DEVELOPMENT OF A MACHINE TO ASSIST WHEELCHAIR USERS TO BOARD A BUS

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This report is submitted
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PEMBANGUNAN MESIN BAGI MEMBANTU PENGGUNA KERUSI RODA UNTUK MENAIKI BAS

MUHAMMAD ASIF ASYRAF BIN ABDUL NASIR

Laporan ini dikemukakan sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal

Fakulti Kejuruteraan Mekanikal

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2020

DECLARATION

I declare that this project report entitled "Development of a Machine to Assist Wheelchair Users to Board a Bus" is a result of my own work accept as cited in the reference.

Signature : ....

Name : Muhammad Asif Asyraf bin Abdul Nasir

Date : ....…

PENGAKUAN

Saya akui laporan ini yang bertajuk “Pembangunan Mesin bagi Membantu Pengguna Kerusi Roda untuk Menaiki Bas” adalah hasil kerja saya sendiri kecuali yang dipetik daripada sumber rujukan.

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Nama :. Muhammad Asif Asyraf bin Abdul Nasir

Tarikh : ....…

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

Signature : ....

Name of Supervisor : Dr. Shamsul Anuar bin Shamsudin

Date : ....

PENGESAHAN PENYELIA

Saya akui bahawa telah membaca laporan ini dan pada pandangan saya laporan ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal.

Tandatangan: ....

Nama : Dr. Shamsul Anuar bin Shamsudin

Tarikh : ....…

DEDICATION

I dedicate this project to my beloved parents and family members, lecturers and friends.

DEDIKASI

Saya mendedikasikan projek ini kepada ibu bapa dan ahli keluarga, para pensyarah dan rakan-rakan.

ABSTRACT

People with physical movement disabilities will likely to have some difficulties in moving from one place to another. A wheelchair has been invented for them in order to make their daily life become easier. Although the use of wheelchair can help people with disabilities to move, they still have a problem in getting onto the bus. Therefore, a few mechanisms such as hydraulic wheelchair lift, ramp and bridge plate has been invented to solve this problem. The purpose of this project is to introduce a new mechanism and improve the existing wheelchair mechanism to help wheelchair users to get into the bus. This new mechanism was designed to enable a lifting process occur at the standard bus that has a high stairs. The design process of this mechanism is started with a survey among civilians which includes some person with disabilities and some students. Through the data obtained from the survey, a House of Quality has been produced to convert the customer requirements into the engineering characteristics. Then, a Product Design Specification is produced in order to be used as a project target specification that must be met. Furthermore, a Morphological Chart is used to obtain some conceptual design whereas the final designs is selected through the Weighted Decision Matrix. After the 3D final design is produced using SolidWorks 2016, some analyses and simulation has been carried out in order to obtain the workability and functionality of the design. A motion study was conducted to observe whether the product design is able to lift the required load or not. Using motion study, the trace path, velocity, acceleration and amount of force use to lift the required load can be determined. Next, a simulation on stress analysis is conducted to obtain the stress data so that the factor of safety of the product design can be classified. Conclusion and recommendation about the project are discussed further.

ABSTRAK

Orang kurang upaya dari segi pergerakan fizikal akan menghadapi beberapa kesukaran untuk bergerak dari satu tempat ke tempat lain. Kerusi roda telah diciptakan untuk mereka agar kehidupan seharian mereka menjadi lebih mudah. Walaupun penggunaan kerusi roda dapat membantu orang kurang upaya untuk bergerak, mereka masih menghadapi masalah untuk menaiki bas. Oleh itu, beberapa mekanisma seperti lif kerusi roda hidraulik, tanjakan dan plat jambatan telah diciptakan untuk menyelesaikan masalah ini. Tujuan projek ini adalah untuk memperkenalkan mekanisma baru dan menambahbaik mekanisma kerusi roda yang sedia ada untuk membantu pengguna kerusi roda menaiki bas. Mekanisma baru ini direka bagi membolehkan proses mengangkat berlaku di bas standard yang mempunyai tangga yang tinggi. Proses reka bentuk mekanisma ini dimulakan dengan tinjauan di kalangan orang awam yang merangkumi beberapa orang kurang upaya dan beberapa pelajar. Melalui data yang diperoleh daripada tinjauan tersebut, sebuah 'House of Quality' telah dihasilkan untuk mengubah keperluan pelanggan menjadi ciri-ciri dalam kejuruteraan. Kemudian, "Product Design Specification" dihasilkan agar dapat digunakan sebagai spesifikasi sasaran projek yang mesti dipenuhi. Selanjutnya, "Morphological Chart" digunakan bagi mendapatkan beberapa reka bentuk konseptual yang mana reka bentuk akhir dipilih melalui "Weighted Decision Matrix". Setelah reka bentuk akhir 3D dihasilkan menggunakan SolidWorks 2016, beberapa analisis dan simulasi telah dilakukan untuk mendapatkan kebolehkerjaan dan fungsi reka bentuk. Kajian gerakan dilakukan untuk melihat sama ada reka bentuk produk mampu mengangkat beban yang diperlukan atau tidak. Dengan menggunakan kajian gerak, jalan jejak, halaju, pecutan dan jumlah penggunaan daya untuk mengangkat beban yang diperlukan dapat ditentukan. Seterusnya, simulasi analisis tekanan dilakukan bagi mendapatkan data tekanan supaya faktor keselamatan reka bentuk produk dapat ditentukan. Kesimpulan dan cadangan mengenai projek dibincangkan lebih lanjut.

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To all the lecturers that had taught me throughout this four years of degree life, thank you very much for your love, kindness and patient in teaching me. Not to forget a big thanks to all the UTeM staff especially the staff at the lab and the workshop for giving me the guidance and knowledge throughout this degree life. Last but not least, thank you to all of my friends who always give a moral support and stay with me through ups and downs.

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LIST OF ABBREVIATION

APTA	-	American Public Transportation Association
CAD	-	Computer Aided Design
DOSM	-	Department of Statistics Malaysia
DSW	-	Department of Social Welfare Malaysia
FBD	-	free-body diagram
FKM	-	Fakulti Kejuruteraan Mekanikal
HOQ	-	House of Quality
MITC	-	Melaka International Trade Centre
MA	-	Mechanical Advantage
MBS	-	Minimum Breaking Strength
MBL	-	Minimum Breaking Load
PSM	-	Projek Sarjana Muda
PDS	-	product design specification
PWD	-	Person with Disabilities
QFD	-	quality function deployment

RPM	-	Revolution per minute
SWL	-	Safe Working Load
FS	-	Factor of Safety
UVL	-	Under Vehicle Lift
UTeM	-	Universiti Teknikal Malaysia Melaka
WLL	-	Working Load Limit
FEA	-	Finite Element Analysis

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

People who have some disabilities especially in their physical movement are often having difficulty to live like a normal person in a daily life routine. Disability is an illness or injury that makes someone to face hardship and makes it difficult for them to do what others can do (Disability, n.d.).

According to the Department of Statistics Malaysia (DOSM), there were 453,258 persons registered as Person with Disabilities (PWD) at the Department of Social Welfare Malaysia (DSW) in 2017 (DOSM, 2018). Figure 1.1 below shows the percentages of registered PWD by the type of disabilities.

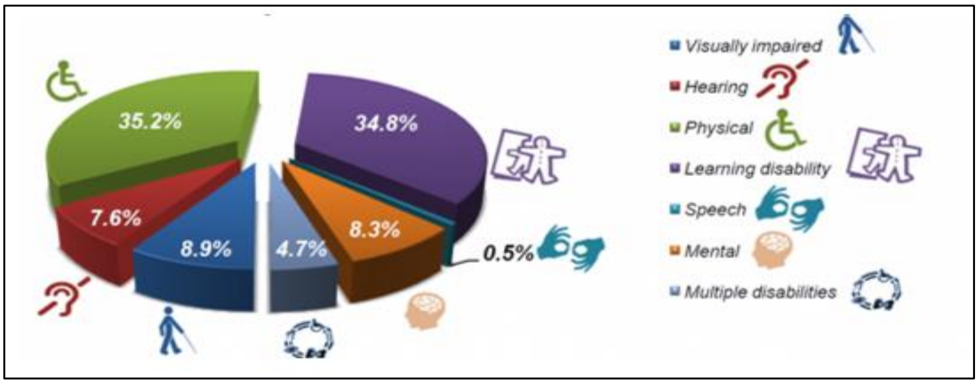


Figure 1.1: Percentages of registered PWD by the type of disabilities.

From Figure 1.1, people with physical disabilities have the highest percentages compared to the others followed by learning disability, visually impaired, mental, hearing, multiple disabilities and speech problems. In order for physical disabilities persons to move around, there are some equipment that have been invented to help them. One of the invention is the wheelchair.

A wheelchair is typically a chair that has some wheels used to transport a disabled person especially for physical disabilities by his or her own push or by being pushed by someone else (Collin, n.d.). There are variety of wheelchairs in the current market from old school to sophisticated one. For wheelchair users, they have the difficulties to get into the vehicles specifically the bus.

Nowadays, there are a few mechanisms developed to solve the problem face by PWD in order to get into the bus. Table 1.1 below shows the mechanisms for wheelchair users to access into the bus.

Table 1.1: The mechanisms for wheelchair users to access into the bus.

Mechanism	Name
	• Wheelchair Lift
	• Ramp

	• Bridge Plate

The purpose of this paper is to introduce a new mechanism and improve the existing wheelchair mechanism to help wheelchair users to get into the bus. The mechanism must be simple to operate and can help the PWD to get into the bus more easily.

1.2 PROBLEM STATEMENT

There are some mechanisms that have been used in order to help wheelchair users to get into the bus such as bridge plate, ramp and wheelchair lift. Nevertheless, these mechanisms have some disadvantages especially when to be implemented in Malaysia. Firstly, the wheelchair lift which is widely use for the buses in the Europe country is high in price and it require a wide opening of buses door. In Malaysia, majority of the buses have small dimension of the door. Furthermore, the use of bridge plate need a suitable high to deploy from a vehicle. The bridge plate is a good alternative to help PWD but it is only suitable to be used for a low floor buses. We can see that in Malaysia the buses are using only the ramp while the lift mechanism or bridge plate are rarely can be seen either in rural or urban area. Therefore, this project which is to introduce a new mechanism and improve the current mechanism will likely manage to help and decrease the problems face by the PWD to get into the bus.

1.3 OBJECTIVES

The objectives of this project are as follows:

1. To design a new concept of mechanism to help wheelchair users to get into the bus.
2. To create a design of machine that can transport PWD into a standard bus which has a high stairs.
3. To create a simulation of the design in order to identify the effectiveness of the design.

1.4 SCOPE OF PROJECT

The scope of this project are as follow:

1. To design and develop a new mechanism that can be used for standard bus that has steep stairs.
2. To analyse the suitable methods to be implemented into the new design concept.
3. To develop a conceptual design using a proper concept design method such as morphological chart.
4. Evaluation and selection of the suitable conceptual design.
5. Making the 3D model of the selected conceptual design by using CAD software.
6. To run the related analysis and simulation of the design concept.

1.5 GENERAL METHODOLOGY

A proper project planning must be done in order to make the project successful. In this section, flow chart and gantt chart are used to make sure the flow of the project run smoothly. Flowchart is used by arranging the processes accordingly in order to achieve the objectives of this project while gantt chart works as a guideline or timeline on how to manage this project and what must be done week by week.

1.5.1 Flow Chart

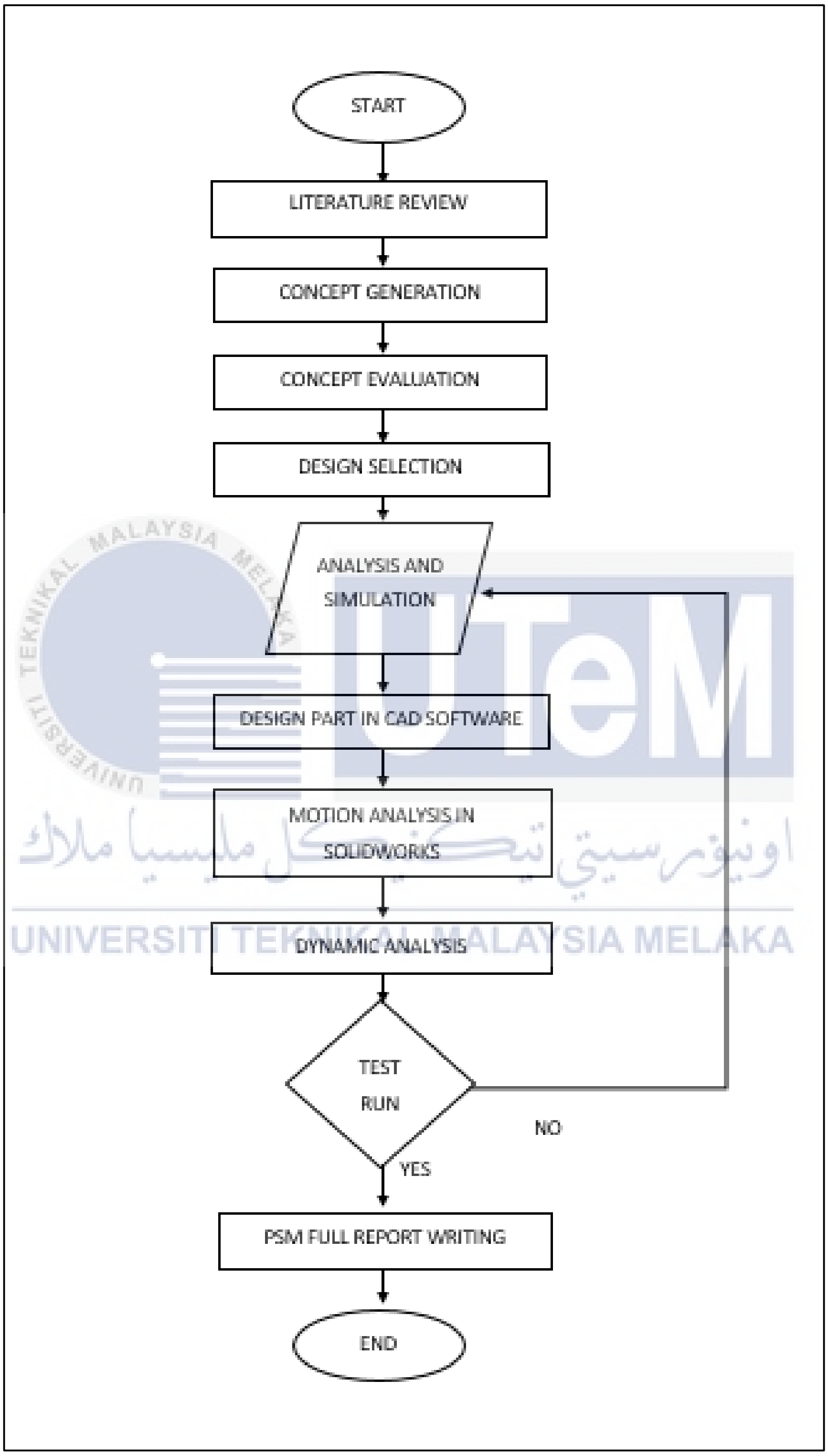


Figure 1.2: Flowchart for PSM

1.5.2 Gantt Chart

Table 1.2: Gantt Chart for PSM.

Processes	Week (Semester 1)													
	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Discussion with supervisor														
Gathering information from internet														
Concept generation and evaluation														
Progress report submission														
Selection of design														
Selection of material and mechanisms														
Part design														
Preparation for report														
PSM 1 presentation														
	Week (Semester 2)													
Analysis of the detail design														
Design part in Solidworks														
Assembly of project in Solidworks														
Motion analysis on machine														
Result and analysis														
PSM 2 presentation														
PSM 2 submission														

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, journals and articles from the internet are reviewed in order to find information related to the study. The information gathered in this section are based on the objectives on how to produce a machine with a new concept of mechanism to help wheelchair users to get into the bus. Then, from the information gathered, the types of mechanisms which has already been used to access wheelchair users into the bus can be identified and can be used as a guide in creating a new mechanisms of wheelchair lift.

This chapter consist of four sections. Section 2.2 will describes about the types of mechanisms used to access the wheelchair users into the bus and their examples. Then, in Section 2.3 will discuss about the conveyor system theory while in Section 2.4 will discuss regarding the winch, hoist and pulley system. Lastly, Section 2.5 will be discussed about the hydraulic system.

2.2 MECHANISMS USED TO ACCESS WHEELCHAIR USERS INTO THE BUS

2.2.1 Retractable Bridge Plate

A bridge plate is basically a ramp that works either manually or automatically which is retractable and have some mechanical movement. It usually can be seen attached at the low-floor light rail vehicles such as light rail and tram and functioned as a boarding devices to connect to the floor (APTA, 2013). The bridge plate deploy from the vehicle to the floor platform and can be manually deploy by someone or by powered source. Usually the front part of the bridge is attached with a movement stopper device that give signal to the bridge plate to stop deploy whenever it touch something. Figure 2.1 below shows the example of bridge plate mechanism.

Figure 2.1: Example of bridge plate mechanism.

2.2.2 Ramp

Nowadays, there are several ramp that have been introduced in order to help wheelchair users to get into the vehicles. Some of the ramps are the concrete wheelchair ramp, threshold wheelchair ramp, modular wheelchair ramp and the portable wheelchair ramp (Stewart, n.d.). The most suitable one to be used by wheelchair users to get into the bus is the manual folding wheelchair ramp. It is mounted on the bus floor and can be operated manually. This ramp is simple to handle as it is not connected to any electrical system. Whenever there are wheelchair users who want to get into the bus, the ramp can be unfolded and make the accessible route for the users. Table 2.1 below shows the information about folding wheelchair ramp named VK-FMWR-A-13-15 Folding Wheelchair Ramp.

Table 2.1: Information of VK-FMWR-A-13-15 Folding Wheelchair Ramp.

Ramp	Details
 	• Apply for low floor city bus • Installed on bus floor • Manually controlled • Unfold to be used • Not using electric system • Take no space

2.2.3 Wheelchair Lift

A wheelchair lift is a device powered by electricity and it is used to lift wheelchairs into the vehicles or buildings. Whenever there is no power source, this device can also be operated manually. There are many types of wheelchair lift such as inclined platform wheelchair lift, vertical platform wheelchair lift and portable wheelchair lift (Hawkins, n.d.). According to Swanson (2011), in order to make maintenance and repair become easier, manufacturers have produced a wheelchair lifts with fewer wire and uncomplicated mechanical systems. By using this device, it can help the wheelchair users who are facing trouble in stepping up the stairs to get into the bus easily. The most famous wheelchair lift use for the bus is the vertical platform wheelchair lift with hydraulic system. Braun Corp. is one of the developers of the wheelchair lift and they had produced various types of lift. Table 2.2 below shows some of their products and their features.

Table 2.2: Braun Corp. products and the details.

Product	Details
	• Century 2 Wheelchair Lift • Economic package • Dual hydraulic lift arms
	• Global Series Lift • Low cost • Lightweight

	• Under Vehicle Lift (UVL) Wheelchair Lift • Retract into tight enclosure under vehicle

2.3 CONVEYOR SYSTEM THEORY

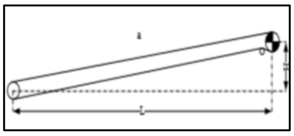
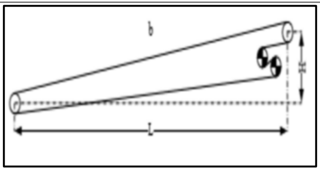
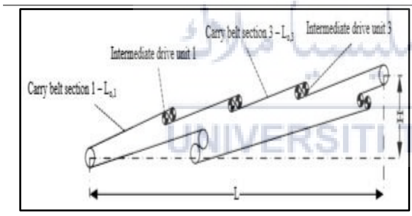
2.3.1 Introduction of Conveyor System

A conveyor system is a mechanical system that helps to transfer materials or things from one place to another and it usually can be seen in the factory. This system had been used in the materials handling industry for a long time (Rogers, 2011). There are various types of conveyor system used nowadays and some of the common conveyors are roller conveyor, belt conveyor and chain conveyor.

2.3.2 Belt Conveyor System

A belt conveyor system is high in efficiency in transferring materials from short to medium distance travels. It consists of two end pulleys at a fixed positions which are the driver and the driven and a high strength belt. Table 2.3 shows the types of conveyor belts and the explanation for each conveyors (Mukalo et al, 2017).

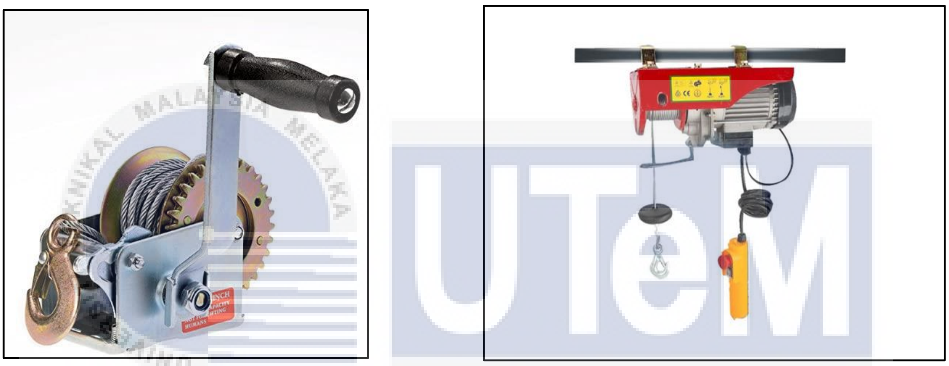
Table 2.3: Types of conveyor belts.

Conveyor Belt	Details
 **Single Drive Belt Conveyor**	• Transfer material with density ρ over a distance travelled L with a lift height H • The drive unit at the head pulley applied the pulling force to the belt Required belts with high rate breaking strength of belt related to belt width
 **Single-Tandem Drive Belt Conveyor**	• Drive unit at head pulley consist of two drive pulley mounted in tandem • Driven by motor-gearbox assembly • Belt with low rate breaking strength of belt related to belt width can be used because of two different points shared the pulling force.
 **Multi-Drive Belt Conveyor**	• One or more drive units along the carry side of the system • Allow to reduce belt weight

2.4 WINCH, HOIST AND PULLEY SYSTEM

2.4.1 Winch and Hoist definition

Both winch and hoist will help a lot in handling an activity consist of mass loading. Winch and hoist are likely to be referred as the same machine but in fact it is different from one another. Figure 2.2 (a) and Figure 2.2 (b) below shows the standard winch and the hoist machine.



(a) (b)

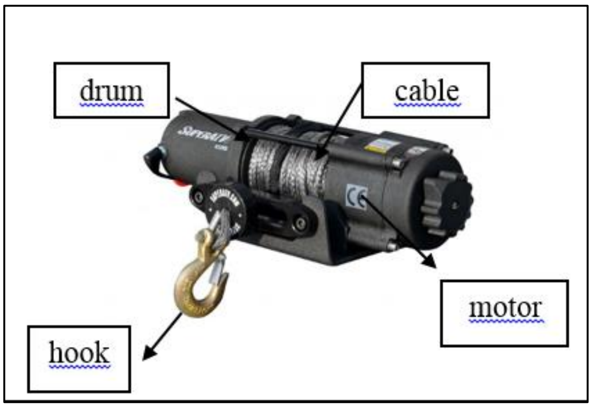
Figure 2.2: (a) The standard winch, (b) The hoist machine.

The standard winch is basically design to pull a load horizontally to a relatively surface level while the hoist is specifically used to lift a load vertically while the load is hanging on the air (Joel, 2018). A load pulling up on an inclined surface is considered as lifting operation because the surface level is not horizontally the same and the load will tend to slide down due to the gravitational force if there is no support to hold the load. In this case, the hoist is the suitable machine to be used for the pulling task rather than the standard winch. Hoist has a better braking system to hold the load compared to the standard winch. Table 2.4 shows the differences in the braking systems between each machine.

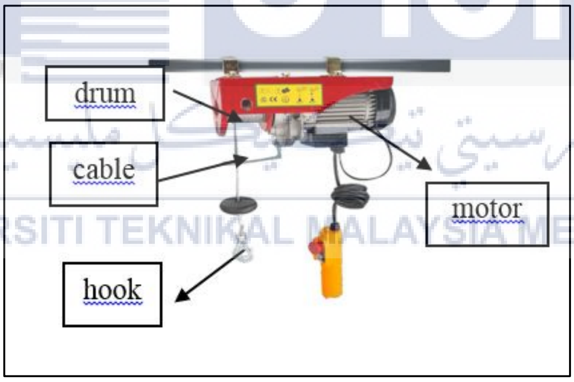
Table 2.4: Differences in braking system of the machines.

Machine	Braking system
Standard winch	• Dynamic brake • Design specifically to support rolling load • Automatic lock of the brake gear when pulling a load • Vertical load lifting can cause damage to system strength resulting load slip • Create gear damage and dangerous to users.
Hoist	• Mechanical brake • Design specifically to support and lock the lifting load • Has load limiter in preventing to lift exceed machine working load limit

There are also some winches being manufactured to function as the winch and hoist. An electric winch which is a type of mechanical tools that can be used for lifting and pulling an object such as lifting a heavy wood and pulling a stuck vehicle has been introduced in the market. This type of winch can be obtained either in a manual or a powered source winch (Toolstastico, 2019). Although there are different kind of electric winch but basically the parts for each winch are the same. Figure 2.3 (a) below shows the example of the electric winch and its parts while Figure 2.3 (b) shows the hoist and its parts.



(a)



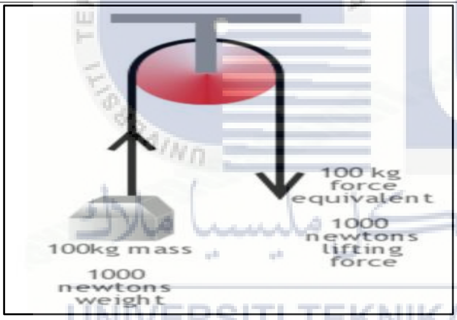
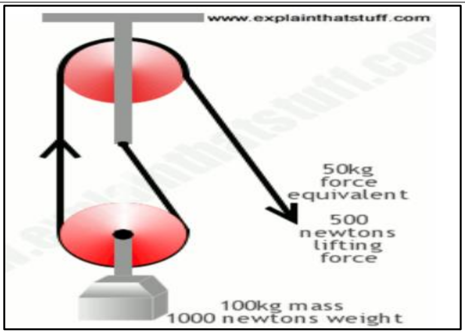
(b)

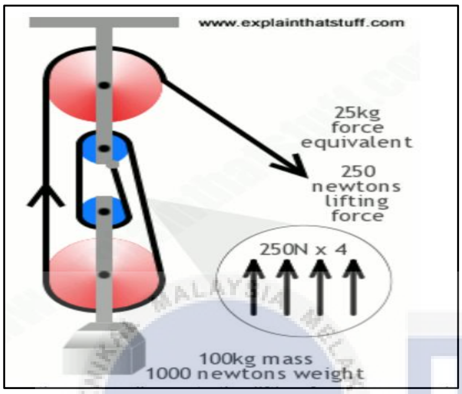
Figure 2.3: (a) Electric winch and its parts, (b) Hoist and its parts.

2.4.2 Pulley System

Pulley is a type of simple machine that helps to multiply the forces needed to lift an object thus making the lifting process become easier. By having more wheels and loops of rope around the wheels, the lifting will become much more convenient and the weight of the object becomes light as it will divide the weight of the object to each ropes (Chris, 2019). Table 2.5 below shows the explanation of using different numbers of wheels in the pulley system to help lifting an object.

Table 2.5: Explanation of using different numbers of wheels in the pulley system.

Number of wheels	Explanation
 (source: www.explainthatstuff.com/pulleys.html)	• One wheel • Helps to reverse direction of pulling forces • Pulling force is equivalent to the mass of the object • Mechanical Advantage, MA=1
 (source: www.explainthatstuff.com/pulleys.html)	• Two wheels • Minimise the amount of forces need to lift the object into half as the mass of the object is divided between the two supported rope or cable

	• To make the object lift 1m, the pulling distance must be doubled which is 2m • Mechanical Advantage, MA=2
 (source: www.explainthatstuff.com/pulleys.html)	• Four wheels • Pulling force will be divided into quarter of the object mass • The object is supported by four rope or cable in a loop • twice times better than two wheels • The pulling distance is four times the lifting height. • Mechanical Advantage, MA=4

For each number of wheels use in a pulley, it has their own mechanical advantages (MA). Mechanical advantages is basically the advantage received by the implementation of the pulley mechanism in the lifting of an object. The more the number of wheels use in the system will contributed to a higher MA value. A high MA value means that the system will become easier to operate and the lifting will become much lighter. MA value is calculated as follows:

$$Mechanical\ Advantages, MA = \frac{Load}{Pulling\ Effort} \tag{2.1}$$

2.5 HYDRAULIC SYSTEM

2.5.1 Introduction of Hydraulic System

According to Fenton (n.d.), hydraulic deals with the fluids mechanical properties such as liquids. For practical applications of the hydraulic system, a fluid mechanics subject provide the theoretical foundation of the system. A hydraulic lift has the same principle as a pneumatic lift where the pneumatic uses a compress air while the hydraulic uses a compresses liquid in order to level up the pressure inside the cylinder (Romina, n.d.). By using a hydraulic lifting system, it can generate 25 times or higher than the 25 times of the force which has been produced by pneumatic lifting systems which are comparable to the hydraulic systems.

2.5.2 Advantages and Disadvantages of Hydraulic System

There are some advantages of using the hydraulic system such as the hydraulic system will produce a much greater force than the pneumatic system. Then, the hydraulic system also have a constant torque and force for the use of the hydraulic system. Besides that, the hydraulic system also have the disadvantages that can be observed. This system will have the risk to the environment as the fluid in the cylinder may lead to the environmental leak. The uses of the hydraulic system requires some parts and components and that will lead to a larger area of requirement.

CHAPTER 3

DESIGN PROCEDURE

3.1 INTRODUCTION

In order to produce a good design of a product, a proper and a careful design procedure must be done. A good design procedure will determine the best factors that will affect the design selection. This chapter will explain on the techniques and what are the processes involved to obtain a good design concept.

To gain the suitable information on how to improve the project, a preliminary function structure can be created in order to get the idea of the machine flow. Furthermore, product design specification (PDS) can also be done in order to obtain the target of the product functionality. Moreover, the quality function deployment (QFD) which is a tool for planning and problem solving can be used to guide and focus the design to meet the customer requirement needs. Next, the House of Quality (HOQ) will convert the customer requirements into the engineering characteristics. After that, the conceptual designs can be made in order to have a rough ideas of the final project design. The suitable parts from each of the design concepts that will be used for the final design of the product can be selected through the morphological chart. Next, the concept design selection can be made through the weighted decision matrix. The final design concept will be drawn in the CAD software for a better view of the product. Lastly, a simple analysis of calculation and simulation of the machine will be made in order to determine the suitable weight that the machine can withstand and how the machine works.

3.2 PRELIMINARY FUNCTION STRUCTURE

Preliminary function structure is basically a block diagram structure which consist of some blocks that represent the process of the machine and some arrows that represent the energy flow, signal and material used. This function structure works as a tool to give the general overview on how the machine will works and how the transformation of energy in the machine will occur. Figure 3.1 shows the preliminary function structure of the machine that will transfer wheelchair users into the bus.

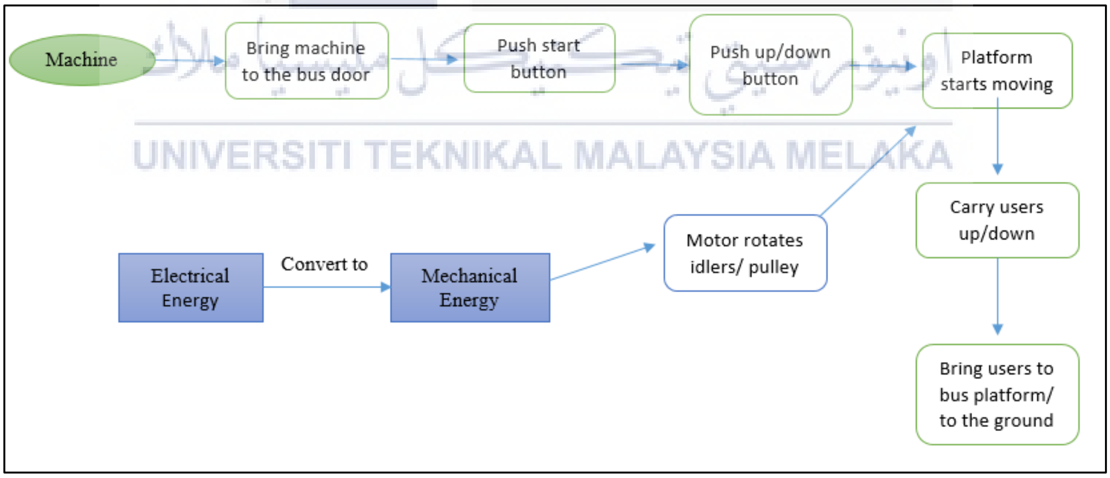


Figure 3.1: Preliminary function structure of the machine.

Based on the Figure 3.1, electrical energy and mechanical energy are required in the flow of the machine. Firstly, the machine will be placed near the bus door in order to make a junction of connection between platform and the bus floor. Then, the start button will be pushed to start up the machine. Later on, the up and down button will be pushed and that will make the platform of the machine starts moving thus helping the users to go up and down. The movement of the machine platform is controlled by the motor which will rotate the idlers or the pulley. The mechanical energy from the motor is converted from the electrical energy supply.

3.3 SURVEY ANALYSIS

To collect information to be used for the project analysis, a survey had been conducted in order to obtain a suitable information regarding the customer requirements. This survey was conducted on 30 respondents comprising of 15 civilians and 15 students. The civilians which had been surveyed are the Mydin MITC Melaka customers and the 15 students are the student of UTeM. The civilians are also consist of people with PWD that use a wheelchair to move. To make the survey at Mydin become easier, a hardcopy of survey had been given to the civilians for them to answer the questions. Then, the answers of the respondents will be transferred into a Google Form application. For the UTeM students, they had been given the link of the Google Form which will direct them into the online survey form and the survey are answered directly into the form. The survey was conducted on 9th December until 11th December 2019.

This survey consisted of three sections which are the demographic data of respondent, the views of respondent on the creation of machine to help wheelchair users to get into the bus and the rate of customer demands based on product characteristics.

3.3.1 Section 1 (Respondents Demographic Data)

In this section, respondents have been asked about their gender, age and the uses of wheelchair for their own. Figure 3.2 shows the percentage of respondents according to their gender.

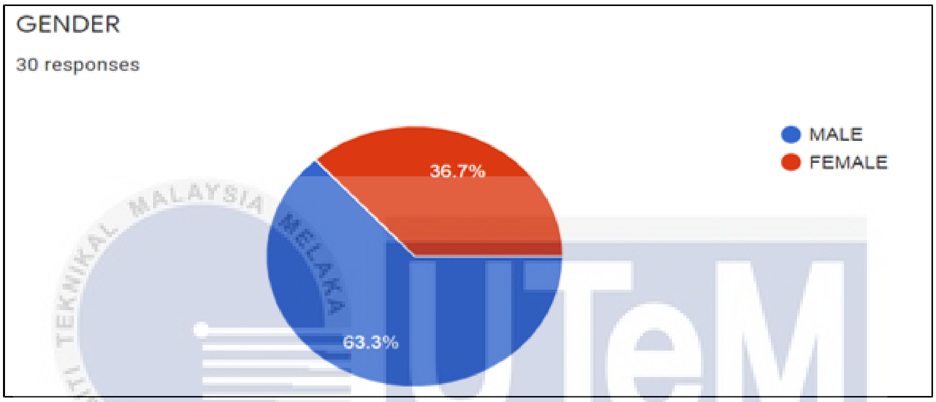


Figure 3.2: The percentage of respondents according to their gender.

Based on the Figure 3.2 shown above, percentage of male respondents which is 63.3% is much higher than percentage of female respondent which is 36.7%.

The Figure 3.3 shows about the respondents age varying from 21 to 30 years, 31 to 40 years, 41 to 50 years and then 50 years and above.

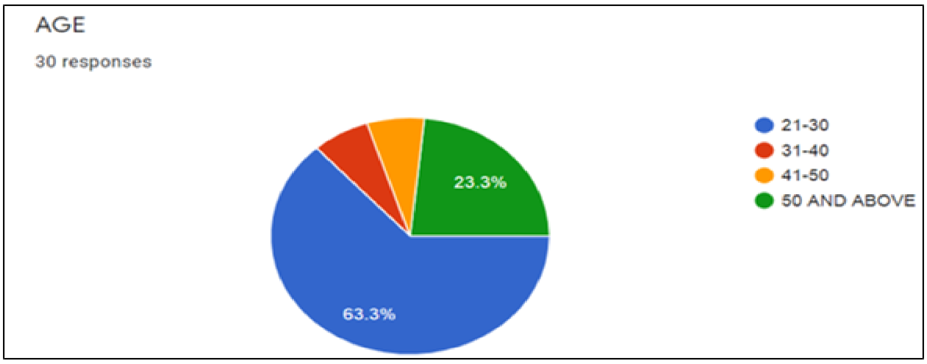


Figure 3.3: Age of respondents.

The majority of the respondents come from respondents age from 21 to 30 years followed by respondents age 50 and above, respondents from 31 to 40 years and lastly respondent age 41 to 50 years. Then, Figure 3.4 shows regarding the uses of wheelchair for themselves.

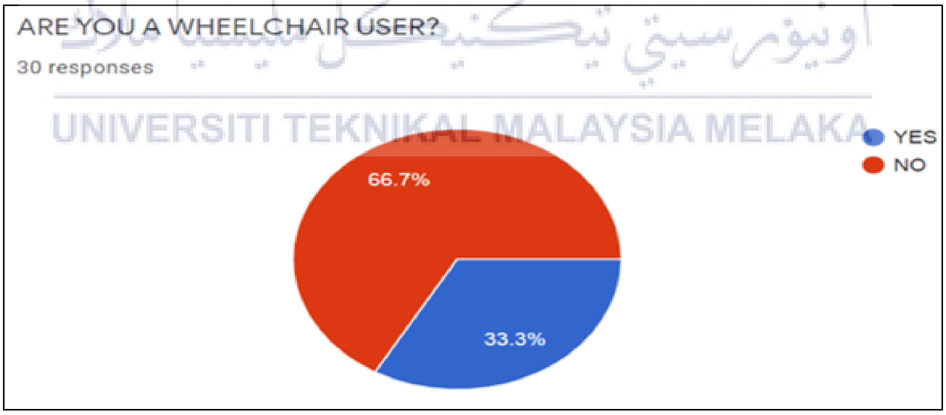


Figure 3.4: The uses of wheelchair for respondents.

From the survey conducted, 33.3% of them are the wheelchair users while 66.7% are non-wheelchair users.

3.3.2 Section 2 (Views of Respondent on the Machine)

This section will be discussed about some of the questions that had been asked to the respondents in the survey. The questions asked are important in determining the interest of respondents towards the product that will be developed. Figure 3.5 shows the opinions of respondents regarding the difficulty of wheelchair users to get into the bus.

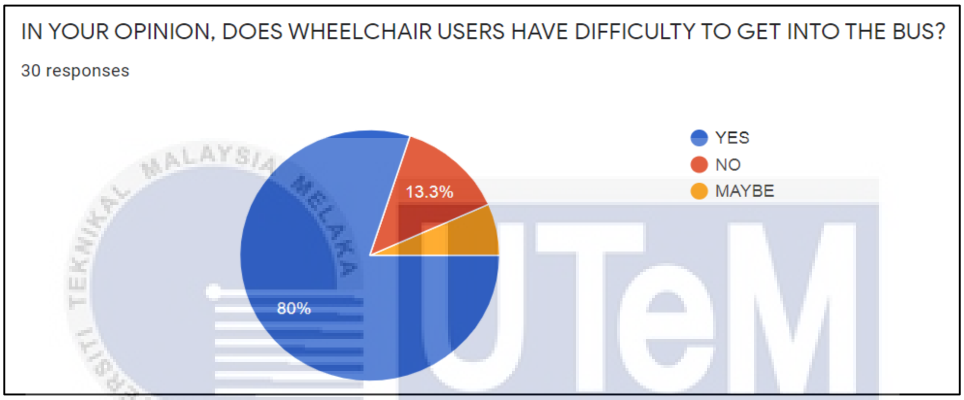


Figure 3.5: Respondents opinions regarding the difficulty of wheelchair users to get into the bus.

From the above result shown in Figure 3.5, about 80% of the respondents agreed that wheelchair users will have the difficulty to get into the bus while 13.3% responded no difficulty will be faced. The rest of the respondents were not sure whether the wheelchair users will have the difficulty or not.

Then, the respondents were asked about their opinions about the interest of the wheelchair users to use the bus after having the difficulty to get into the bus. Figure 3.6 below shows the results obtained from the survey.

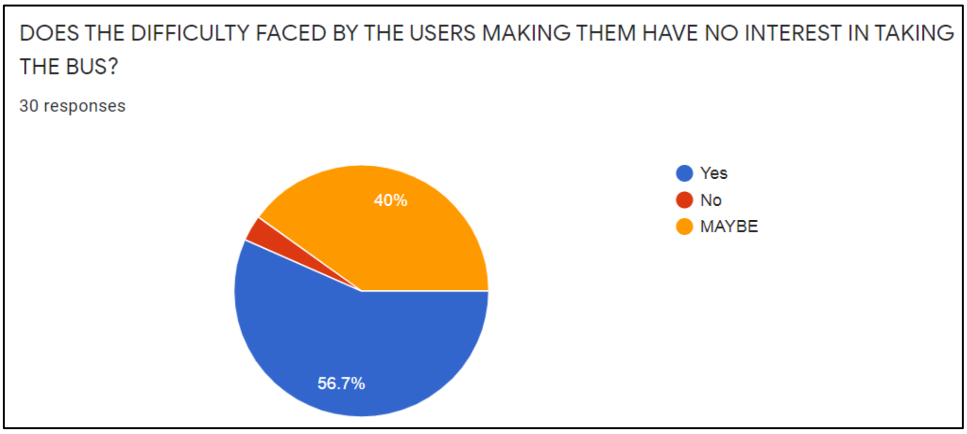


Figure 3.6: Respondents opinions regarding interest of wheelchair users after faced the difficulty to get into the bus.

Based on the figure above, 56.7 % of the respondents agreed that the wheelchair users will have no interest to take a bus after facing the difficulty to get into the bus. There are about 40% of the respondents that are not sure whether the respondents were having the difficulty or not and the rest of them stated that wheelchair users will have the interest to take a bus although they faced the difficulty to get into the bus.

The respondents are also had been asked whether they have seen any machine that can lift a wheelchair users into the bus. Figure 3.7 shows the result obtained from the survey conducted.

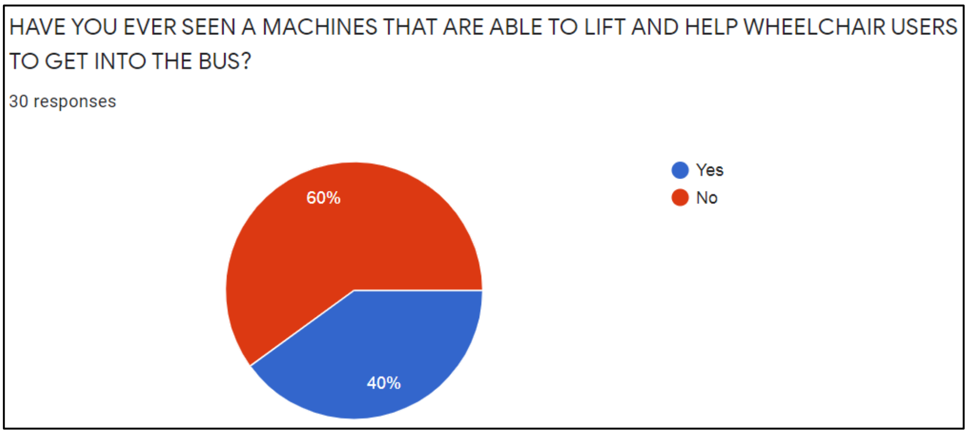


Figure 3.7: Respondents information regarding wheelchair lifting machine.

According to the Figure 3.7, 60% of the respondents have never seen the machine that can lift a wheelchair users into the bus. There are 40% of them that have seen that kind of machine.

Next, the respondents were asked about their opinions on the use of the machine in helping the wheelchair users to get into the bus. Figure 3.8 shows the percentage of the respondents' opinions regarding the usefulness of the lifting machine.

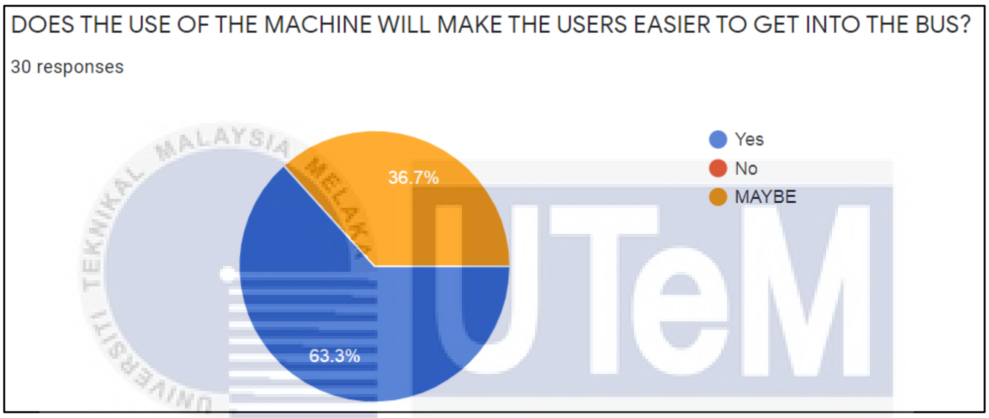


Figure 3.8: Respondents' opinion on the usefulness of lifting machine.

From the above figure, there are 63.3% of the respondents agreed that the lifting machine can make the wheelchair users to get into the bus easily while 36.7% of them are not sure with the question.

In the survey, the respondents were also asked about their interest on the lifting machine. Figure 3.9 shows the results of the survey regarding the interest of the respondents towards the machine.

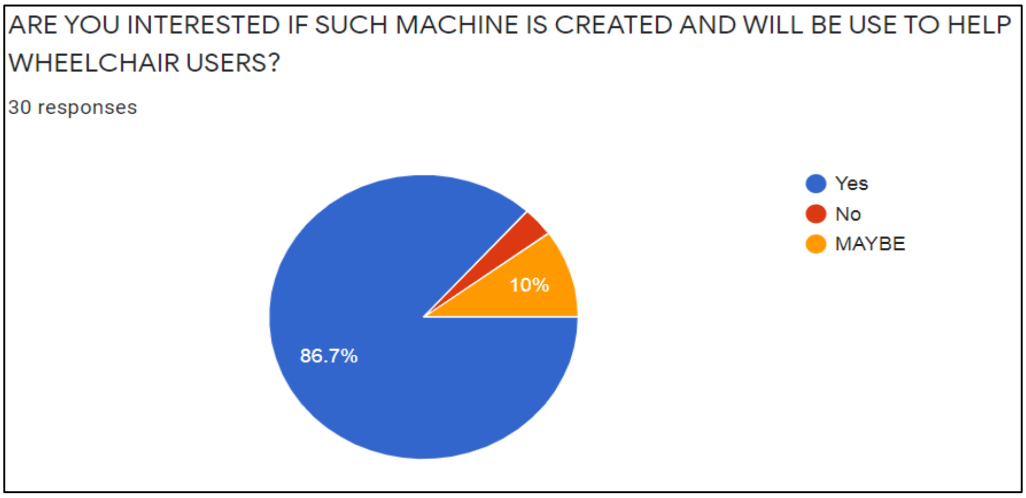


Figure 3.9: The interest of the respondents towards the machine.

It can be seen in the figure above 86.7% of the respondents are interested if such machine is created and 10% of them are not so sure about the machine creation. The rest of the respondents are not agreed with the creation of the machine.

All of the respondents are asked whether the creation of the machine will be useful or nor in helping the wheelchair users to get into the bus. Figure 3.10 shows the results of the respondents' answers.

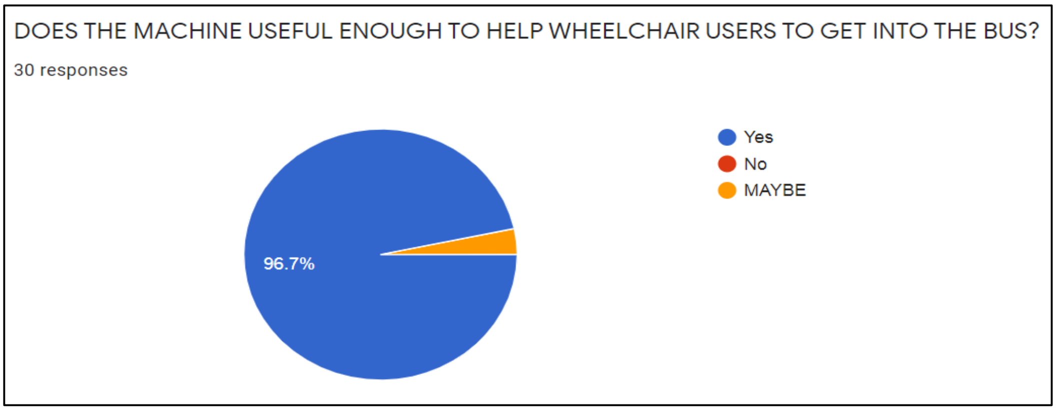


Figure 3.10: Respondents' opinion regarding the usefulness of the conveyor belt lifting machine.

3.3.3 Section 3 (Rate of Customer Demands Based On Product Characteristics)

In Section 3, the respondents had been asked about some of the product characteristics that are suitable to be the benchmark in obtaining the customer requirements of the product. Figure 3.11 shows the rating of the respondents regarding the speed of the machine movement.

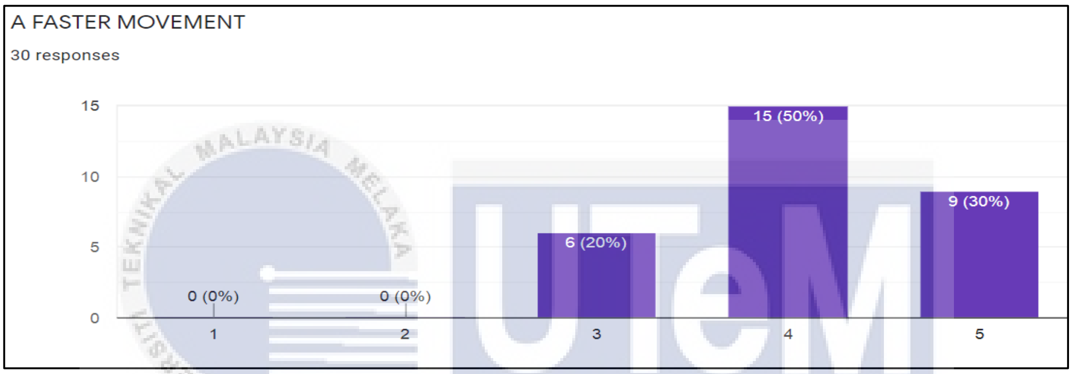


Figure 3.11: Rating of the respondents regarding the speed of machine movement.

Based on the chart above, 50% of the respondents choose to have a machine that can move fast but not too faster. There are 30% of the respondents that choose the machine to be high in speed followed by 20% of them that choose moderate speed.

Then, the respondents are also been asked whether the machine must be not easily damage or not. Figure 3.12 shows the respondents answers regarding the questions.

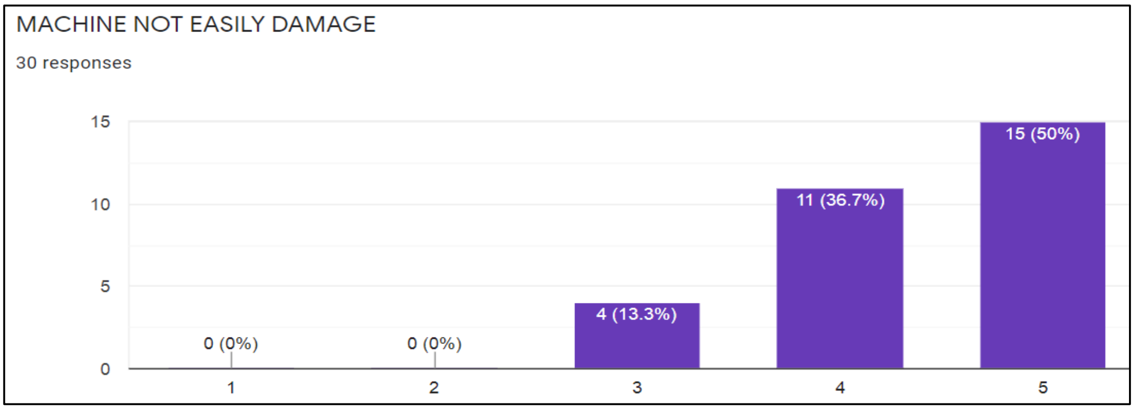


Figure 3.12: Rating of the respondents regarding the endurance of the machine.

There are 50% of the respondents that very agreed with the statement stated while 36.7% of them agreed that the machine must be not easily damage. 13.3% of them are not quite sure whether the machine must be not easily damage or not.

Then, the respondents are asked about the lifespan of the machine whether it must have long lasting life or not. Figure 3.13 shows the results of the survey.

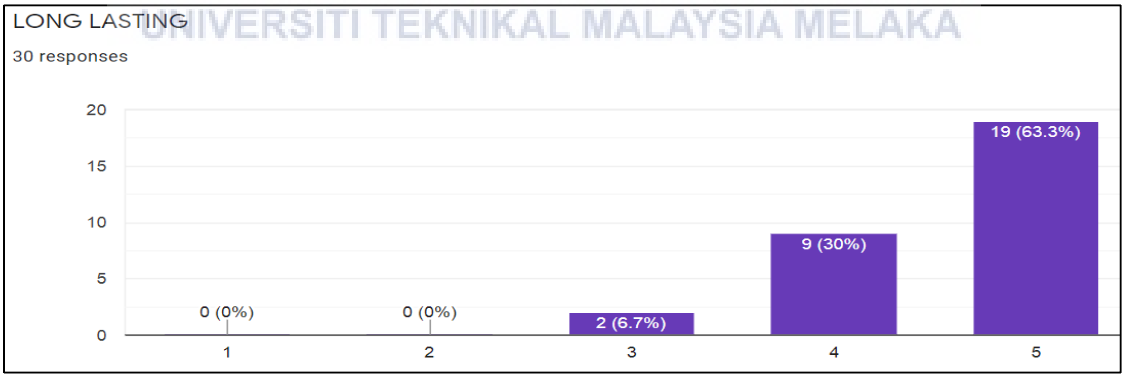


Figure 3.13: Rating of the respondents regarding the lifespan of the machine.

According to the figure above, 63.3 % of the respondent are very agreed if the machine have a long lasting lifespan. About 30 of them are also agreed that the machine should have a good and long lasting lifespan while 6.7% respondents did not sure whether the machine must be long lasting or not.

Furthermore, the respondents are also been asked about the safety of the machine. Figure 3.14 shows the respondents' answers on the safety of the machine.

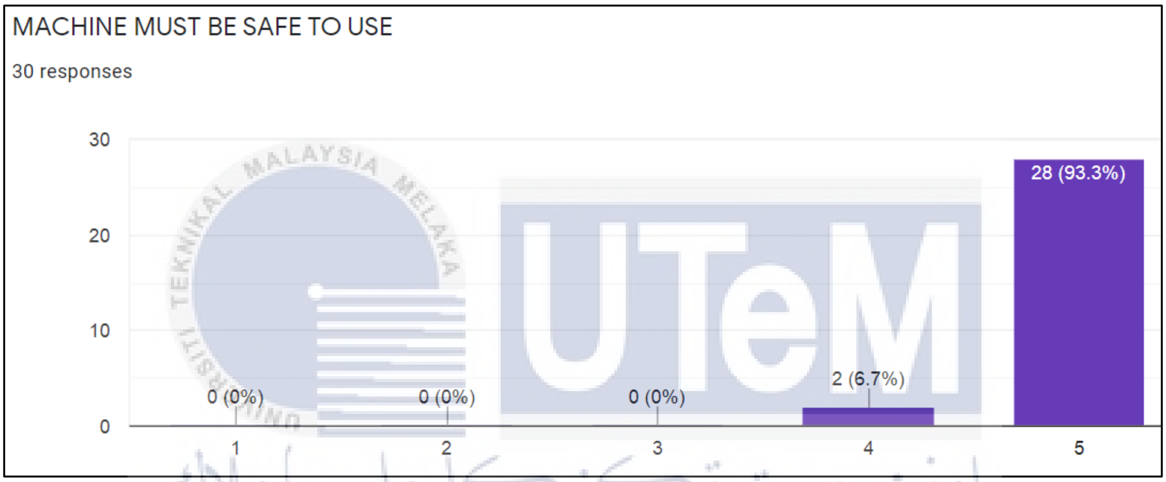


Figure 3.14: Rating of the respondents regarding the safety of the machine.

From the above figure, 93.3% of the respondents rated the machine to be very high in safety and 6.7% also rate the machine to be safe in use.

3.4 QUALITY FUNCTION DEPLOYMENT (QFD)

As stated in the introduction of Chapter 3, QFD works as a guide and help to focus the design to meet the customer requirement needs in the overall product development process. By using this tool, the important set of requirements for the product development process planning can be determined. QFD is a graphical tool that helps a design team to define all the elements that go into the product development process and establish relationship matrices at each step of the process between key parameters (Dieter & Schmidt, 2013).

3.4.1 Customer Requirements

The demand of the clients on how the product must function and how the product must solve a problem is basically what the customer requirements looks like. The creation of a product is to solve a problem and the product must meet the customer requirements. For this project, the customer requirements are extracted from the survey which had been conducted.

3.4.2 House of Quality (HOQ)

The function of the House of Quality (HOQ) is to create a relationships between the customer needs from a product and the overall performance parameters and features of the product which are the most critical things to fulfil (Dieter & Schmidt, 2013). By using HOQ, the customer requirements and engineering characteristics can be related in order to obtain the relationship between both factors. The information in the HOQ such as customer requirements and engineering characteristics are based on the related information gained from the survey conducted. Figure 3.15 shows the HOQ of the wheelchair lift.

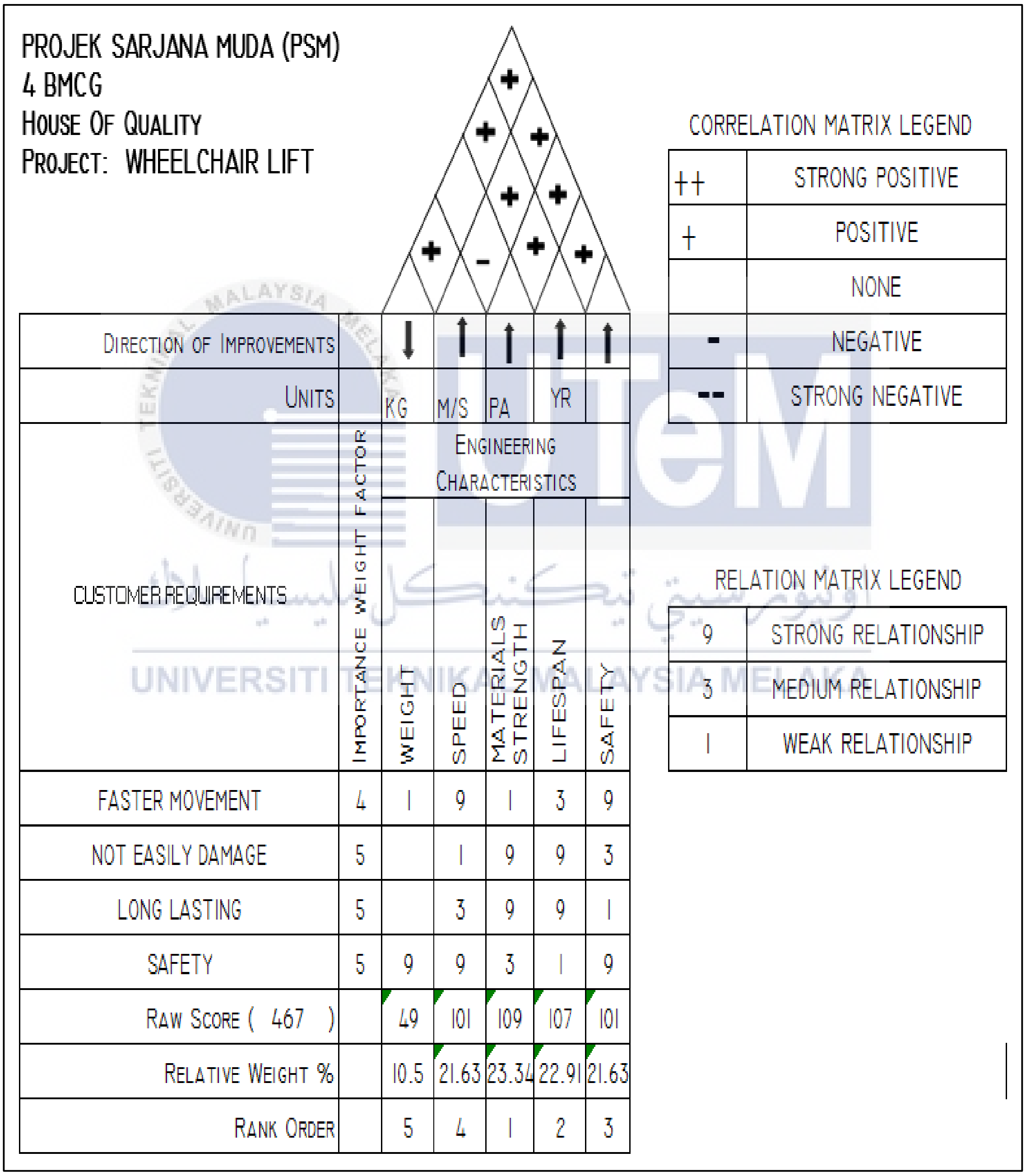


Figure 3.15: HOQ of the Conveyor Belt Wheelchair Lift.

3.5 DESIGN PROBLEM SPECIFICATION

3.5.1 Product Design Specification (PDS)

A set of Product Design Specifications (PDS) put together the results of the design planning process that control the engineering design tasks in the product development process. The PDS works as a reference document and the basic control for the design and the product manufacture plus it is a type of document that stores the facts which related to the product development outcome. By implementing the PDS, the process in setting up the customer needs can be finalized and prioritized thus can help to turn them into the technical framework in order for the design concept to be established (Dieter & Schmidt, 2013). Table 3.1 below shows the PDS of the project and the explanations.

Table 3.1: PDS of the project and the explanations.

Product Design Specification	Explanations
Product Identifications	**i. Basic function of product** • This product must be able to carry a wheelchair user into or exit the bus. **ii. Special features of the product** • This product should be able to fit the standard bus stairs and can be flipped to make storing become easier.

	iii. Key performance target • The machine must be able to lift maximum 150 kg of load plus the 20 kg platform weight assumption. • The machine should be easy to operate and maintenance. • The machine should have a good strength in order to have a good safety.
Manufacturing Specifications	**i. Materials** • The material selected for the machine frame must be strong, high in durability and able to resist impact. • The selected material must be stable enough in order to hold the users and the component of the machine. **ii. Joint** • The use of welding technique, screw and bolt nuts joining can be used to joint between the frame and other parts. **iii. Manufacturing process** • The manufacturing process must be done in the workshop and use the selected and provided material in order to avoid a costly machining process.

Physical Descriptions	**i. Weight** • The maximum weight of the machine must not exceed 180 kg. **ii. Appearances** • The machine should have a nice appearances such as suitable colour selection and must have something that can alert other people when the machine is in use such as reflective sticker. **iii. Size** • The size of the product must be able to fit the bus storage compartment and can fit the bus door nicely.
Market Identification	**i. Target market** • The target market of this product is for the organization or institute that have the PWD in their care. • The use of this machine will likely give ease for the PWD to get into the bus and travel from one place to another. **ii. About product** • Initial launch at FKM, UTeM. • Able to be used on steep stairs of the standard bus **iii. Brand name** • Hoist Wheelchair Lift

Financial Requirements	**i.**	**Targeted cost**
	•	The product cost is targeted to be in between RM 500 to RM 600.
Life Cycle Targets	**i.**	**Lifespan**
	•	The useful life of product is estimated for 5 years and longer with proper maintenance.
Social, Political and Legal Requirement	**i.**	**Safety**
	•	The machine must follow the safety and regulation of environmental.
	•	The safety issues for the product are the speed of the lifting and the stability of the machine platform.

3.6 CONCEPT GENERATION

3.6.1 Morphological Chart

Morphological analysis is one of the ways of generating new forms and a way of structuring the problem synthesis of different components in order to require the exact functionality needed (Dieter & Schmidt, 2013). There are three general steps in order to use the morphological approach to design something. Firstly, the design problems are divided into a simpler form of subproblems. Then, each of the subproblems will be solve by generating a solution concepts. Next, the subproblems solutions are combine into a different solutions systematically and the combinations will be evaluated later (Dieter & Schmidt, 2013). In this morphological chart, the function of the design are labelled from (a) to (e) and each functions have 2 or three types of solution. Figure 3.16 below shows the morphological chart for the Wheelchair Lift.

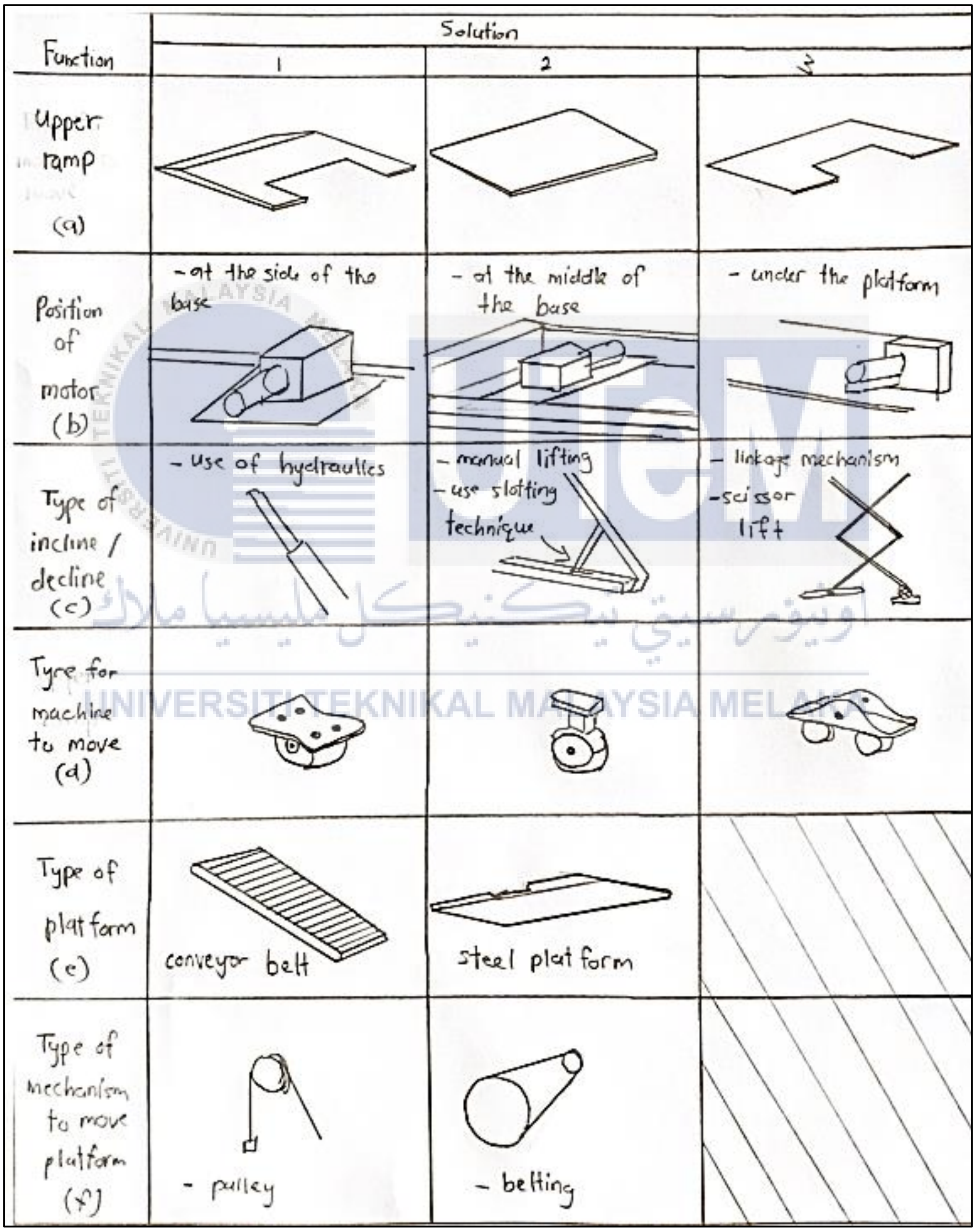


Figure 3.16: Morphological chart for the Wheelchair Lift.

3.6.2 Conceptual Design

From the morphological chart, some conceptual designs have been made which are Sketch 1, Sketch 2 and Sketch 3. Figure 3.17 shows the Sketch 1, figure 3.18 shows the Sketch 2 and Figure 3.19 shows the Sketch 3.

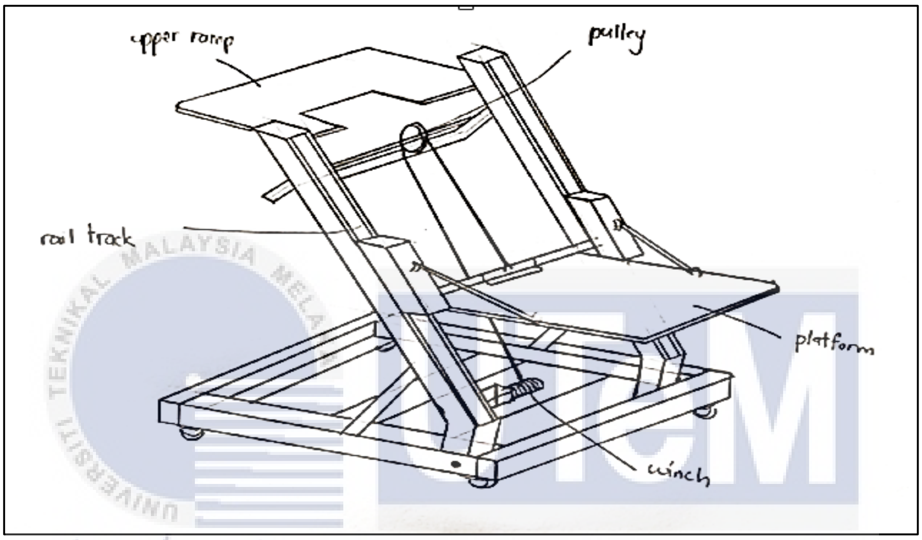


Figure 3.17: Sketch 1.

Function:

This Sketch 1 design concept is the combination of functions a1, b2, c2, d1, e2 and f1. The design concept uses a hoist and pulley system to lift the platform for the users to get into the bus. It consist of a rail track with rollers for a better and smooth movement of the platform while lifting. The hoist at the base will pull and retract the cable that will be attached at the platform.

Advantages:

- Suitable to be used for steep stair angle such as in the standard buses.
- Can be flipped and stored under bus compartment.

Disadvantages:

- Do not have a part or component to fix the machine at the bus stairs.

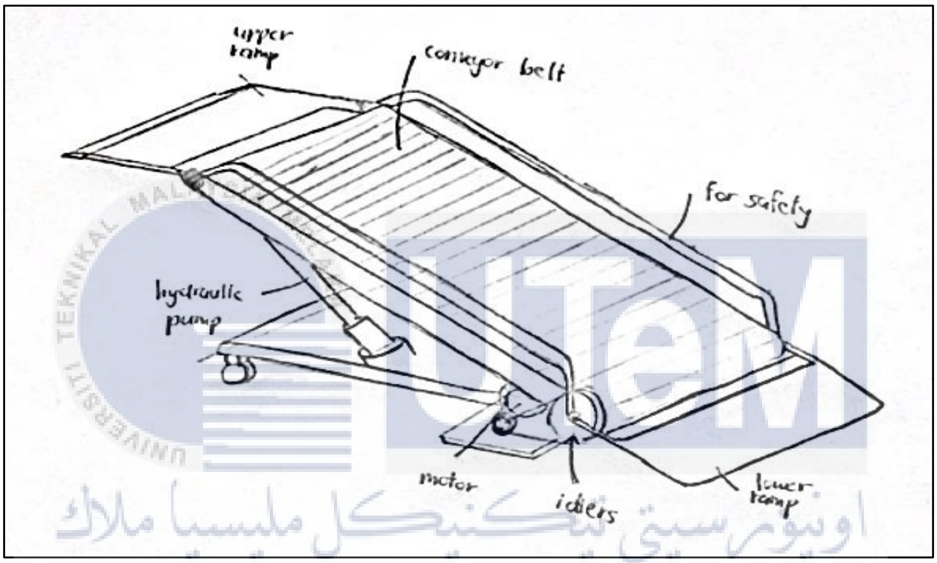


Figure 3.18: Sketch 2.

Function:

Sketch 2 consists of functions a1, b1, c1, d2, e1 and f2. The idea of this design is to use a conveyor belt system to help wheelchair users to get into the bus. The motor will rotates the idlers thus will make the belt starts to move. The movement of the belt will help the users move from the ground to the bus platform.

Advantages:

- Have safety guard wall along the conveyor platform.
- Uses hydraulic system to lift the platform incline or decline.

Disadvantages:

- Because of the steep stair angle of the bus, the platform is a bit too long.
- Wheelchair users may facing slippery when on board.
- Large space needed.

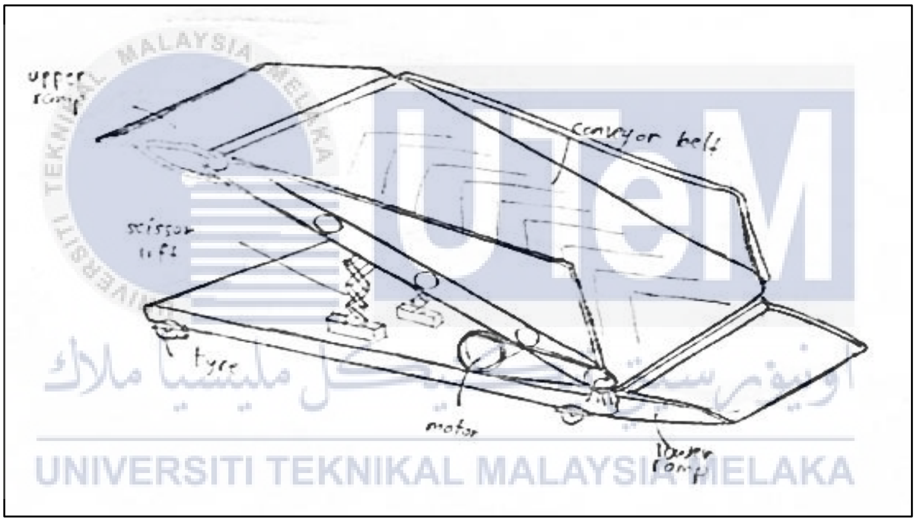


Figure 3.19: Sketch 3.

Function:

For this Sketch 3, is consist of a2, b3, c3, d3, e1, and f2 functions. This design is quite similar to the Sketch 2 design which uses a conveyor belt system to lift the users. In this design, it uses a linkage mechanism named scissor lift to lift the platform.

Advantages:

- Consists of safety guard wall along the conveyor platform.
- Uses scissor lift to lift the platform.

Disadvantages:

- May be bigger in size.
- Although being equipped with tyres but it may be hard to move.
- Large space needed.

3.6.3 Weighted Decision Matrix

Dieter and Schmidt (2013) stated that the decision matrix is a tool for assessing concepts by giving rating to the design criteria with weighting factors and giving score to the degree in which the criteria is met by each design concepts. The decision matrix table is use to determine which of the design concepts has the highest rating. The evaluation of the design concepts using the weighted decision matrix for the design concepts are shown in the Table 3.2.

TABLE 3.2: The weighted decision matrix for the design concepts.

WEIGHTED DECISION MATRIX							
DESIGN CRITERION	WEIGHT FACTORS	SKETCH 1		SKETCH 2		SKETCH 3	
		SCORE	RATING	SCORE	RATING	SCORE	RATING
MATERIAL COST	0.10	8	0.80	8	0.80	8	0.80
MANUFACTURING COST	0.05	8	0.40	7	0.35	8	0.40
SPEED	0.30	8	2.40	8	2.40	8	2.40
TIME TO PRODUCE	0.01	9	0.09	8	0.08	7	0.07
DURABILITY	0.20	8	1.60	8	1.60	8	1.60
LIFESPAN	0.10	8	0.80	8	0.80	8	0.80
SAFETY	0.24	9	2.16	9	2.16	9	2.16
SUM	1		8.25		8.19		8.23

From the above table, Sketch 1 has the highest rating followed by Sketch 3 and Sketch 2. Therefore, the design concept of Sketch 1 will be selected to be the final design concept as it has the highest rating compared to the others.

3.6.4 Final Design Concept

A final design concept of the project will be produced by using SolidWorks 2016 CAD software. By using the CAD software, a 3D model can be produced for a better view of the project. Alloy steel materials are considered to be applied for the design components. Figure 3.20 shows the CAD 3D model drawing of the project.

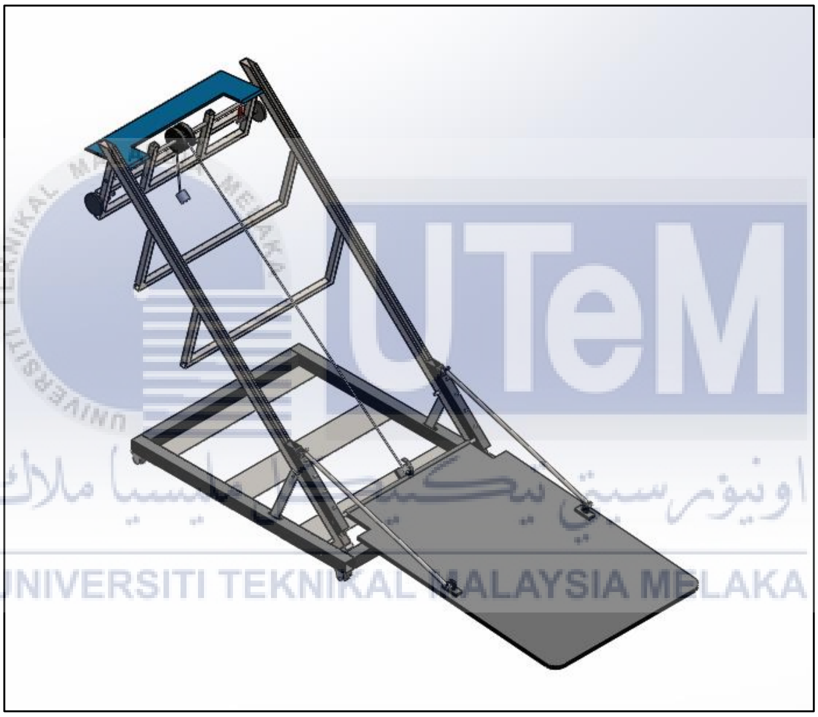


Figure 3.20: The 3D model of the project.

In the 3D model, some improvement of the design have been made in order to solve the disadvantages of the design. This design is equipped with a fixed and tighten component where it will fixed the rail track at the side wall of the bus stairs. The tighten components will be slotted at the specific mounting slot at the side wall and then will be tighten for a better grip. Figure 3.21 shows the slotted tighten component of the machine.

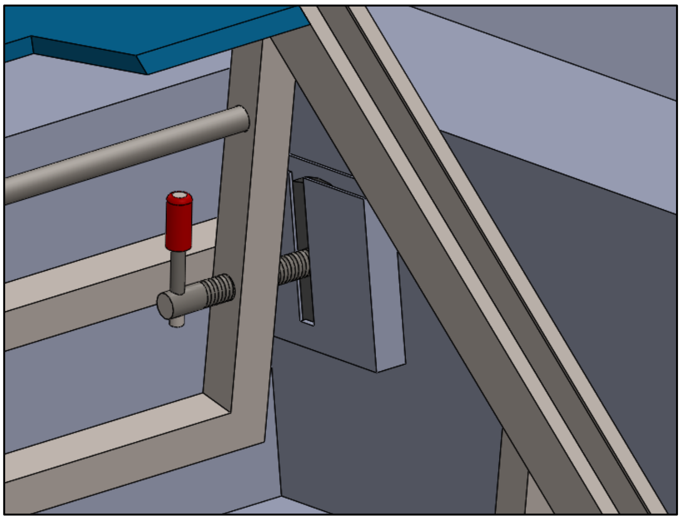


Figure 3.21: The tighten component being slotted at the mounting slot.

Moreover, a metal square bar with tighten are added at the back of the rail in order for the rail to fit the stairs nicely for a better stability and give grip to the stair wall. The pulley rod is supported with a square bar metal in order to prevent the rod from bending and breaking. Figure 3.22 shows the square bar with tighten at the back of the rail while Figure 3.23 shows the supported square bar at the pulley rod.

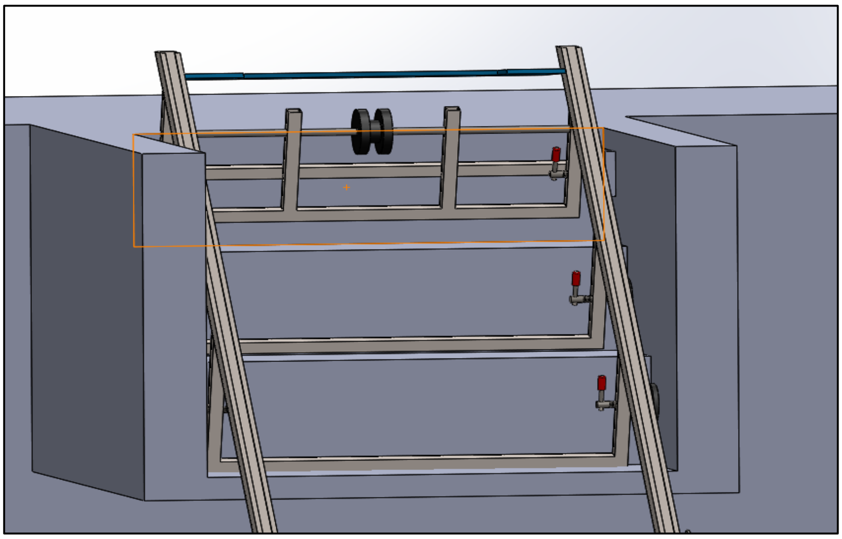


Figure 3.22: Square bar with tighten at the back of the rail.

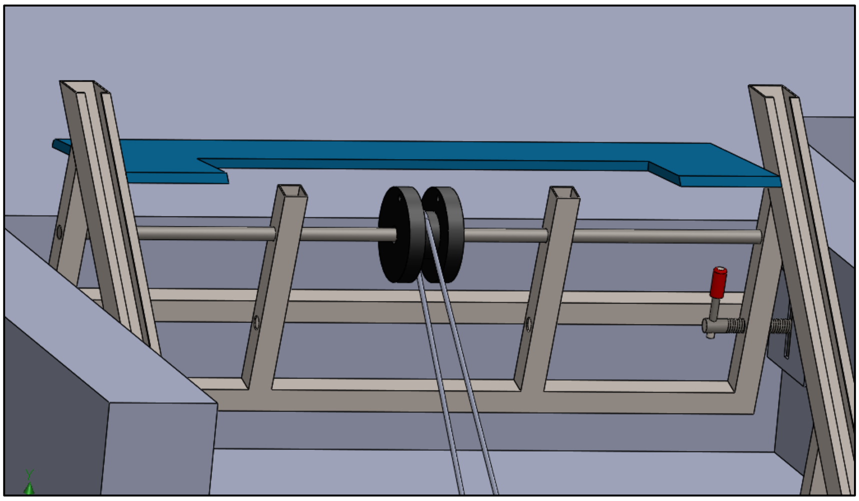


Figure 3.23: Pulley rod is supported by two square bar.

3.7 ANALYSIS OF DESIGN

In order for the machine to operate well, a good selection of the hoist will likely give the impact to the machine. If the hoist selected does not have enough lifting force to lift the load, the objectives of the machine creation will not be achieved. To obtain a good and suitable hoist for the use of the machine, an analysis can be made in order to help in the selection of the hoist.

In this paper, the information of the bus door width and the height of the bus platform from the ground are taken from the Universiti Teknikal Malaysia Melaka (UTeM) bus. The UTeM bus selected is a high-floor bus where the stairs are steep in position. Figure 3.24 shows the type of UTeM bus that has been selected in order to collect information regarding a bus while Figure 3.25 shows the stair of the bus.

Figure 3.24: The type of UTeM bus that had been selected.

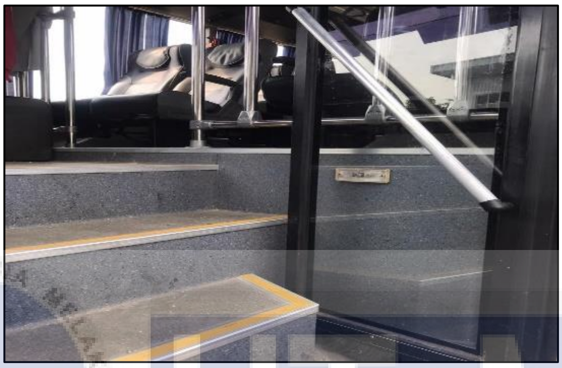
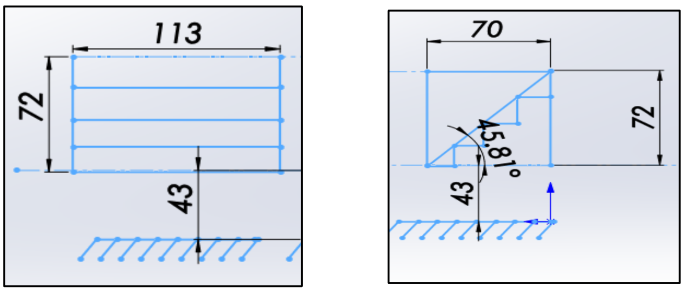


Figure 3.25: The stair of the selected UTeM bus.

3.7.1 Dimension of the bus door.

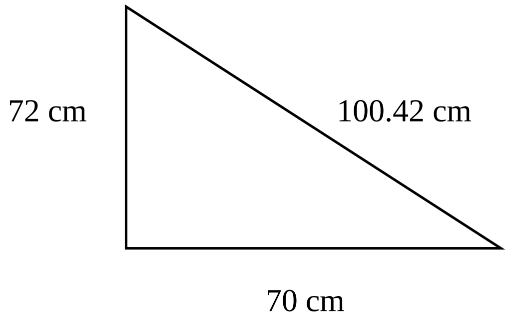
Figure 3.26 below are the bus door dimension which has been measured (in centimetre, cm) and collected from the selected UTeM bus.



(a) (b)

Figure 3.26: (a) The front view of the UTeM bus stair, (b) The side view of the UTeM bus stair.

Based on the figures, the angle of the stair are calculated as follow:



By using the Pythagoras theorem,

$$\sqrt{72^2} + \sqrt{70^2} = 100.42\ cm$$

To obtain the stair angle,

$$\tan\theta = \frac{72}{70}$$

$$\theta = \tan^{-1}\frac{72}{70}$$

$$= 45.81°$$

3.7.3 Calculation in determining the lifting force of the load.

In order to determine the force required to lift the load, a simple calculation on the FBD of the machine can be done. The friction force in the calculation is considered frictionless as the machine use rollers to move up and down. Figure 3.27 shows the FBD of the machine.

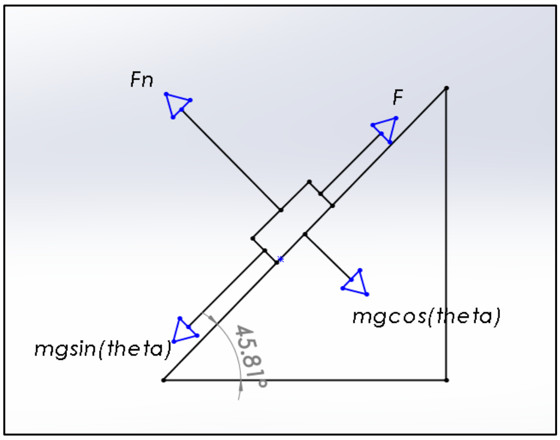


Figure 3.27: The FBD of the machine.

$$Angle\ of\ machine\ platform\ =\ 45.81^{\circ}$$

$$Assume\ mass, m =\ 170\ kg$$

$$(\nwarrow) \sum F_y = 0$$

$$FN - mgcos\theta\ = 0$$

$$FN = (170)(9.81)\cos(45.81)$$

$$FN = 1162.45\ N$$

$$(\nearrow) \sum F_X = 0$$

$$F - mgsin\theta = 0$$

$$F = (170)(9.81)sin(45.81)$$

$$F = 1195.79\ N$$

$$T = F\ x\ d$$

$$T = (1195.79)\ (1.76\cos 45.81)$$

$$T = 1.466\ kNm$$

From the calculation above, the force required to make the load stay in static condition on an inclined plane is 1195.79 N. This information show that in order to lift the load upwards, the force needed must exceed 1195.79 N and with a torque more than 1.466 kNm.

3.7.4 Selection of hoist.

The selection of the hoist must consider the lifting capacity that the hoist can provide. For a safety purposes, the hoist lifting capacity must be more than the heaviest load on the machine (Thomasnet, n.d.). The heaviest load on the machine is 170 kg taken into account the 150 kg load on the platform plus the 20 kg assumption of the platform load part itself. Therefore, the lifting capacity must exceed 170 kg of load for a safety use of the hoist on the machine.

In the market, there are many hoists with different lifting capacity such as 150 kg, 200 kg and 400 kg. For this project, a hoist with 200 kg lifting capacity is selected because it already exceed 170 kg of load plus the cost of the hoist is affordable. Table 3.3 shows the selected 200 kg electric wire hoist and its details (SafetyLiftinGear, n.d.)

Table 3.3: Selected 200 kg electric wire hoist and the details.

Name	Details
 **Electric wire hoist 200kg**	• Electric wire hoist • 200kg / 1962 N of Working Load Limit (WLL) • 18m lift height • 240V power supply • 1.5m pendant length including emergency stop switch • 8 m/min or 0.133 m/s lifting speed (1.27 RPM) • Price is RM 431.45

Based on the Table 3.3, it is stated that the WLL of the hoist is 200 kg or 1962 N. WLL or also known as Safe Working Load (SWL) refers to the load that is safe to be lifted by the lifting machinery without having fear of damaging and breaking the machine. Usually, SWL is 1/5 the value of Minimum Breaking Strength (MBS) or Minimum Breaking Load (MBL) (Industrial Wire Rope, 2020). The MBL of this hoist is refer to the breaking force of the rope. Figure 3.28 shows the technical data of the hoist.

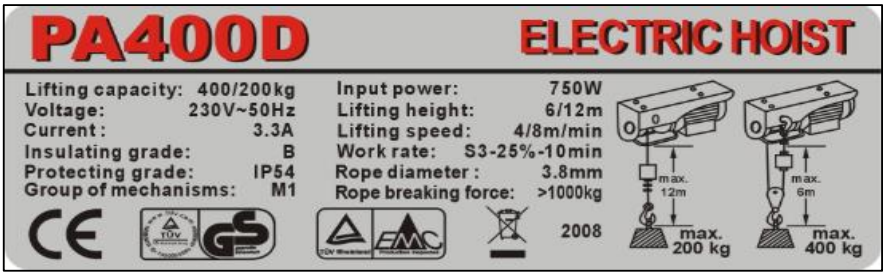


Figure 3.28: The technical data of electric hoist.

From the figure above, the breaking force of the hoist rope is 1000 kg or 9810 N. By using the information collected, the safety factor (SF) of the hoist can be determined. The calculation to determine the SF are as follows:

$$WLL = \frac{MBL}{SF}$$

$$SF = \frac{MBL}{WLL}$$

$$WLL = \frac{9810}{1962}$$

$$SF = 5$$

A safety factor of five shows that the electric hoist is safe to be used. The hoist will likely manage to withstand five times of the SWL but it is not recommended and may bring dangerous and harm when in use.

3.7.2 Tipping calculation of the machine.

The stability of the machine is one of the most important factor to be considered in the calculation analysis. A calculation in determining the force required to make the machine tip over must be taken into consideration in order to make sure the safety of users are keep to safe. Figure 3.29 shows the estimation of total mass of the machine in the mass properties of SolidWorks 2016.

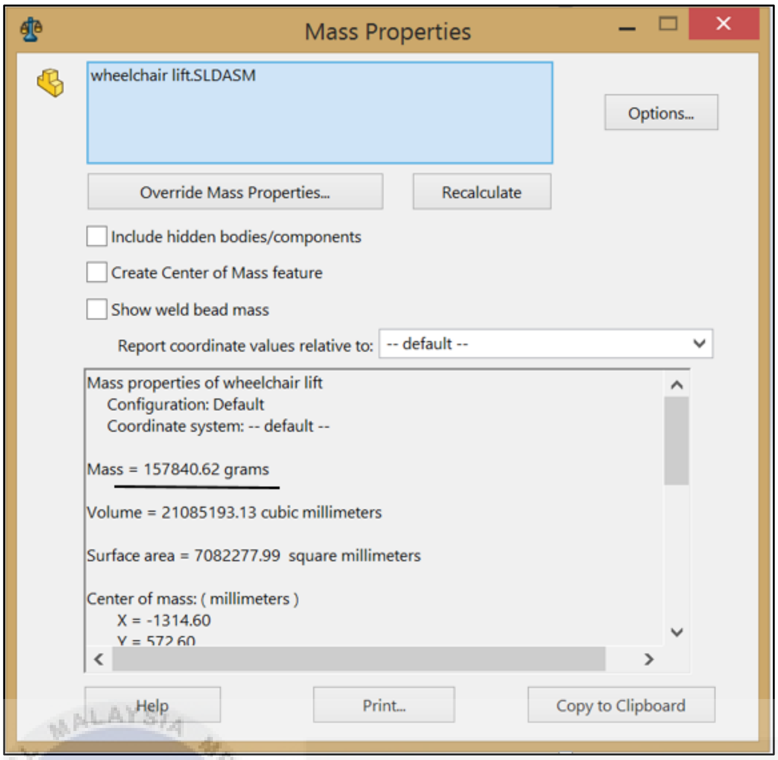


Figure 3.29: Estimation of the machine mass in mass properties SolidWorks 2016.

Based on the figure above, it is estimated that the total mass of the machine is 157.84 kg and being round off to 160 kg. Using the information obtained, a calculation to determine the tipping force can be done as follow:

$$Mass, m = 160\ kg$$

$$Weight, Wm = mg$$

$$= (160)(9.81)$$

$$= 1570\ N$$

The average mass of 200 kg electric hoist is around 10 kg to 11 kg. Therefore, by considering the mass of the hoist is 11 kg,

$$Weight, Ww = mg$$

$$= (11)(9.81)$$

$$= 107.91\ N$$

$$Total\ Weight, Wtotal = Wm + Ww$$

$$= 1570 + 107.91$$

$$= 1677.51\ N$$

A simple free-body diagram (FBD) in Figure 3.30 has been produced in order to calculate the force needed to make the machine tip over. In the FBD, the platform use to lift users exceed the middle height of the lifting. The calculation to determine the required force are as follows:

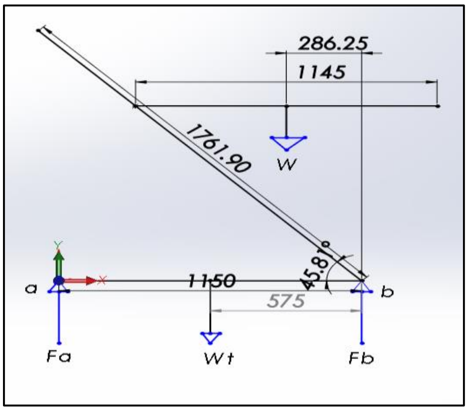


Figure 3.30: FBD of machine.

By assuming moment at point b in positive counter-clockwise direction,

$$\sum Mb = 0$$

$$0.575\ Wtotal + 0.286W = 0$$

$$W = \frac{-0.575\ (1677.51)}{0.286}$$

$$= -3373\ N$$

The value of W is -3373 N where it indicates that the moment direction where tipping will occur is on the clockwise direction. Fa in this moment calculation is considered 0 because the point does not touch the ground.

$$W = mg$$

$$m = \frac{W}{g}$$

$$= \frac{3373}{9.81}$$

$$= 344\ kg$$

From the calculation, it would needs mass about 344 kg on the platform in order to make the machine tip over.

CHAPTER 4

RESULTS AND ANALYSES

4.1 INTRODUCTION

In this chapter, the results of the simulation and analysis on the product will be explained. Analyses such as motion study analysis and finite element analysis has been conducted on the product in order to obtain the workability information of the product design. The product design is analysed by using the SolidWorks 2016 software.

4.2 MOTION STUDY ANALYSIS

4.2.1 Trace Path Analysis

From the SolidWorks 2016 software, a trace path analysis of the lifting process has been conducted. This trace path analysis is conducted in order to observe the lifting pattern in the lifting process. Figure 3.27 shows the trace path line of the product design.

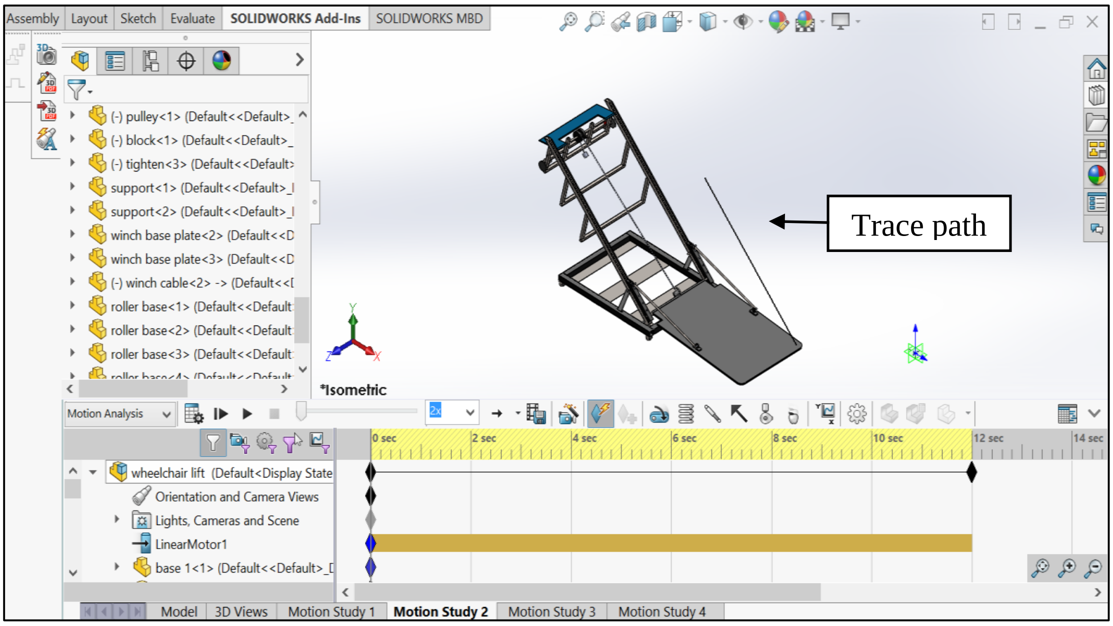


Figure 4.1: Trace path line of the product design.

From the figure above, it is shown that the flow path of the lifting process is linear and stable. This shows that when the product design lift a load, the flow will be smooth and it will help in the stability in the lifting process.

4.2.2 Linear Velocity Analysis

With the use of the linear velocity analysis, the velocity of the lifting process can be obtained. A gravity force valued 9.81 N and the motor speed valued 1.27 RPM which has been selected in section 3.7.4 Selection of Hoist are used in order to observe the lifting velocity of the design platform. The platform has been loaded with 1195.79 N of load based on the previous calculation. Figure 3.28 shows the analysis of linear velocity of the product design.

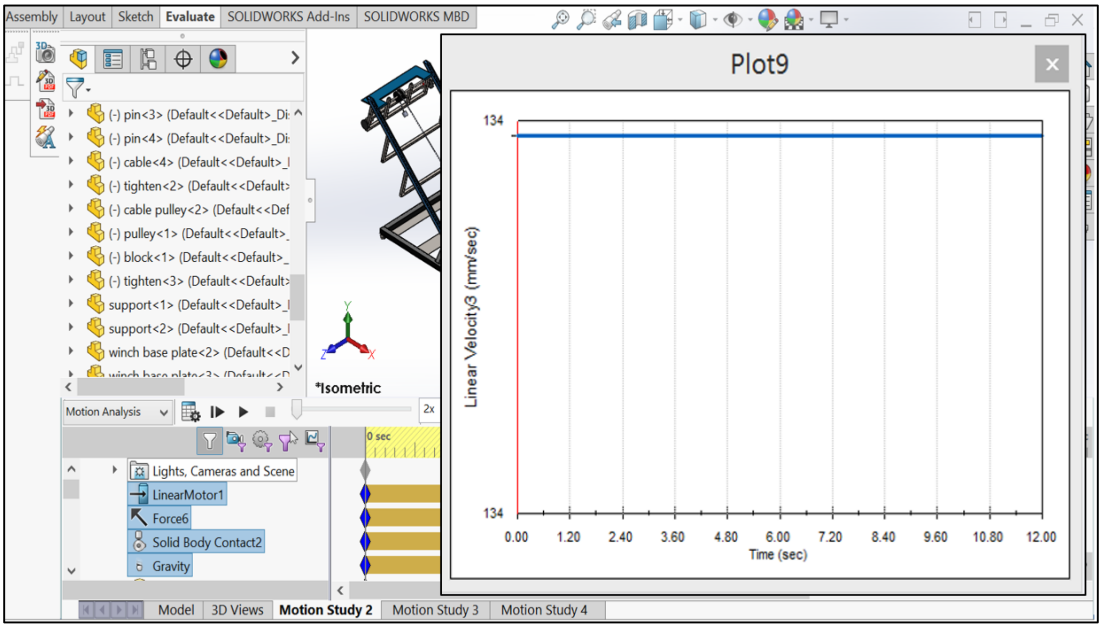


Figure 4.2: Linear velocity analysis of the product design.

From the result obtained through the analysis, it is proved that a 200 kg hoist with a 1.27 RPM of speed manages to lift 1195.79 N of load. The lifting process takes around 12 seconds from the bottom to reach the top. This is quite logical because a 200 kg hoist has 0.133 m/s speed where 0.133 times 12 will give 1.60 m and the value is same with the length of the rail. In the analysis, the lifting velocity is 134 mm/s or 0.134 m/s and it is constant over time as the path of the lifting is linear and stable.

4.2.3 Linear Acceleration Analysis

For the linear acceleration analysis, the restrictions are the same which are 9.81 N of gravity, 1.27 RPM of motor speed and 1195.79 N of load. Figure 3.29 shows the result of the analysis.

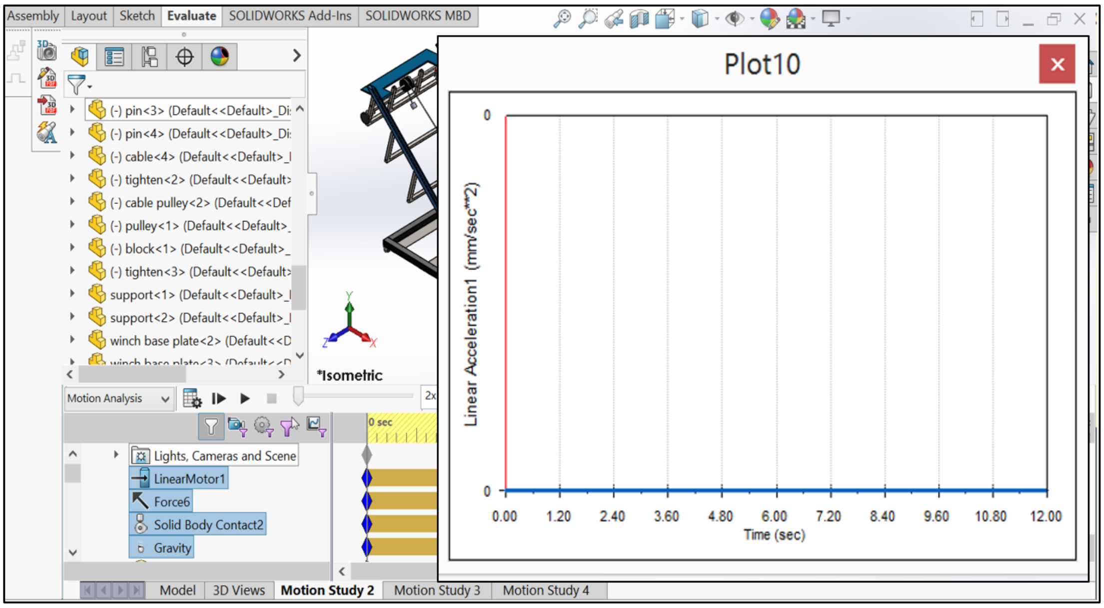


Figure 4.3: Linear acceleration analysis of the product design.

According to the figure above, it is shown that the acceleration of the lifting process is 0 m/s^2. The acceleration is null because from the previous analysis, we obtain a constant and uniform velocity.

4.2.4 Force Analysis

The force analysis is perform in order to obtain the estimated force required to lift 1195.79 N of load. From the previous calculation in 3.7.3 Calculation in determining the lifting force of the load, the force must exceed 1195.79 N to make sure the lifting manage to occur. Figure 3.30 shows the result of the force analysis.

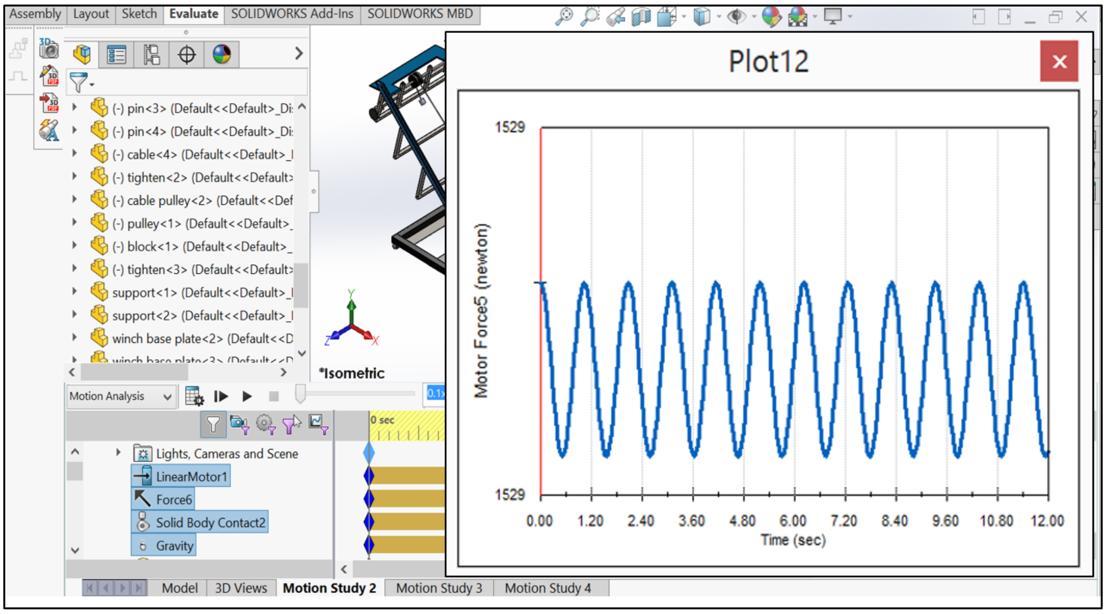


Figure 4.4: Force analysis of the product design.

According to the Plot 12 graph in the figure above, it is shown that the force obtained is 1529 N which is exceed far from the minimum force value required to perform the lift. The force is also constant over time as the path of lifting flow is linear and stable.

4.3 FINITE ELEMENT ANALYSIS

When a component is applied with force and stress, a computerized analysis program can be used to analyse the related data information and the program is known as finite element analysis (FEA). Before analysing the component, a meshing gird must be applied onto the component and the component materials must be considered. The smaller the size of the grid will produce a better and precise value of stress data. Through FEA, the material strength, Von Mises stress and stress distribution on the component can be identified. For this product, the analysis are divided into two part which are part A and part B.

4.3.1 Part A analysis

Part A consist of several components which are the lift platform, cables, rod and the platform support. Figure 4.5 shows part A of the product design.

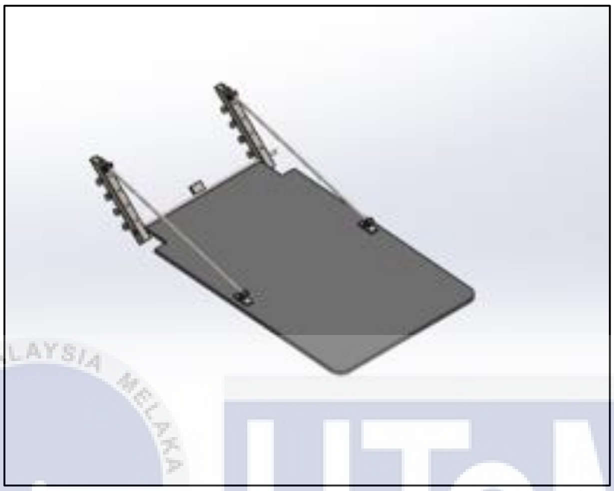
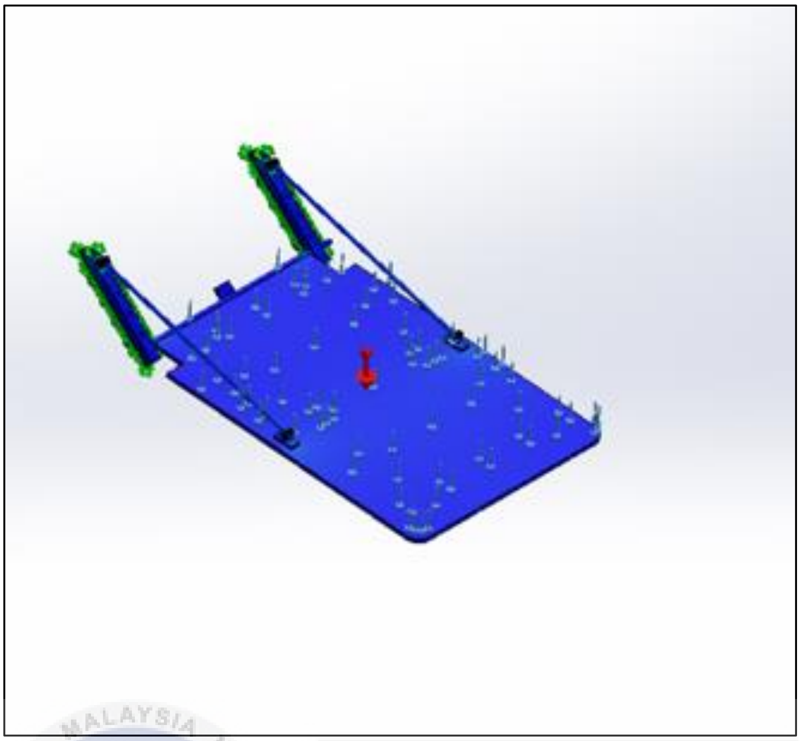


Figure 4.5: Part A of product design.

The rollers and the platform support are fixed at their position to imitate the movement of the rollers on the rail when it stopped moving. Then, the platform has been loaded with 1195.79 N of load to imitate the maximum load that the product design can hold in a lifting process. A 9.81 m/s^2 gravity is also applied in this analysis. Figure 4.6 (a) shows the results of the analysis, Figure 4.6 (b) shows the maximum and minimum stress value of part A while Figure 4.6 (C) shows the properties of part A.



(a)

Name	Type	Min	Max
Stress1	VON: von Mises Stress	8.698e+001N/m^2 Node: 224804	3.287e+008N/m^2 Node: 16936

(b)

Properties	
Name:	Alloy Steel
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	6.20422e+008 N/m^2
Tensile strength:	7.23826e+008 N/m^2
Elastic modulus:	2.1e+011 N/m^2
Poisson's ratio:	0.28
Mass density:	7700 kg/m^3
Shear modulus:	7.9e+010 N/m^2
Thermal expansion coefficient:	1.3e-005 /Kelvin

(c)

Figure 4.6: (a) Results of the analysis, (b) The maximum and minimum stress value of part A, (c) Properties of part A.

From Figure 4.6 (b), the maximum stress obtained after being loaded with 1195.79 N is 3.287 x 10^8 N/m^2. The yield strength of the platform part is 6.204 x 10^8 N/m^2 as shown in Figure 4.6 (c). The FS for this part can be calculated using the information gathered.

$$\text{FS} = \frac{\sigma_{yield\ strength}}{\sigma_{maximum\ strength}}$$

$$FS = \frac{6.204 \times 10^8}{3.287 \times 10^8}$$

$$FS = 1.89\ \ >1$$

From the FS calculation, the value 1.89 is higher than 1 and the result shows that it is safe to use the lifting platform part of the product design with the maximum load.

4.3.2 Part B analysis

For part B, it consists of components such as base, base plat, rails, stand 1 and 2, tighten, pulley rod, pulley and ramp. Figure 4.7 shows the part B.

Figure 4.7: Part B of product design.

In part B, the fixed components are rollers at the base, tighten and the supports of the rails. The roller base are fixed to imitate a static condition of the product while the tighten are fixed to imitate a fixed condition of the component to the stair wall. The rail supports are fixed to show that both supports will connect the base and the rails in a fixed condition. The force is applied at the rails in X-direction of the maximum lifting load which is 833.52 N. Gravitational force 9.81 m/s^2 is applied in the simulation. Figure 4.8 shows the FBD of the load while Figure 4.9 (a) shows the results of the analysis, Figure 4.9 (b) shows the maximum and minimum stress value of part B and Figure 4.9 (C) shows the properties of part B.

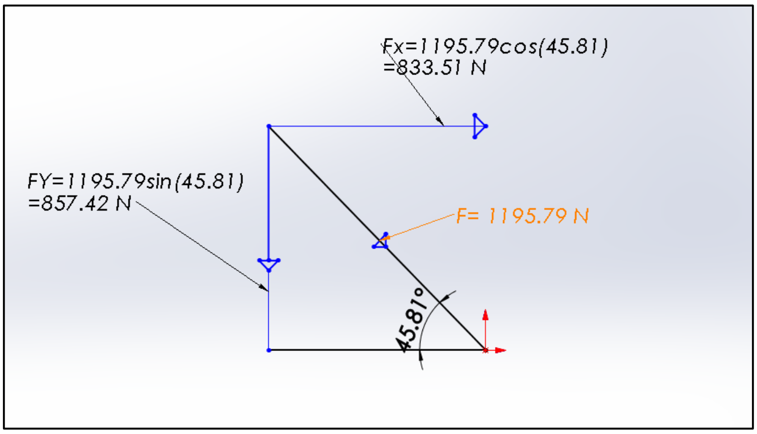
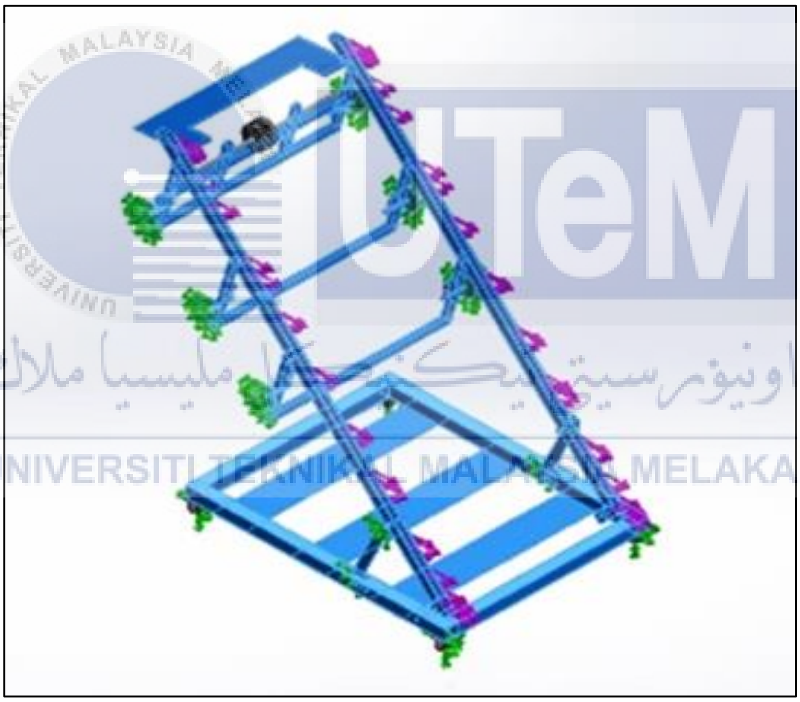


Figure 4.8: FBD of the load.



(a)

Name	Type	Min	Max
Stress1	VON: von Mises Stress	9.882e+000N/m^2 Node: 276350	9.652e+007N/m^2 Node: 155642

(b)

Properties	
Name:	Alloy Steel
Model type:	Linear Elastic Isotropic
Default failure criterion:	Unknown
Yield strength:	6.20422e+008 N/m^2
Tensile strength:	7.23826e+008 N/m^2
Elastic modulus:	2.1e+011 N/m^2
Poisson's ratio:	0.28
Mass density:	7700 kg/m^3
Shear modulus:	7.9e+010 N/m^2
Thermal expansion coefficient:	1.3e-005 /Kelvin

(c)

Figure 4.9: (a) Results of the analysis, (b) The maximum and minimum stress value of part B, (c) Properties of part B.

From Figure 4.9 (b), the maximum stress obtained after being loaded with 1195.79 N is 9.652 x 10^7 N/m^2. The yield strength of the platform part is 6.204 x 10^8 N/m^2 as shown in Figure 4.6 (b). The FS for this part can be calculated using the information gathered.

$$FS = \frac{\sigma_{yield\ strength}}{\sigma_{maximum\ strength}}$$

$$FS = \frac{6.204 \times 10^8}{9.652 \times 10^7}$$

$$FS = 6.43 \ >1$$

The FS value is 6.43 which is higher than 1 and the result indicates that it is safe to use part B of the product design to lift a load.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter, the results obtained from the simulation and analysis will be summarized and the conclusion of this project is stated. Moreover, some recommendations to improve the product design also will be discussed.

5.2 CONCLUSION

As a conclusion, this Hoist Wheelchair Lift has successfully achieved the objectives. The new concept design of this product can be used to transport PWD into the standard bus that has a high stairs. This product design uses a one wheel pulley because it is suitable to be used at a limited space between the rail and the stairs. The simulation and the analysis of the design are run through the SolidWorks 2016 software. Based on the simulation and analysis outcome, it is proved that this product design can function well and safe to use. The trace path analysis shows that the platform movement is linear and stable with a speed of 0.134 m/s. With a maximum load 1195.79 N, the motion analysis shows that with the force, speed and the power of the 200 kg hoist it is capable to lift the load on the platform.

Moreover, the acceleration is 0 m/s^2 because of a constant and stable velocity. Next, through the force analysis it is shown that the lifting force is much higher than the minimum force required to lift the load. Lifting force 1529 N definitely will be able to lift 1195.79 of load. In the FEA, the product safety of factor has been determined. It is proved that the use of this product design is safe as the FS obtained is more than value 1. Based on the analysis and simulation, the product design will have no problem in lifting PWD to get into the bus.

5.3 RECOMMENDATION

Due to the Covid-19 pandemic, the fabrication of the product design cannot be continued and the comparison between simulation and real life situation cannot be made. Therefore, a proper fabrication of the product design can be made in the future to enable the comparison. Moreover, the use of different numbers of pulley wheel with some changes in design might help to decrease the lift force. Then, the simulation and analysis of the product design can be done more precisely using the software such as Ansys and Autodesk Inventor.

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APPENDICES

APPENDIX A

Survey Questionnaire

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN MEKANIKAL

BORANG SOAL SELIDIK BERKAITAN PENGGUNAAN MESIN UNTUK MEMBANTU PENGGUNA KERUSI RODA MENAIKI BAS

PENYELIDIK: MUHAMMAD ASIF ASYRAF BIN ABDUL NASIR

I. Borang soal selidik ini bertujuan untuk mengumpul maklumat dan mengkaji berkaitan penggunaan sesuatu mesin bagi membantu pengguna kerusi roda untuk menaiki bas.

II. Segala maklumat yang diperolehi melalui soal selidik ini akan dirahsiakan dan digunakan bagi kepentinga Projek Sarjana Muda (PSM) Fakulti Kejuruteraan Mekanikal sahaja.

III. PSM yang bakal dijalankan adalah mengenai mesin untuk membantu pengguna kerusi roda untuk msuk ke dalam bas.

Bahagian A – Maklumat Diri

Arahan: Sila baca setiap kenyataan dengan teliti dan tandakan (/) pada jawapan anda.

Maklumat diri responden:

1. **Jantina**

a. Lelaki ☐ b. perempuan ☐

2. **Umur**

a. 21-30 tahun   b. 31-40 tahun   c.41-50 tahun   d.50 tahun dan ke atas

3. **Adakah anda pengguna kerusi roda?**

a. Ya   b. Tidak

Bahagian B – Soal Selidik

A)

Arahan: Tandakan (/) pada jawapan anda untuk soalan dibawah.

Soalan	**Ya**	**Tidak**
Pada pendapat anda, adakah pengguna kerusi roda mempunyai kesulitan untuk menaiki bas?		
Adakah kesulitan yang dihadapi menyebabkan pengguna kerusi roda tidak gemar untuk menaiki bas?		
Pernahkah anda melihat mesin yang berupaya untuk mengangkat dan membantu pengguna kerusi roda untuk masuk ke dalam bas?		
Adakah dengan menggunakan mesin dapat memudahkan pengguna kerusi roda untuk masuk ke dalam bas?		
Adakah anda berminat sekiranya mesin tersebut dicipta dan digunakan untuk membantu pengguna kerusi roda?		
Adakah mesin ini berguna untuk membantu pengguna kerusi roda masuk ke dalam bas?		

B)

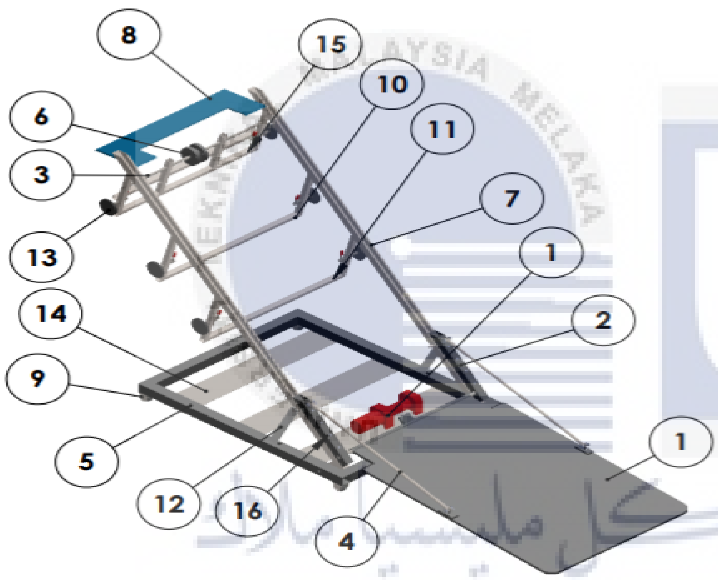
Arahan: tandakan (/) pada jawapan mengikut skala yang ditetapkan.

Skor	1	2	3	4	5
Nilai skor	Sangat rendah	Rendah	Sederhana	Tinggi	Sangat tinggi

Pada pendapat anda, apakah ciri-ciri yang perlu ditepati dalam penciptaan mesin yang berfungsi untuk membantu pengguna kerusi roda untuk masuk ke dalam bas dengan mudah?

Ciri-ciri	**1**	**2**	**3**	**4**	**5**
Pergerakan yang cepat					
Tidak mudah rosak					
Tahan lama					
Mempunyai tahap keselamatan yang baik					

APPENDIX B1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	platform	steel	1
2	platform support	alloy steel	2
3	pulley rod	alloy steel	1
4	cable	steel	2
5	base	alloy steel	1
6	pulley	alloy steel	1
7	rail	alloy steel	2
8	ramp	steel	1
9	roller base	steel,rubber	4
10	stand 1	alloy steel	1
11	stand 2	alloy steel	1
12	support	alloy steel	2
13	tighten	steel,rubber	2
14	base plate	alloy steel	3
15	pulley support	alloy steel	2
16	roller	steel,rubberl	8

	NAME	SIGNATURE	DATE
DRAWN	Muhammad Asif		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE: Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)

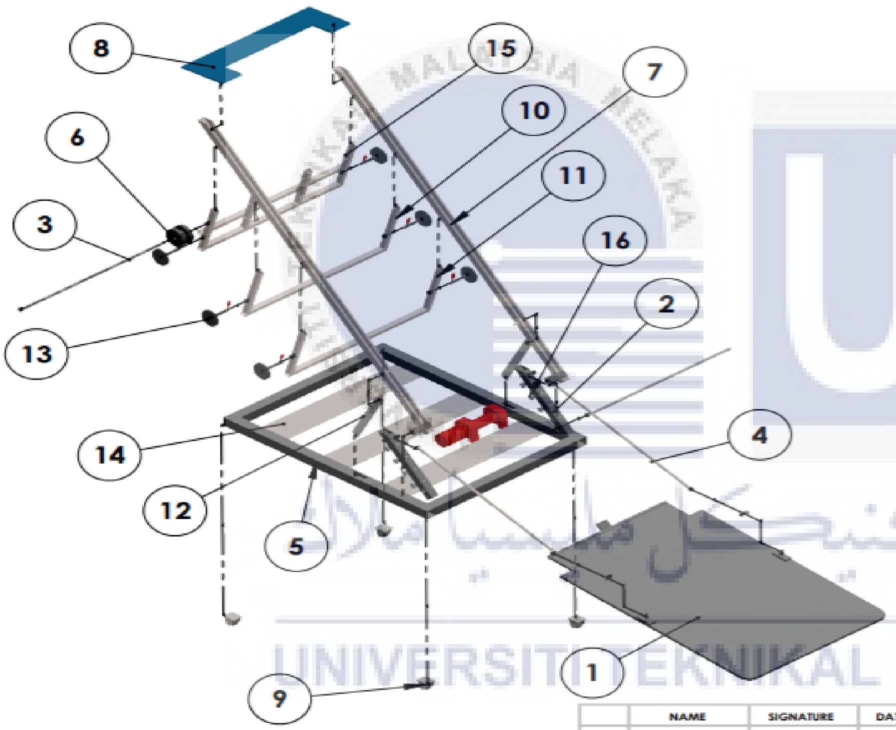
MATERIAL:

DWG NO. **Hoist Wheelchair Lift** A4

Drawing in mm unit

SCALE:1:50 SHEET 1 OF 1

APPENDIX B2



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	platform	steel	1
2	platform support	alloy steel	2
3	pulley rod	alloy steel	1
4	cable	steel	2
5	base	alloy steel	1
6	pulley	alloy steel	1
7	rail	alloy steel	2
8	ramp	steel	1
9	roller base	steel,rubber	4
10	stand 1	alloy steel	1
11	stand 2	alloy steel	1
12	support	alloy steel	2
13	tighten	steel,rubber	2
14	base plate	alloy steel	3
15	pulley support	alloy steel	2
16	roller	steel,rubberl	8

	NAME	SIGNATURE	DATE
DRAWN	Muhammad Asif		
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

Drawing in mm unit

TITLE: Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)

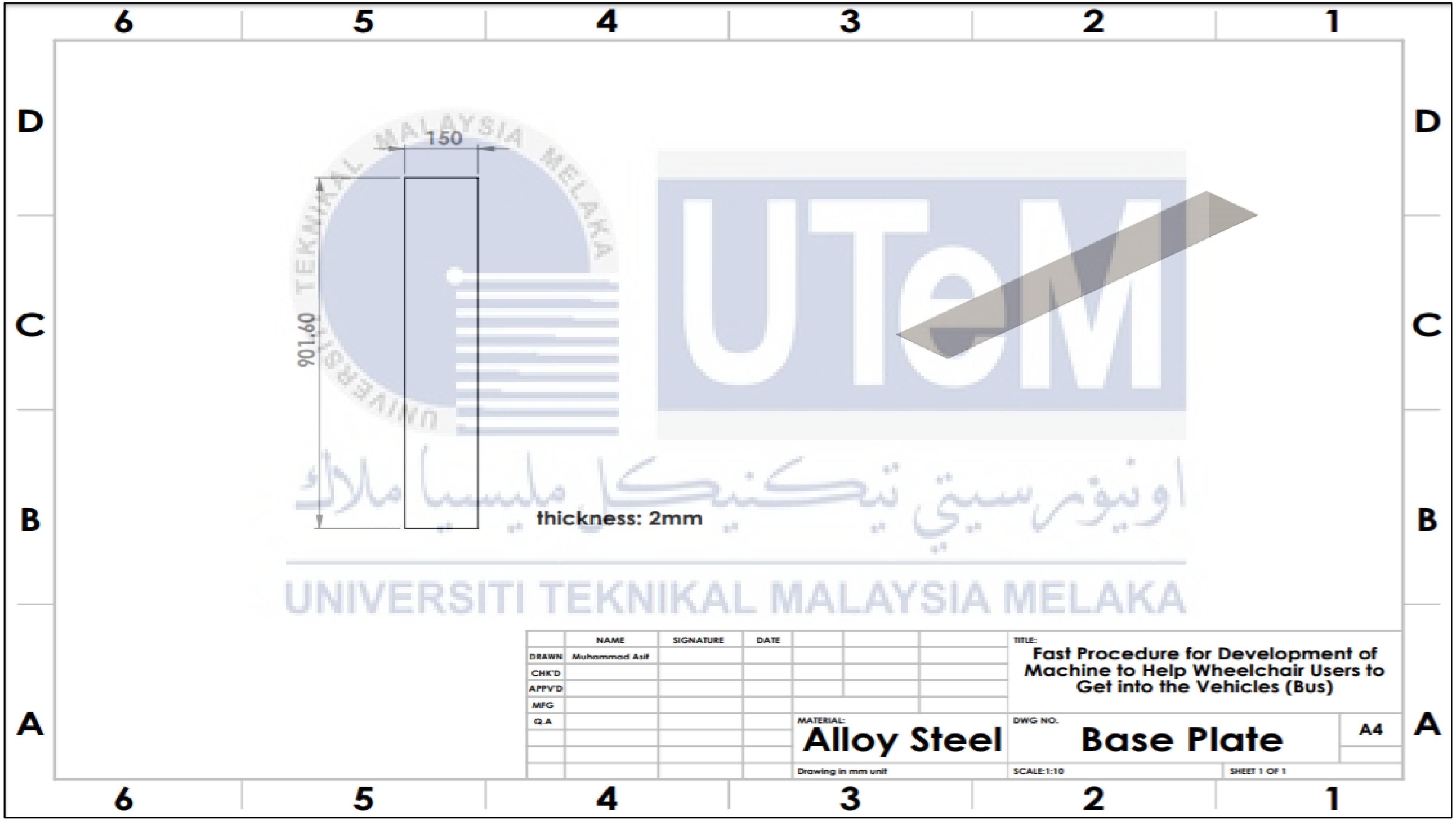
DWG NO. Hoist Wheelchair Lift

A4

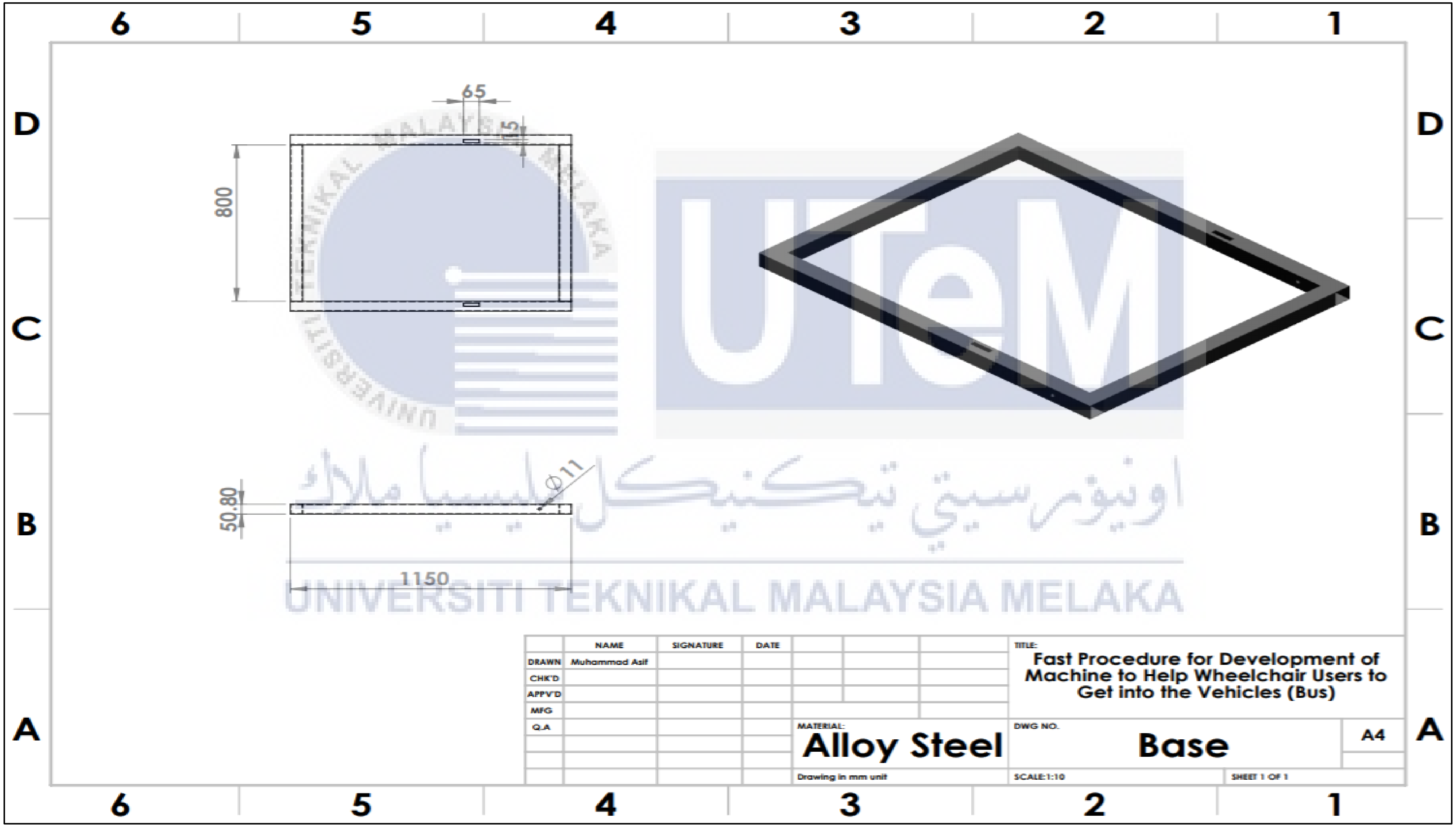
SCALE:1:100

SHEET 1 OF 1

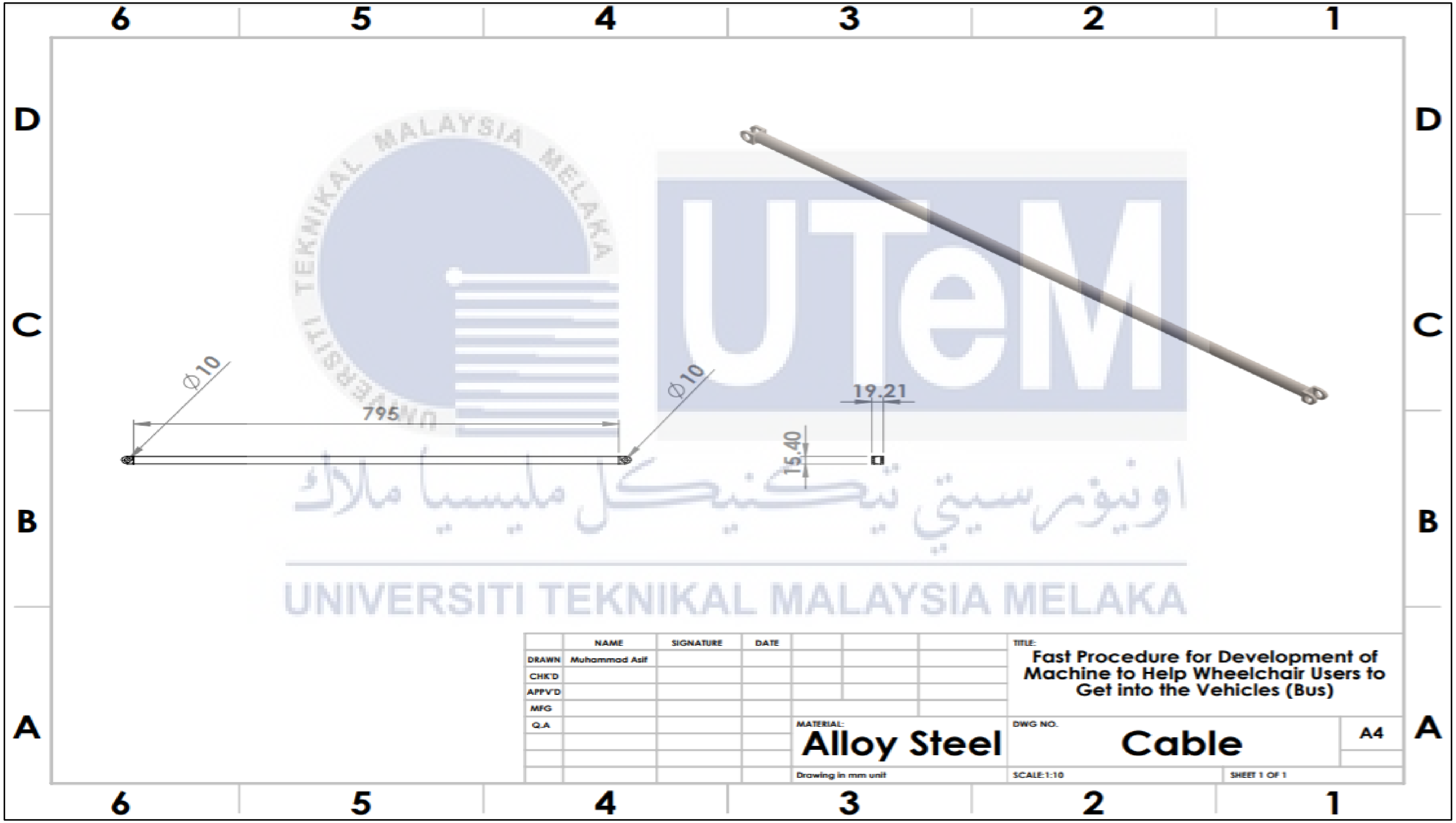
APPENDIX B3


150
901.60
thickness: 2mm
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
Alloy Steel
Drawing in mm unit
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
DWG NO.
Base Plate
A4
SCALE:1:10
SHEET 1 OF 1

APPENDIX B4

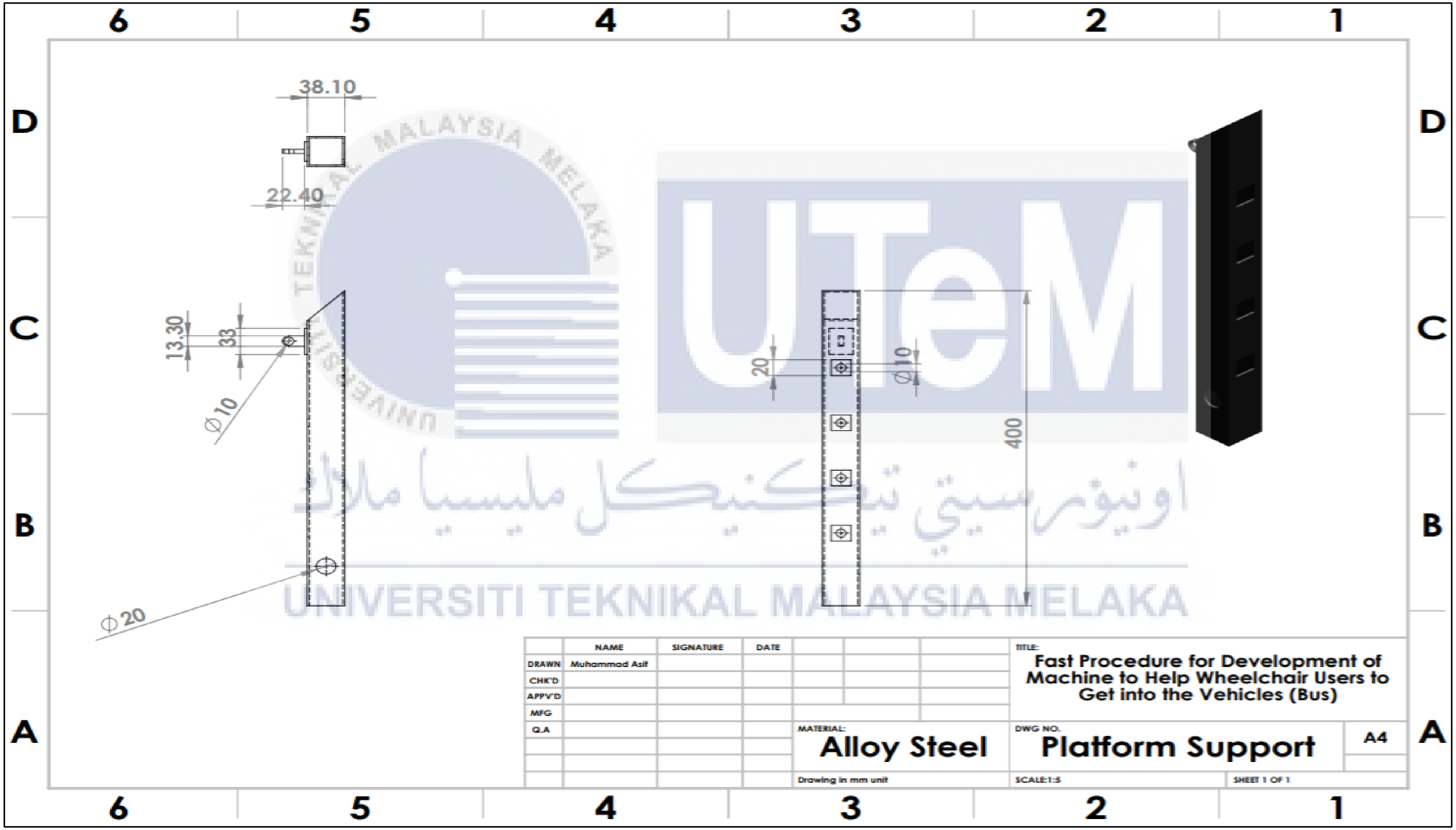

65
15
800
Ø11
50.80
1150
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
MATERIAL:
Alloy Steel
DWG NO.
Base
A4
Drawing in mm unit
SCALE:1:10
SHEET 1 OF 1

APPENDIX B5

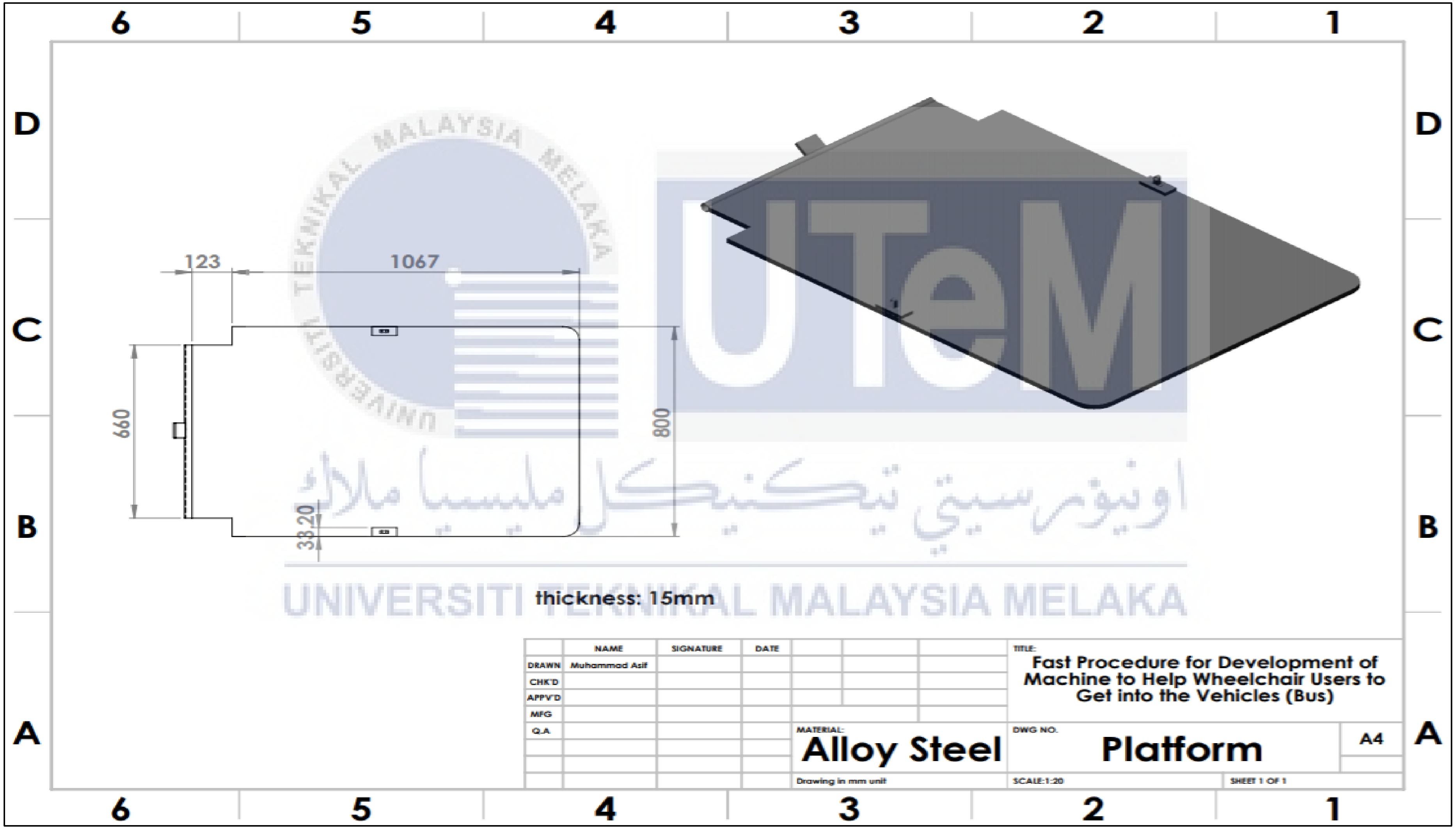


Ø10
795
Ø10
19.21
15.40
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
MATERIAL:
Alloy Steel
DWG NO.
Cable
A4
Drawing in mm unit
SCALE:1:10
SHEET 1 OF 1

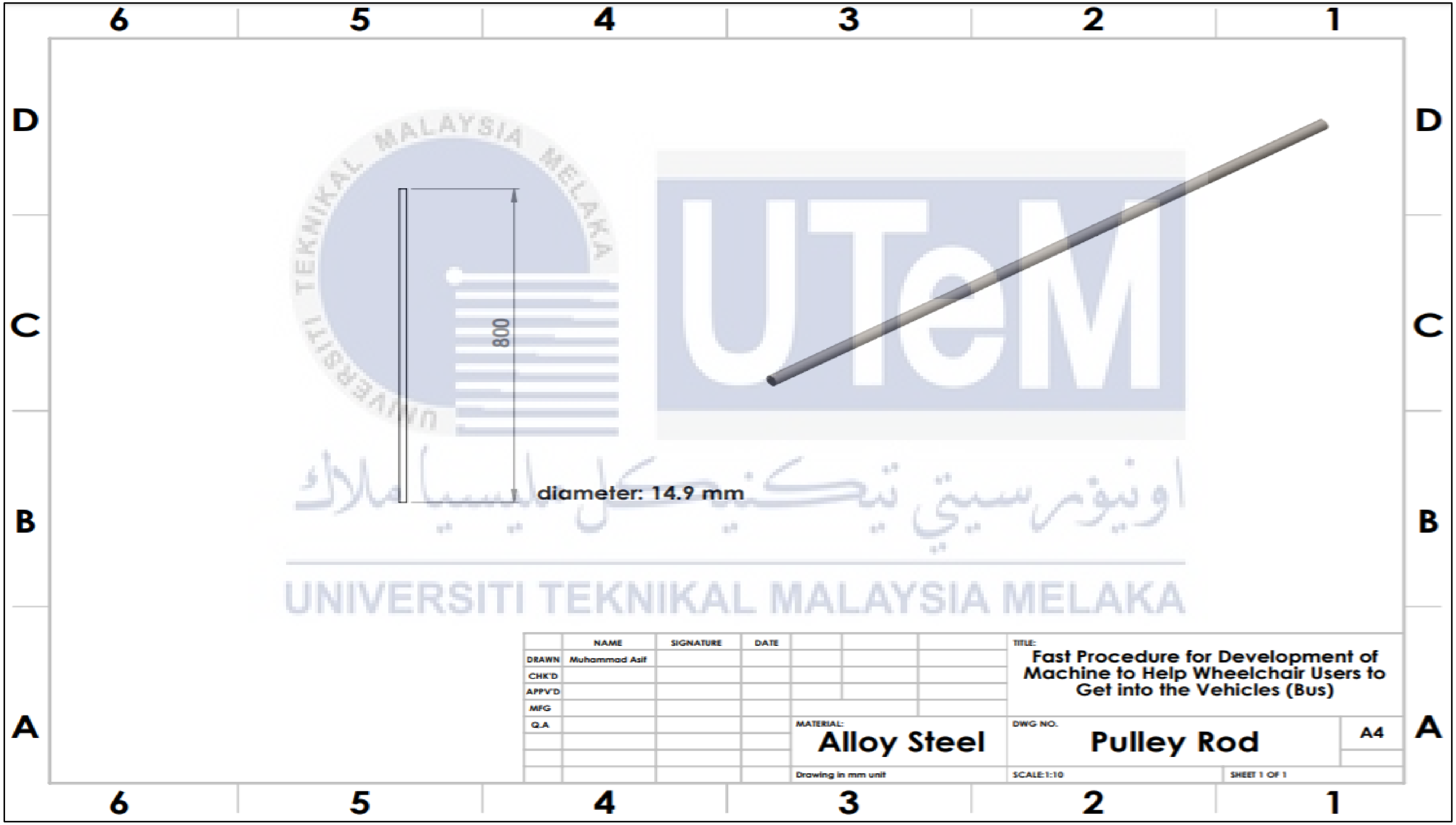
APPENDIX B6


38.10
22.40
13.30
33
⌀10
⌀20
20
⌀10
400
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
MATERIAL:
Alloy Steel
DWG NO.
Platform Support
A4
Drawing in mm unit
SCALE:1:5
SHEET 1 OF 1

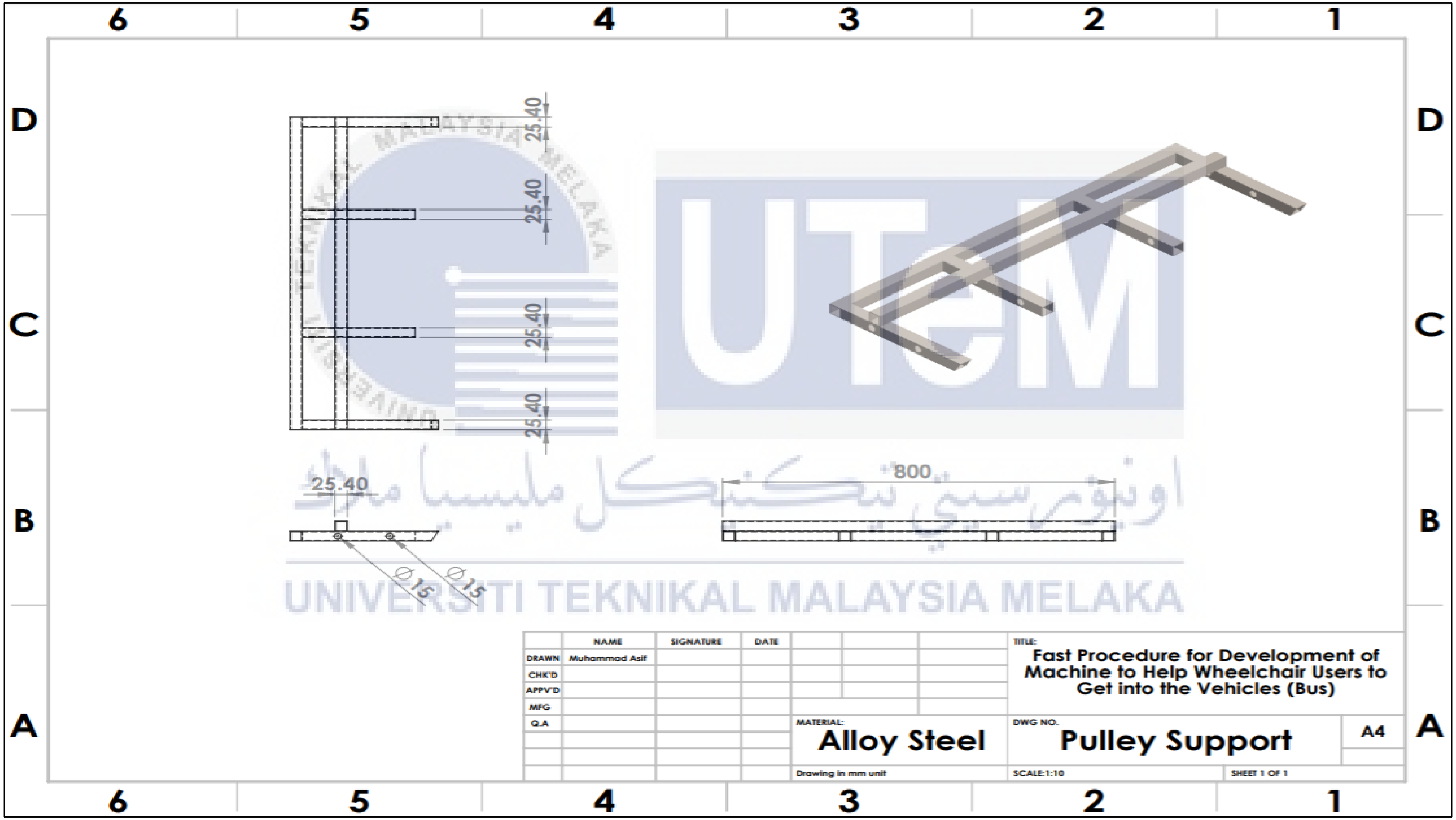
APPENDIX B7


123
1067
660
800
33.20
thickness: 15mm
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
Alloy Steel
Drawing in mm unit
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
DWG NO.
Platform
A4
SCALE:1:20
SHEET 1 OF 1

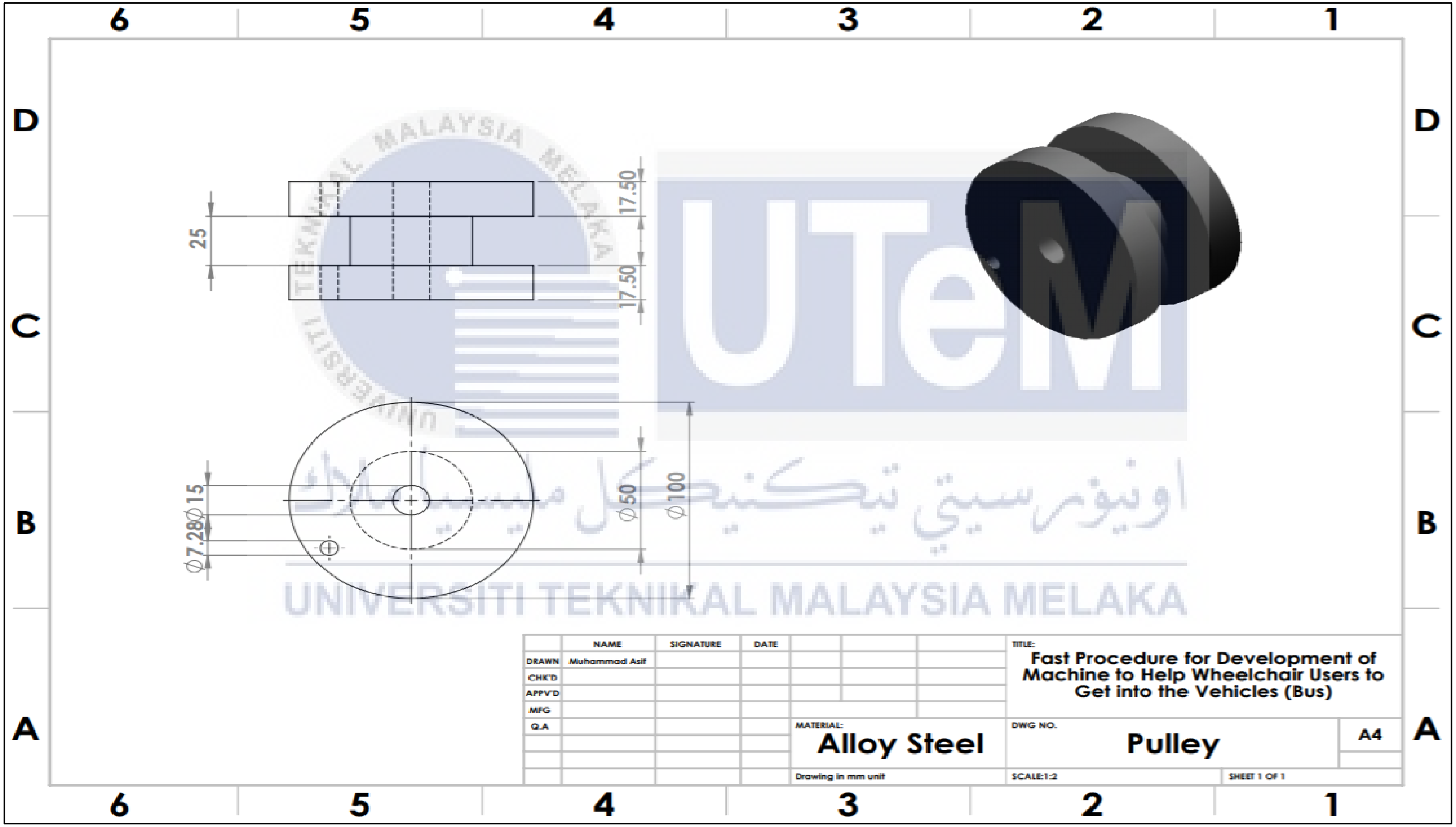
APPENDIX B8


800
diameter: 14.9 mm
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
MATERIAL:
Alloy Steel
DWG NO.
Pulley Rod
A4
Drawing in mm unit
SCALE:1:10
SHEET 1 OF 1

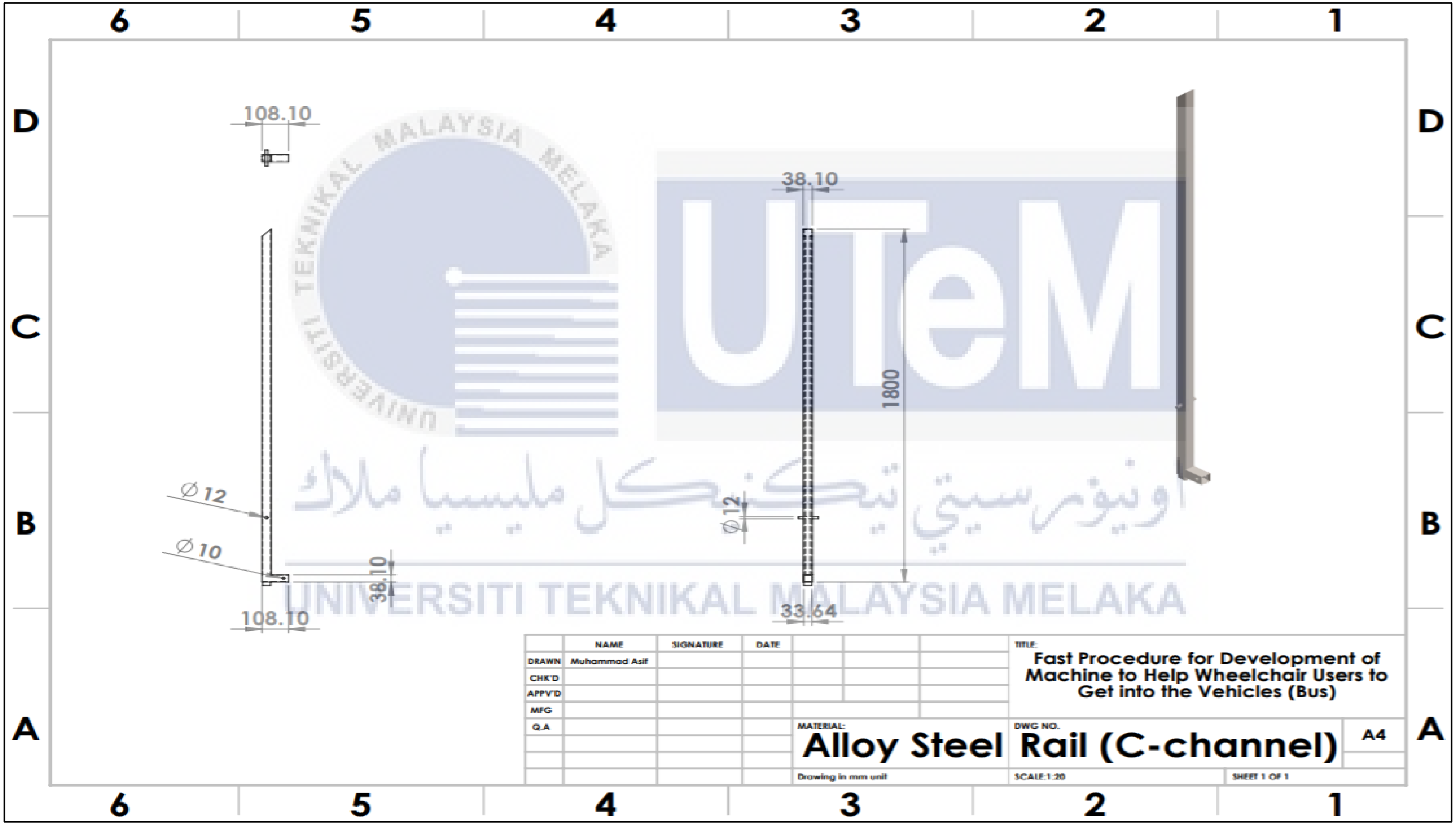
APPENDIX B9


25.40
25.40
25.40
25.40
25.40
⌀15
⌀15
800
NAME
SIGNATURE
DATE
DRAWN
Muhammad Asif
CHK'D
APPV'D
MFG
Q.A
TITLE:
Fast Procedure for Development of Machine to Help Wheelchair Users to Get into the Vehicles (Bus)
MATERIAL:
Alloy Steel
DWG NO.
Pulley Support
A4
Drawing in mm unit
SCALE:1:10
SHEET 1 OF 1
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

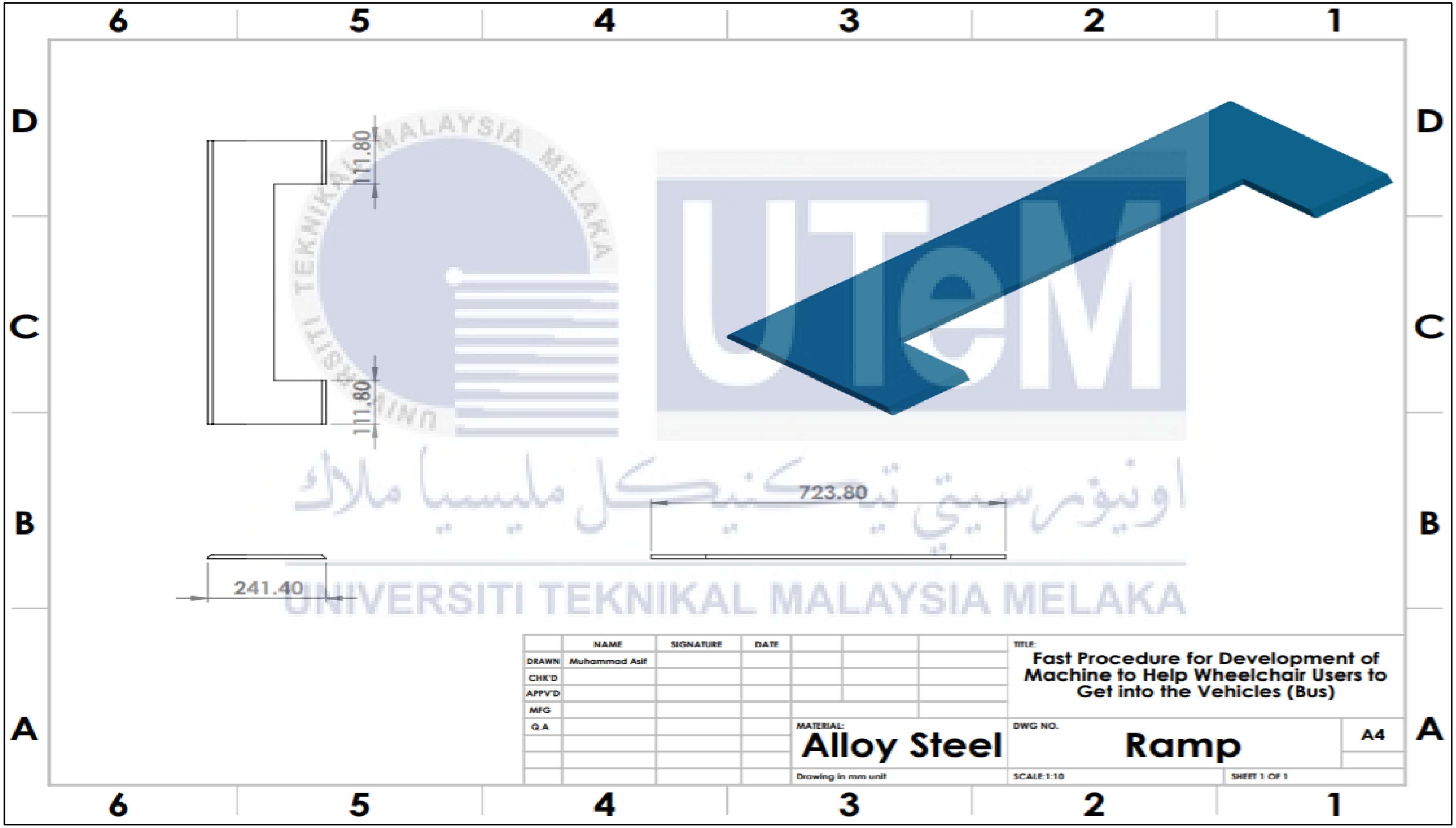
APPENDIX B10



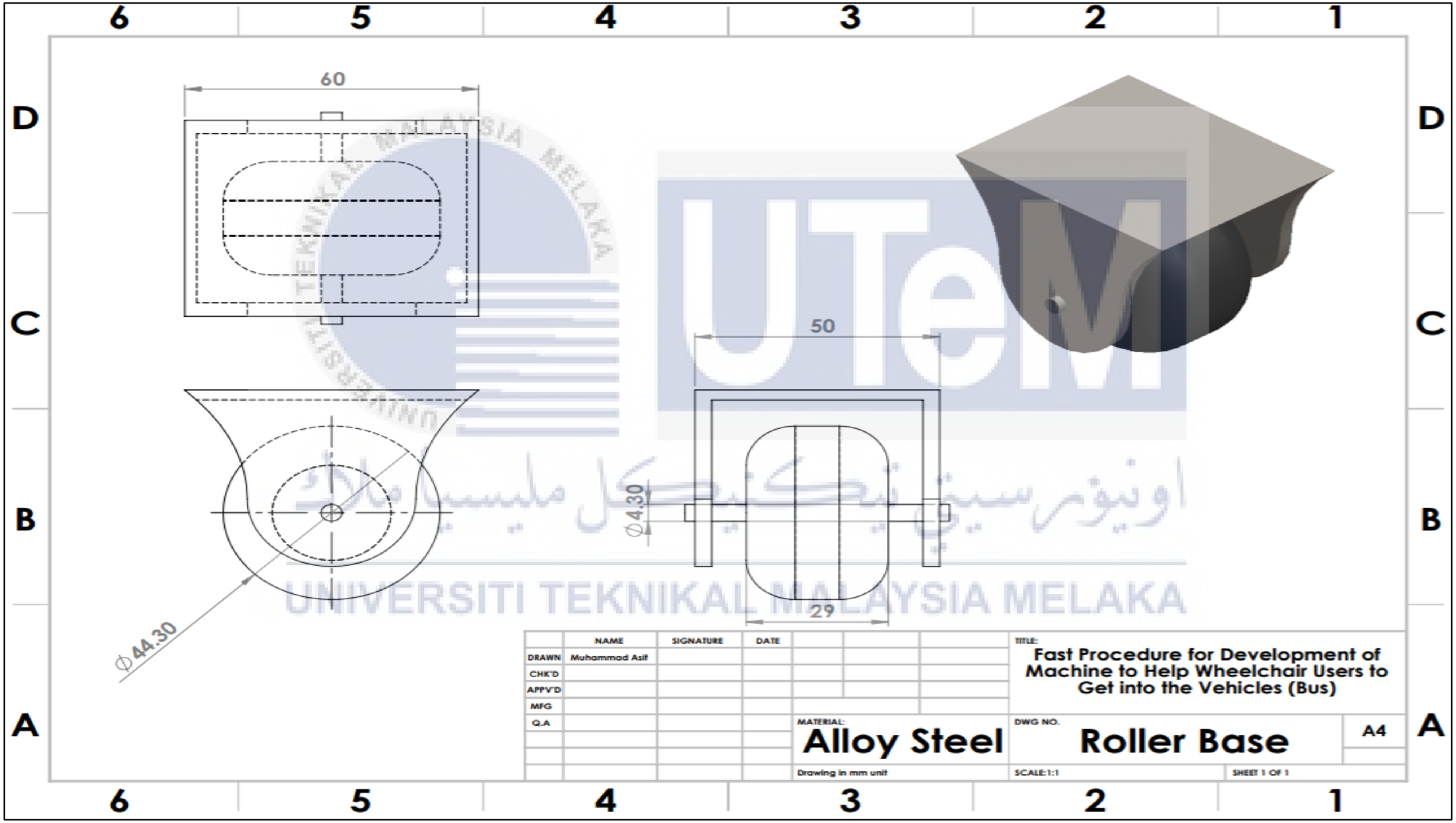
APPENDIX B11



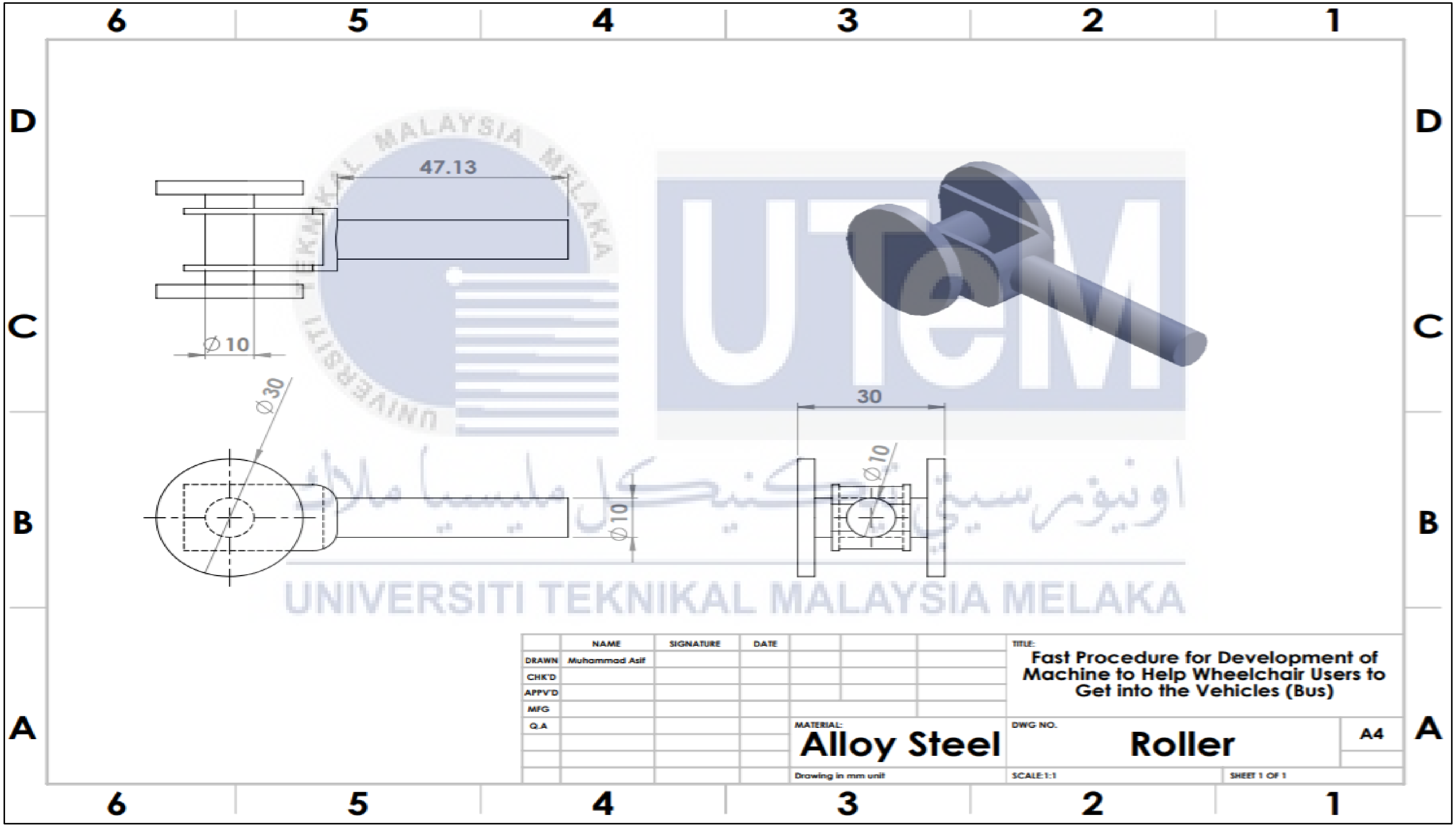
APPENDIX B12



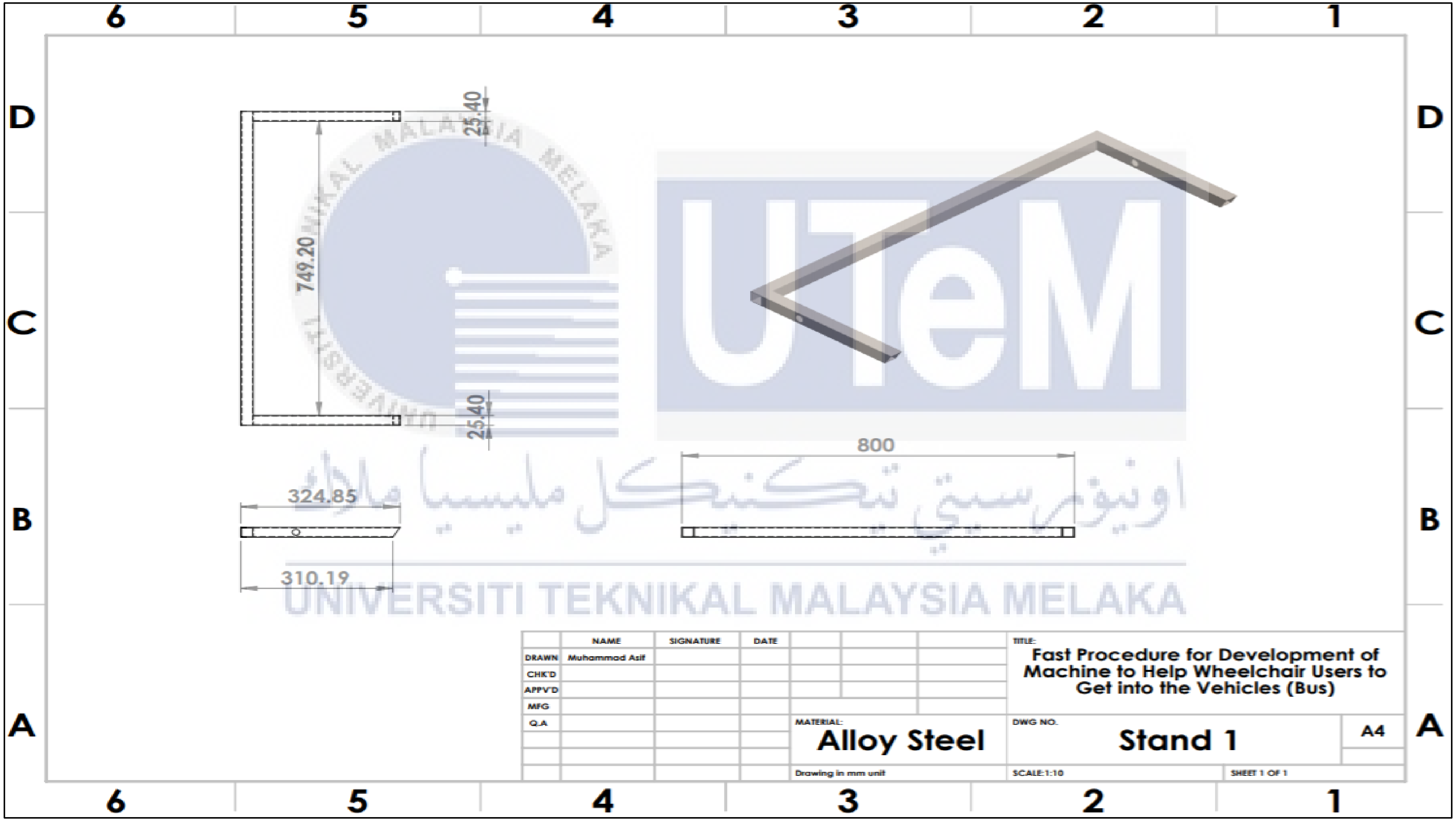
APPENDIX B13



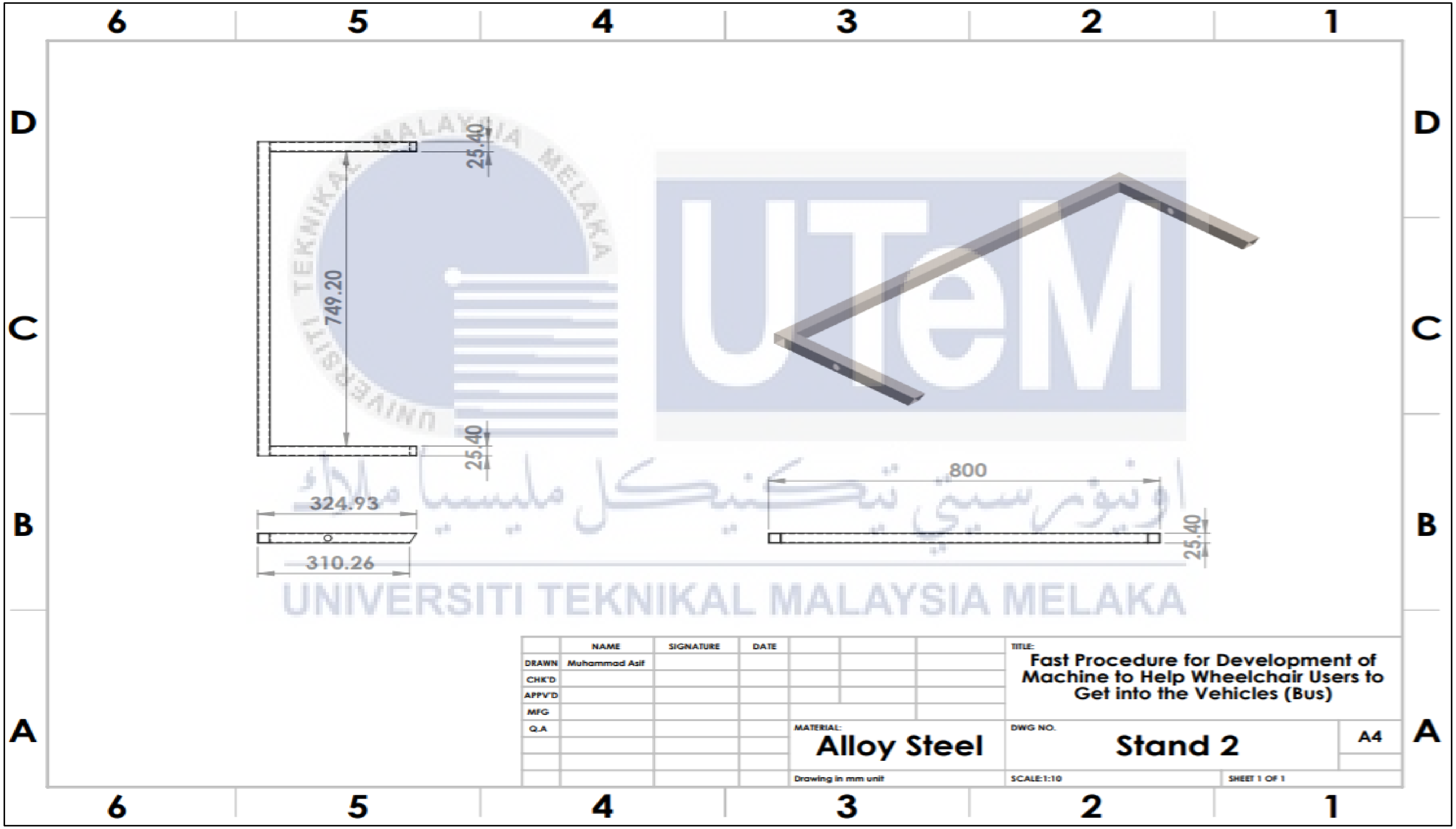
APPENDIX B14



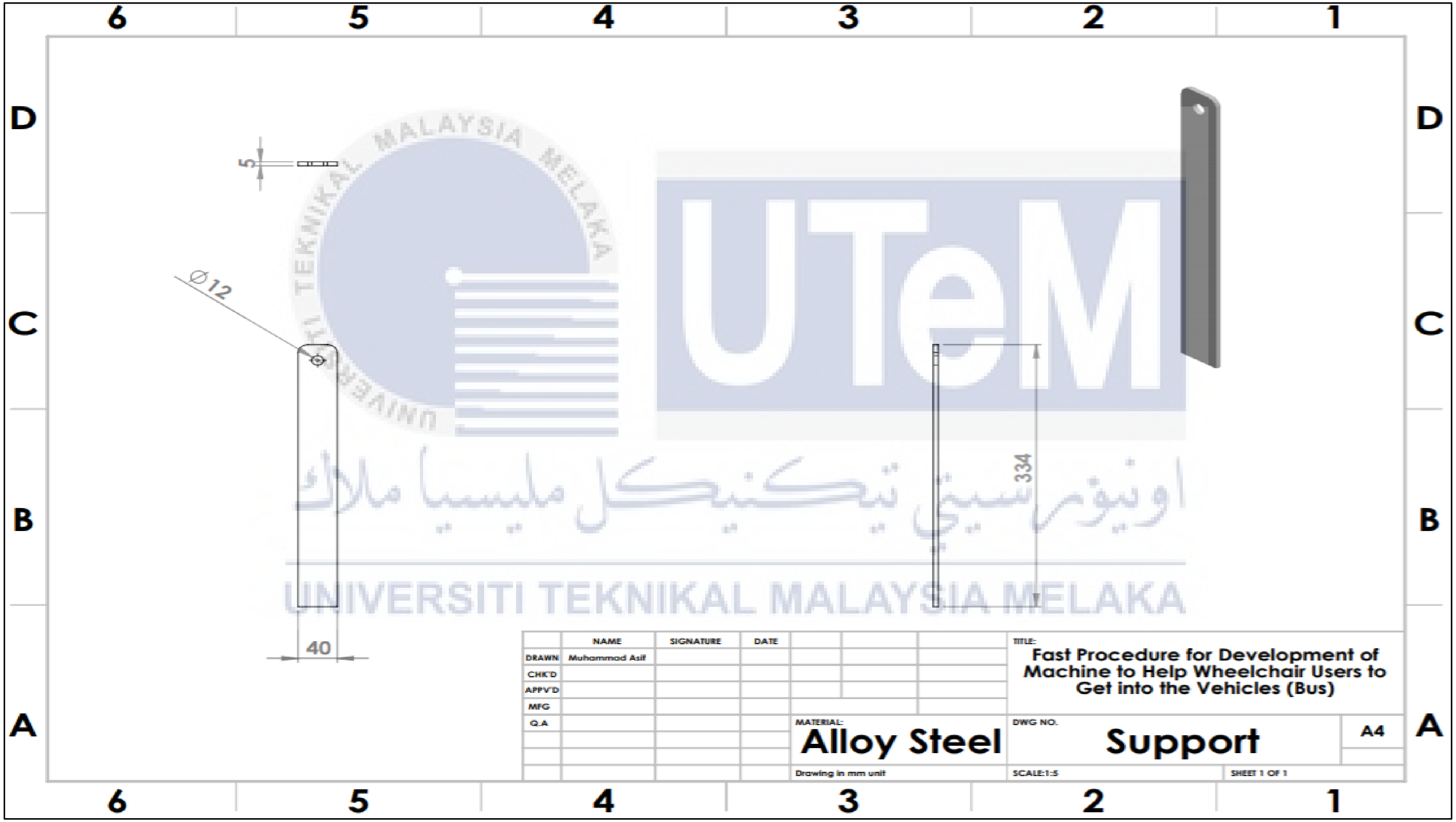
APPENDIX B15



APPENDIX B16



APPENDIX B17



APPENDIX B18