UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PRODUCT DESIGN AND ANALYSIS OF WALKER USING IoT

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Faculty of Mechanical and Manufacturing Engineering Technology

Product Design and Analysis of Walker Using IoT

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Bachelor of Manufacturing Engineering Technology (Product Design) with Honors

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Product Design and Analysis of Walker Using IoT

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**A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Product Design) with Honours**

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled " Product Design and Analysis of Walker Using IoT" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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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 : ....

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....

Date : 11/1/2023

....

DEDICATION

This work is wholeheartedly dedicated to all my valuable treasures:

For my beloved parent:

Zainurin Bin Marsan

Rosmawati Binti Miskam

For my supportive siblings:

Nurul Syamimie Athirah Binti Zainurin

Nurul Safiya Arisha Binti Zainurin

Thank you for always providing me moral, emotional, financial support and gave me strength when I thought of giving up.

For my respective superviso:

Ts. Dr Syahibudil Ikhwan Bin Abdul Kudus

For all Utem lectures, Engineer Assistance, and my treasured friend:

Who shared their word of advice and encouragement to finish this study

ABSTRACT

A walker is a device that is prescribed to help a certain user such as a lower limb disabled, elderly, or blind person move. Nowadays, technological advancements have the potential to improve the quality of life of the lower limb disabled or elderly by developing various types and functions of walkers to assist with their daily life activities; however, these walkers have limitations that may be harmful to the user's body. The aim of the research work described in this report is to design and phototype development of walker for IoT device monitoring analysis using Blynk application. Additionally, evaluating the performance of the variable device monitor, which is heart rate, step count and fall detection monitor. The QFD is a technique for gathering consumer feedback and converting the needs of the responders into technical specifications. In accordance with the information gathered from the interview session, the House of Quality (HOQ) of walker was constructed, which was then used to examine the product's features and its connection matrix. Besides, the standard walker will cause users to present a forward-leaning posture which will cause them to suffer from back or neck pain. The user's requirements were satisfied and the issues they ran into while using the walker were resolved via modification and enhancement of the device. In addition, the QFD integrated model is developed and validated via analysis of the design process and results. Simultaneously the next step is engineering drawing and 3D modelling. By utilising the QFD integration, the walker might be improved with a workable solution. By using the integration on QFD could help in improving the walker with a suitable solution. After do the 3D modelling, the process of prototype the walker has conducted. And the lastly is doing the testing on the walker. Usability test is the method that used in the testing product.

ABSTRAK

Pejalan kaki ialah peranti yang ditetapkan untuk membantu pengguna tertentu seperti anggota bawah yang kurang upaya, warga emas atau orang buta bergerak. Pada masa kini, kemajuan teknologi berpotensi untuk meningkatkan kualiti hidup anggota bawah OKU atau warga emas dengan membangunkan pelbagai jenis dan fungsi pejalan kaki untuk membantu aktiviti kehidupan seharian mereka; walau bagaimanapun, pejalan kaki ini mempunyai had yang mungkin berbahaya kepada badan pengguna. Matlamat kerja penyelidikan yang diterangkan dalam laporan ini adalah untuk mereka bentuk dan pembangunan fototaip walker untuk analisis pemantauan peranti IoT menggunakan aplikasi Blynk. Selain itu, menilai prestasi monitor peranti berubah-ubah, iaitu kadar denyutan jantung, kiraan langkah dan monitor pengesanan jatuh. QFD ialah teknik untuk mengumpul maklum balas pengguna dan menukar keperluan responden kepada spesifikasi teknikal. Selaras dengan maklumat yang dikumpul daripada sesi temu bual, House of Quality (HOQ) walker telah dibina, yang kemudiannya digunakan untuk meneliti ciri-ciri produk dan matriks sambungannya. Selain itu, pejalan kaki standard akan menyebabkan pengguna menunjukkan postur condong ke hadapan yang akan menyebabkan mereka mengalami sakit belakang atau leher. Keperluan pengguna telah dipenuhi dan isu yang mereka hadapi semasa menggunakan pejalan kaki telah diselesaikan melalui pengubahsuaian dan peningkatan peranti. Selain itu, model bersepadu QFD dibangunkan dan disahkan melalui analisis proses dan keputusan reka bentuk. Pada masa yang sama langkah seterusnya ialah lukisan kejuruteraan dan pemodelan 3D. Dengan menggunakan penyepaduan QFD, pejalan kaki mungkin dipertingkatkan dengan penyelesaian yang boleh dilaksanakan. Dengan menggunakan penyepaduan pada QFD boleh membantu dalam menambah baik walker dengan penyelesaian yang sesuai. Selepas melakukan pemodelan 3D, proses prototaip walker telah dijalankan. Dan yang terakhir adalah melakukan ujian pada walker. Ujian kebolehgunaan ialah kaedah yang digunakan dalam produk ujian.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
HMI	-	Human Machine Interface
IDE	-	Integrated Development Environment
bpm	-	Beats Per Minute
SUS	-	System Usability Scale
QFD	-	Quality Function Development
HOQ	-	House of Quality

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the framework of this study. It includes the research background of mobility aids, problem statement, objectives, the scope, and limitation of project.

1.2 Background

Walker are device that are utilised by millions of people throughout the world, even though most people are ignorant of their existence. People with disabilities endure obstacles that we could never anticipate, such as inconvenient incidents in their everyday lives. Year after year, the number of persons with disabilities will increase.

Walkers have been used by persons who have difficulty moving about or who are recovering and need rehabilitation for millennia. Nonetheless, the road to the creation of walker has not been smooth, and there are several flaws that must be addressed and improved. There are various types of walkers that can obtain in the marketplace that could optimize the life quality of user who has mobility issue such as canes, crutches, walkers, and wheelchairs. The walker, also known as a walking frame or Zimmer frame, is a popular mobility device that was first introduced in the early 1950s. A rollator is more advanced than a regular walker since it is lower in weight and is equipped with hand brakes to slow or halt the rollator's movement. (M.Martin, P.Santos, Neto, & Ceres, 2012)

Furthermore, several actual research show that walker users have a higher risk of falling. Approximately 80% of the participants purchase a rolling walker without having received proper operation instruction or consulting a medical expert, 61% operate the walker haphazardly, and 19% of users receive their walker from medical professionals without receiving proper operation instruction. The most prevalent issue was inappropriate rolling walker height, which accounted for 55% of all cases. Around 17% of the rolling walkers had maintenance issues. Furthermore, 40% of users will have a forward-leaning posture while standing and utilising the walker for support, and 50% will have a forward-leaning posture while using the walker to mobilise. A forward-leaning posture during mobilisation is most likely to result in the user falling ((Liu, 2009).

According to WHO, the world's elderly population is anticipated to increase from 900 million to 2.0 billion between 2015 and 2050. The demand for walker is increasing among the geriatric population, owing to the benefits they provide to users, such as improved balance, extra support, and the ability to carry out daily activities independently. Furthermore, due to the critical function that rehabilitation equipment plays in improving the lives of the physically challenged, demand for it is rising. In 2015, walkers had a profit share of 31.65%, which was a record high ((Reportlinker, 2016)). Walkers provide various benefits over traditional walker, including the potential to increase a user's walking abilities, ensuring safety and comfort while walking, and providing additional support as well as a high weight-bearing capacity.

1.3 Problem Statement

Although walkers are helpful devices that help people enhance their quality of life by improving their balance and stability, they do have certain drawbacks. Walkers are often used by people who have weak lower limbs and are given walkers to compensate for their condition. However, continuous use of walkers can put additional strain on upper extremity joints, leading to arthritis, tendinitis, and carpal tunnel syndrome. The loads applied to the walker by the user are determined by the person's medical condition. Users with lower limb prostheses and spinal cord injuries apply 85% to 100% of their full weight to the walker, whereas people with supranuclear palsy apply 30% of their body weight to the walker. By increasing the weight on the walker, the stresses on the user's upper extremities rise, increasing the likelihood of further issues occurring. (Foley, Johnson, E. Kalbach Jr., & McNally, 2010)

A considerable number of walker owners have reported difficulties with the usage or design of their walker, and the number of incidents has been growing faster than the number of users. Falls are the most often reported walker-related incidents. The more often a walker is used, the more accidents occur, raising the question of whether or not walkers are truly safe to use. Furthermore, in order to employ assistive equipment like walkers, physiotherapist must guarantee that patients walk for a suitable amount of time during the rehabilitation process. This is a difficult task. Physiotherapists must verify that patients are performing the necessary exercises to enhance their walking. As a result, they must assist patients in changing their walking pace in accordance with their disease, as well as specify specific limitations for walking distance workouts and give extra assistance when patients lose their balance. As a result, it is critical to identify ways to make this process more objective and productive. (M.Martin, P.Santos, Neto, & Ceres, 2012)

1. Incorrect posture while using a walker leads to body pain ((Liu, 2009)
2. Physiotherapists need to ensure that the patients are doing the adequate exercises to improve their walking. (M.Martin, P.Santos, Neto, & Ceres, 2012)

1.4 Research Objective

The research objective that needs to be achieved in this research are:

1. To design and phototype development of walker for IoT device monitoring analysis using Blynk application.

2. Evaluating the performance of the variable device monitor, which is heart rate, step count and fall detection monitor.

1.5 Scope and limitation

The major goal of this project is to address the shortage of walker availability and reduce the risk of damage caused by improper posture when using it, as well as its mobility. Furthermore, the existing walker design does not take into account the actual user needs; the walker should be designed to be portable yet simple, with ergonomic considerations such as handgrip position and angle, walker height, and others, so that the user can enjoy using the walker that makes their life easier. Furthermore, scenarios such as the user who has recently been discharged from the hospital, long-term walker users, children with developmental disability problems, and others must be considered to guarantee that the walker design is innovations or designs in terms of inventive design, hence improving the design of walkers is required.

The restriction of this project is to build a walker that meets the demands of several types of users. For example, the user may be a young guy with mobility issues as a result of an accident, or an old person with a loss of individual strength, both of which must be considered when creating. Second, because only specific ethnic groups would utilise this product, finding responders will be challenging, particularly during this epidemic era. A disadvantage in this study is that the design focuses on whether the direction of creative design fits the users' needs.

The restriction of this project is to build a walker that meets the demands of several types of users. For example, the user may be a young guy with mobility issues as a result of an accident, or an old person with a loss of individual strength, both of which must be considered when creating. Second, because only specific ethnic groups would utilise this product, finding responders will be challenging, particularly during this epidemic era. A disadvantage in this study is that the design focuses on whether the direction of creative design fits the users' needs.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The definitions and related studies of walker make up this chapter's literature review. Definitions and detailed information on walkers are included in this subtopic. Some analyses, including as specification analysis and market analysis, are carried out to sort the facts and data about the walker based on the associated research and other studies carried out at the start of this project.

2.2 Walker

2.2.1 Definition of Walker

A walker, often referred to as a walking frame, is a tool that offers extra support to assist maintain balance and stability when walking, most commonly due to age-related mobility problems including frailty. In contrast to manual or electric wheelchairs, which are meant for those with more severe disabilities, walkers help people with reduced mobility get from one place to another. On the other hand, white cane or guide dog are helpful to assist those who are sightless or unsighted. Therefore, people who is disable or having health problem such as multiple sclerosis, arthritis, Parkinson’s illness, 7 muscle pain, Cerebral Palsy and other diseases that cause mobility problems would be suggested to use ambulation devices (Grimmer, Riener, Walsh, & Seyfarth, 2019)

In the past, if a patient's lower limbs were wounded and needed support when walking, a walker was frequently utilised as part of their mobility therapy. Walkers are available in a variety of sizes to accommodate users ranging from adults to children. The majority of it is light enough for the user to pick up, and the materials utilised in the walker include aluminium tube frame, plastic handgrips, and rubber tips as indicated in Figure 2.1. Some walking frames are made to work in tandem with electronic travel aids. In the past, an adjustable and foldable walker was used to educate patients' ambulation. The walker is designed with a crutch and features a pair of adjustable and detachable crutch attachments with arm. Roller walker is attaching with roller or wheel is benefits in rolling, plastic utility tray can be removed, and height of roller walker is adjustable as shown in Figure 2.2 (W.Farmer, 1978)

Figure 2.1 Main Design of the Walker

Figure 2.2 Farmer, 1978

Figure 2.3 depicts the walker, which was originally known as a "walkerette" and was eventually developed into the walker we know today by Charles M. Williams in 1924. It was built for his Aunt Frances, who was recovering from a hip injury at Cincinnati's Good Samaritan Hospital. It was built of wood and resembled a current aluminium walker in form. By 1955, aluminium had surpassed steel as the preferred material for frame production, ushering in the contemporary lightweight walking frame, which is today produced in the hundreds of thousands across the world. Patients employ a variety of changes to the original design.

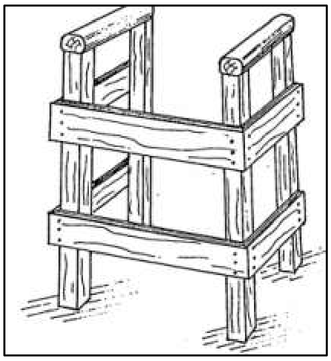


Figure 2.3 Walkerette

2.2.2 Type of Walker

Walkers are frames created for individuals who need more stability and assistance while walking. Walkers come in a wide variety of styles today. Each of them is designed differently and has unique features and functionalities. Standard, 2-wheel, and rollator walkers are among the popular varieties.

Figure 2.4 Walker without the Wheel

The most fundamental kind of walker on the market is a standard one. The walker can alter the four-legged assistive device's height and width to meet particular physical needs. To increase stability and prevent floor/carpet damage, the legs may have metal-reinforced rubber tips. A standard walker helps to control body and learn to maintain an upright posture. It is primarily designed for people with mobility issues that can be managed independently. Before each step, you must pick up the object and move it. Hand grips made of hard rubber or soft foam are attached to the walker's handles. Soft foams are convenient to hold and use, but they lose their durability more quickly than hard rubber alternatives. Most standard walkers can be folded, making storage and transportation simple. However, anticipate these models to be more expensive than their non-folding equivalents. Attachable trays are another option for carrying small items with regular walker.

Figure 2.5 Walker with the Wheels at Front

A 2-wheel walker, also called a hybrid rolling walker, has two wheels and resembles a standard walker, but it functions very differently. You start to lean on the walker. It also slides forward as you walk rather than being lifted by you with each step. Two front wheels that roll along and back glides that control the speed enable this movement. The best candidates for this assistive device are people with limited strength and mobility. However, it can also help a slow walker because the casters can quicken their stride. A more natural gait is facilitated by two-wheel walkers. They come assembled, needing little to no modification, and are better on carpets. The small wheels, however, render this walker unsuitable for outdoor use due to the increased risk of getting stuck in more difficult terrains. Although a rolling walker or rollator is an expensive option, it is one of the most adaptable kinds of walkers. They come in three-wheel and four-wheel versions and are a wheel-based substitute for conventional walkers. Nevertheless, they are a little more fashionable than regular walkers. The people who need rollators the most are those whose arms are too weak to hold a traditional walker, those whose upper body strength is insufficient to push a standard walker, and those who must stop frequently while walking. Additionally, four-wheeled models come with a seat that gives you room to sit and relax on longer journeys. For added support, the majority include a backrest. Rollators typically weigh more than conventional walkers because of the seat and the wheel & brake system. Rollators typically weigh 15 to 18 pounds. However, there are models with lightweight claims that weigh between 11 and 14 pounds.

Figure 2.6 Walker with Wheels

2.2.3 Specification Analysis of Walker

This study's focus is on the creation and enhancement of walkers. An examination of the walker specification was done consequently. A healthcare professional, pharmacy, or even internet business may sell walkers in a variety of designs. Customers should choose a walker that fits their needs. The findings of the specification analysis were reported, and twelve walkers were included in this sub-topic. The study provides clear information on the products, including the name, brand, price, weight capacity, and other details. It helped the walker's progress throughout the inquiry by enabling us to completely understand the product details. The findings of the examination of walkers' specification are shown in Table 2.1.

Table 2.1 Specification Analysis

Bil	Figure	Description
1	 Figure 2.7 Karman R-3600 Three-Wheel Rollators Brand: Karman Price: 85 US dollar (RM346.29) Weight capacity: 113 kg Nett weight: 6.8 kg Product Size: 89-104 cm (overall height); 56 cm (overall length); 64 cm (overall width) Brake style: Loop brakes	User / Situation: Elderly, Patient, Lower extremity patient Outdoor, Shopping, or others public interior space Function Long-term life assistance(always) Operating Instruction: λ Check the walker, step into it from the back, and push it forward at the same time. λ Treat the brakes to slow down and stop, or lock them in place, to prevent the walker from rolling away inadvertently. Structure: Walker with three wheels in triangle shape for improve the speed. Features: λ Adjustable λ Ergonomic design perspective λ Easy to store λ Need some spaces. Potential Problems: λ User is easy to make mistakes λ Wheel skidding

2	 Figure 2.8 Dive Medical Nitro Rollator (RTL10266) Brand: DeVilbiss healthcare Weight capacity:136 kg Nett weight:8 kg Adjustable height: 85-97cm Product size: 59cm(width);48cm(depth);46cm (seat width);20cm (seat depth);52cm (seat height) Material: Aluminium, Nylon cloth	User/Situation: Elderly, lower limb disability Outdoor, Shopping, Public interior space Function: 1. Short-term rehabilitation(3~6 months) 2. Mid-term rehabilitation(7~18 month) 3. Long-term life assistance(always) Operating Instruction: λ The user positions the walker in front of them, steps into it from behind, and propels it forward at the same time. λ The walker's brakes can be used to slow down and stop while walking, or they can be locked in the on position to prevent the walker from rolling away. λ User could have a seat for resting and put their belonging in the bag. Structure: Walker in trolley shape with square seat to let user push it smoothly. Features: λ Adjustable height λ Ergonomic design perspective λ Easy to store. λ Need some space. Potential Problem: λ Wheel would degrade. λ User would make mistake. λ Unstable seat

3	 Figure 2.9 Adult Cavalier Anterior Walker Brand: Living made easy Price: 1680dollar (RM6872.04) Weight capacity: 85 kg Nett weight: 18kg Seat height: 64-78cm Product size: 105,112cm(length);75,81cm(width) Materials: Aluminium, Sponge, Plastic	User/Situation: Children, kid patient with lower limb ability. Outdoor, Park Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) 3. Long-term life assistance(always) Operating Instruction: λ User could slow down the speed or stop moving by pressing the brakes. λ User could lean on the walker λ User could sit on the seat for resting. Structure: The walker in bicycle structure to support the user while walking. Features: λ Adjustable seat height λ Ergonomic design perspective λ Not easy to store. Potential Problem: λ User is easy to make mistake. λ Occupied a lot of space. λ Storage problem
4	 Figure 2.10 Duo Walking Trolley Brand: complete-care shop Price: 50.78 dollar (RM207.72) Weight capacity: 127kg	User/Situation: Elderly, Patient, Lower limb disability Indoor, Home, Ward Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) Operating Instruction: λ Put the item into the plate, hold the frame with both hands then stand still with feet together. λ Pick up the walker and move it forward a short distance before setting

	Trolley weight: 6 kg Tray capacity: 5kg Adjustable height: 83.5-98cm Product size: 40.5cm (width between handles);58.2cm (frame width at front); 60.3cm (frame width at rear); 52.5cm	it down with all four tips firmly on the ground. λ Placing your body weight through the walker while moving forward with one leg and then step forward the other leg. Structure: The walker in frame shape with two plates to let user to put item on it. Feature: λ Adjustable height λ Ergonomic design perspective λ Not easy to store. λ Need some space. Potential Problem: λ Items would drop while walking. λ Wheel would degrade.
5	 Figure 2.11 Walking Frame Brand: PRADO Price: RM74.52 Weight Capacity: 200kg Nett weight: 2kg Adjustable height: 80cm – 90cm Product size: 78 x 53 x 10cm Material: aluminium tubing with anodized finish.	User/Situation: Frail people, Patient, Elderly Outdoor, Shopping, or others public interior space Function 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) Operating Instruction: λ Hold the frame with both hands then stand still with feet together. λ Pick up the walker and put forward a bit then put it down with all four tips steadily on the ground. λ Placing your body weight through the walker while moving forward with one leg and then step forward the other leg. Structure: Walker in square shape to increase the stability while walking. Features:

		λ Adjustable height λ Ergonomic design perspective λ Easy to store λ Need little space Potential Problem: λ User would put it too forward and cause injured. λ Occupied a lot of space.
6	 Figure 2.12 Forearm Walking Frame Brand: No brand Price: RM290 Weight capacity: 200kg Nett Weight: 3.9kg Adjustable height: 7 height adjustable level Product Size: 118 x 54 x 52 cm Materials: Aluminium Alloy, sponges, rubber	User/Situation: Elderly, Patient with limited mobility Indoor, Hospital Therapeutic centre Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) Operating Instruction: λ User should undo the strap and place their forearm on the platform and their hand around the handgrip. λ Repeat for the other arm and adjust the height if required and the position and the angel of the handgrip. Structure: The walker is height and in frame shape, it enables user to put their arm on platform to reduce risk from falling. Features: λ Adjustable height λ Ergonomic perspective λ Easy to store. λ Need some space. Potential Problem: λ User would make mistake. λ Occupied a lot of space.

7	 Figure 2.13 Upright Walker Brand: No brand Price: RM778.00 Weight Capacity: 100kg Nett weight: 13.4kg Product Size: As shown in picture. Material: Carbon steel, sponge, rubber.	User/Situation: Elderly, patient with joint or muscle pain. Indoor, hospital, therapeutic centre Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) Operating Instruction: λ Adjust the walker's height before using it to ensure exact positioning depending on the user. λ The user rests his or her forearms on the armrests and grabs the handgrips to achieve stability. λ In an upright position, the user can then walk while the four wheels take care of the rest. λ The handgrips include brakes to provide additional safety and autonomy to the user. Structure: Walker is height, rectangular shape to support user whether in standing or sitting position. Features: λ Adjustable height λ Ergonomic design perspective λ Not easy to store. λ Need big space. Potential Problem: λ User is easy to make mistake. λ Storage problem λ Occupied a lot of space
8		User/Situation: Elderly, Lower extremity patient Outdoor, Exterior space, Indoor, Travel use Function: 1. Short-term rehabilitation (3~6 months) Operating Instruction:

	 Figure 2.14 Ez Fold "N Go Walker Brand: Think-Mobility Price: 312dollar (RM 1276.24) Weight capacity: 181 kg Nett weight: 3.4 kg Adjustable height: 81-98 cm Product size: 55 cm(depth);65 cm(width);46cm (handle width) Materials: Aluminium, Nylon cloth	λ When the arm is stretched down, adjust the handle to match the height of the user's waist. λ Hold the handle with both hands, then slide it forward and move with one leg through the frame while putting your full weight through it, and then bring the other leg through the first. λ Collapse the walker like an umbrella stroller with the touch of a finger to smash the walker. λ Keep it in the nylon pouch when finish using. Structure: The walker in pyramid shape, easy for user to fold. Features: λ Adjustable height λ Ergonomic design perspective λ Very easy to in store λ Need little space. Potential Problem: λ Not stable λ Not able to support user weight
9	 Figure 2.15 Rollator Walker Brand: ESCO Price: RM399 Weight Capacity: 90kg Nett Weight: 8kg	User/Situation: Elderly, Lower extremity patient Outdoor, Indoor, Public interior space Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) 3. Long-term life assistance(always) Operating Instruction: λ The user positions the walker in front of them, steps into it from behind, and propels it forward at the same time. λ The walker's brakes can be used to slow down and stop while walking, or they can be locked in the on position

	Adjustable handle height: 80-92cm Size:60cm (seat height),46cm(width) Materials: Powder coated aluminum, Sponge, Rubber.	to prevent the walker from rolling away. λ The user may choose to sit and place their belongings in the basket. Structure: Steel of walker in square shape with chair for resting use. Features: λ Adjustable height λ Ergonomic perspective λ Not easy to store. λ Need some space. Potential Problem: λ Wheel would degrade λ User is easy to make mistake
10	 Figure 2.16 Walking Tutor-Heavy Duty Brand: DVA Price: 383dollar (RM1204.29) Weight capacity: 180 kg Nett weight: 12.2 kg Adjustable height: 103-127cm Product size: 88cm(length);65cm(width) Materials: Aluminium, Plastic, Sponge	User/Situation: Elderly, Limited hand and wrist strength patient Outdoor, Indoor, Public interior space Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) 3. Long-term life assistance(always) Operating Instruction: λ Adjust the height of forearm rest before using it. λ Place both forearm on the platform and grab the handle foe stability. λ Slide walker forward to make movement. λ Pull the brakes for slower down the walking speed or stop moving. Structure: The walker in triangular shape enable to store it easily. Features: λ Adjustable height λ Ergonomic design perspective λ Easy to store. λ Need some space.

		Potential Problem: λ User would make mistake
11	 Figure 2.17 Legged Lightweight Folding Rollator Brand: BZEI-WALKERS Price: 99.75 dollar (RM 408.53) Weight capacity: 136kg Nett weight: 2.9kg Product size: 56cm(length);58cm(depth);81-91cm(height) Material: Aluminium alloy	User/Situation: Elderly, lower limb disability, Patient Outdoor, Indoor, Shopping, Public interior space Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) 3. Long-term life assistance(always) Operating Instruction: λ Hold the sides of both hands, slide them forward, and move with one leg, putting the body's weight across the frame, and then carrying the other leg past the first. λ Pull the brakes that down the handle for slower down the walking speed or stop moving. Structure: Two stick shape steel connected to increase stability. Features: λ Adjustable height λ Ergonomic design perspective λ Easy to store. λ Need some space. Potential Problem: λ Wheels would degrade. λ Unfold able

12	 Figure 2.18 Dual Riser Walking Frame Brand: Cofoe Price: RM126.90 Weight capacity: 160kg Nett weight: 2.2kg Product size: 51x46x72 cm;10cm (folding thickness) Materials: Aluminium, rubber	User/Situation: Elderly, Patient, lower limb disability, the blind Outdoor, indoor, public interior space Function: 1. Short-term rehabilitation (3~6 months) 2. Mid-term rehabilitation (7~18 month) Operating Instruction: λ Put both hands on the first pair of handgrips when user in a sit position and want to stand up. λ Users stand up and lean the body weight on the walking frame with both hands. λ After standing up, place both hands on the second handgrips. λ Pick up the walking frame and put it forward then both legs steps forward one-by-one, repeat it for walking. Structure: Both side of the walker in R shape with two sets of grips to help user easier to stand up from chair. Features: λ Adjustable height λ Ergonomic design perspective λ Easy to store. λ Need little space. Potential Problem: λ User is easy to make mistake. λ Occupied a lot of space

Specification analysis is a sort of fundamental study that informs the designer of the product's current market status. Using the table of specification analysis, one may comprehend the position of the product on the market at hand. In order to do additional research and documentation for this specification study, information regarding walkers was acquired from the internet, articles, online stores, and other sources. The walker's name, price, function, user/situation, operating instructions, structure, features, possible difficulties, and other pertinent facts are provided in Table 2.1 with the walker's figure. Most walkers, it was discovered, are designed for the elderly since walking wears them out. However, individuals who have lower limb limitations may utilise a walker to enhance their mobility and increase their quality of life. There are many walkers' functionality available depending on whether the walker is used for short-term treatment (36 months), middle-term rehabilitation (718 months), or long-term life assistance (always). For example, customers often acquire Karman R-3600 three-wheel rollators shown in Figure 2.7 for long-term life assistance because they are more durable than the Ez Fold 'N Go Walker shown in Figure 2.14, which is more suited to short-term rehabilitation such as travel. After looking at current walkers on the market, it's clear that the most majority of them are created with ergonomics in mind and are adjustable to accommodate the user's body size. In addition, as illustrated in Figures 2.9, 2.13, and 2.15, certain walkers, such as the Adult Cavalier Anterior Walker, Upright Walker and Rollator Walker provide a seat allowing the user to halt and rest as needed.

The many types of walkers available on the market, including two-wheel, three-wheel, four-wheel, and pick-up walkers, are also shown in Table 2.1. A two-wheel walker, like the Legged Lightweight Folding Rollator shown in Figure 2.17, is a good option for people who have problems maintaining their balance when walking or need to go slowly. Due to the additional support, it offers, a two-wheeled walker is more stable than a three- or four-wheeled one. Two wheels may be found in the front, and rubber stoppers can be found at the back. Despite being challenging to use on carpeted surfaces, the stoppers provide the user extra stability. One of the flaws is that the two-wheeled walker is not suitable for usage in various environments, such as uneven outdoor surfaces. Swivel front wheels are available on several two-wheeled walker models. This may make them more manoeuvrable than fixed-wheel variants, but it also makes them less stable.

As seen in Figure 2.8, four-wheel walkers, like the Drive Medical Nitro, frequently come with a seat for resting and a basket for the user's belongings. Three-wheel walkers, like the Karman R-3600 three-wheel rollators, are more manoeuvrable in small spaces. For people who can balance well but need help due to lower-limb weakness, both walkers are suitable. The pick-up walker is also suitable for persons who need a lot of help since, unlike a standard walking frame, it lacks wheels. The best way to use it is to pick it up off the ground and set it down again after each step.

Table 2.1 demonstrates how various walker designs offered various purposes. For instance, it is recommended to use a Cavalier Walking Frame for a small child with mobility difficulties who needs upper body support and a seat to rest. The gadget has a saddle component that enables the user to unwind and sit comfortably on it. The user may precisely control the walker's movement and direction by adjusting the steering connected to it (Hansen, 2021). For those with mobility challenges who need assistance with daily duties at home, such as picking up food, hot beverages, and other items around the house, the Duo Walking Trolley, as shown in Figure 2.10, is a great option. The design of this walker is suitable and suggested to patient who deal with occupational therapists and physiotherapists. It is manoeuvrable due to the two front castors; this innovative combination walking frame and the household trolley is made from sturdy steel.

The analysis as a whole shows that the majority of walkers use the same kind of brakes, which are not as safe as previously claimed after prolonged use. Furthermore, even if some of the walkers may be folded, some of them still have a huge size and take up a lot of space. As the walker is enhanced, these concerns will be taken into account.

2.3 Block Diagram

This project consists of block diagram, hardware, software, and materials of the project. The block diagram had 3 columns important parts starting with input, processor, and output. The main input has a sensor followed by processor which is Arduino Ide and main output has device which is phone or laptop to see the result. This hardware is an important material for this project. If without this thing, this project will not run properly.

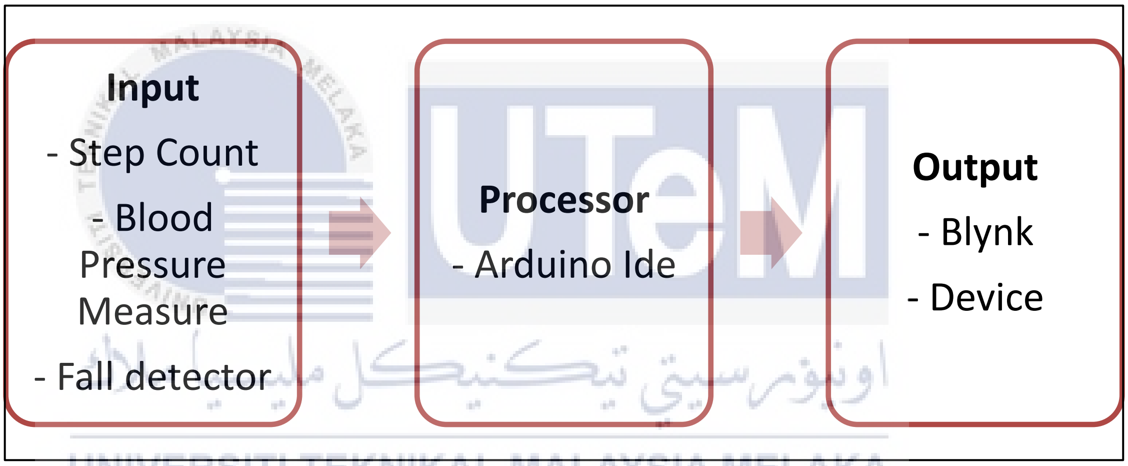


Figure 2.19 Block Diagram (Input, Processor and Output)

This project used three sensors which are ADXL 345 sensor, MX 303102 sensor and step detector. The data of the sensor will be sent to the Arduino Ide and the result will be displayed on the device. When turn on the switch the battery will give power to the run program. Function of switch is for well prepared to start move of the walker. For android applications, this project used the Blynk software which connects with phone to see the result.

2.4 Software Development

2.4.1 Arduino

Hernando Barragán, a student from Colombia, developed the Wiring development platform for his master's thesis at the Interaction Design Institute Ivrea in Ivrea, Italy, in 2004. His thesis was supervised by Massimo Banzi and Casey Reas, who is well-known for his work on Processing. The goal was to develop affordable, user-friendly tools that non-engineers could use to build digital projects. The Wiring platform included a hardware PCB with an ATmega128 microcontroller, a Processing-based integrated development environment (IDE), and library functions for quick microcontroller programming. Massimo Banzi, David Mellis, who was then a student at IDII, and David Cuartielles added support for the less expensive ATmega8 microcontroller to Wiring in 2005. But instead of carrying on with Wiring, they forked (or copied) its source code and began using it for their own Arduino project. Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino, and David Mellis made up the original core team for the Arduino. The bar in Ivrea where some of the project's founders used to meet is where the name "Arduino" originates. Arduin of Ivrea, the margrave of Ivrea and King of Italy from 1002 to 1014, has also inspired the name of the bar. (Zlatanov, 2016)

The system-running Arduino IDE is a unique programme that enables the creation of sketches for various Arduino boards. The very basic hardware programming language called Processing, which is similar to the C language is the foundation of the Arduino programming language. The sketch must be uploaded to the Arduino board for execution after being created in the Arduino IDE. By using specific rules for code structuring, the Arduino IDE supports the languages C and C++. The Wiring project's software library, which offers numerous common input and output operations, is made available through the Arduino IDE.

For the sketch to start and the main programme loop, user-written code only needs two fundamental functions. These functions are combined with a programme stub main () and GNU toolchain, which is also distributed with the IDE, to create an executable cyclic executive programme. The executable code is converted by the Arduino IDE's use of the programme AVRDUDE (AVR Downloader Uploader) into a text file with hexadecimal encoding, which is then loaded into the Arduino board by a loader programme in the board's firmware.

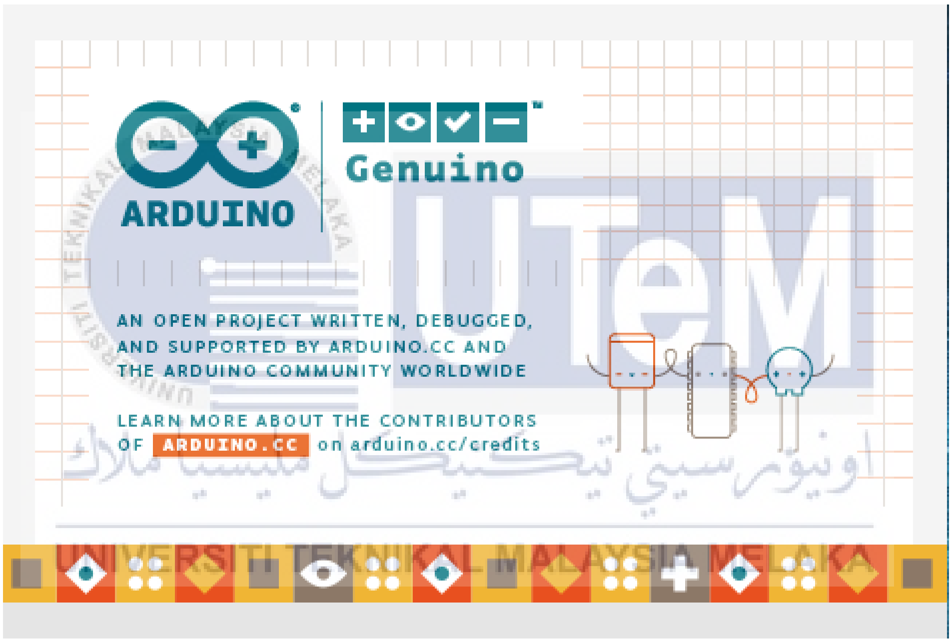


Figure 2.20 System-running Arduino IDE

2.4.2 Blynk

As an input/output device for reading the status of the connected electrical appliance or device, the IoT control application requires a smartphone. Using a wireless connection, the smart phone is linked to the IoT hardware. Internet, Wi-Fi, Ethernet, and Bluetooth are all forms of wireless connectivity. In order to connect to the IoT hardware, the smartphone must run a compatible operating system. For many types of IoT hardware, Android OS is the most compatible OS. Many different IoT hardware products with a variety of features are on the market. For a given application, one can select better hardware. The most popular Internet of Things hardware includes the Arduino, Raspberry Pi, NodeMCU, and ESP32.

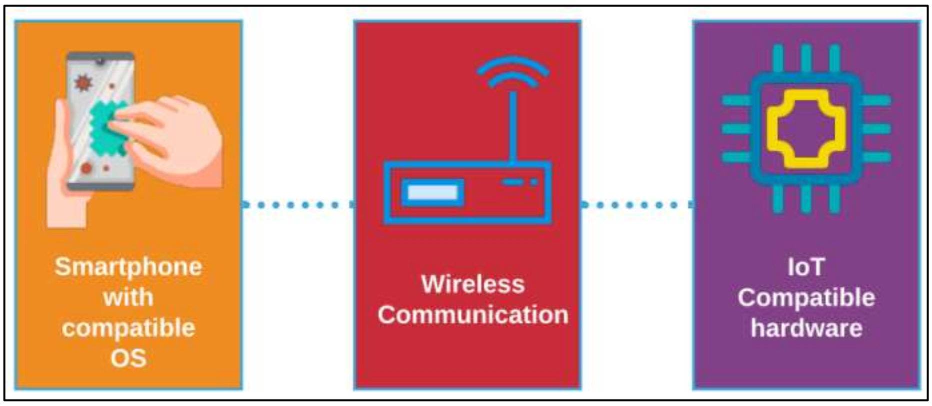


Figure 2.21 IoT process

For control applications, the proposed work is connected via the Blynk IoT server. Here, the connected hardware pins' status is continuously transmitted to the Blynk server, and the Blynk application-equipped smartphone is given access to the saved data on the IoT server. With the aid of Blynk hardware, the hardware can also be wirelessly controlled from a smartphone. Installing the appropriate Blynk library on the IoT hardware unit is necessary in order to connect it to a Blynk server. The architecture of the proposed IoT control system through Blynk hardware is shown in the Figure 2.22.

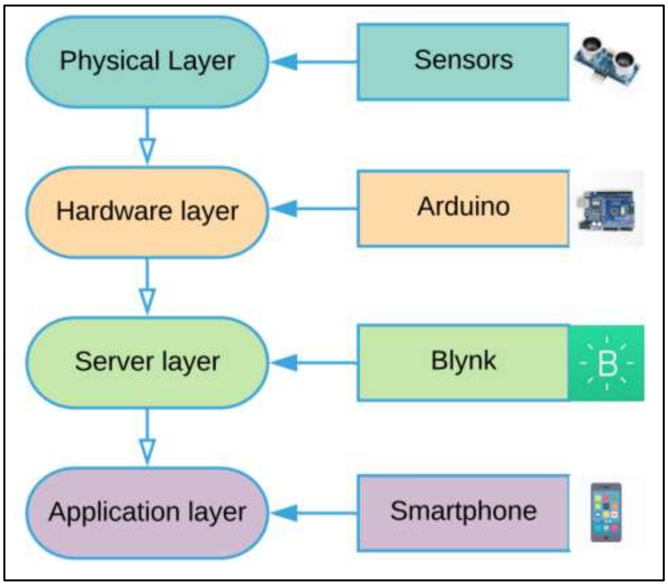


Figure 2.22 Server layer-Blynk

Table 2.2 Explanation about Blynk app with its server and libraries

Blynk App	Using the many provided widgets, it enables the creation of stunning user interfaces for projects.
Blynk Server	It handles all the communications between the hardware and the smartphone.
Blynk Libraries	It allows all widely used hardware platforms to communicate with the server and processes all incoming and outgoing commands.

Figure 2.23 Blynk

This project used the Blynk server which is the walker only used the hardware and smartphone. When someone presses the Button in the Blynk application, a process is started that sends the data to the Blynk Cloud, where it magically appears on the installed hardware.

2.5 Hardware Development

2.5.1 Buzzer

The joy buzzer has been shocking unsuspecting victims since 1928 and is a favourite of pranksters everywhere. Danish inventor Soren Sorensen Adams, who founded the S.S. Adams Co., the leading manufacturer of novelty goods in the 20th century, invented the device. In the years following the invention of his first practical joke, Cachoo Sneeze Powder, Sorensen went on to invent prank products that have become standards, including the razzberry cushion, the snake nut can, and the exploding cigar. The buzzer, which was first formally patented in 1932, merely vibrates loudly to "shock" the gullible while not actually delivering an electric current. (Townsend, 2011) An Arduino buzzer is a beeper. An electronic device called an Arduino buzzer emits sound when an electric current flows through it. By applying various frequency electric pulses to the Arduino buzzer, which can be connected directly to the Arduino, the buzzer can produce a variety of tones. The Arduino buzzer is most frequently used as a beeper in any system, as an alarm device, a timekeeper, a security system, and to produce sound when a user input is confirmed in many systems.

Figure 2.24 Buzzer

To alert people if a patient falls, this project uses a buzzer. This buzzer will make a loud sound and a notification will appear on the device. Other than that, the buzzer at the device will also ringing to inform that the patient has fallen.

2.5.2 Switch

Over the years, Robert Boschert has donned several absurd hats, both literally and figuratively. But this 73-year-old has worn them all with pride. Boschert is most well-known for wearing the "hat" of electrical engineering and contributing to the development of low-cost, high-volume switching-mode power supplies. Every electronic device in our homes and workplaces now includes these gadgets as necessary tools. They are responsible for producing more cost-effective, smaller electronic products than were previously possible with linear-style power supplies. (Kilbane, 2009)

A switch with on/off marks in the form of a rocker is a popular design. The ON symbol is "I" (a straight line), while the OFF symbol is "O" to comply with IEC 60417. (a circle). It is crucial to consult the relevant equipment standard for instructions regarding the placement of "on," as some may specify that the "I" be installed vertically. These on/off indications might be found on the actuator's end or on its face. The actuator is the mechanical component that is used to manually switch on and off a circuit.

Figure 2.25 Switch

2.5.3 Sensor

To complete this project, the walker used three sensor development which fall detector, step detector and blood pressure measure.

2.5.3.1 Fall Detection

Before the development of fall detection technology, victims of falls might have lain on the ground for several hours before anyone realised, they needed assistance. Today's fall detection technology works by identifying a person's abrupt change in position to help lower the risk of long-term injury. Even if the user is unable to call for assistance themselves, the device does so, triggering an immediate emergency response to deal with the situation. Wearable sensors and ambient sensors are the two categories of fall detection devices.

A global issue that affects life expectancy is ageing. According to the World Health Organization (WHO), 20% of the global population is over the age of 65. According to another study, there will be 1.5 billion people over the age of 65 on the planet by the year 2050. The general physical, cognitive, and sensory functionalities decline with age. As a result, an older adult finds it challenging to carry out simple tasks like eating, dressing up, and jogging. In the elderly population, falling presents a serious risk that can shorten life expectancy. Over the age of 65, 35% of people experience one or more falls annually. In addition to getting older, falls can also be caused by the environment, physical activity, and cardiovascular diseases. It is a significant contributor to physical injuries, many of which necessitate hospitalisation. 37.3 million falls each year result in medical attention, and 0.65 million falls result in fatalities, (Park, 2021).

In recent years, the development of fall detection and prevention systems has become a hot research topic. Such systems are developed using a variety of approaches. Wearable systems and non-wearable systems are the two broad categories of these systems. Table 2.8 show the different between non-wearable sensor device and ambient sensor device.

Table 2.3 Different Between Wearable Sensor Device and Non-wearable Sensor Device

Wearable Sensor Devices	**Non-wearable sensor**
When someone falls, an accelerometer sensor built into a watch, pendant, belt, or clip-on accessory measure how quickly the person is moving toward the ground. If the person fell, it is determined by an algorithm. If so, the device alerts the monitoring crew of the manufacturer. The person is then contacted by an agent via the device's speaker. The agent notifies the user's emergency contact listed in the system if the person reports having fallen. If the person	Video cameras are strategically positioned throughout a person's home using ambient sensor devices to monitor their movements. The monitoring service contacts the individual through a speaker in the home when the ambient sensors identify a fall. The monitoring service representative notifies the person's emergency contact if the person admits to falling. When the person who has fallen does not respond or

who may have fallen doesn't speak, their emergency contact will be alerted right away. Many wearable sensor devices also have a manual button, allowing the user to report a fall on their own, if they are able.	provide feedback, their emergency contact is automatically informed.

2.5.3.2 Step Count

Distance measurements have long been done by counting steps. Researchers developed an interest in using daily steps to measure ambulatory physical activity starting in the middle of the 20th century. Following the 1995 release of reasonably accurate spring-levered pedometers with digital displays, this field of study gained momentum. Since 2010, the number of private individuals using accelerometer-based "activity trackers" has multiplied. As a metric for measuring physical activity, steps have several benefits: they are simple, straightforward, objective, and they represent a basic unit of human ambulatory activity. Due to the biological variability that comes with measuring a human behaviour, measurements must be spread out over 3–7 days to produce accurate and valid estimates. There are numerous types of step counters designed to be worn at various locations on the body; each of these devices has advantages and disadvantages. Strong associations between steps per day and health variables have been documented in cross-sectional studies. At least eight prospective, longitudinal studies using accelerometers are currently underway, which may aid in establishing dose-response relationships between steps per day and health outcomes. Longitudinal interventions with step counters have shown that they can help inactive people increase their daily steps by 2500. Step counting is useful for surveillance, and studies have been conducted in several countries around the world. Future challenges will include establishing testing protocols and accuracy standards, as well as determining the best placement sites, (Bassett, P.Toth, & R.LaMunion, 2016).

Every time the user takes a step, the step detector sensor starts an event. The event timestamp is the moment the user's foot touched the ground, and the value reported in the on Sensor Changed () method is always one with a fractional part of zero. The step detector sensor reports steps with a very low latency, typically within 1 to 2 seconds. In comparison to the step counter sensor, the step detector sensor has lower accuracy and generates more false positives. Since the step counter sensor takes extra time after each step to weed out any false positive values, it is more accurate but has a longer reporting lag. The step detector sensor is advised for applications that require the ability to track steps in real time and to keep a history of each step's timestamp.

2.5.3.3 Blood Pressure Measure

The primary sign that doctors regularly check for after a patient arrives is heartbeat. The frequency with which a heart beats and relaxes in each amount of time is referred to as heart rate (usually per minute). Age groups have different heart rates. A normal resting heart rate for an adult human is around 72 beats per minute (bpm). When the patient's heart rate is lower while at rest, the heart is said to be functioning efficiently. Older children's heart rates are roughly 90 bpm, while babies' heart rates are much higher than adults' at 120 bpm. A condition known as bradycardia is indicated by a heart rate that is lower than normal, and a condition known as tachycardia is indicated by a heart rate that is higher than normal.

Heart rate monitoring system is one of these electronic devices. This project measures a patient's various characteristics and show them on a software programme. The simplest way to determine heart rate is to place the thumb over a pulse sensor for a short period of time while waiting for Arduino to receive an analogue value. In order to calculate heart rate per second, the heart rate is then recorded for 5 seconds. The heart rate in beats per minute is obtained by multiplying these values by 60. (Beats per minute). Although straightforward, this method lacks accuracy and can produce mistakes when the rate is high.

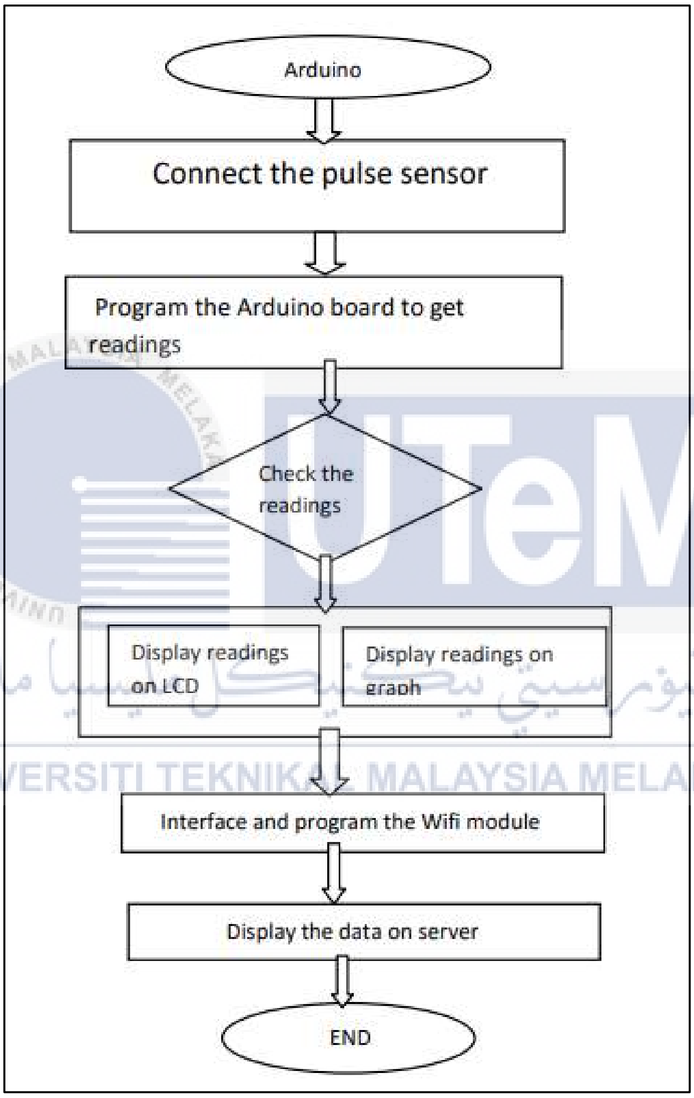


Figure 2.26 Flow Chart of Heart Rate Monitoring System

2.5.4 Battery

The 3.7v lithium battery is a lithium cell with a 3.7v nominal voltage and 4.2v at full charge. There are several hundred to several thousand mAh in it. It is typically utilised in a variety of instruments and metre types, testing devices, medical devices, point-of-sale equipment, notebook computers, and other products. Regarding the 3.7V lithium battery capacity, the more parallel lithium batteries there are, the larger the volume of a single lithium battery will be, or we can say, the larger the capacity will be. A 3.7v lithium battery typically requires a "protection board" to prevent overcharging and discharge. Because a lithium battery's ideal full charge voltage is 4.2 volts, a battery without a protection board can only be charged up to 4.2 volts without risking damage. If the voltage is higher than 4.2 volts. When charging in this manner, it's important to constantly keep an eye on the battery's health. On the other hand, a 5V charger can be used to charge a battery with a protection board (range from 4.8V to 5.2V). As we all know, a 5V charger can typically be used for USB on computers and mobile devices. The 3.7V battery has a 4.2V charging cut-off voltage and a 3.0V discharge cut-off voltage. Consequently, the battery ought to be able to charge when its open-circuit voltage is lower than 3.6V. To avoid having to keep track of the charging time, it is preferable to use the 4.2V constant voltage charging mode. Overcharging is simple to occur when 5V charging is used.

Figure 2.27 Battery

Figure 2.27 show the type of battery that used at the walker. This project used command 7.4V which is two battery. The function of the battery is to supply the power at the Arduino. Other than that, this project used lithium battery because it can rechargeable.

2.6 Summary

In summary, this chapter covers the research and findings based on the research's focus areas, which include the definition of mobility aids, an analysis of walkers' specifications, an examination of the market's positioning, and the development of software and hardware.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is mainly focusing 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, use of the methods and the implementation steps of the methods will also be introduced.

3.2 Research Design

If a project begins with a hazy vision or a user's desire to build a product, the entire product development process may be quite difficult. It is crucial to establish a framework to carefully guide the process and guarantee that it is controlled, traceable, and well-documented. A flow chart showing the progress made had been created, as seen in Figure 3.1. Depending on the objective of each assignment, the project's process was separated into four parts. It is necessary to gather all of the project's data at the beginning of the first stage, which is also the preliminary phase. Data on references, product details, and consumer needs will now be gathered for future use as references. The theses, journals, and books that were related to this project's and the walker's concept of product development. A walker that is available on the market should be researched and evaluated regarding its material, function, size, design, usefulness, safety, and other factors. In addition to analysing the characteristics of the product, it's critical to consider the demands of the user, which include requirements such as being practical for the user, being height-adjustable, being transportable and lightweight so that it's easy for the user to carry, and so on. Following the specification study, the information will be used to build a market positioning analysis to determine market segmentation.

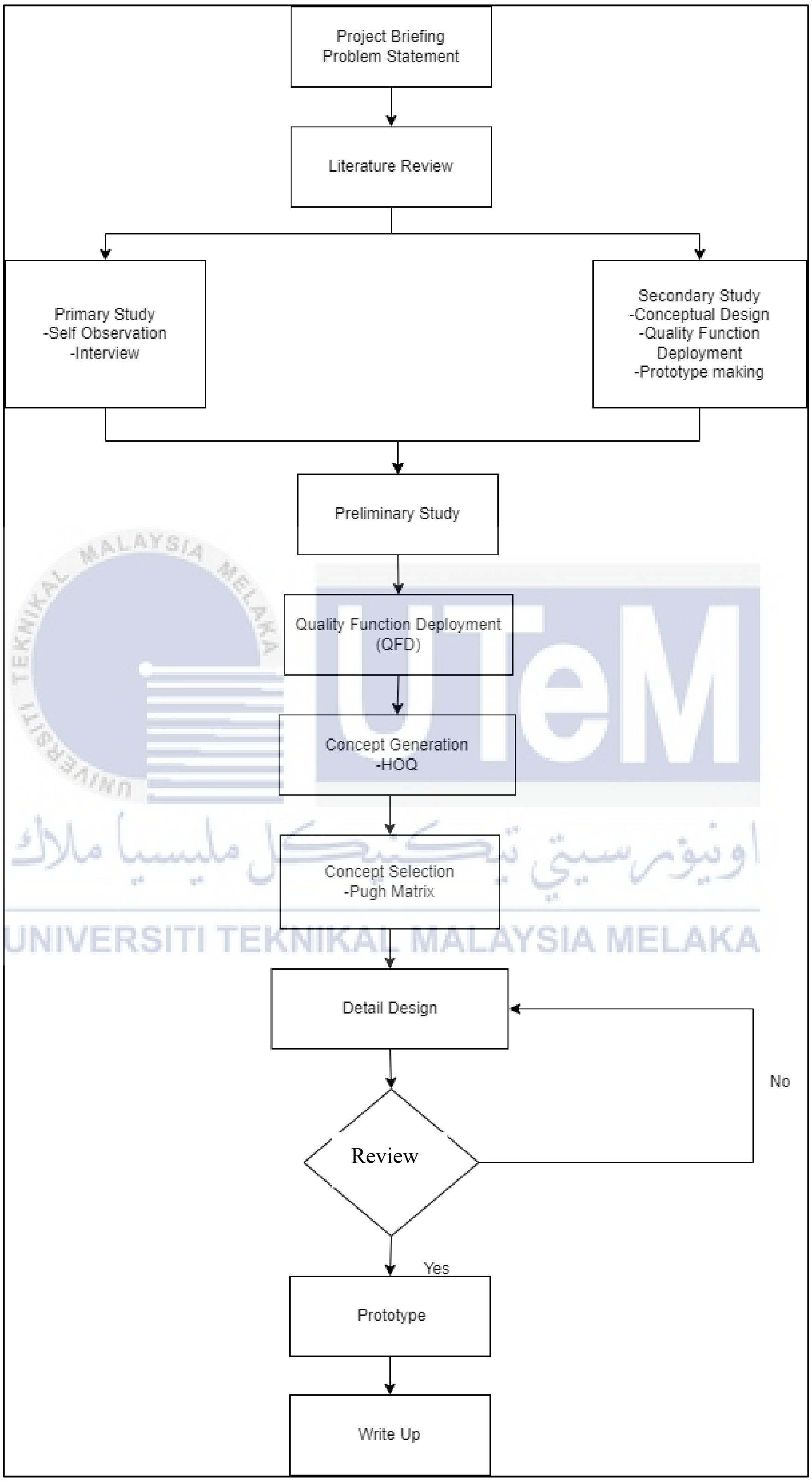


Figure 3.1 Workflow of The Project

The second part of the project is data analysis, which involves analysing all the data gathered in stage one. As a first step, problem statements must be created based on the data acquired in the first stage, such as the potential for damage when using the product, its price, its size that makes it difficult for users to operate, and its complex, unfriendly design. A set of questions will be asked during an interview to identify the user's demand and comprehend their requirement.

Development of the product is the third stage. Design development is best started with concept development and hand-drawn sketches. The final product's 3D model and 3D representation will subsequently be created using the SolidWorks application. The exam and its results make up the fourth step. The prototype will be constructed and finalised at this phase. The validation and verification of the design will next follow. The project outcome design, poster, and report will be created when the prototype has undergone testing.

3.3 Project Planning

The Gannt Chart is used in this project as a time management tool since it is essential to accomplishing a project to manage time effectively. A Gantt Chart was created using Excel as a reference to organise the project's activities to ensure that all of the tasks are finished on time. The Gantt chart may also be used to swiftly evaluate the condition and progress of the project. As a result, the project's efficiency will increase if the tasks are finished within the time frame specified at the beginning. According to the progress flow chart and the Gantt chart in Appendix A, the project is expected to start in the first quarter of 2022 and finish in the first quarter of 2023. The project's first task is subject selection; before going on to the next stage, we must speak with the supervisor about the project's subject. Once the topic was established, there are a few key steps to complete, including data gathering, PSM planning, fundamental analysis, and finding and looking through Walker's references. The logbook is required every week in order to monitor the project's progress. The PSM 1 draught might be submitted after the report was written. As a result, the presentation for PSM 1 will go on.

On the other hand, one of PSM 2's initial tasks is to gather user needs through an interview. The interview will be conducted using questionnaire questions. Data will then be altered and analysed to determine the needs for the design. There is also the design development process, which includes 3D modelling and engineering drawings. According to the needs of the model, the material will be purchased to prototype the product. The product must be tested to receive design validation and verification. These procedures must be finished before creating the poster and presentation slide for the PSM-2 presentation and submitting the PSM-2 draft.

3.4 Proposed Methodology

The selection of an appropriate approach for the project is given top attention during the design and product development processes. In this project, the Quality Function Deployment (QFD) was employed. In addition, quality tools, design aids, and planning tools are used to gather data, analyse it, and come to conclusions that will enhance both the design and development process and the quality of the final product. Journals, papers, books, and theses have been used to compile information about the walker, QFD approach, including its definition, facts, and related study.

Additionally, the interview survey approach is utilised to gather customer wants and views to acquire comparison data. A database with information about walkers has also been produced for specification examination. By collecting information about walkers' brand, price, material, size, operation manuals, and features, among other things, specification analysis serves the objective of examining walkers. Following the analysis and documentation of the data, we were able to make comparisons and understand the challenges associated with building a walker. It is first necessary to design a walker from an ergonomic perspective and make it portable so that it meets the demands of the user and achieves the project's objectives.

Lastly, to determine how the existing walker is viewed by the market, a market positioning study is required. In terms of ergonomic design, adaptability, style, and foldability, a comparison was made among the walkers that were evaluated in specification analysis. Afterward, Pugh matrix is used in this project to decide the final design concept. SolidWorks also used to make a rendering. Furthermore, for the result this project used the Microsoft Excel to do the graph comparison of walker and other device.

3.5 Design Improvement

The design improvement process is implemented in 3 steps. The first step in creating the design of the walker at this stage is to clarify the goals. It is used to specify the intended or anticipated outcome of a walker. This is done to make sure the walker is designed, made, and capable of achieving the project's goals.

Furthermore, secondary data is gathered for design research from books, websites, and other published sources. To interpret the potential functions, materials, part components, applications, and design structure, a minimum of five design research are analysed. Each crucial component is outlined for benchmarking purposes to enhance the walker's design.

After product design specification, design walker based on the product design specification that evaluated from collected secondary data. Solidworks software is used to design the 3D modelling walker.

3.6 Usability

Testing a product or service's usability involves evaluating it using real users. Normally, participants in a test attempt to complete typical tasks while observers watch, listen, and take notes. The purpose of this study is to find any usability issues, gather qualitative and quantitative information, and ascertain the participant's satisfaction with the product. The development and design teams can find issues prior to coding by using usability testing. The sooner problems are found and resolved, the less expensive they will be in terms of staff time and potential schedule impacts.

This project used usability test to be testing the walker. An effective usability test requires a well-thought-out test plan, participant recruitment, analysis, and reporting of results. Besides that, it's importance to remember that usability testing is more than just a task to be completed on the project schedule. The walker should have a purpose for the product testing, and then implement the findings. Usability test will be conducted in this stage to gather users' feedback on the walker prototype at the end of chapter 4 to identify usability issues and provide discovered problems for future research to improve the walker prototype.

3.7 Summary

This chapter focused on the information of progress flow chart and Gantt chart, they are used at the early stage of the project as project planning tools to manage time to increase the project's efficiency and smoothness of the progress by completed all the activities within the given duration. There are several methods used for collecting required data such as interview session, refer to resources, and existing product analysis is data collection method used whereas the specification analysis, market positioning analysis, QFD method for data analysis and usability test.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

From the previous chapter, this chapter displays the results of walker prototype development and design improvement. To achieve the desired result within the parameters of the research, specific actions are taken as described in Chapter 3.

4.2 Product Analysis

4.2.1 Product Location and Market Analysis of Walker

After some research and discoveries, data on walkers is gathered in order to analyse the market positioning analysis. Understanding the product market category, consumer intent analysis, and market positioning are the three main objectives of this study. The study's findings will be displayed in a position map, which will make it apparent what category and where each item is in the current market according to customer perceptions.

Table 4.1 Position Map 1

Position Map 1: Ergonomic design VS Adjustability													
Ergonomic design X-axis ← No → Yes							Adjustability Y-axis ← No → Yes						
-3	-2	-1	0	1	2	3	-3	-2	-1	0	1	2	3

Table 4.2 Position Map 2

Position Map 2: Style VS Foldability													
Style X-axis Streamline ⟷ Geometric							Foldability Y-axis No ⟷ Yes						
-3	-2	-1	0	1	2	3	-3	-2	-1	0	1	2	3

A set of predetermined criteria was used to analyse all of the existing walker data. To evaluate the circumstances surrounding the current product, choose the ergonomic design, adaptability, style, and foldability depending on the design features of this product. The objective of this project is to design a portable walker, therefore flexibility, foldability, and style must all be carefully considered. Additionally, designing a comfortable yet secure walker is essential, therefore ergonomic design was used to assess the current walker.

The criteria will be applied to determine the walkers' scores, which will range from -3 to +3. How to create two-position maps is shown in Table 4.1. The x-axis of position map 1 represents the product's ergonomic design. High grades will be given to walkers with an ergonomic design, while poor marks will be given to walkers lacking an ergonomic design. For instance, if a walker is made with the user's body type and posture in mind, they won't experience any pain or harm while using it, and the product will be given great marks. The flexibility of the walkers is shown on the y-axis. A low score will be given to the walker if it cannot be adjusted; however, a higher score will be given if the device can be adjusted. On the other side, the x-axis of Position Map 2 displays the design of the product. Since it has a simple appearance and is less resistant to walking, a streamline-modelled walker will have a low value. On the other side, a product with a geometric design will perform well on this criterion. The y-axis of position map 2 displays the walker's foldability.

A walker is considered portable if it is foldable, light, and simple to move around. A product will be given a score based on how well it folds, and a product with a low foldability score will be given a low score. The walkers who obtained various grades based on their performance are listed in Table 4.3.

Table 4.3 Grades for The Walker Based on The Performance

		
Karman R-3600 three-wheel rollators Ergonomic design: - 1 Adjustability: +1 Style: +1 Foldability: +1	Drive Medical Nitro Ergonomic design: +1 Adjustability: +1 Style: +3 Foldability: +1	Legged Lightweight Folding Rollator Ergonomic design: 0 Adjustability: +2 Style: +1 Foldability: +1
		

Duo Walking Trolley Ergonomic design: 0 Adjustability: 0 Style: +1 Foldability: -2	Walking Frame Ergonomic design: - 2 Adjustability: +1 Style: -2 Foldability: +1	Forearm Walking frame Ergonomic design: +3 Adjustability: +2 Style: +1 Foldability: +1
		
Upright walker Ergonomic design: +3 Adjustability: +3 Style: +2 Foldability: -2	EZ FOLD 'N GO WALKER Ergonomic design: - 1 Adjustability: +1 Style: -1 Foldability: +3	Rollator walker Ergonomic design: 2 Adjustability: +1 Style: +2 Foldability: +1
		

Walking Tutor-Heavy Duty Ergonomic design: +2 Adjustability: +3 Style: +3 Foldability: +1	Legged Lightweight Folding Rollator Ergonomic design: 0 Adjustability: +2 Style: +1 Foldability: +1	Dual riser walking frame Ergonomic design: - 1 Adjustability: +1 Style: -1 Foldability: +1

Figure 4.1 compares the flexibility of walkers and their ergonomic design. The walkers in Zone 1 on the map are designed with fewer ergonomic considerations, and they are typically adjustable, including in terms of height. For instance, when using a walking frame, the user may adopt a forward-leaning posture, which could result in back pain. The second zone's walkers all had a somewhat customizable design and an ergonomic build Indicating that the walkers in this zone have ergonomic elements such handgrip form, walker structure, wheels, etc., the third zone displays the positive area of both the x-axis and the y-axis. Finally, zone 4 walkers excel in terms of adaptability and ergonomic design. The majority of walkers in zone 4 have armrests, therefore people who value walker ergonomics would pick one with an armrest that can be adjusted for height as well as forearm height or the angle of the hand grip.

Figure 4.1 Position Map 1-Ergonomic design VS Adjustability

The consumers choose walkers that are adjustable, which is a crucial feature for a walker, according to position map 1's findings. The walkers in zones 1 and 2 are characterised by their straightforward designs, ease of use, and lack of features, which makes them less ergonomic than walkers in zones 3 and 4. For example, walkers in zones 3 and 4 have features designed with consideration for the human body, such as wheels with ergonomic handbrakes that could lessen the user's required strength because typically, people are the ones who are going to operate the walker, and they also have the sit-stand feature. Thus, walkers are zone 4 would be the target design for this project as it fulfils both adjustability and ergonomic criteria.

Table 4.4 Zone Description for Position Map 1

Zone	Description
1	Ergonomic design: No ergonomic design due to rough design which not considered the detail. Adjustability: Moderately adjustable due to the adjustable walker height.
2	Ergonomic design: Moderately ergonomic design due to size of walker which not really suit to user's body size. Adjustability: Moderately adjustable due to the adjustable walker height.
3	Ergonomic design: Ergonomic design perspective which walker provided features and able to fit user's body size. Adjustability: Walker with basic adjustable function.
4	Ergonomic design: Ergonomic design perspective which walker provided features and able to fit user's body size. Adjustability: High adjustable in height, angle of handgrip and etc of walker.

Figure 4.2's Position Map 2 depicts a comparison of the foldability and style of walkers. The walkers in Zone 1 are more streamlined in form, and most of them are classic or standard walkers, which feature a straightforward frame construction to support the user while walking. Walkers in zone 2 have a high degree of foldability, are frequently transportable, and are easy to use. In addition, zone 2 is home to walkers with both geometric and streamline designs, each of which has advantages of its own. The zone 3 sections follow,

displaying walkers with basic foldability and a focus on geometric modelling design. These walkers have more features than zone 1 walkers and greater structural variety. The walkers are less foldable, or perhaps not foldable at all, in zone 4, and the designs are more geometric. The potential challenge for walkers in this area is that they would inconvenience people who are unable to travel great distances. We may infer that users prefer folding walkers because many of the walkers are positioned in the foldable zone. Additionally, prior research has shown that consumers choose walkers 36 with an additional function, such as a storage bag, basket, or seat pad, which may be taken into consideration for this project.

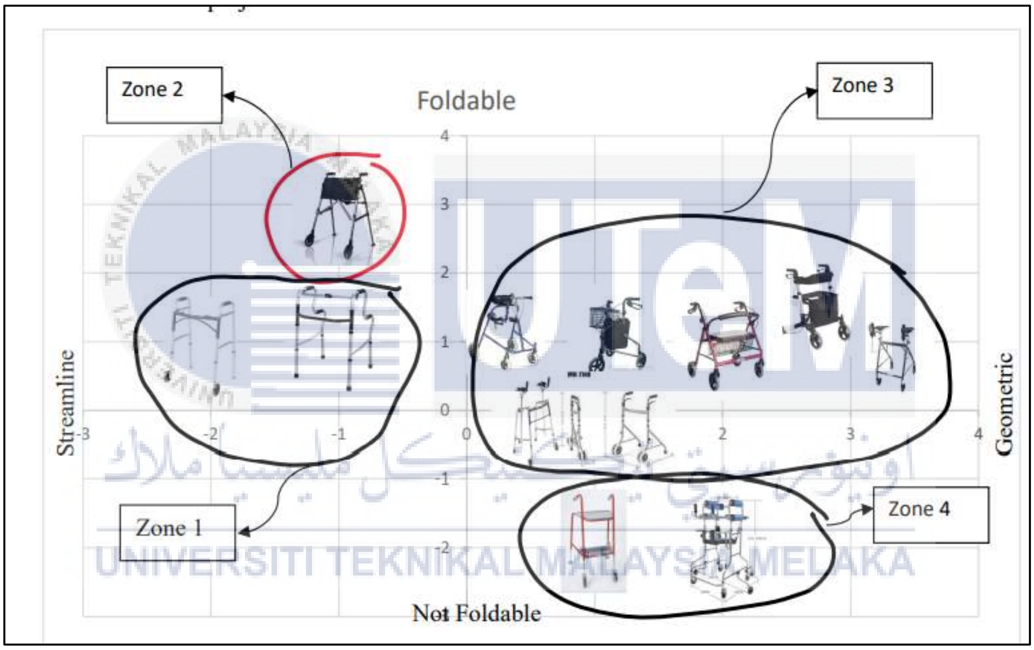


Figure 4.2 Position Map 2- Style VS Foldability

Table 4.5 Zone Description for Position Map 2

Zone	Description
1	Style: More toward streamline modelling which the appearance of walker is simplified. Foldability: Moderately foldable which walkers could be folded roughly
2	Style: In between geometric and streamlined modelling. Foldability: High foldability which walker could be collapse to a small size.
3	Style: More toward to geometric modelling which the design is multi-element. Foldability: Mostly foldable which walkers could fold and portable
4	Style: More toward to geometric modelling which the design is multi-element. Foldability: Less foldable which pattern of walker almost fixed

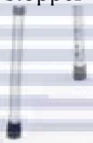
Therefore, based on the results of position map 1 in Figure 4.1, the design direction should aim towards zone 4. (Ergonomic design VS Adjustability). Because of user-centred design, a designer must take the user's perspective into account and improve the design quality. The current objects in zones 3 and 4 are more ergonomically sound and adaptable, as shown by position map 1 of the space. Since the walkers in both zones of the position map 2 in Figure 4.2 may be folded, this might make the walkers portable and take up less space. Therefore, zone 2 is planned to be the design direction. By using both styles while building the walker, the outer look of the device might be made to be more distinctive and appealing. The style in this area is somewhere between streamline and geometric design, both of which have their benefits.

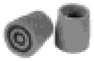
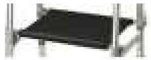
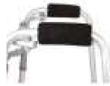
4.2.2 Morphological Chart

A morphological chart is a visual depiction of the desired product functionality that lets users to test different techniques and combinations to accomplish that functionality. Further knowledge into the nature of the existing walker's attributes is required to create an appropriate walker for this project. This might allow us to consciously choose a suitable choice for each feature. Table 4.6 displays several characteristics of the walker, including foldability, size, material, form, ergonomics, manufacturing procedure, etc.

Table 4.6 Morphological Chart

No	Main Feature	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
1.	**Foldable**	unfold able	Foldable	-	-	-	-	-
	Brake System	Not provide	Provide (have wheels)	-	-	-	-	-
2.	**Size(mm)**	L:440-470 W:550-580 H:780-980 	L:457-497 W:559-589 H:812-965 	L:559-589 W:685-715 H:838-868 	L:750-780 W:620-650 H:700-880 	L:610-640 W:610-640 H:812-965 	L:520-550 W:600-630 H:1050- 1210 	L&W: sameas normal H: adjustable
	Size -Fold Size (mm)	T: 90-100 	T:150-200 	T:200-250 	T:300-490 	T:100-150 	T:85-120 	T: Remainthe size
	Material-1 Main Frame	MagnesiumAlloy 	Aluminumalloy 	Carbonfiber 	Mild steel 	Stainlesssteel 	Titanium 	Titaniumalloy 
	Frame Shape And Size	Round	Ellipse	Square rounded corners	Rectangular	Semi-circle	Triangle	Cylindrical

3.	**Structure Style**	Triangleshape 	Rectangularshape 	Treadmillshape 	R-shape atthe side 	Curve shapein front 	Bicycle structure 	L-shape structure 
	Wheel	No Wheel 	Two wheels 	Three wheels 	Four wheels 	-	-	-
	Leg Typeand Material	Leg with non slip mat 	Leg with rubber stopper 	Leg withroller 	Leg with roller andbrake 	-	-	-
4.	**Ergonomic**	No Ergonomic commiserated	Armrest 	Hand-gripshape 	Adjustable height 	Add seat 	Hand-gripangle 	Backrest 

5.	**Material-2 Handle Or Other Part**	Rubber 	Plastic 	Nylon 	Foam 	Sponge 	Gel 	Oxford fabric 
6.	**High adjustable (mm)**	Not adjustable	Adjustable 770-880	Adjustable 780-980	Adjustable 800-950	Adjustable 813-965	Adjustable 970-1100	Adjustable 1060-1210
7.	**Weight- Bearing**							
8.	**Extra Function**	Seat 	Basket 	Platform support 	Bottle holder 	Storage 	Tray 	Cane holder 
9.	**Type of wheel**	5.5” rotary wheel 	7” Five star wheel 	6” cross country wheel 	6” five holes wheel 	6” Mercedes wheel 	Universal wheel 	Xingye wheel 

10.	**Fold Structure**	Square	Rectangular	Semi-circle	Oval	Triangle	Trapezoid	Cylindrical
11.	**Joint Technical**	Welding	Bending	Joining	Cutting	Milling	Forming	Assembling
12.	**Others**	Double cross bar	Can bar	Thick padded backrest	Leg rest	Front fronk	Light kit	

The most popular option for a walker's foldability is either foldable or unfold able, and it is obvious that the feature choice would be foldable given the project's goal. The size of the walker depends on its design. A standard walker is typically designed with dimensions of 440-470mm in length, 550-580mm in width, 812-965mm in height, and 90-100mm in folded thickness.

A portable travel walker would be roughly 457-497mm in length, 559-589mm in width, 812-965mm in height, and 150-200mm in folded thickness. A two-wheeled walker would be approximately 559-5. Option 4 has dimensions of between 750 and 780 mm in length, 620 to 650 mm in width, 700 to 880 mm in height, and 300 to 490 mm in folded thickness, making it less foldable than the previous alternatives. In addition, option 5's dimensions are as follows: length 610-640mm, width 620-650mm, height 812-965mm, and folded thickness 100-150mm; the armrest walker's dimensions are around 520-550mm, 600-630mm, 1050-1210mm, and 85-120mm, respectively. The materials available for the walker in the order hand are titanium, titanium alloy, carbon fibre, mild steel, stainless steel, and magnesium alloy.

The material that is most frequently utilised for the primary frame of walkers is aluminium alloy since it is lightweight and tough enough to handle weight bearing. Since magnesium alloy has a high strength and good impact resistance, it is also commonly utilised. If the frame is sturdy enough, the shape of the walker might be round, elliptical, square with rounded corners, rectangular, semi-circular, or even triangular.

Furthermore, there are several options for structure style which included triangle shape, rectangular shape, treadmill shape, R-shape at the side, curve shape in front, bicycle structure and L-shape structure. Each of the structure style has its advantage, such as triangle shape could reduce the space in front which reduce the obstacle, whereas bicycle structure usually designed with seat, reduce the tireless of user. The walker could be no wheel which known as pick up walker, two wheels, three wheels or four wheels depending on the need of the engineering requirement. In additional, the common leg type for walker that exist in the market is the leg with non-slip mat or rubber stopper, this kind of walker's leg could increase stability to ensure the safety. Additionally, legs with rollers and brakes are frequently built for use with walkers and four-wheel walkers to halt movement.

As the ergonomic viewpoint is crucial in the design of a walker, characteristics like adjustable height, a handgrip angle, and a backrest may be taken into account. Additionally, while handles with cushioned handgrips or foam grips are effective at giving the user a comfortable hand-touching experience. In addition, there are several handle patterns. Some of these patterns, such Straight grip, Classic finger grip, Rib-finned grip, Honeycomb grip, Flanged Tapered grip, Softtex hand grip, and Contour ribbed grip, were used as examples in figure 4.6.4.2.2. The Straight Grip is a well-liked grip with a straightforward and conventional design. It is built to firmly fit on a typical 1" bar, but the material's elasticity allows it to adapt to unique forms if the outside circle permits a secure fit. In contrast, the flanged tapered grip's sharp flange inhibits any forward movement and prevents the user's hand from slipping off the grip's end. The material for the main frame of the walker has already been discussed, but there are other components that also contain materials that need to be investigated and understood. These components include foam or gel for the handle, nylon for the bag, and plastic for other parts. Rubber is used as a stopper for the walker to increase stability. The sizes that were previously indicated are 770-880mm, 780-980mm, 800-950mm, 813-965mm, and 1060-1210mm, respectively. Armrest walkers had a higher height than other walkers, although these values are not exact.

A survey of walkers has shown that the walker typically supports between 90 and 220 kg of user weight. The size of the wheel could also be considered when designing the walker, as there are many options for wheel types. Wheels that are typically installed on walkers include rotary wheels, five-star wheels, cross country wheels, five-hole wheels, Mercedes wheels, Universal wheels, and Xingye wheels.

Some folded structures, such squares, rectangles, semicircles, ovals, triangles, and trapezoids, might be used as examples. The manufacturing process for the walker's frame joint might then include welding, bending, joining, cutting, milling, shaping, assembling, or combining many different techniques. As the walker is often produced using fabrication techniques, welding, cutting, and other processes are required. Last but not least, there were additional features on the walker available on the market, including a double cross bar or can bar that connected the walker's tubes, a thickly padded backrest, leg rest, and front flange for mounting the wheel.

4.3 Customer Needs

Customer needs are defined as the goals, needs, wishes and expectations of customers. To speed up parallel work, the information on customer needs used in the design phase should be precisely defined, with as little ambiguity and ambiguity as possible. Table below shows the need statement development based on the customer requirement.

Table 4.7 Need Statement

No.	Customer Need	Need Statement
1.	I want walker has wheels.	The walker has wheels at the front and can be moved freely.
2.	I want a lightweight walker.	The walker is lightweight as it is designed using lightweight material.
3.	I want walker has IoT development.	The walker support IoT development through coding development.
4.	I want walker can adjust the hight and width.	The height and width of the walker is adjustable as the structure is retractable.
5.	I want the walker easy to use.	The walker is user friendly.
6.	I want a walker foldable.	The walker is foldable.
7.	I want a walker easy to store.	The walker is easy to store.

8.	I want the walker that is long lasting.	The walker is long lasting as it is made of rust-resistance material.
9.	I want the walker that is safe to use.	The walker is safe to use as no sharp corner for the structure of the worker.
10.	I want the walker to be cheap and affordable.	The walker is affordable depends on the material and features.
11.	I want the attractive design for the walker.	The design of the walker is attractive.

The table below shows the importance weight of the customer requirement. With this information, the Quality Function Development (QFD) can be carried out.

Table 4.8 Importance Weight of Customer Requirements

No.	Customer Need	Need Statement	Label	Important Rate
1.	I want walker has wheels.	The walker has wheels at the front and can be moved freely.	User-friendly	5
2.	I want a lightweight walker.	The walker is lightweight as it is designed using lightweight material.	Lightweight	4
3.	I want walker has IoT development.	The walker support IoT development through coding development.	Feature	5
4.	I want walker can adjust the hight and width.	The height and width of the walker is adjustable as the structure is retractable.	Adjustability	4

5.	I want the walker easy to use.	The walker is user friendly.	User-friendly	5
6.	I want a walker foldable.	The walker is foldable.	Feature	5
7.	I want a walker easy to store.	The walker is easy to store.	User-friendly	5
8.	I want the walker that is long lasting.	The walker is long lasting as it is made of rust-resistance material.	Durability	4
9.	I want the walker that is safe to use.	The walker is safe to use as no sharp corner for the structure of the worker.	Safety	5
10.	I want the walker to be cheap and affordable.	The walker is affordable depends on the material and features.	Price	3
11.	I want the attractive design for the walker.	The design of the walker is attractive.	Aesthetic	2

4.4 Quality Function Development (QFD)

The Quality Function Development (QFD) is developed through House of Quality (HOQ). HOQ is the core of Quality Function Configuration (QFD). A quality house is a diagrammatic method for determining the relationship between customer needs and the performance of the corresponding product or service. Table above shows the HOQ where we insert the importance weight of the customers' requirement and product specification. By constructing HOQ method, the most critical feature or specification can be determined.

Table 4.9 House of Quality (HOQ)

		Engineering Characteristics										
Improvement Direction		↓	↑	↑	↓	↓	↑	↑	↑	↑	↑	↑
Units		kg	n/a	$	cm	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Customer Requirement	**Important Rating**	**Less than 10kg**	**High strength**	**Around RM201**	**L:750-800/W:620-651**	**Streamline design**	**Ergonomic structure**	**Armrest walker**	**Foldable body structural**	**Attractive design**	**Retractable body structure**	**Stable structure**
Feature	5				3			3	3		3	3
Adjustability	4										3	
User-friendly	5	1				2	1	2				
Lightweight	4	3										

Durability	4		3						3			
Safety	5						3					2
Aesthetic	2					2		1	1	3	2	1
Price	3		1	3	2							
Importance rating		17	15	9	21	14	20	27	29	6	31	27
Percent of importance %		7.87	6.94	4.17	9.72	6.48	9.26	12.50	13.43	2.78	14.35	12.50
Rank Order		6	7	9	4	8	5	3	2	10	1	3

Each customer requirement is rated based on priority. The customer requirements are then related to each correlated engineering characteristics where the highest value (3) shows strong relation. Importance rating is calculated by sum up all the multiplied of the importance rating with the number of relations. Through calculating the percent of important, the engineering characteristic which having the highest value of it is the most concern part that need to be focused on. As can be seen from the table above, the retractable body structure of the walker is the focus of the design, followed by fordable body structure, stable structure, etc.

4.5 Design Concept Development

Evaluation of a Concept Strategic planning must include product features. Comparing a product's or service's key characteristics is helpful for determining any gaps and gauging the competitive advantage. It aids in the conceptualization of the walker's design, which is important for its advancement. The alternative for choosing features that are available on the market now were displayed in a morphological chart in the section before this. In order to determine the attributes that would be most appropriate for the walker in this project, the product feature analysis, as indicated in Table 4.10, referenced the morphological chart.

Moreover, the walker's design is intended to have a rectangular shape since it is the most stable construction and can help prevent the issues that the responder mentioned during the interview, including falling off the walker and not being solid enough. The two-wheeled walker offered benefits such as not requiring significant weight bearing and maintaining balance without exerting much effort. Therefore, the goal of this project was to create a two-wheeled walker. Front wheels make up the walker's leg style. Additionally, the cushioned hand grip will be considered since it can make the walker feel more comfortable using it. The handle would be roughly be contour ribbed grip which could make the handle to be ergonomic.

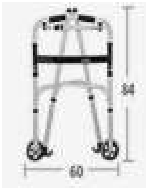
No.	Product Feature	Design direction	Analyzation
1.	**Foldability**	Foldable	Foldable walker to reduce it's size by making the height of walker shrinkable.
2.	**Size(mm)**	L:520-550 W:600-630 H:1050-1210 	Walker design would be armrest walker to solve the posture issue.
3.	**Size -Fold Size (mm)**	T:85-120 	Walker aimed to have a folded size of 85-120.
4.	**Structure Style**	Rectangular shape 	Walker structure would have the element of rectangular shape to increase stability.
5.	**Wheel**	Two wheels	Walker with 4 wheels to reduce the strength that needed from user.
6.	**Handle Type**	Padded handgrip 	The handle has padded hand- grip.
7.	**Handle shape**	Contour ribbed grip 	Curve surface of handle provide better hand touch and ergonomic.
8.	**Type of wheel**	Front Wheels (6 in) 	Big wheel (6 in) and the front to increase stability on uneven ground.
9.	**Fold Structure**	Square	Easy to be store

Table 4.10 Product Feature

4.6 Design Sketches

Three different walker design ideas have been produced. The Smart Walker, Motorised Walker, and Y-Walker are these three design ideas. Using the Pugh matrix, the walker's final concepts will be chosen.

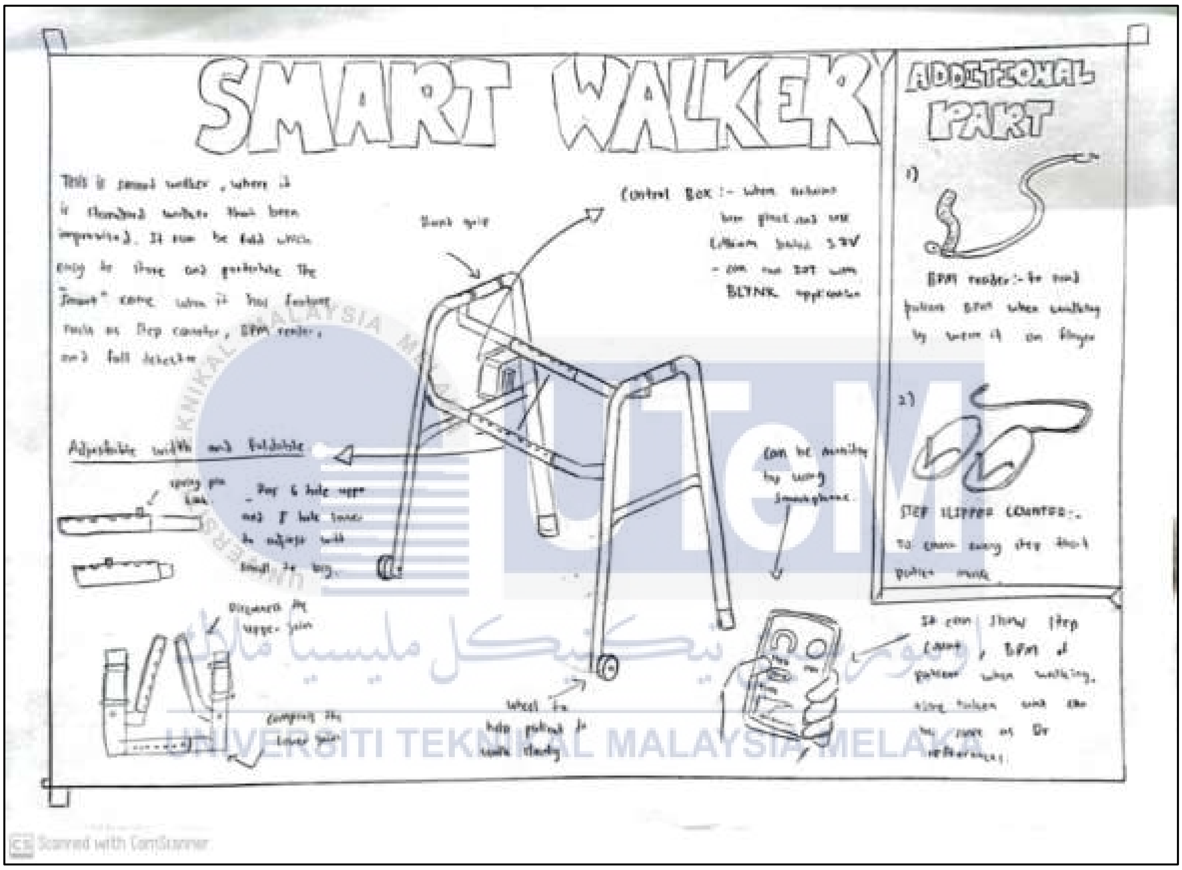


Figure 4.3 Design Concept 1

Design concept 1 as shown in Figure 4.3 Smart Walker's lightweight folding walkers have exceptional strength and durability while still being portable and simple to use. Smart walkers have a push-button mechanism for quick folding. The U-shaped frame of the Smart walker offers greater clearance, and its improved cross-frame design gives the user greater stability. A contoured hand grip and adjustable height settings make this front-wheeled walker both indoors and outdoors even more comfortable to use. It also has 5" wheels and newly designed rear glide caps for use on a variety of terrain. Besides, it's height and width are adjustable which suitable to difference height of user.

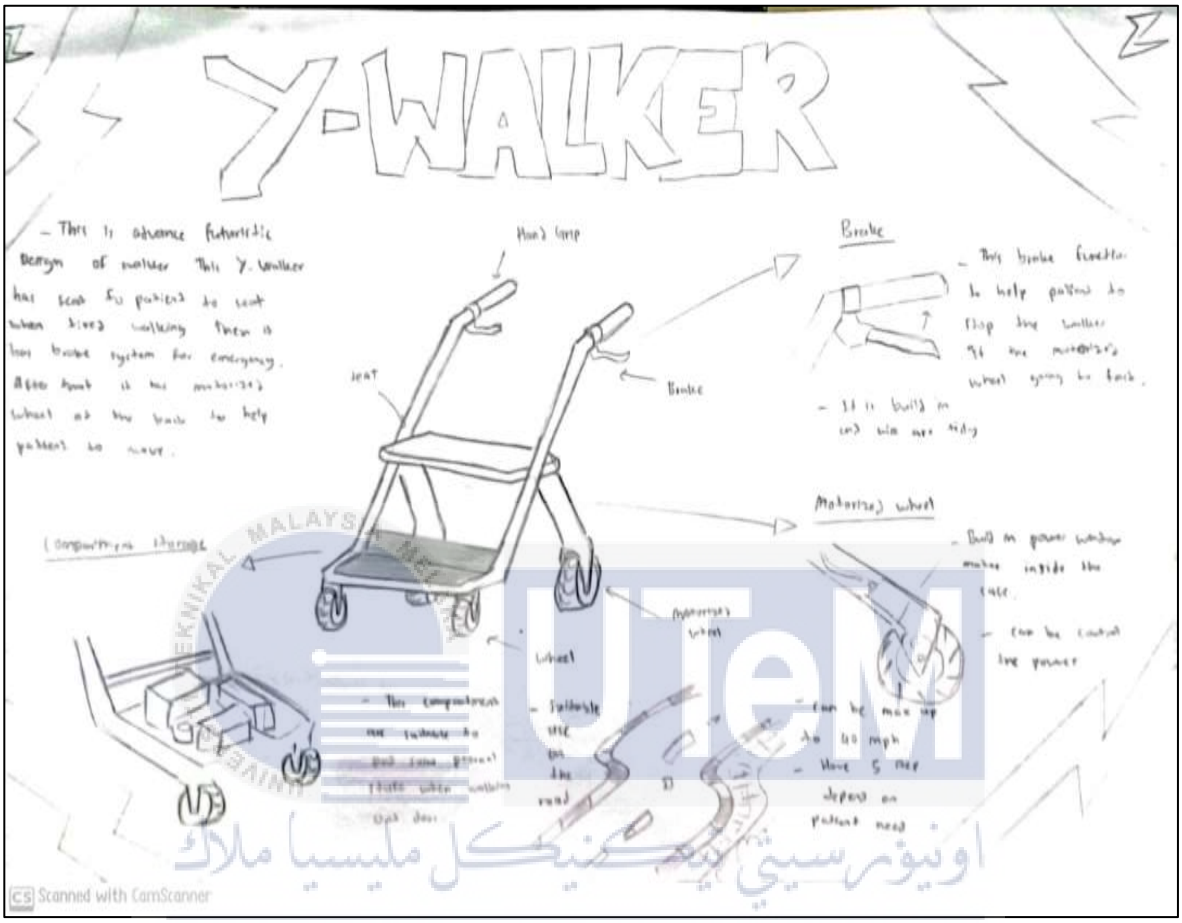


Figure 4.4 Design Concept 2

Design concept 2 as shown in Figure 4.4 has named as Motorised Walker. The Motorised Walker is an upright walker that great in assist user who needs extra support while walking. The unique point of this walker is that it had two ways to use it. User could use the walker either upright form by simply flip down both armrests and lock the wheels. Besides, it's height is adjustable which suitable to difference height of user. The adjustable spring pin lock work as height adjuster follow with 4 types of height. Motorised walker also works as feature to get the minimize size when to store BI walker. The circuit box, where all the electrical part are store.

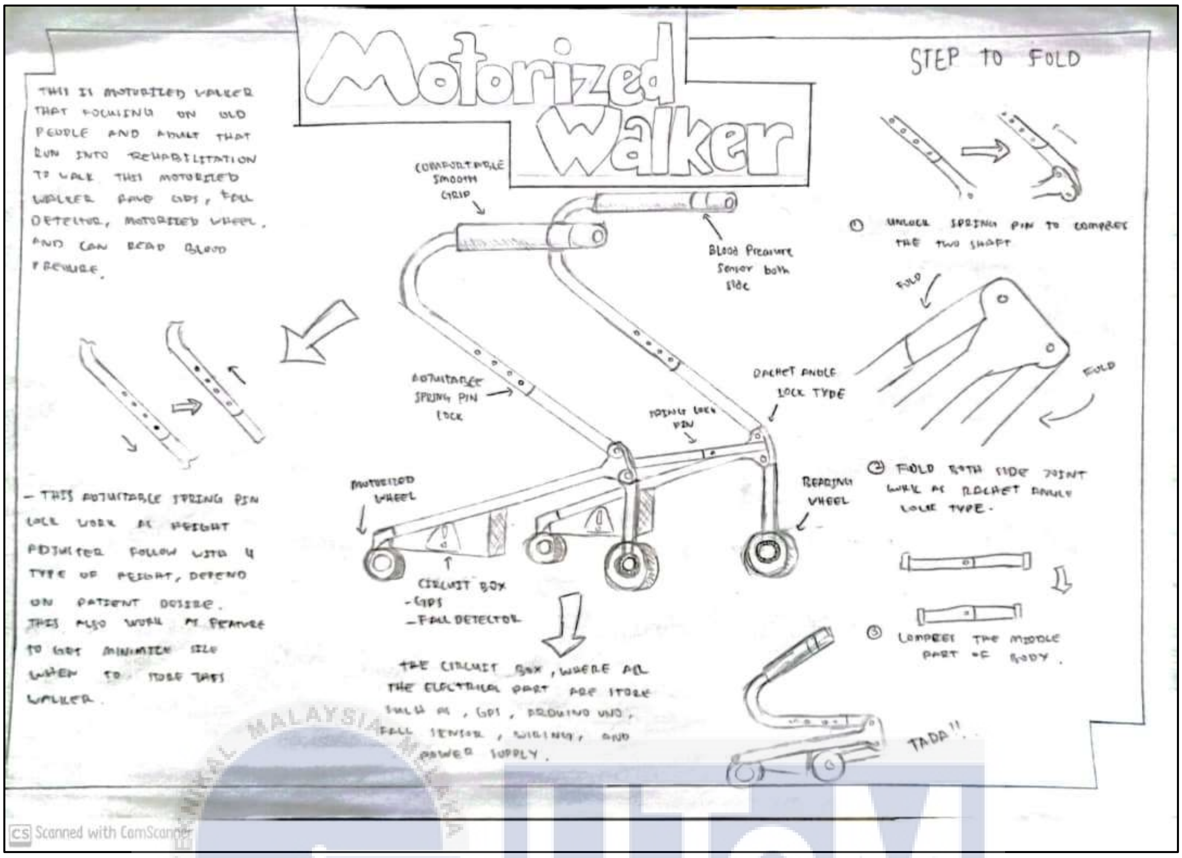


Figure 4.5 Design Concept 3

Design concept 3 as shown in Figure 4.5 has named as Y-Walker. This is advance futuristic design of walker. The front wheels are designed bigger to make it able to move on uneven ground. The unique point of this walker is that it had two ways to use it. User could use the walker either upright form by simply flip down both armrests and lock the wheels. The unique point of this walker is that it had two ways to use it. User could use the walker either upright form by simply flip down both armrests and lock the wheels.

4.7 Final Design Selection

There are many ways to approach making decisions in engineering, and one of the methods is the Pugh Metrix, which is a comparative analysis. Three design concepts the Smart walker, Motorised walker, and the Y-walker must be chosen, and the Pugh Matrix chart for walkers has been completed as shown in Table 4.11.

4.7.1 Introduction

A Pugh matrix is a selection tool that may be used to assist in making a decision between various concepts for a new procedure, good, or service. When compared to consumer requirements and the present baseline design, it was initially used to assess and choose between several product or process designs.

4.7.2 Method

Here is a step by step how to do the Pugh Matrix:

1) **Step 1**: To create a vertical list using the criteria.
2) **Step 2**: Choose the Datum
3) **Step 3**: List the various options in a horizontal list
4) **Step 4**: The Pugh Matrix being marked
5) **Step 5**: Adding Up the Scores

4.7.3 Result

Table 4.11 Pugh Matrix

Design concept / Selection criteria	Important Rate	Weight	Concept 1	Concept 2	Concept 3
Light weight	7	6.5	0	-	-
Price	6	5.7	0	0	+
Feature	5	7.2	0	-	-
Safety	2	14	0	-	-
User friendly	4	8.7	0	+	0
Aesthetic	9	6.0	0	0	+
Adjustable	1	17	0	0	0
Durability	3	11	0	+	0
SUM (+)			0	3	3
SUM (-)			0	-3	-3

Total			0	-1	-1

The Pugh Matrix can be classified in to three parts and the first part is Pair-Wise comparison. To evaluate the design concepts, the positive aspect of the selection criteria of the particular concept would be given a plus, for negative aspect of the concept would be given a minus and if the concept is neutral then it would have a zero. The key to the Pugh Matrix is that there will have a datum concept as an object raw to comparing against. For this case, Smart walker had become the datum concept, therefore it given zero aspect for all the selection criteria. For example, the size of Motorised walker is smaller than the Smart walker after being folded therefore it given a plus, whereas the Y-walker walker size is neutral therefore it given a zero.

In the other hand, the second part is about the evaluation base which is the selection criteria as mentioned. The selection criteria here are taken from the technical requirements of HOQ which based on the customer requirement that obtained from an interview session to justify the relationship of the design concept.

Lastly, the third part which also the critical point of the Pugh Matrix is that it is not about given a final product or idea directly but to cut down the set of large ideas and identify the reasonable ideas in the solution space for the design interaction. After evaluation for the design concept, the Motorised Walker has 2 plus, 3 minus and the total score is -1, whereas the Y-Walker has also 2 plus, 3 minus and total score is -1. Here we could summarize that the Smart Walker would be the best selection as it is more suitable as compare with the other two walkers.

4.8 Final Design

Design concept 1, which is the Smart walker, has been chosen as the final design in relation to the Pugh Matrix result in the preceding sub-topic. Smart walkers are foldable, making them portable and easy to store. Additionally, it is transportable because it can be expanded and folded. Figure 4.6 and 4.7 displays SolidWorks' s 3D modelling of the walker.

After the 3D modelling was complete, SolidWorks also created a 3D rendering of the walker to show how it would appear in daily life. Most of the material used to construct the walker's body is an aluminium alloy that is sufficiently durable to guarantee the user's safety. The walker is simple to use and understand thanks to its streamlined design.

Figure 4.6 3D Model of The Walker

Figure 4.7 Assembly of The Walker

Figure 4.8 3D Rendering of The Walker

Figure 4.9 3D Rendering of The Walker

4.9 Software Development

4.9.1 Integrate Coding

Coding is very important to integrate the sensor at the walker. This project used Arduino software to generate the coding. This walker used 3 sensors, buzzer, and switch. The sensor that used in the walker are ADXL 345 and MX 303102. ADXL 345 used to detect the fall detection while MX 303102 is used to read the blood pressure. Both sensors are included in the Arduino software. The figures show the coding of the walker.


```
#define BLYNK_TEMPLATE_ID           "TMPLnbLCFsQ8"
#define BLYNK_DEVICE_NAME           "Project Walker"
#define BLYNK_AUTH_TOKEN            "D4MfcMoQmvmvB5Gc29XTmBrkA1nde-DX"
```

Figure 4.10 Library/ Header of The Coding

Figure 4.8 show the library of the Arduino. All the coding will save at the library and the coding will read when turn on the switch.

```
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

#include <Wire.h>
#include "MAX30105.h"

#include "heartRate.h"
```

Figure 4.11 Coding for Wi-Fi setting

Figure 4.9 show the coding of the Wi-Fi. To use the walker, Wi-Fi is necessary as the software needs to operate with Wi-Fi connection.

```
void sendSensor()
{

 sensors_event_t event;
 accel.getEvent(&event);

 /* Display the results (acceleration is measured in m/s^2) */
 //Serial.print("X: "); Serial.print(event.acceleration.x); Serial.print(" ");
 //Serial.print("Y: "); Serial.print(event.acceleration.y); Serial.print(" ");
 //Serial.print("Z: "); Serial.print(event.acceleration.z); Serial.print(" ");Serial.println("m/s^2 ");

 if((event.acceleration.y < 4 && event.acceleration.z > 7) && (notiL == 0) )
 {
  digitalWrite(buzzer,HIGH);
  Blynk.virtualWrite(V2, HIGH);
  //Blynk.logEvent("gas_alert","Gas Leakage Detected");
  notiL = 1;
 }
 else if(event.acceleration.y < 4 && event.acceleration.z < -5 && notiL == 0)
 {
  digitalWrite(buzzer,HIGH);
  Blynk.virtualWrite(V2, HIGH);
  notiL = 1;
 }
```


Figure 4.12 Coding for Fall Detector Sensor

Figure 4.10 show the fall detector sensor. The sensor will read the coding when the walker fall.

```
BLYNK_WRITE(V3)
{
  steps = param.asInt();
  if(steps == 0)
  {
    valuestep = 0;
    Blynk.virtualWrite(V4,valuestep);
  }
  digitalWrite(buzzer,HIGH);
  delay(50);
  digitalWrite(buzzer,LOW);
}

void countstep()
{
  buttonState = digitalRead(buttonPin);
  //Blynk.virtualWrite(V7,stepValue);
  //Serial.println(stepValue);
  //Serial.println(stepValue);

   if(buttonState == LOW && lockstep == 0)
   {
      valuestep = valuestep + 1;
      lockstep = 1;
      //Serial.println(valuestep);
      Blynk.virtualWrite(V4,valuestep);
```

Figure 4.13 Coding for Step Value Sensor

Figure 4.11 show the coding for step value sensor. When the user walks, the software will read and count the step based on the coding created.

```
void displaySensorDetails(void)
{
  sensor_t sensor;
  accel.getSensor(&sensor);
  Serial.println("------------------------------------");
  Serial.print  ("Sensor:       "); Serial.println(sensor.name);
  Serial.print  ("Driver Ver:   "); Serial.println(sensor.version);
  Serial.print  ("Unique ID:    "); Serial.println(sensor.sensor_id);
  Serial.print  ("Max Value:    "); Serial.print(sensor.max_value); Serial.println(" m/s^2");
  Serial.print  ("Min Value:    "); Serial.print(sensor.min_value); Serial.println(" m/s^2");
  Serial.print  ("Resolution:   "); Serial.print(sensor.resolution); Serial.println(" m/s^2");
  Serial.println("------------------------------------");
  Serial.println("");
  delay(500);
}
```

Figure 4.14 Coding for Sensor Calling

Figure 4.12 show Arduino calls all the sensors when the user types in the time and the input will be read and sent to the application.

4.9.2 Blynk

After registering the Blynk account, enter the prepared project walker in the Blynk app where you are already logged in. Connect the WI-FI to the walker and turn on the switch at the walker and enter the relevant data, the time that need to be observed. After entering the data, press the start button on the Blynk app. The data entered will then appear in the Blynk application. The graph will then be displayed.

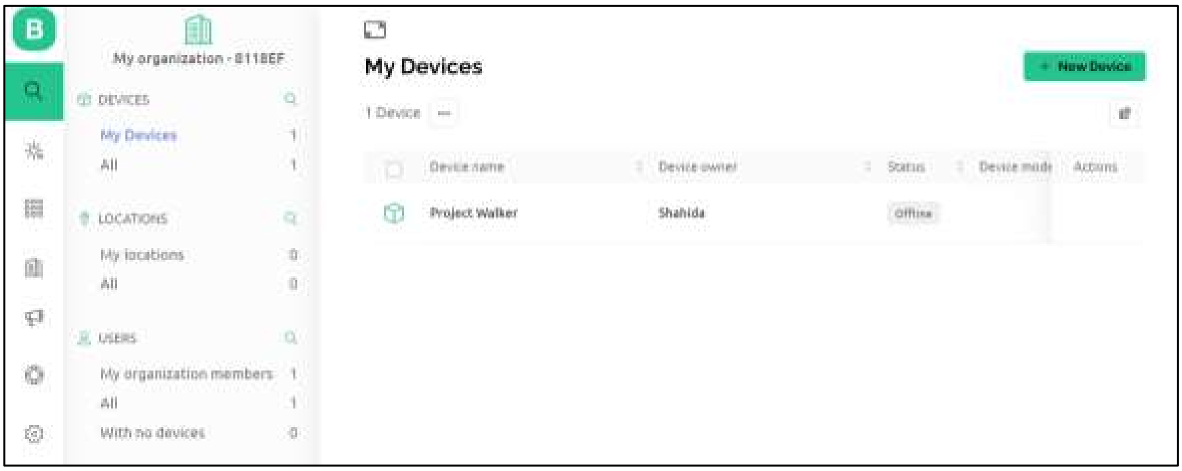


Figure 4.15 Device Connecting in Blynk

Figure 4.13 shows the interface of Blynk app when open at the laptop. When open the Wi-Fi the status will change to online.

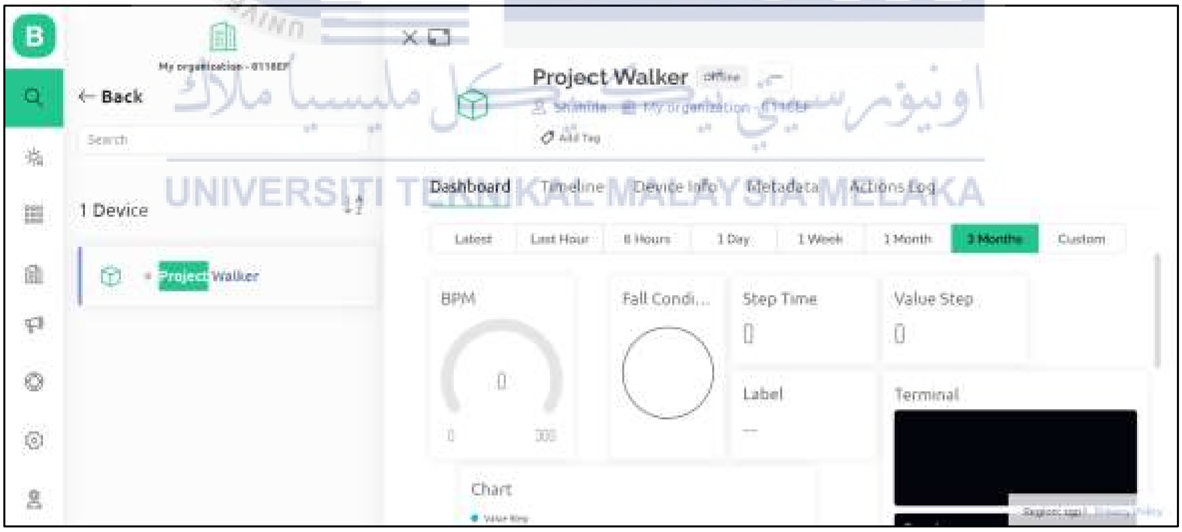


Figure 4.16 Dashboard for The Project Walker

Figure about shows the interface when we operate the project walker. It included heart rate bpm result, fall detector, step time and value step. The heart rate values and the number of steps is displayed after the set time value has been reached.

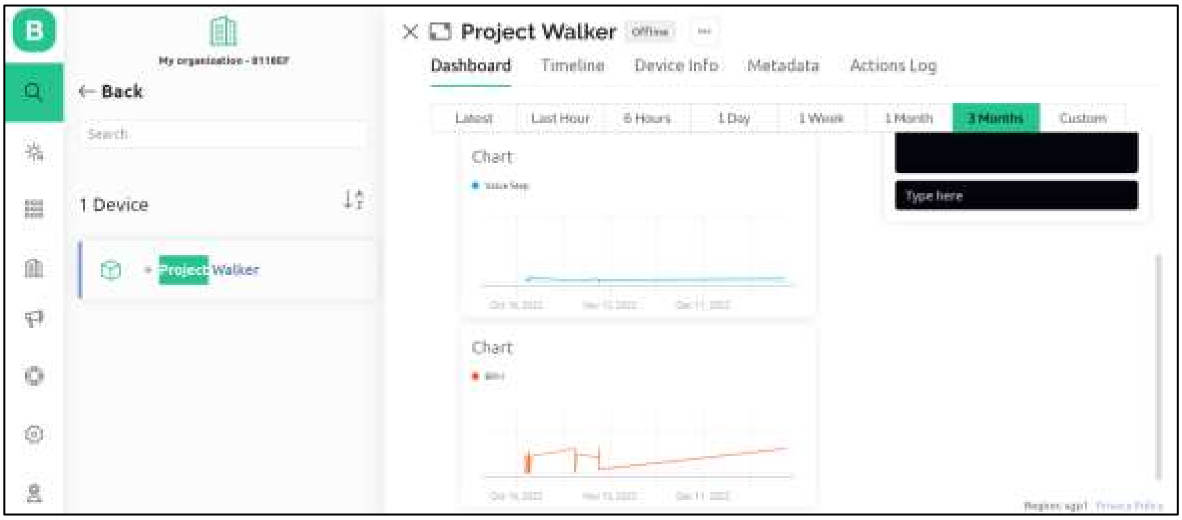


Figure 4.17 Data Collected Within Specific Time

Figure 4.15 illustrated the data collection that has been acquired throughout the use of the walker. All data will be saved and stored in the Blynk app.

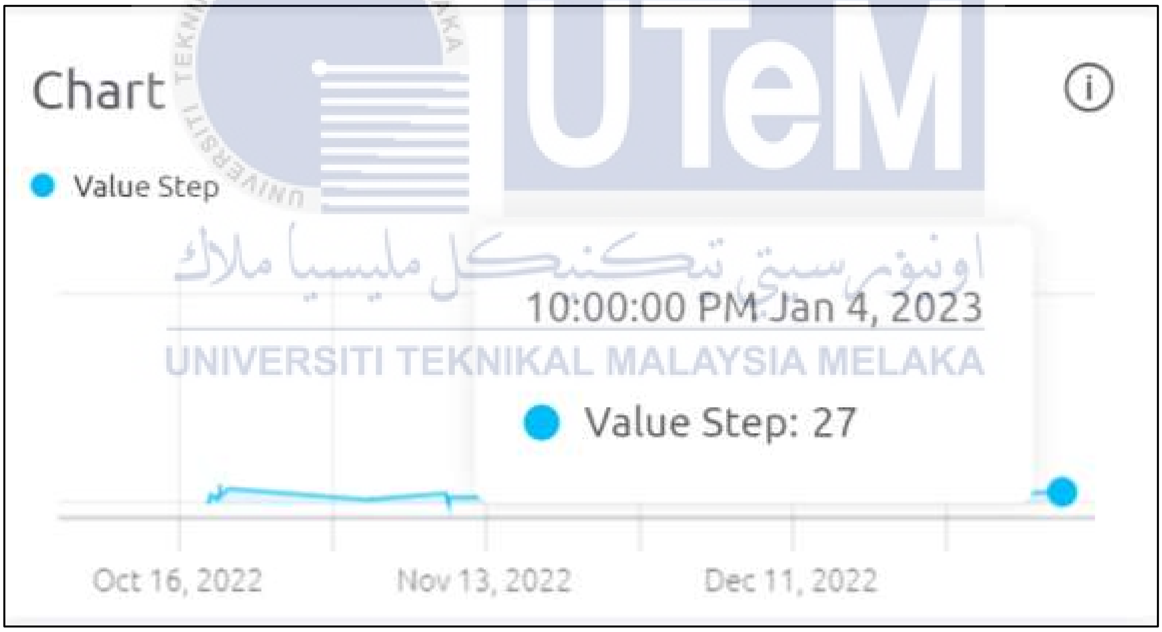


Figure 4.18 Graph Display on Blynk for Step Count

The image above shows the value step chart that has been recorded. Each data will show the time, date and value step.

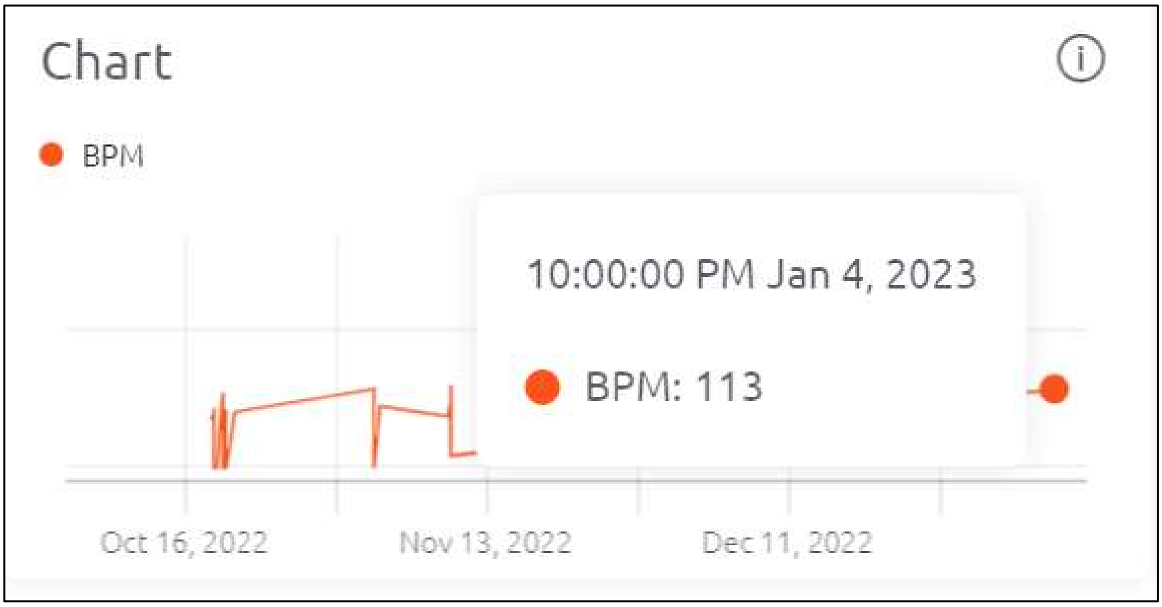


Figure 4.19 Graph Display on Blynk for Heart Rate

Figure 4.17 illustrates the heart rate value (bpm) chart. The chart consists of time, date, and the heart rate measurement.

4.9.3 Electric Development

4.9.3.1 Flow Chart

A flowchart is a sort of diagram that illustrates a process or activity. A diagrammatic description of an algorithm, or a step-by-step process for addressing a problem, is another definition of a flowchart. The flowchart displays the processes as various types of boxes and their sequence by joining the boxes together using arrows. A solution model to a specific problem is shown in this diagrammatic representation. In many different disciplines, flowcharts are used for process or programme analysis, design, documentation, or management.

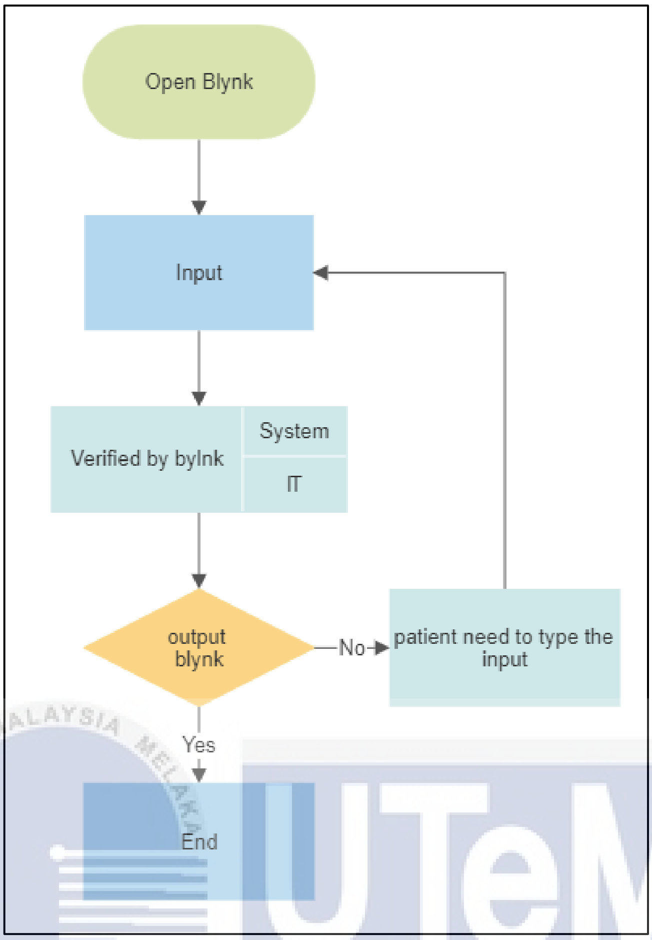


Figure 4.20 Flow Chart

Figure 4.18 show the flow chart of the application Blynk. The flow chart start from input and the end of the flow chart is result. After we key in the time that we need (input), the software will run the coding and process the input.

4.9.3.2 Schematic Diagram

The schematic, whether it be for a rigid board or flexible board, is a design that shows the logical connections between components on the board. In essence, it displays the electrical connections between the parts. Every link in the design, as shown by the picture, is listed in a netlist, a straightforward data structure that is part of a schematic. A schematic diagram is displayed in the picture below.

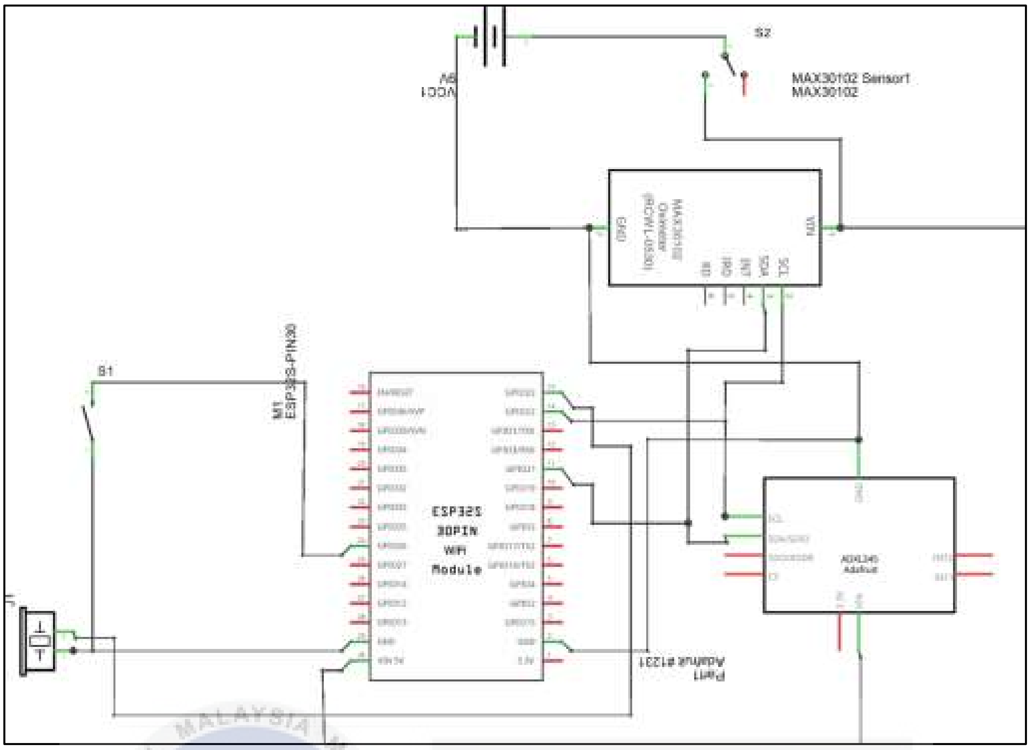


Figure 4.21 Schematic Diagram

Figure 4.19 show the schematic diagram of the walker. The walker used esp325, adxl345 and max30102. There is the sensor that attach at the walker. Max30102 is a heart rate sensor while adxl345 is a fall detector sensor.

4.9.3.3 Circuit Diagram

Circuit diagram used to understand how the components are connected, how the signal flows through the device, what voltages and waveforms should appear where, and what the component values are.

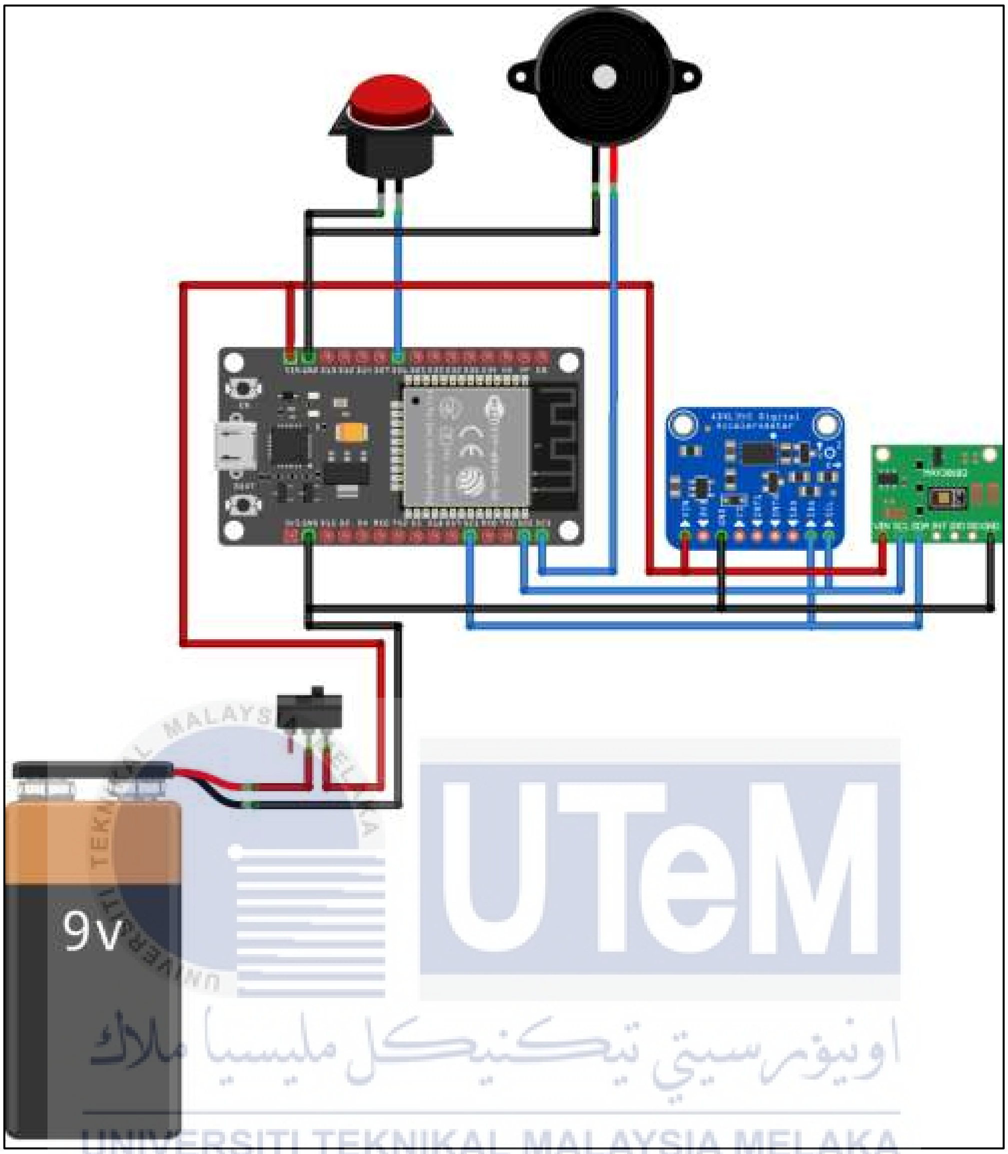


Figure 4.22 Circuit Diagram

Figure 4.20 show the circuit diagram of the walker. The circuit show the walker used 9v battery. Other than that, the figure also shows the Arduino, sensor, switch, and buzzer. This circuit also can be used for electric part installation session. All the part will show at the prototype making.

4.10 Prototype Development

The prototype making started from 15th October until 15th November which is one month period to complete the walker prototype. Starting from do the walker frame prototype and after done the walker frame continue do the electrical part. Figure below show the prototype making.

Figure 4.23 Walker frame

Figure 4.24 Walker frame

The figure above represents the prototyping process of the walker throughout the week. As the body structure of the walker was designed to be retractable and could be adjusted in width or height with a single pole, the first step that needed to be done was to distribute the 2 poles from the original structure.

Figure 4.25 Walker Frame

Figure 4.26 Walker Frame

After making the cut on the front of the rod, the next step is to make a hole in the cut rod that shown as figure above. The holes made are according to the scale that has been set. The hole is cut using a drill. After finishing the process of drilling holes, the next step is to install the rod and spray rod.

Figure 4.27 Arduino installation

Figure 4.28 Arduino installation

Figures 4.25 and 4.26 show the electrical part installation process. The electrical part installation session took almost 2 weeks to complete. This is because there was many troubleshooting done during the installation session.

Figure 4.29 Prototype Walker

Figure 4.30 Prototype Walker

This figure show the smart walker after finishing. Adjustable width can be used as the objective wants. The same goes for the sensors that have been installed. All three sensors run successfully.

4.11 Results and Analysis of comparison data

4.11.1 Objective

The analysis is carried out to compare the heart rate value and step count between walker and other devices or methods such as Pulse Oximeter and manual count. The main objective for this analysis is to measure the accuracy of data gathered by the walker.

4.11.2 Method

Five participants took part in this analysis. Once they used the walker, data such as heart rate and step count were collected. Alternative devices or methods are provided to interpret the same data for comparison. The average and percentage error for the data are calculated after collecting the data.

The average for the heart rate value and step count is calculated by using formula 1.1. where a_n is the value for the heart rate or step count for each participant, and n is the number of the participant.

$$Average, \bar{x} = \frac{\sum a_n}{n} \tag{4.1}$$

In the mathematical branch of numerical analysis, percentage error is the difference between an approximation and a true value. Percentage errors can occur due to the certain factors. In this project, the percentage error is used to compare result between walker and the other devices used. The formula is shown as below, where $\bar{x}_1$ is the average heart rate value or step count for walker and $\bar{x}_2$ is the average heart rate value or step count for other devices (pulse oximeter or manual count).

$$Percentage\ error, PE = \frac{\bar{x}_1 - \bar{x}_2}{\bar{x}_2} \times 100 \tag{4.2}$$

4.11.3 Result

The result shows the comparison of heart rate value and step count between walker and another device. 5 participants took part in this test. Body weight and height varied for all participants. The test was carried out five times by different people and at different times. The first test performed was for 10 seconds, then 40 seconds, 60 seconds, 60 seconds and finally once for 30 seconds. Each participant does one test with a pre-determined time. Each participant will perform 2 tests, a step count detector, and a heart rate measurement.

4.11.3.1 Result of comparison between BPM sensor and pulse oximeter

Table 4.12 Comparison of heart rate value and step count between walker and pulse oximeter

	Walker					Pulse Oximeter				
	10 sec	40 sec	60 sec	60 sec	30 sec	10 sec	40 sec	60 sec	60 sec	30 sec
Heart Rate (bpm)	113	100	90	75	110	97	99	95	71	97

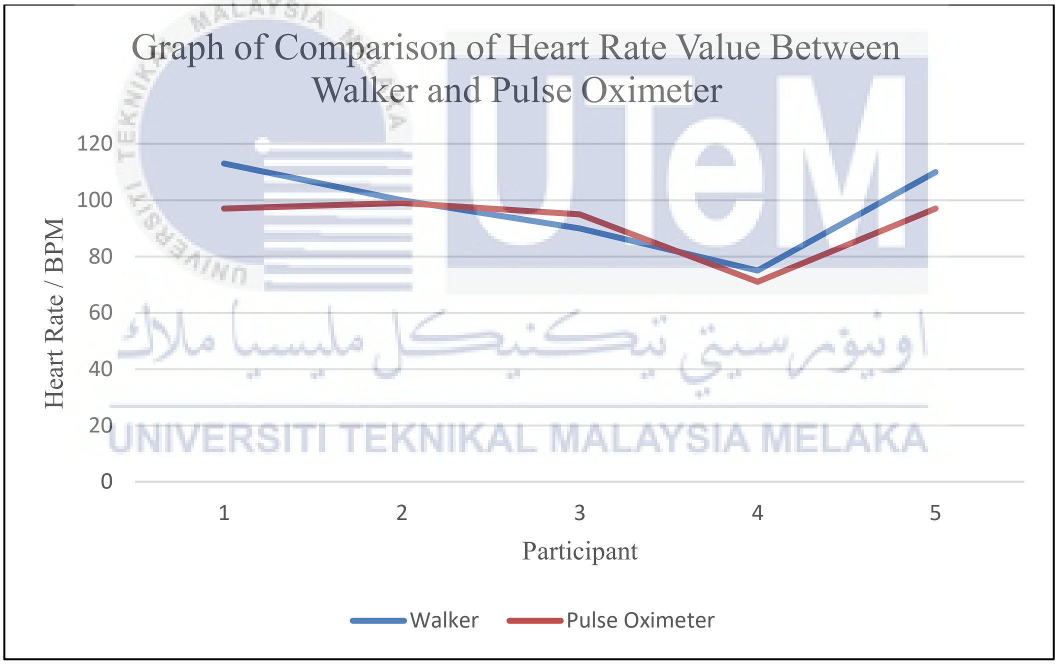


Figure 4.31 Graph of Comparison of Heart Rate Value Between Walker and Pulse Oximeter

All the data collected was illustrated in graphical form. The figure above shows the graph of comparison of heart rate between walker and pulse oximeter. The blue line is the walker, and the red line is the pulse oximeter. A comparison between the walker and the pulse oximeter revealed little difference between the values. This could be due to the incorrect position of the heart rate (walker) on the finger. It can be seen that the results for the second test participant were almost constant, which is 100bpm on the walker sensor and 99 bpm on the pulse oximeter.

After five tests had been conducted, an estimate of the percentage error between the walker and the pulse oximeter was taken to determine the error value of the heart rate recorded in the blood of the participant using the walker. The results of the percentage error calculations can be seen in the table below. The average of heart rate value is calculated to obtain the percentage error between the walker and pulse oximeter. The results are shown below:

Table 4.13 The average value and percentage error for the heart rate value

	Walker	Pulse Oximeter
Average	97.6	91.8
Percentage error (%)	6.32%	

The table shows the comparison of heart rate sensor between pulse oximeters. 5 participants took part in this test. Percent errors show how significant measurement mistakes are. A 5% mistake, for instance, shows that were quite near to the acceptable number, but a 60% error shows that were rather far from the real value. Percentage error of the walker and pulse oximeter is 6.32% that mean the result is acceptable as it is not more than 60%.

4.11.3.2 Result of comparison of step count sensor and manual count

Table 4.14 Comparison of heart rate value and step count between walker and manual count

	Walker					Manual Count				
	10 sec	40 sec	60 sec	60 sec	30 sec	10 sec	40 sec	60 sec	60 sec	30 sec
Step Count	11	27	20	30	10	11	27	20	30	10

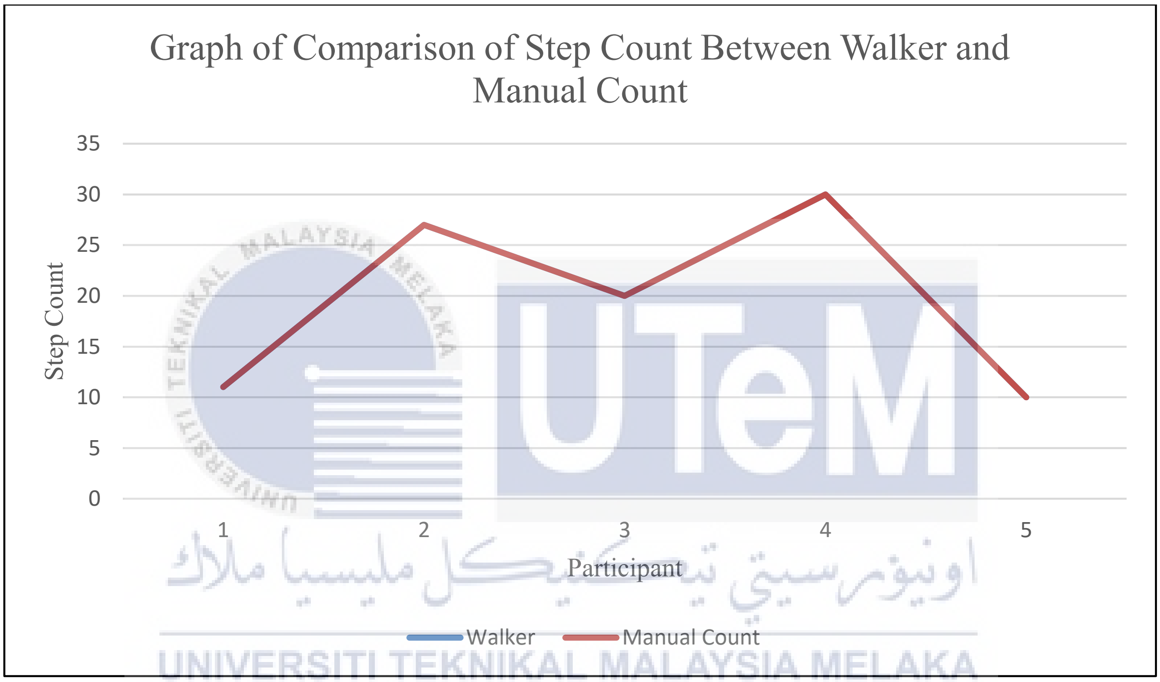


Figure 4.32 Graph of Comparison of Step Count Between Walker and Manual Count

The figure above shows the graph of comparison of step count between walker and manual count. The red line in the graph is the manual count and the blue colour is the step count sensor at the walker. The graph shows the manual count result is same with the sensor step count. The graph can't see the line of the walker because both results are same.

After five tests were carried out, an estimate of the percentage error between the step count sensor and the manual count was taken to determine the value of the recorded error.

The average of step count is calculated to obtain the percentage error between the walker and manual count. The results are shown below:

Table 4.15 The average value and percentage error for the step count

	Walker	Manual count
Average	19.6	19.6
Percentage error (%)	0	

The table shows the comparison of step count sensor between manual count sensors. 5 participants took part in this test. Percent errors show how significant measurement mistakes are. A 5% mistake, for instance, shows that were quite near to the acceptable number, but a 60% error shows that were rather far from the real value. They are 0% percentage error between step count sensor and manual count.

4.11.4 Discussion

According to Table 4.13, it indicated that the heart rate values between the walker and the pulse oximeter are slightly different from each other e even when different times are set. The low percentage error for heart rate value between walker and the pulse oximeter indicated that the high accuracy for the walker to gather the heart rate value.

It is clearly illustrated that there is not difference for the step count between walker and manual count in Table 4.15. By referring the result and the analysis data, it can be concluded that the walkers have a high degree of accuracy in collecting data for the step count.

4.12 Usability Test

4.12.1 Method

Usability test, or ease of use testing. It is a technique for assessing whether a product meets the needs of users through their use of it and plays an important part in the user experience as it reflects their real-life experiences. In other words, usability test is the process of allowing users to use a prototype or finished product, observing, recording, and analysing their behaviour and feelings to improve the product and make it more relevant to their habits.

System Usability Scale (SUS), developed by John Brooke (1986), is a standardised questionnaire as it is objective, universal, repeatable, and quantifiable. It widely used to quickly test product system interfaces, desktop applications and web interfaces.

Generally, SUS consists of 10 questions, using a five-point Likert scale. Questions 1, 3, 5, 7 and 9 are positive questions and questions 2, 4, 6, 8 and 10 are negative questions. Hence, the calculation will be different for the positive and negative directions. The questions are shown as below:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.

9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Once the participant has completed the series of tasks, the SUS can be quickly scored. It is then necessary to convert the scores for each question, with odd-numbered items being scored using "raw score - 1" and even-numbered items being scored using "5 - raw score". As it is a 5-point scale, the range of scores for each question is recorded as 0 to 4 (with a maximum of 40) and the range of SUS is 0 to 100, so the converted scores for all items need to be added together and finally multiplied by 2.5 to obtain the SUS score.

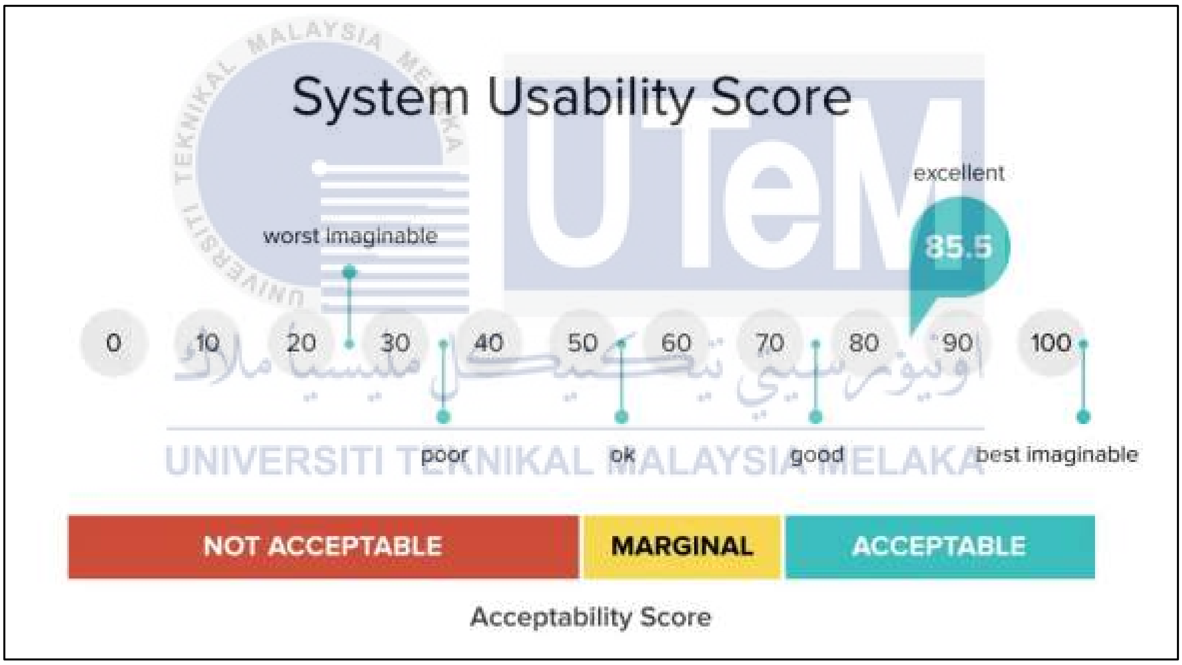


Figure 4.33 Level of SUS Score (Andrew Smyk, May 2020)

The figure above shows SUS score contains several levels: worst imaginable, poor, ok, good, excellent, and best imaginable.

4.12.2 Participant

5 participants were involved in the usability test, which is the same with the method for result and analysis of comparison data. Their personal information including names are kept confidential while their weights and heights were recorded as references. The following table shows their individual weights and heights.

Table 4.16 Participant's weights and heights

No.	Participant	Weights (kg)	Heights (cm)
1.	Participant 1	104	160
2.	Participant 2	45	153
3.	Participant 3	63	170
4.	Participant 4	74	165
5.	Participant 5	52	166

4.12.3 Procedure

The questionnaire is designed based on System Usability Scale (SUS). The questionnaire was divided into 3 sections which are usability, applicability, and effectiveness. The participants were allowed to use the walker before answering the questionnaire. This will give a better understanding of the full experience or needs of the participants during and after use.

Table 4.17 Explanation About the Usability, Applicability, and Effectiveness

Usability	Focus on whether the product meet the habits and needs of the participants. The questions are shown below: • The walker is easy to use. • The IOT for walker is complicated to operate. • The structure of walker is sturdy and strong enough to support maximum weight.
Applicability	Focus on the feature of the product such as analysing the suitability of the purpose method used for the product (walker). The questions are shown below: • The walker is not easy to store in any environment. • The walker is suitable for everyone to use it. For example, people of all ages. • The walker does not function well (in terms of collecting data). • The walker can be used in medical related areas (heart rate and step count).

Effectiveness	Focus on the performance for the feature of the product (walker) whether it meets the criteria of the participants. The questions are shown below: • The walker cannot be assembled quickly. • The walker can gather information quickly. • The walker cannot gather information accurately.

The questionnaire for the usability test was carried out via Google Form. It consists of 3 sections: Section A (Usability), Section B (Applicability) and Section C (Effectiveness). Each section contains 3 questions. Participants were encouraged to use the walker before answering the question given.

4.12.4 Result

4.12.4.1 Google Form Results

Google Form Results for Section A (Usability), Section B (Applicability) and Section C (Effectiveness) of the usability test are shown below:

Section A(Usability):

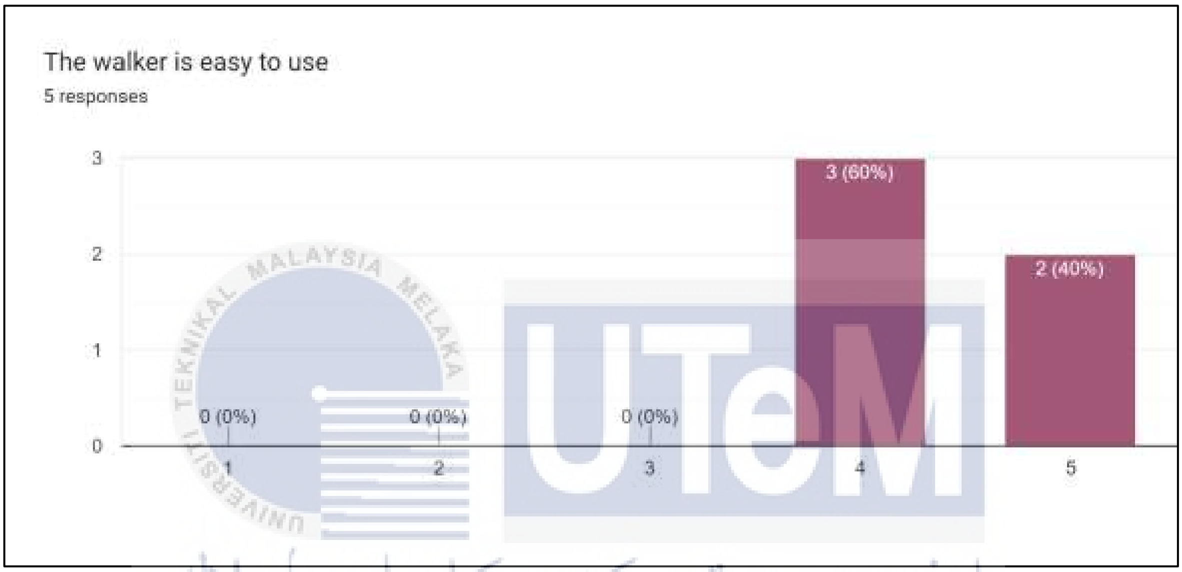


Figure 4.34 The Walker is Easy to Use

Based on the figure above, most of the participants (60%) agreed that the walker is easy to use while only 2 participants strongly agreed with this statement.

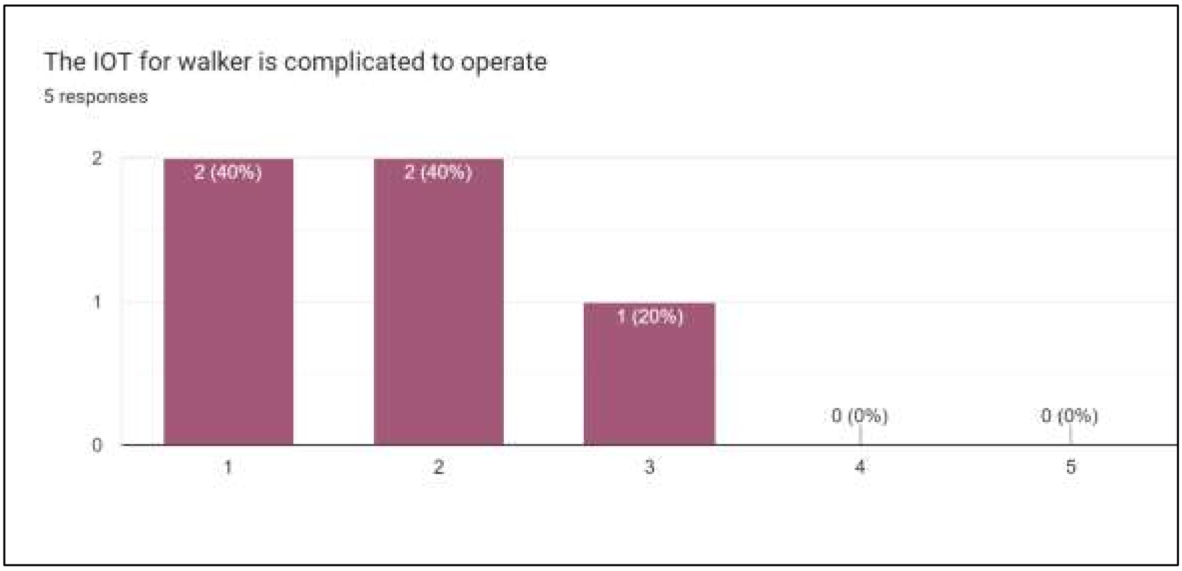


Figure 4.35 The IOT for the Walker is Complicated to Operate

40% of participant disagreed that the IOT for the walker is complicated to operate. Only 1 participant felt neutral about the IOT for the walker is complicated to operate.

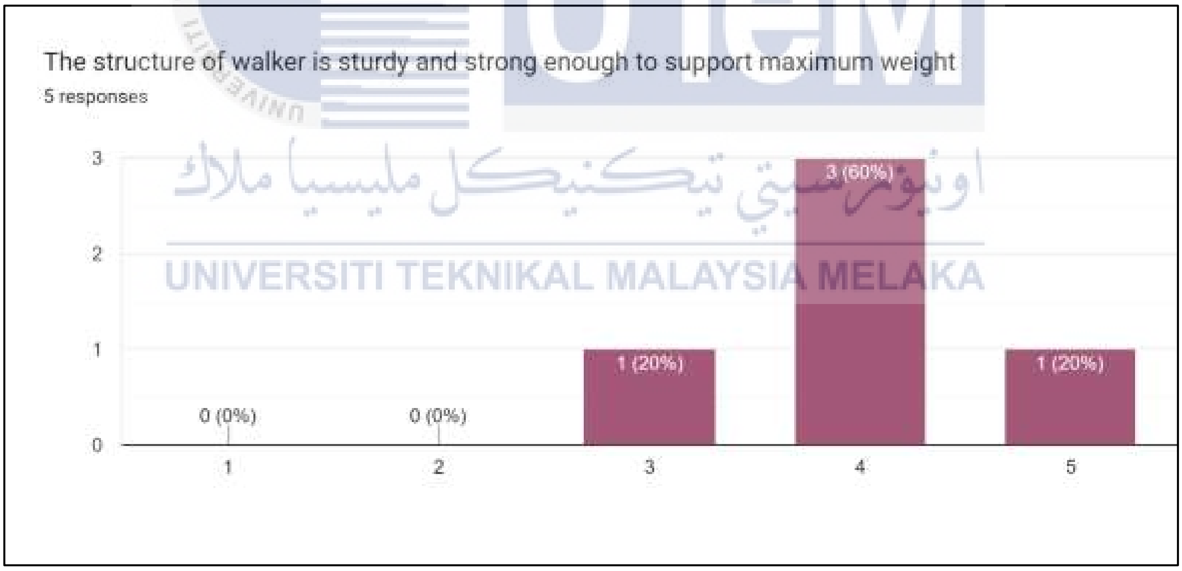


Figure 4.36 The Structure of Walker is Sturdy and Strong Enough to Support Maximum Weight

The figure found that 60% of participants agreed that the structure of the walker strong enough able to support maximum weight.

Section B (Applicability):

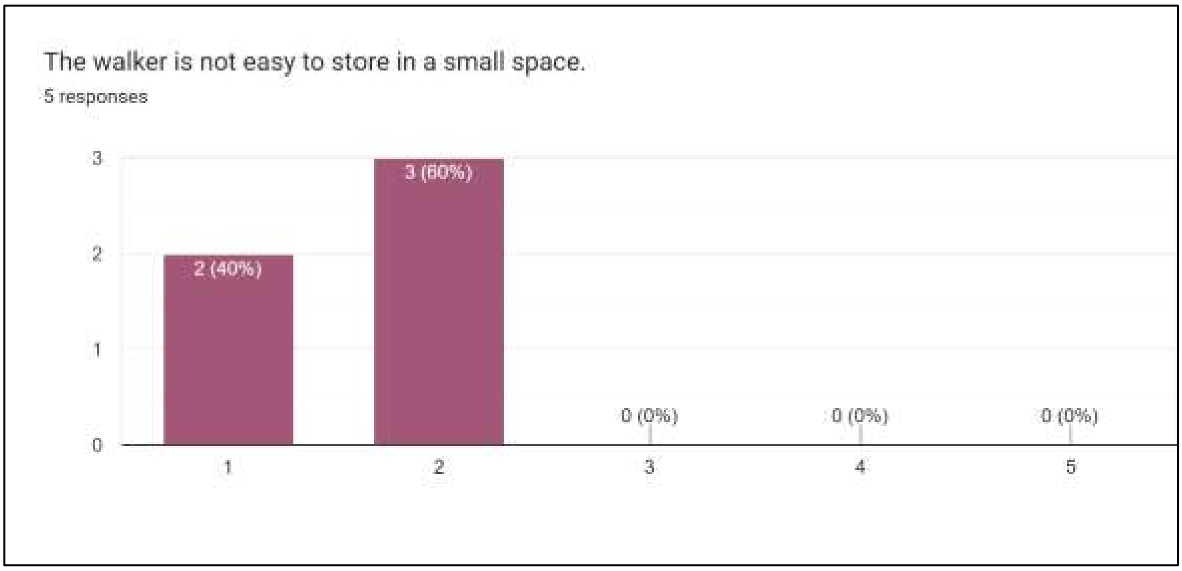


Figure 4.37 The Walker is Not Easy to Store in a Small Space

40% of the participants strongly disagreed that the walker is not easy to store in a small space. In overall, all the participants agreed about the walker is easy to store in any environment.

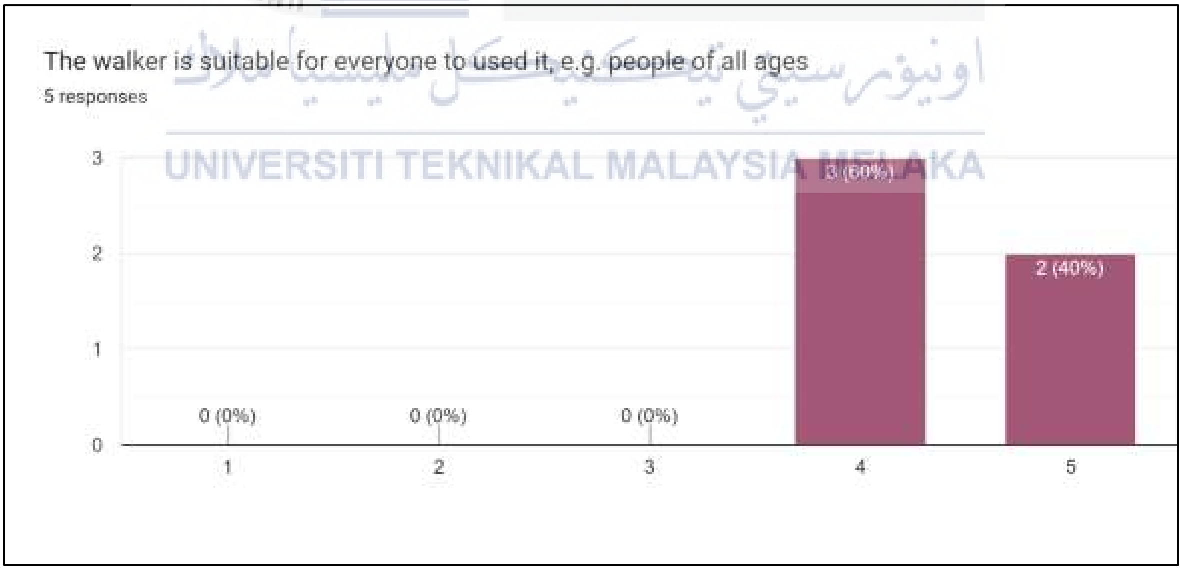


Figure 4.38 The Walker is Suitable for Everyone to Used It, e.g. People of All Ages

Based on Figure 4.26, it can be concluded that all participants agreed that the walker is suitable for everyone to use as 3 participants and 2 participants of the 5 participants are agreed and strongly agreed with it respectively.

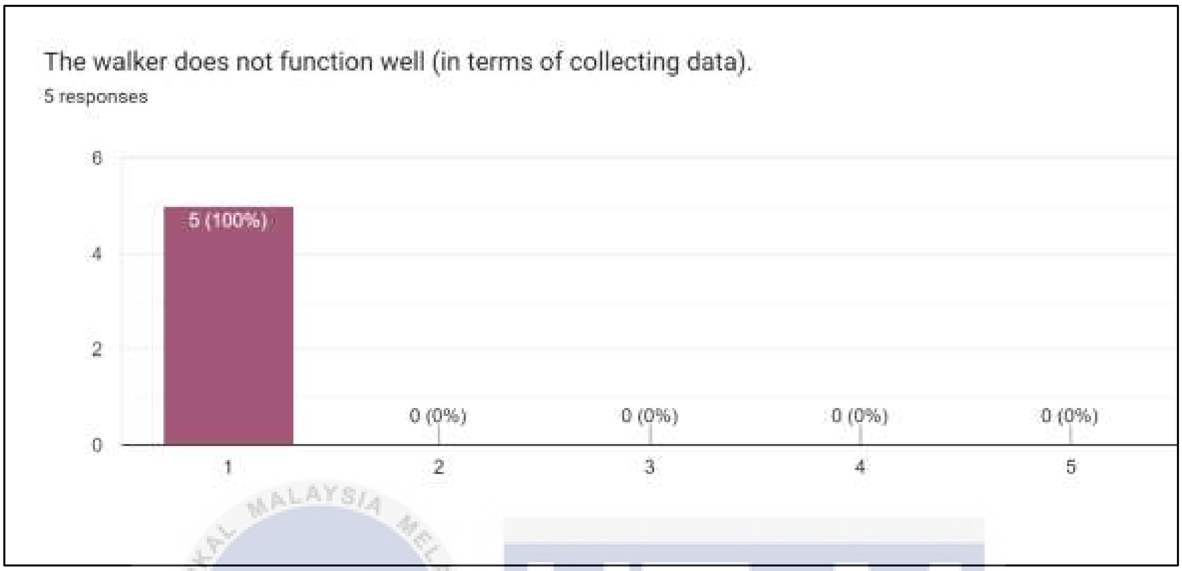


Figure 4.39 The walker does not function well (in terms of collecting data)

The figure above shows that all participants disagreed about the walker does not collect data well. This indicates that the walkers functioned well in collecting heart rate values and step counts.

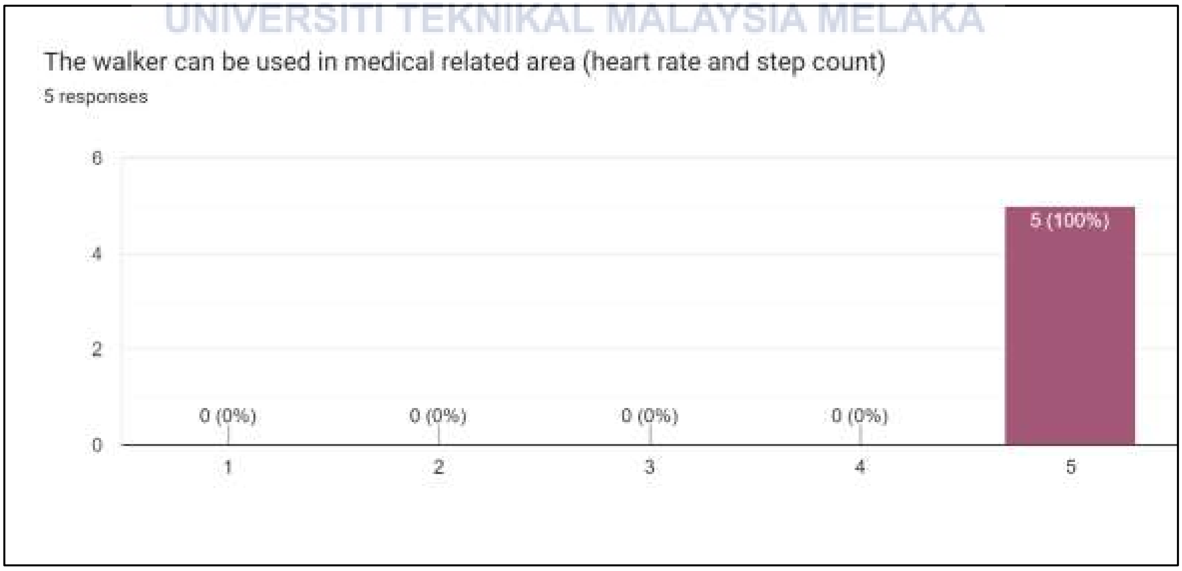


Figure 4.40 The Walker Can Be Used in Medical Related Area (Heart Rate and Step Count)

The figure above shows that all participants strongly agreed about the walker can be used in medical related area.

Section C (Effectiveness):

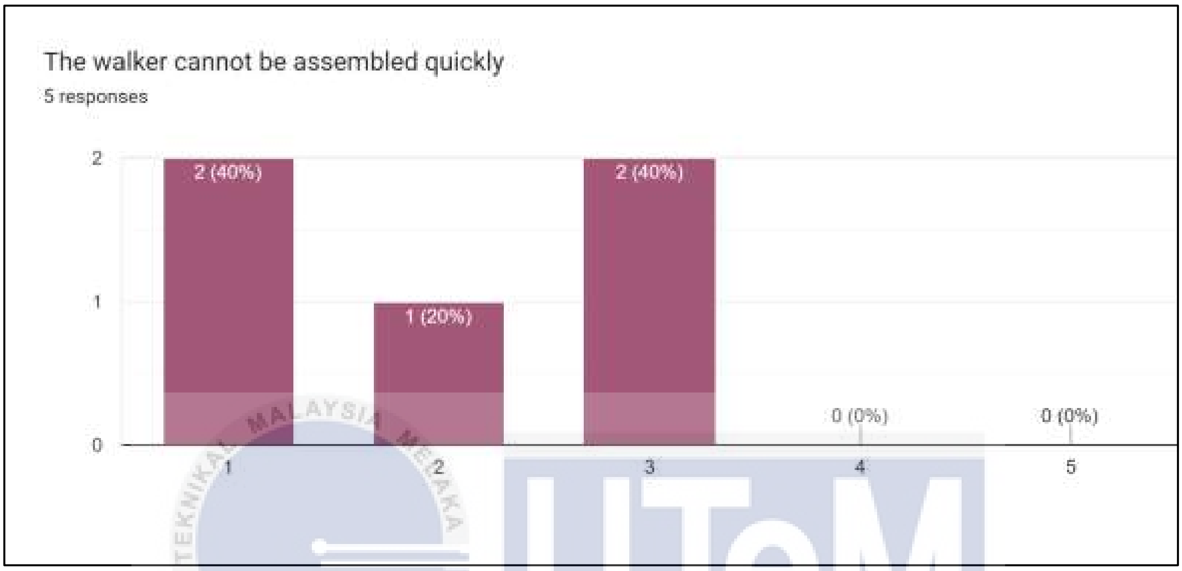


Figure 4.41 The Walker Cannot Be Assembled Quickly

Most participants disagreed that the walker cannot be assembled quickly while 2 participants felt natural about the statement.

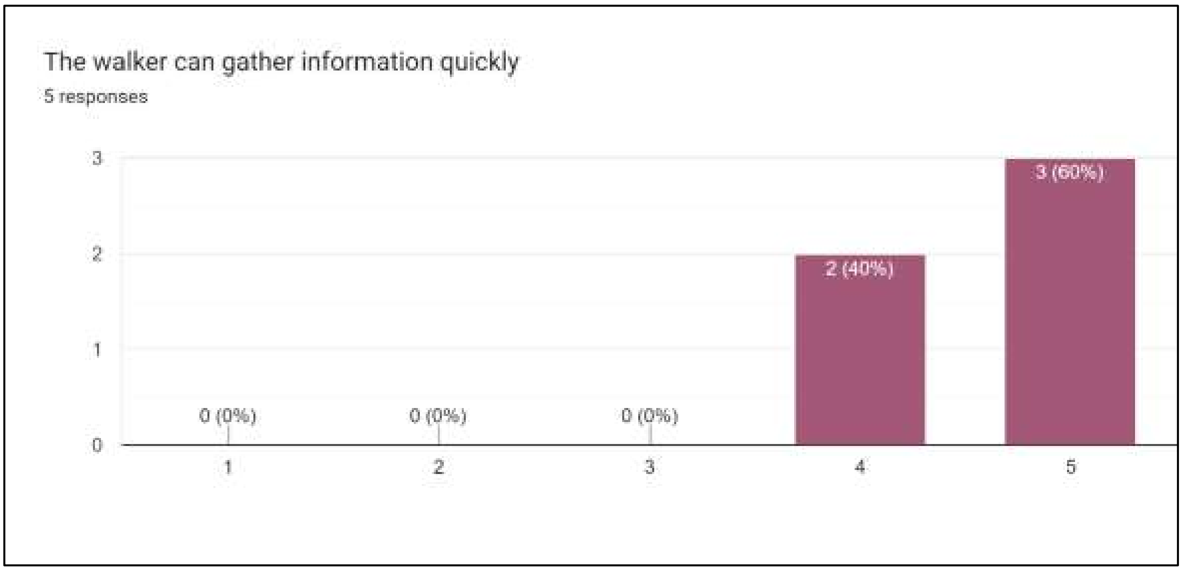


Figure 4.42 The Walker Can Gather Information Quickly

Based on Figure 4.40, it can be concluded that all participants agreed that the walker can gather information quickly as 2 participants and 3 participants of the 5 participants are agreed and strongly agreed with it respectively.

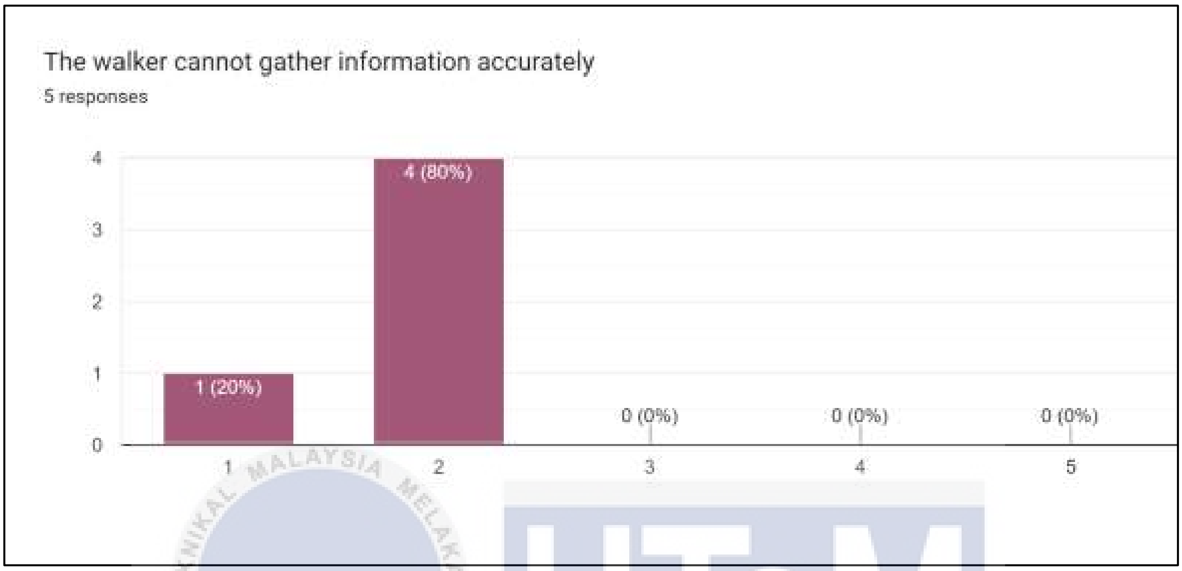


Figure 4.43 The Walker Cannot Gather Information Accurately

From the figure above, it indicated that all participants disagreed that the walker cannot gather information accurately as 4 participants and 1 participants of the 5 participants are disagreed and strongly disagreed with it respectively.

4.12.4.2 Usability Test Result

The score for each question was calculated. the raw score for System Usability Scale (SUS) was the sum of the scores for each question and the final score for SUS was multiplied by 2.5. The SUS final score represents the total score out of 100. From the table below, the average of the SUS score for the usability test (walker) is 85.5 out of 100.

Table 4.18 SUS Score

Participant	Question									SUS Raw Score	SUS Final Score
	1	2	3	4	5	6	7	8	9	10		
1	3	3	3	4	3	4	4	3	3	3	33	82.5
2	3	3	2	3	3	4	4	2	4	3	31	77.5
3	3	2	3	3	3	4	4	4	3	4	33	82.5
4	4	4	4	3	4	4	4	4	4	3	38	95
5	4	4	3	4	4	4	4	2	4	3	36	90
Average												85.5

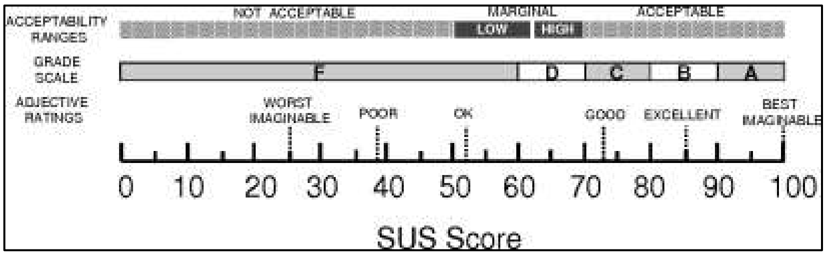


Figure 4.44 SUS Score scale

Based on the average of the sus score, can conclude that the result is acceptable which is 85.5%. It's at the excellent scale that can see at the figure 4.40.

4.13 Summary

In short, this chapter shows the accuracy of the walker to collect data by comparing the heart rate value and step count between the walker and other alternative device or method (pulse oximeter and manual step). It also shows how to interpret result for usability test of the walker through System Usability Scale (SUS).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The walker for IOT device monitoring analysis using Blynk application is successfully designed and prototyped. The coding for the Wi-Fi setting and fall detector is successfully generated by using Arduino software. Through Blynk software, the heart rate and step count of the walker could be collected once the participant had used the walker. The performance of the walker has been approved based on the following criteria:

1. High accuracy for the walker to collect data.

The small percentage error value (6.32% for heart rate and 0% for step count) between the walker and the other alternative device or method (pulse oximeter and manual step count) indicated that the walker collected data such as heart rate and step count accurately.

2. High usability satisfaction.

The result of usability test by using System Usability Score (SUS) design shows that the participants are satisfied after using the walker as it gets 85.5 out of 100 for SUS score which achieving the excellent level.

5.2 Scope and limitation

It is acknowledged that the research undertaken with numerous attempts and investigations to obtain satisfactory results. However, it is not denied that this project still has some limitations that need to be considered. The walker is designed to be used by people who are inconvenienced, like the elderly, and for people who are receiving rehabilitation. Due to some certain factors, some features could not be included in the project. The limitations are shown as below:

1. Insufficient equipment such as fall detector to collect or interpret the data or analysis.

Falls are a terrible situation for specific people, especially for older people. Fall detection device can prevent the worst from happening. However, it was not included in this project as no suitable relevant equipment was identified which causes the analysis process cannot be carried out successfully.

2. Find other available software to replace paid software (Blynk)

Blynk is an Internet of Things (IoT) service designed to make remote control and reading sensor data from devices as fast and easy as possible. However, due to the budget constraints, alternative software must be considered or other method to access Blynk.

5.3 Recommendations

Although the objectives of this project have been successfully achieved, some recommendations can be considered to improve the design as well as the feature of the walker. The suggestions are shown below:

1. Improving the aesthetic design of the walker

The performance of the features for the walker is extremely important, as is the appearance. A good aesthetic attracts the attention of the user which enhances their interest in the product (walker). Therefore, aesthetic style of the walker needs to be redesigned to replace the existing design.

2. Increasing the number of participants

The number of participants can be increased from the current 5 to 50 people of all ages and professions or occupations. This would allow for more accurate data to be obtained would give a true and full understanding of the needs of the users.

5.4 Project Potential

Based on this project, there are a number of potentials that will give advantages for both students and organisations that can be highlighted. The following are some potentials for this project:

1. Has potential to enter final year project exhibition.
2. Has the potential to develop into a real product and real use in a smart walker.
3. Can be patterned to prevent copyright and abuse of the design
4. When develop the project, it has market value with the right target market consumer.

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APPENDICES

APPENDIX A : Gantt Chart

No.	Project Activity	Expected / Actual	WEEK													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PSM 2 briefing	Expected														
		Actual														
2	Research for information	Expected														
		Actual														
3	Information organization	Expected														
		Actual														
4	Interview	Expected														
		Actual														
5	Generate Concept and Concept Selection	Expected														
		Actual														
6	Final Specification	Expected														
		Actual														
8	3D design, drawing, and assembly	Expected														
		Actual														
9	Prototype Making	Expected														
		Actual														
10	Data Comparison for better assembly time	Expected														
		Actual														
11	Chapter 4: Result and Discussion	Expected														
		Actual														
12	Chapter 5: Conclusion	Expected														
		Actual														
13	Report Draft Checking and meet with Supervisor	Expected														
		Actual														
15	Turnit- it Result	Expected														
		Actual														
16	Logbook, Excucative Summary, and Report Submission (PSM2)	Expected														
		Actual														
17	Poster Submission (PSM2)	Expected														
		Actual														
18	Presentation (PSM2)	Expected														
		Actual														

APPENDIX B : The Figure of The Interview Session

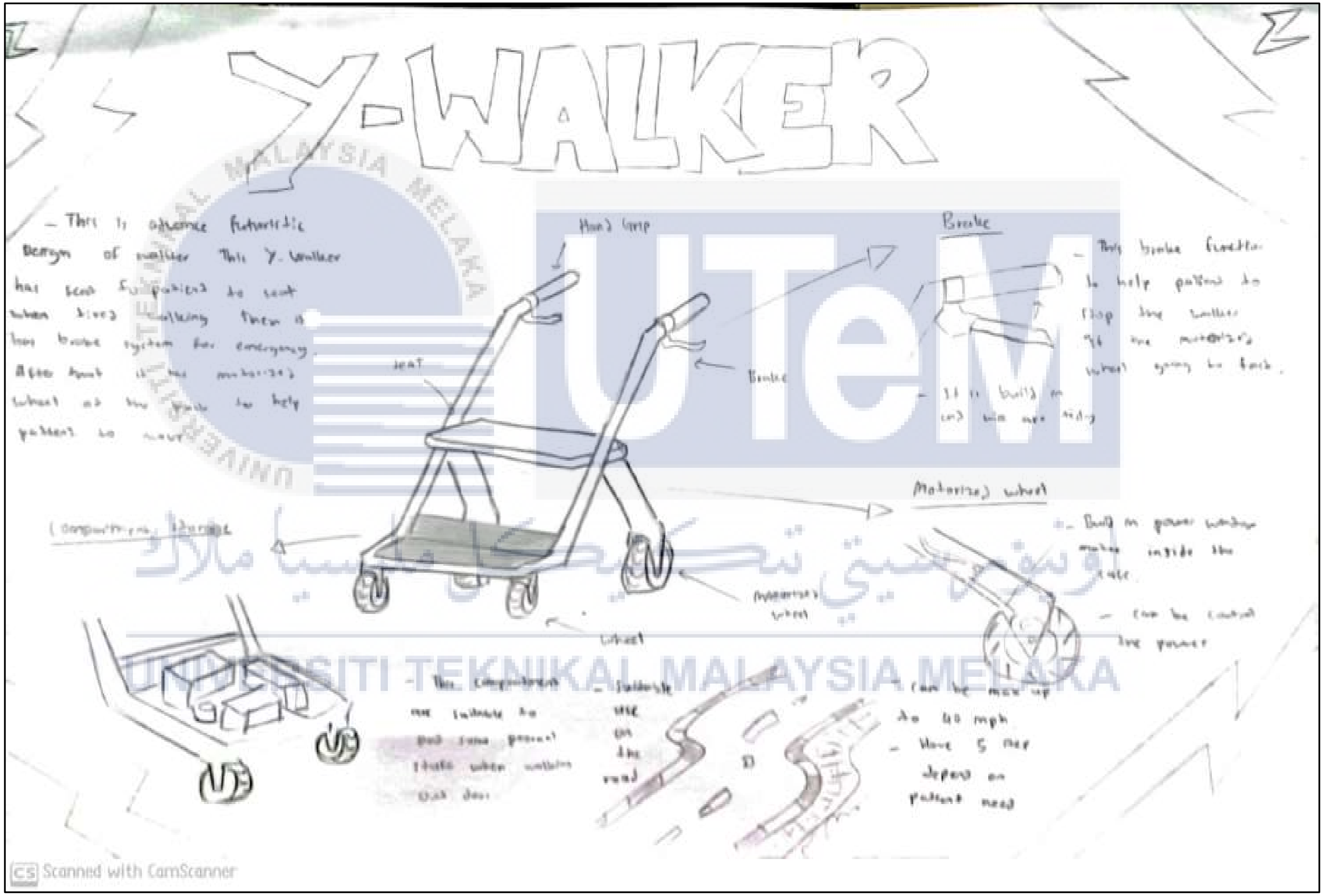
ELAMAT DATANG

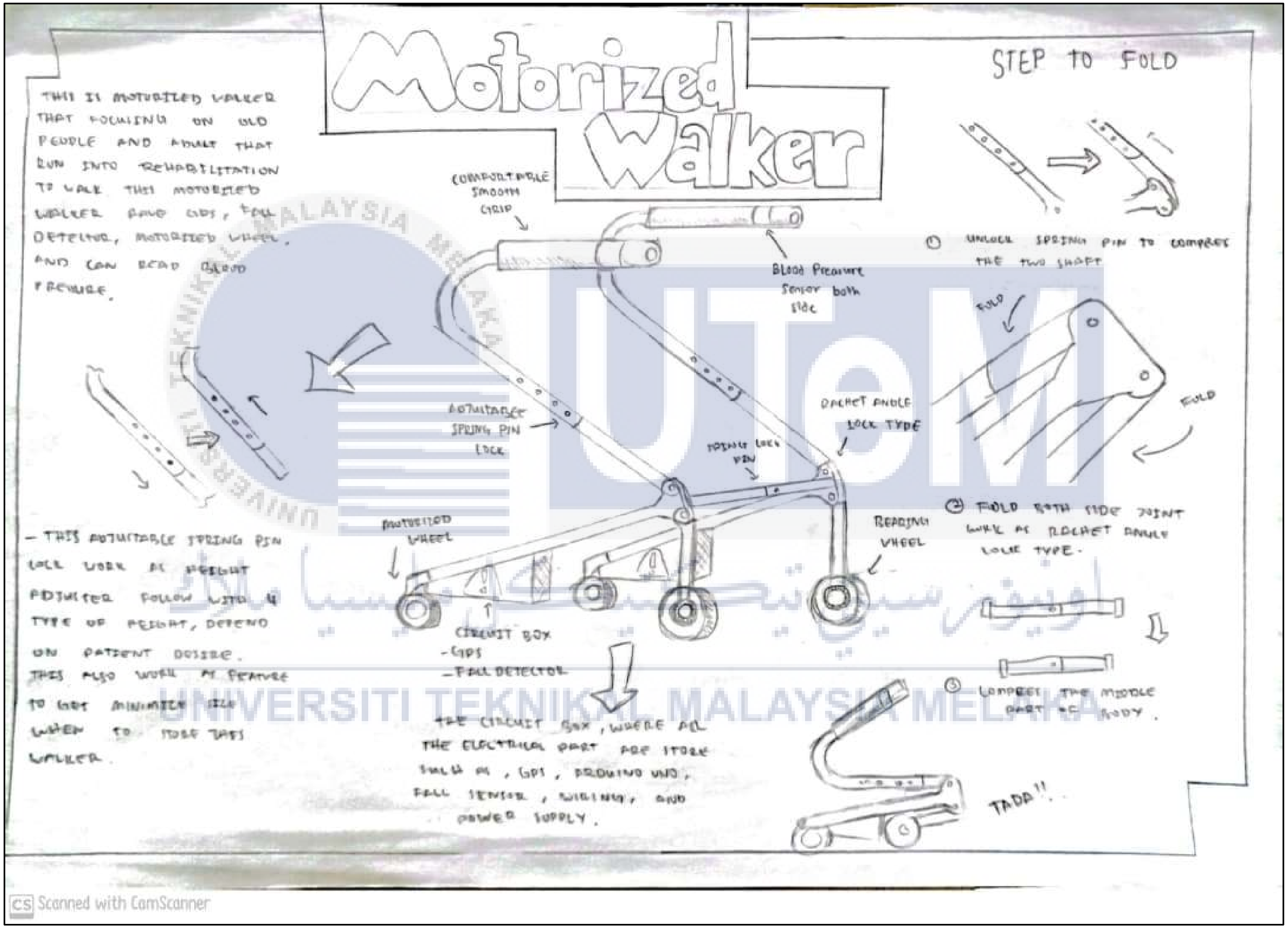

PERKESO
PUSAT REHABILITASI
PERKESO
TUN ABDUL RAZAK


Shahrul Akmal
You

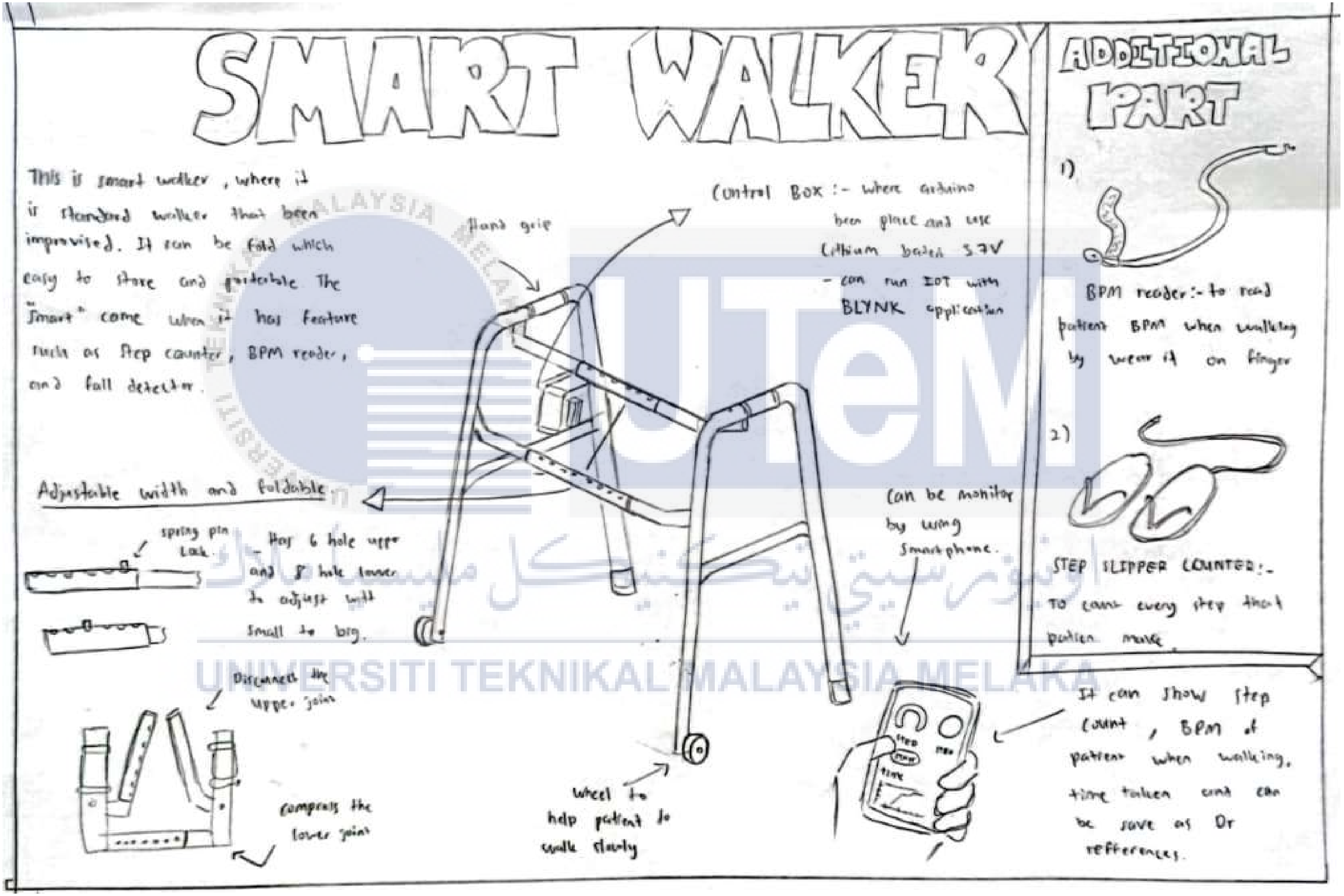

meet.google.com/ydd-ohmw-nbn
20:05 | ydd-ohmw-nbn
You

APPENDIX C : Concept Development

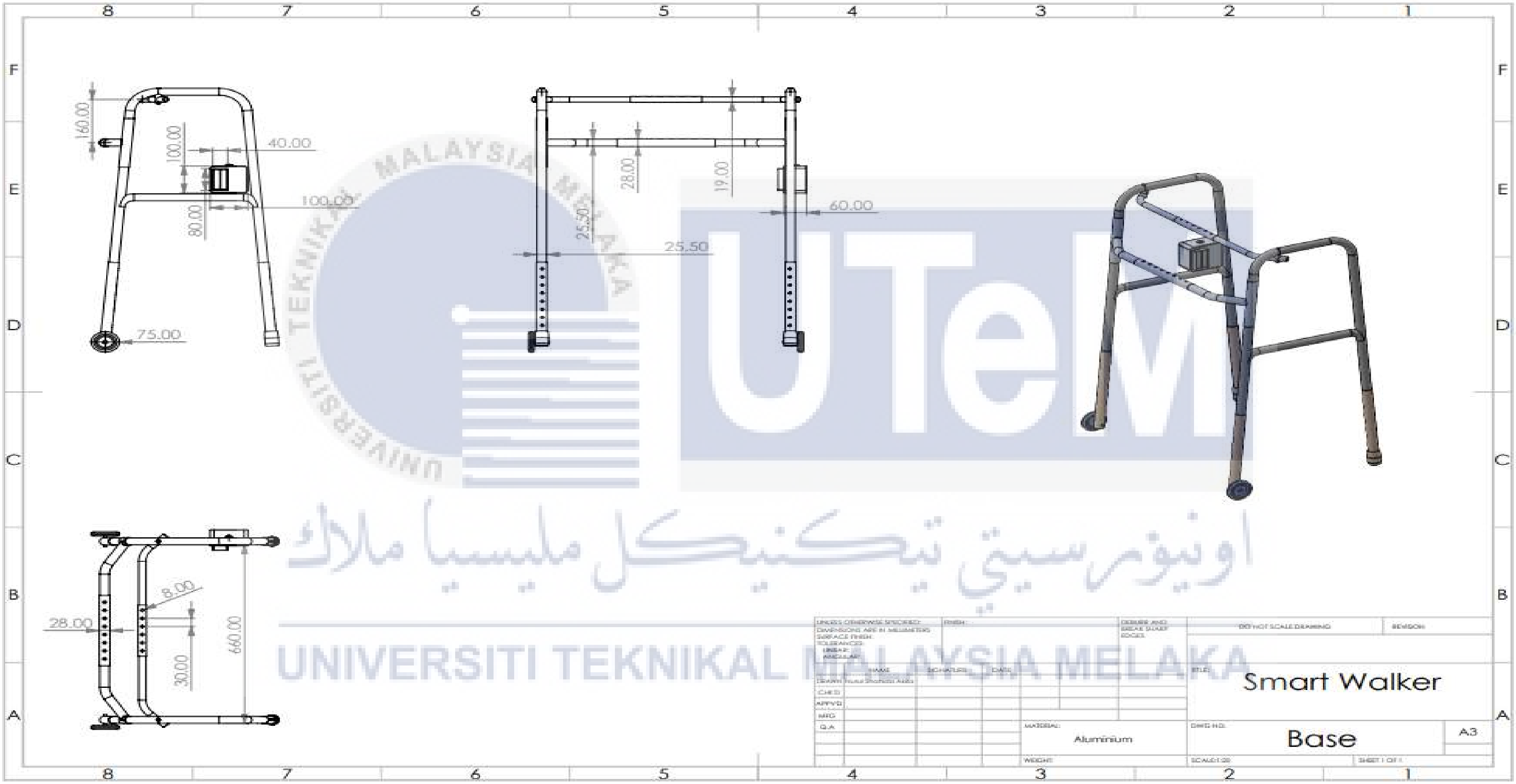


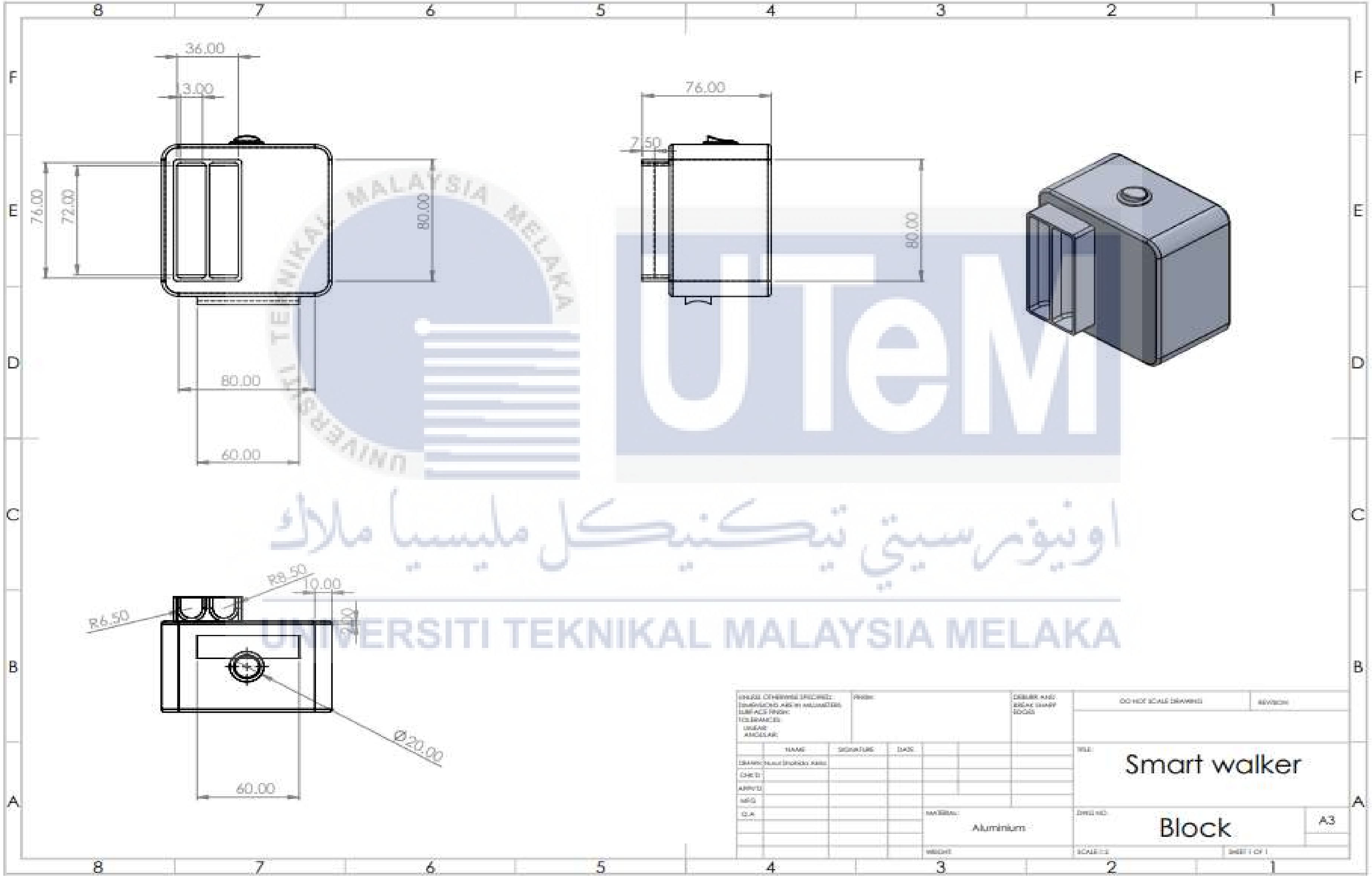


Motorized Walker
STEP TO FOLD
COMFORTABLE SMOOTH GRIP
Blood Pressure Sensor both side
ADJUSTABLE SPRING PIN LOCK
RACHET ANGLE LOCK TYPE
MOTORIZED WHEEL
ROAMING WHEEL
CIRCUIT BOX
- GPS
- FALL DETECTOR
FOLD
TADA !!
Scanned with CamScanner


SMART WALKER
ADDITIONAL PART
This is smart walker, where it is standard walker that been improvised. It can be fold which easy to store and portable. The "Smart" come when it has feature such as step counter, BPM reader, and fall detector.
Hand grip
Control Box :- where arduino been place and use Lithium based 3.7V
- can run IOT with BLYNK application
1)
BPM reader :- to read patient BPM when walking by wear it on finger
2)
STEP SLIPPER COUNTER :- TO count every step that patien move.
Adjustable width and foldable
spring pin lock
Has 6 hole upper and 8 hole lower to adjust with small to big.
can be monitor by using Smartphone.
Disconnect the upper joint
compress the lower joint
Wheel to help patient to walk steady
It can show step count, BPM of patient when walking, time taken and can be save as Dr refferences.

APPENDIX D : Engineering Design of Final Design

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13.00
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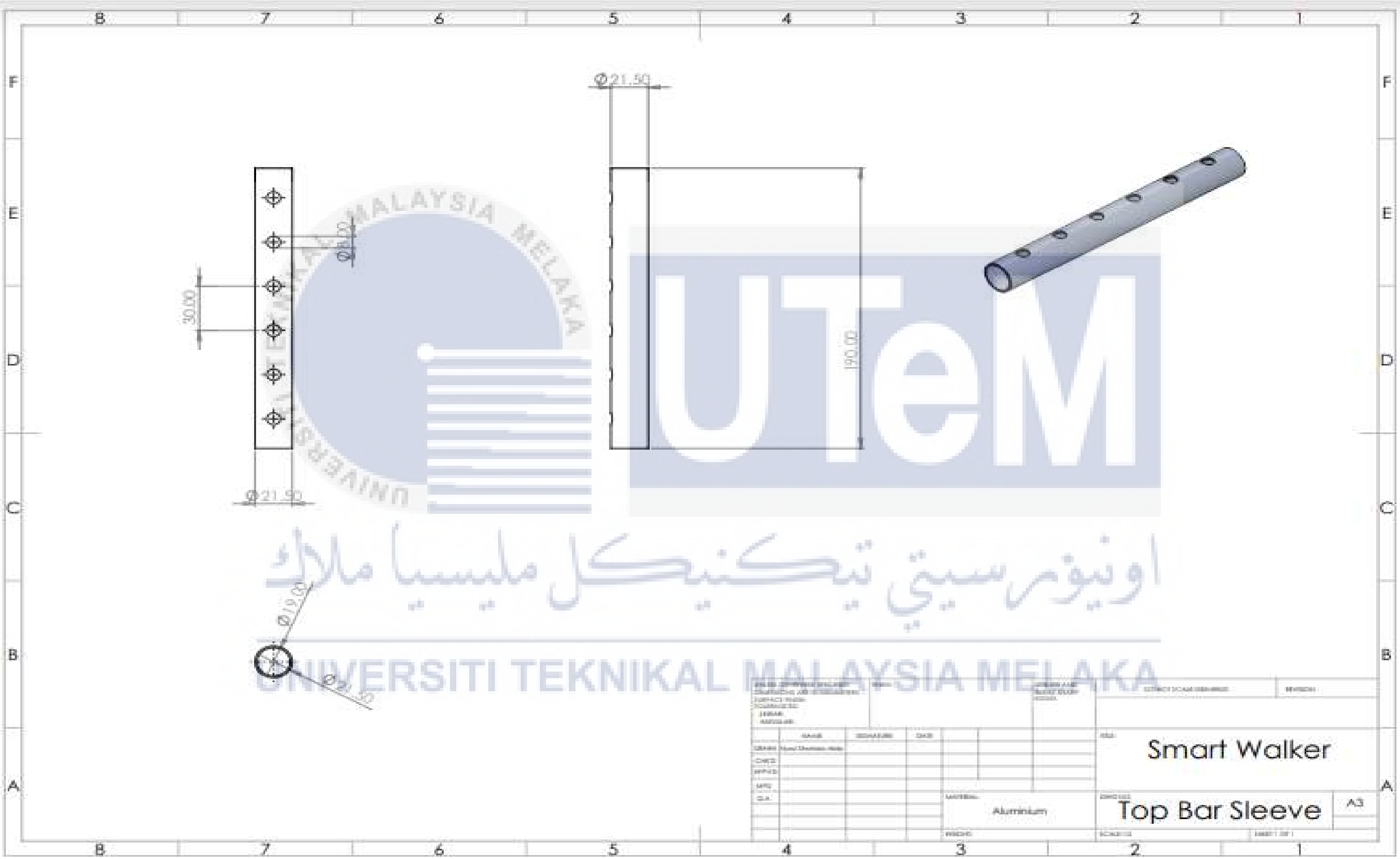
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
Aluminium
WEIGHT:
TITLE:
Smart walker
DWG NO.
Block
A3
SHEET 1 OF 1



Ø21.50
30.00
Ø8.00
190.00
Ø21.50
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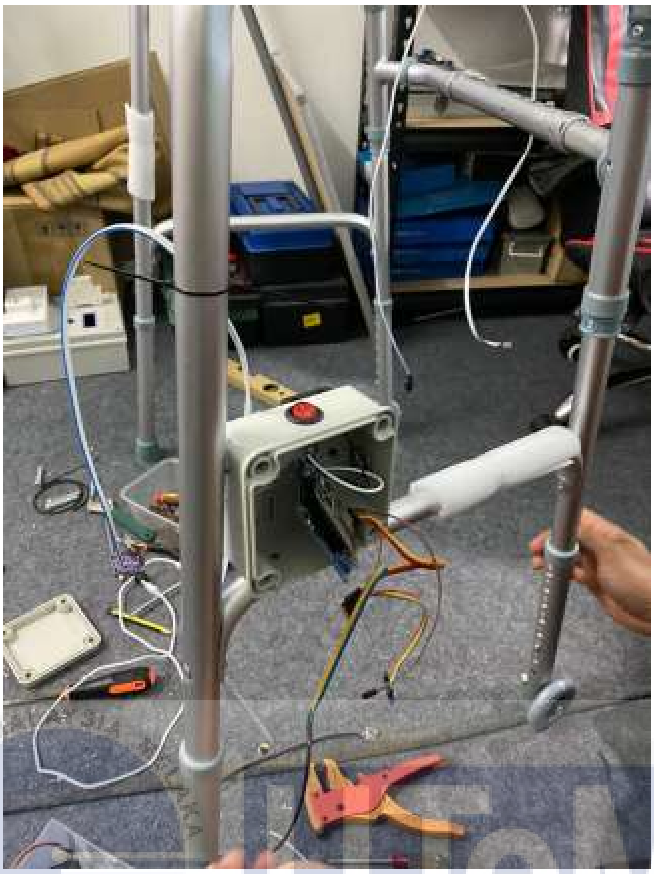
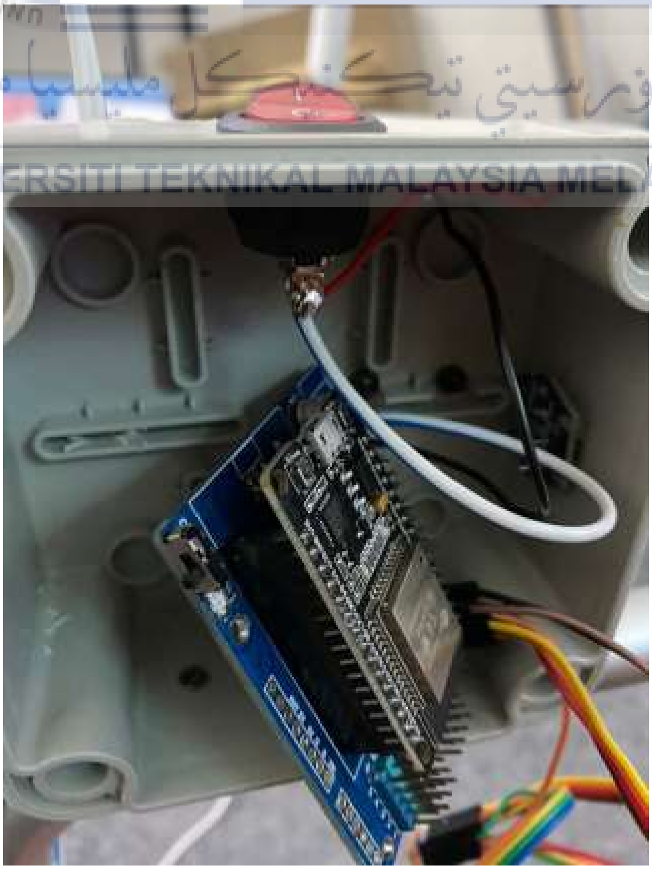
Smart Walker
Aluminium
Top Bar Sleeve
A3

APPENDIX E : Prototype Making





APPENDIX F : Smart Walker

APPENDIX G : Usability / Participant testing


D 365 D
PMJ
2020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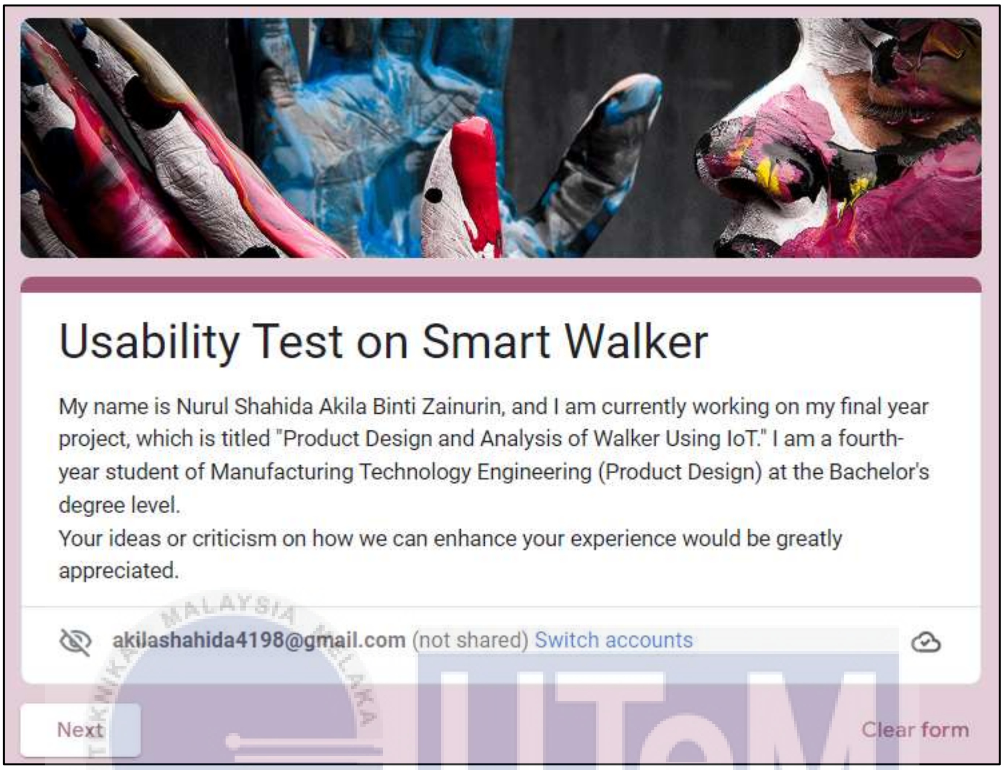
2020

APPENDIX H : Questionnaire Design (Google Form)



Usability Test on Smart Walker

My name is Nurul Shahida Akila Binti Zainurin, and I am currently working on my final year project, which is titled "Product Design and Analysis of Walker Using IoT." I am a fourth-year student of Manufacturing Technology Engineering (Product Design) at the Bachelor's degree level.
Your ideas or criticism on how we can enhance your experience would be greatly appreciated.

akilashahida4198@gmail.com (not shared) Switch accounts

Next

Clear form

Usability

Focus on whether the product meet the habits and needs of the participants

The walker is easy to use

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The IOT for walker is complicated to operate

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The structure of walker is sturdy and strong enough to support maximum weight

	1	2	3	4	5	
Strongly Diagree	○	○	○	○	○	Strongly Agree

Applicability

Focus on the feature of the product
such as analysing the suitability of the purpose method used for the product (walker).

The walker is not easy to store in a small space.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The walker is suitable for everyone to used it, e.g. people of all ages

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The walker does not function well (in terms of collecting data).

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The walker can be used in medical related area (heart rate and step count)

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Effectiveness

Focus on the performance for the
feature of the product (walker) whether it meets the criteria of the
participants.

The walker cannot be assembled quickly

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

The walker can gather information quickly

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

The walker cannot gather information accurately

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Effectiveness

Focus on the performance for the
feature of the product (walker) whether it meets the criteria of the
participants.

- Walker can be assembled quickly

1	2	3	4	5
○	○	○	○	○

- Walker can gather information quickly

1	2	3	4	5
○	○	○	○	○

Walker can gather information accurately

1	2	3	4	5
○	○	○	○	○

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		