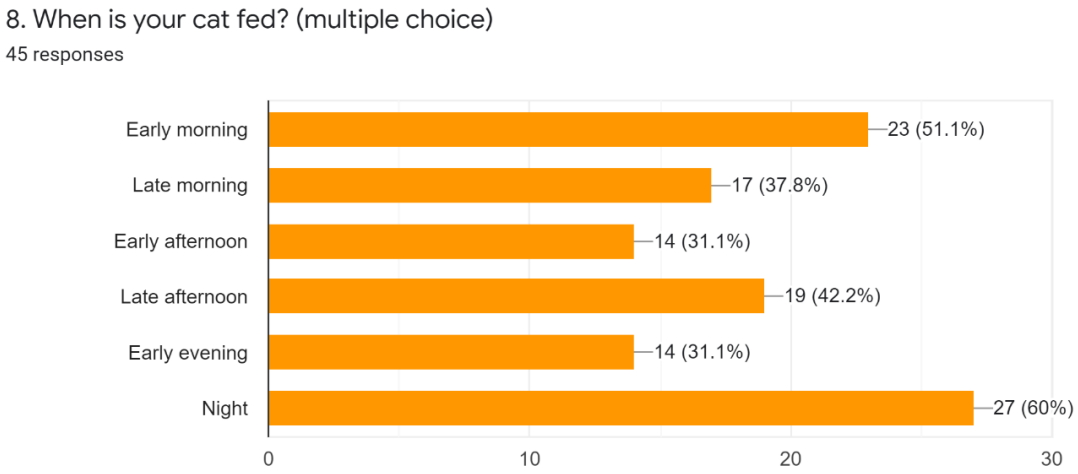


Figure 4.26 analysis of cat mealtime

Based on the result, 51.1% which is 23 of the respondents feed their cats in the early morning. 37.8% which is 17 of the respondents feed their cats in the late morning. 31.1% which is 14 respondents feed their cats in the early afternoon. 42.2% which is 19 of the respondents feed their cats in the late afternoon. 31.1% which is 14 of the respondents feed their cats in the late evening. 60% which is 27 of the respondents feed their cats in the night time. From this analysis, mostly respondent feed their cats in early morning, late afternoon, and night.

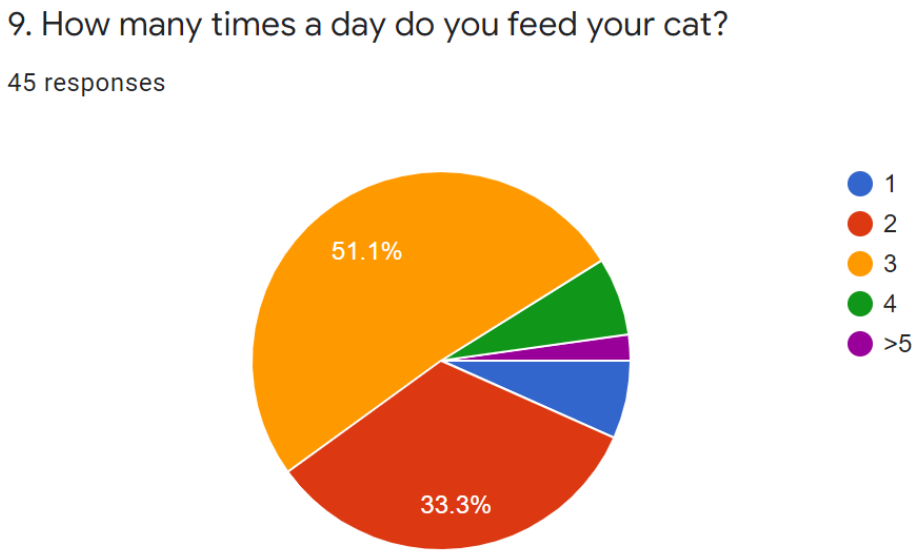


Figure 4.27 Analysis of cat mealtimes per day

The result shows that 51.1% of the respondents feed their cats 3 times a day. 33.3% feed their cats two times a day. 6.7% feed their cats once a day. 6.7% feed their cat four times a day and only 2.2% feed their cat more than five times a day. Majority of the respondents feed their cat 2 or 3 times a day.

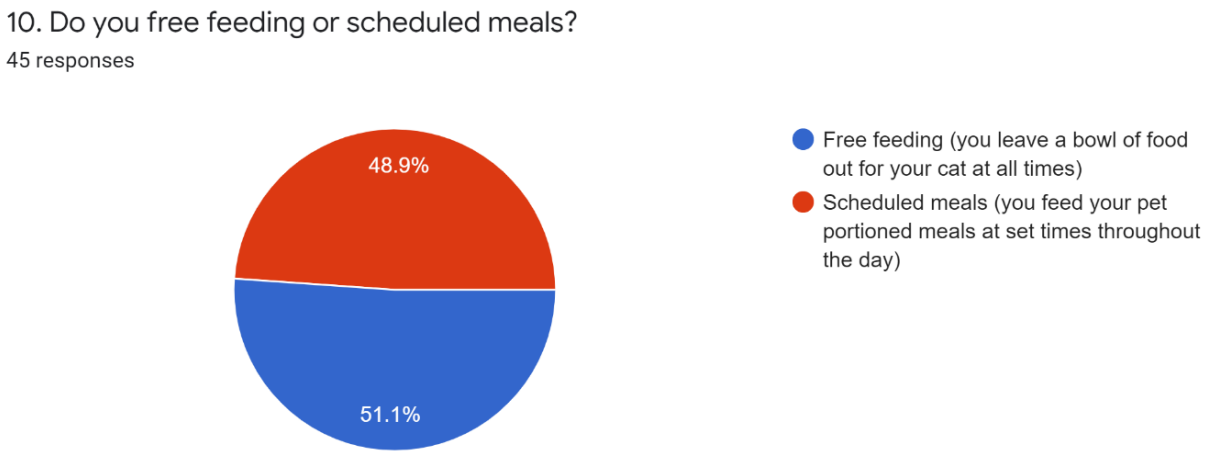


Figure 4.28 Analysis of the way cats are fed

The result shows that 51.6% of the respondents chose scheduled meals which is feeding pet portioned meals at set times throughout the day meanwhile 48.9% of the respondents preferred free feeding which is always leaving a bowl of food out for their cat. From the answer, most respondents preferred scheduled meals over free feeding.

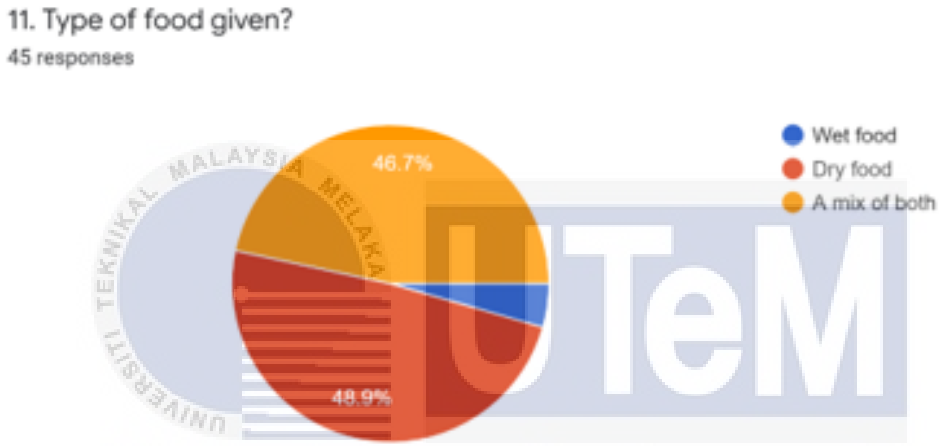


Figure 4.29 Analysis of food type

Based on the results, the group of dry food received 48.9% meanwhile a mix of both received 46.7%. For group of wet food only received 4.4%. Based on this analysis, majority of respondents fed their cat with dry food or mix of both food.

SECTION C

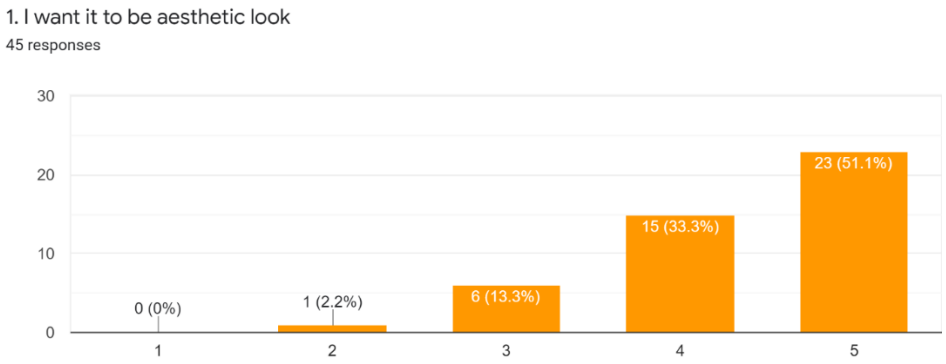


Figure 4.30 Analysis of aesthetic appearance

From this question, aesthetic appearance of the product can be decided whether it should be emphasized or not. The answer allows respondents to choose more than one answer. According to the chart in Figure 4.30 above, there are 5 scales can be chosen. There are 51.1% which is 23 of the respondents strongly agree with aesthetic appearance. Moreover, there are 33.3% which is 15 of the respondents agree aesthetic appearance for cat feeder, 13.3% which is 6 of the respondents chose neutral and 2.2% which is only one respondent disagree with aesthetic appearance of cat feeder. From this answer, majority of respondents strongly agree want an aesthetic design to be emphasized on automatic motorized cat feeder for large cat cage.

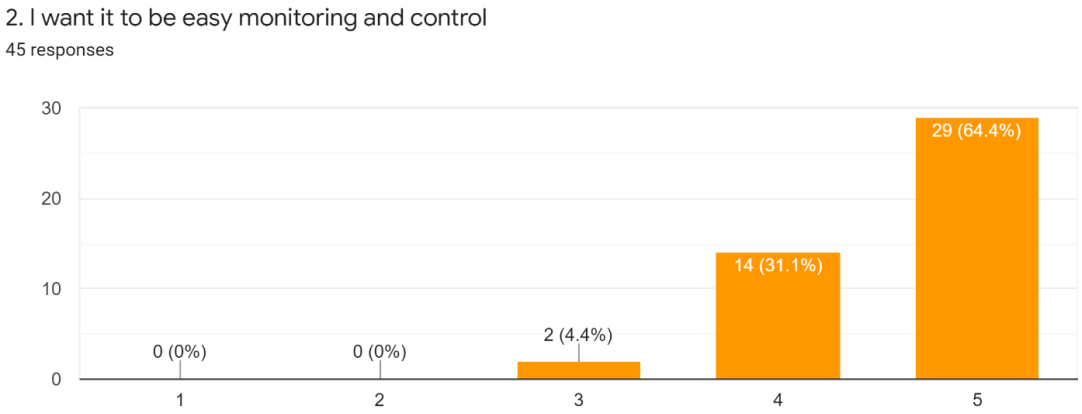


Figure 4.31 Analysis of monitoring and control

Based on the results, 64.4% which is 29 of the respondents strongly agree. Moreover 31.1% which is 14 of the respondents agree meanwhile 4.4% which is 2 of the respondents chose neutral. From this answer, majority of the respondents strongly agree with easy monitoring and control that should be emphasized for automatic motorized cat feeder.

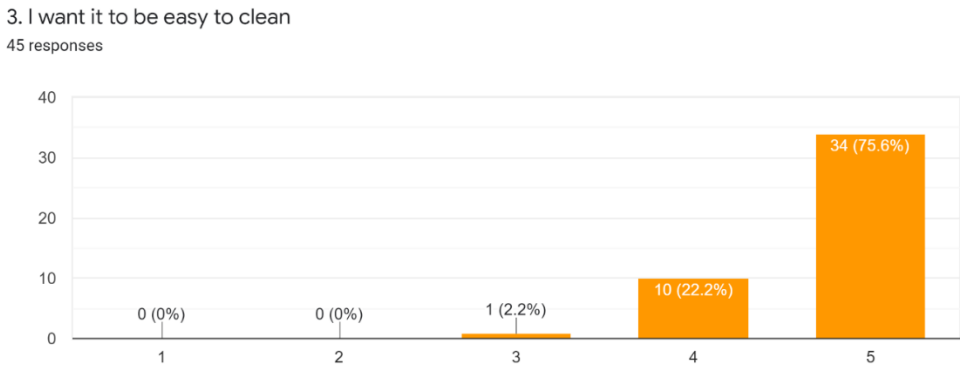


Figure 4.32 Analysis of user opinion about the ease of cleaning

The result shows that 75.6% which is 34 of the respondents strongly agree. 22.2% which is 10 of the respondents just chose to agree and 2.2% which is just only one respondent chose neutral. From this answer, majority of the respondents were strongly agreed that these automatic motorized cat feeders are easy to clean.

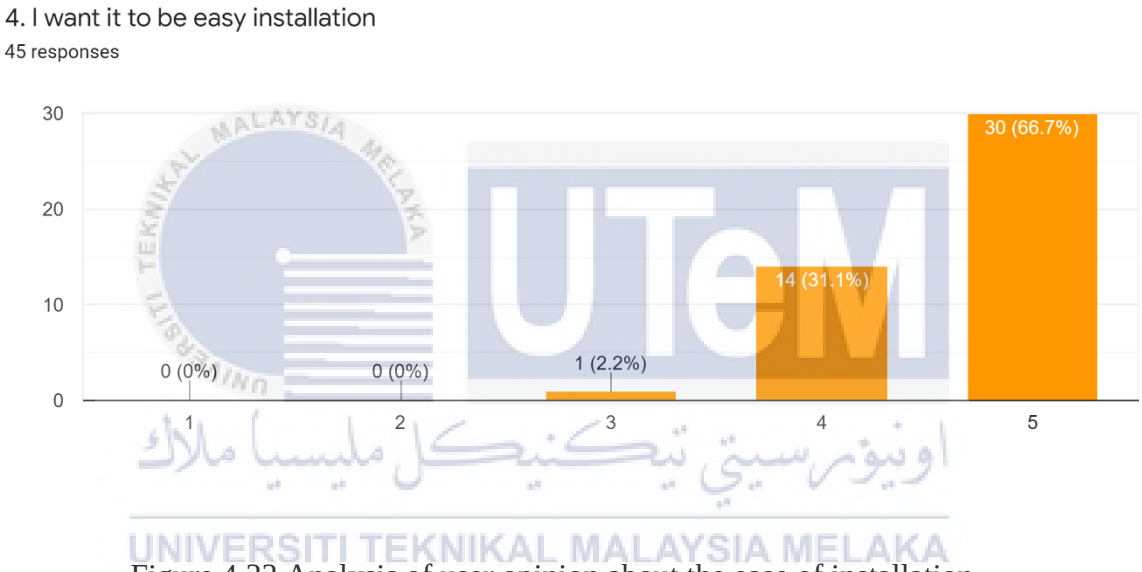


Figure 4.33 Analysis of user opinion about the ease of installation

Based on the result in Figure 4.33, 66.7% which is 30 respondents strongly agreed. Meanwhile 31.1% which is 14 of the respondents just chose to agree and 2.2% which is only one respondent chose neutral. From this answer, majority of the respondents agreed to make sure automatic motorized cat feeder must be easy to install and assemble.

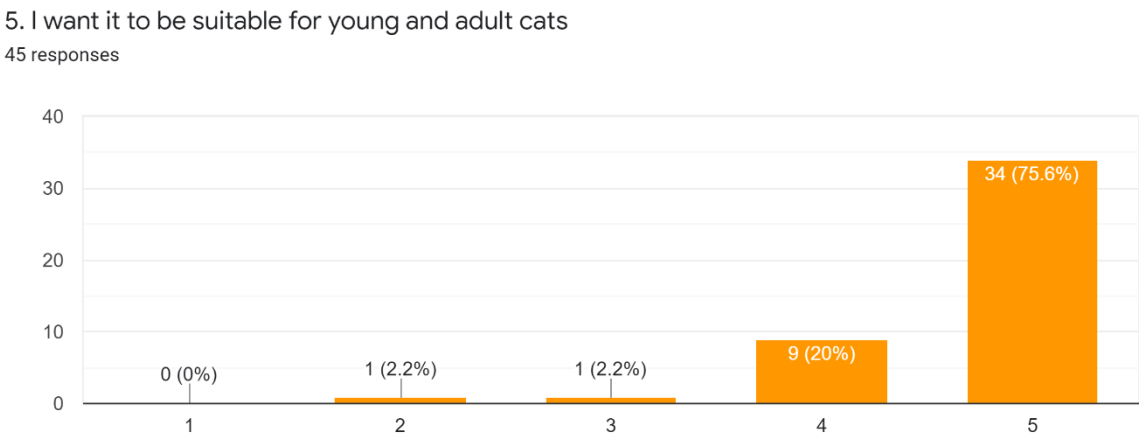


Figure 4.34 Analysis of cat suitability

The result shows that 75.6% which is 34 of the respondents strongly agree. Moreover, 20% which is 9 of the respondents chose to agree meanwhile 2.2% which is just one of the respondents chose neutral and 2.2% which is one of the respondents disagree. From this answer, majority of respondents want automatic motorized cat feeder suitable for young and adult cats.

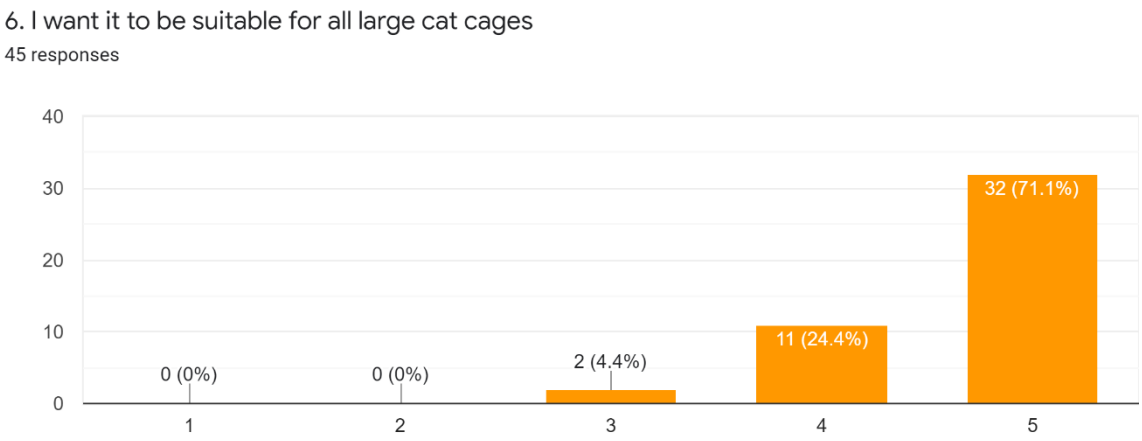


Figure 4.35 Analysis of cat cage suitability

Based on the result of the question, 71.1% which is 32 of the respondents strongly agreed and 24.4% just chose agreed. Meanwhile 4.4% which is only 2 of the respondents chose neutral for this question. From this answer, many users want automatic motorized cat feeder suitable for all large cat cages.

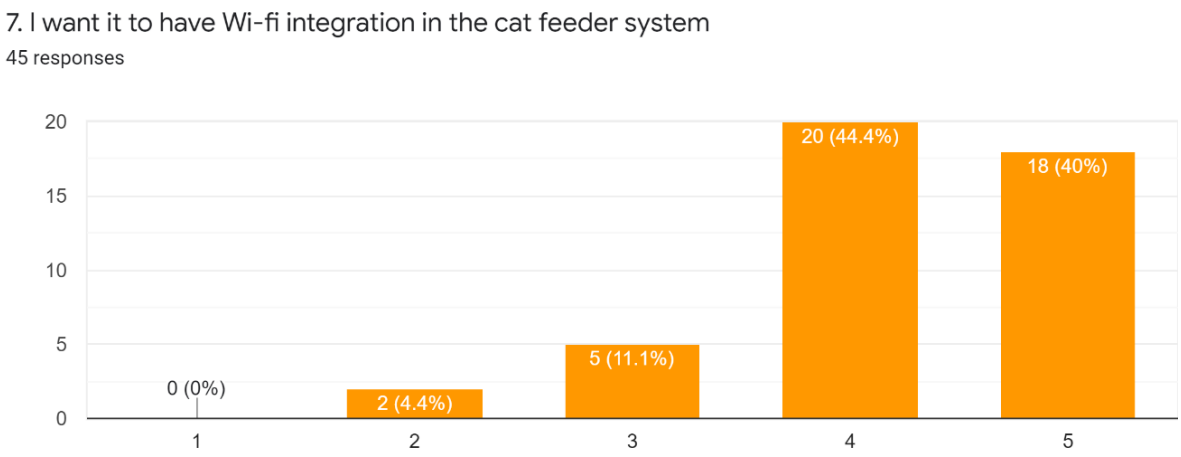


Figure 4.36 Analysis of cat feeder system

The result shows that 40% which is 18 of the respondents strongly agreed with this feature while 44.4% which is 20 of the respondents chose agreed. Moreover, 11.1% which is 5 of the respondents chose neutral meanwhile 4.4% which is only 2 respondents chose to disagree. From this answer, Majority of respondents agreed that wi-fi integration should be emphasized in the cat feeder system.

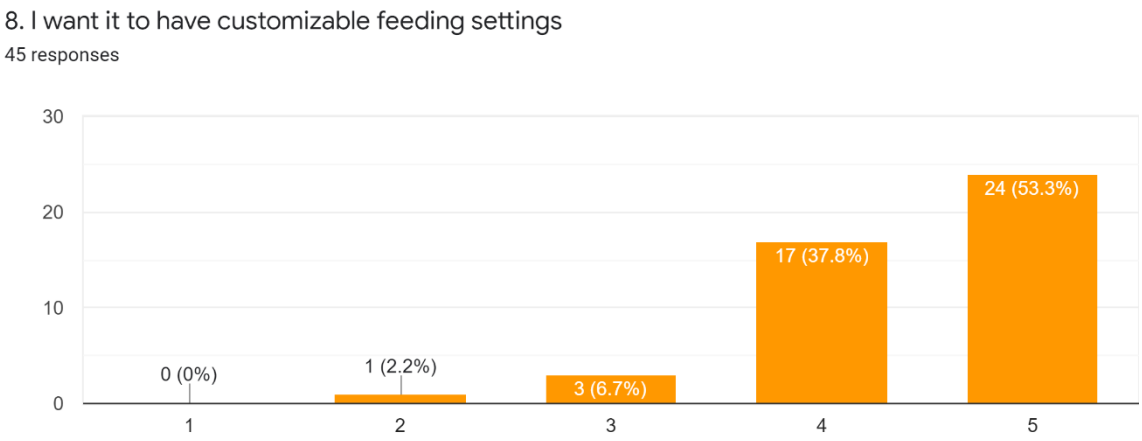


Figure 4.37 Analysis of customizable feeding settings

Based on the result in Figure 4.37, 53.3% which 24 of the respondents choose to strongly agree and 37.8% which is 17 of the respondents choose to agree. Moreover, 6.7% which is 3 of the respondents chose neutral meanwhile only 2.2% which is one respondent choose to disagree. From this answer, majority of respondents strongly agree that customizable feeding settings should be emphasized in large cage automatic motorized cat feeder.

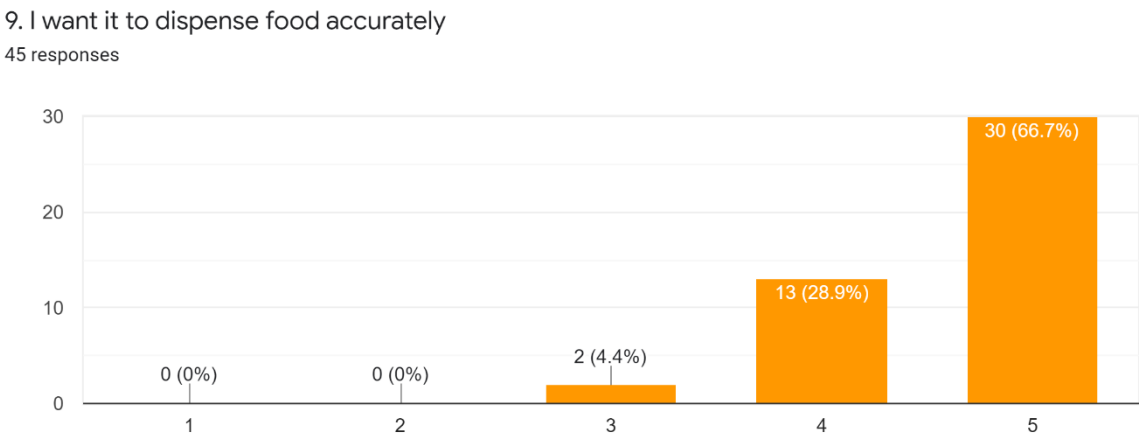


Figure 4.38 Analysis of food dispenser accuracy

The result shows that 66.7% which is 30 of the respondents strongly agree with this feature while 28.9% which is 13 of the respondents chose to agree meanwhile 4.4% which is only 2 respondents chose to disagree. From this answer, majority of respondents choose to strongly agree that automatic motorized cat feeder dispense cat food accurately to make sure their cats get adequate portions.

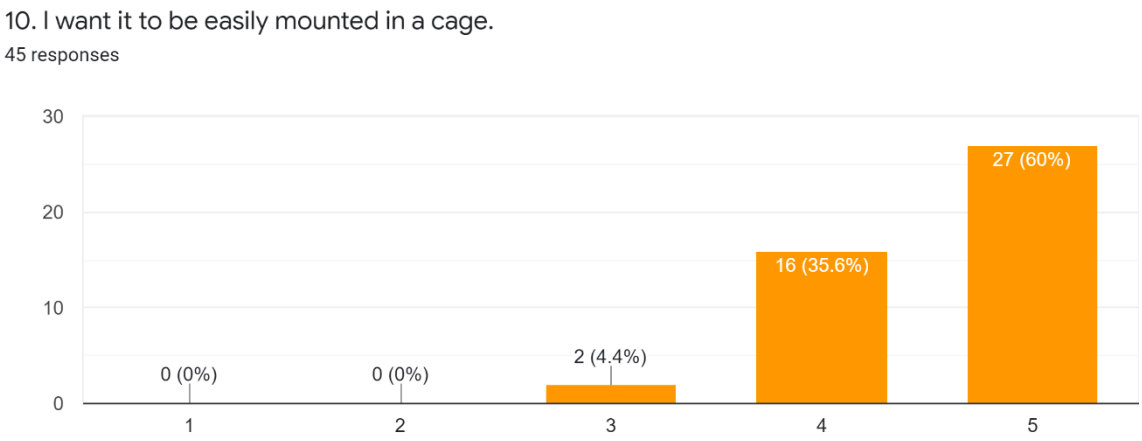


Figure 4.39 Analysis of cat feeder mount

Based on the result in Figure 4.39, 60% which 27 of the respondents choose to strongly agree and 35.6% which is 16 of the respondents choose to agree. Next, only 4.4% which is 2 of the respondents chose neutral. From this answer, majority of respondents strongly agree that automatic cat feeder should be easily mounted outside the cage.

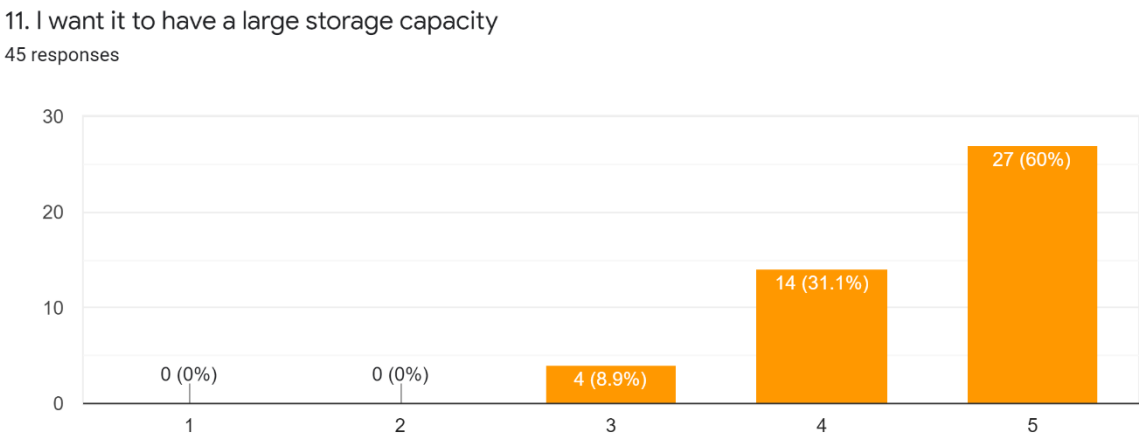


Figure 4.40 Analysis of large storage capacity

Based on the results in Figure 4.40, 60% which is 27 of the respondents strongly agree. Next 31.1% which is 14 of the respondents choose to agree meanwhile 8.9% which is only 4 of the respondents chose neutral. From this answer, majority of the respondents strongly agree with large storage capacity that should be emphasized for automatic motorized cat feeder.

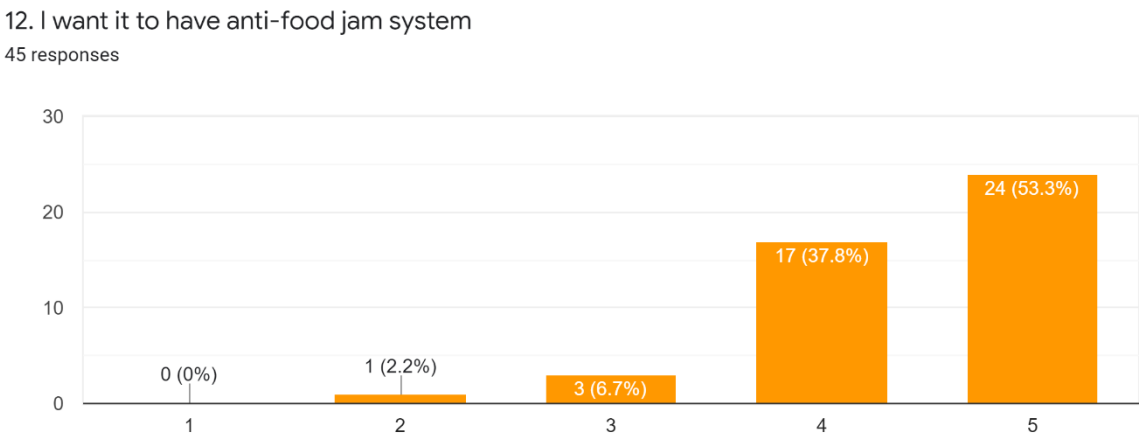


Figure 4.41 Analysis of anti-food jam system

Based on the results in Figure 4.41, 60% which is 24 of the respondents strongly agree. Moreover 37.8% which is 17 of the respondents choose to agree meanwhile 6.7% which is 3 of the respondents chose neutral and 2.2% which is only one respondent choose to disagree. Majority of the respondents strongly agree with anti-food jam system that should be emphasized for automatic motorized cat feeder.

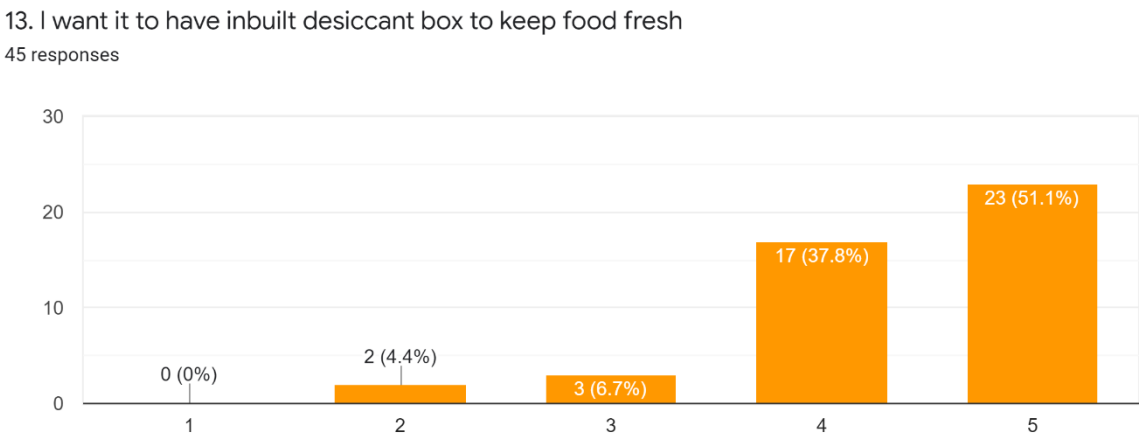


Figure 4.42 Analysis of desiccant box

Based on the results in Figure 4.42, 51.1% which is 23 of the respondents strongly agree. Moreover 37.8% which is 17 of the respondents choose to agree meanwhile 6.7% which is 3 of the respondents chose neutral and 2.2% which is only one respondent choose to disagree. From this answer, majority of the respondents strongly agree with inbuilt desiccant box that should be emphasized for automatic motorized cat feeder.

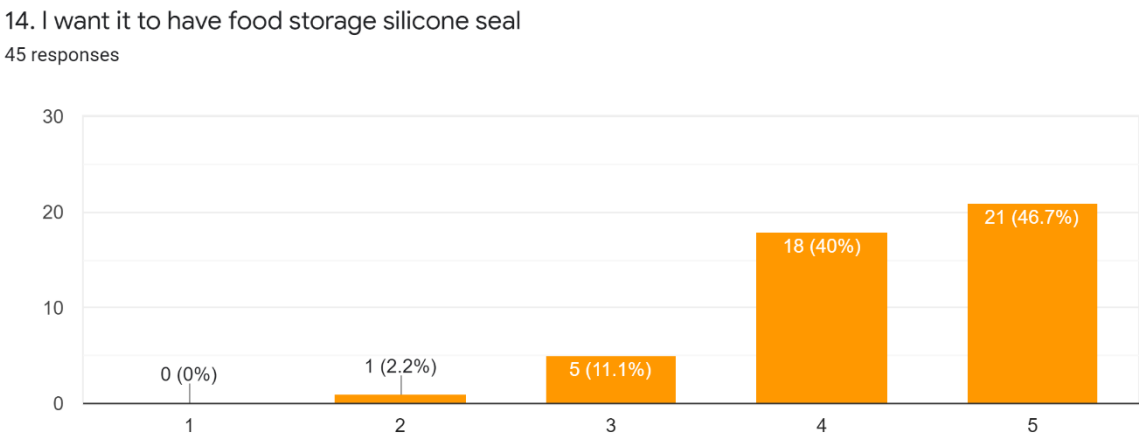


Figure 4.43 Analysis of food storage silicone seal

The result shows that 46.7% which is 21 of the respondents strongly agree with this feature while 40% which is 18 of the respondents chose to agree meanwhile 11.1% which is 5 of the respondents chose neutral and only 1 respondent choose to disagree. From this answer, majority of respondents choose to strongly agree that food storage for automatic motorized cat feeder should have silicone seal to make sure cat food does not catch cold.

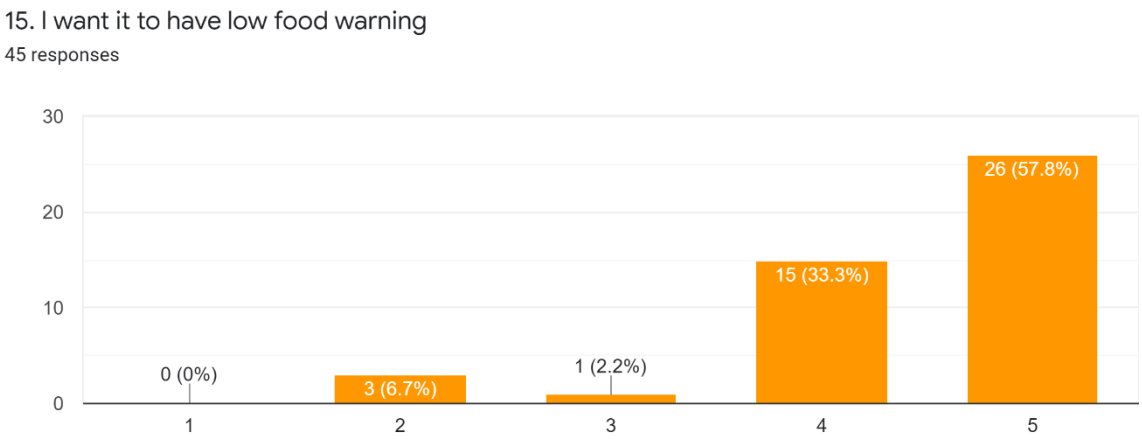


Figure 4.44 Analysis of low food warning

Based on the results in Figure 4.44, 57.8% which is 26 of the respondents strongly agree. Moreover 33.3% which is 15 of the respondents choose to agree meanwhile 2.2% which is only 1 of the respondents chose neutral and 6.7% which is 3 of the respondents choose to disagree with this feature. From this answer, majority of the respondents strongly agree with low food warning feature that should be emphasized for automatic motorized cat feeder.

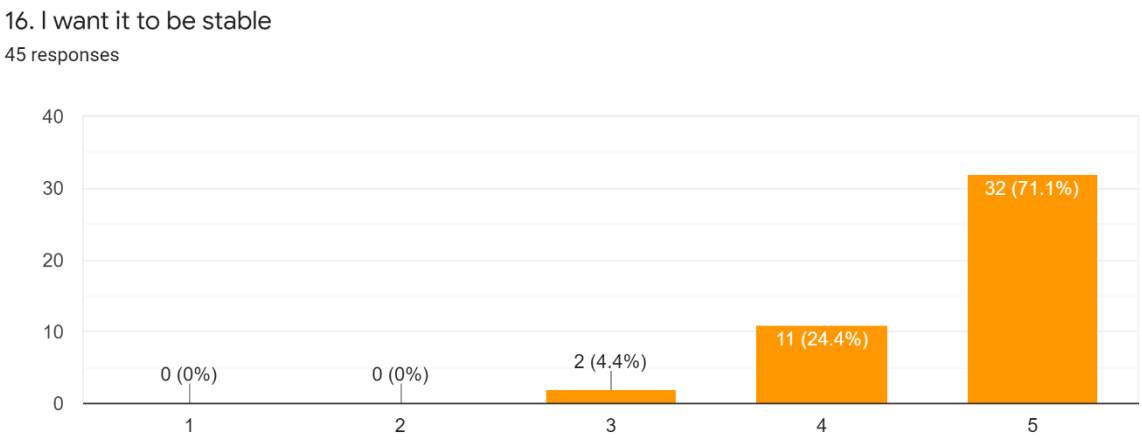


Figure 4.45 Analysis of cat feeder stability

According to the data in Figure 4.45, 71.1 percent of the respondents, or 32 people, strongly agree. Following that, 24.4 percent of respondents, or 11 people, selected to agree, while 4.4 percent, or only two people, picked indifferent. Most respondents strongly agree that when mounted on a cat cage, the motorised cat feeder could be Stable.

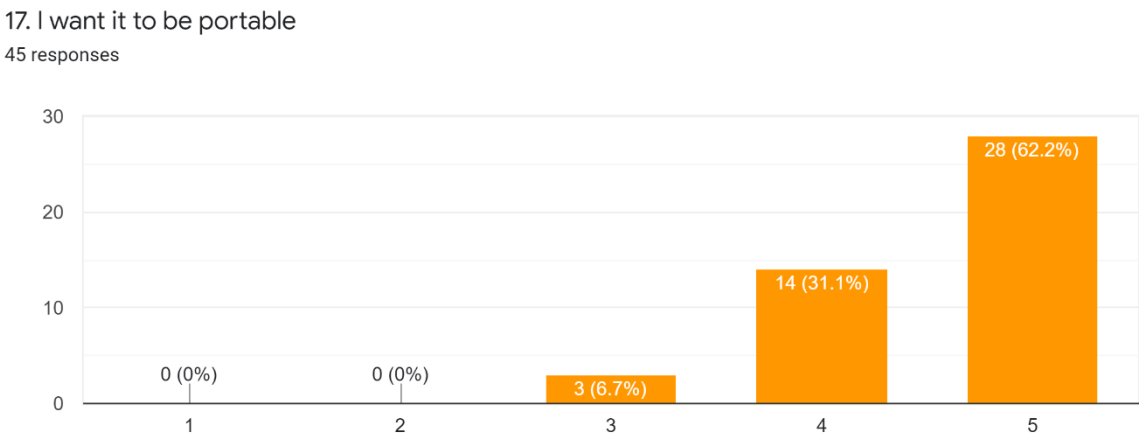


Figure 4.46 Analysis of cat feeder portability

The result shows that 62.2% which is 28 of the respondents strongly agree with this feature while 31.1% which is 14 of the respondents chose to agree meanwhile 6.7% which is 3 of the respondents chose neutral. Most of the respondents chose to strongly agree that an automatic motorised cat feeding should be portable based on this response.

4.2.2 Conclusion of The User Requirement Survey

The summary of the questionnaire results will be discussed in this sub-topic. The design direction, design needs, and design preferences of the automatic motorized cat feeder were determined by analyzing each section of the questionnaire survey. Depending on the outcome, the target market for the automatic motorized cat feeder must be determined.

From the survey result, the target market of the automatic motorized cat feeder can be set depending on the result of Section A. Based on the result of Section A, most of them are male and they are in the range of 20 to 29 years old. Other than that, most of the respondents are students with an education level of a bachelor's degree. In short, the design

of the automatic motorized cat feeder will be considered to fulfill the needs of the consumer from the data collection.

Based on Section B, respondents were asked a question concerning a cat care scenario such as the number of cats they have, how long cat owners's owned a cat, what kind of cat they have, how long they can leave their cat at home with fresh food and water at all times, the reason they cannot leave their cat at home for long periods, their preference when leaving their cat when they are away, their cat play time, feeding time and type of food. The results of this analysis can be helpful to apply to automatic motorized cat feeders.

For Section C, all the criteria obtained more than 2 marks. The criteria will be slightly important if obtained 3 marks, fairly important if obtained 4 marks, and very important if obtained 5 marks. The criteria that were voted by the respondents as 5 marks will be prioritized and the criteria are function, feature, safety, quality, and appearance.

4.3 Implement of QFD

Quality Function Deployment is a methodology for developing customer-oriented products (Ginting et al., 2020). The planning process known as QFD assists the organisation in identifying every issue by assisting in the appropriate implementation of various technical support tools. QFD is a method of improving the quality of products and services by identifying consumer wants and then connecting those needs with the technical requirements to create products or services in each step of the production process (Ginting et al., 2020).

Quality Function Deployment can be defined as a process that identifies the wants and needs of the customer, then translates those demands into technical qualities that can be understood and improved upon at every organisational level and functional level (Ginting et al., 2020).

Additionally, the QFD's implementation helps ensure that early information regarding consumer wants and preferences is received. At every stage of the life cycle of a product or service, the planning process stages are used. The manufacturing process will benefit from the usage of QFD in order to achieve a competitive edge, and customer satisfaction can be raised thanks to the high-quality characteristics of goods and services (Ginting et al., 2020).

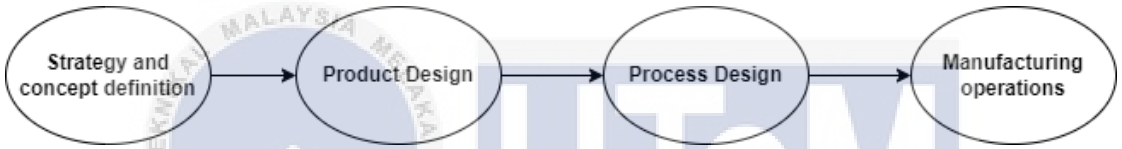


Figure 4.47 QFD four phases

Figure 4.47 shows the four phases of the QFD. In general, a step-by-step approach can be used to outline the product development process from customer needs to manufacturing process operations, identifying the points at which the requirements for intermediate outputs are formed and go-or-no-go decisions can be made.

1.3.1 House of Quality (HOQ)

When the product development team get all the information from the costumer requirement, it must be translate into technical term. This technical term also know as design characteristic. HOQ is a tool for making product planning. House Of Quality (HOQ) consist nine (9) type of room which is Costumer Need, Importance Rating, Competitive Analysis, Technical characteristics, Relationship Matrix, Importance Rating, Target Value, Engineering Analysis and lastly is Correlation Matrix. This HOQ data is being taken from

the Need Statement analysis and it has relationship between this two which is HOQ and Need Statement.

Quality function development is a quality tool for meeting customer needs and demands, and it may be used to design products and services in accordance with CRs. In other words, QFD can implement the set of Customer Requirement (CRs) that can be satisfied using product function (Aghdam et al., 2015) . Then connecting those needs with technical characteristics to generate products or services in each step of producing products and services (Ginting et al., 2020) .

Table 11 House Of Quality (HoQ)

		Technical Characteristics											
Improvement Direction		↑	↑	↑	↑	n/a	↑	↓	n/a	↓	n/a	↑	
Customer Requirement	**Important Rating**	Food container	Food Tank lid	Food Outlet	Mounting	Display And control panel	Food Nozzle	Material	Google assistant (IoT) system	Servo Motor	Power supply	Body Case	
Easy to wash	4		9	9			9					3	
Aesthetic	1			1			3	9				1	
Ease of mount	5	3			9							3	
Ease of assemble	4				3							3	
Large Storage Capacity	3	9											
Ease of Use	5	1		3		9	9		9	9		9	
Safety	4		9					9	3	3	9	3	
Precision	3			9		9			3	9	3		
Portability	2				1								
Stability	4				9			3					
Total		**47**	**72**	**79**	**95**	**72**	**84**	**57**	**66**	**84**	**45**	**97**	**798**
Relative Weight %		5.89	9.02	9.9	11.9	9.02	10.5	7.14	8.27	10.5	5.64	12.15	
Rank Order		**8**	**5**	**4**	**2**	**5**	**3**	**7**	**6**	**3**	**9**	**1**	
Strong(9)				Medium(3)					Weak(1)				
Maximize(↑)				Minimize(↓)					Target(n/a)				

Table 12 HOQ important rating

Important rating	Score
Strong	9
Medium	3
Weak	1

Based on the HoQ analysis, the body case of the product is the priority to be emphasized during the development of the product to ensure it is ease to clean, ease to use, and easy to mount on the cage. Therefore, the mounter must be stable, easy installation and convenient for the consumer when it is mounted to the cat cage. Besides that, food nozzles should be easy to clean, ease to use, and safe. Moreover, material selection is the priority to be emphasized during development to ensure the durability of the product.

4.4 Preliminary concept

Creating concept sketches that show the form and function of potential designs is an essential part of the product design process, (Johnson & Reynolds, 2005). Authors describes these sketches usually depict the product from one or more perspectives in order to convey significant geometric aspects of the object and its components. Consider how the geometry and functional behavior of a product's constituent parts can vary, and designer can help reveal what types of variations are interesting or appropriate, (Johnson & Reynolds, 2005).

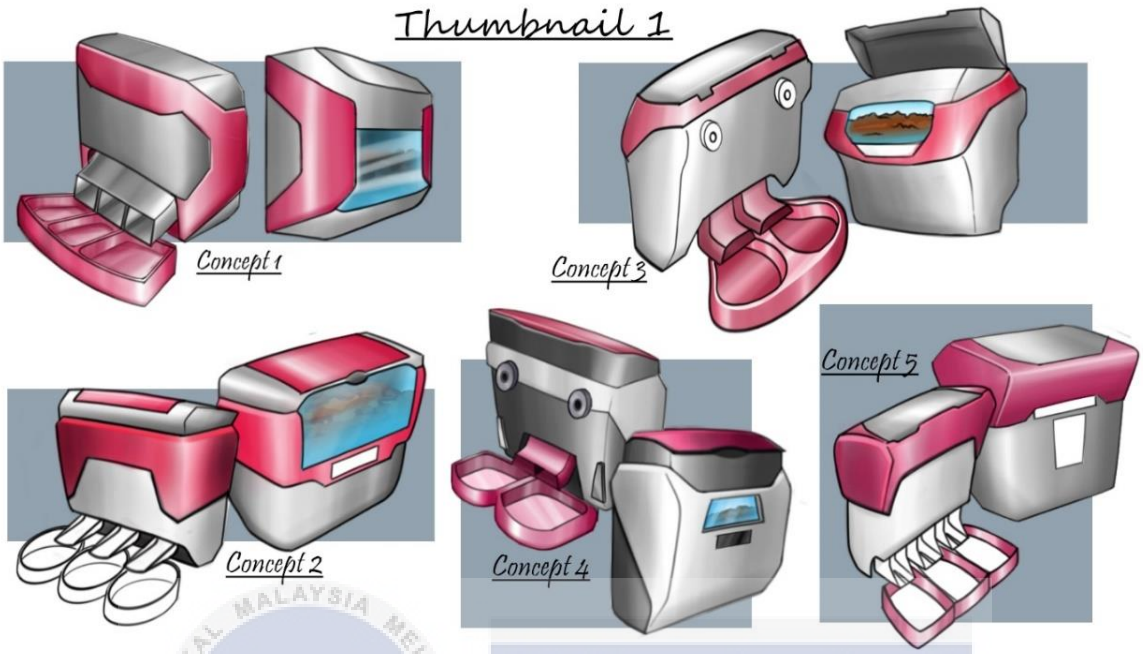
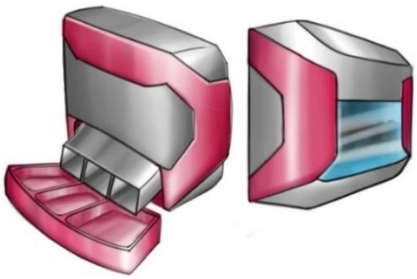
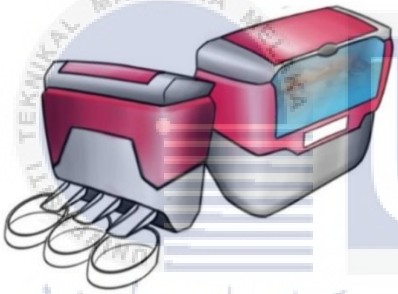
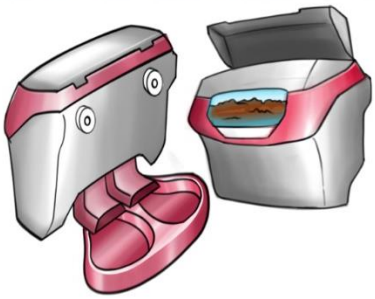
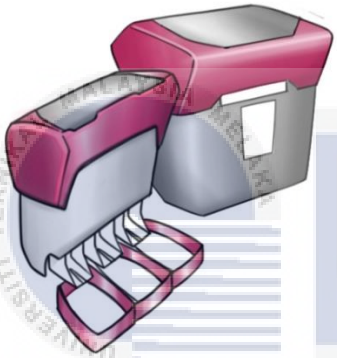
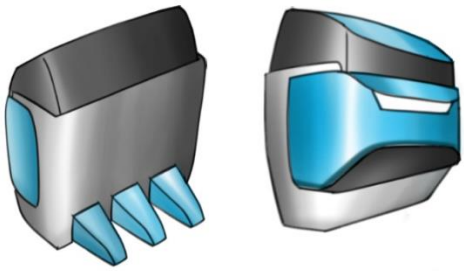


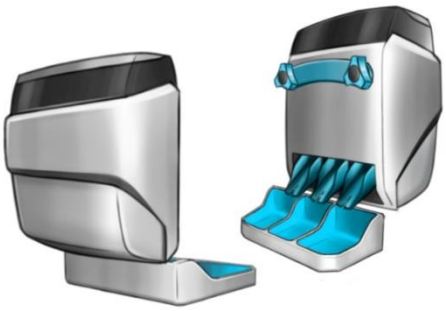
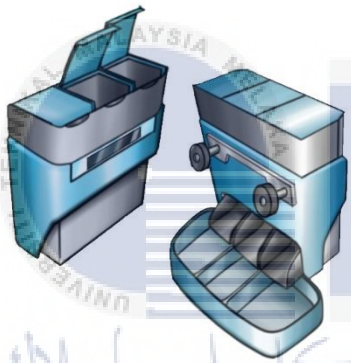
Figure 4.48 Explorative sketch 1

Figure 4.49 Explorative sketch 2

Table 13 Concept explanation

No	Concepts	Explanation
1	 (a) Concept 1	The elements of this design concept are sleeker and well-organized in terms of shape. This concept has minimal lines at every corner of the design. Moreover, on the front of the product, there is a transparent glass that can show the level of cat food.
2	 (b) Concept 2	This concept includes a shape element that is inspired by a spaceship. It is because the casing with a futuristic design surrounds the entire product and transparent glass is placed in the middle of the casing so that it looks like a spaceship window.
3	 (c) Concept 3	This concept is more towards aesthetics and only has two food dispensers. Furthermore, the lid of the food container only has one food nozzle and the food nozzle can be installed separately.

4	 (d) Concept 4	This concept has a modern and more futuristic look. It has two food bowl and nozzle that joined together.
5	 (e) Concept 5	Concept 5 is bulkier and less aesthetic because this design emphasizes the function and capacity of the cat food container.
6	 (f) Concept 6	The visuals of this concept look complex and fierce. The top and bottom of the food nozzle are closed. Each nozzle must be installed to the cat feeder body separately.

7	 (g) Concept 7	This concept's visual appeal is minimal and clean. Furthermore, this device only has one large food storage area but three food exit sections.
8	 (h) Concept 8	This concept appearance is a big and boxy shape that appears soft and nice. The food storage lid is composed of three sections that may be opened and closed, allowing the user to easily fill one of the food storage containers.
9	 (i) Concept 9	This product's appearance look is more complicated and aesthetic. Furthermore, the food nozzle is integrated with the mounting element to reduce the number of components required for installation, which can be troublesome for users.

4.4.1 Concept screening

According to Pugh (1996), one of the most difficult, sensitive, and critical tasks in design is selecting the optimal concept with which to proceed to detail design and, eventually, manufacture (Okudan & Tauhid, 2008).

Designers should examine not just the product functionality required at the early design stage, but also other criteria such as life-cycle difficulties such as manufacturability, ease of assembly, reliability, and maintainability (Okudan & Tauhid, 2008).

Pugh (1991, 1995) developed a graphical method that utilises a matrix with columns (detailing concepts) and rows (showing judgement criteria), as illustrated in Figure 3.44. This decision-making process consists of four steps (Okudan & Tauhid, 2008):

- Any one of the concepts is chosen as the datum against which all other concepts are evaluated.
- Each concept is compared to the datum, and a '+' is assigned if it is judged better than the datum, and a '-' is assigned if it is judged worse than the datum; an 'S' score is assigned if the concept is judged the same as the datum.
- All '+' and '–' are summed up for each concept
- Lower scoring concepts are rejected, and the process is repeated until a choice is achieved.

	Concept 1	*Concept 2*	*Concept 3*	*Concept 4*	*Concept 5*
Criterion A	+		+	–	+
Criterion B	–		+	S	+
Criterion C	S	D A T U M	S	S	–
Criterion D	S		+	–	–
Σ +	1		3	0	2
Σ –	1		0	2	2
Σ score	0		3	–2	0

Figure 4.50 Pugh's evaluation matrix (Okudan & Tauhid, 2008)

Figure 4.51 Datum concept

Table 14 Concept Comparison and Evaluation Matrix for Automatic Motorized Cat Feeder

Selection criteria	**Concept Alternatives**									
Criteria	**Design 1**	**Design 2**	**Design 3**	**Design 4**	**Design 5**	**Design 6**	**Design 7**	**Design 8**	**Design 9**	**Baseline**
Easy to wash	-	+	-	+	+	-	+	+	+	D
Aesthetic	+	-	+	+	+	+	=	-	+	A
Ease of mount	+	-	-	=	-	-	=	=	=	T
Ease of assemble	-	-	+	+	-	-	-	+	-	U
Large storage capacity	+	+	+	+	+	+	+	+	+	M
Ease of Use	=	=	+	=	=	=	+	+	+	
Safety	=	=	=	+	=	=	+	+	+	
Precision	-	-	-	+	-	-	+	+	+	
Portability	-	-	-	-	-	-	-	-	-	
Stability	-	-	-	+	-	-	+	+	+	
Quantity +	3	2	4	7	3	2	6	7	7	NA
Quantity -	5	6	5	1	5	6	2	2	2	NA
Quantity =	2	2	1	2	2	2	2	1	1	NA
Final Score	-2	-4	-1	6	-2	-2	4	5	5	NA
Develop?	No	No	No	Yes	No	No	Yes	Yes	Yes	NA

This Pugh's Chart in Table 14 shows that the concepts for redesign directly address to the top customer needs and give them a much higher score. The Net Score from the Pugh Chart identifies Design 4, Design 7, Design 8, and Design 9 as got highest scores. This design is the best because it addresses the important need for stability, precision, ease of use, and ease to wash. If the owner is alerted every time their pet has been fed, it provides peace of mind for the owner that none of the other designs can match. Ease of use will be top priority owner feedback, and if these concerns can be addressed, the design will be successful. These 4 concepts offer significant improvements in stability because it is improving the most unreliable part as it can accommodate the load of cat food in food storage.

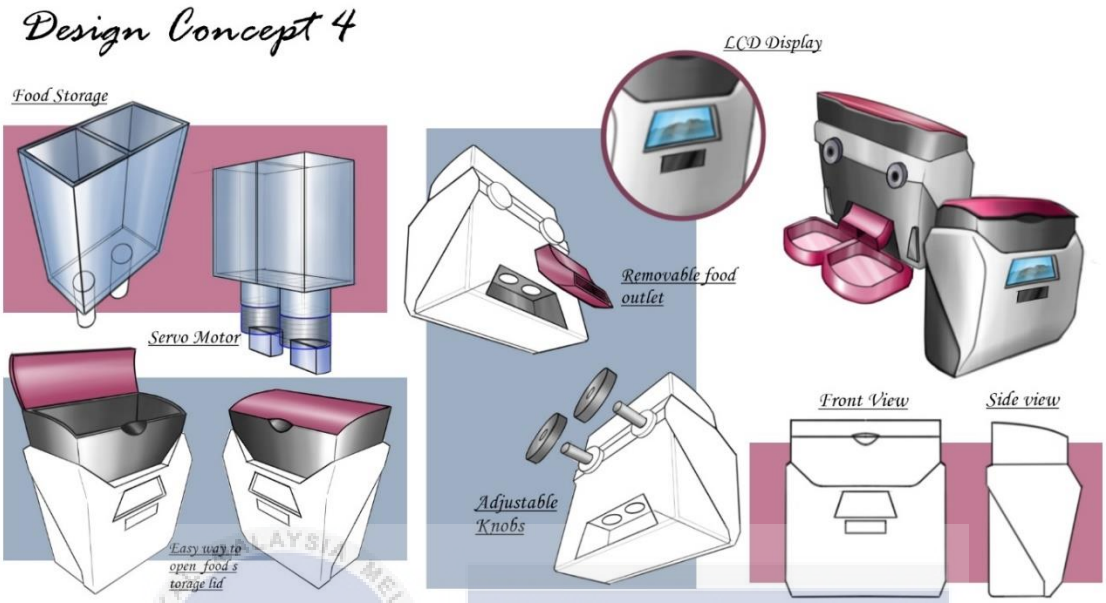


Figure 4.52 Design Concept 4

Based on Figure 4.52, this product concept has two food storages combined into one that can be removed. Meanwhile, the food nozzle has a splitter that dispenses cat food directly to the food bowl. Moreover, the food storage lid can be opened and closed at a 90-degree angle. The mounting uses knobs that can be rotated up tight to keep the product sTable and sturdy when mounted on a cat cage.

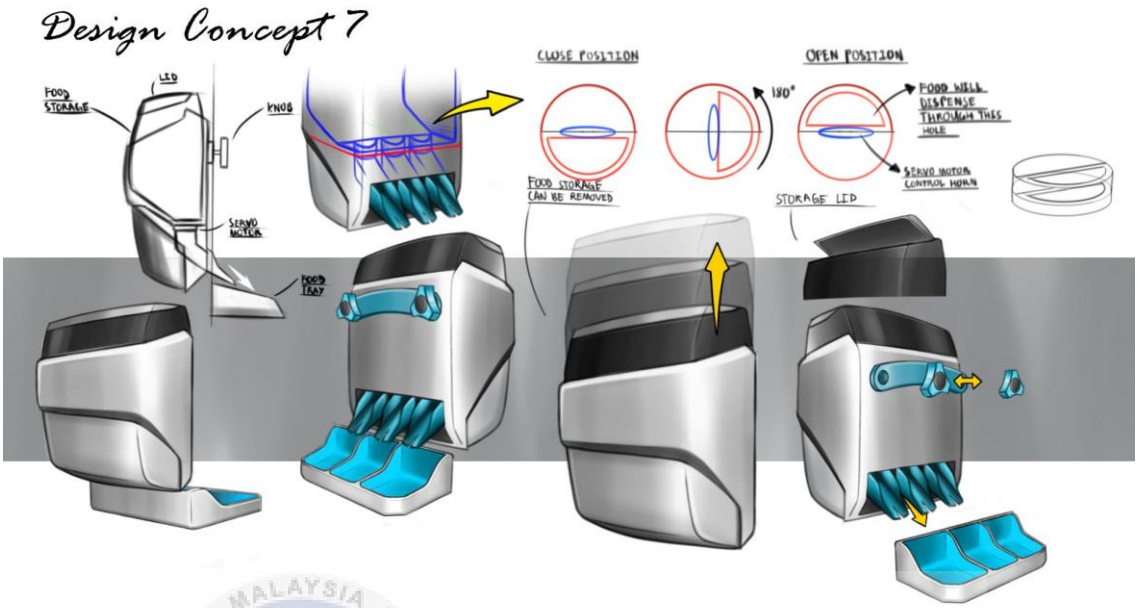


Figure 4.53 Design Concept 7

Design concept in Figure 4.53, the sketch explains about product's position when it mounts on the side of the cat cage using the rotatable knob. The appearance applied for this concept is simple and sleek. Also, this product only has one big food storage but has three food exit sections. Furthermore, cat food will come out from food storage via a servo motor that can be rotated up to 180 degrees for each serving and this product also comes with a 3 connected bowls design.

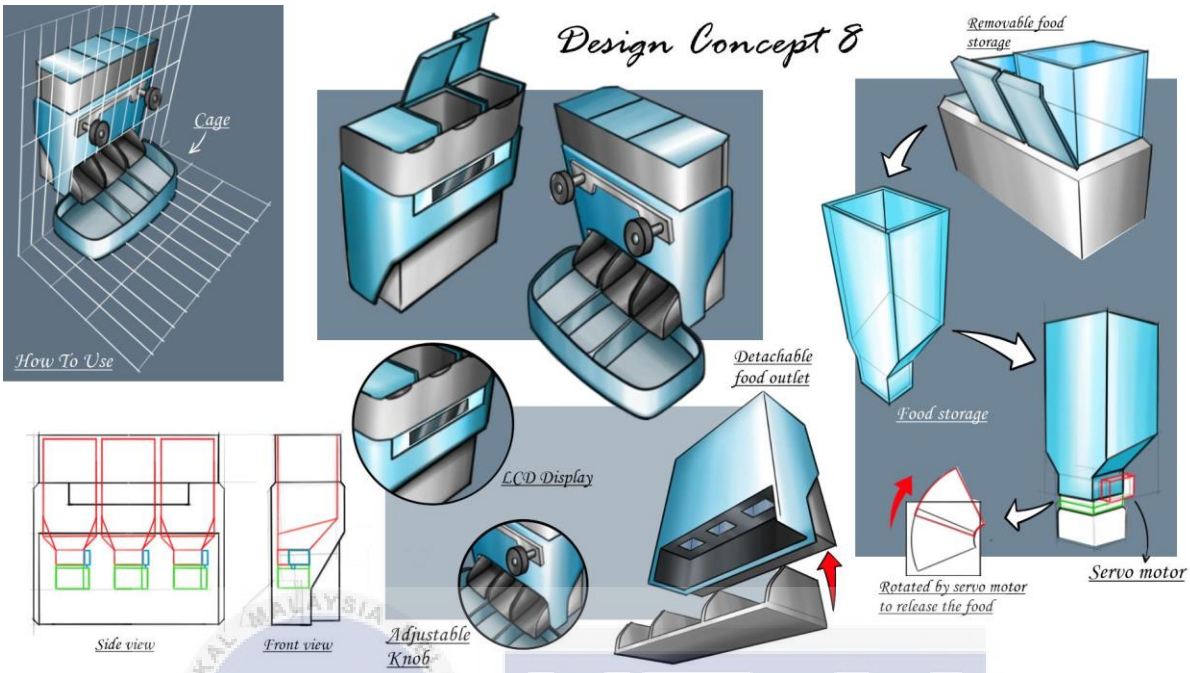


Figure 4.54 Design Concept 8

Based on the design concept in Figure 4.54, the appearance of the product is a bulky and delightful shape which is the shape looked soft and pleasant. The food storage lid is made up of three parts that can be opened and closed, making it simple for the user to refill one of the food storage containers. For cleaning purposes, each food storage can be removed and reinstalled. An LCD screen is located on the front of the product to monitor the food dispense. The food nozzles located beneath the food outlet can be removed and installed for the user's convenience.

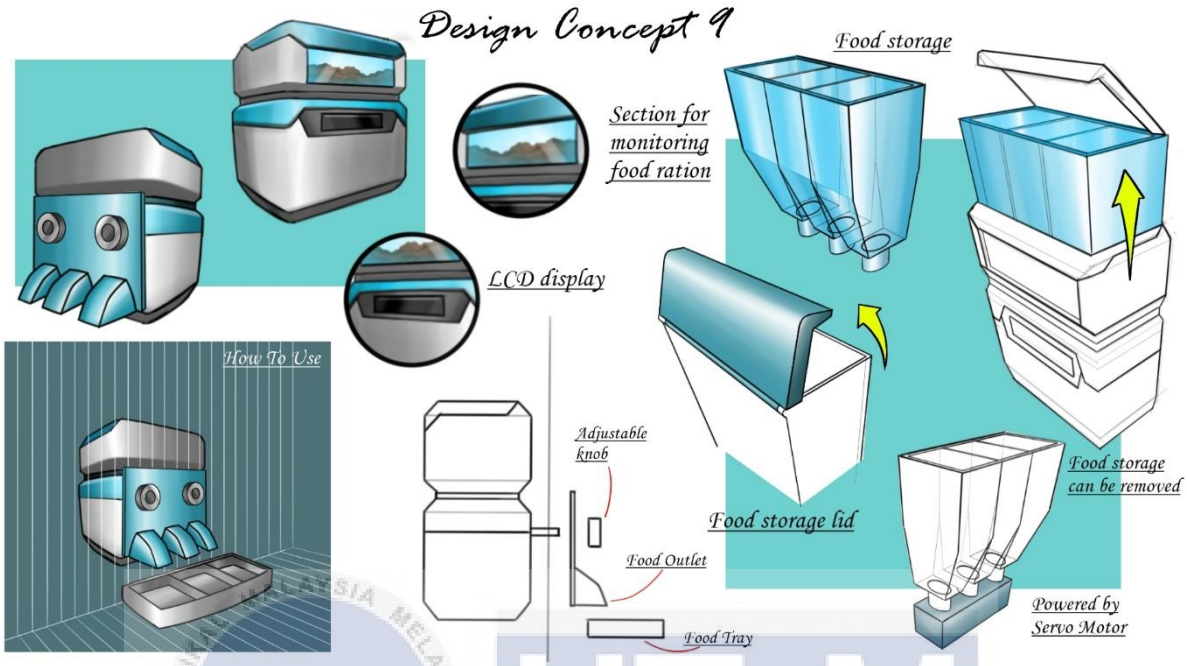


Figure 4.55 Design Concept 9

Based on the design concept in Figure 4.55, the appearance look applied to this product is more complex and aesthetic. Moreover, the food nozzle is combined with the mounting part to reduce the many components when installation which can be inconvenient for users. Besides, The design for the food container has 3 parts and each part can be filled at different rates. on the front of this product, there is an LCD screen that can monitor the cat's feeding time.

4.4.2 Concept selection

Based on the result of the weighted rating method in Table 15, 4 concepts alternatives were selected from Pugh's method and compared them with criteria that have been collected from customer requirements. Design concept 8 gains the highest score because the value given on each of the listed criteria meets the user requirements.

The procedures:

- Team selects evaluation criteria
- Prepare a matrix
- Give importance weight (total=100%)
- Concepts are identified in columns
- Team decides the rates
- Each concept rating is multiply by its representative weight and summed to produce an overall rating for the concept

Table 15 Construction of Weighted Rating Method (4 selected concepts)

		Concept Alternatives							
		Design 4		Design 7		Design 8		Design 9	
Criteria	Importance Weight (%)	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Easy to wash	15%	1	0.15	3	0.45	3	0.45	1	0.15
Aesthetic	t5%	3	0.15	3	0.15	1	0.05	3	0.15
Ease of mount	15%	2	0.30	3	0.45	3	0.45	2	0.30
Ease of assemble	10%	2	0.20	1	0.10	4	0.40	1	0.10
Large storage capacity	10%	2	0.20	2	0.20	3	0.30	3	0.30
Ease of Use	10%	3	0.30	2	0.20	2	0.20	2	0.30
Safety	10%	3	0.30	3	0.30	2	0.20	2	0.20
Precision	5%	2	0.10	1	0.05	2	0.10	3	0.15
Portability	5%	2	0.10	1	0.05	1	0.05	1	0.05
Stability	15%	3	0.45	3	0.45	4	0.60	2	0.30
	100%	N/A	2.25	N/A	2.40	N/A	2.80	N/A	2.00

Table 16 Ranking rate

Rating	Value
Unsatisfactory	0
Just tolerable	1
Adequate	2
Good	3
Very Good	4

Table 16 is the list of the ranking rate required to obtain data based on criteria and concept alternatives. The ranking rate has five levels which are unsatisfactory, just tolerable, adequate, good, and very good.

4.4.3 Feasibility concept

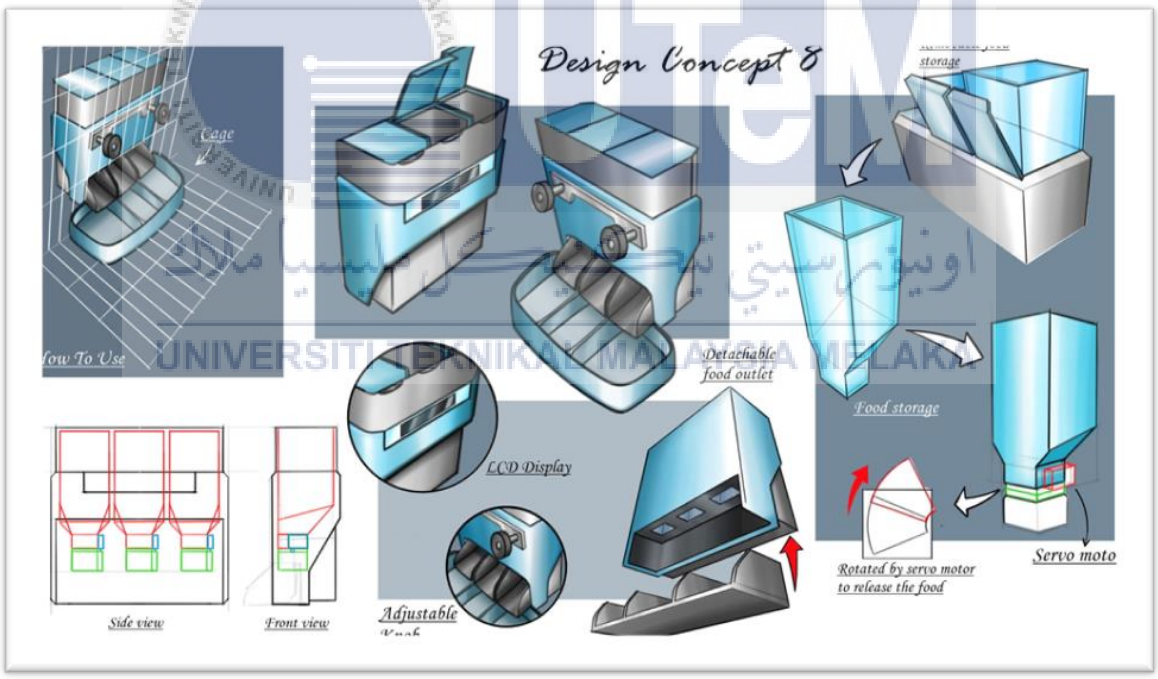


Figure 4.56 Final concept

In Figure 4.56, the result that has been collected is used to resolve the customer requirement before selecting the concept for our product. A product concept is an approximate description of the technologies, working principles, and form of the product. For the selection of the concept for a product, it is necessary to choose it correctly. It can

determine whether it can solve our customer's problems or not. Conceptual Sketches are an important part of the design and development process. It was also great for brainstorming ideas and collaborating with the team members.

Concept selection tools are usually used for integration into engineering design education to reduce the risks and uncertainties of early-phase design ideas. Therefore, when studied about the impact of concept selection tools on the flow of creative ideas, it is important to not only explore the effectiveness of a decision tool for providing recommendations on the selection of creative ideas, but the concept selection that is perfect for consumer decision also needs to be identified. These concept selection instruments can provide only directions or suggestions on the designs to select for further development. Conceptual sketches & concept selection are important because of their impact on the quality, cost, and desirability of the final product, as well as their impact on the development time and cost of later design stages.

4.5 Detail Design

4.5.1 Engineering Drawing

Technical drawing, often known as drafting or drawing, is the act and practise of creating drawings that graphically explain how something functions or is constructed. Technical drawings are divided into two groups based on graphical projection. This is used to project a three-dimensional picture onto a two-dimensional surface. Two-dimensional representation use orthographic projection to generate an image in which only two of the object's three dimensions are visible. All three dimensions of an item may be seen in a three-dimensional depiction, also known as a pictorial.

Assembly drawings demonstrate how various components fit together, identify those pieces by number, and include a parts list, sometimes known as a bill of materials. This style of drawing is known as an exploded view drawing or diagram in a technical service handbook. These components may be utilised in engineering. Table 4.6 shows the 3D modelling of this concept built by using Solidworks software while all the technical drawings of the parts of this concept can be referred to as **Appendix C**.

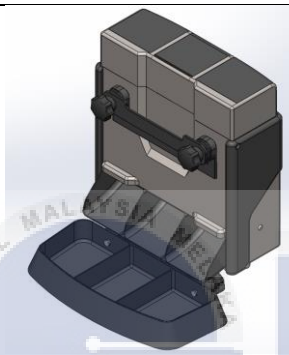
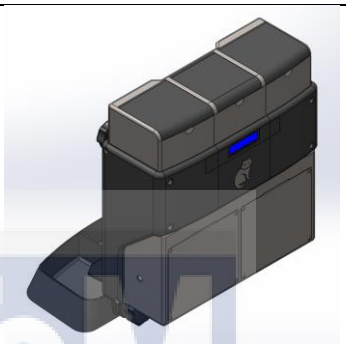
4.5.2 3D modelling (assembly)

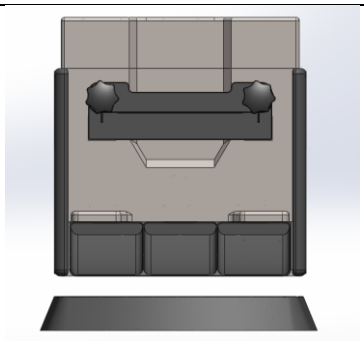
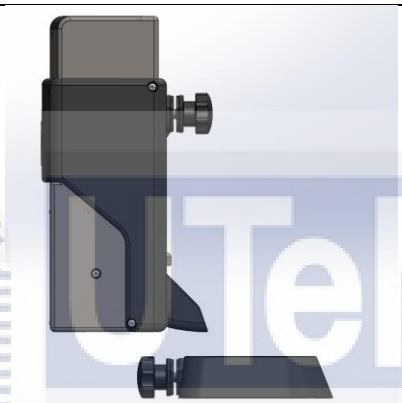
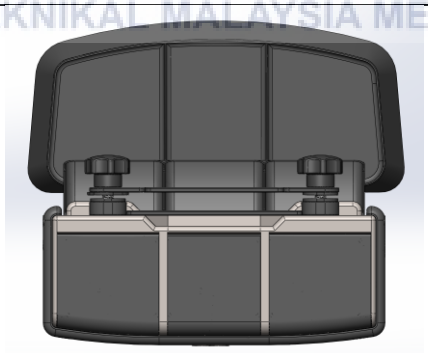
In 3D computer graphics, 3D modelling is the process of using specialised software to manipulate edges, vertices, and polygons in a simulated 3D environment to create a mathematical coordinate-based representation of any surface of an object (inanimate or living) in three dimensions (History et al., 2020).

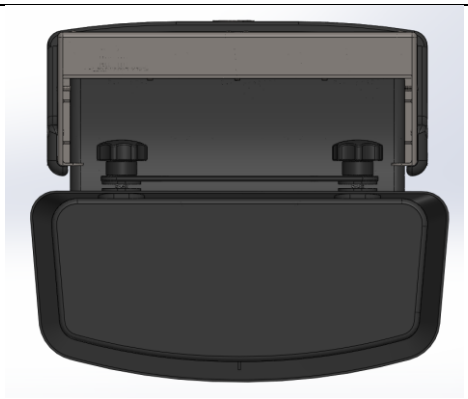
A polygon mesh is created by joining points in 3D space, referred to as vertices, by segments of a line. Because they are adapTable and computers can display them so quickly, textured polygonal models make up the major proportion of 3D models created today.

Polygons, on the other hand, are planar and can only simulate curved surfaces by employing a lot of them (History et al., 2020). In Table 17 shows the various viewpoints of the product included Isometric, front, back, side, and top view.

Table 17 3D model views

No.	3D
1.	 (a) Isometric view (back view)  (b) Isometric view (Front view)
2.	 (c) Front view

3.	 (d) Back view
4.	 (e) Side view
5.	 (f) Top view

6.	 (g) Bottom view

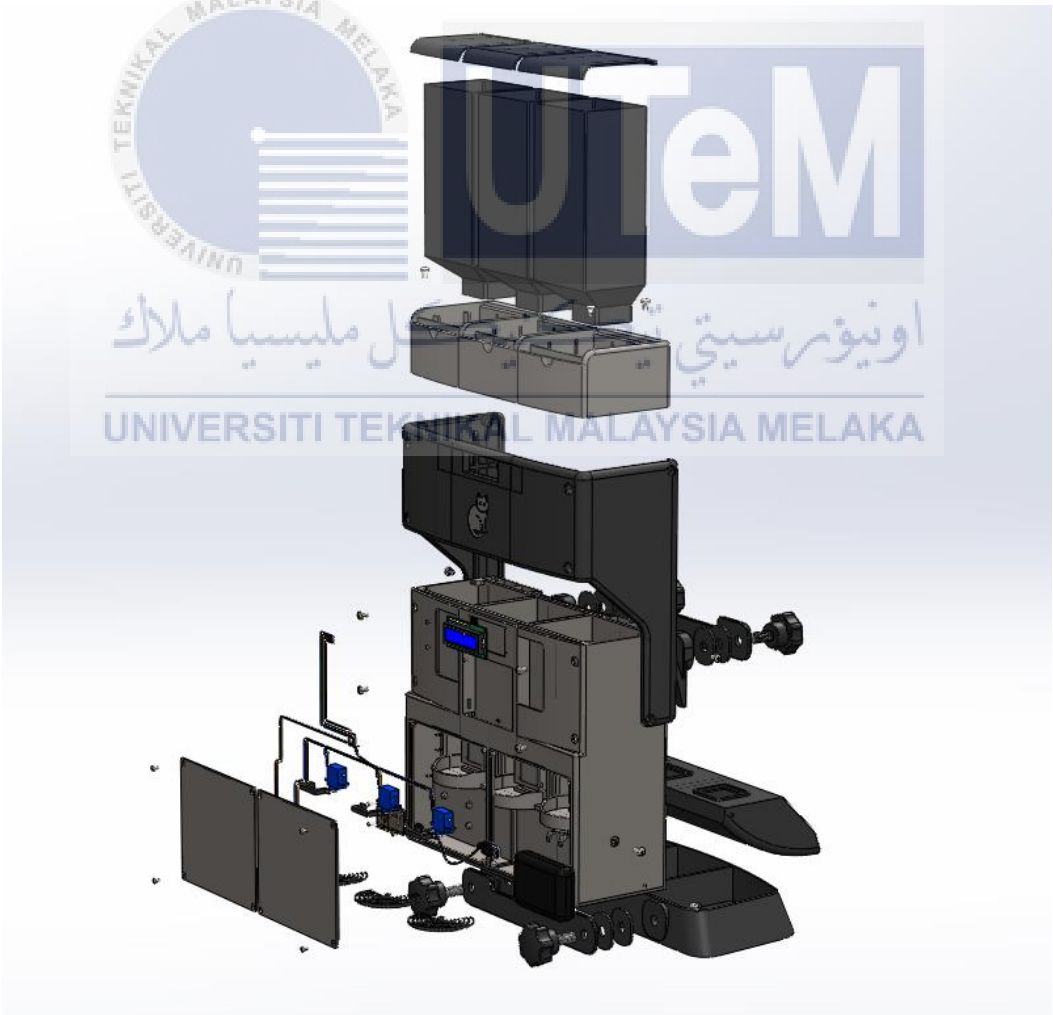


Figure 4.57 Exploded view

A model view that demonstrates the proposed assembly of mechanical or other pieces is an exploded-view. It demonstrates how each component of the assembly fits with the others. In mechanical systems, the component closest to the centre is typically constructed first or serves as the focal point for the assembly of the other components. This illustration can also serve to illustrate how components are typically disassembled, with the exterior components typically being removed first.

There is a complete list of the components needed for the product in Table 17. There is a different quantity for each component and IOT system components are also included.

Table 17 List of components of automatic motorized cat feeder

No.	Parts	Quantity
1	Top	1
2	Bottom	1
3	Main Body	1
4	Case	1
5	Mounter	1
6	Food container	3
7	Right Lid	1
8	Left Lid	1
9	Middle Lid	1
10	Food Dispenser	3
11	Food Nozzle	1
12	Front Lid	2
13	Microservo SG90	3
14	Node MCU ESP8266	1
15	LCD Display	1
16	Servo Bracket	3
17	Power Source (Powerbank)	1
18	Food Bowl	1
19	Clamper	2
20	Knob	4
21	Thread	4
22	Pin	9
23	Cable Jumper	15
24	USB connector	2
25	Arduino UNO	1

4.5.3 3D rendering

After the 3D model is built, this automatic motorized cat feeder set is rendered based on the actual color, material, texture, and appearance. 3D modeling and rendering by using Solidworks Visualize that can save time and cost. Through these methods, the real product's appearance, material, and size can be adjusted according to the requirements.

Figure 4.58 Isometric View (front)

Figure 4.59 Isometric View (back)

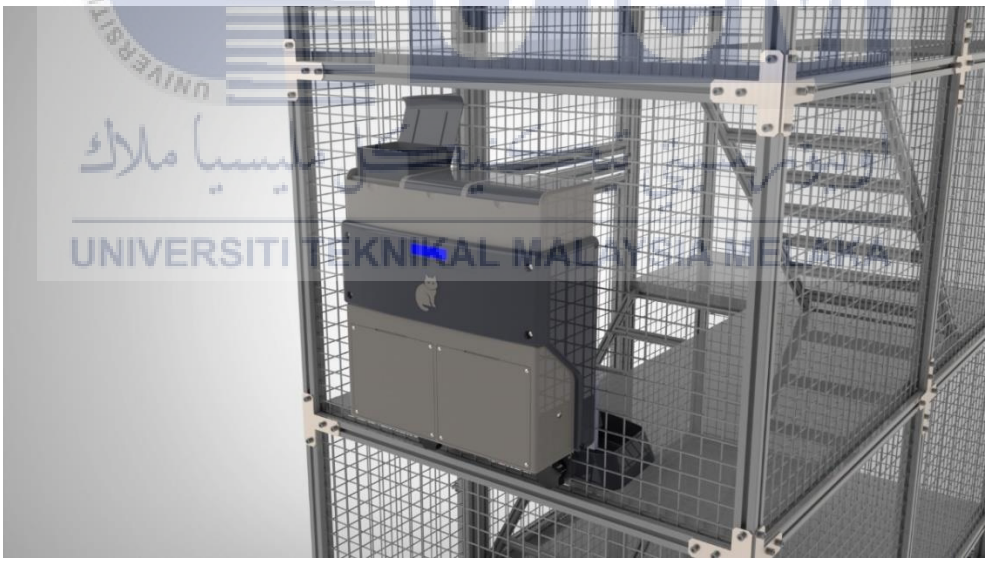


Figure 4.60 Isometric View

Figure 4.61 Isometric Views

Figure 4.62(i) Scenery 1 (Cat room)

Figure 4.62(ii) Scenery 2 (Living room)

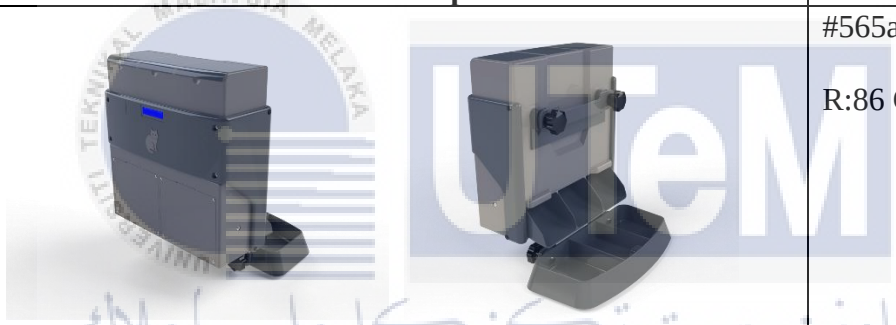
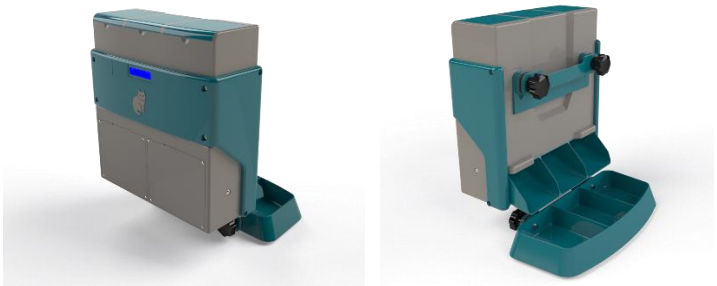
Based on Figures 4.62 (i) and (ii) above is a scenery rendering 1. This rendering shows a representation of how the cat feeder with a large cage is placed in the cat room and living room.

4.6 Design Modification

4.6.1 Colour Selection

Utilizing the solidworks visualisation software. Based on Table 18, three color samples which are HOF grey, rausch, and kazan were listed in this project. The color code for each color is also provided. The colour HOF grey was chosen from these three to be used for the prototype and 3D model.

Table 18 Colors idea

No.	Color sample	Color code
1	 (a) HOF grey	#565a5c R:86 G:90 B:92
2	 (b) Rausch	#ff5a5f R:255 G:90 B:95

3	  (c) Kazan	#007a87 R:0 G:122 B:135

4.6.2 Material Selection

Fabrication considerations are the main element to focus on selecting the most suiTable material. The Nylon-12 powder (Polyamide) is chosen as the main material to fabricate the alpha prototype. The cost of Nylon -12 powder (Polyamide) is free because this material is recycled and provided by faculty. Furthermore, Nylon -12 powder (Polyamide) has a high level of dimensional stability and has one of the lowest friction coefficients compared to other similar components. It is also a highly processable component and resists fatigue when dealing with high-frequency cyclic loading. Thus, prototyping using these recycled materials is well worth it.

4.7 Platform Design Analysis

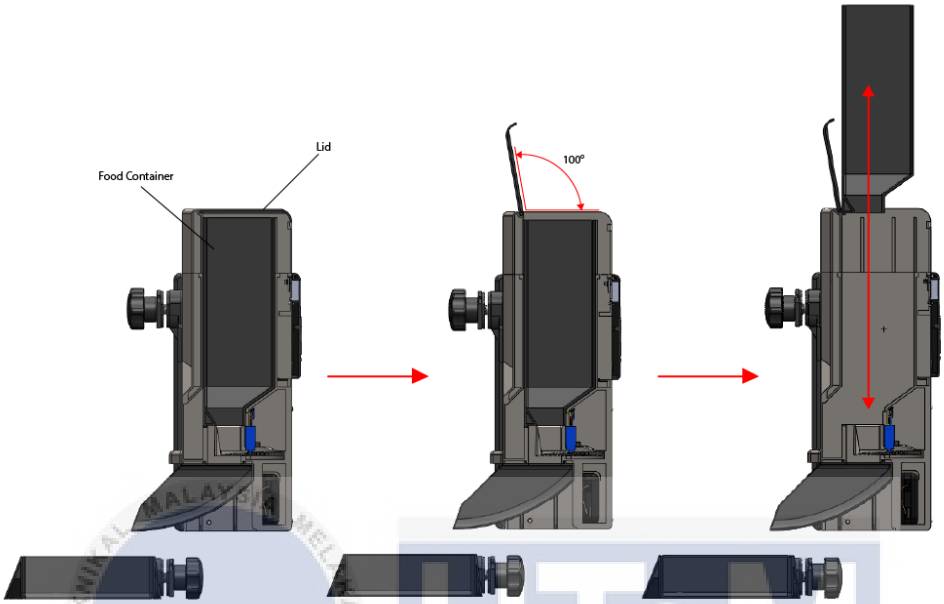


Figure 4.63 Lid and food container mechanism

Figure 4.63 shows the side view of the product. The lid can be opened up to 100 degrees while the food container can be removed and inserted vertically.

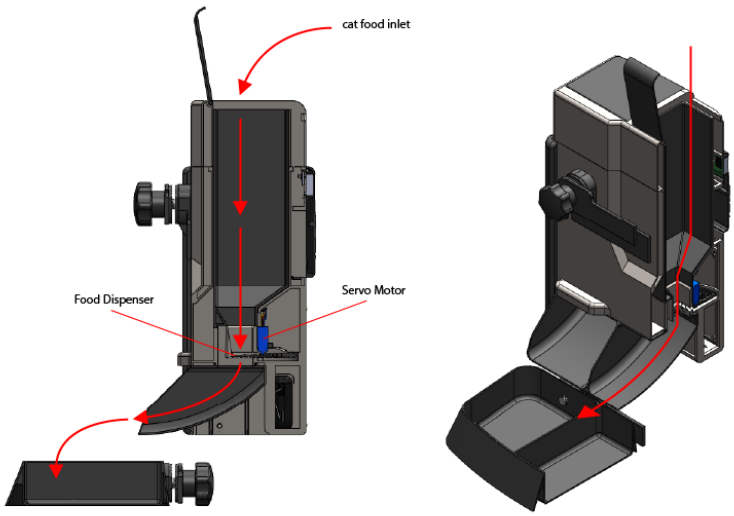


Figure 4.64 Kibbles in and out

Figure 4.64 illustrates the flow of cat food as it enter the food container and passes through the food dispenser, which is controlled by a servo motor. Cat food will come out according to the measurement controlled by the servo motor and then the food will pass through the food nozzle directly into the cat food bowl.

Table 19 Food Dispenser open and close position

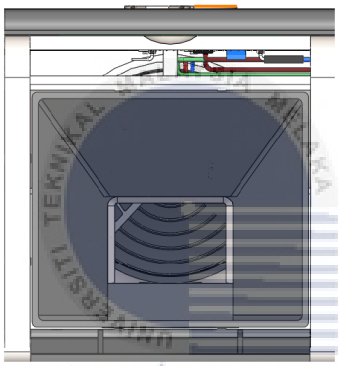
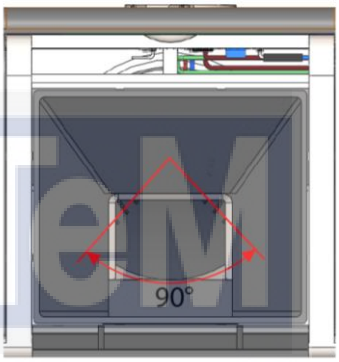
Close position	**Open position**
	
(a) Close position of food dispenser	(b) Open position of food dispenser

Table 19(a) shows the position angle of the food dispenser when the cat's feeding path is closed. Meanwhile, Table 19(b) shows the 90 degree opening position of the food dispenser.

4.8 Finite Element Analysis for Automatic Motorized Cat Feeder

4.8.1 Stress and Factor Of Safety Analysis

In this stage, static analysis is performed by using SolidWorks software to analyze and verify the design of automatic motorized cat feeder that can be supported 10 kg of load while mounted on the cat cage. Either a mounter or food dispenser is selected to conduct the analysis in this study.

$$1\ kg = 9.81\ N$$

$$Force = 10/2 \times 9.81$$

$$\therefore Force = 49.05\ N$$

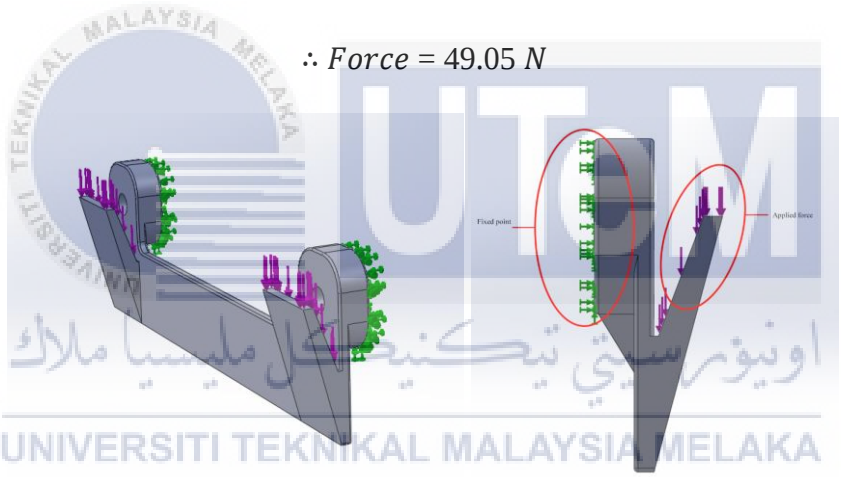


Figure 4.65 Area of force and fixture apply on cat feeder mounter

Hence, 45.05 N force is applied on the mounter based on the calculated force while the surface contact between cage and mounter fixed as shown in the Figure 4.65 above.

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	2.51518 mm
Tolerance	0.125759 mm
Mesh Quality	High

Figure 4.66 Component mesh setting information

In this static analysis, the mesh quality is set to high with finest element mesh. High mesh quality will produce more accurate results. Figure 4.67 shows the detail of component meshing setting.

Total Nodes	90287
Total Elements	56878
Maximum Aspect Ratio	8.0138
% of elements with Aspect Ratio < 3	99.5
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:16
Computer name:	BEYJAA

Figure 4.67 Mesh information - Details

After meshed, Figure 4.67 shows a total of 90287 of nodes and 56787 of elements are generated for the walkable chair design in this static analysis.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.0N/mm^2 (MPa) Node: 13608	2.1N/mm^2 (MPa) Node: 89085

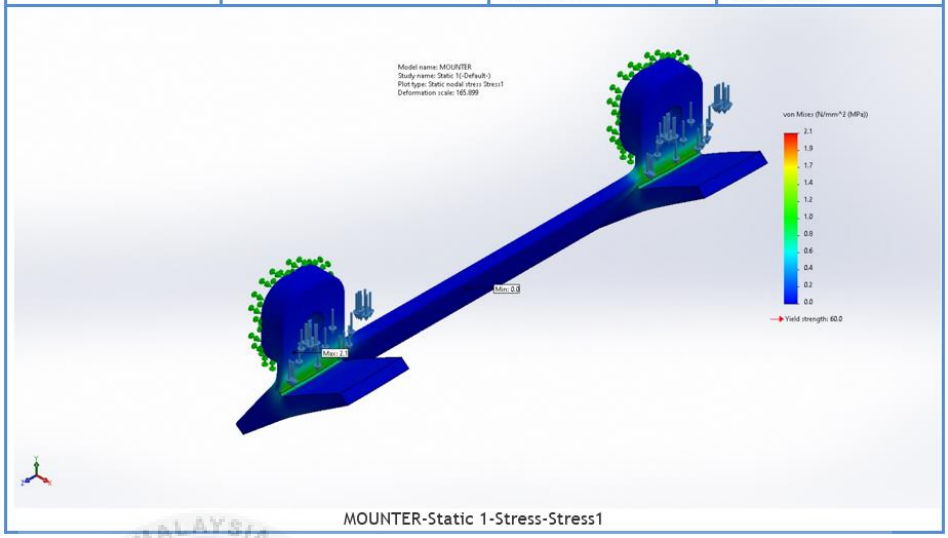


Figure 4.68 Static Analysis – von Mises Stress

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000mm Node: 12	0.177mm Node: 5164

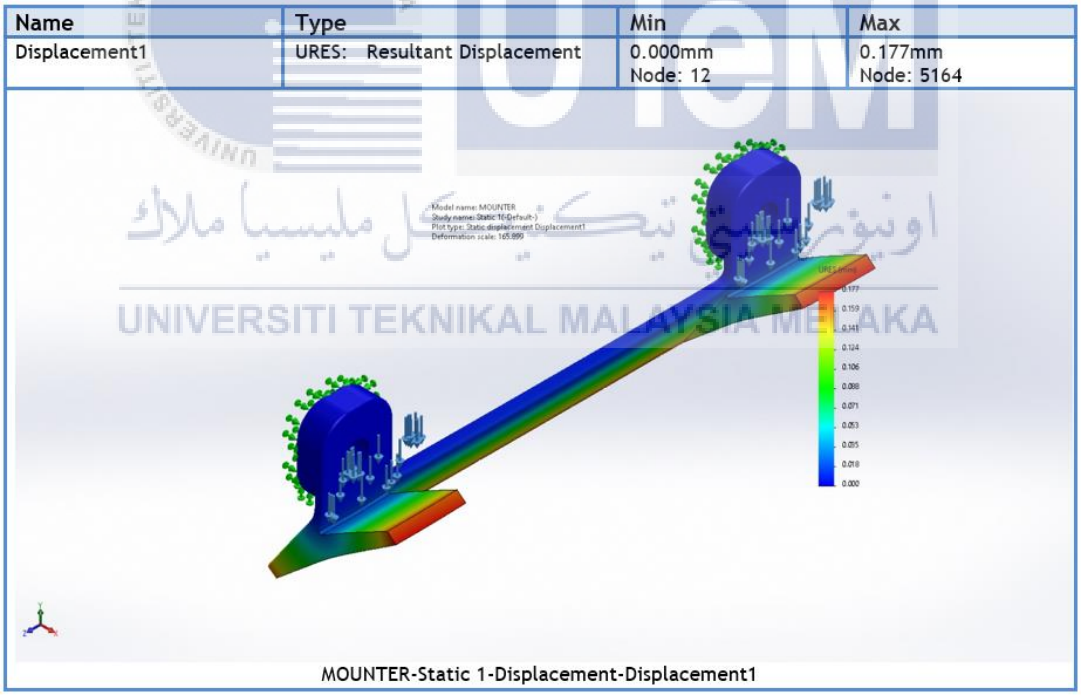


Figure 4.69 Static Analysis – Displacement

In Figure 4.69 shows the displacement result whereby the maximum deflection is 0.177 mm. While the maximum von Mises stress in overall structure is 2.1N/mm^2 (MPa). This indicates the design structure is accepTable because it does not exceed the material

yield strength which is 611.8 kgf/cm^2. All the components will not undergo plastic deformation. Furthermore, nylon 101 material is considered as a ductile material, thus, yield strength of nylon 101 is used to calculate to determine the factor of safety.

Name	Type	Min	Max
Factor of Safety1	Automatic	2.903e+01 Node: 89085	2.257e+06 Node: 13608

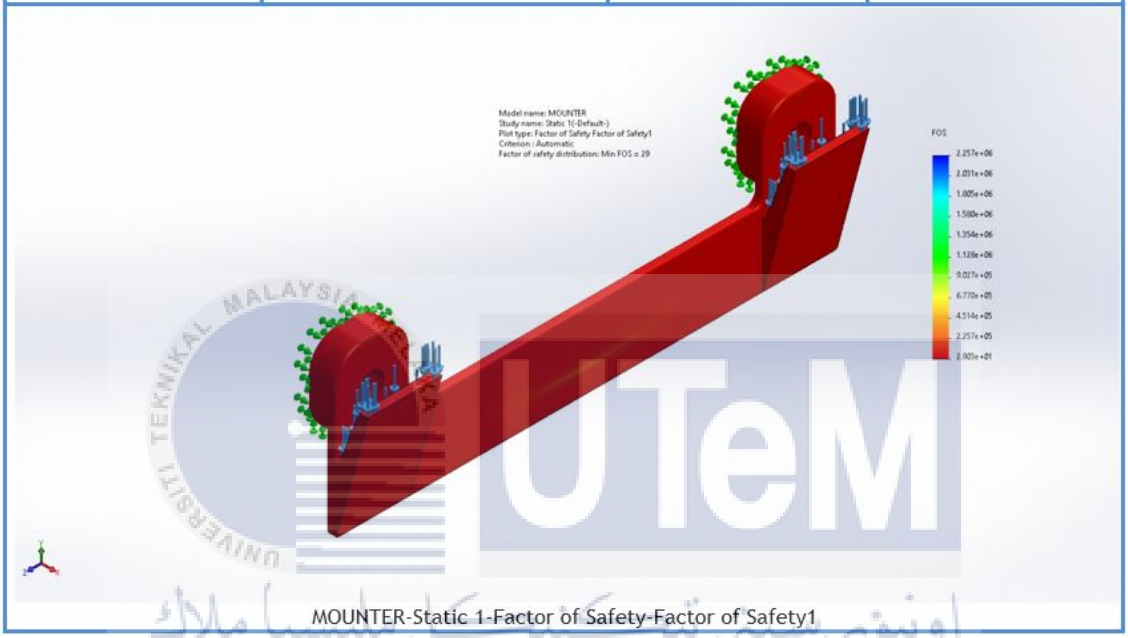


Figure 4.70 Static Analysis – Factor of Safety (FOS)

$$Factor\ of\ safety = yield\ strength\ maximum/allowable\ stress$$

$$Factor\ of\ safety = 60/2.1$$

$$Factor\ of\ safety = 28.57$$

The factor of safety of 28.57 indicates that the structure is designed to be much stronger than it needs to be to support the expected loads. This may be appropriate in some cases, such as when the structure must be extremely strong or the consequences of failure are severe. In other cases, a lower factor of safety may be acceptable as long as it is still sufficient to ensure the structure's safety and stability.

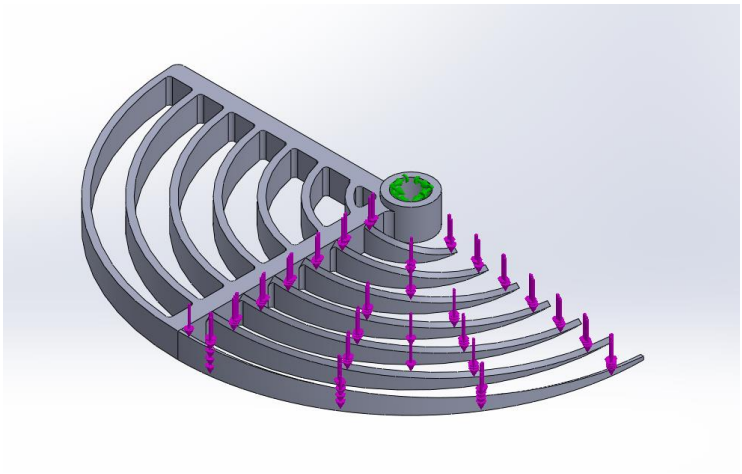


Figure 4.71 Area of force and fixture apply on cat feeder dispenser

Each food storage has a volume of 0.36 liters. Therefore, the total weight of cat food is maximum 500 grams for each storage. So the food dispenser needs to accommodate a load of 5 N after convert the unit from gram to newton. Hence, 5N force is applied on the dispenser based on the calculated force while the surface contact between kibbles and dispenser as shown in the Figure 4.71 above.

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	0.672007 mm
Tolerance	0.0336004 mm
Mesh Quality	High

Figure 4.72 Component mesh setting information

In this static analysis, the mesh quality is set to high with finest element mesh. High mesh quality will produce more accurate results. Figure 4.73 shows the detail of component meshing setting.

Total Nodes	96170
Total Elements	55424
Maximum Aspect Ratio	37.087
% of elements with Aspect Ratio < 3	98.8
% of elements with Aspect Ratio > 10	0.117
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:20
Computer name:	BEYJAA

Figure 4.73 Mesh information - Details

After meshed, Figure 4.73 shows a total of 96170 of nodes and 55424 of elements are generated for the walkable chair design in this static analysis.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.0129N/mm^2 (MPa) Node: 210	232N/mm^2 (MPa) Node: 68570

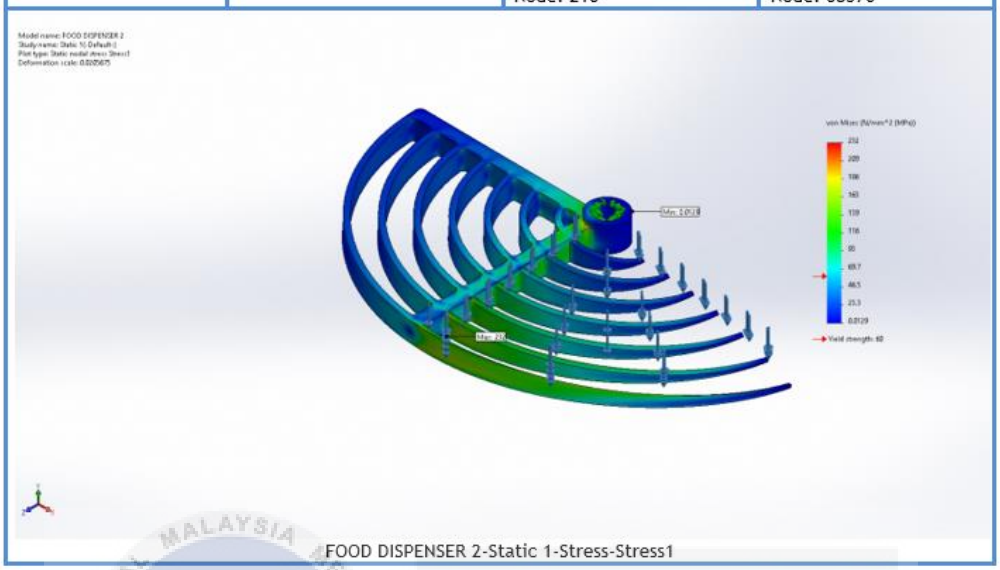


Figure 4.74 Static Analysis – von Mises Stress

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 28	3.676e+02mm Node: 291

Figure 4.75 Static Analysis – Displacement

In Figure 4.75 shows the displacement result whereby the maximum deflection is 0.368 mm. While the maximum von Mises stress in overall structure is 232N/mm^2 (MPa). This indicates the design structure is accepTable because it does not exceed the material

yield strength which is 611.8 kgf/cm^2. All the components will not undergo plastic deformation. Furthermore, nylon 101 material is considered as a ductile material, thus, yield strength of nylon 101 is used to calculate to determine the factor of safety.

Name	Type	Min	Max
Factor of Safety1	Automatic	2.582e-01 Node: 68570	4.635e+03 Node: 210

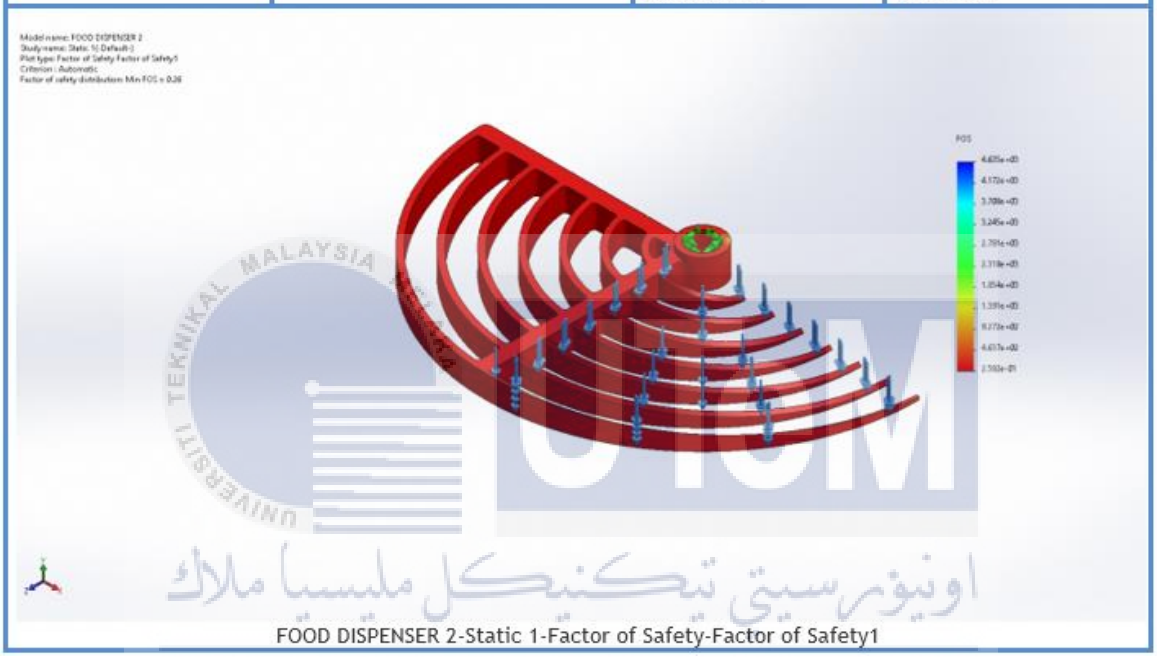


Figure 4.76 Static Analysis – Factor of Safety (FOS)

$$Factor\ of\ safety = yield\ strength\ maximum/allowable\ stress$$

$$Factor\ of\ safety = 60/232$$

$$Factor\ of\ safety = 0.26$$

A factor of safety of 0.26 is extremely low and would not be considered accepTable for the majority of structural designs. This would imply that the structure is only slightly stronger than the anticipated loads, which is insufficient to ensure the structure's safety and stability.

In general, structural designs should aim for a safety factor of at least 1.0 to 1.5, depending on the project's specific circumstances and the consequences of failure. In some cases, such as when the structure is designed to be temporary or when the loads on the structure are well understood and unlikely to change, a lower factor of safety may be accepTable. A factor of safety of 0.26, on the other hand, is generally considered too low and would be unaccepTable in most cases.

4.9 Prototype Development

4.9.1 Fabrication Process

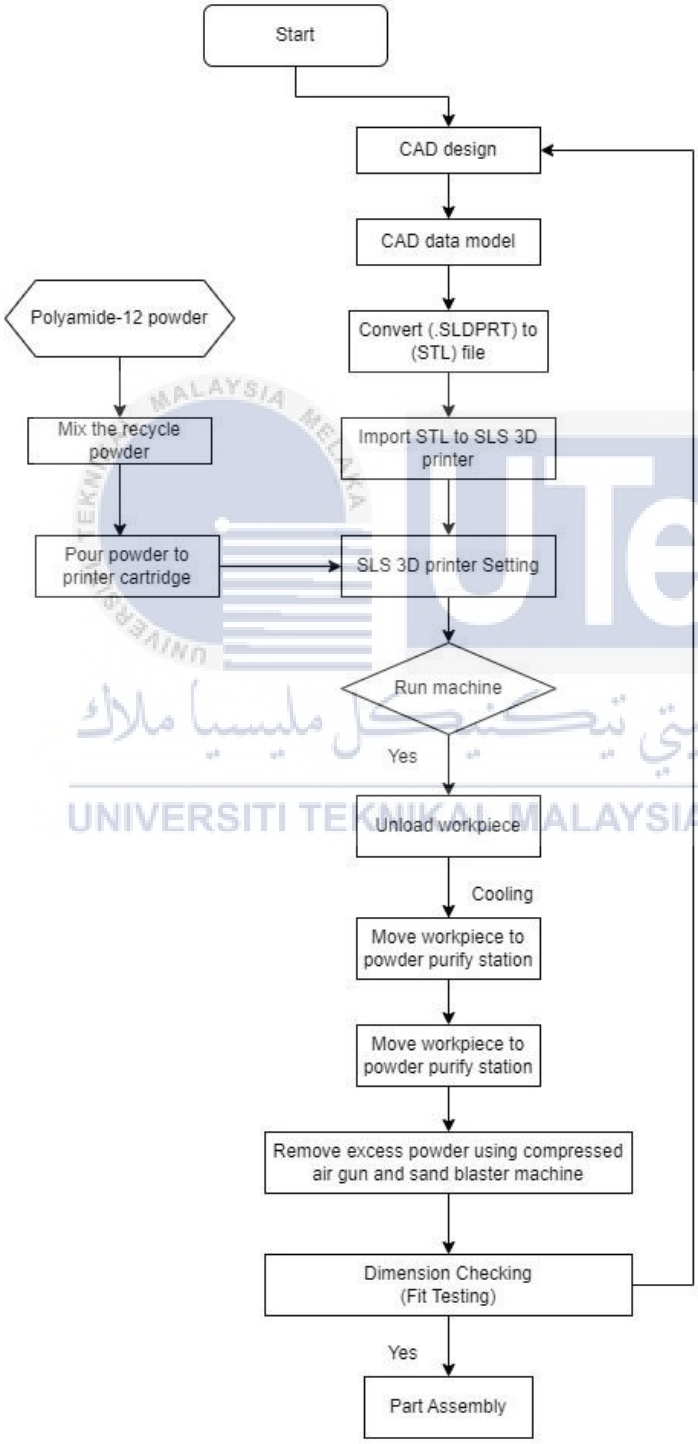


Figure 4.77 Automatic Motorize Cat Feeder Fabrication Flow Chart

The prototype making is started on 3 August 2022 and ends on 5 October 2022. There is a total around 2 months to complete this prototype. Figure 4.77 shows the complete fabrication flow chart, start from cad design until prototype assembly. The model views of the prototype include the isometric view, front view, top view, and side view are created. The model of the main body of the prototype is shown in Figure 4.78 whereas the model view of the cat feeder is shown in Figure 4.79, 4.80 and 4.81.

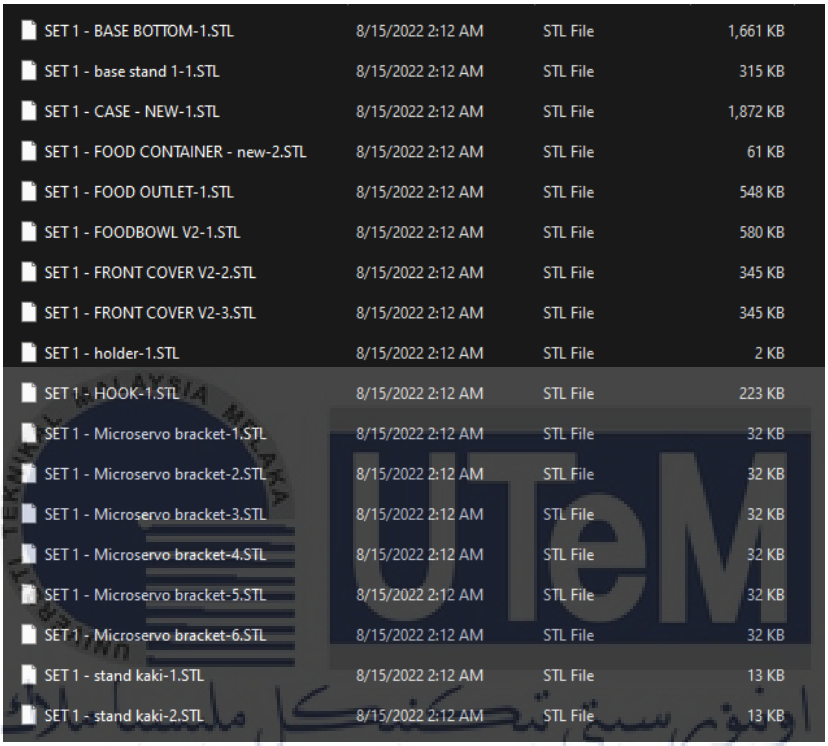
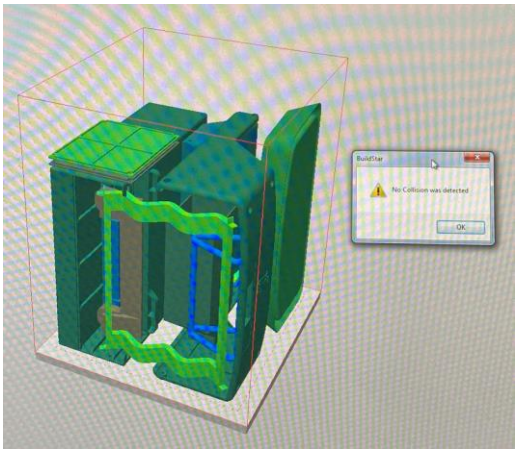
Figure 4.78 Complete Automatic Motorized Cat Feeder for large cat cage

Figure 4.79 Front View

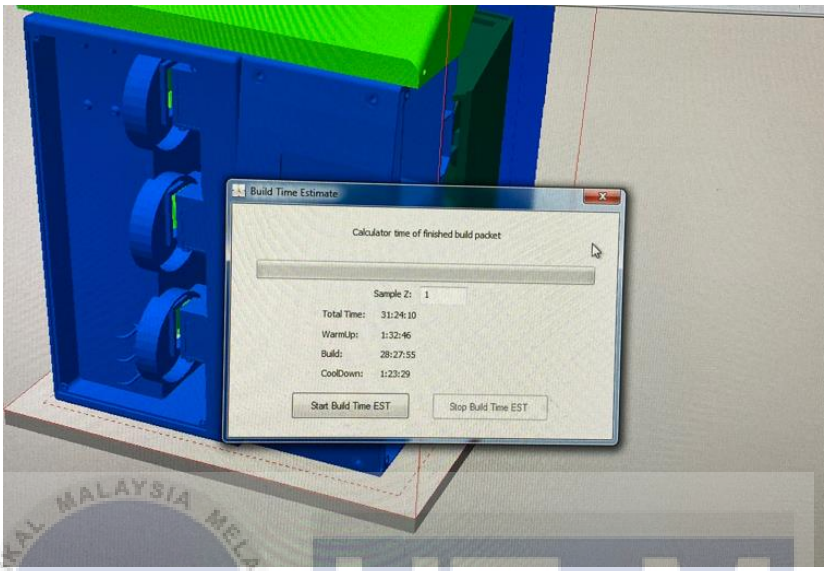
Figure 4.80 Top view

Figure 4.81 Side view

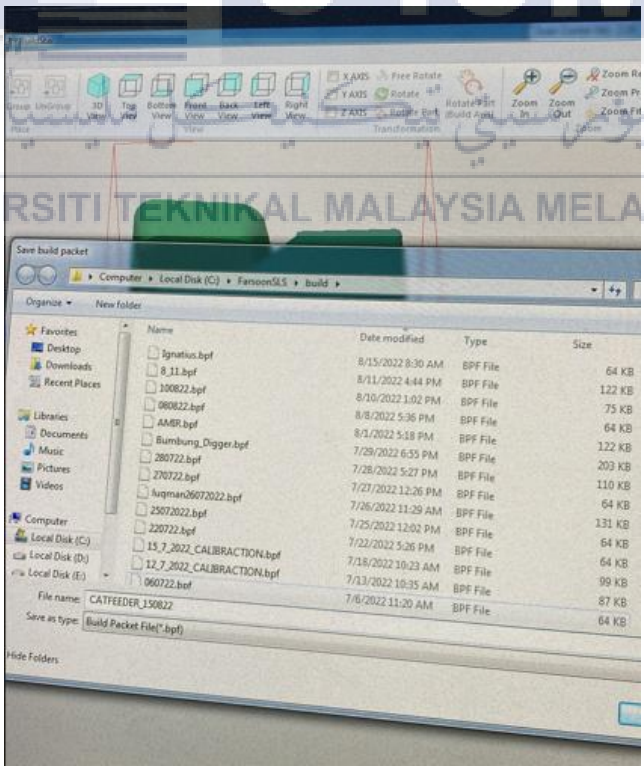
Table 20 shows fabrication process of the prototype.

Task
• Buying the materials
• Convert Solid works files (. SLDPRT) to (. STL) files 
• Upload STL files to SLS 3D printer software (Buildstar) • Organize parts in printing build size: 320x320x380mm • Make sure no Collision was detected 

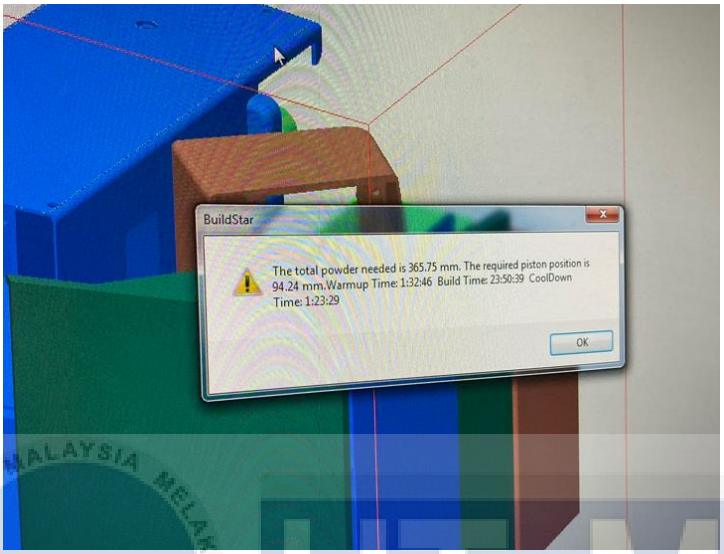
- Build time Estimate



- Transfer data from BuildStar system to MakeStar P System

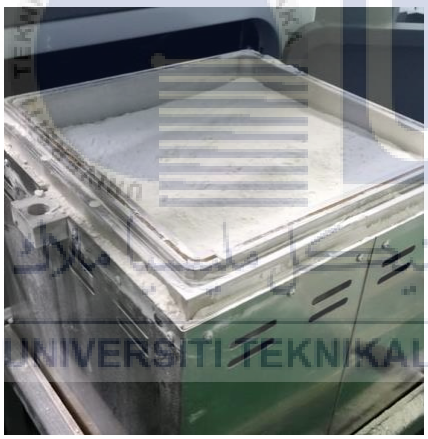


- Make sure there is enough powder in left cartridge

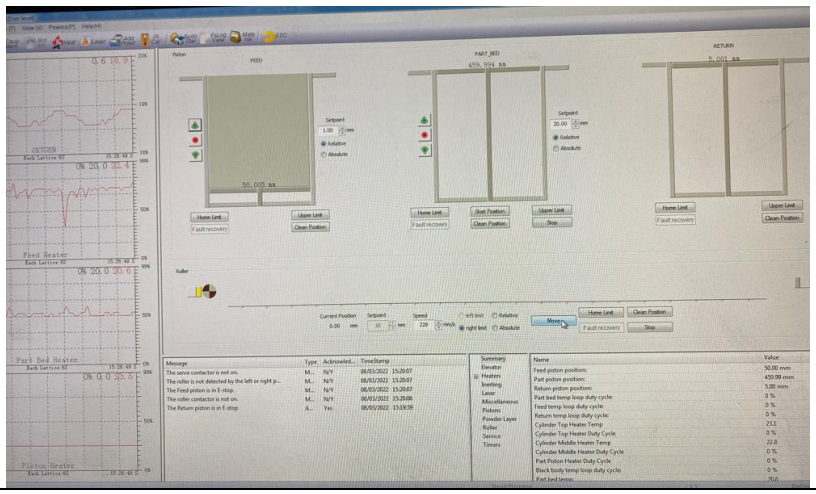


- Mix the recycled polyamide-12 powder

- Pour the powder into SLS 3D printer left cartridge

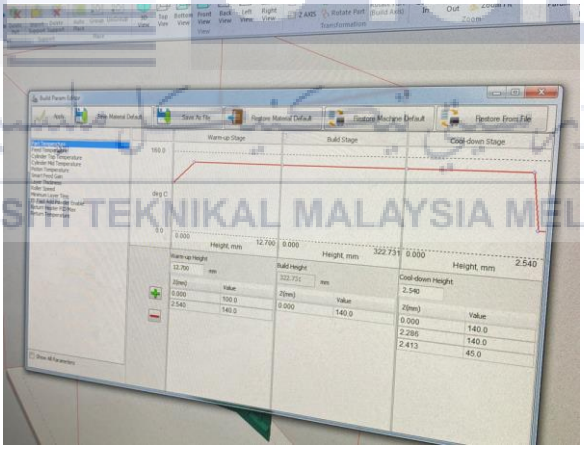


- Set the powder limit

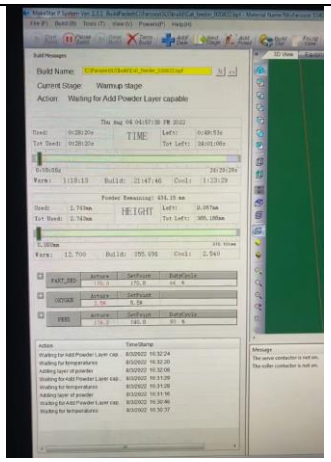
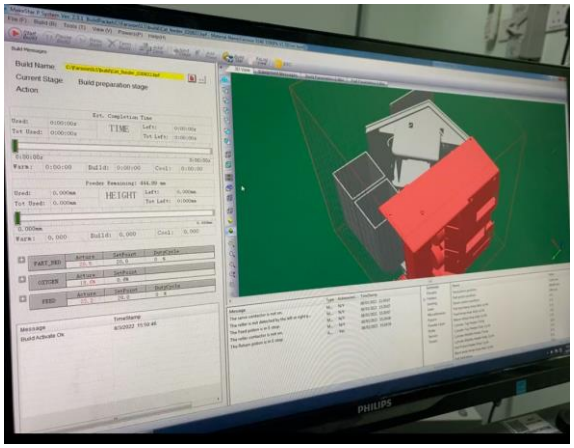


- Flatten the powder manually by using wiper

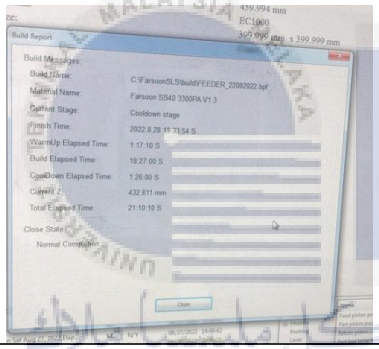
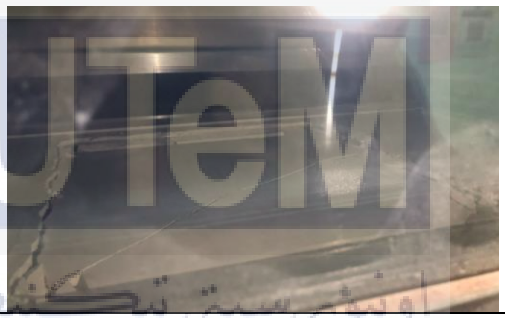
- Print setting by using Build Parameter Editor



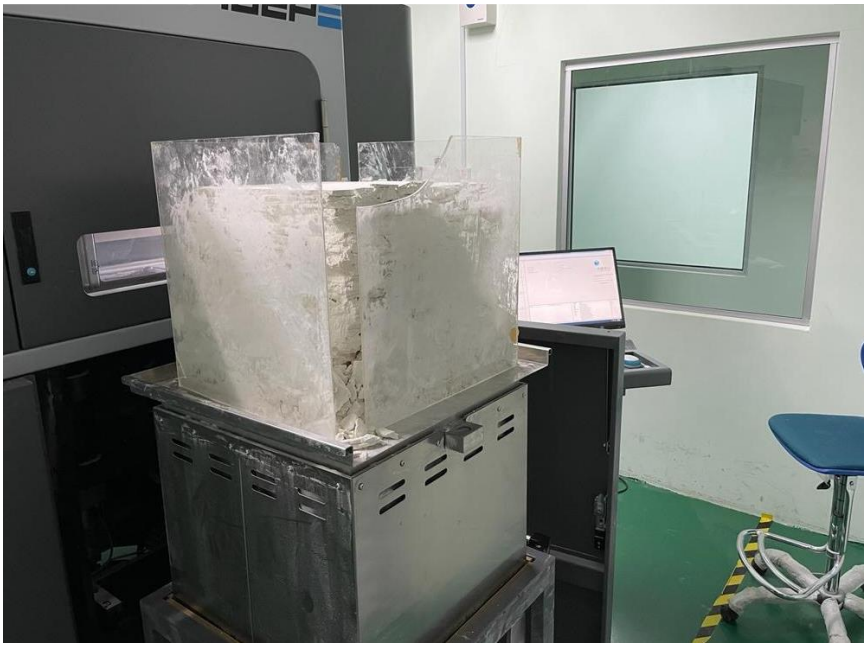
- Printing process in 3 stages
    - Warmup stage: 1h:18m:13s
    - Build stage: 21h:47m:46s
    - Cool stage: 1h:23m:29s

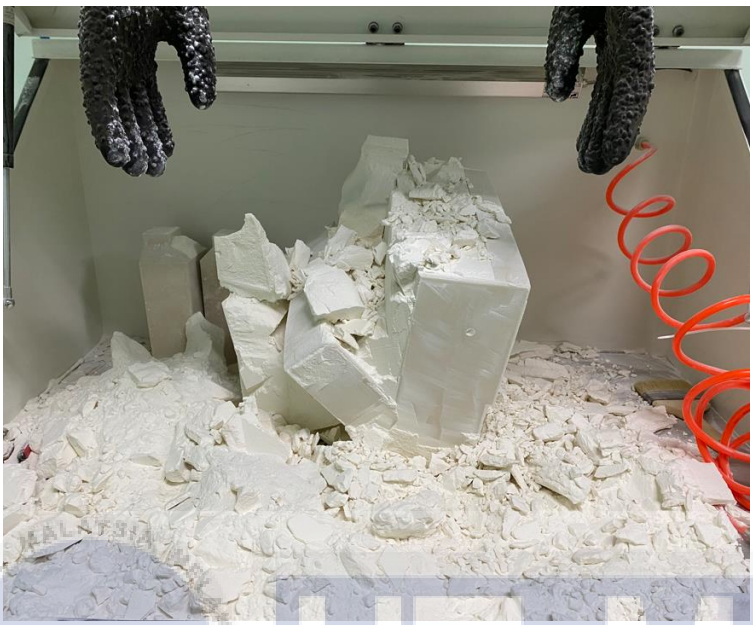
- Build Report

- Remove the printed part from the machine and leave it for a few hours for the cooling process so that the part does not bend

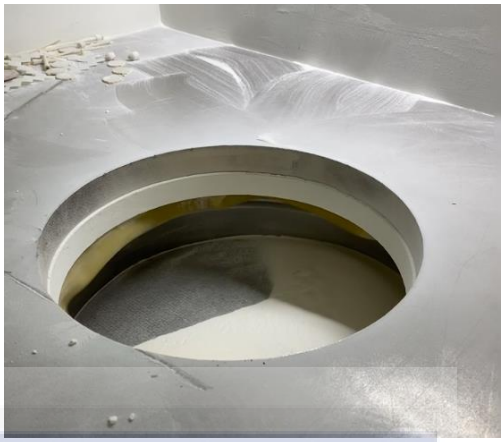


- Move printed parts from SLS 3D printer to powder purify station



- Remove excess powder from parts using compressed air gun and sand blaster machine.

- Filter all excess powder using powder purify station



- Fitment Testing

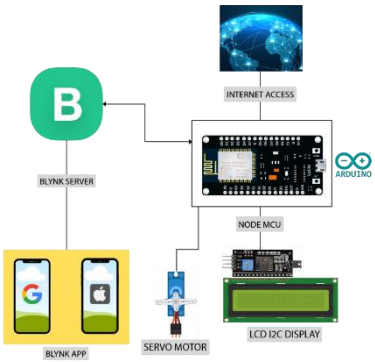
- Smooth the surface of every part by using sandpaper

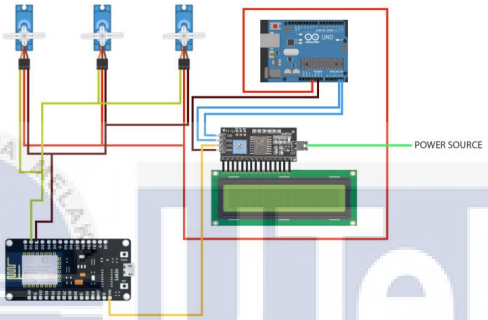
- Spray primer paint to ensures that every part would not flake or fade.

- Spray color paint

- Coding the system by using Arduino uno software
- Upload coding to Arduino ESP8266

- Install the Arduino system in automatic motorized cat feeder based on circuit diagram
- System testing





- Assembly
- Final prototype

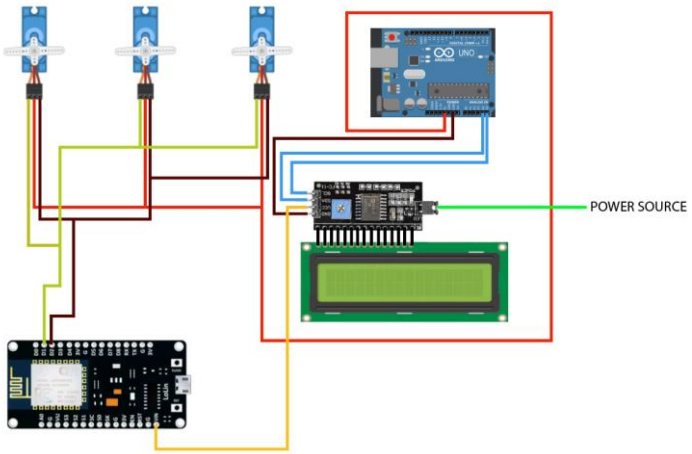


Figure 4.82 Arduino connection diagram of NodeMCU ESP8266 and arduino uno

In this circuit diagram, 3 servo motor are connected with NodeMCU ESP8266. PWM=orange are connected to pin D1 meanwhile VCC=Red are connected to pin D2. For LCD module, SCL are connected to pin A5 meanwhile SCA connected to pin A4. Therefore, VCC are connected with pin VIN at NodeMCU ESP8266 and pin GND are connected to GND at arduino uno.

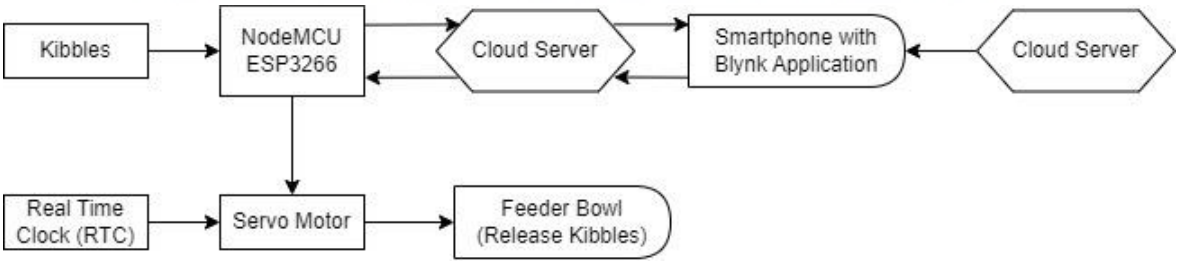


Figure 4.83 Block diagram of operational project

Based on Figure 4.83, The NodeMCU ESP3266 Wi-Fi module acts as a controller module to receive data that will be transferred through Wi-Fi to the cloud server and smartphone using the Blynk Application. Furthermore, this controller module can assist the Blynk Application in transmitting manual kibble release instructions to the servo motor

(SG90). As a result, the kibbles will be released in this section based on the user's preferences.

To begin coding on the Arduino platform. To begin, connect a computer to the internet, then connect an Arduino ESP8266 to the computer through a USB A-to-B connector.

Secondly, Browse to the Arduino website (https://www.arduino.cc/) and select the "Software" option from the top menu. Click the "Download the Arduino IDE" button for your operating system under the "IDE" section. Follow the on-screen instructions to instal the Arduino IDE on your computer.

Finally, once the Arduino IDE is installed, follow these instructions to begin your first project. Use the USB cord to connect the Arduino board to the PC. Open the Arduino IDE and choose the appropriate port and board type from the Tools menu before writing the code in the Arduino IDE editor. Select the "Upload" option.

Figure 4.84 Codes in Arduino software

```
#define BLYNK_TEMPLATE_ID "TMPLSoe58FJL"
#define BLYNK_DEVICE_NAME "Quickstart Template"
#define BLYNK_AUTH_TOKEN "5pMn9nh2v6IvapfodEYRXeXqindaKjmH"
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Servo.h>
#include <NTPClient.h>
#include <WiFiUdp.h>
#include <LiquidCrystal_I2C.h>
#include <Wire.h>


WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org", 28800);


Servo servo;
LiquidCrystal_I2C lcd(0x27, 16, 2);


char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "Melati-2.4GHz@unifi";//Enter your WIFI name
char pass[] = "BMMD@4321";//Enter your WIFI password
Servo servo1, servo2, servo3;
```

```
BLYNK_WRITE(V0)
{
  int s0 = param.asInt();
  servo1.write(s0);
  Blynk.virtualWrite(V1, s0);
}
void setup()
{
  // Debug console
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass);
  servo1.attach(D1);
}
void loop()
{
  Blynk.run();
}
```


Codes Explanation

1. Blynk template information.

```
#define BLYNK_TEMPLATE_ID "TMPLSoe58FJL"
#define BLYNK_DEVICE_NAME "Quickstart Template"
#define BLYNK_AUTH_TOKEN "5pMn9nh2v6IvapfodEYRXeXqindaKjmH"
```

2. Included are servo libraries, WiFi, and Blynk. The servo object was then created with the name "servo."

```
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Servo.h>
#include <NTPClient.h>
#include <WiFiUdp.h>
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
```

3. Auth Token for servo motor control project and device servo motor control

```
char auth[] = BLYNK_AUTH_TOKEN;
```

4. Blynk code and WIFI connection information.

```
char ssid[] = "Melati-2.4GHz@unifi";  //Enter your WIFI name
char pass[] = "BMMD@4321";  //Enter your WIFI password
```

5. This code rotates the servo motor using result calculated from the Blynk app.

```
BLYNK_WRITE(V0)
{
    int s0 = param.asInt();
    servo1.write(s0);
    Blynk.virtualWrite(V1, s0);
```

```
}
```

6. Begin the Blynk library and serial monitor in the setup function. In addition, the PIN number associated with the servo motor is attached to the servo library.

```
void setup()
{
    Serial.begin(115200); // Debug console
    Blynk.begin(auth, ssid, pass);
    servo1.attach(D1);
}
```

7. In the loop function, the Blink library is activated.

```
void loop()
{
    Blynk.run();
}
```

8. Select board as shown in Figure 4.85, After that, verify the code then select Nodemcu board as shown in Figure 4.85. Then select ports 'COM6' then upload the code to ESP 8266 board. Other than, run previously prepared Blynk app interface.

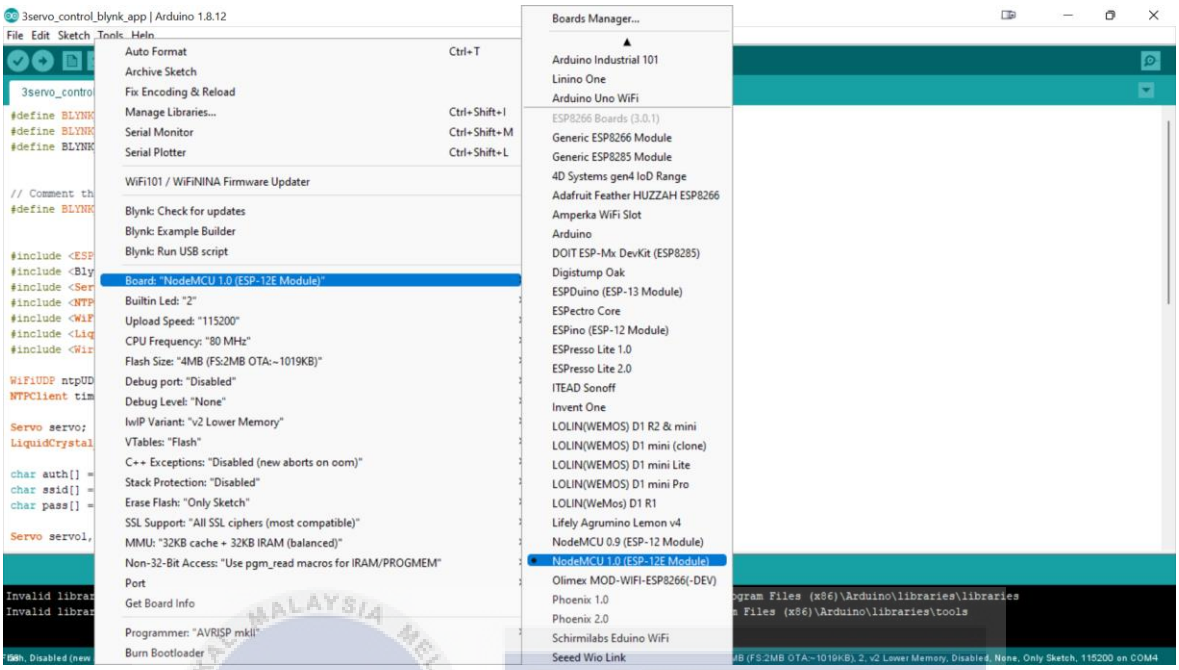


Figure 4.85 Select board

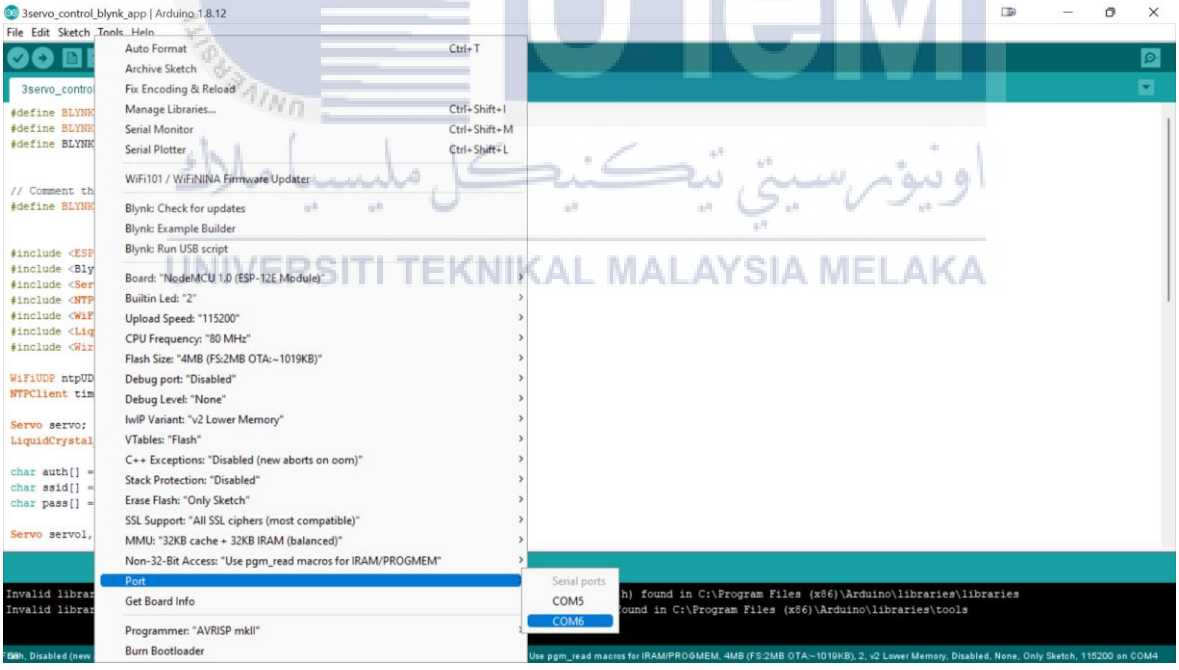


Figure 4.86 Select Port

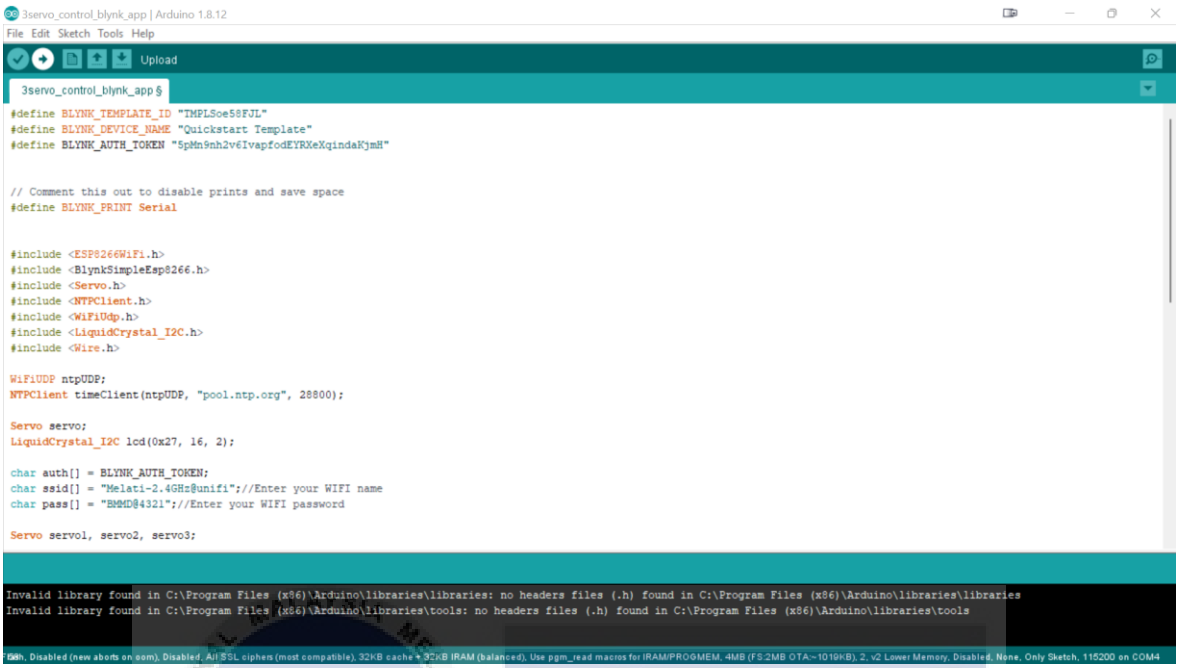


Figure 4.87 Verify and Upload to board

When the Nodemcu board is turned on, it creates a WiFi connection with the blynk cloud. Following that, the Nodemcu board and Blynk app connect. So, using the interface that already developed, servo motor can be rotated.

1) Create a Blynk account

   To record user projects and access them from multiple devices and from anywhere in the world, a user account is necessary. More info It also serves as a security precaution. Moreover, users can always create their own Private Blynk Server and maintain complete control.

2) Select "New Project" from the menu. Enter your preferred name after that, then decide onthe device and connection type. Select "Confirm" from the menu. Add the

widget to this interface.Click on the "+" sign to the right to accomplish this. Add a "slider" widget next.

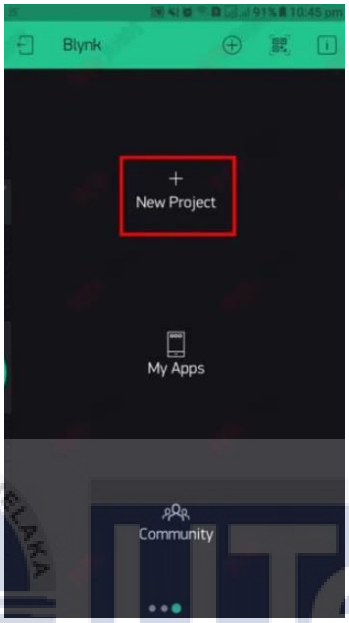


Figure 4.88 Blynk-create new project

3) Add the widget to this interface.Click on the "+" sign to the right to accomplish this. Add a "slider" widget next.

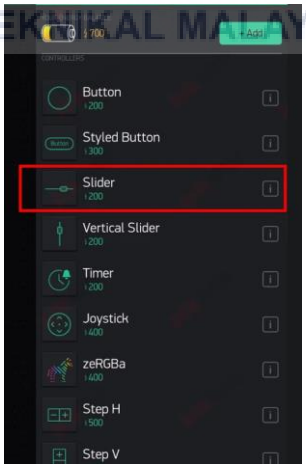


Figure 4.89 Widget selection

4) click over slider widget. Then, give the slider whatever name After that, set the PIN to "virtual V0" with a value range of 0 to 180. Last but not least, modify the slider widget to user preference liking.

Figure 4.90 Slider modification

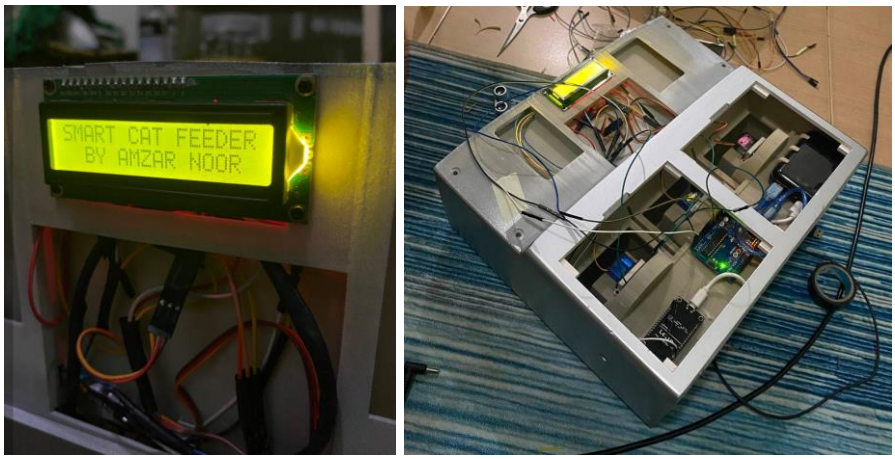


Figure 4.91 System assembled and run

After completed the assembly and testing the system as shown in Figure 4.92. The results of the code will be received on any output devices attached to the Arduino, such as an LCD screen. Once the project was up and running, the Arduino Integrated Development Environment (IDE) was used to modify the code and upload it to the Arduino board. This allows to fine-tune of the the project and make any necessary changes.

Before proceeding with any more development or modifications, it is important to ensure that the project is running well and as intended. If the system encounters any bugs or problems, Arduino IDE's built-in debugging tools can be utilised to help identify and resolve the issue.

4.9.2 Budget Plan

Table 21 Bill of Materials

Item	Description	Unit	Price	Amount
1	SG90 Plastic Gear 180 Degree Micro Servo Motor	3	6.90	20.70
2	Jumper Wire Female to Female	3	0.80	2.40
3	Jumper Wire Male to Female	2	0.80	1.60
4	Mini PowerBank 12000mAh	1	18.30	18.30
5	NodeMCU Lua V3 ESP8266 WiFi with CH340C	1	15.50	15.50
6	Arduino Serial IIC I2C LCD 1602 (16x2) Yellow Liquid Crystal Display Module	1	15.40	15.40
7	M12 Stainless Steel SS304 Threaded Bar	2	11.90	23.80
8	Female M12 CSM 1p Black star grip knobs	4	14.00	56.00
9	M5, 8mm Philips Pan Head Screw DIN Stainless Steel AISI 304	15	0.10	1.50
10	M3, 8mm Philips Pan Head Screw DIN Stainless Steel AISI 304	15	0.30	4.50
11	M2, 5mm Screw	40	0.20	8.00
12	M3, 5mm Screw	10	0.20	2.00
13	Samurai Putty Primer Spray	5	20.80	104.00
14	Samurai Matt Grey Spray	2	11.50	23.00
15	Samurai Yamaha Matt Grey Spray	2	11.50	23.00
16	Samurai White Spray	2	8.50	17.00
17	Cat Cage 1 level	1	38.50	38.50
18	Arduino Uno	1	45.00	45.00
			Total RM	420.20

From the budget analysis, the overall cost for our project is approximately RM420.20. The budget is slightly higher as manufacture everything from the scratch.

4.11 Usability Test

One of the surveys that may be used to assess the usability of a variety of products or services is the System Usability Scale (SUS). The SUS has various qualities that make its use attractive (Bangor et al., 2009).

The SUS has various qualities that make its use attractive. First, it is made up of only ten statements, making it short and simple for study participants to complete and administrators to evaluate (Bangor et al., 2009). Second, because it is nonproprietary, it is affordable to use and may be scored instantly, immediately after completion. Third, the SUS is technology agnostic, which implies that it may be used to evaluate practically any sort of user interface by a diverse group of usability practitioners (Bangor et al., 2009).

Usability testing helps to uncover problems, discover opportunities, and learn about users. The alpha prototype is tested by a small group of people and the result of usability test is collected by using questionnaire via google form and it is evaluated and discussed in this section.

4.11.1 Method

The SUS is composed of 15 statements, each having a five-point scale that ranges from Strongly Disagree to Strongly Agree. There are 3 section which is usability that is for the ease of use at using the tool, applicability that is the suitability of the proposed method and effectiveness that is the ability of the tool. 5 statements are provided for each section.

Table 22 15 statements of System Usability Scale (SUS)

Usability test- ease of use at using the tool						
No.	Statements	Strongly disagree				Strongly agree
1	Easy to maintain the product.	1	2	3	4	5
2	Easy to clean the product.	1	2	3	4	5
3	Ease of product installation.	1	2	3	4	5
4	Ease of product monitoring and control.	1	2	3	4	5
5	Ease of mounts to the cage.	1	2	3	4	5
Applicability- the suitability of the proposed method						
6	The design of the product	1	2	3	4	5
7	Compatibility of the product with the cat cage	1	2	3	4	5
8	The variety of kibbles	1	2	3	4	5
9	The portion size of the cat food	1	2	3	4	5
10	Stability of the product when it mounts to the cage	1	2	3	4	5
Effectiveness- the ability of the tool						
11	Easy to refill the food in storage	1	2	3	4	5
12	The durability of the food bowl	1	2	3	4	5
13	Sufficiency of cat food for a week	1	2	3	4	5
14	Weight of the product	1	2	3	4	5
15	Food feeding accuracy	1	2	3	4	5

4.10.2 Obtaining data

Table 23 SUS questionnaire result

No.	Statements	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	
Usability												
1	Easy to maintain the product.	4	4	5	4	5	4	4	5	5	5	
2	Easy to clean the product.	4	5	5	5	5	4	5	4	5	4	
3	Ease of product installation.	2	4	5	4	5	3	2	4	3	3	
4	Ease of product monitoring and control.	5	5	5	3	5	4	5	4	3	4	
5	Ease of product mounts to the cage.	5	4	5	4	5	4	4	4	5	4	
Possibility												
6	The design of the product	5	5	5	4	5	5	5	5	4	4	
7	Compatibility of the product with the cat cage	3	4	5	4	5	5	4	4	2	5	
8	The variety of kibbles	5	2	2	2	5	2	4	3	4	3	
9	The portion size of the cat food	4	4	5	4	5	5	3	4	5	4	
10	Stability of the product when it mounts to the cage	3	4	2	3	5	4	5	4	5	4	
Effectiveness												
11	Easy to refill the food in storage	5	4	4	4	5	5	5	5	4	4	
12	The durability of the food bowl	4	4	5	4	5	5	5	4	5	4	
13	Sufficiency of cat food for a week	3	4	5	4	5	4	4	5	5	5	
14	Weight of the product	4	4	5	3	5	4	5	4	4	3	
15	Food feeding accuracy	2	4	2	3	2	4	2	4	1	3	**Average**
	SUS Raw Score	**25**	**30**	**34**	**34**	**29**	**33**	**22**	**34**	**27**	**34**	**30.2**
	SUS final Score	**62.5**	**75**	**85**	**85**	**72.5**	**82.5**	**55**	**85**	**67.5**	**85**	**75.5**

Table 23 contains the results of the questionnaire. From a total of 10 respondents, 2 respondents were from pet shop promoter, 5 of respondents were cat owner, 3 respondents declared themselves to be neutral. This indicates that many respondents will provide information about the product.

Table 24 Total response

	Number	Percentage
Pet shop promoter	2	20%
Cat owner	3	30%
Neutral	5	50%
Total Responses	10	100%

After the data is collected, the next step is to process the data. Two results are added and multiplied by 2.5. If the SUS score is above 76.75 then it is considered above average and if it is below 76.75 then it is considered below average. The results of the SUS assessment can be seen in Table 24.

Table 25 The final result SUS

Respondents	SUS Score	Adjective Ratings
1	62.5	OK/ Fair
2	75	Good
3	85	Excellent
4	85	Excellent
5	72.5	Good
6	82.5	Good
7	55	OK/ Fair
8	85	Excellent
9	67.5	OK/ Fair
10	85	Excellent
Average SUS Score	75.5	Good

SUS results are scored from 0 to 100 rather than as a percentage, which can occasionally make them difficult for certain individuals to understand. Table 25 includes an adjective rating scale for the SUS score to make it simpler to interpret and comprehend the findings.

Table 26 SUS Score interpretation (Pradini et al., 2019)

SUS Score	Adjective Ratings
92	Best imaginable
85	Excellent
72	Good
52	OK/ fair
38	Poor
25	Worst imaginable

For analysis, numerical equivalents of 1 through 5 were assigned to the adjectives from Best imaginable to Worst imaginable, respectively. First, a correlational analysis was conducted to determine how well the ratings (using the adjective rating scale) matched the corresponding SUS scores given by participants.

4.10.3 SUS Score result discussion

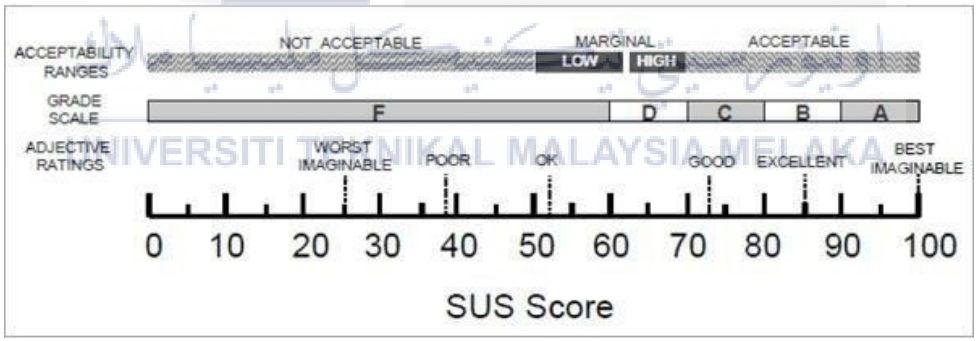


Figure 4.92 Grade rankings of SUS scores (Brooke, 2020)

This study discusses the usability evaluation of automatic motorized cat feeders for large cat sizes. The evaluation of usability is used to determine (whether feasible / not) as well as user satisfaction with using the product. SUS is used to answer the usefulness of the product.

After gathering information through the distribution of surveys by SUS guidelines. The test conducted an in-depth analysis and found answers to the 3 research questions which are usability, portability, and effectiveness that has 5 statements for each question.

The first to fifteenth questions in the questionnaire are calculated using SUS and prove that the product is quite useful for the cat owner, this is evidenced by the final average SUS score result of 75.5 which has an adjective rating of Good. Based on the analysis of the SUS questionnaire that was given to respondents in Table 23. SUS score for respondent 1 is 62.5 which has an adjective rating of OK/Fair, respondent 2 is 75 which has an adjective rating of Good, respondent 3 is 85 which has an adjective rating of Excellent, respondent 4 is 85 which has an adjective rating Excellent, respondent 5 is 72.5 which has an adjective rating Good, respondent 6 is 82.5 which has an adjective rating Good, respondent 7 is 62.5 which has an adjective rating OK/Fair, respondent 8 is 85 which has an adjective rating Excellent, respondent 9 is 67.5 which has an adjective rating Excellent and respondent 10 is 85 which has an adjective rating Excellent.

From the second question, 2 of the respondents thought that the product was complicated to install the product in the cage. So that respondents feel difficulty installing the product and need help from others for easy installation. Therefore, the product needs to be improved to make it more user-friendly so that all people can do the installation easily.

From the seventh question, 1 of the respondents thought the product are not compatible with a cat cage because every cat has a different breed and size. Meanwhile, from the eighth question, 4 of the respondents thought the product is not suitable for all types of dry cat food to use because dry cat food had various types of kibble sizes. Besides, from the tenth question, 1 of the respondents thought the product are not sTable when it was mounted

to the cage because the cage used for the prototype is small. Moreover, from the fifteenth question, 4 respondents thought cat food was inaccurate because the kibbles got stuck in the nozzle.

Overall, the results are satisfying. However, the product's developer should keep making improvements to make it better and more useful for all cat owners. Only usability values can be answered by the system usability scale. The System Usability Scale is unable to provide specific recommendations for how to increase usability. As a result, identifying the details that need to be changed to enhance a system's usability necessitates the use of additional tools or techniques.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Overall, this project aims to design and develop an automatic motorized cat feeder for large cage sizes. Hence, three objectives are declared and completely achieved.

RO 1: To design and develop automatic motorized cat feeder that matches a large cage size.

As shown in Figure 4.56 in chapter 4, the final concept was successfully selected using two methods: Pugh's and weighted rating. After creating the detailed design shown in Table 17 in chapter 4, static analysis is performed using Solidworks software to validate the chosen materials and component design. Figures 4.65 and 4.71 in chapter 4 demonstrate that the cat feeder will not fail under the desired applied load when mounted to the cage. A platform design analysis was conducted to explain the mechanism of the food dispenser, lid, and food container as shown in Figure 4.63, Figure 4.64 and Table 19. Hence, it can be concluded that this cat feeder can save cat owners time and energy by allowing them to care for their cats at home without having to worry.

RO 2: To develop the feeding mechanism of an automatic motorized cat feeder by using the Arduino system.

As shown in Figure 4.82 in chapter 4, Arduino connection diagrams show the connections between the various components of an Arduino system, such as the microcontroller, power supply, serial communication devices, and other peripherals. It is useful visual assistance for learning how the various components of an Arduino system are

connected and interact with one another. An Arduino connection diagram is a valuable tool for understanding the layout and function of an Arduino system, and it can be beneficial for developing or troubleshooting an Arduino project. Therefore, the process of writing the coding in Arduino software and the setup of the Blynk app is successfully done by referring Figure 4.83 to Figure 4.90 in chapter 4. Figure 4.91 in chapter 4 shows the finished Arduino system assembly and testing with the Blynk app on a smartphone. Hence, it can be concluded that cat owners who always forget to feed their cats on occasion, due to forgetfulness and business no longer need to worry because they can control and monitor the cat feeder using a Blynk app in their smartphone.

RO 3: Analyze the design and system of an automatic motorized cat feeder prototype through usability test for target users.

As shown in Table 23 in chapter 4, the first to fifteenth questions in the questionnaire are calculated using SUS and prove that the product is quite useful for the cat owner, this is evidenced by the final average SUS score result of 75.5 which has an adjective rating of Good. Hence, The System Usability Scale (SUS) test score is simply the result of the test. The SUS score can be used to evaluate a system's perceived usability, compare the usability of different systems, and track changes in usability over time. In addition to the SUS score, reviewing the individual responses to the SUS questions and any additional comments or feedback provided by test participants is beneficial. This can provide more detailed insights into specific areas of the system that may be causing problems for users and suggest improvements.

5.2 Limitations

In this section, several limitations have restrained the cat feeder's intended functions. Based on SUS results, there were several responses from respondents when testing the prototype. They believe the product is not suited for all types of dry cat food because the food container's bottom design is rather narrow and not ideal for bigger kibbles. Besides that, the design of the food nozzle is quite horizontal and prevents the cat food from going straight down into the cat food bowl. Due to the feedback, Flow simulations of improved food container and nozzle designs should be conducted. Due to a simulation error, this simulation could not be created.

5.3 Recommendations

In this project, an automatic motorized cat feeder is an alpha prototype. Thus, design refinement and improvement can be sought to produce a final automatic motorized cat feeder for commercial.

- Perform design optimization using flow simulation for variable kibbles efficiency.
- Design and select adequate materials for an automatic motorized cat feeder to use on large cat sizes.
- Enhance the appearance design to meet the user's preference.
- Enhance the feeding system with advanced IoT technology.
- Enhance the design of the food container and food nozzle.

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APPENDICES

APPENDIX A Gantt Chart

PSM 1																
NO.	**TASK NAME**	**STATUS**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
1	**Automatic Motorized Cat Feeder for large cat cage**	PLAN														
		ACTUAL														
2	**Topic Selection**	PLAN														
		ACTUAL														
3	**Discussion with Supervisor**	PLAN														
		ACTUAL														
4	**Data collection** -Research of automatic motorized cat feeder -User needs	PLAN														
		ACTUAL														
5	**PSM Planning** -Gantt chart	PLAN														
		ACTUAL														
6	**Definition** -Cat feeder Innovation design	PLAN														
		ACTUAL														
7	**Basic Analysis** -Specification analysis -Market position	PLAN														
		ACTUAL														
8	**Finding and Reading References** -Quality Function Deployment (QFD)	PLAN														
		ACTUAL														
9	**Define the Problem Statements** -Define Customer requirement	PLAN														
		ACTUAL														
10	**Literature Reviews Writing**	PLAN														
		ACTUAL														
11	**Logbook submission**	PLAN														
		ACTUAL														
12	**Report Writing**	PLAN														
		ACTUAL														
13	**PSM-1 Draft Submission**	PLAN														
		ACTUAL														
14	**Questionnaire Design**	PLAN														
		ACTUAL														
15	**Data Convert**	PLAN														

		ACTUAL														
16	**Data Analysis**	PLAN														
		ACTUAL														
17	**Setup Design Criteria**	PLAN														
		ACTUAL														
18	**Design Development** -Design Sketching -Define Design Requirement HOQ -Pugh's Method -Weighted Rating Method	PLAN														
		ACTUAL														
19	**Select Final Design**	PLAN														
		ACTUAL														
20	**PSM-1 Presentation Preparation** -PowerPoint Preparing	PLAN														
		ACTUAL														
21	**PSM-1 Presentation**	PLAN														
		ACTUAL														

PSM 2																
NO.	**TASK NAME**	**STATUS**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
1	**CAD and Engineering Drawing** -Build 3D model	PLAN														
		ACTUAL														
2	**Purchase the Prototype Materials**	PLAN														
		ACTUAL														
3	**Prototype Making**	PLAN														
		ACTUAL														
4	**Report Writing**	PLAN														
		ACTUAL														
5	**PSM-2 Presentation Preparation** PowerPoint Preparing	PLAN														
		ACTUAL														
6	**PSM-2 Draft Submission**	PLAN														
		ACTUAL														
7	**PSM-2 Presentation**	PLAN														
		ACTUAL														

APPENDIX B User Questionnaire survey

USER QUESTIONNAIRE SURVEY

Assalamualaikum and greeting to everyone

I am Muhamad Amzar bin Md Noor, a third-year student from Bachelor of Manufacturing Engineering Technology (Product Design) with Honours in University Teknikal Malaysia Melaka (UTeM). Currently, i am conducting a survey of selecting the suiTable adjective for Large Cage Automatic Motorized Cat Feeder

This study is conducted as a requirement to complete my Final Year Project (FYP) research. I would like to request your kind cooperation to complete this survey which only take roughly 5-6 minutes to answer and your identity will be kept confidential.

Section A: Basic Information

In this section, please categorize your answer based on your background. Please tick only one answer to each of the following questions.

1. Gender
   - ☐ Male
   - ☐ Female

2. Age
   - ☐ <19 years old
   - ☐ 20-29 years old
   - ☐ 30-39 years old
   - ☐ 40-49 years old
   - ☐ 50-59 years old
   - ☐ >60

3. What is your Occupation
   - ☐ Student
   - ☐ Self-employed
   - ☐ Private
   - ☐ Government
   - ☐ Unemployed
   - ☐ other:_____

Section B: Cat Care Scenario

This section helps me to know the respondent's experience about cat care. Please tick only one answer to each of the following questions.

1. How many cats do you have?
   - ☐ <5
   - ☐ 5-10
   - ☐ 10-15
   - ☐ 15>
2. How long have you been taking care of your cat?
   - ☐ <1 year
   - ☐ 1-2 years
   - ☐ 2-3 years
   - ☐ 3-4 years
   - ☐ 4-5 years
   - ☐ >5 years
3. What kind of cat do you have?
   - ☐ Indoor
   - ☐ Outdoor
   - ☐ Both
4. How long you can leave your cat at home with fresh food and water at all times?
   - ☐ Less than 24 hours
   - ☐ 1-2 days
   - ☐ 2-3 days
   - ☐ 3-4 days
   - ☐ 4-5 days
   - ☐ 5-6 days
   - ☐ 6-7 days
   - ☐ Over a week

5. What is your reason if you cannot leave your cat at home for long periods? (multiple answers)
   - ☐ Lonely
   - ☐ Anxious or depressed
   - ☐ Run out of food and water
   - ☐ Could get injured or sick
   - ☐ Becoming destructive
   - ☐ Peeing and pooping in the house
   - ☐ Others:_____

6. Where do you prefer to leave your cat when you are away?
   - ☐ Inside the Cage
   - ☐ Outside the cage

7. When is your cat actively playing? (multiple answer)
   - ☐ Early morning (5am-8am)
   - ☐ Late morning (11am-12pm)
   - ☐ Early afternoon (1pm-3pm)
   - ☐ Late afternoon (4pm-5pm)
   - ☐ Early evening (5pm-7pm)
   - ☐ Night (9pm-4am)

8. When is your cat fed?
   (multiple answer)
   - ☐ Early morning (5am-8am)
   - ☐ Late morning (11am-12pm)
   - ☐ Early afternoon (1pm-3pm)
   - ☐ Late afternoon (4pm-5pm)
   - ☐ Early evening (5pm-7pm)
   - ☐ Night (9pm-4am)

9. How many times a day do you feed your cat?
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ >5

10. Do you free feeding or scheduled meals?
    - ☐ Free feeding (you leave a bowl of food out for your cat at all times)
    - ☐ Scheduled meals (you feed your pet portioned meals at set times throughout the day)

11. Type of food given?
    - ☐ Wet cat food
    - ☐ Dry cat food
    - ☐ A mix of both

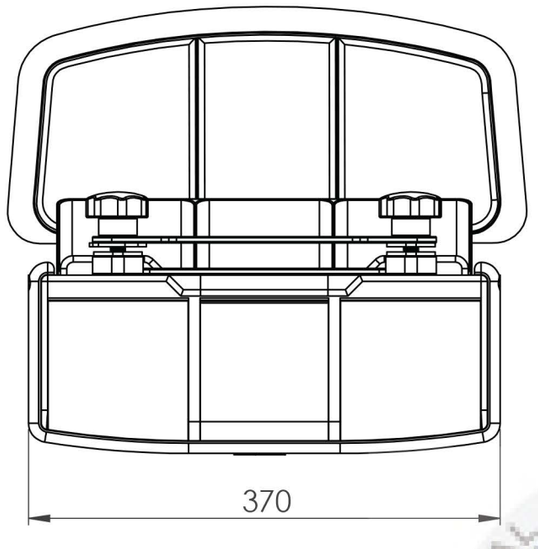
Section C: User's requirements

Goal: Build a automatic motorized cat feeder for large cat cage that meets user's requirements

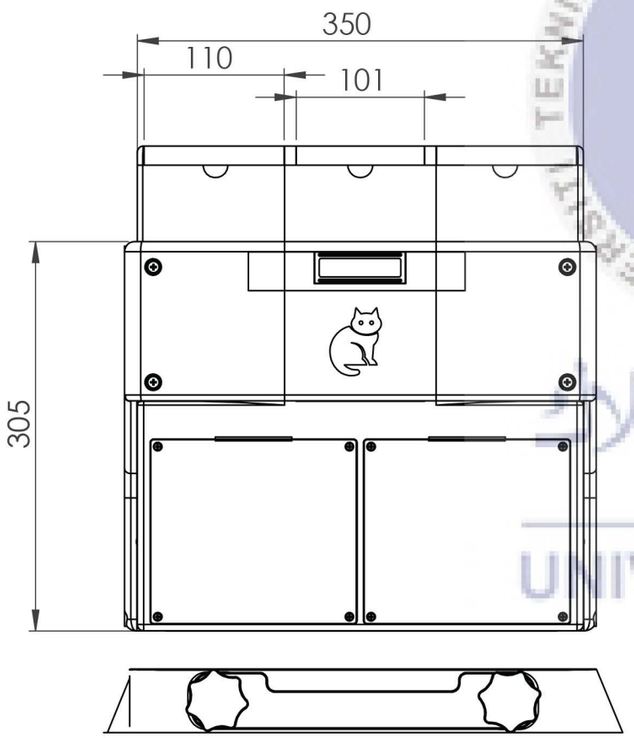
Please use Scale 1 until 5 which indicates the level from weak to strong and tick only one answer
to each of the following questions.

No	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	I want it to be simple and aesthetic					
2	I want it to be easy monitoring and control					
3	I want it to be easy to clean					
4	I want it to be easy to install and remove					
5	I want it to be suiTable for young and adult cats					
6	I want it to be suiTable for all large cat cages					
7	I want it to have Wi-fi integration for the system					
8	I want it to have customizable feeding settings					
9	I want it to dispense food accurately					
10	I want it to be easily mounted in a cage.					
11	I want it to have a large storage capacity					
12	I want it to have anti-food jam system					
13	I want it to have inbuilt desiccant box to keep food fresh					
14	I want it to have food storage silicone seal					
15	I want it to have low food warning					
17	I want it to be sTable					
18	I want it porTable					

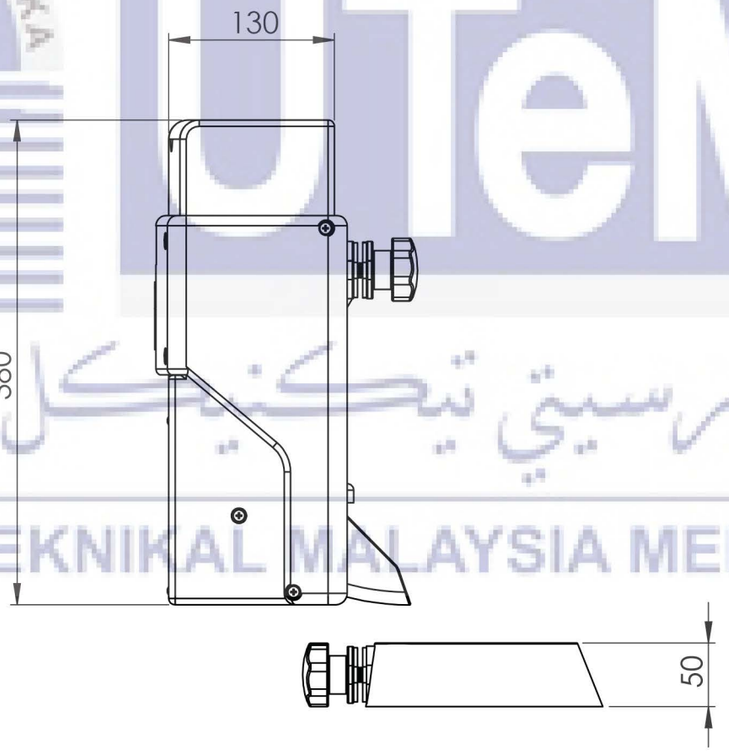
APPENDIX C Technical Drawing



TOP VIEW

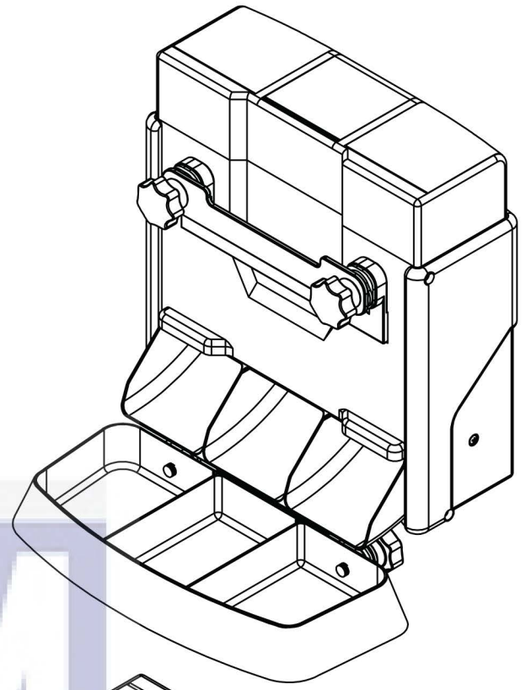


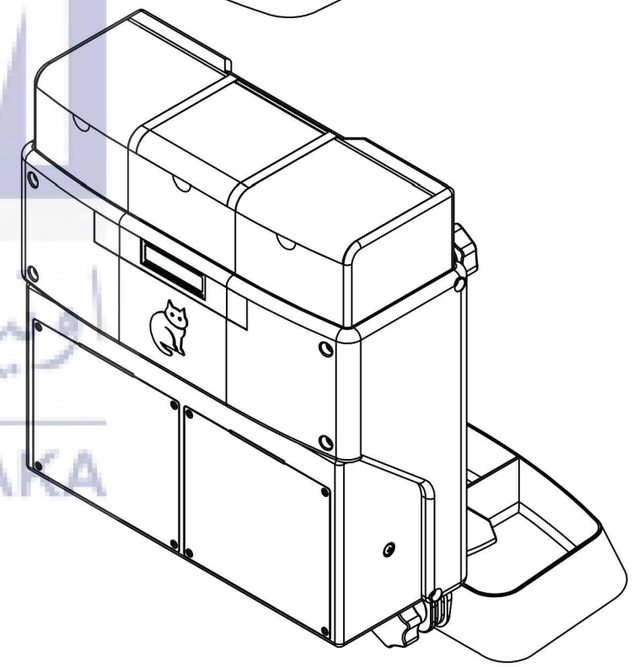
FRONT VIEW



SIDE VIEW

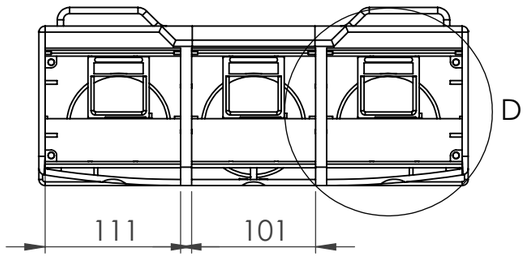
ISOMETRIC VIEW



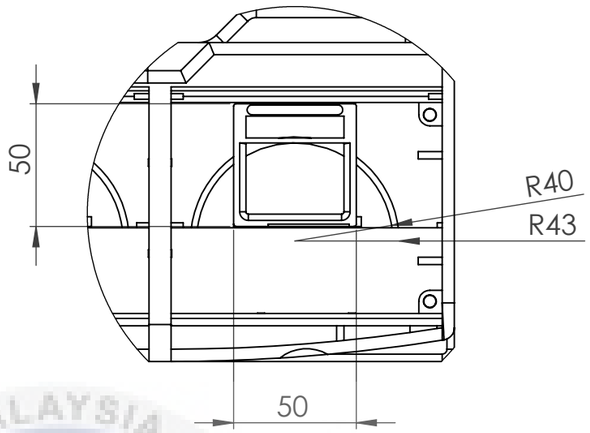


		NO.	PART NAME	SIZE			
			ASSEMBLY				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
MUHAMMAD AMZAR BIN MD NOOR	B091910375	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
NAME	DATE						

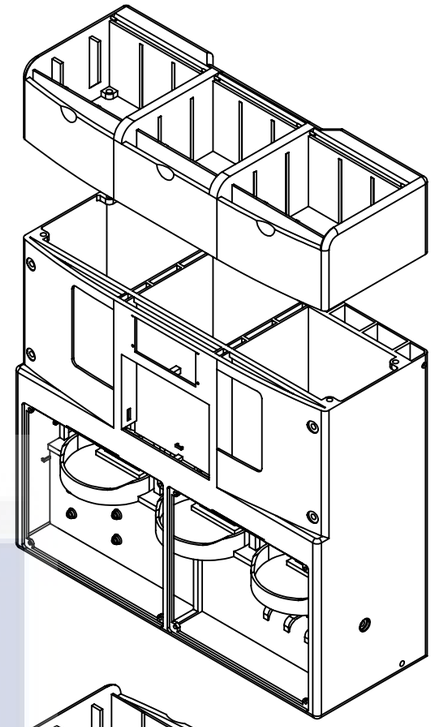
SW

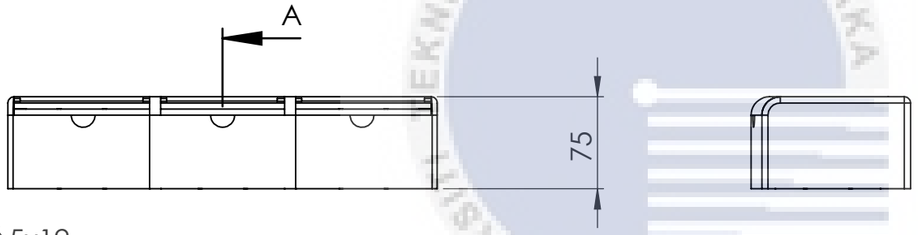


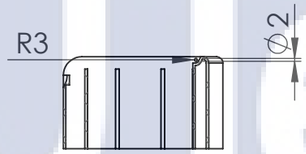
TOP VIEW

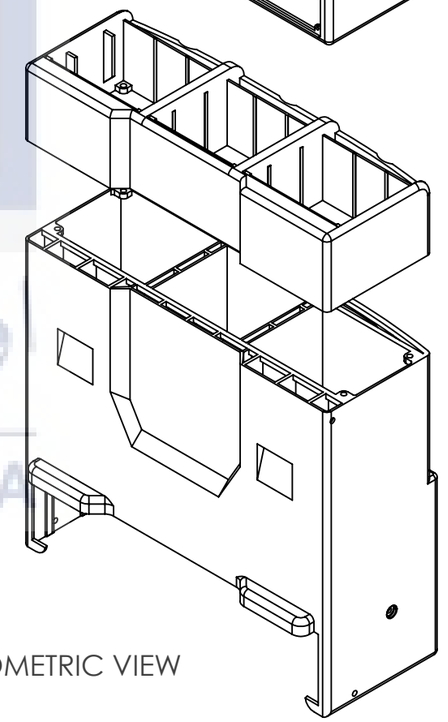


DETAIL D
SCALE 2 : 5

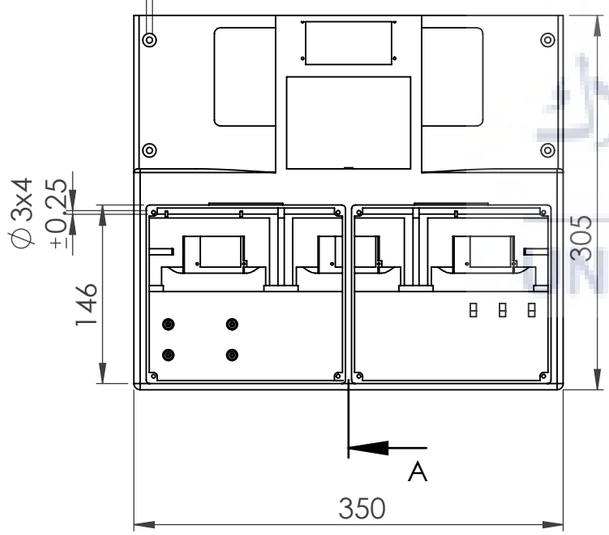




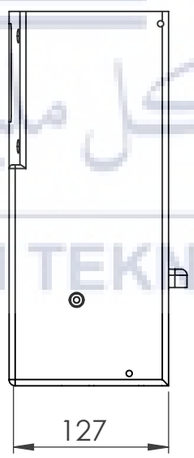




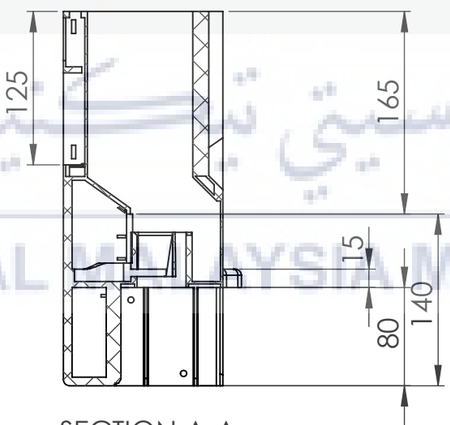
ISOMETRIC VIEW



FRONT VIEW



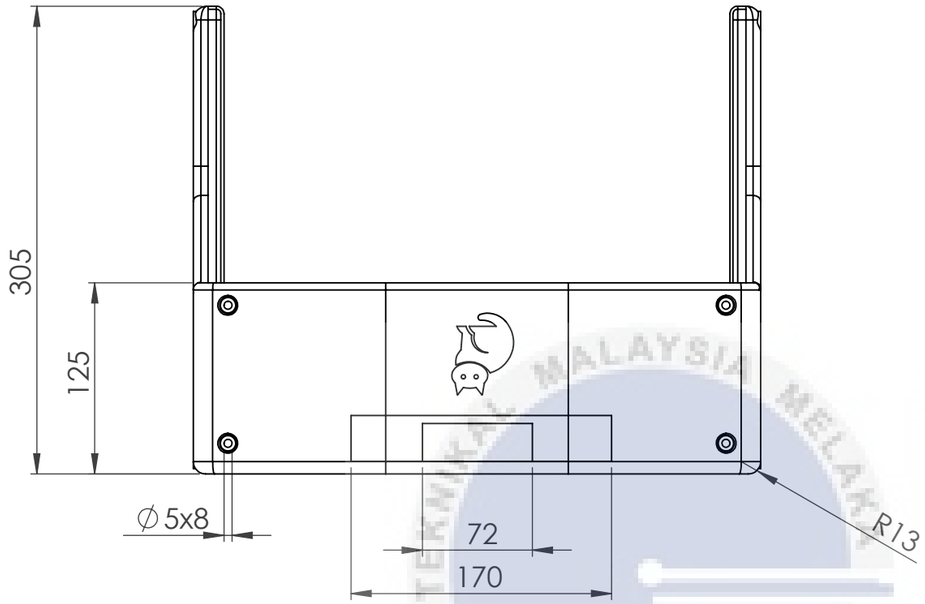
SIDE VIEW



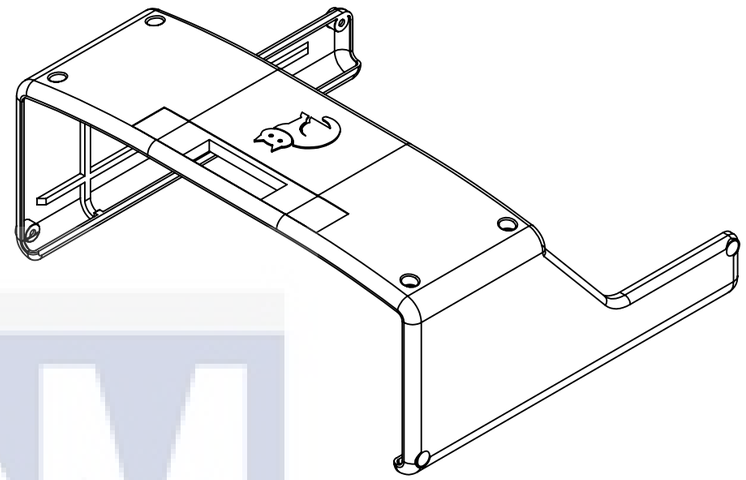
SECTION A-A

		NO.	PART NAME	SIZE			
			TOP AND BOTTOM BODY				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	B091910375						
NAME	DATE						

SW



FRONT VIEW



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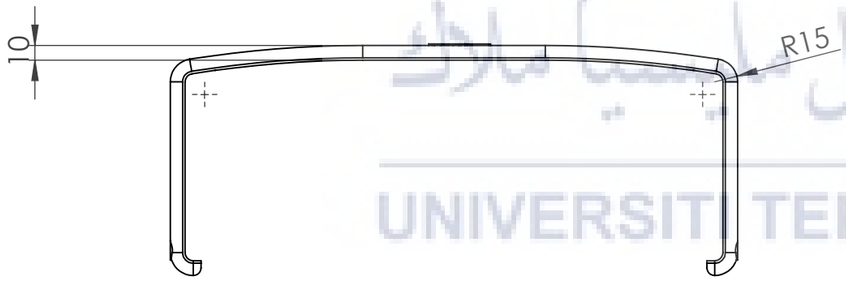
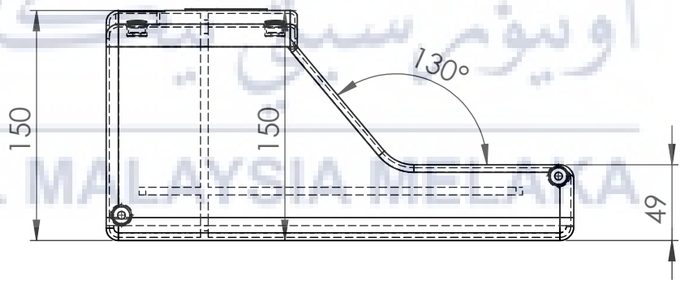


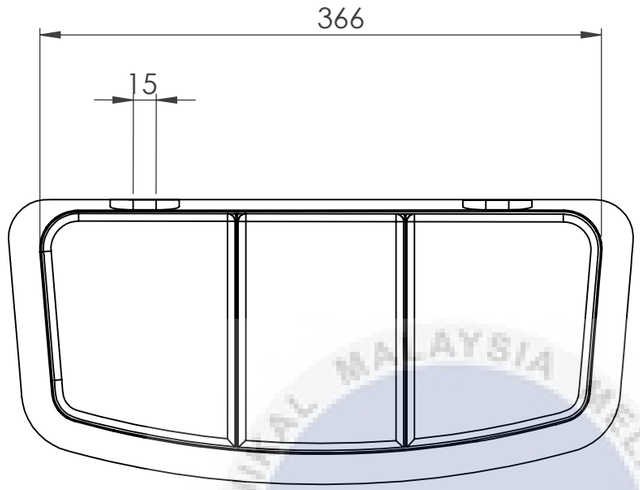
TOP VIEW



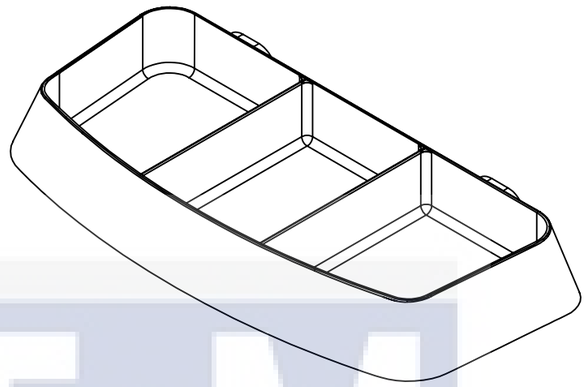
SIDE VIEW

		NO.	PART NAME	SIZE			
			MIDDLE CASE				
			SCALE	MATERIAL		HARDNESS	QTY
			1:1			-	1
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

SW



TOP VIEW



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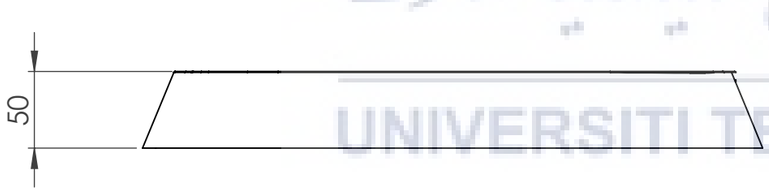
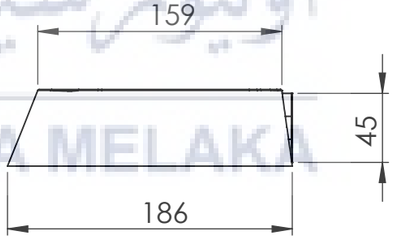


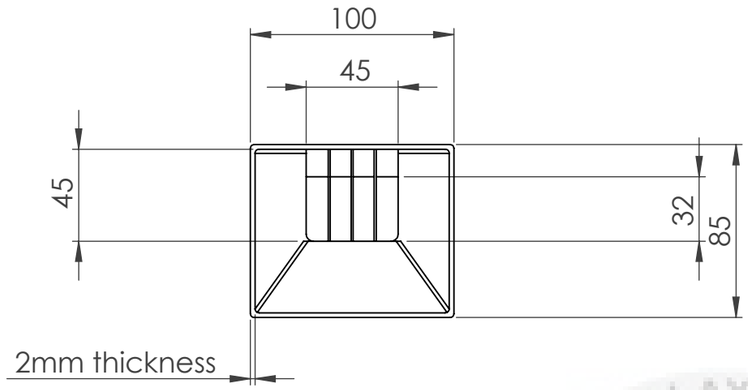
FRONT VIEW



SIDE VIEW

		NO.	PART NAME	SIZE		
			FOOD BOWL			
			SCALE	MATERIAL	HARDNESS	QTY
			1:1		-	1
		APPD	CHKD			
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS			
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**					
NAME	DATE					

SW



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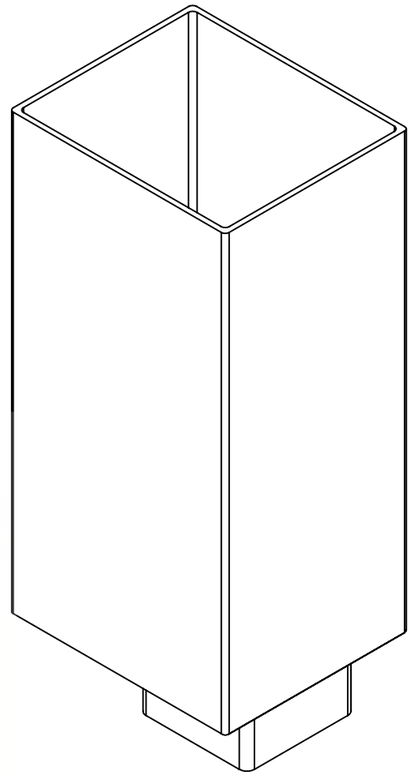

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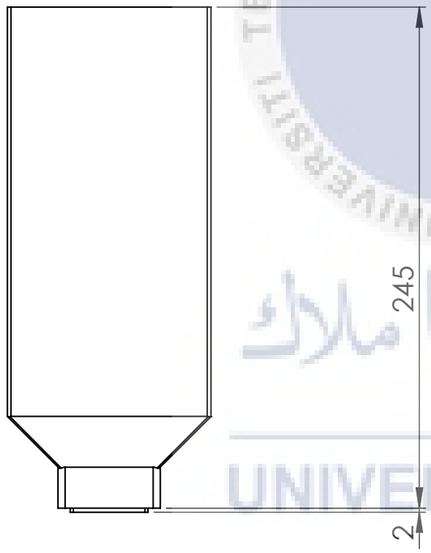

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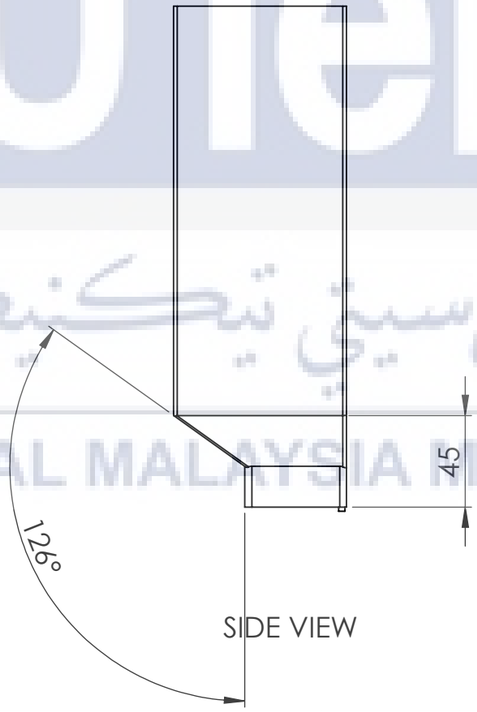
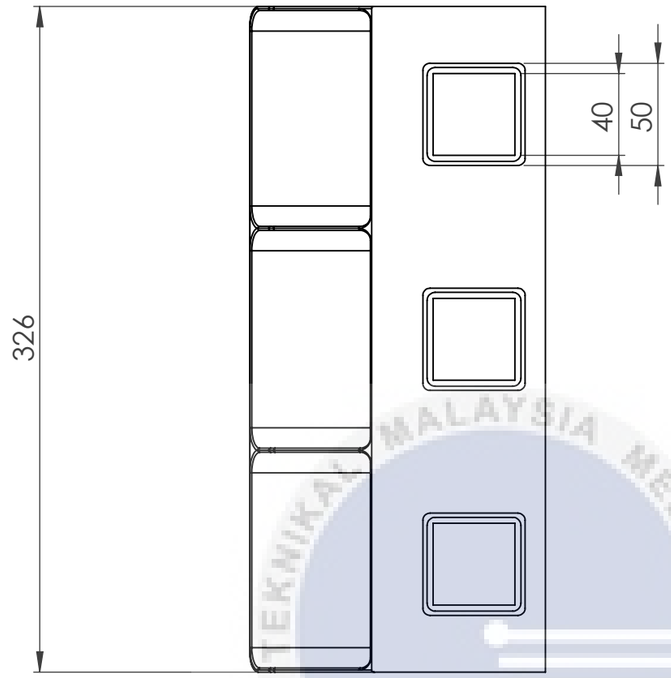


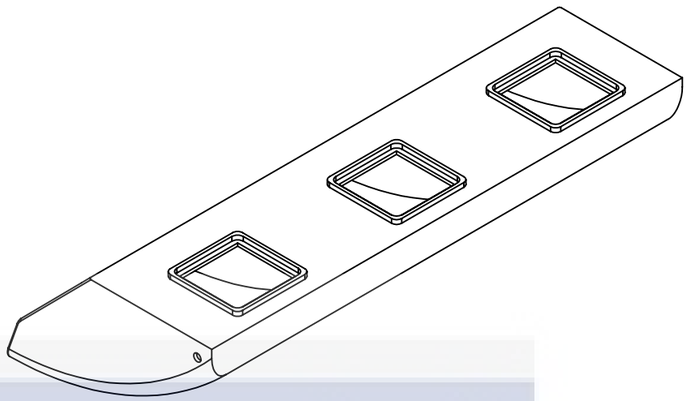
SIDE VIEW

		NO.	PART NAME	SIZE			
			FOOD CONTAINER				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

SW



TOP VIEW



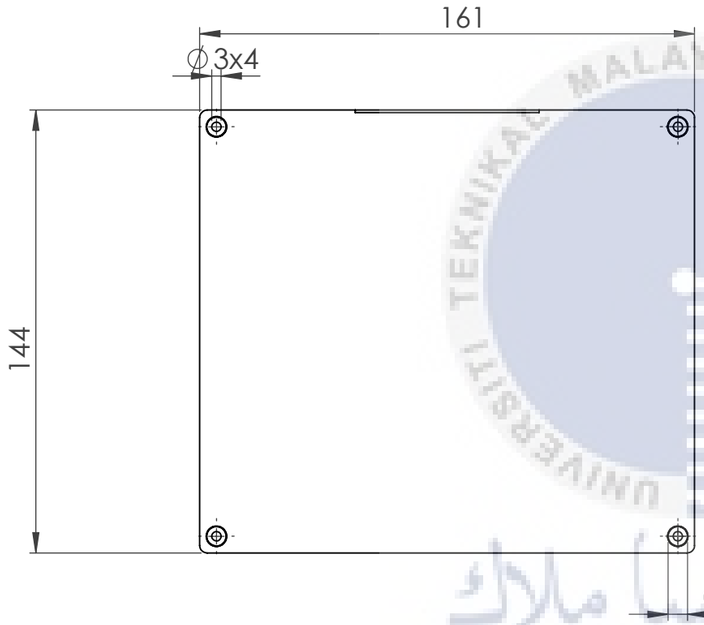
ISOMETRIC VIEW

FRONT VIEW

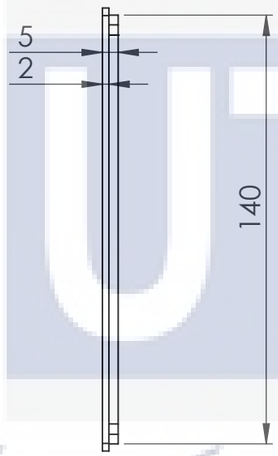
SIDE VIEW

		NO.	PART NAME	SIZE			
			FOOD NOZZLE				
			SCALE	MATERIAL		HARDNESS	QTY
			1:1			-	1
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

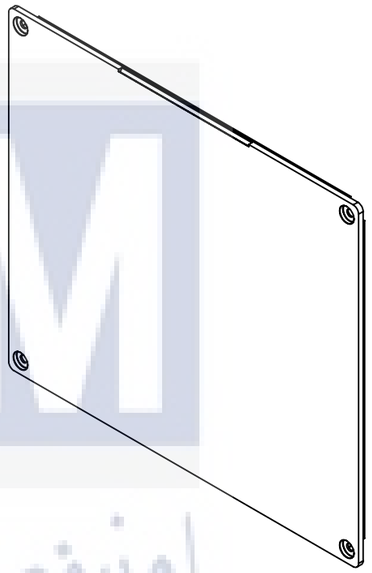
SW



FRONT VIEW



SIDE VIEW

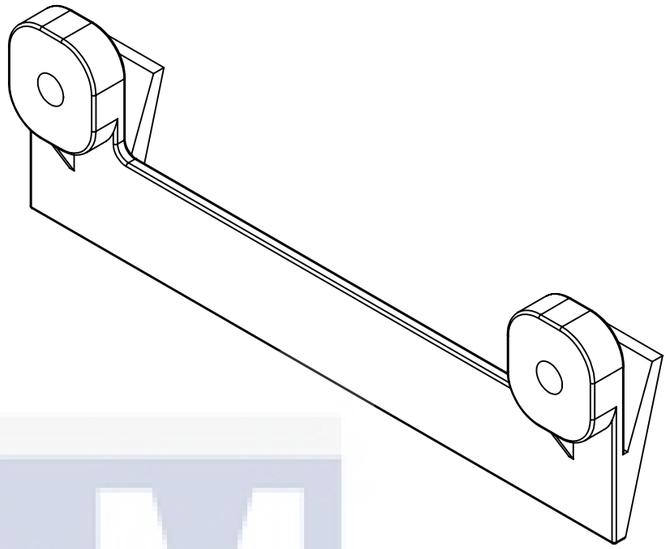


ISOMETRIC VIEW

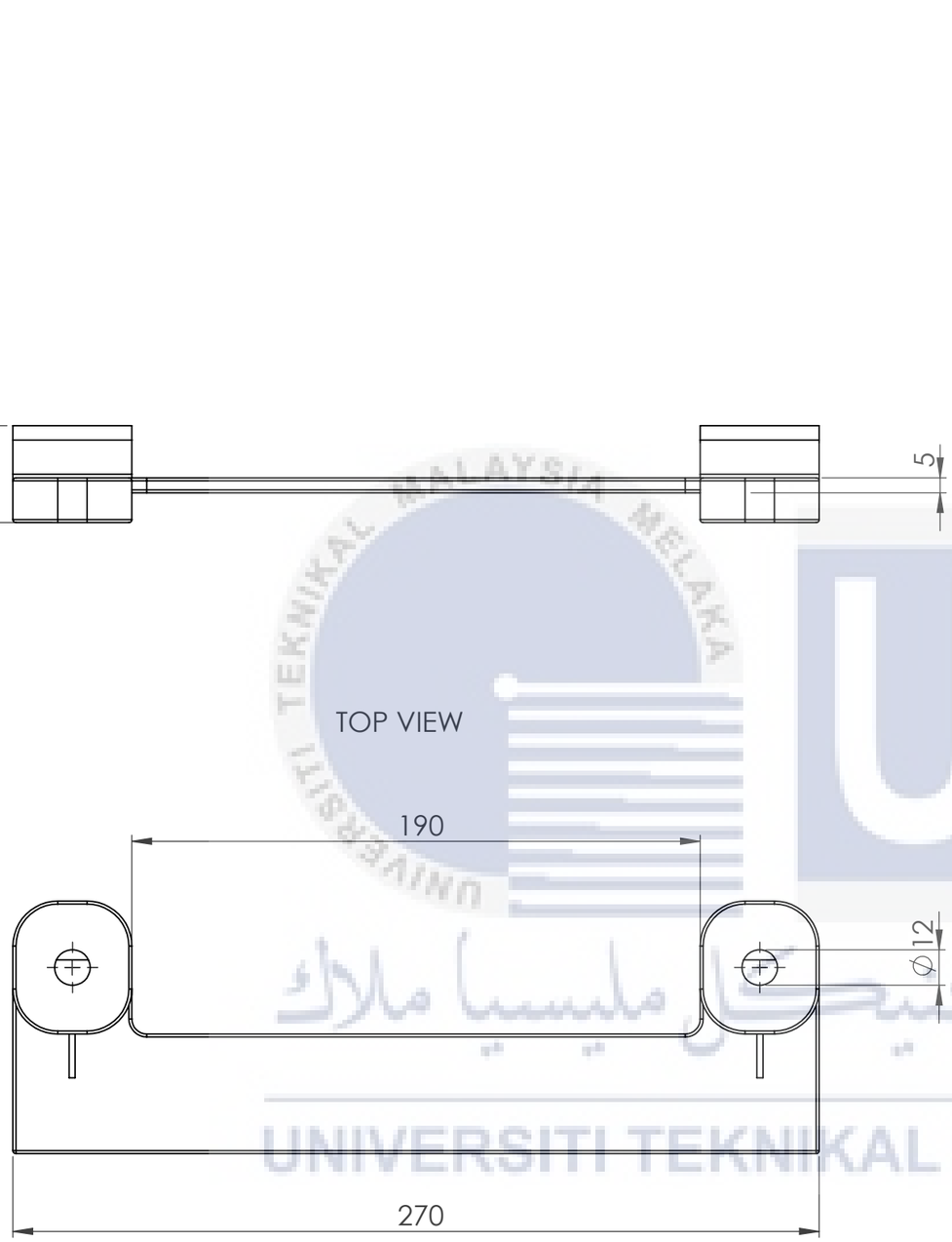
		NO.	PART NAME	SIZE			
			FRONT COVER				
			SCALE	MATERIAL		HARDNESS	QTY
			1:1			-	1
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

SW

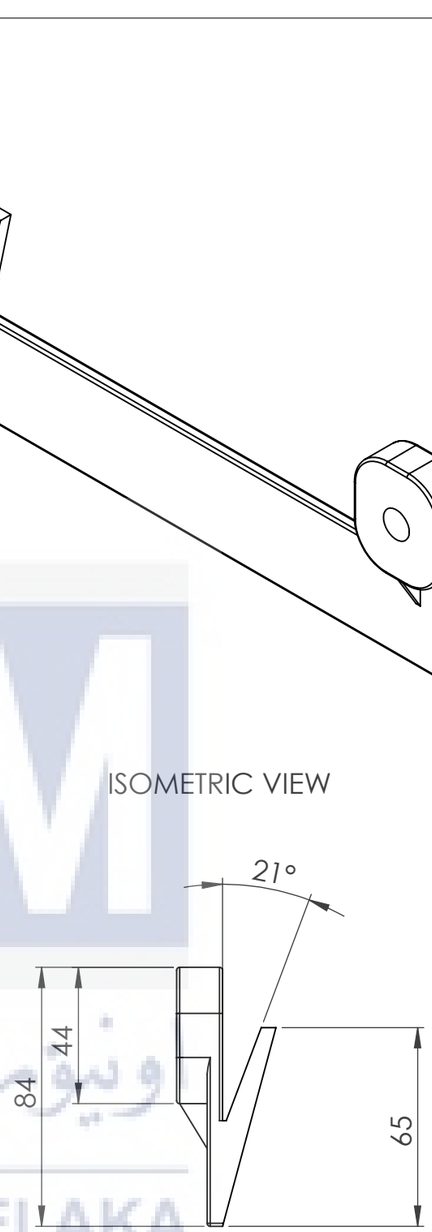
TOP VIEW



ISOMETRIC VIEW



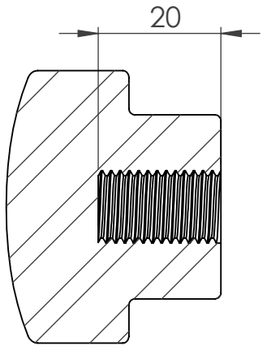
FRONT VIEW



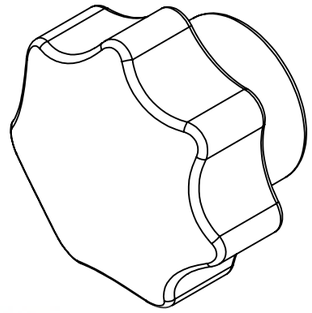
SIDE VIEW

		NO.	PART NAME	SIZE			
			HOOK				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

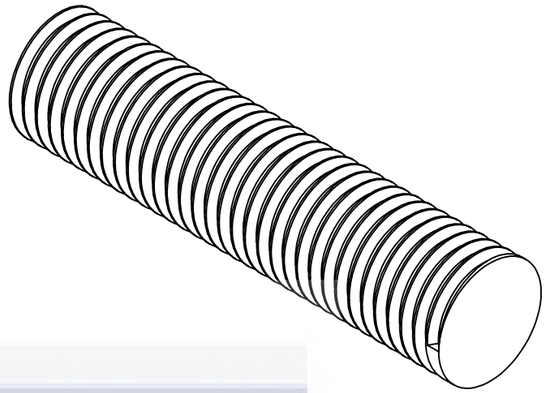
SW



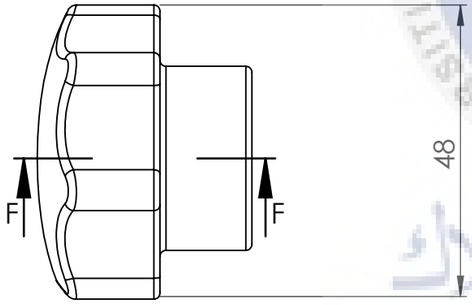
SECTION F-F



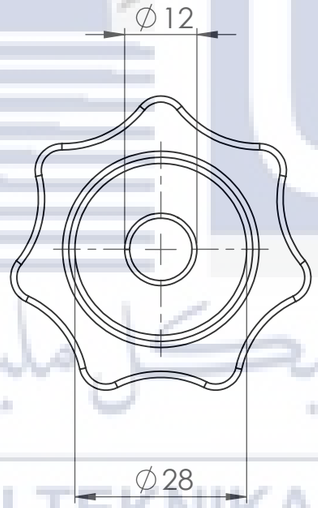
ISOMETRIC VIEW



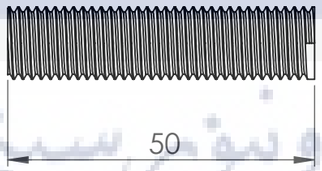
ISOMETRIC VIEW



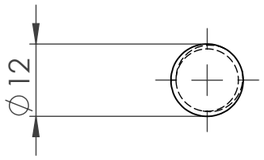
SIDE VIEW



FRONT VIEW



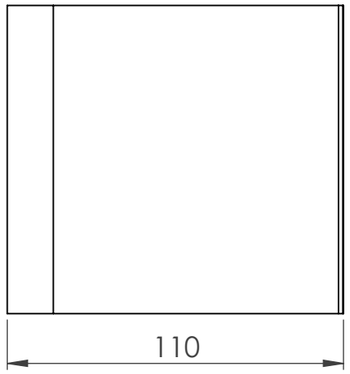
SIDE VIEW



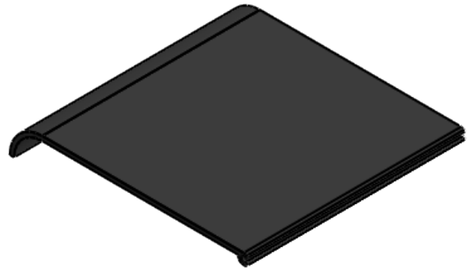
FRONT VIEW

		NO.	PART NAME	SIZE			
			KNOB AND THREAD				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

SW



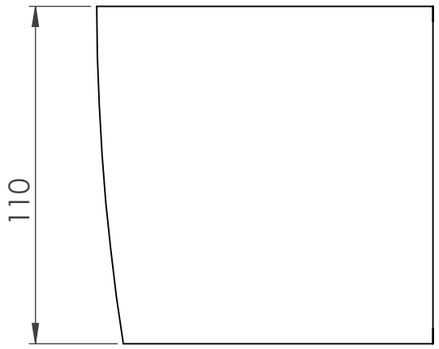
TOP VIEW



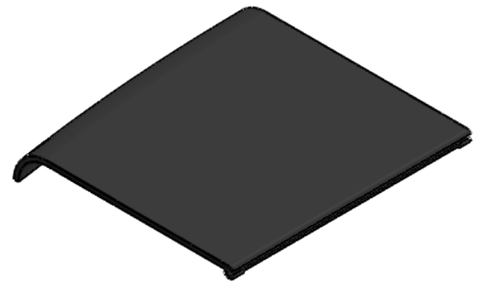
ISOMETRIC VIEW

FRONT VIEW

SIDE VIEW

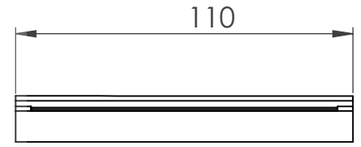


TOP VIEW

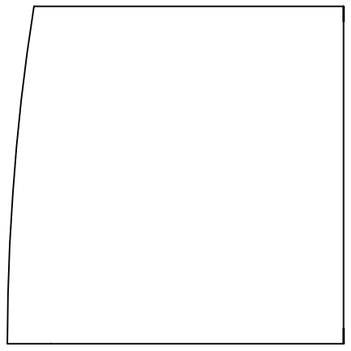


ISOMETRIC VIEW

FRONT VIEW

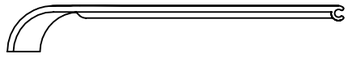


SIDE VIEW

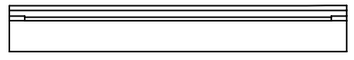


TOP VIEW

ISOMETRIC VIEW



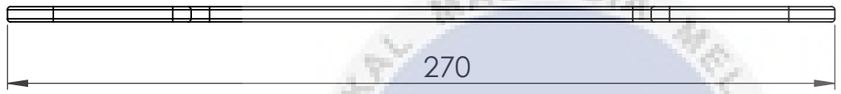
FRONT VIEW



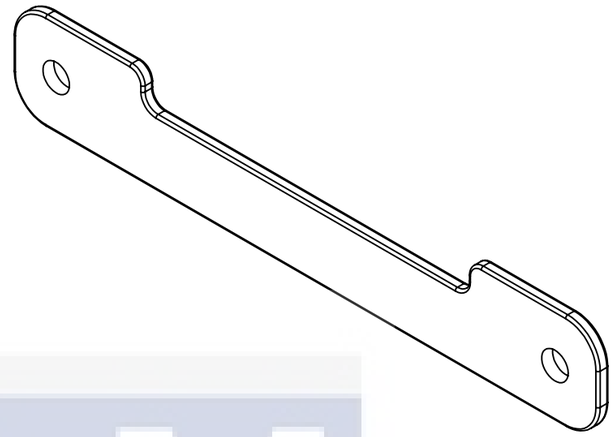
SIDE VIEW

		NO.	PART NAME	SIZE			
			LIDS				
			SCALE	MATERIAL	HARDNESS	QTY	
			1:1		-	1	
		APPD	CHKD				
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS				
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**						
NAME	DATE						

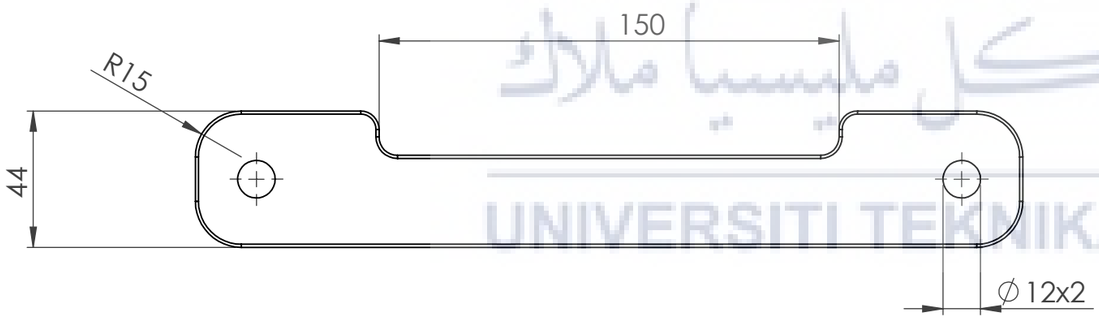
SW



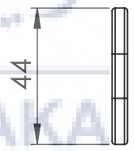
TOP VIEW



ISOMETRIC VIEW



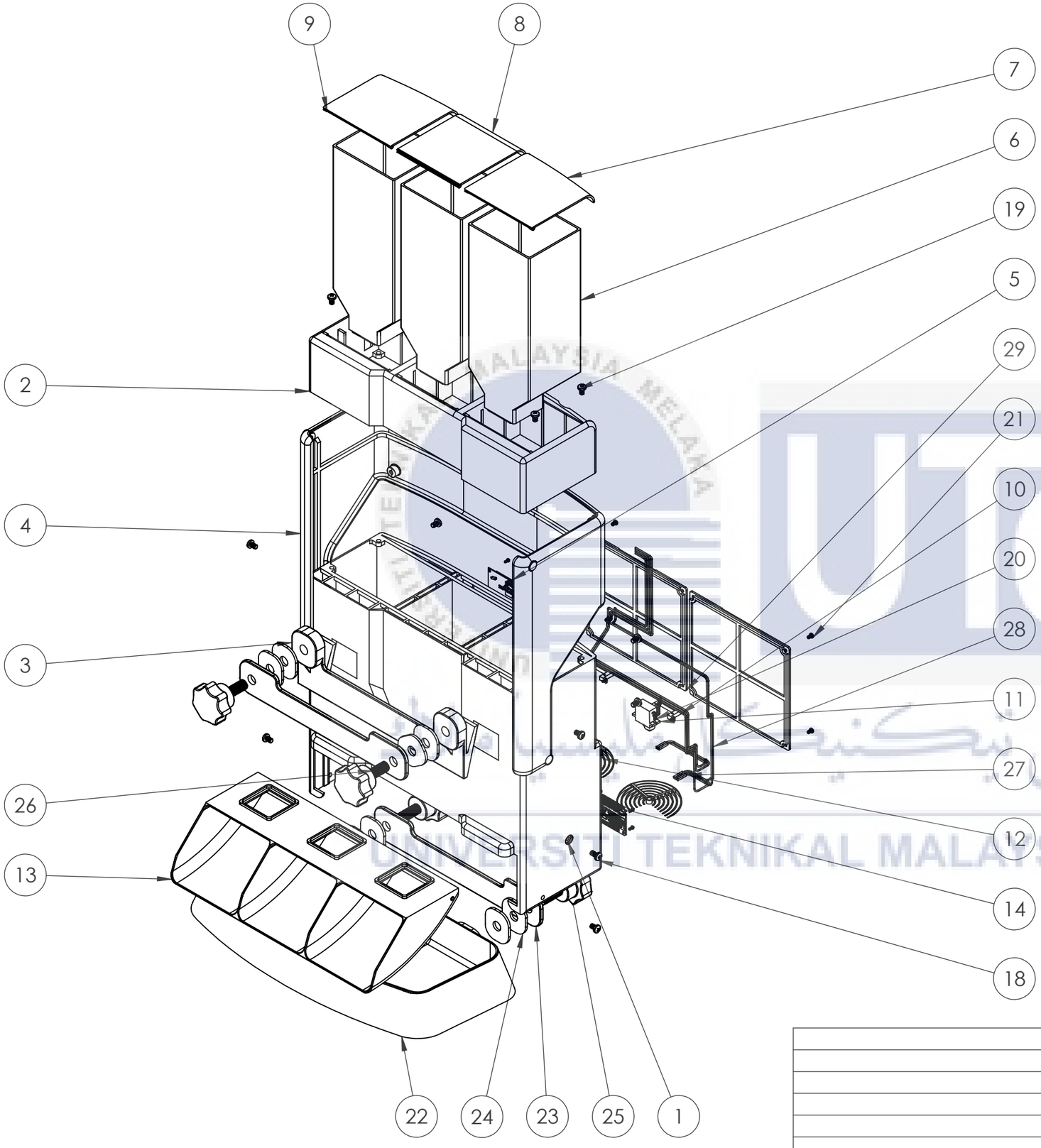
FRONT VIEW



SIDE VIEW

		NO.	PART NAME	SIZE		
			CLAMPER			
			SCALE	MATERIAL	HARDNESS	QTY
			1:1		-	1
		APPD	CHKD			
		TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS			
MUHAMMAD AMZAR BIN MD NOOR	**B091910375**					
NAME	DATE					

SW



ITEM NO.	PART NUMBER	QTY.
1	Bottom Base	1
2	Top Base	1
3	Hook	1
4	Case	1
5	LCD module 16x2 new	1
6	Food Container	3
7	Left Lid - NEW.step	1
8	Middle Lid - NEW.step	1
9	Right Lid - NEW.step	1
10	Microservo bracket	3
11	microservo SG90	3
12	Food Dispensr	3
13	Food Nozzle	1
14	Lolin NodeMCU ESP8266 V3	1
15	PowerSource	1
16	MicroUSB	1
17	USB Connector Type A male	1
18	B18.6.7M - M5 x 0.8 x 10 Type I Cross Recessed PHMS --10S	2
19	B18.6.7M - M5 x 0.8 x 8 Type I Cross Recessed PHMS --8S	12
20	B18.6.7M - M2 x 0.4 x 5 Type I Cross Recessed PHMS --5S	20
21	B18.6.7M - M3 x 0.5 x 5 Type I Cross Recessed PHMS --5S	8
22	Food Bowl	1
23	clamper	2
24	Clamp Rubber	8
25	Knob	4
26	thread	4
27	pin	9
28	cables	1
29	FRONT COVER V2	2

		NO.	PART NAME	SIZE		
			EXPLODED VIEW (BOM)			
			SCALE	MATERIAL	HARDNESS	QTY
			1:1		-	1
		APPD	CHKD			
MUHAMMAD AMZAR BIN MD NOOR	B091910375	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS	TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS			
NAME	DATE					

SW