ERGONOMICS DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN CLASSROOM

NUR NADIHA TASHA BT BAKRI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ERGONOMICS DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN CLASSROOM

NUR NADIHA TASHA BT BAKRI

A report submitted
In fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering with Honours

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2019

DECLARATION

I declare that this project report entitled “Ergonomics Design of Walking Chair for Disable Children in Classroom” is the result of my own work except as cited in the references

Signature : _____

Name : _____

Date : _____

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 with Honours.

Signature : _____

Name : _____

Date : _____

DEDICATION

To my beloved father and family

ABSTRACT

The purpose of this research project is to design and perform structural and ergonomics analysis on the walking device for the children with physical disabilities. In accomplishing this study, the literature review was implemented and there are few types of method that have been conducted such as internet research, concept design, concept selection, detail design and software analysis. For the first stage, all of the information or research data for this study have been gathered as the reference. Next, the further study is continued based on the information collected from the observation and interview at Pusat Pemulihan Dalam Komuniti (PDK). The information and data must be related to the objective of the research project. The research is carried on by studying the existing conceptual design of the walking device. The purpose of study the existing concept design is to find the solution based on customer requirement. The ideas of new conceptual design were generated based on the observation and survey at PDK. Moreover, the next stage is analysis of the design. For this project, there are two types of analysis which are Finite Element Analysis and RULA Analysis. Both of this analysis can be performed by using the CATIA analysis software. The selection of material and the load acting on the parts are the main things to consider in order to calculate the factor of safety. RULA analysis is used to investigate the position of body when using the walking device. This analysis will determine either the device is safe to use or not. For this project there are two mannequin used which are man and woman. The result obtained from existing design of standing shows the final score 3 in standing and sitting position. Regarding to the result, the design concept design was created for the improvement. After improvement have been make, the final score for standing, sitting and pushing position is 2 so, the conceptual design was accepted. The study was concluded by finding the future research limitation and identifies the current limitation of the product design.

ABSTRAK

Tujuan utama projek penyelidikan ini dijalankan adalah untuk merekabentuk dan melaksanakan analisis struktur dan ergonomik pada 'Alat Bantuan Berjalan' untuk kanak-kanak yang cacat fizikal. Dalam melaksanakan kajian ini, pelbagai kaedah telah dilaksanakan dan terdapat beberapa jenis kaedah yang telah dijalankan seperti penyelidikan internet, reka bentuk konsep, pemilihan konsep, reka bentuk terperinci dan analisis perisian. Untuk peringkat pertama, semua maklumat atau data penyelidikan untuk kajian ini telah dikumpulkan sebagai rujukan. Seterusnya, kajian lanjut diteruskan berdasarkan maklumat yang dikumpulkan dari pemerhatian dan temuduga di Pusat Pemulihan Dalam Komuniti (PDK). Maklumat dan data mestilah berkaitan dengan objektif projek penyelidikan. Penyelidikan ini dijalankan dengan kajian reka bentuk pada bahagian alat untuk berjalan. Seterusnya, idea reka bentuk konsep direka dengan memenuhi konsep reka bentuk kejuruteraan. Selain itu,kaedah seterusnya adalah dengan melakukan analisa ke atas produk berkenaan. Untuk projek ini, terdapat dua jenis analisa yang merupakan Tekanan Analisa dan Analisa RULA. Kedua-dua analisa ini boleh dilakukan dengan menggunakan perisian CATIA. Pemilihan bahan dan beban yang bertindak pada bahagian-bahagian produk adalah perkara utama yang perlu dipertimbangkan untuk mengira faktor keselamatan. Analisa RULA digunakan untuk menyiasat kedudukan badan apabila menggunakan alat untuk berjalan. Analisa ini akan menentukan sama ada alat ini selamat digunakan atau tidak. Dengan semua penyelidikan, peningkatan struktur baru yang dihasilkan memenuhi semua aspek dan alat untuk selamat untuk digunakan.

Reka bentuk produk yang telah dicadangan telah diuji dan boleh diteruskan berdasarkan keputusan daripada hasil analisa struktur dan ergonomik. Keputusan hasil ujian analsisa ergonomik terhadap alat untuk berjalan yang terdahulu,ialah 3. Berdasarkan keputusan tersebut terdapat banyak kekurangan keppada alat untuk berjalan dan perlukan perubahan Hasilnya, setelah melakukan beberapa perubahan, akhirnya, keputusan ujian analisa ergonomik telah berkurang daripada 3 menjadi 2 Jadi, reka bentuk yang baru selamat untuk digunakan Akhir sekali, kajian ini dijalankan bagi mengenalpasti had semasa reka bentuk produk dan mencari batasan penyelidikan masa hadapan.

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LIST OF ABBREVIATION

WHO	World Health Organization
PWMD	Person with Mental Disabilities
CP	Cerebral Palsy
GMFCS	Gross Motor Function Classification System
PDK	Pusat Pemulihan Dalam Komuniti
QFD	Quality Functional Deployment
HOQ	House of Quality
CAD	Computer aided design
FEA	Finite element analysis
CATIA	Computer-Aided Three Dimensional Interactive Applications

CHAPTER 1

INTRODUCTION

1.1 Introduction

The Final Year Project or better known as 'Projek Sarjana Muda' (PSM) is referred as an academic research which related with the Mechanical Engineering course. This project is a part of major requirement for Degree level. This project covered certain scope which is has been learned such as mathematical engineering, design engineering and also related with the safety and sustainability. This chapter explaining about the background of the project which is covered the importance fundamental, objectives, scope, problem statement and a summary of the project. All of the information about the research project will be explained in this chapter.

For this PSM, the title of the research project is Ergonomics Design of Walking Chair for Disable Children in Classroom. A Person with Disabilities or known as OKU is also part of the community in Malaysia. There are various definitions for OKU. OKU is defined as a person who is incapable of self-determination of part of his or her own needs or is unable to live fully in society due to a lack of both physical and mental and requires assistance from others to continue their life (Ariffin, 2006). OKU is also a person who is obstructed by its movement function which requires specially designed facilities such as buildings, tools and equipment as well as outsourcing of areas to overcome their movement barriers. Regarding to Jabatan Kebajikan Masyarakat, there are many categories of disabilities registered in Malaysia such as Physical

Impairments, Spinal Cord Disability, Brain Disability, Vision Disability, Hearing Disability, Cognitive or Learning Disability, Psychological Disability Invisible Disability.

1.2 Project Background

This special children's school level is the same as other normal children starting with Pre-School, Primary School and Secondary School. The children start pre-schooling through the Pre-School Program at Special Education school when they are six years old and have fourteen years of age. They must be certified by medical practitioners as special children and can take care without the help of others and upon completion of pre-school, special education children may enter primary school according to the academic stream (Zainuddin, 2007).

After graduating from the primary school, this special child can enter secondary school and the requirement that need to fulfil is children aged from 13 to 19 years old and certified by a medical practitioner and can take care without the help of other.According to the definition given by the Department of Social Welfare of Malaysia (2008), OKU or Special Education children is a person who is unable to determine for themselves in acquiring the full or part of the ordinary needs of an individual or unable to live fully in society due to their weakness, whether it has occurred since birth whether it's happening since birth or later. Correspondingly to statistics from the Department of Social Welfare up to 2007, there are 220,250 disabled persons who have been registered with this department. Of the total registered, 20,039 people belong to the less category visual aids, 31,715 people with hearing impairment, 73,559 persons with physical disabilities, 85,812 persons with temporary disability education category 9,125 persons in disability category.

Nowadays, there are many successes of this group in education as the normal student. Those successes have opened the way for these groups to pursue to higher education level. However, the facilities for the disabled are very important to enable them to be in a friendly environment. The classroom environment should be appropriate to enable disabled people to move freely without assistance. The environment of the school with disabilities to be provided should meet the guidelines set by the Standards & Industrial Research Institute of Malaysia (SIRIM) and the Ministry of Housing and Local Government. This research project was carried out to identify barriers faced by students with disabilities in an institute of education in Malaysia. The project was focused on the disabled student who has physical difficulties to move freely in the classroom.

In this project, the research will definitely focused on the children with Cerebral Palsy. Cerebral Palsy (CP) is basically caused by brain damaged which is brain development in abnormal stage that transpire a child's brain which is still developing, before birth, during birth, or immediately after birth (MacLennan, 1999). The study of research project will identify the concept design that is multifunctional for the children and moderately an affordable yet economically walking device.

The main purpose of this project is to create a physical design of workstation and other facilities that included the design analysis of ergonomics. For this application of designed, it is specialized to set up areas of the classroom based on the needs of the students and classroom space and also to create environments that increase engagement and prevent challenging behaviours. By applying the design ergonomics analysis for this project, it will improve the design facilities of workspaces and environments to minimize risk of injury or harm.

1.3 Objective

This project embarks on the following activities:

1. To design an assistive walking chair in the classroom that is suitable for student who has physical disabilities.
2. To perform an ergonomics analysis, stress analysis and safety for the users.

1.4 Problem Statement

Special education for children with disability not only need to be specified based on co-curriculum and teachers with specialized skills in related fields, but this special children also need a conducive learning environment appropriate to their level of ability. Lack of provision of facilities for disabled persons or special education at school and institute higher education level has been causing these people to not live a comfortable and perfect life like other citizens or students (Derek G. Shendell, 2004).

This situation causes disabled people to experience difficulties and difficulties in carrying out activities and learning. Furthermore, it is worrying and diligent in continuing to study at the highest level as it is thought that in institutions of higher learning also not concerned in providing facilities for them in continuing their ongoing learning on campus. In fact, some of the institutions that reject the application of OKUs with the most frequently used reason are that there is no basic facility for disabled people to continue their routine life. There are also students who have to move to other institutions of higher learning.

Nowadays, the level of awareness among the management towards providing OKU friendly access and facilities is considered at the lower state. There are many other weaknesses that still exist in almost every institutions of learning whether public or private in Malaysia with respect to the provision of access and facilities for disabled students.

Therefore, this study should be conducted to study the learning facilities to meet the needs of the disabled.

1.5 Scope of the Project

The outlined scopes for this project are:

1. Study and understand the problem that always occurs among the OKU students.
2. Study the classroom environment that is fulfils the safety requirement for OKU.
3. Study a suitable facilities used for the student with physical disabilities.
4. Design and analysis the selected design by using Computer Aided Design (CAD) software and analytical software

1.6 Organization of the Report

This report explains that design of chair for disable people in classroom consider as an important element for student to increase the focus and concentration in study environment. The first chapter in this report introduces the background and problem statement of this study. The second chapter provides the literature review of this study. The information data for literature review comes from the journal and other sources from internet.

Chapter 3 explains the methodology for this study. The methods used for this study are interview and observation at PDK to identify the customer requirements. All of the information data was explained in detail in this chapter. Chapter 4 and chapter 5 show the conceptual design and details design that have been proposed for this study respectively. The characteristic and functionality for each of the concept design was explained in this chapter. This chapter also highlights the final concept design functionality of the walking chair.

In chapter 6, there are two analysis carried out for this study. First is structural analysis and the next one is ergonomics analysis. The value for safety factor was identified to ensure the conceptual design is safe to use. Lastly, Chapter 7 discusses the conclusion and recommendation future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss more about the issues that related to the disable children (OKU). Disability awareness in school is kind of necessary nowadays as a result of to educate students to become a far better member of community within the future (McPherson, 2011). The definition of facilities and the disable children (OKU) has been explained more clearly so that the study can be done accurately. The categories and types of disabilities are also identified so that the need for provision of comfortable facilities is appropriate to this group. The convenient facilities and free-to-use environment are the things that need to be emphasized because of these disable students need to be independent to perform daily activities just like normal students. Therefore, accessibility facilities for creating a free-bound environment should take into account the needs of these disabled people.

In this chapter some previous studies have been outlined which have to do with the subject of this study. The information about these study can be archived through the trusted website, journal article and library books.

2.2 Definition of Disable People (OKU)

Generally, Disabled people (OKU) is someone that need an extraordinary advantage to encourage them to survive independently into a society. People with disabilities according to the World Health Organization (WHO) and the Organization of United Nations, defined as someone who does not want for themselves to amass fully or partially of the standard wants of a personal needs and can't board the community entirely due to a scarcity of either physical or mentally. Approximately, people with disabilities is about 15 percent of the world's population which is exactly more than one billion people around the world regarding to attitudinal, organizational and physical barriers, have restricted access to even-handed participation in family, community, and political life (World Health Organization,2015).

People with disabilities are often divided into classes. First, people with physical disability can be described as someone who loss or disfunction one among limbs like foot or hand and will conjointly cowl disfunction of the complete body (Verhaaen P, 1981). Vision disabilities regarding to the literature review from (Hewett, 1974) which has brightened up the definition of vision blindness used in the United States in 1961 stated that someone who has experienced maximum vision deficiency when the vision is 20/200 or less. Visual destruction does not fully happen when a person is able to see between 20/200 and 20/70 based on the Snellen chart for testing one's level of vision (Sacks, 1998). In addition, someone will be category as blind person if he has a field or border of sight (visual field) limited to 20 degrees or less determined solely by doctor or an eye specialist (Sacks,1998).

Other than that, Regarding to the Disabilities Act 2008, Persons with Mental Disabilities (PWMD) is outlined as person who has been below medicine treatment for a minimum of 2 years. Mental disability referred as the condition of brain development that is stunted in terms of intelligence and requires special care of treatment from specialist (Mohd Iqbal Haqim Mohd Nor, 2017). Besides that, mental incapacity can also be classified as somebody that always considers himself as someone that doesn't match with his age. Regarding to the statement from American Association on Mental Deficiency (AAMD), mental disabilities refer to the intellectual function below an average that involves the ability to adjust thinking behaviour in age's their development.

There are a few samples of diseases that related to the Person with Mental Disabilities (PWMD) are schizophrenic psychosis, mood disorder and organic psychological disorder (Mohd Iqbal Haqim Mohd Nor, 2017).People with disabilities who have this mental deficiency have a lower sense of mind than normal people. After knowing that these groups of people are physically or mentally drawbacks compared with normal people, the term of "OKU" nowadays has been highlighted to avoid mention the disabled person who means labelling the person is imperfect from all aspects without categorized (Hashim Omar, 2004). Person with Mental Disorder (PWMD) is entitled to a disabled card once it complies with these criteria that bring several edges like conveyance discounts, medical and medical facilities discounts, defective allowances and even tax exemptions.

2.3 Facilities

Generally, facilities mean public utilities. Facilities represents as the physical facilities and services provided for an area. In this research study, the area was more focused on the design of a classroom. The provision of complete and comfortable facilities

is extremely importance as it has a great impact on for the teachers and students. The researchers typically conclude that lack of facilitation provided will indicated to a negative impact because it's extraordinarily troublesome to serve massive numbers of kids with advanced desires (Derek G. Shendell, 2004) .According to the Akta Perancangan Bandar dan Desa (Akta 172), the facility is intended as the quality or condition of a place or area that will cause the area to be fun, harmonious and enjoyable such as open space, parks, recreational parks and playgrounds

In this era globalization, The National Education Philosophy emphasizes that the important effort of the country's education sector is to produce Malaysians who are knowledgeable and educated capable of achieving well-being as well as contributing to harmony and prosperity of society and country. Nowadays, there are many achievements that OKU students face comparable with normal students. That success have open the way for these groups to pursue higher in education. In addition, to produce more successful disabled children, the government should take an action to improve infrastructure facilities that are in line with today's modern technology. Thus, the good quality of facilities and environment is very important to motivate the children. The physical and emotional health of students and teachers influenced by the standard of the physical location, which is the building is confirm to be saved and provide healthy buildings essential. Therefore, facility is extremely important things needed to be take care of to create a peaceful and entertaining environment that can be enjoyed by human beings perfectly.

In the last decade, however, increasing numbers of educators have begun to believe that alternative dimensions of the physical setting might influence on students' behaviour and attitudes. There are 5 primary aspects to create a peaceful and comfortable classroom for students. There are acoustics/noise, air quality, lighting, temperature, and space.

2.3.1 Acoustics and Noise

Noise levels greatly will affect the performance of teacher and student in the classroom. Excessive noise is the main reasons of dissatisfaction and increase the stress level for the lecturers and students. Scientific proof has instructed chronic noise exposure in communities close to air, road, or rail traffic, as a stress and distracting input, will result in noise-induced deafness, annoyance, sleep disturbance, stress, mental state and behaviour issues, and small college performance and psychological feature delays (Derek G. Shendell, 2004). Children within the classroom that have excessive noise level are found to have bigger inflexibility and were unable to deal expeditiously with ever-changing task demands (Dornic, 2003). This finding research stated that a class have excessive noise will take a longer time for transition subject or longer time to the new activities.

The existence of unwanted noise will disturb the performance on the task. Similar effect happened when the familiar continuous noise come to a close (Anderson, 2005). Therefore, the performance on complex tasks will decrease due to excessive noise and the students need to put a lot of effort to complete the tasks during the presence of the noise. For normal student, they had difficulty hearing the teacher when more than 12 feet away and noise levels exceeded the average background of 50 dB (A), even though normal conversation is about 60 dB (A) (Wakefield, 2002). Disabilities children are commonly sensitive to the sound. These children need a peaceful environment so that they easily adapt with the environment.

2.3.1 Lighting

Lighting may be associate unmarked issue for children's success in class. However, studies have shown that lighting quality affects students' skills to work out clearly, concentrate and perform well in the classroom.

Since lighting plays a vital role in our everyday lives, it is one of the things that need to be taken to improve the performance of these students in the classroom. (Loisos, 2003). There is various study clarify about the effect of the colour and quality of lighting can either impair of increase the student's visual skills and academic performance.

There are more than 20% of students entered the school will have a common problem such as difficult to focus in the class, eye tracking, training and lazy eye, (Michael S. Mott, 2006). The literature review from (Winterbottom, 2009) proposed that some of the lighting options will cause uneasiness and impair visual and psychological feature performance. The characteristic of lighting option bring in the unnoticeable 100 Hz flicker from fluorescent lighting and glare convinced by natural light and fluorescent lighting, interactive whiteboards (IWBs) and dry-erase whiteboards (DWBs) (Winterbottom,2009).

Before the arrival of low cost electricity, school usually uses natural light as the main sources (Loisos, 2003). In these present years, when the prices of power dropped, the use of artificial light in the classroom is increasing. Regarding to the researcher, the use of natural light will build up student's performance compared to the use of artificial light (Tanner, 2008). Nowadays there are many researches that explain the important of using natural light in the classroom. Based on research from (Derek G. Shendell, 2004), the arrangement of the facilities in the classroom also played an important role.

Firstly, make sure the direct day lighting on to or reflective off surfaces such as desks or pc screens must be reduced. Next, the student desk should not be placed straight to the window due to the negative impact that affects the learning ability. In addition, the fluorescent lights should be turned off when the indirect natural lightweight through windows is enough. Study from (MichaelS.Mott,2006)stated that using cool white fluorescent light in classroom can extremely increase the behavior of students.

Nowadays, there are various types of industrial-style fluorescent lights. The use of industrial fluorescent light may interfere students learning especially, students with syndrome or sensitive hearing would possibly notice the noisy of fluorescents distracting. The use of industrial fluorescent light is not available for the classroom since that there are many research have proof the advantages of using the natural.

2.3.2 Proper Temperature and Control of Temperature

Uncomfortable temperatures can cause a distraction to students. Temperature impacts student's mental capacity and additionally affects various different mental and physical activities. Subconsciously, the brain has to regulate to completely different temperatures to form positive the body is cooperative (Wargocki P, 2007). Once temperatures don't seem to be ideal, the brain gets constant interruptions from the body communication it to readjust to the temperature.

Regarding to numerous researches, the perfect temperature for classroom during the summer is in between 23 and 26°C (73–79°F) (Haverinen-Shaughnessy, 2015). These ranges of temperature are good enough for inactive or marginally energetic person.

2.3.3 Classroom Size and Space

Classroom with comfortable and safe arrangement will permits additional positive relation between children and teachers and decrease the challenging behaviour occurred (Martella. R, 2003). Besides, modifying the classroom surroundings could function a right away interfere for children who demonstrate in progress harmful behaviour (Conroy M.A,

2003). Although there are many advantages of well-designed classroom, there is little analysis concerning about the impact setting modification on behaviour and learning (C, 2009). Environmental alteration within the classroom are a preventative, whole-class approach which will decrease chronic behaviour drawback, forestall behaviour drawback for students who are in danger and permit children with minimal or no drawback behaviour to access learning without interruption (Emmer E.T, 2006).

Classroom design for disable children should be free space since that some of the children will use a wheelchair or other device to walk. The classroom design must be friendly to these children so that they can move freely without any problem. Students who won't be able to pass through the areas will still participate in school if their classroom and various areas available with the large walkways and friendly place which is either to sit or position on a chair (Jennae Bulat, 2017). Furthermore, if the toilet or toilet is too narrow, assistants with the same gender are assigned to assist students with disabilities using the facility. The well-organized arrangement of the furniture in the classroom will make children feels comfortable and generate positive environment (Conroy M.A, 2003).

Regarding to the (UNESCO, 2009), the walkway for the classroom and open areas should be free from any barrier. Moreover, for creating a open spaces classrooms for disable children, all students should be allocated in the “U” shape. Next, every overkill object displayed in the classroom walls, can thwart students from paying full attention during classroom learning.

The study from (J, 2010) stated that the effect of classroom that had several wall displays or no wall displays. Student in the classroom with extra wall display are more unfocused and didn’t perform well on lesson compared to the children who stay in the classroom with minimal wall displays. Providing a classroom that's appropriate for kids

with disabilities isn't essentially a chic or tough task. Therefore, provide a comfortable environment and well organized arrangement of the classroom will increase the performance of the children and ensure that all children, including those with disabilities, can learn and reach their fullest potential.

2.4 Physical Disabilities

Disability is one of the reasons that limit a person from performing tasks of daily living. Physical disability is the long haul misfortune or disability of part of a man's bodywork, bringing about a constraint of physical working, versatility, adroitness or stamina (Chung, 2008). Physical disability is a situation that affect the physical activities for instance walking, climbing stairs, carrying and many more.

Several study stated that people with physical disabilities always have problem to join in the school activities (Egilson, 2005). However, it is usually difficult to coverage the challenge that students encounter related to individual factors or the lack of the surroundings to accommodate students' desire (Egilson S. T., 2009).

Physical disabilities can be divided into two types which is Muscular Skeletal Disability and Neuro Muscular Disability. Muscular Skeletal Disability defined as the inability to do individual activities associated with the body movement due to the muscular or bony deformities, diseases or degeneration (Nicholas W. Gelbar, 2005). Types of Muscular Skeletal Disability are Loss or Deformity of Limbs, Osteogensis Imperfecta and Muscular Dystrophy.

Meanwhile, Neuro Muscular Disability represent as the incapability to control the movement of body that affected due to diseases, degeneration or disorder of the nervous system. The categories for this disability are Cerebral Palsy, Spina Bifida, Poliomyelitis,

Stroke, Head Injury and Spinal Cord Injury (Nicholas W. Gelbar, 2005). People with physical disabilities commonly use devices like wheelchairs, crutches, frames, walking sticks and artificial limbs for performing movement (Z.P.Nkabinde, 2010).

2.4.1 Walking Stick

Balancing is that the results of management of the middle of gravity on the boundaries of stabilization the fullest (Allison L, 2001). Literature review from (Tyson SF, 2006) stated that the perception of balance reactions, posture, postural reactions, and postural control are main thing to illustrate the meaning of balancing in a proper way. Using external support is significant to increase the sensory input and psychological support in physical disabilities.

The researcher have found that walking sticks are the most favoured walking help since that stick are comfortable to use and acceptable to the community (Esra Dogru, 2016). First of all, walking is the one among the foremost standard types of physical activity. For disable children, walking is most challenging factor for them since that they cannot move freely like other normal children. Therefore, for children with mobility impairments, a variety of walking aids and devices are available for this group to accommodate support, motion and access, as well as to allow these children to lead active and fulfilling lives.

Walking aids are typically accustomed preserve walking capability by balancing for underlying impairments. In these present day, there are various type of waking aid such as walking frames with and without wheels, 3-point or 4-poin canes, crutches, and straight canes as shown is **Figure 2.1** (Laufer, 2004). The walking aids used to keep up walking capability by facing the challenges and rising stability thereby enhancement disable

individual's sense of security and reducing the worry of falling (Lara Allet, 2009). Walking sticks also can improve the stability of body posture and to reduce the load on the weak side of the lower extremities (Laufer, 2003). Moreover, the walking stick may also have the negative effect on the balance since that the disable children usually cannot move and easily to fall on the side (Lara Allet,2009).

Figure 2.1: Types of Walking Sticks

(Source: Lara Allet, 2009)

Provide assistive for disable children be able to help them performing movement as early as possible will facilitated their development with the purpose to improve walking and increase safety. In the previous study, the researcher have founded the significances of helpful devices on walking parameter to people with have problem to walk

The result of analysis stated that walking aid can increase the step length and control the walking speed, and improve walking symmetry (Beauchamp MK, 2009). Therefore, due to the previous study, there are many benefits of using the walking aids. The walking aid is extremely gives a lot of advantages to disable people their free walk may not be superb as normal people, at least it can gives them moral support for them to continue survive in thecommunity.

2.4.2 Wheelchair

Approximately 10% of the worldwide population, concerning 650 million people has disabilities (Geneva, World Health Organization, 2008). Wheelchair is assistive technology device for disable people to enhancing them performing movement independently. Wheelchair is also one of the alternative ways for these groups of people to become a productive member in society and enjoying human rights.

Indeed, a study incontestable that the chair itself was thought of by the users because the main issue moving their community participation (E. S. Chaves, 2004). Wheelchair users usually form the people who are not sufficiently expert of standing up and running regarding to paralysis or disability either from the lower abdomen or from the neck down. In these recent years, wheelchairs are available in a large sort of formats to fulfil the particular desires of their users. These wheelchairs are designed based on general daily uses, for single activities, sports, and others. Figure 2.2 shows manual wheelchair that used for general daily. Manual wheelchair usually drove by users.

Other features for instance foot or leg rests, front caster outriggers, adjustable backrests and controls may be supplementary to the fundamental model may supplementary to the fundamental model. The other accessories such as width and depth for the seat size, seat-to-floor height, and seat angle also called seat dump or squeeze relative to the horizontal plane can be improved (Lara Allet,2009).

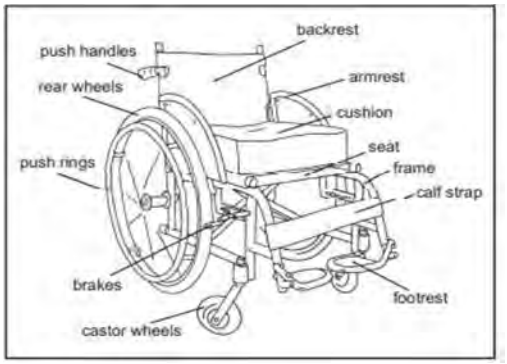

Figure 2.2: Manual Wheelchair

(Source: World Health Organization, 2010)

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Figure 2.3: Attendant-Propelled Wheelchair

(Source: 2015, Retrieved March 23 2019 from Complete Car Shop:www.completecareshop.co.uk,)

According to the **Figure 2.3**, the attendant-propelled wheelchair is an upgraded designed from manual wheelchair. This wheelchair designed with the small diameter wheels at the front and rear and propelled by applying forces at the handle. This wheelchair is better known as “transfer chair” probably among a hospital or field to maneuver mobility disable people when there are no other facilities available.

Furthermore, other types of wheelchair are rigid frame wheelchair shown in **Figure 2.4**. Rigid frame wheelchair is commonly unfolded wheelchair type with a base of support is on the person sits. In other designed model, the backrest of the chair can be folded, and the wheels have a fast release mechanism to transform the wheelchair as an easy-going transportation and storage.

Figure 2.4: Rigid Frame Wheelchair

(Source: 2018, Retrieved March 23 2019 www.sunrisemedical.com,)

Moreover a motorized wheelchair shown in **Figure 2.5** is also one of types of wheelchair that frequently used. The power chair is moved by the power of electric motor controlled by either the user or an attendant. This power chain is designed exclusive for the disable people who incapable to move the manual wheelchair or who may need to use a wheelchair for long distances.

Manual wheelchairs offer quality to people with physical disabilities, however is not suitable to people with amalgamation of physical disability and cognitive or perceptual impairments. Manual wheelchairs are the most favourable wheelchair compared to the powered wheelchairs but powered wheelchairs have all the requirement cognitive and physical skills that not all of the walking devices possess. The power chairs have access to

the total vary of wheelchair choices, together with ones which are challenging to offer in an unpowered manual chair but the power chair also have a disadvantages which is cannot providing extraweight.

Figure 2.5: Motorized Wheelchair

(Source: Retrieved March 29 2019 from www. thebestwheelchair.com)

Last but not least, nowadays there is a wheelchair specifically designed for sports, which is there is no more limited access for the disable people to equitable participation in family and community. Range of disabled sports is developed for disabled athletes, together with basketball, rugby, tennis, sport and performing arts. The wheelchairs that have been used for each sport have followed the special requirement and safely to use since that the wheelchair is non-folding which is to increase rigidity. The wheels of the wheelchair provide extra stability and it is advantageous in making sharp turns. The wheelchair usually made from the material which islightweight.

Figure 2.6 shows the racing wheelchair which is commonly used. According to the World Health Organization, the wheelchair that is suitable to use is fulfilled the requirement of users and environment condition. Next, the wheelchair contributes good fit and body posture support and safe to use. In addition,the most important things is the

wheelchair is accessible in the country, easy to maintenance and services sustained with reasonably priced.

Figure 2.6: Modern Racing Wheelchair

(Source: Retrieved March 29 2019 from www.askaboutsports.com)

2.5 Cerebral Palsy

Cerebral Palsy or (CP) is the effect of a brain injury or a brain abnormality. Cerebral palsy may be a cluster of long lasting movement of disorder body posture causing the limitation of activity due to unprogressive disturbances within the brain occurring early in development (Rosenbaum P, 2007). Cerebral Palsy also can be expressed as an "umbrella term covering a group of non-progressive, but frequently transforming, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the primary phases of its growth" (Mutch L,2003).

CP is basically caused by brain damaged which is brain is development in abnormal stage that transpire a child's brain which is still developing, before birth, during birth, or immediately after birth. According to the study, almost 75% to 80% of Cerebral Palsy cases are the consequence of prenatal injury and less than 10% due to significant birth trauma or asphyxia (MacLennan, 1999).

The person who is suffered with Cerebral Palsy will probably display the signal of physical impairment. However, the function of movement body, position of limbs involved and the as well as the extent of impairment will be dissimilar from one person to another. Cerebral Palsy people will undergo difficulty with muscle coordination, organization, and processing of sensory information, functional limitations impact by spasticity or altered tone, and an underlying abnormal musculoskeletal system (Prue Morgan, 2018). The effect can be seen at arms, legs, face and it also can affect one limb, several, or all. Once the people have been confirmed with Cerebral Palsy, it will disturb the muscles and the ability of person to control them. For this case, the muscles can contract excessively or too scanty, or the muscle can perform both at the same time. Limbs are often stiff and being forced to transform into painful and difficult positions.

Besides, the person will have problem to walk, to sit, or tying shoes while the others might have difficulty grabbing objects. This is all because of the Cerebral Palsy that affects the balance, posture, and coordination of human body. The understanding for children with CP to walk has been significantly boosted by the system has been widely used to classify the rigid motor function with importance on mobility (Palisano R,1997).

GMFCS is stand for The Gross Motor Function Classification System is a multi-level categorization technique that helps to give explanation about varied levels of severity in people with Cerebral Palsy (CP) (Adria Kling, 2010). This can be determined either the person is possible to walk independently or will need a wheelchair. Mobility is one of five levels of GMFCS, on the basis of independent movement with emphasis on sitting, walking, and wheeled mobility (Prue Morgan, 2018). The level is classified based on functional abilities, the necessity for additional devices such as walkers, crutches, or canes, the uses of wheeled mobility and independence walking performance on stairs or uneven

surfaces (Prue Morgan, 2018). Description and illustration of the level of GMFCS have been described in **Figure 2.7.**

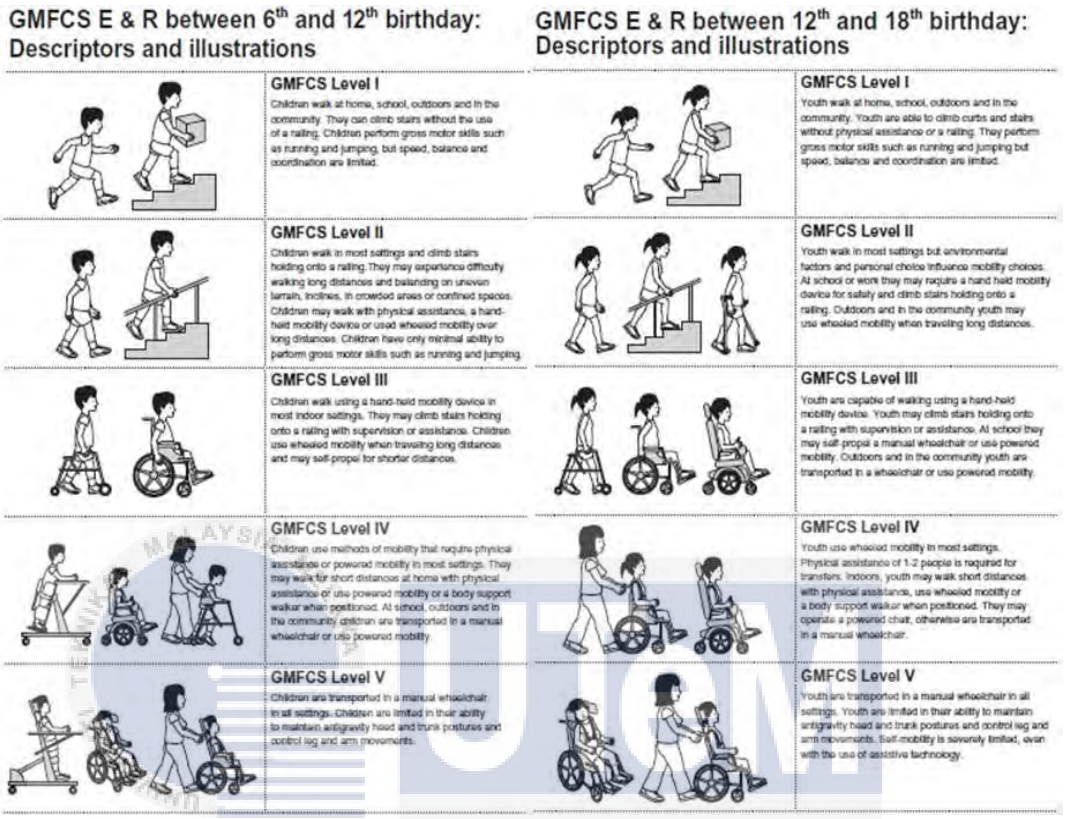


Figure 2.7: Classification of GMFCS

(Source: Prue Morgan, 2018)

2.6 Disability Awareness in Schools

Children with disabilities and people with disabilities normally are usually times unnoticed and mocked by at intervals the walls of the many schools from all over the world. Nowadays, the major changes related to children disabilities are the build-up integration in regular schools (Rosenbaum, 2010). However, successful integration isn't an easy method. Disabilities children need a positive environment in class so that they can easily adapt with the environment and become friendly with other students (D.J. Thomson, 2004).

Inclusion is the key for supports and understanding because interaction between the group of majority and minority is an effective technique to get rid of discrimination and support tolerance for dissimilarities (Maulik, 2007). The researchers have discovered disabilities awareness programs in school are necessary to generate the positive impact towards children with disabilities so that they will not feel neglect (Maulik, 2007). According to the Disability Discrimination Act 2005, talk about to the concern of all public sector authorities with further responsibilities relating to individuals with disabilities. Public school is the main part when talked about theawareness.

Children with disabilities need to feel like they belong in the school where they are a part of, so they can get the benefit of learning conditions in developing positive attitude towards dissimilarities (Ison, 2010). Disability awareness program will educate normal students to care for and encourage positive vibes towards students with disabilities. The researcher founded that negative attitudes towards individuals with disabilities started from primary stage of development process (Krahe, 2006). Awareness training is favourable when include hands-on activities representing the life of children with disabilities may be like (Williamson, 2014).

Simulations, discussions, literature exposure, real-life contact and collaboration, and role-playing are the part of disability awareness program (Williamson, 2014). Conducting the simulation is essential for student to understand if someone needed to do something in unusual way, it may not affect in their life. The element such as an eBook reader should be bring along together and encouraging normal student to teach disabled student to use them is definitely a helpful activity to create the positive environment among them.

Positive environment is the most critical part to develop disability awareness program. The school needs to take initiative to boost awareness of disability education in the classroom so that the students will have stronger connection probability of fostering peer acceptance and accommodate students with disabilities (McPherson, 2011). The positive atmospheres are additional contributing to learn and as a result, if the children with disabilities are easier feel comfortable with their surroundings, then increase academically performance and development more positive vibes in thesociety.

2.7 Ergonomics

Ergonomics is that the study of however instrumentality are regularly organized so that individuals will work or alternative activities additional with efficiency and well. Ergonomic is ensuring the complements style of the strength and talents of individuals and reduces the consequences of limitations, instead of forcing them to adapt (Oram, 2014). The essence of ergonomic is that the development of human work conditions such as devices, tools and work environment with relevance the capabilities of the person specified in health, safety, comfort, and potency are upgraded. The design of a tool or helpful device is aimed at the restoration of a modality of functions and at enhancing the standard of the client's standard of living point towards at communication or interaction with the environment.

Ergonomics is very important due to daily lives because of the body is stressed by a clumsy body posture, warm temperature, or recurrent movement your system is affected (Harsh Rajvanshi, 2015). The musculoskeletal disorders (MDS) are the situation where that disturb the body’s muscles, joints, tendons, ligaments, and nerves (Harsh Rajvanshi, 2015).MDStakesplacewhenthepersonworkingforalonghoursandhaveastressful

working posture. Factors about ergonomic risk in workplaces need to be introduced as an important first step in rectifying hazards and increasing protection against workers.

The good ergonomics could be a wholesome applies involving correct nutrition, posture, workplace, and exercise (Nicholson AS, 1988). The advantages of the ergonomics are increased saving. If the ergonomic factors have been introduced in workplace, it will prevent any injuries and increased productive and sustainable employees. Besides, improving the productivity of ergonomics can trim down the primary risk factors for MSDs, and workers can be more productive and have excessive job enjoyment. Lastly, ergonomic design can decrease the number of worker that experiencing pain.

2.7.1 Ergonomics in Design Wheelchair

The researcher about analysis of manual wheelchair propulsion from ergonomics observant was initially recognized in Europe by the German cluster of Hildebrandt and Engel (Engel, 1971). Mechanical efficiency and energy expenditure were studied in reference to many specific wheelchair configuration options for instance seat position (Brubaker, 1984), Lever length and mechanical improvement in lever driven wheelchairs (Brubaker C. , 1984).

Moreover, there are early studies about muscle activity and force generation in wheelchair ambulation (Brubaker C. M., 1986). The study was more focused on hand rim wheelchairs until now because of due to both the complexity of the wheelchair user combination and the different finding in the research technique. There are no ergonomic guidelines are developed aimed toward high potency associate degreed low energy price of locomotion and implying an optimum fitting of the wheelchair to the user.

There are four main important standards that associated to the wheelchair which is Force, Repetition, Duration, and Posture. The first criteria are force. Excessive force on your joints will produce a possible for fatigue and injury. Many wheelchairs have their own functions to move where they finally flap their hands at the end of the lap causing unwanted pressure on the shoulder joint. Next is Repetition. Increases the repetition of movements will cause irritate tendons and increasing the pressure on nerves. In order to reduce the amount of pushes coasting which suggests to stay the tires inflated and also the wheelchair well maintained, slow speed are often advantageous as a lot of pushes are required to travel quicker.

Furthermore, continuous muscular effort is represent to the duration. Small continuous exertions are as additional nerve-racking to your tissues than a quick however significant effort. For instance, give pressure on arm which is leaning on armrest. This happened usually when the wheelchair have a poor seat connecting with back relation and continues put some load on shoulders. Being on a wheelchair with static posture for a long period of time will resists blood flow and damage muscles. Heavy and continuous work is obligatory on the neck and shoulder if sitting in an exceedingly poor body posture. Remain active and fixing body posture throughout the day wouldn't involve within the frequently application of muscles movement.

Last but least is body posture. The awkward postures or unsupported body posture that stretch physical limits can apply pressure on nerves and irritate tendons. Lack of excellent posture in wheelchairs usually causes people spending plenty of time on armrests. Adjust the seat angle and back angle according to the degree of upper body balance and your body shape. **Figure 2.8**, **Figure 2.9** and **Figure 2.10** show the suggested posture which is taken into account to be optimum is comparatively additional upright, permitting the spine to support users (Oram,2014).

Wheelchair need to be designed ergonomically to reduces the pressure that caused due to extensive use of product. Wheelchairs also offer postural support and sitting regarding to perform a good posture and reduce the excessive force on users.

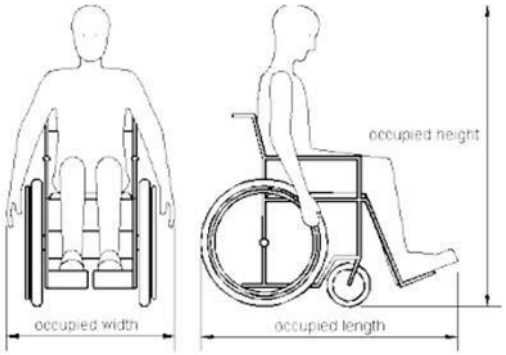


Figure 2.8: The Posture for Occupied Length, Weight and Height

(Source: Oram, 2014)

Figure 2.9: Pressure Sensitive Area (Side View)

(Source: Oram, 2014)

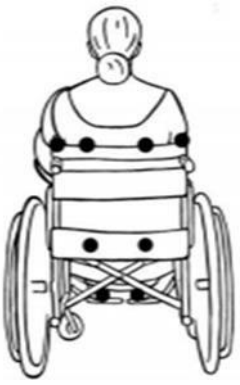


Figure 2.10: Pressure Sensitive Area (Back View)

(Source: Oram, 2014)

2.8 Summary of Chapter 2

Chapter 2 explains the literature review for this research study. The purpose of finding the literature review is to gather the information data and most important is to help the students to understand more about the research project. In this chapter, there are more explanation about the ergonomics design of wheelchair, children with Cerebral Palsy and many more. All of the information data come from existing journal and other resources such as books and internet. The information data from this chapter will help students to proceed into the next chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the method used throughout the study and process needed to completed the study of research project. Methodology is the process of the implementation of the project. It is very important to explain each step to accomplish during this project. The process flow of the project is shown in Figure 3.1. This project is divided into two parts which is the first step is design a facilities to children with disabilities in classroom. The second part is to perform ergonomic analysis to the device to identify either it is safe to use or not.

According to the **Figure 3.1**, the first thing to set out the Final Year Project is the project titles will be proposed by the Supervisor of the Faculty of Mechanical Engineering, University Teknikal Malaysia Melaka. After that, Supervisor will give more explanation about the objective of the project, the scope and the things that student needs to find for the project research. Next, after receive the task, the progression of the project started with finding what is customer requirement based on the title of the project. The finding of the information is based on the interview and observation. The location of finding the information this project research is Pusat Pemulihan Dalam Komuniti (PDK).

Furthermore, the project research continues by reading the Literature Review. The main resource of finding the literature review is based on journal, website and others that are related to the project. All of the information that students get from the journal needs to

be study carefully regarding to the name of the author, and most important things is the date when the journal is published.

The literature review will help the students to understand more about the project research .Then, after the information gathered, the concept design has been illustrated by using the information regarding to the customer needs. For this project, it required at least 3 concept designs which are an upgraded version of old design that are suitable and useful to the customer.

Moreover, the next process is focusing on producing a suitable design which can helps the user to move. The same source of Literature Review has been used to produce the conceptual design. In the conceptual design consists of the Morphology Chart which is having a few of design that can be chosen. Then, it will come out with the detail design based from the Morphology Chart. Lastly, the structure will be analyzed and then final design of this project will produce.

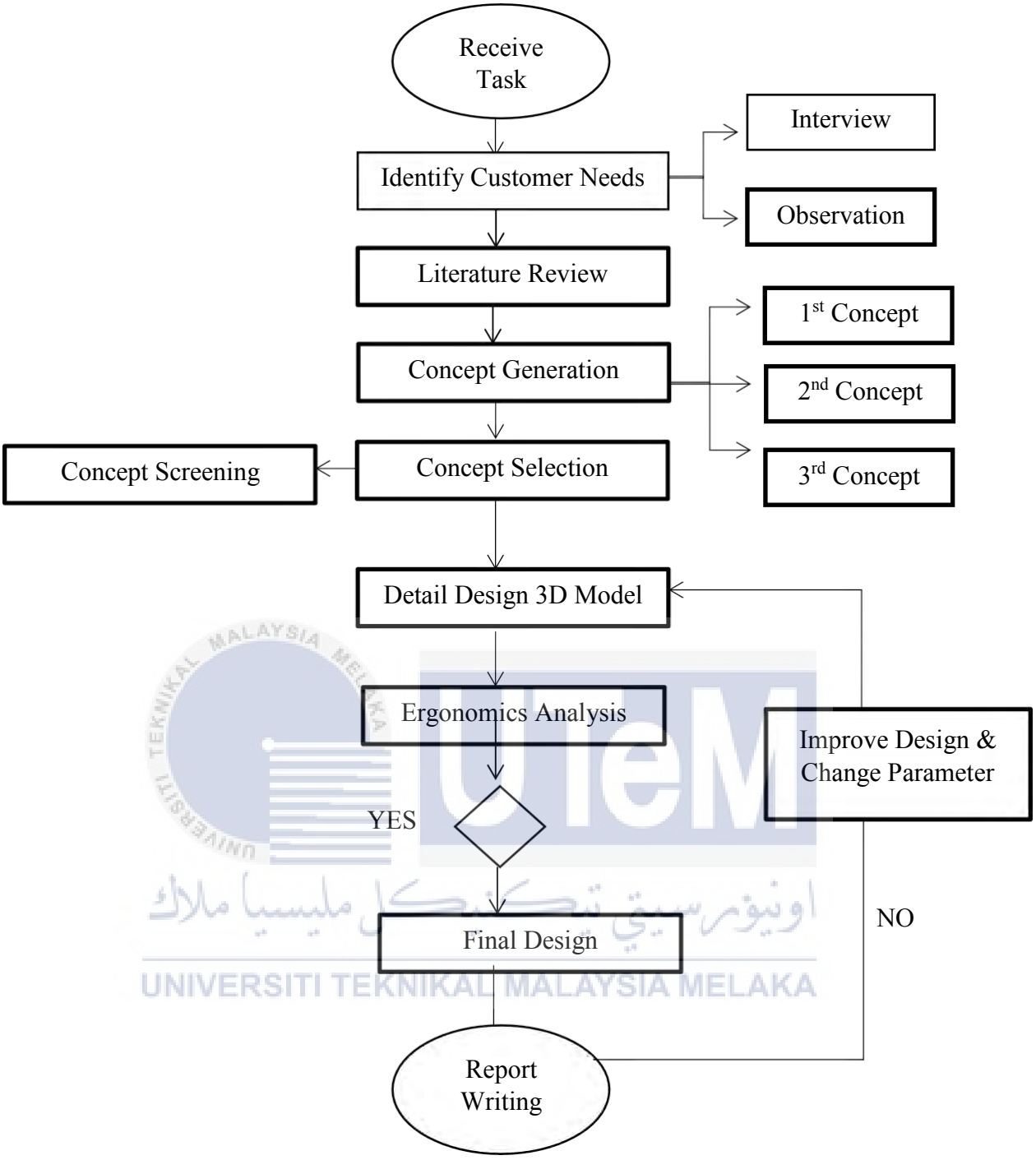


Figure 3.1: Flow Chart of the Project Outline

(Source: Author)

3.2 Identify Customer Needs

Voice of the customer defined as the spoken and unspoken which is stated the customer requirements (Kennet, 2016). The sources of the information can be gained from requirement report, survey, observation and etc. There are many things to be considered when designing a survey tool. The interview or survey need to be constructed carefully. Attention being paid to both the comprehensive of the questions and their usefulness-there is no point in asking a question if no action can result in answer.

a) The goals of doing the identifying customer need are to:
    i. Make sure the product designed due to the customer requirement.
    ii. Identify the hidden needs as well as explicit needs.
    iii. Prepared a fact base explaining the product specifications.
    iv. Generate the record of the needs activity of the development process.
    v. Make sure all of the customer requirement achieve without any missed or forgotten.
    vi. Develop a common understanding for customer needs among members of the development team.

The requirement of customer is very important for development of product in term of engineering specification. The product under progression describe the range of customer that design team should be consider. The design team needed to identify the requirement of product to be successful and consider the target market to make sure the requirement fulfils the customer needs.

The process of identifying the customer needs is mostly related to the concept generation, concept selection and establishment of product specifications. There are five steps to identify the customer needs:

i. The information data was gathered as CustomerStatement.
ii. Translate the data in terms of customerneeds.
iii. Organize the needs into the hierarchy of primary, secondary ortertiary.
iv. Create the relative important of theneeds.
v. Reflect on the result and the process.

To identify the customer needs, there are two methods used to ensure that this project works according to what has been planned. First method is interview the head master of the Pusat Pemulihan Dalam Komuniti (PDK). The last method used on this project is observation at the PDK.

i. Based on the interview at the PDK, the main problem of these childrenwith physical disabilities are limited in almost all aspects of their lives in one way or another. Children with physical disabilities also may have problems related to movement, posture, for instance standing or sitting, grasping or manipulating objects, communication, eating, perception and reflexmovements.
ii. From the observation, there are a few of the facilities that have been provided for these children. Regarding to the ergonomics analysis. The design of the classroom and facilities used for this children need to be improved due to ergonomic analysis to provide a better life for thesechildren.

3.2.1 Result from the Observation

This research project was focused on disable children with physical disabilities. To complete the objective of the project, student went to the Pusat Pemulihan Dalam Komuniti (PDK). The objective of PDK is to encourage the attentiveness, independence and sense of responsibility of the local community in the rehabilitation of the disabled (OKU). Since that the project is specific for design the facilities in the classroom, all of the information about data and problem are gathered together to find the solution. **Figure 3.2** shows the classroom available at the PDK. The concept of PDK is Home Based, Centre Based, and Centre-Home Based.

Figure 3.2: Classroom Design at Pusat Pemulihan dalam Komuniti (PDK)

(Source: Author)

The concept of PDK is not based on the education only. Children with disabilities was trained to be independent like normal children which is they learnt how to manage their own self. Children with Cerebral Palsy at PDK also have their own classroom which is the teachers trained them to walk. **Figure 3.3** shows the facilities that have been provided at PDK for disable children with physical disabilities. The standing chair is used by the children practice for walking. This standing chair is universal for children and adult.

a) Front View

b) Side View

c) Top View

Figure 3.3: Standing Chair

(Source: Author)

3.2.2 Result from the Survey

Table 3.1: List of Customer Requirement and Technical Voice
(Source: Athor)

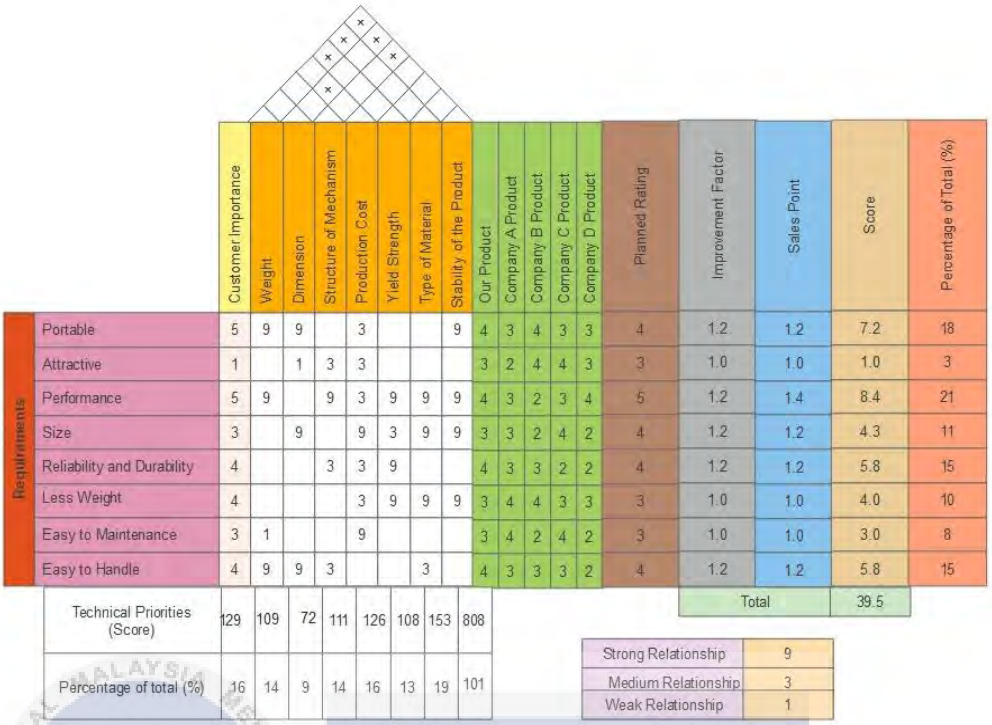
Voice of Customer	Technical Voice
Portable	Safety
Attractive	Economic
Performance (Speed and Accuracy)	Functionality
Size	Weight
Reliability and Durability	Ergonomic design
Less Weight	Mechanism
Easy to maintenance	Change of material
Easy to handle	Usability

Table 3.1 shows that the result obtained after the observation and interview at the Pusat Pemulihan Dalam Komuniti (PDK). Monitoring the product operation is the fundamental method for collecting information about the product function. Based on the observation, there are three children with Cerebral Palsy at the school. The major problem for these children is difficult to move freely. The voice of customer come out after a few questions was submitted to the headmaster of the school. Founding the engineering characteristic could be an important step toward writing the product design specification.

3.2.3 House of Quality

Quality Functional Deployment or sometimes called the “House of Quality (HOQ)” is used to translate the customer requirement to the engineering specification (Kennet, 2016). It is very powerful as it incorporates the voice of the customer in the design. QFD is applied in the primary stages so that the customer wants, are incorporated into the final product. QFD could be a for the most part graphical technique that aids a style team in consistently characteristic all of the weather that move into the merchandise development method and making relationship matrices between key parameters at every step of process (Kennet, 2016) . Gathering the data needed for the QFD method forces the look team to answer the question that may be glossed over in a very less rigorous methodology and learn what it doesn't understand the matter

Figure 3.4 shows the House of Quality designed based on the customer requirement. House of quality is extremely important to create a good product and improve the quality of the product. The house of quality is a planning tool as it identifies the most important areas in which effort should be focus in relation to the technical capabilities (Kennet, 2016). The progression of HOQ starts with the voice of customer on the product design. Firstly, the design of the walker for disable children must be portable since that it can move freely. Since the walker is design for the children, the concept of the design should be attractive and easy to handle. The ergonomics of designed is a priority while designed a product so that the product is safe to use and be able to survive for a long time. Therefore, the designed should be comfortable to the user and eco-friendly to the environment and was offered at reasonable prices.



Requirements	Customer Importance	Weight	Dimension	Structure of Mechanism	Production Cost	Yield Strength	Type of Material	Stability of the Product	Our Product	Company A Product	Company B Product	Company C Product	Company D Product	Planned Rating	Improvement Factor	Sales Point	Score	Percentage of Total (%)
Portable	5	9	9		3			9	4	3	4	3	3	4	1.2	1.2	7.2	18
Attractive	1		1	3	3				3	2	4	4	3	3	1.0	1.0	1.0	3
Performance	5	9		9	3	9	9	9	4	3	2	3	4	5	1.2	1.4	8.4	21
Size	3		9		9	3	9	9	3	3	2	4	2	4	1.2	1.2	4.3	11
Reliability and Durability	4			3	3	9			4	3	3	2	2	4	1.2	1.2	5.8	15
Less Weight	4				3	9	9	9	3	4	4	3	3	3	1.0	1.0	4.0	10
Easy to Maintenance	3	1			9				3	4	2	4	2	3	1.0	1.0	3.0	8
Easy to Handle	4	9	9	3			3		4	3	3	3	2	4	1.2	1.2	5.8	15
															Total		39.5	
Technical Priorities (Score)	129	109	72	111	126	108	153	808										
Percentage of total (%)	16	14	9	14	16	13	19	101										

Strong Relationship	9
Medium Relationship	3
Weak Relationship	1

Figure 3.4: House of Quality

(Source:Author)

Regarding to **Figure 3.4**, the HOQ is defined as the customer requirement and the engineering characteristic to describe the value that needed to be decided by the designer. First of all, the first customer requirement is portable. Based on the HOQ, portable is related stronger to the weight, dimension and stability of the product. To create a design with portable use, these three aspects are very important because of the weight and dimension will determine either the product is portable or easy to carry or not. The stability of the product also has strongly connected to theportable.

Next point is attractive. The connection between the attractive and engineering parameter such as structure of mechanism and the production cost is medium. The next customer requirement is performance. Performance is the critical part for making a new design. The relationship between this parameter to the engineering parameter for instance weight, structure of mechanism, yield strength, type of material and stability of the product is stronger. The performance of the design depends on this parameter engineering.

Moreover, size has powerfully connected with dimension, production cost, type of material and stability of the product while connection between yield strength is medium. Furthermore, reliability and durability is sharply related to the yield strength and medium connected to structure of mechanism and production cost.

Besides, the next customer requirement is less weight. Less weight has powerfully linked to the yield strength, type of material and stability of the product. For easy to maintenance, it has strongly connected to the production cost meanwhile for last customer requirement is easy to handle has toughly related to weight and dimension.

3.3 ConceptualDesign

3.3.1 Classroom Design for Children with Physical Disabilities

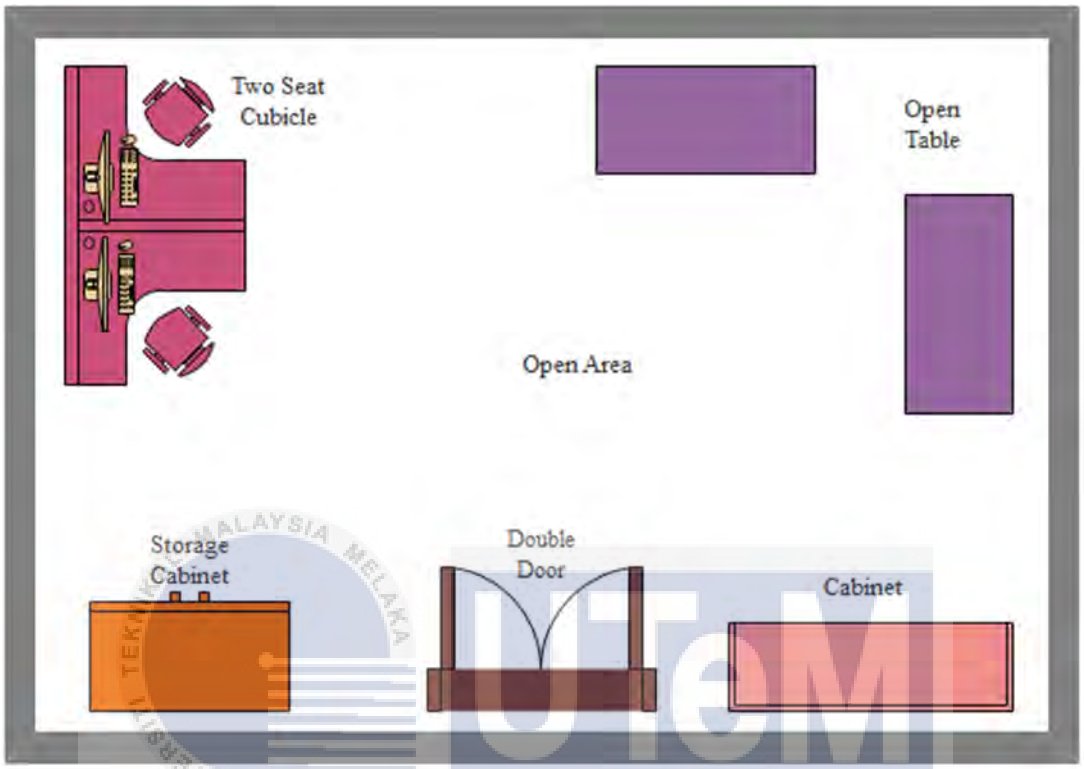


Figure 3.5: Classroom Design
(Source: Author)

Figure 3.5 represents the idea of designing classroom for student with physical disabilities. Student with physical disabilities usually used a device such as wheelchair so, classroom design must be friendly with this children for accessible for classroom supplies and other learning materials. The arrangement of the furniture for the classroom also must be as simple as can because of this children are using device to perform movement. The classroom suppliers need to be placed in location that free from blockage.

First thing to do to set up the classroom is make sure to use the open cabinet with wide shelves for placing their learning material. The store boxes need to be placed at arm's length or nearer to the floor for students using wheelchair or any other device to get around the classroom.

Next, the arrangement of the table desk or working station must be placed at open corner. This is because of the children can turn wheelchairs and move freely without any problem. Moreover, the arrangement of the classroom furniture is very important things since those children who using a device need to move round the work station to work with their friends.

The computer stations also need to be arranged same as the other classroom furniture that allows easy movement for children to go to the computer station. Last but not least, basic material such as pencils, notebooks, tape, stapler, glue and many more may be placed in supply box. The stationary box is placed at the cabinet that easy for them to reach.

3.4 Product Design Specification

The objective of design process planning is to identify, search and assemble all of the information to decide whether the product development is safe to use and can bring the good investment for the company and highly requested product. The result of the planning process is compiled in the form to create the product design specification. The product design specification consists of all information related to the outcome of product developing due to customer requirement.

The final concept designs that have been selected are based on maintaining good posture and stability. This is because regarding to the disabilities children with Cerebral Palsy, they needed an assistive device that can help them to move independently in the classroom. Table 3.2 shows the background of the walking device selected.

Table 3.2: Background of New Walking Device

(Source: Author)

Potential	i. The walking device is easy touse. ii. The design of device is portable, attractive and easyto handle.
Lifetime Product	i. Longlasting.
Environment	i. The walker was designed eco-friendly to the surrounding. ii. Energy saving and sustainability ofenvironment
Material	i. Material used must be safe to theenvironment. ii. Material used must be durable, rustles and easy tofind. iii. Material suitable for operation and goodquality.
Manufacturing	i. Process of manufacturing must not be exceedthan RM1000
Aesthetic Product	i. Designed with needs of mild, moderate and complex users. ii. Provide elegant design with attractivecolour.
Ergonomics Design	i. Easy to move freely and access throughdoors. ii. Provide excellent stability and backsupport iii. Easy for user to operate the walkingaid.
Quality	i. Follow the standard productspecification ii. Follow the entire customerrequirement. iii. Compare the existing product with new product toget solution for a betterproduct iv. Take a fast move to find solution whenreceive complaint from customer

Safety	i. The designs must be analysis first to prevent anyharm to theuser. ii. Ensure the warning sign is clear and easyto understand.
Criteria that need to be consider	i. ProductDesign ii. ControlMechanism iii. ComponentSystem iv. MaterialSelection

3.4.1 Target Product Design Specification

With an eye to select the best design of walking aids, the information need to be gathered and start making comparison to identify the best design of the product. **Table 3.3** shows the target of design specification.

Table 3.3: Target Product Design Specification
(Source: Author)

Customer Needs	Target Product Design Specification
Easy to Use	i. Design for this project is simple and easy to use. ii. Consist of adjustable seat and arm rest holder iii. Features provide
Easy to Handle	i. Have manually operates ii. Design eco-friendly to the environment ofclassroom
Durability	i. The product has stronger support design because the material used is high strength.
Portability	i. Design consists of tyre which means the walking devicecan be transferred anywhere

Regarding to the **Table 3.3**, the final concept design will be evaluated and selected based on the criteria that fulfil the customer requirement. The design requirement developed in order to offer more comfortable device for children with physical disabilities. The assistive walking device must be easy to handle since that these kinds of people have a limitation in their movement. The component or features for this device available have been set up as simple possible to ensure the user can be familiar with the device. Last but not least, the concept design can be easily transported since that it has tyres to facilities the walking device to move freely.

3.5 Detail Design and Analysis

The selected final concept design will move forward to the next another level which is 3D detail design. The software used in this project is CATIA V5 R16. The walking devices will be designed part by part and then assembled to create a full design of the product. The accurate dimension based on the standard engineering dimension.

Computer aided design (CAD) software is a technology that is used to design a product by using computer based on models during design process enabling other downstream processes to be planned and developed accordingly. The CAD consist two type of modelling which is in two-dimensional or three-dimensional diagram. The graphic model gives clear information so that the interpreted model unambiguously. In addition, the data can easily be accessed for revision, modification as well as for manipulation (Muzammil, 2010).

The next step after the design was completely assembled is analysis data. The entire part of concept design will undergo the stress analysis to determine the Von-Misses Stress and the safety factor. In addition, the designed concept also must be analysis by using RURA analysis to determine either it is safe to use or dangerous to the user. The purpose

of this analysis is to ensure the strength ability of the design that could withstand with the force, pressure and any constrain.

3.6 Finite Element Analysis

Finite element analysis (FEA) is a computerize method analysis that calculating the environment factor such as force when it is apply to the design model. FEA method is used to determine the behaviour of things condition in term of mechanical stress or well known as stress analysis, mechanical vibration, heat transfer and considerably more (Muzammil, 2010).

In order to start the analysis, the completed 3D model ought to be designed first. Computer-Aided Three Dimensional Interactive Applications or known as CATIA V5 R16 consists of two modes of solid element which is linear or parabolic that meshes the element. The linear types have the faster computationally compared to the parabolic. However, the result of linear element is not pleasing since that it has less accuracy as opposite to parabolic element (Muzammil, 2010).

After that, the property of each material needed to be identified. For this step, the analysis of yield strength of the material, young's modulus, displacement and poison ration will be computerize by the software. The load will be applied on the 3D model and the behaviour of force towards the model will be investing (Muzammil, 2010).

In addition, for this project, RULA analysis also will be applied on the 3D model instead of FEA analysis. RULA is the short form of Rapid Upper Limb Assessment. RULA analysis according to (Yusuf, 2016) is used to estimate the exposure of a person to ergonomic risk factor. The evaluation of this analysis will cover the body posture, force and repetition. **Table 3.4** stated the score available for this analysis.

Table 3.4: RULA Analysis Score
(Source: Middlesworth, 2012)

Score	Level
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now

3.7 Selection of Materials/ Material Properties

The material selection method is definitely important tasks and it is included as a step for design process. Picking out the suitable material can minimize the production cost while meeting the target of product performance. Furthermore, the good quality of materials can affect the performance of the product. Each of the material has their specific benefit with regards to the price, strength and durability.

For this project, after the 3D model has completely designed, the selection of material method will be used for the data analysis. From this process, the value of Elastic Modulus or Young Modulus, Poison ratio, Density and Yield Strength can be concluded. **Table 3.5** illustrated the varieties of materials that can be used for this project.

Table 3.5: Material Properties
(Source: CATIA software)

Material	Young Modulus (N/m^2)	Poisson Ratio	Density (kg/m^3)	Yield Strength (N/m^2)
Aluminium	$7x10^{10}$	0.346	2710	$9.5x10^7$
Mild Steel	$2x10^{11}$	0.266	7860	$2.5x10^8$
Iron	$1.2x10^{11}$	0.291	7870	$3.1x10^8$
Stainless Steel	$2x10^{11}$	0.265	7800	$1.7x10^8$

Table 3.6 explains in detail about the advantages and disadvantages of these materials. This comparison way is hugely important process to determine the most appropriate material for the structure design of walking device.

Table 3.6: Comparison between the Materials

Types of Material	Advantage	Disadvantage
Aluminium	• Strong • Light	• High Cost • Difficult to weld
Mild Steel	• Affordable • Easy to weld	• Low tensile strength
Iron	• Strong	• High density • Heavy
Stainless Steel	• Strong • High strength	• High Cost • Difficult to Handle

3.8 Theoretical Calculation

Factor of safety is or known as Safety Factor in engineering describe as a system that expressed the strength of the product that needs to be for intended load. Other the other hand, the safety factor also can be defined as the actual load bearing capacity of the

structure. In general the minimum value of safety factor is 1 if the component with Factor of safety less than 1. For this case, the design will be declare as failed since that it cannot support additional load.

The value of the safety factor depends on the function of the component. To ensure the safety and the component must be last longer, and then the safety factor should be greater than 5. The value of safety factor is associated together to the lack of confidence in design process.

The simplest equation of safety factor have been illustrated in **Equation 3.1**

$$FS = \frac{Syt}{\sigma\ Von\ Misses} \quad \textbf{(Equation 3.1)}$$

Equation 3.1 where;

FS = Factor of Safety

S_{yt} = Yield Tensile Strength

$\sigma_{VonMisses}$ = Maximum of Material Stress

3.9 Summary of Chapter 3

This chapter explains the information data obtained based on the observation and interview at Pusat Pemulihan Dalam Komuniti (PDK). The voice of customer was identified and has been translate into engineering specification by using the HOQ method. Next, this chapter also clarifies the concept of detail design regarding to the customer requirement. In addition, the material selection, yield strength for each of the material has been stated in this chapter. Lastly, there are a little bit of explanation about the analysis that will be used in this research study.

CHAPTER 4

CONCEPT GENERATION

4.1 Introduction

For this chapter, there will be more discussion about the concept design that has been proposed regarding to the data collected from observation and voice of the customer. Basically, the conceptual design is the process that needed to be look out before the fabrication and testing process of the product.

Generally, children with Cerebral Palsy will have the problem issue with the movement coordination. Most of the children with Cerebral Palsy can't walk by their own. Thus, they need another alternative option such as by using the assistive walking device to lend a 'hand' for them moves independently. For this project, the final concept design will be specifically more focused on the walking device or walkers for these children. The idea ware developed based on the observation at Pusat Pemulihan dalam Komuniti (PDK) and discussion and interview from the headmaster of PDK. All of the information gathered together and the idea to start developed the new walking has been represented and illustrated into the concept design. The designed must be evaluated and the best final concept design will be selected.

4.2 Design Requirement

There are 3 concept design presented for this project. Each of the concept design has their own specialty and characteristic that fulfils the customer requirement. Customer requirement was done by carrying out the observation and interview with the responsible party that in charge to handle the children with Cerebral Palsy as well as their parent.

The requirement must achieve the feature characteristic which is functional, safety and engineering requirements. For functionality, the design can be multifunctional where the walking device can operated with dissimilar required function. This multifunctional concept design was highlighted as another method to reduce the cost production.

Next, the main goal for this project is for children with GMFCS level II or III. These children have the ability to perform walking but demanding assistant in standing and walking. They also necessitating repeated walking therapy. In addition, the walking device designed purposely for indoor, mainly used in the classroom. The objective of designing this walking device is to give moral support for these children as they can also go to school and studying like normal children. Moreover, the walking device should be easily to be transported around and comfortable to use.

The safety requirement is the crucial part for designing the product. Each of the design must following the requirement that listed below:

1. The stability during standing and walking was offered.
2. Using non-toxic material and environmentally friendly.
3. Can operated perfectly without any problem

Lastly, for the engineering requirement the cost must be affordable for the all level of family income. Next, the design must be strong enough to support the intended usage and the most important is easy to maintenance. The material of the waking device should be

easily to discover. **Table 4.1** shows the table range of the weight and height of these children.

Table 4.1 Weight and height range.

Age Range	Weight Range (kg)	Height Range (mm)
4-12	15-30	94-130

4.3 Conceptual Design

4.3.1 First Concept Design (Concept A)

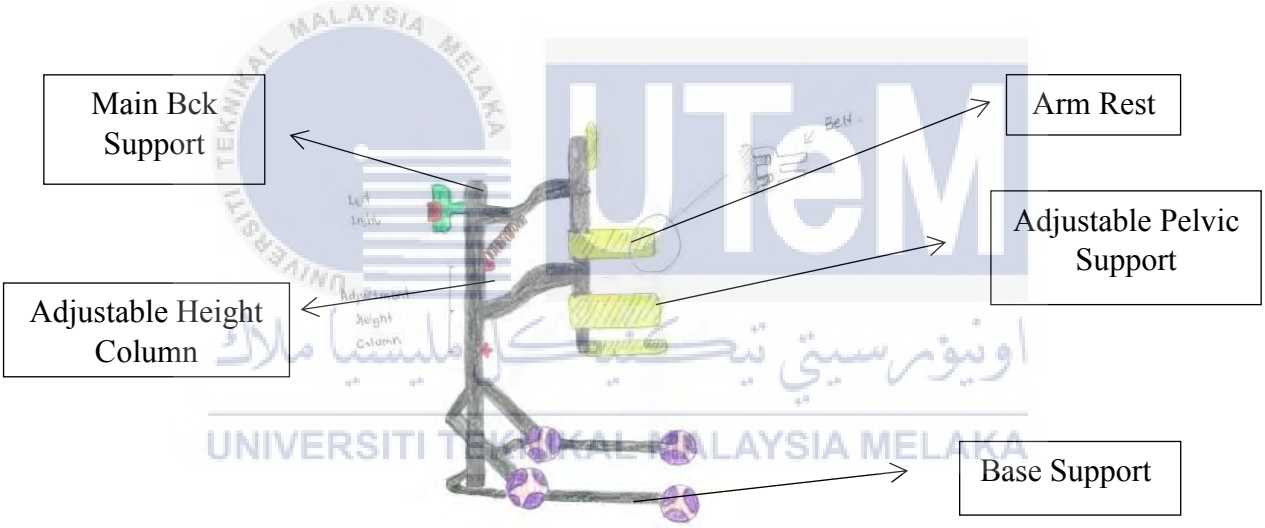


Figure 4.1 Concept Design A

(Source: Author)

Figure 4.1 shows the first concept design. This walking aid is the solution to improve the walking performance by providing partial weight, maintained a good body posture and provided a comfortable back support from behind. This walking aid is suitable

for twelve months old, children and teenagers. Regarding to the figure, shows that the front of the device is open due to the easily for the children to walk in the classroom since that no blocking interact with people and object.

The features available are having adjustable pelvic support and hip guide thus, the users will feel safe and comfortable while using this device. The seatbelt also provided for safety. The walking aid is universal device since that it have adjustable height column to adjust the height of the users.

4.3.2 Second Concept Design (Concept B)

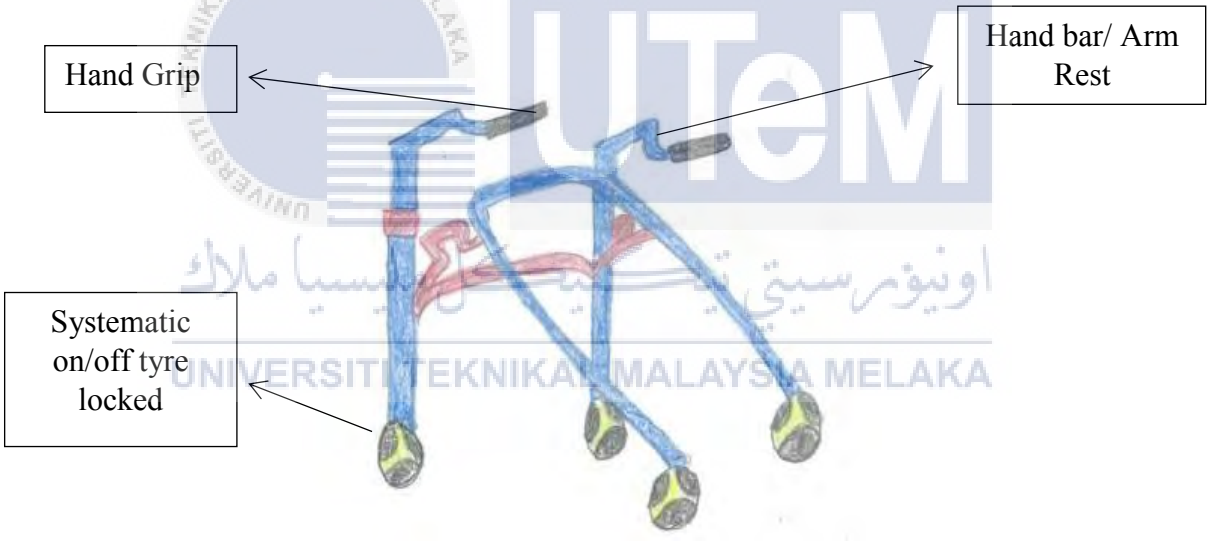


Figure 4.2 Concept Design B

(Source: Author)

Figure 4.2 represents the second concept. The design of this walker is an improvement from the old version of walker. The walker is design specifically to maintain the balance. The light, easy to handle, and safe to use designed for the young children and adult. These walking aids also allowed free movement and facilitates walking in upright position by providing the maximum support and stability.

The walking device consists of multi adjusted handle at the front to give a comfortable hand grip for the users. The systematic on/off tyre locked also provide in term of safety to minimize the speed of the device. The unique things about these design is the device can folded and easy to carry. Next, the device also offers the attractive, simple and portable design.

4.3.3 Third Concept Design (Concept C)

Figure 4.3: Concept Design C

(Source: Author)

Figure 4.3 is wheelchair designed specifically for the people with limited or no ability to move independently. This wheelchair is suitable for children, teenagers and adult people. The wheelchair design is portable, safe to use and easy to handle. Besides, the design also provided comfortable body posture from behind and offer stable position.

The wheelchair consists of brake system for safety to control the speed and the back seat can lift. The walking device also designed as eco-friendly to thesurroundingsince that there is no use of fuel or hazardous material that can affect the environment. This walking device also provided a relaxing head support to prevent any injury happened

4.4 Concept Screening

Concept screening will discuss about the evaluation process of new product ideas in order to determine either the new concept design achieve the customer's need. The functionality and specialty for the entire concept will be discovered and then being compared with the existing design at Pusat Pemulihan dalam Komuniti (PDK). Refers to Table 4.2 shown the simple code used to evaluate the design concept (+ for 'better than' and – for 'worse than').

Regarding to the result in **Table 4.2**, the value of net score for concept design A and B is 5. Based from the observation, these two concepts is the best design followed by the concept design C. The status for the concept design will be continue which means that all the concept accomplish the customer requirement.

Table 4.2: Concept Screening
(Source: Author)

Selection Criteria	Datum	Concept		
		A	B	C
Easy to Handle	+	+	+	+
Easy to Use	+	+	+	+
Easy to Manufacturing	+	+	+	-
Portability	-	+	+	-
Durability	-	+	+	+
Sum +'s	3	5	5	3
Sum –'s	2	0	0	2
Net Score	1	5	5	1
Rank		1	1	2
Continue		Yes	Yes	Yes

4.5 Weighted Rating Method

Weighted rating method is the method that weighted scoring prioritization by using numerical scoring to rank the strategic initiatives against benefit and cost categories. This method is useful for product teams looking for objective prioritization techniques that factor in multiple layers of data.

Regarding to **Table 4.3**, the weight rating method has shown that concept design A has the highest value while concept design c has the lowest value.

Table 4.3: Weight Rating Method
(Source: Author)

Design Criterion	Weight Factor	Concept A		Concept B		Concept C	
		R	W	R	W	R	W
Attractive	0.05	3	0.25	3	0.17	2	0.23
Easy to Use	0.15	3	0.19	4	0.31	2	0.22
Portable	0.20	4	0.51	4	0.45	3	0.29
Size	0.10	2	0.16	3	0.24	2	0.12
Weight	0.05	2	0.23	2	0.10	3	0.05
Safety	0.30	4	0.68	3	0.34	3	0.41
Low Maintenance Cost	0.15	3	0.42	4	0.48	2	0.13
Total	1		2.44		2.09		1.45

R= Rating W= Weightage

4.6 Concept Selection

Concept selection is the process to identify the best concept design regarding to the demand of customer and fulfils the standard specification for further investigation. Regarding to the three concept design proposed, student have carry out the process of concept screening to determine which one of the concept is the best. Based on the result form **Table 4.2**, the entire concept has a status of 'continue'. The status stated that all of the concept have characteristic that fulfils the customer's needs.

To overcome the problem since that all of the three concept design is okay, student have decided to generate a new conceptual design with new improvement and functionality accordingly to the three previous concept designs. Based on the requirement, the design concept is minimalist which is as simple as possible while achieving the entire customer requirement.

The concept for main support spine and bottom base support is come from the first conceptual design (**Figure 4.1**) while the handle bar is come from the second conceptual design (**Figure 4.2**) and last but not least the concept design of seat for this new walking device is based on the third conceptual design (**Figure 4.3**) where the seat can give a comfortable support for the user.

4.7 Summary of Chapter 4

In this chapter, the detail design of the concept design proposed has been explained. To select the best concept design, there are two methods used in this study which are concept screening and weighted rating method. The final concept design has been selected according to the results from these methods.

CHAPTER 5

DETAIL DESIGN

5.1 Background

In this chapter, the detail of conceptual design will be discussed in detail. The characteristic and functionality of the design will be explained. **Figure 5.1** shows the existing standing chair available at the Pusat Pemulihan dalam Komuniti (PDK). The standing chair is used by the children practise for walking. This standing chair was specifically design for indoor purpose and mainly used in the classroom.

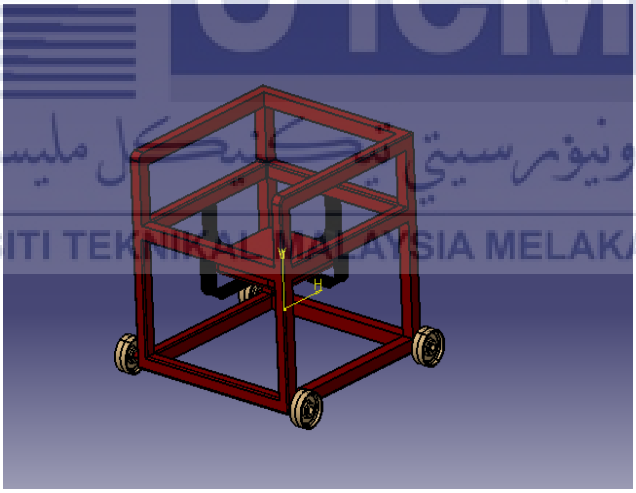


Figure 5.1: Standing Chair

(Source: Author)

Regarding to the **Figure 5.1**, this existing standing chair consists of four wheels. The standing chair can more freely and easy to transport everywhere since that it consist of wheel. This standing chair also have handle bar. The user of this standing chair will hold the handle bar while walking.

There are two types of handle bar in this standing chair. The upper handle bar is designed for tall person while the lower handle bar designed for petite person. The standing chair also provided seat for the user.

The purpose of the seat is to give a comfortable support for the hip part. The seat consists of clip that supports it to the frame structure of the design. If the user is petite and using the lower handle, the seat might be disturbance the user to perform walking so, the seat can be removing by unplug the clip.

5.2 Improvement Design

The new concept design of walking device has been developed to interchange the design of existing standing chair. The new concept design fulfils the characteristic and the whole requirement according to the customer's needs. All of the functionality of new concept of walking device is similar to the existing standing chair, but there are few mechanisms have been transformed for the better version to make the new assistive walking device looks attractive.

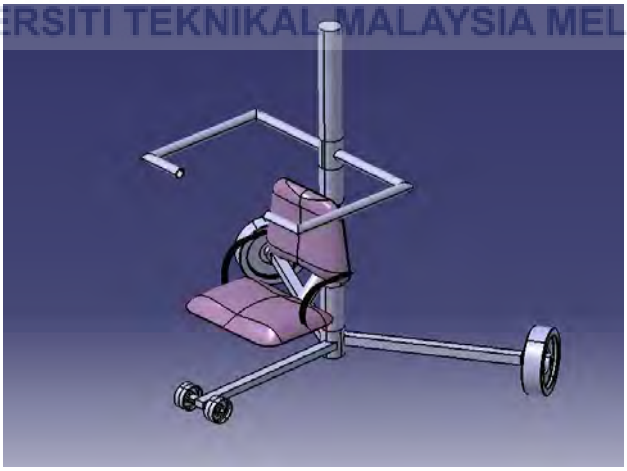


Figure 5.2: New Concept Design

(Source: Author)

Figure 5.2 shows the new upgraded concept design. The main structure for this concept design is the support spine bar which is be responsible to support the other part that attached to it. The seat that attached to the spine have the speciality which is it can be adjusted in height. The handle bar designed can be swing forward and backward to support the arm that lay on top of the hand bar. For the base support, consist of three wheels which are detachable and can offered stability to the walking device.

Besides, the walking device intentionally designed with multiple function modes according to the customer demand. The first mode that assistive walking device offer is standing and sitting. **Figure 5.3** illustrated the example of sitting mode. Once the person get exhausted for standing too long, either he or she may be seated on the seat provided. Besides that, this first mode will allow the person to carry exercises for instance, sitting and standing to build up the arm muscle and also a therapy technique for development of the muscle. **Figure 5.4** shows the standing mode for this new walking device.

Figure 5.3: Sitting Mode

(Source: Author)

Figure 5.4: Standing Mode

(Source: Author)

Furthermore, the second mode is the well-known among the walking devices which is wheelchair mode. This concept is the simplest concept for children who are not strong

enough to start walking by their own self or they felt tired during the learning session. The child can be seated and someone can push the walker form the back. **Figure 5.5** shows the concept of this mode.

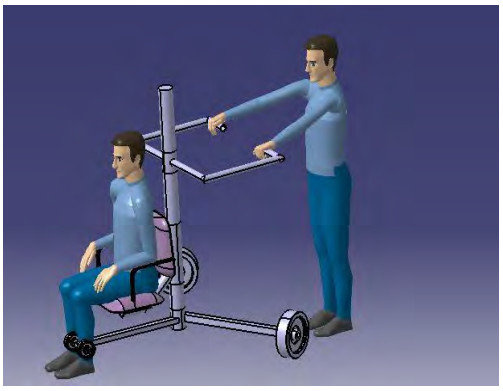


Figure 5.5: Wheelchair Mode

(Source: Author)

Last but not least, the idea for third mode is fundamentally come from the concept of standing and walking mode. This mode preferred the child that to start walking in dependently by holding at the arm rest for the support. At this mode, the seat might be removed as it may be disturbance during the walking session. These methods as shown in **Figure 5.6** definitely the best for children under physiotherapy where this device can assist them slowly learn how to walk.

Figure 5.6: Standing and Walking Mode

(Source: Author)

5.3 Detail Design

The final concept design has been selected according to the information gathered from the observation. The improvement hasbeen made this design turn into extraordinary design as it has various style of functionality. The walking device was designed to be a multipurpose which is consists of the key mode of device's functionality which is standing and sitting mode, the wheelchair mode where the person seated on the seat while someone pushed from the back and lastly the pushing mode. This conceptual design was built up from several major parts which are the adjustable bar, spine, armrest, armrest holder, bottom part and wheel that can strengthen the stability.

Figure 5.7 shows the main support spine of this walking device. This spine works as critical role as it is the main structure of this device. Most of the other part of this device is attached with the spine. The main support or the spine was designed with few small holes as the holes are the base support for the pin to lock the parts such as handle bar and seat. By using this pin the parts can be adjusted according to the desire of the customer.

Besides, regarding to **Figure 5.8**, it represent the handle bar which is works as hand support. The handle bar can be adjusted according to the child's height. The adjustable handle bar works by using the pin that will attach the handle bar to the main support and locked it. In addition, the handle bar also will help the person in the standing position. The speciality of this handle is, it can swing forward and backward depends on the mode used

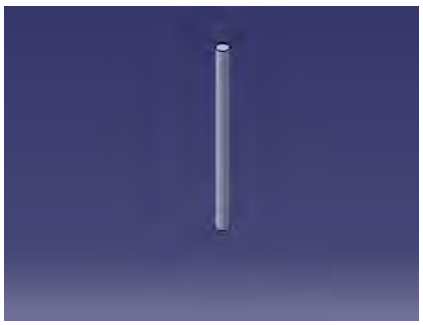


Figure 5.7: Main Support/Spine

(Source: Author)

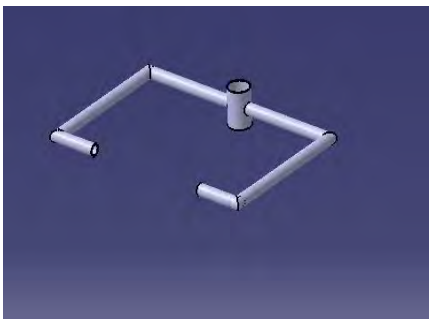


Figure 5.8: Handle Bar

(Source: Author)

Furthermore, the next part is the adjustable seat. The seat also has the similar function as the adjustable bar where it can move forward and downward. It can be adjusted according to the height of the user. In addition, the seat also can be removed from the walker in case of it might be disturbance for the user during the walking session. **Figure 5.9** illustrated the design of the adjustable seat.

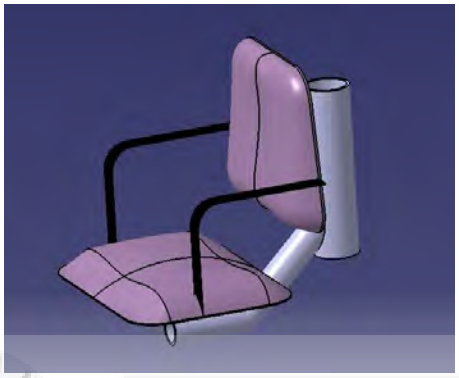


Figure 5.9: Seat

(Source: Author)

Lastly, the bottom part as shown in **Figure 5.10** of the walking device consists of wheel. The functionality of the wheels is it can easily transport the walking device everywhere. For this project, there are four wheels used which are two of them is wheel with bigger size and the other two is small wheels. The process of waking performance will be smooth if suitable wheelsused.

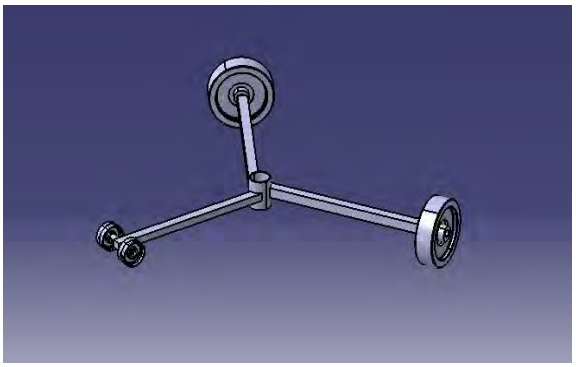


Figure 5.10: Bottom Part with Wheels

(Source: Author)

5.4 Summary of Chapter 5

This chapter explains in detail about existing standing chair. The concept and functionality have been discovered and analyzed to make a better improvement. Next, after finding the problem from existing design, new improvement have been made to upgrade the design become more comfortable and easy to use.

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Stress Analysis by using CATIA Analysis

This chapter will discuss about the analysis of the product design. There are two types of analysis in this project which are Finite Element Analysis and RULA Analysis. The analysis was run by using the CATIA software. FEA is used to determine the stress analysis of the product when there are load applied and forces acting on it. The purpose of doing the analysis is to identify the factor of safety on the new assistive walking device. In the end of this analysis, the theoretical result comes to pass after the defined parameter has been analysed.

There are two types of parameter used in FEA analysis. The first type is material selection and the either one is load or force distribution. In general, there are four types of material used in this analysis. The first material used to conduct the analysis is steel. The material was applied in all structure of new walking device. The result and value of safety factor was calculated. The analysis will be carrying on with the other material for instance aluminium, iron and stainless steel.

The analysis was carried out part by part starting with the bottom part of the product design. The first critical part was bottom part. The weight was assumed as 350N which comes from the maximum weight of the user which are 35kg per person. Next, the weight of the walking device can be assumed as 200N. The total force applied is sum of user weight and sum of walking device can be assumed as 550N acting vertically onwards. **Figure 6.1** shows the force applied on top of the bottom part of the product design.

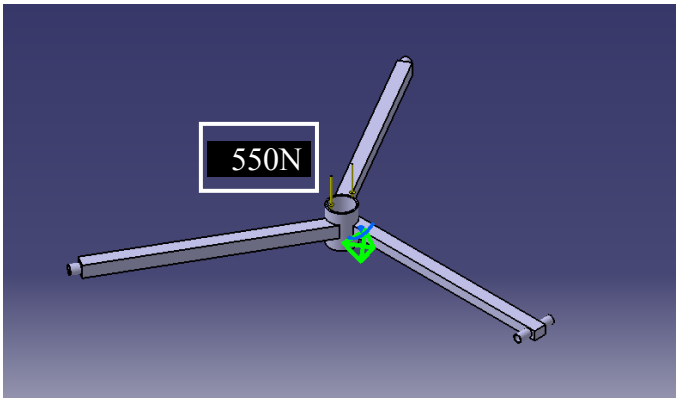


Figure 6.1 Load Distributions for Bottom Part

(Source: Author)

The second critical part need to be analysed is the seat. **Figure 6.2** shows force was directly applied to the seat. The sum of force applied is user weight which is 350N acting vertically downwards. The analysis was run and the result was recorded.

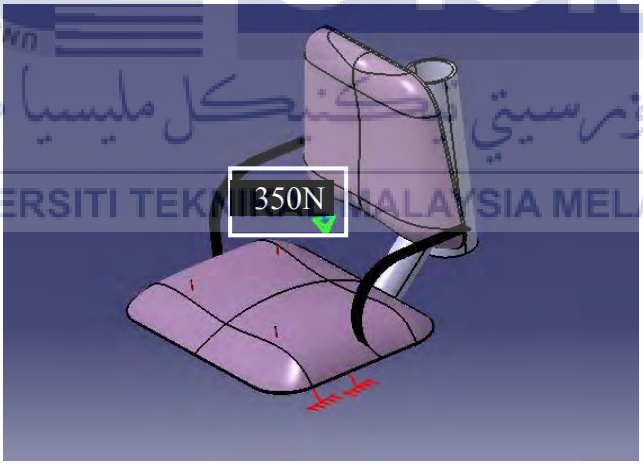


Figure 6.2: Load Distribution at Seat

(Source: Author)

Lastly, the handle bar was the last part identified as critical. The handle bar consists of two analyses. The first analysis is based on the wheelchair mode where the functionality of the armrest part is where someone going to push the whole walking device.

For this mode, the handle bar will be swing to backward. This circumstance happened when the user is exhausted and decided to use the wheelchair mode. Therefore, **Figure 6.3** shows the force applied at the handle of arm rest which is 30N. The walking device wills slowly moves due to the force exert on it.

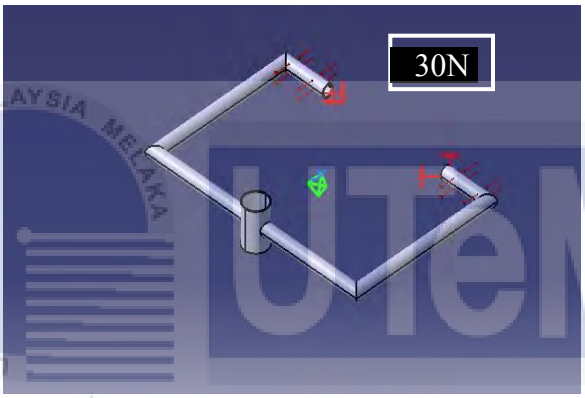


Figure 6.3: Load Distribution for Handle Bar

(Source: Author)

The second analysis for this handle bar is when the assistive walking device was switch to the mode of standing and walking. For this mode, the user will holding into the bar and perform slowly walk. The sum of force applied for this situation is the weight of the user which is maximum 35kg per person. Thus, the sum of load distribution is 350N shown in **Figure 6.4**.

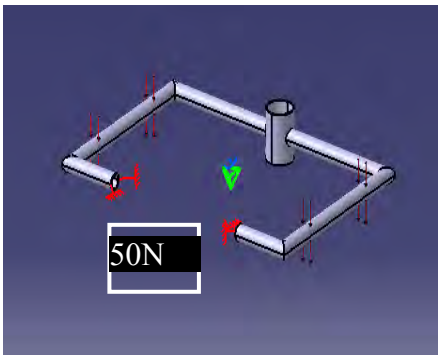


Figure 6.4: Load Distribution for Handle Bar

(Source: Author)

Next, the RULA analysis also has been used to identify either the modes that available at multifunctional assistive walking device is safe to use according to the ergonomic analysis. The analysis was carried out by loaded the mannequin into the product design. The mannequin can be set up in many different conditions such as stand, sit and many more. For this analysis there is no distribution of load or sum of force acting on the walking device. The mannequin was set as a 50^{th} percentile male move according to the mode of position. 50^{th} percentile male was chosen due to the maximum value of height and weight as reference for the worst case scenario. The position of the mannequin has been placed by following themode.

6.2 Result Analysis for Finite Element Analysis

Referring to the analyses, there are three major critical parts that have undergo the analysis process. Each of the part has been applied by four dissimilar types of material. The material used for this analysis is Steel, Stainless Steel, Iron and Aluminium. The purpose of this analysis is to identify the maximum stress von misses of each material applied then, from the value the factor of safety can be determine by using the formula from **Equation3.1**.

6.2.1 Mild Steel

The first material used for this analysis is Mild Steel. For the analysis of bottom part the force applied at this part is 550N. **Table 6.1** shows the material properties of the Mild Steel.

Table 6.1: Material Properties of Mild Steel

(Source: CATIA Software)

Material	Mild Steel
Young Modulus (N/m^2)	$2x10^{11}$
Poisson Ratio	0.266
Density (kg/m^3)	7860
Thermal Expansion (Kdeg)	$1.17x10^5$
Yield Strength (N/m^2)	$2.5x10^8$

6.2.1.1 Bottom Part

Figure 6.5 and **Figure 6.6** display the result of von misses and displacement vector for the bottom part respectively. The material used for the analysis is mild steel. Regarding to the result, the value of maximum stress is 9.42 MPa while the value for the displacement vector is 0.095mm. The load applied for this analysis is 550N. According to the data analysis, the value for safety factor was calculated.

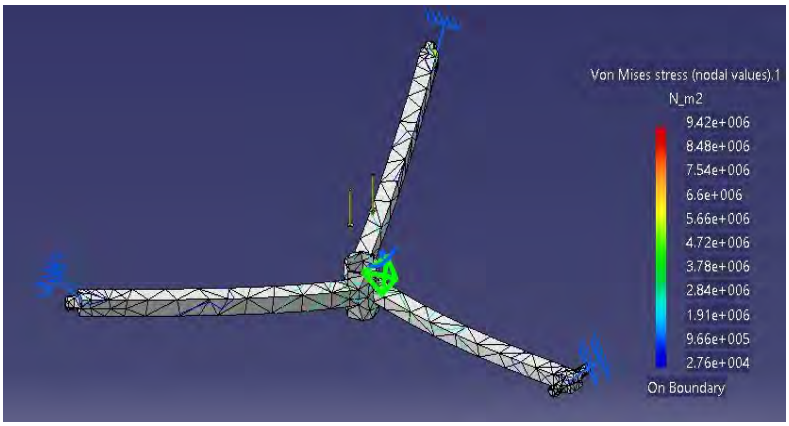


Figure 6.5: Von Misses Stress of Bottom Part usingMild Steel

(Source:Author)

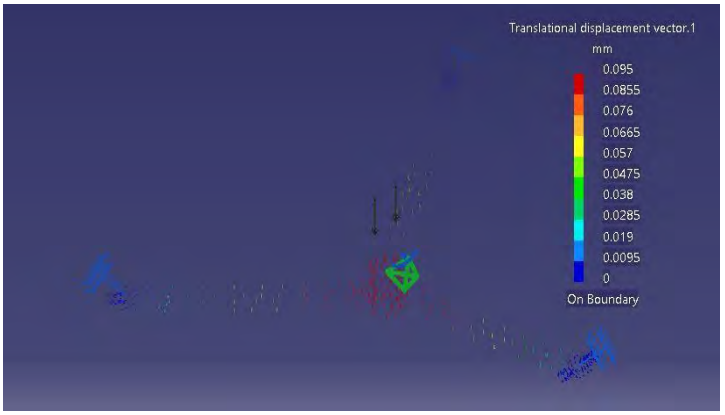


Figure 6.6: Displacement Vector of Bottom Part using Mild Steel

(Source: Author)

6.2.1.2 Seat

Figure 6.7 and **Figure 6.8** show the result of von misses and displacement vector for the seat respectively. The force applied is 350N acting downwards. The value of maximum stress is 6.88 MPa while the value for the displacement vector is0.126mm.

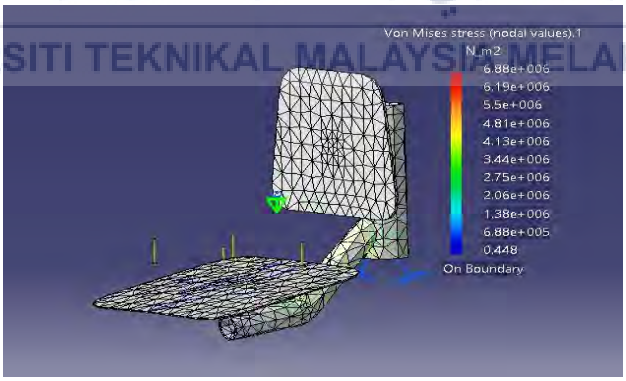


Figure 6.7: Von Misses Stress of Seat using Mild Steel

(Source: Author)

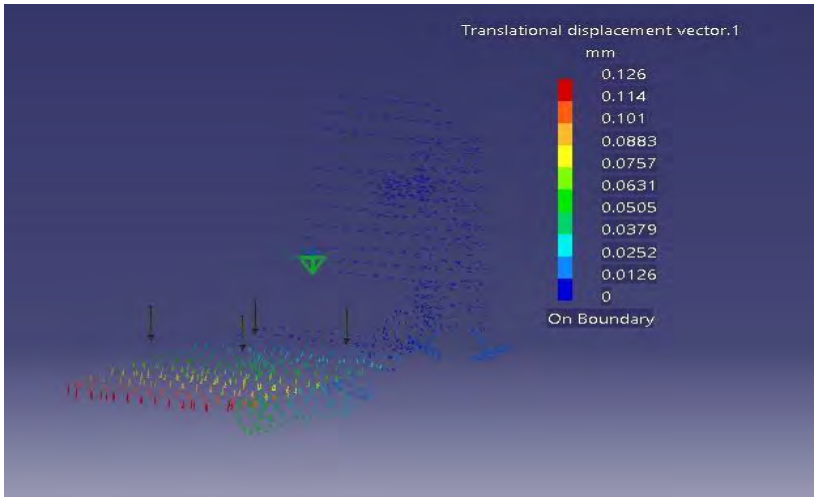


Figure 6.8: Displacement Vector of Seat using Mild Steel

(Source: Author)

6.2.1.3 Handle Bar

Figure 6.9 and **Figure 6.10** show the result of von misses and displacement vector for the handle bar respectively. The handle bars have undergo two analysis. First analysis is 30N load was applied. The 30N load refers to the force that pushes the trolley forward. The value of maximum stress is 0.31MPa while the value of displacement is 0.00072mm.

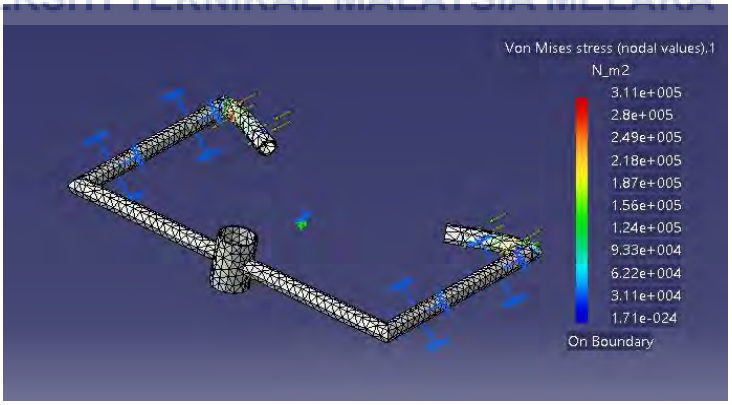


Figure 6.9: Von Misses Stress of Handle Bar with30N using Mild Steel

(Source: Author)

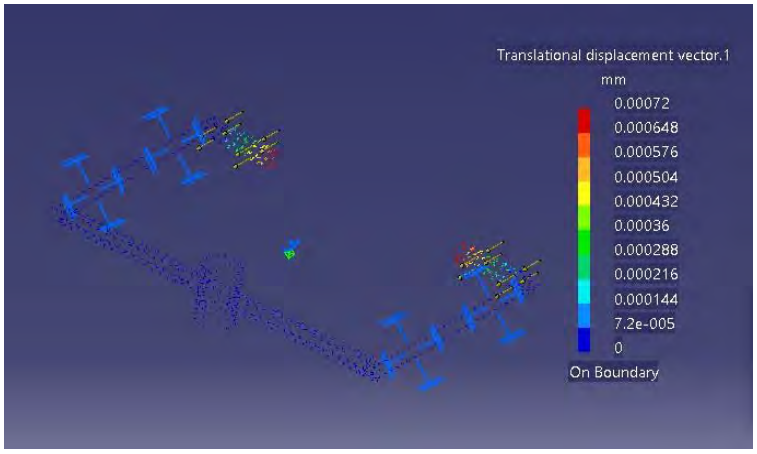


Figure 6.10: Displacement Vector of Handle Bar with30N using Mild Steel

(Source: Author)

Load applied for this analysis is 50N. The load is due to the load of the user that holds the handle bar when the he or she starts walking. The value of maximum stress is 1.37MPa while the value of displacement is 0.0326mm. **Figure 6.11** and **Figure 6.12** show the result of analysis of the handle bar respectively.

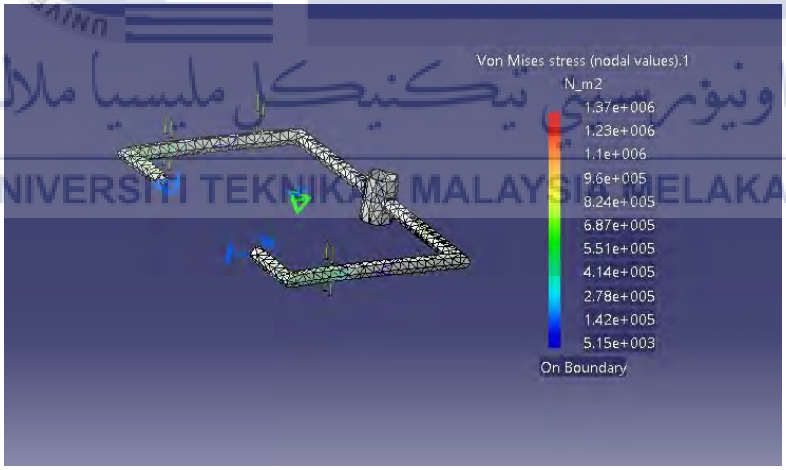


Figure 6.11: Von Misses Stress of Handle Bar with50N using Mild Steel

(Source: Author)

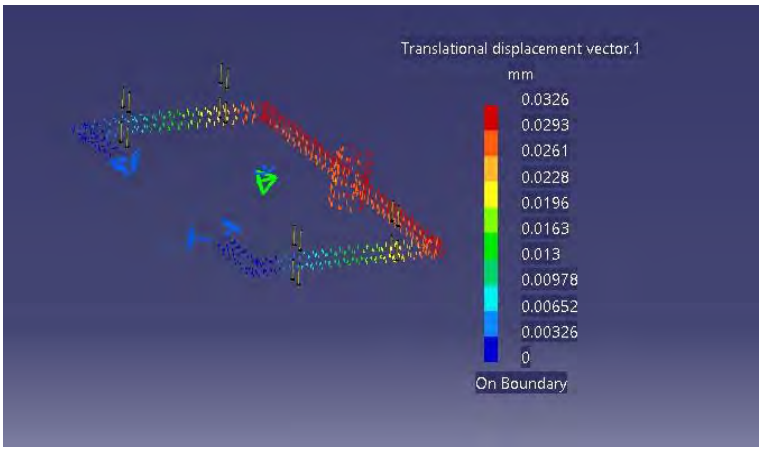


Figure 6.12: Displacement Vector of Handle Bar with50N using Mild Steel

(Source: Author)

6.2.2 Stainless Steel

The next material used for the analysis is Stainless Steel. **Table 6.2** shows the material properties of Stainless Steel.

Table 6.2: Material Properties of Stainless Steel

(Source: CATIA Software)

Material	Stainless Steel
Young Modulus (N/m^2)	$2x10^{11}$
Poisson Ratio	0.265
Density (kg/m^3)	7860
Thermal Expansion (Kdeg)	0
Yield Strength (N/m^2)	$1.7x10^8$

6.2.2.1 Bottom Part

Figure 6.13 and **Figure 6.14** display the result von misses and displacement vector for the bottom part using stainless steel respectively. Regarding to the result, the value of maximum stress is 5.25 MPa while the value for the displacement vector is 0.092mm. The load applied for this analysis is 550N.

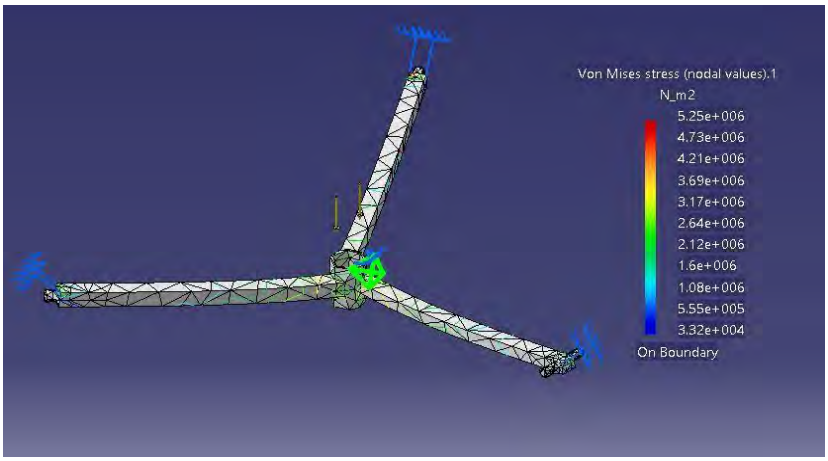


Figure 6.13: Von Misses Stress for Bottom Part using Stainless Steel

(Source: Author)

Figure 6.14: Displacement Vector for Bottom Part using Stainless Steel

(Source: Author)

6.2.2.2 Seat

The load applied at the seat is 350N. The maximum stress value is 6.84 MPa. The value for displacement vector is 0.0796mm as shown in **Figure 6.15** and **Figure 6.16**.

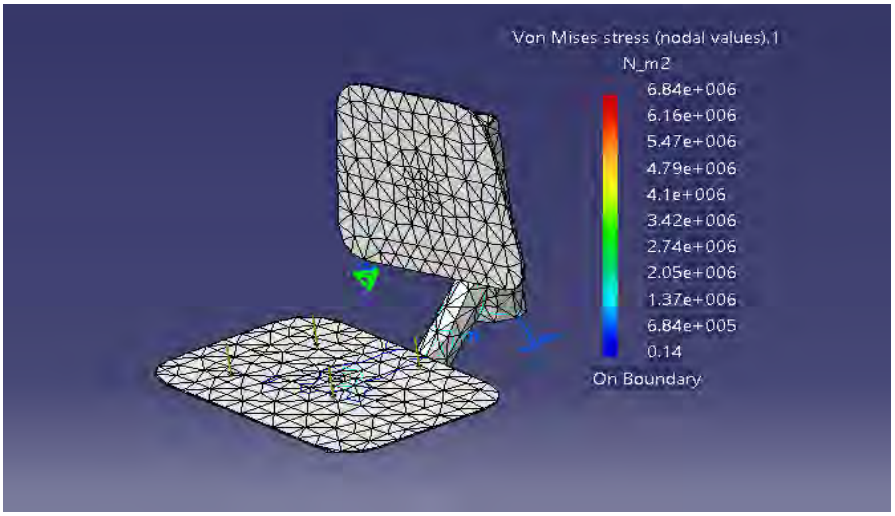


Figure 6.15: Von Misses Stress for Seat using Stainless Steel

(Source: Author)

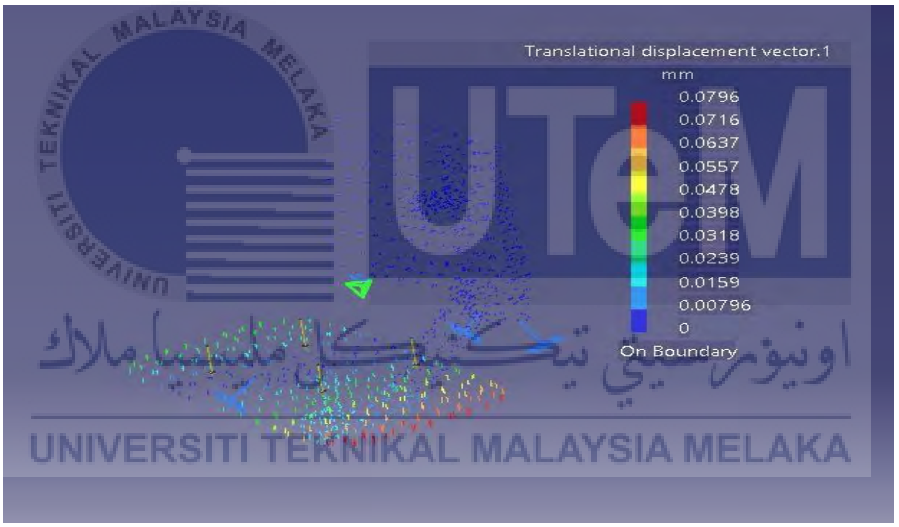


Figure 6.16: Displacement Vector for Seat using Stainless Steel

(Source: Author)

6.2.2.3 Handle Bar

The value of maximum stress for 30N is 0.32MPa while the value of displacement vector is 0.000722mm. Result of the analysis shown in **Figure 6.17** and **Figure 6.18**.

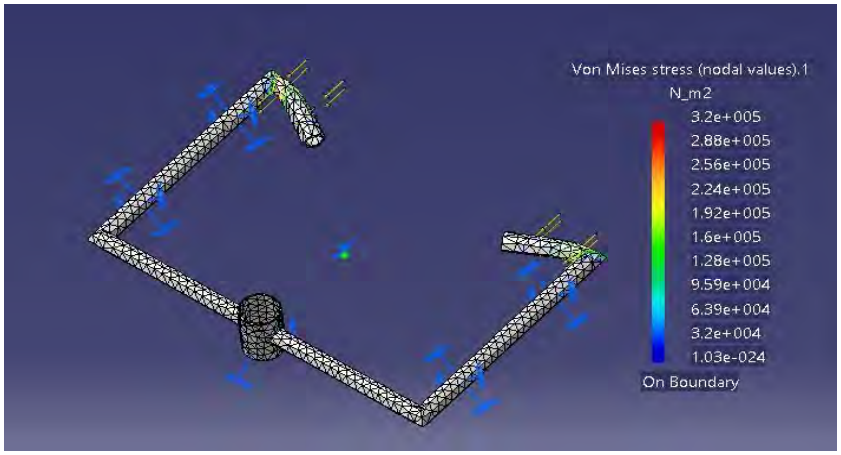


Figure 6.17: Von Misses Stress for Handle Bar with 30N using Stainless Steel

(Source: Author)

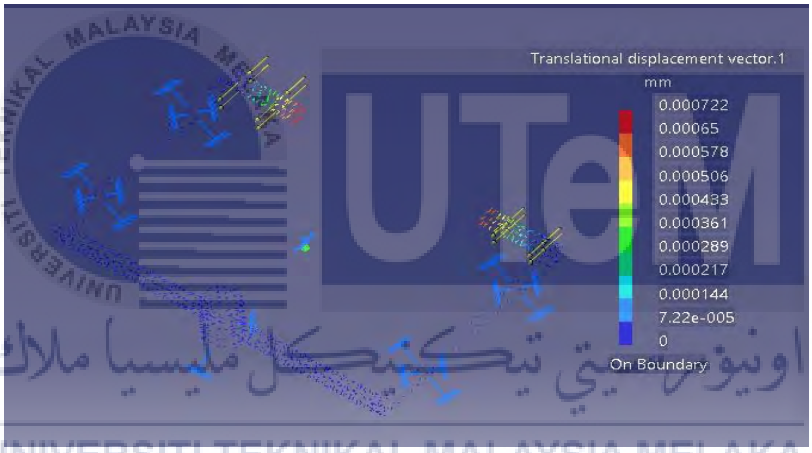


Figure 6.18: Displacement Vector for Handle Bar with 30N using Stainless Steel

(Source: Author)

The value of maximum stress for 30N is 1.32MPa while the value of displacement vector is 0.0372mm. Result of the analysis shown in **Figure 6.19** and **Figure 6.20**.

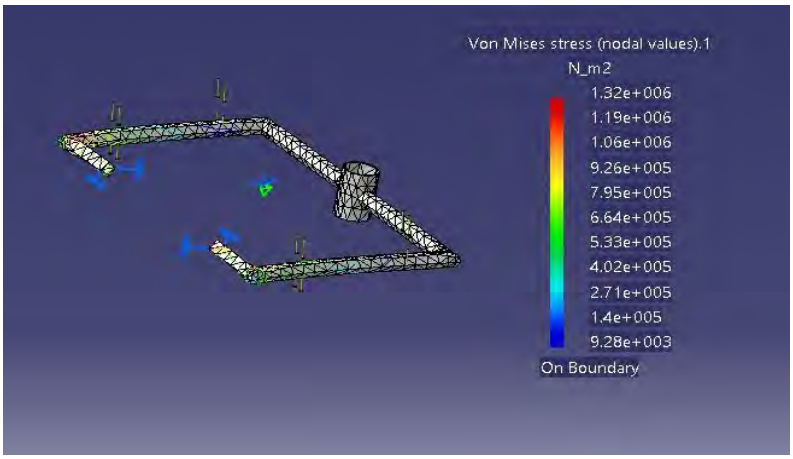


Figure 6.19: Von Misses Stress for Handle Bar with 50N using Stainless Steel

(Source: Author)

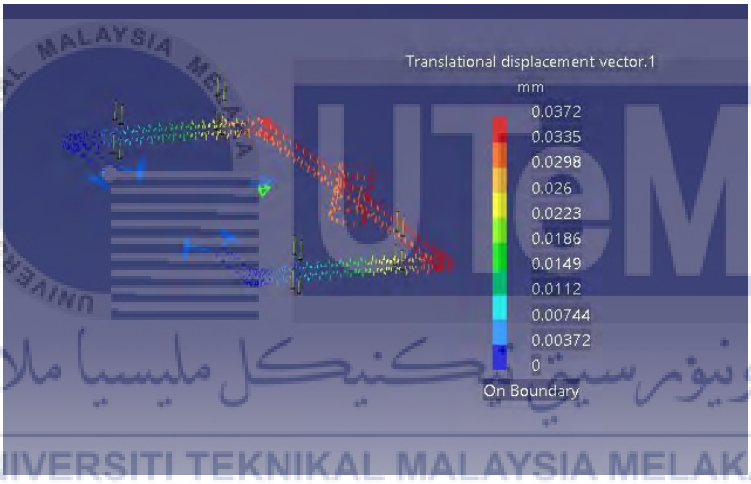


Figure 6.20: Displacement Vector for Handle Bar with 50N using Stainless Steel

(Source: Author)

6.2.3 Iron

Table 6.3 explained the material properties of Iron.

Table 6.3: Material Properties of Iron

(Source: CATIA Software)

Material	Iron
Young Modulus (N/m^2)	$1.2x10^{11}$
Poisson Ratio	0.291
Density (kg/m^3)	7870
Thermal Expansion (Kdeg)	$1.21x10^{-5}$
Yield Strength (N/m^2)	$3.1x10^{8}$

6.2.3.1 Bottom Part

Figure 6.21 and **Figure 6.22** explain the result von misses and displacement vector for the bottom part using iron respectively.

Regarding to the result, the value of maximum stress is 9.36 MPa while the value for the displacement vector is 0.158mm. The load applied for this analysis is 550N.

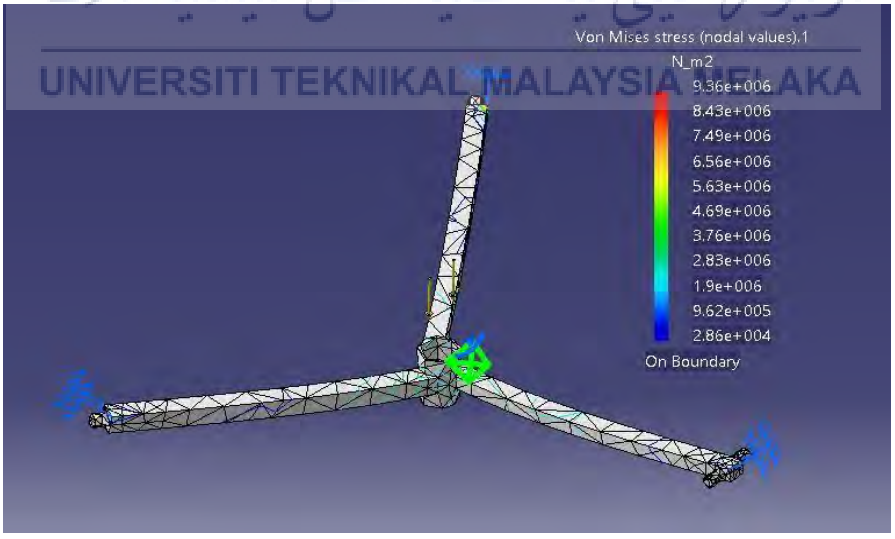


Figure 6.21: Von Misses Stress for Bottom Part using Iron

(Source: Author)

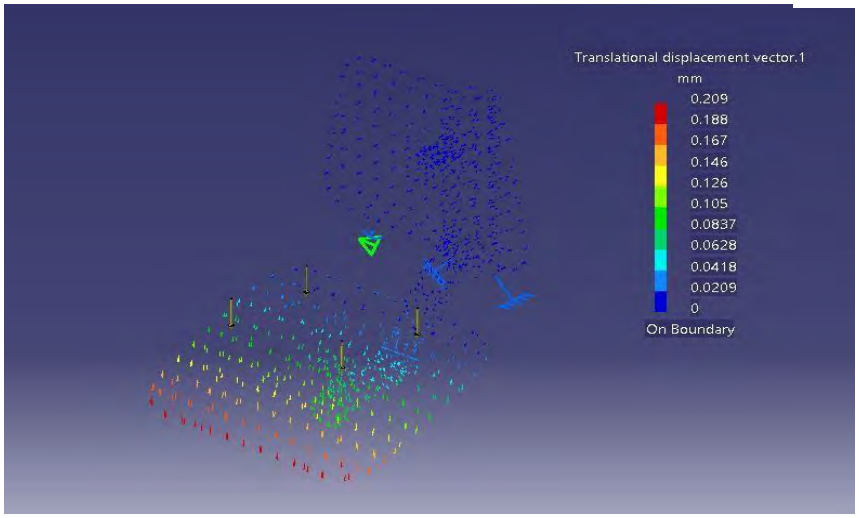


Figure 6.22: Displacement Vector for Bottom Part using Iron

(Source: Author)

6.2.3.2 Seat

The load applied at the seat is 350N. The maximum stress value is 6.7 MPa. The value for displacement vector is 0.209 mm as shown in **Figure 6.23** and **Figure 6.24**.

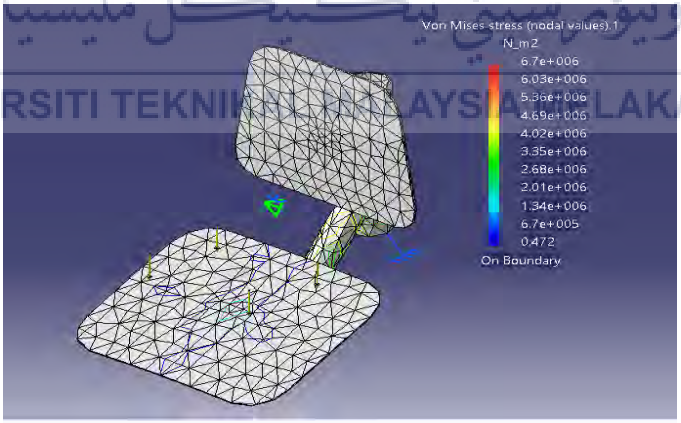


Figure 6.23: Von Misses Stress for Seat using Iron

(Source: Author)

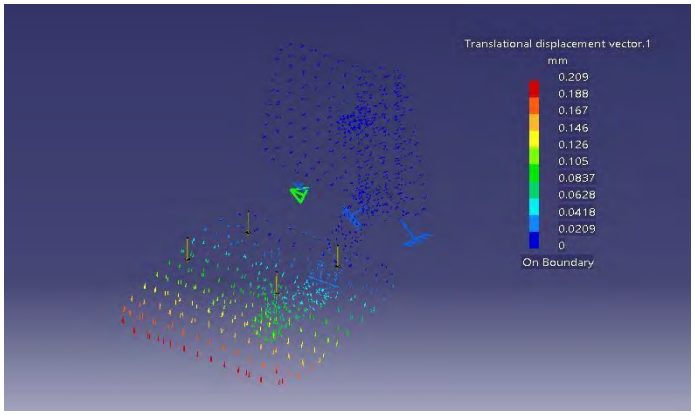


Figure 6.24: Displacement Vector for Seat using Iron

(Source: Author)

6.2.3.3 Handle Bar

The value of maximum stress for 30N is 3.16MPa while the value of displacement vector is 0.0012mm. Result of the von misses stress and displacement vector for handle bar have shown in **Figure 6.25** and Figure **6.26**.

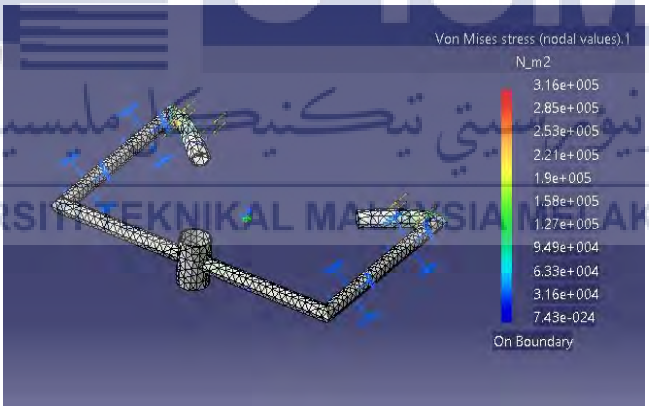


Figure 6.25: Von Misses Stress for Handle Bar with 30N using Iron

(Source:Author)

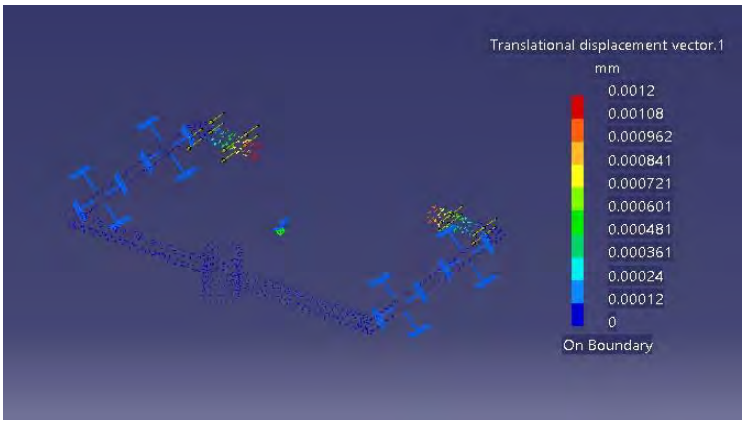


Figure 6.26: Displacement Vector for Handle Bar with 30N using Iron

(Source: Author)

The value of maximum stress for 50N is 1.64MPa while the value of displacement vector is 0.0645. Result of the von misses stress and displacement vector for handle bar have shown in **Figure 6.27** and Figure **6.28**.

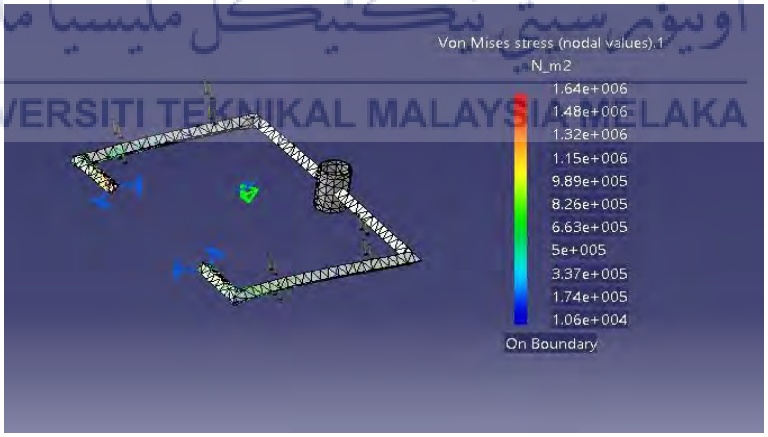


Figure 6.27: Von Misses Stress for Handle Bar with 50N using Iron

(Source: Author)

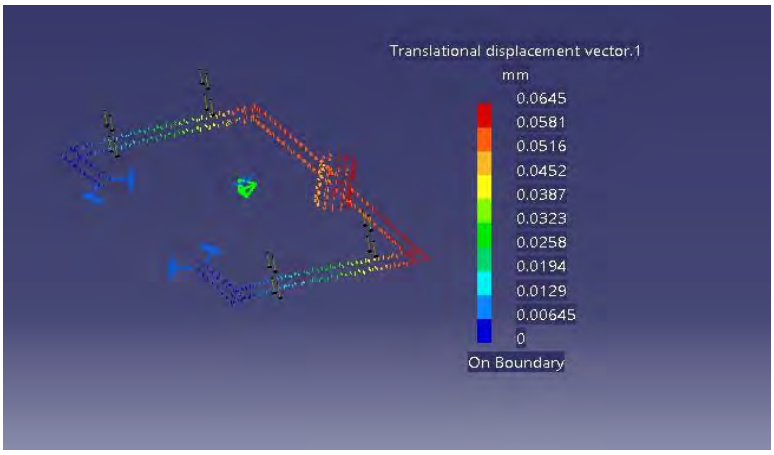


Figure 6.28: Displacement Vector for Handle Bar with 50N Using Iron

(Source: Author)

6.2.4 Aluminium

The last material that has been used for this analysis is aluminium. **Table 6.4** shows the material properties for the aluminum

Table 6.4: Material Properties of Aluminium
(Source: CATIA software)

Material	Aluminium
Young Modulus (N/m2)	7x1010
Poisson Ratio	0.346
Density (kg/m3)	2710
Thermal Expansion (Kdeg)	2.3x10-5
Yield Strength (N/m2)	9.5x107

6.2.4.1 Bottom Part

Figure 6.29 and **Figure 6.30** explain the result analysis for the bottom part. Regarding to the result, the value of maximum stress is 9.18 MPa while the value for the displacement vector is 0.27mm. The load applied for this analysis is 550N.

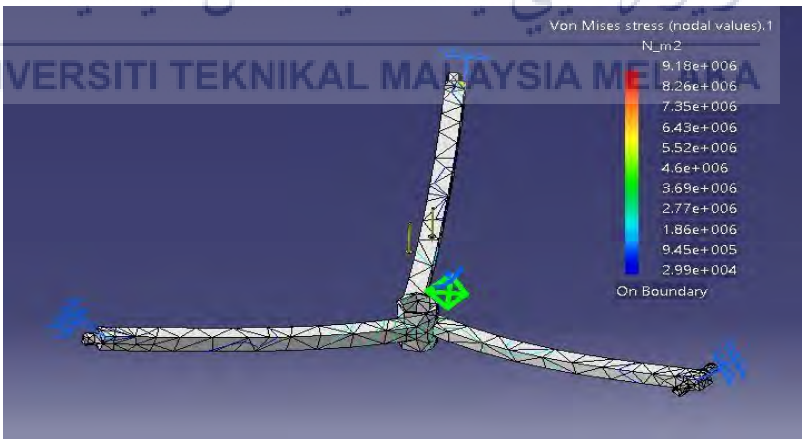


Figure 6.29: Von Misses Stress for Bottom Part using Aluminum
(Source: Author)

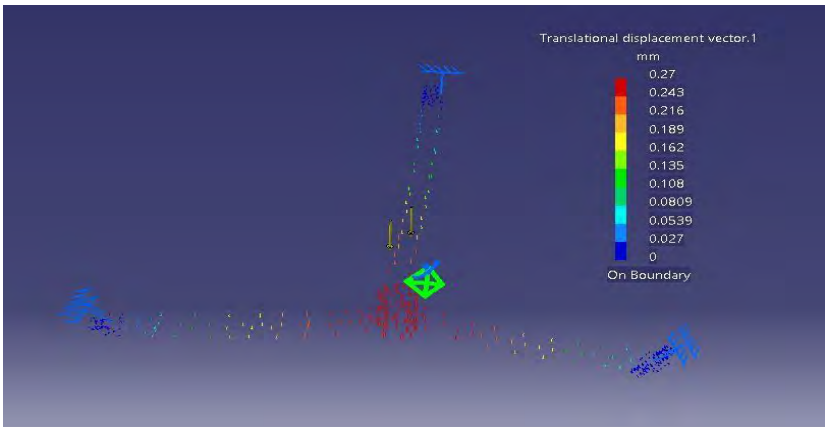


Figure 6.30: Displacement Vector for Bottom Part using Aluminium

(Source: Author)

6.2.4.2 Seat

The load applied at the seat is 350N. The maximum stress value is 6.28 MPa. The value for displacement vector is 0.35mm as shown in **Figure 6.31** and **Figure 6.32**.

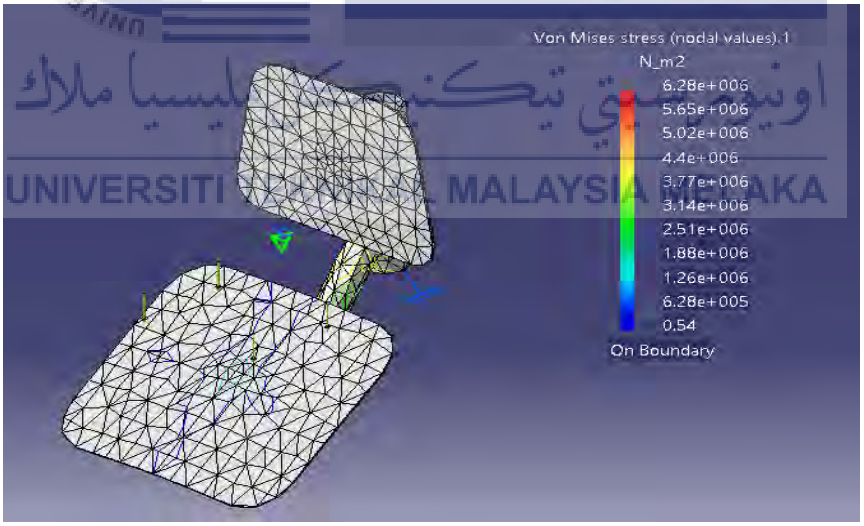


Figure 6.31: Von Misses Stress for Seat using Aluminium

(Source: Author)

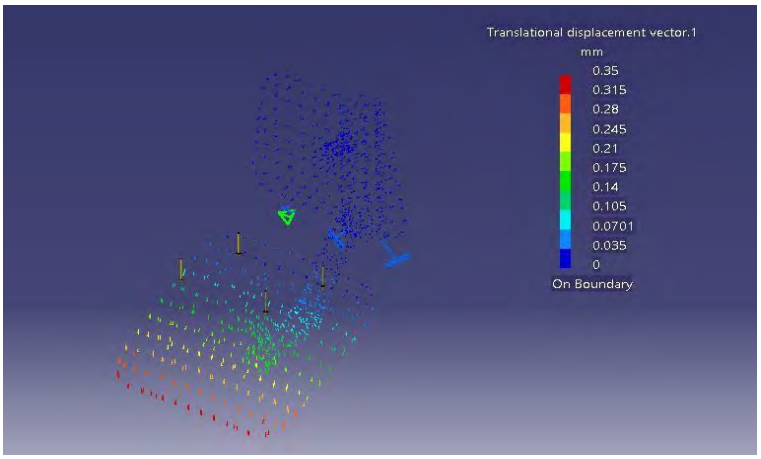


Figure 6.32: Displacement Vector for Seat using Aluminium

(Source: Author)

6.2.4.3 Handle Bar

The value of maximum stress for 30N is 2.99 MPa while the value of displacement vector is 0.0023mm. Result of the analysis shown in **Figure 6.33** and **Figure 6.34**.

Figure 6.33: Von Misses Stress Handle Bar with 30N using Aluminium

(Source: Author)

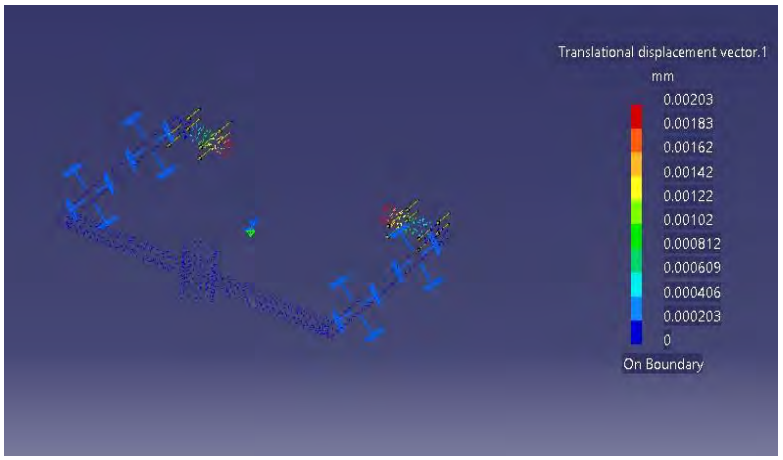


Figure 6.34: Displacement Vector for Handle Bar with 30N using Aluminium

(Source: Author)

The value of maximum stress for 50 N is 1.54 MPa while the value of dispacement vector is 0.106mm. Result of the analysis shown in **Figure 6.35** and **Figure 6.36**.

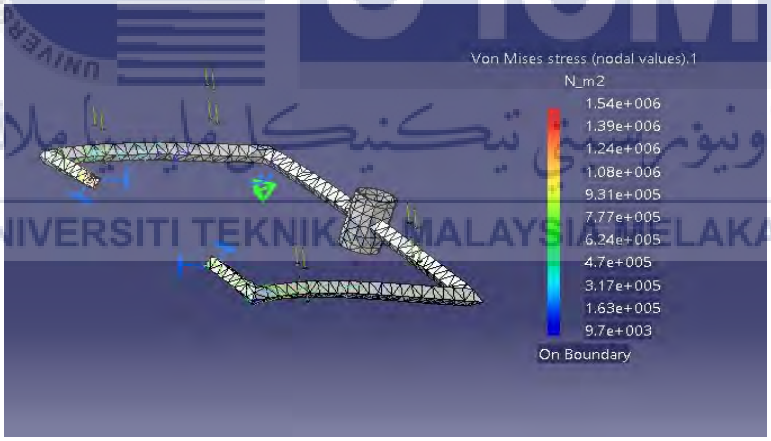


Figure 6.35: Von Misses Stress Handle Bar with 50N using Aluminium

(Source: Author)

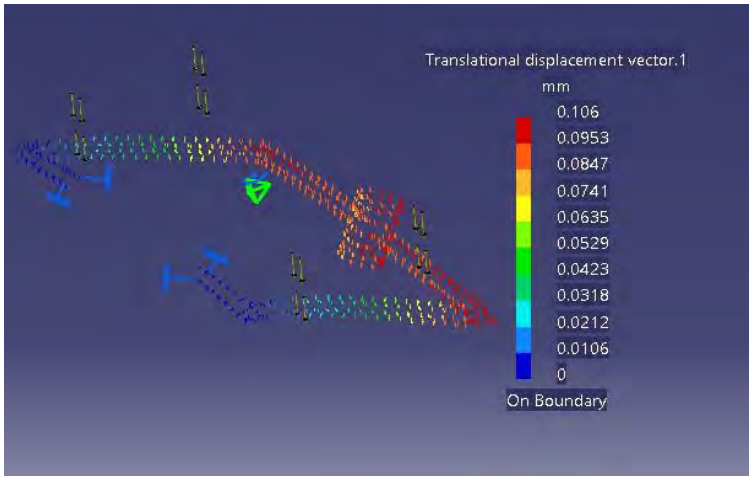


Figure 6.36: Displacement Vector for Handle Bar with 50N using Aluminium

(Source: Author)

The safety factor of the parts was calculated by using the formula at **Equation 1**. Each of the material undergoes the FEA analysis and the safety factor was identified. The result forms the analyses are shown in **Table 6.5, Table6.6, Table 6.7** and **Table 6.8**. This is the example calculation of bottom part by using the Mild Steel as the material.

- Yield tensilestrength, S_{yt} = $2.5x10^8$Pa
- Von Misses Strength, $\sigma_{VonMisses}$ = $9.2x10^6$Pa

$$\text{SafetyFactor} = \frac{Syt}{\sigma\ Von\ Misses}$$

$$= 2.5x10^8 / 9.2x\ 10^6$$

$$= 27.17$$

Table 6.5: Safety Factor of BottomPart

Material	Yield Strength (N/m^2)	Maximum Stress (N/m^2)	Factor of Safety
Mild Steel	$2.5x10^8$	$9.2x10^6$	27.17
Stainless Steel	$1.7x10^8$	$5.25x10^6$	32.38
Iron	$3.1x10^8$	$9.36x10^6$	33.12
Aluminium	$9.5x10^7$	$9.18x10^6$	10.39

Table 6.6: Safety Factor ofSeat

Material	Yield Strength (N/m^2)	Maximum Stress (N/m^2)	Factor of Safety
Mild Steel	$2.5x10^8$	$6.88x10^6$	36.33
Stainless Steel	$1.7x10^8$	$6.84x10^6$	24.85
Iron	$3.1x10^8$	$6.7x10^6$	46.27
Aluminium	$9.5x10^7$	$6.28x10^6$	15.13

Table 6.7: Safety Factor of Handle Bar with 30N

Material	Yield Strength (N/m^2)	Maximum Stress (N/m^2)	Factor of Safety
Mild Steel	$2.5x10^8$	$3.11x10^5$	803.86
Stainless Steel	$1.7x10^8$	$3.20x10^5$	531.25
Iron	$3.1x10^8$	$3.16x10^5$	981.02
Aluminium	$9.5x10^7$	$2.99x10^5$	317.73

Table 6.8: Safety Factor of Handle Bar with 50 N

Material	Yield Strength (N/m^2)	Maximum Stress (N/m^2)	Factor of Safety
Mild Steel	$2.5x10^8$	$1.37x10^6$	182.48
Stainless Steel	$1.7x10^8$	$1.32x10^6$	128.79
Iron	$3.1x10^8$	$1.64x10^6$	189.02
Aluminium	$9.5x10^7$	$1.54x10^6$	61.69

6.3 StructuralAnalysis

Referring to the **Table 6.5**, **Table 6.6**, **Table 6.7**, the value of factor safety for each material used is in the midmost between high and low value. However, the value of safety factor for Table 6.8 shows the different as the result of safety factor slightly increases. As the solution for this unstable safety factor value, the material and dimension of the design structure need to be optimize in order to the safety factor flanking to the intendvalue.

Referring to all list of table, the value of safety factor for all of the aluminium material is low. This is because the material has lowest value in terms of yield strength. Regarding to the advantage material properties, Aluminium was probably the ideal material. Aluminium is very high materials and also a good conductor of electricity. However, although the aluminium material offers many beneficial of material properties, it will be excluded as the ideal material according to the high price. Aluminium material is more expensive than steel material.

Iron is probably not a suitable material to use due to the highest number of safety factor. The Iron material has the highest value of yield strength compared to the other material. Besides, Iron material has high density that lead the material becomes too heavy.

According to the safety factor form all of selective material, the results shows that all of the material is suitable to use. But, in order reduce the cost of production, the material properties must be selected properly due to the price and the functionality of the material. Mild steel is the cheapest material among the others so, probably mild steel is the ideal material. In addition, mild steel is the durable material and can withstand the external pressure acting on it. The dimension of the product design also plays the importance role. The dimension needs to be smaller in order to minimize the production cost. Material selection also needs to be highlight to create an affordable design with good quality. The material with low yield strength value produces the lowest safety factor.

6.4 RULA Analysis

For this project, the design of product has undergone the ergonomics analysis by using the RULA Analysis software. RULA Analysis is used to estimate the exposure of a person to ergonomic risk factor. The RULA Analysis will identify the safety of the product design. For this research project, the walking device consists of three modes. The modes that available for the new assistive walking device are sitting and standing, wheelchair mode and last but not least is sitting and standing. The analysis started with insertion of man and woman mannequin. The mannequin will 'act' as the children that used the assistive walking device according to the three configuration modes available. The percentile for each of mannequin is 50^{th} and population selected is Japanese which is representing as characteristic of Asian people.

6.3.1 Analysis of Existing Design

The ergonomic analysis started with the existing standing chair. The purpose of this analysis is to identify the risk factor occurred towards the design. Once the risk factor was

identified, the action for improvement needed to improve the design of walking device. **Figure 6.37**, **Figure 6.38**, **Figure 6.39**, and **Figure 6.40** show the result of RULAanalysis for both man and woman in sitting position.

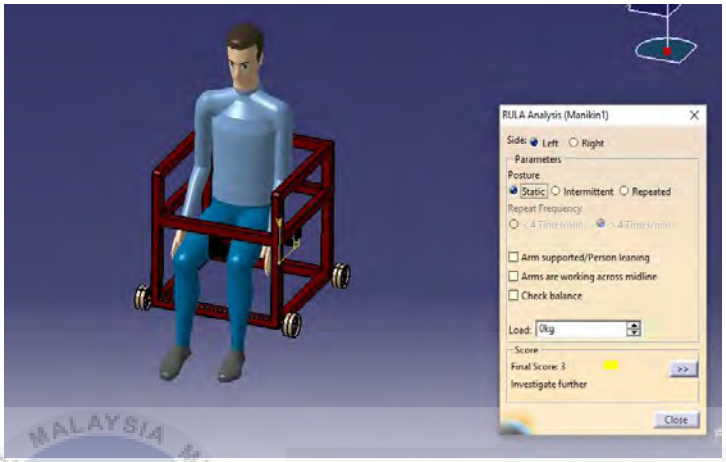


Figure 6.37: RULA Analysis of Sitting Position for Man

(Source: Author)

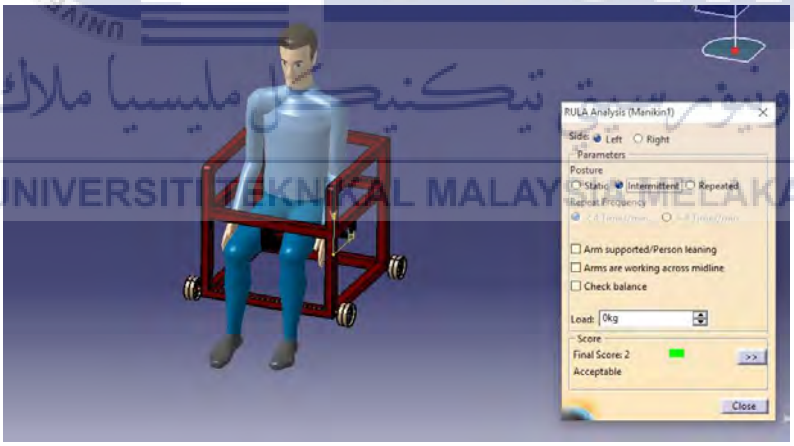


Figure 6.38: RULA Analysis Sitting Position for Man

(Source:Author)

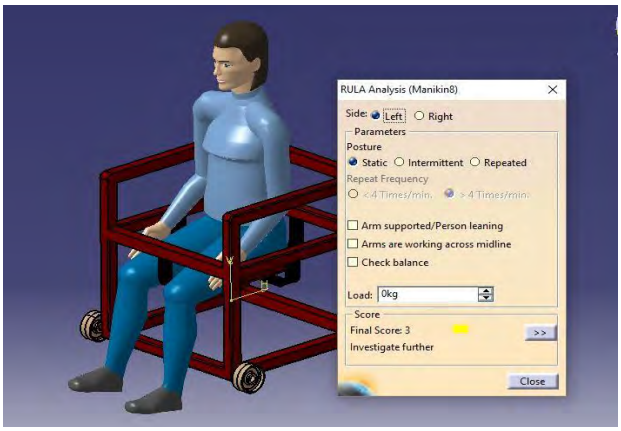


Figure 6.39: RULA Analysis Sitting Position for Woman

(Source: Author)

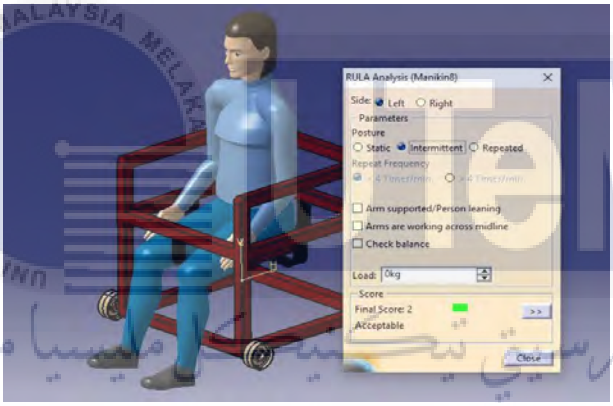


Figure 6.40: RULA Analysis Sitting Position for Woman

(Source:Author)

According to the figures above, the ergonomics analysis for both mannequins displays 3 as the final score for both conditions which is static and intermittent. Based on the **Table 3.4**, the RULA Analysis score can cause low risk and the design needed to be investigated further.

Another analysis was carried out to study the result score for the standing position. **Figure 6.41**, **Figure 6.42**, Figure 6.43, and **Figure 6.44** show both mannequins in the standing position. The final score result for this analysis is 3.

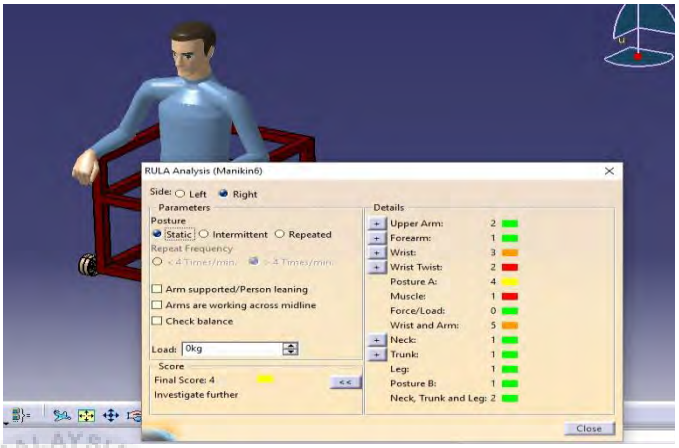


Figure 6.41: RULA Analysis Standing Position for Man (Source:Author)

Figure 6.42: RULA Analysis Standing Position for Man (Source:Author)

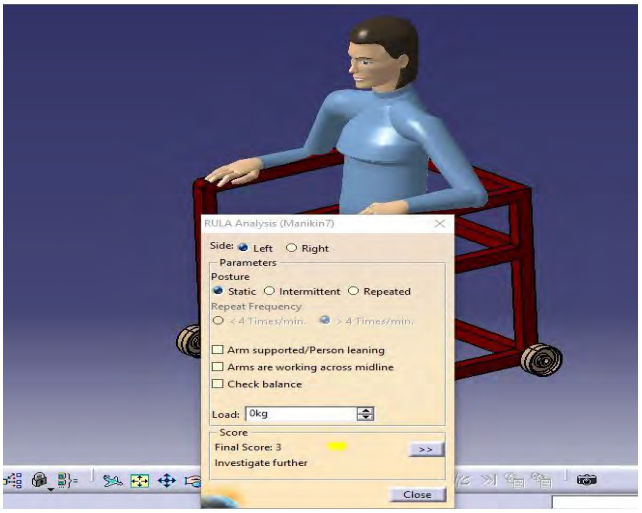


Figure 6.43: RULA Analysis Standing Position for Woman

(Source: Author)

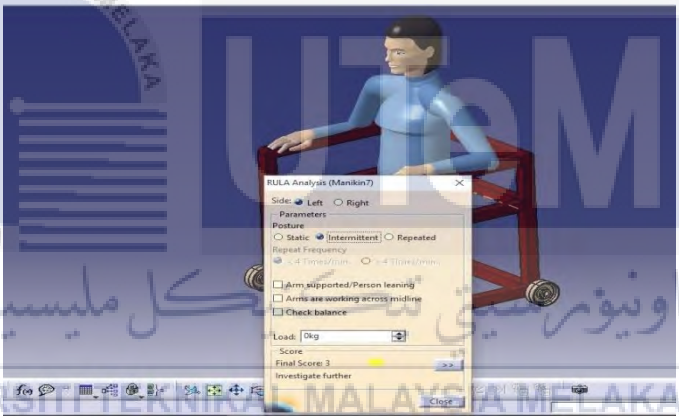


Figure 6.44: RULA Analysis Standing Position for Woman

(Source:Author)

The result of ergonomics analysis for this standing position for the existing standing chair is 3. Referring to all of the figures above, the result from this analysis needed to be investigated further to the higher final score.

To overcome this problem, the data of ergonomic analysis for this device need to be reviewed to identify the problem occurred. The main objective for the ergonomic analysis is to reduce the strain of the body that can cause injury for human. The existing design needed to improve in terms of design to fulfil the goals of the ergonomic analysis.

6.3.2 Analysis of Improvement Design

The first ergonomics analysis is standing and walking position**. Figure 6.45, Figure 6.46, Figure 6.47** and **Figure 6.48** show the results based on the analysis for the standing and walking position. Two mannequins with different gender have been tested to identify the final score for each of the mannequin. The tested was carried out to identify the final score for the posture of mannequin in static condition and intermittent condition.

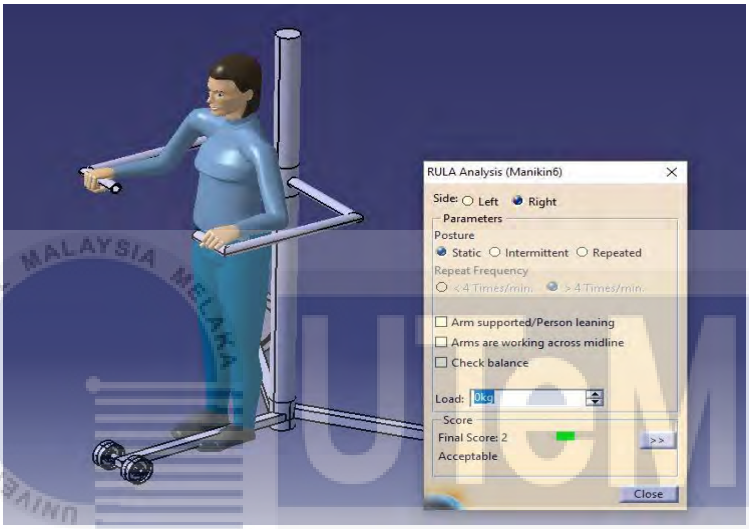


Figure 6.45: RULA Analysis Standing Position for Woman

(Source: Author)

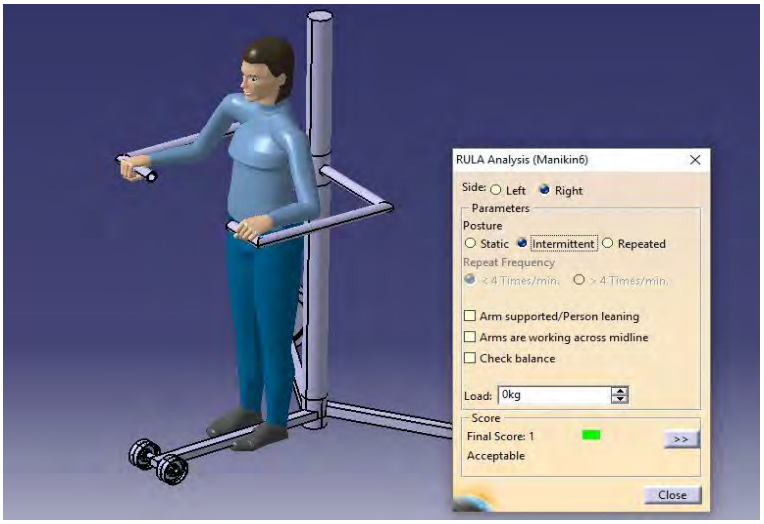


Figure 6.46: RULA Analysis Standing Position for Woman

(Source: Author)

Figure 6.47: RULA Analysis Standing Position for Man

(Source: Author)

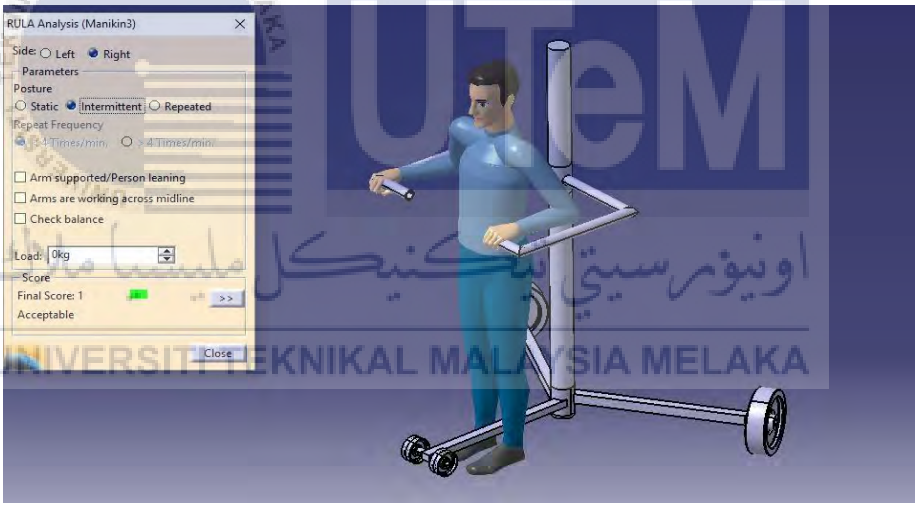


Figure 6.48: RULA Analysis Standing Position for Man

(Source: Author)

Regarding to the result of analysis from **Figure 6.45**, **Figure 6.46**, **Figure 6.47** and **Figure 6.48**, it display the final score for the two condition of the user. The result from static condition for both man and woman stated that the final score is 2 while for the intermittent condition, the final score is 1.

Based on the result stated for both of the mannequin, it illustrated that the product design is safe to use in term of ergonomics. The percentage of risk happened while using this device is decrease. Therefore, no action for improvement requirement needed since that the results stated that the position of body posture for this assistive walking device is suitable touse.

Next analysis is the evaluation of body posture for sitting mode. The body posture of sitting mode is used in the first configuration mode which is sitting and standing and the other configuration mode that used the body posture of sitting is in wheelchair mode. Similar to the analysis of standing mode, there are two mannequins represent as womanand man. The mannequin was set into the sitting position and the RULA test was run. **Figure 6.49**, **Figure 6.50**, **Figure 6.51** and **Figure 6.52** show the result of the analysis.

Figure 6.49: RULA Analysis Sitting Position for Woman

(Source: Author)

Figure 6.50: RULA Analysis Sitting Position for Woman

(Source: Author)

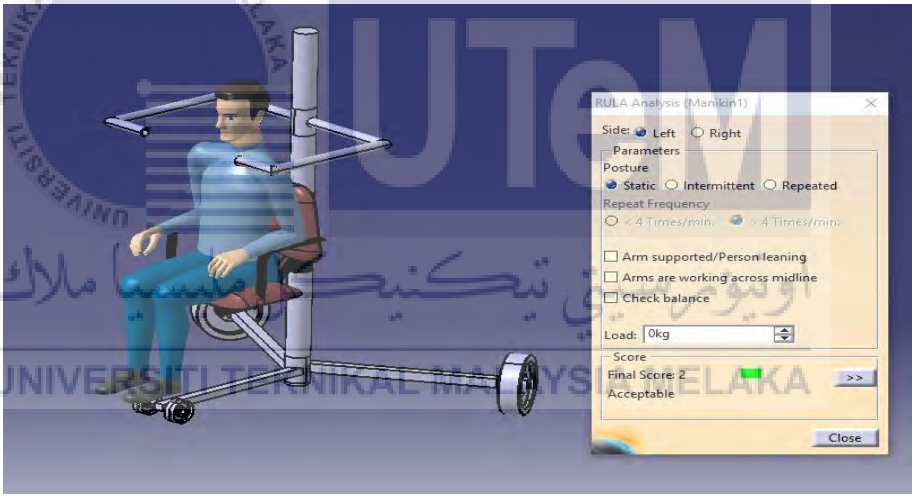


Figure 6.51: RULA Analysis Sitting Position for Man

(Source: Author)

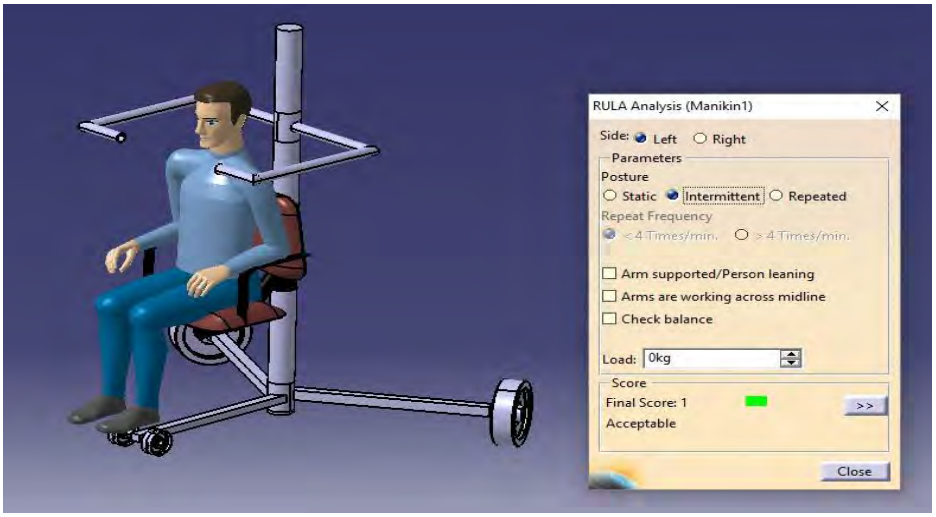


Figure 6.52: RULA Analysis Sitting Position for Man

(Source: Author)

Based on the result of RULA Analysis, it shows that the final score for both mannequin man and women which are in sitting position is acceptable. For the static condition, it explained that the value of final score is 2 for both mannequins while for intermittent condition also displays flying colours results which is the final score for the analysis is 1 for both man and woman mannequin.

Lastly, the RULA Analysis is used to investigate the ergonomic score for the mannequin in the posture of pushing position. The body posture for pushing position appearance is shown in **Figure 6.53**, **Figure 6.54**, **Figure 6.55** and **Figure 6.56** for men and women. Regarding to these figures, the final score for pushing position in static condition is 2 and the score for intermittent condition is similar to the other position mode which 1. This pushing position is safe to use as it followed the ergonomics principle. There are no excessive forces for this position that would affect the musculoskeletal system that will lead the failure of the system.

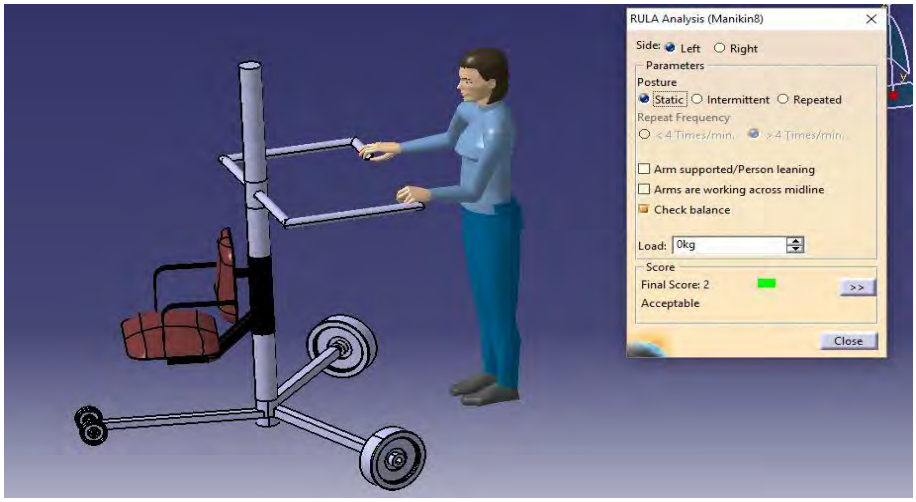


Figure 6.53: RULA Analysis Pushing Position for Woman

(Source:Author)

Figure 6.54: RULA Analysis Pushing Position for Woman

(Source:Author)

Figure 6.55: RULA Analysis Pushing Position for Man

(Source: Author)

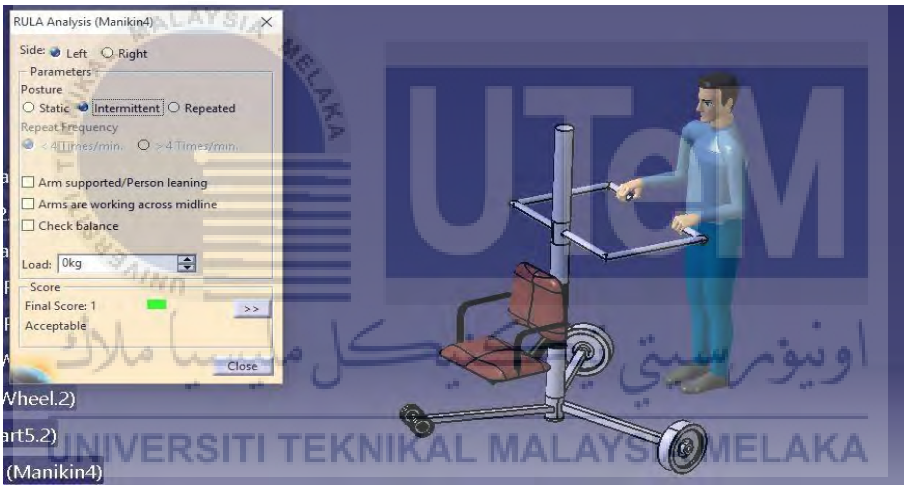


Figure 6.56: RULA Analysis Pushing Position for Man

(Source: Author)

Referring to the figure, the final score for the test is 2. The posture was set into intermittent since that the user will operate body movement as slowly walking. The final score value was acceptable. This method is safe to use as it followed the ergonomic principle. There are no excessive forces for this position that would affect the musculoskeletal system that will lead the failure of the system.

Table 6.9 stated the result of existing standing chair obtained from RULA analysis. Based on the result display in the table, the final score have exceed the safe value which is

the final score must be less than 2. So, the existing design of standing chair must be analyzed and make some improvement to prevent any risk.

Table 6.10 shows the result of new improvement design obtained from the RULA analysis. Regarding to the result form table, it is clearly stated that the final for RULA analysis which is the value must not exceed 2. In conclusion, the design is safe to use to both men and women.

Table 6.9: Final Score of RULA analysis for Existing Design

(Source: Author)

Gender	Static Position		Intermittent Position	
	Standing	Sitting	Standing	Sitting
Men	4	3	3	2
Women	3	3	3	2

Table 6.10: Final Score of RULA analysis for Proposed Design

(Source: Author)

Gender	Static Position			Intermittent Position		
	Standing	Sitting	Pushing	Standing	Sitting	Pushing
Men	2	2	2	1	1	1
Women	2	2	2	1	1	1

Regarding to all of the ergonomic analysis based on the result shown in the table, the final score for each of the body posture for the position such as sitting standing and pushing was acceptable. The new assistive product design was fulfil the safety characteristic in term of ergonomic analysis compared to the existing design which is standing chair. In general, the new walking devices introduced three functionality of configuration modes compared to the existing design of standing chair. For the improvement to the new walking device, the wheelchair was being introduced where the children can sit on the seat while the guardians can push them from theback.

In term of the ergonomic analysis, the new assistive walking device provides an excellent final score for all of the position of body posture. As been mention earlier, the new walking have three configuration modes with is the first one is sitting and standing mode. For this mode, it allows the person to do exercises for instance, sitting and standing at the same time to build up the arm muscle and also a therapy technique for development of the muscle. The different between sitting and standing modes of existing design and new walking design is, the new walking device provide comfortable hip support and back body support for the user. Meanwhile, the new walking device also offered stability for arm support which is the handle bar of new walking device can be adjusted according to the height of the users. The seat also provides the similar function where it can beadjusted.

The next configuration mode available is wheelchair mode. The purpose of designed this mode is to make the transportation of walking device become easier. The result of ergonomic analysis for this position is acceptable for both man and woman mannequin. So, this pushing position proposed for the new walking device is safe to use and there no action for improvement required.

In order to get the best result for the ergonomic analysis, the test was been run for two condition which is both mannequin will remain static without any movement for each of the body position such as standing, sitting and pushing. The additional condition is intermittent posture. Intermittent posture is the position of body posture that makes a movement for instance, standing and sitting in a certain time. The result of ergonomics analysis for new assistive walking device stated that all of the position is up to standard and the most important things are the risk of accident occurred can bereduced.

Last but not least, the new improvement was makes to provide a better version of walking device to offer the good stability of body posture and provide more comfortable support for the user.

6.5 Summary of Chapter 6

There are two analysis was carried out for this project. The purpose of doing the analysis is to determine the safety factor for the design product and also to identify the risk factor by using the RULA analysis. For structural analysis, the analysis carried out each part of the detail design by using different material. For RULA analysis, the analysis used two mannequin which is male and female to identify if the product design is safe to use for all types of people. Based on the result obtained, the product design fulfils all the safety criteria and also the most important is fulfils the customer requirement.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

7.1 Conclusion

As has been mentioned, the objective for this project was accomplished. The design assistive walking device with ergonomic analysis was successfully designed. An improved assistive walking device design that has multifunctional way was successfully constructed. The walking device was developed according to background research at Pusat Pemulihan dalam Komuniti (PDK) by gathering the data from voice of the customer and successfully transformed into the technical specification.

First and foremost, the device functionality was made up by three configuration modes such as sitting and standing mode, wheelchair mode, standing and walking mode. The highlight part for this research project is performing the analysis to investigate the factor of safety for the walking device. There are two analyses that have been used. The first analysis used is FEA analysis to determine the maximum stress value for each material applied on the parts of the product design. The material used for this research project is Mild Steel, Stainless Steel, Iron and Aluminium. Other than that, RULA Analysis was carried out to identify either the assistive walking device will cause harmful or not to the user. For this analysis, the evaluation of body position, movement, muscle was examining regarding to the three functional modes available.

Based on the methodology, the first method to starting up the project is the information gathered by interviewed the headmaster of PDK. The gathered data was generated to create a few of conceptual design based on the voice of customer.

The conceptual design was fulfil the customer characteristic by evaluating all the customers' needs and problem occurred.

The design of the new assistive walking device was improved in order to generate the best conceptual design. The modification of the concept design provides a better quality in terms of strength and functionality. In addition, the new improvement also provide a better result for minimize the weight of the device and failure occurred.

Overall, the improvement of structural design for this research project was a success. The result for each analysis represented for this project was very positive. The ability and functionality of the new assistive walking device fulfil the standard safety specification and was ready to be generating as a prototype.

7.2 Recommendation

Although the product design indicate a proof of achieving the main objectives of the design, but there are some areas that that must be improved. There are several aspects in term of design that need to be investigating further to produce a good quality of the design. There are some improvement that is specifically made to simplify the manufacturing process and minimizing thecost.

The handle bar for this project may possibly design in various types and in order to identify which are the best designs according to the ergonomic analysis. Regarding to result of analysis, the dimension of the design could be larger due to excessive force applied on the handle bar. If the dimension of the handle bar and the whole of product design was increase, there might be possible for the walking device to become universal

and suitable for teenagers andadult.

Another recommendation is simplifies the design structure by reducing the number of custom made parts such as wheels. In order to minimize the cost of production, wheels should be reduced. By reducing the parts, the excessive force or stress that acting on the parts will decrease.

Furthermore, the walking device was analysis by using the 50^{th} percentile of female and male regarding to the characteristic of Asian population. In order to get a better version of walking device, the additional of analysis should be improved by modify the percentile of human and characteristic of the human in RULA Analysis. Thus, this recommendation will upgrade the maximum load applied on the walking device since that there are many various types of analysis have been done.

Last but not least, the design for this assistive walking device should be improved year by year. This is because the voice of customer requirement might change regarding to the passing of time. Nowadays, the engineering technology has changed rapidly. In the future, by referring to the latest technology and the idea concept of the young generation, the new concept design of walking device for children with physical disabilities can be improved to a better version.

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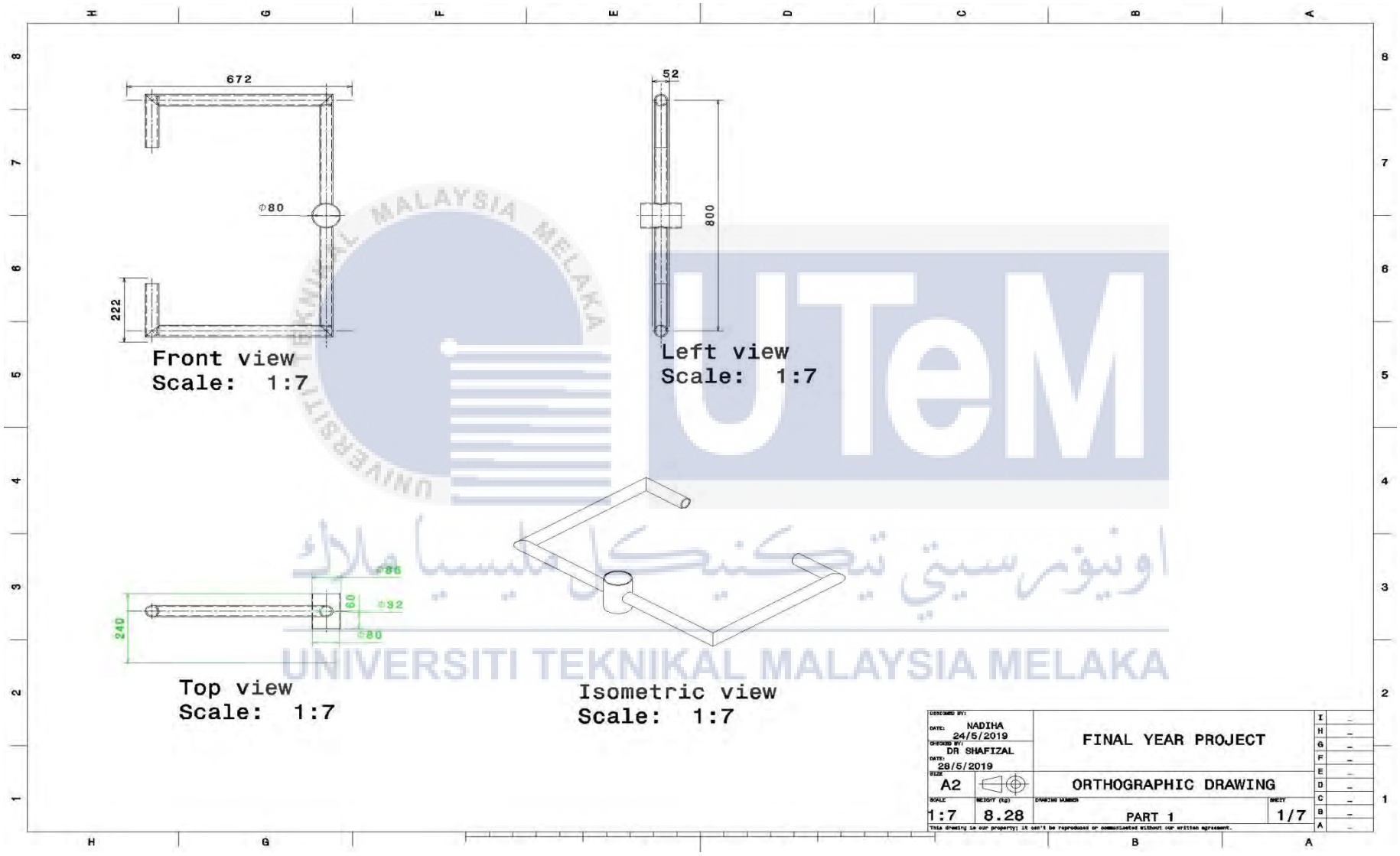
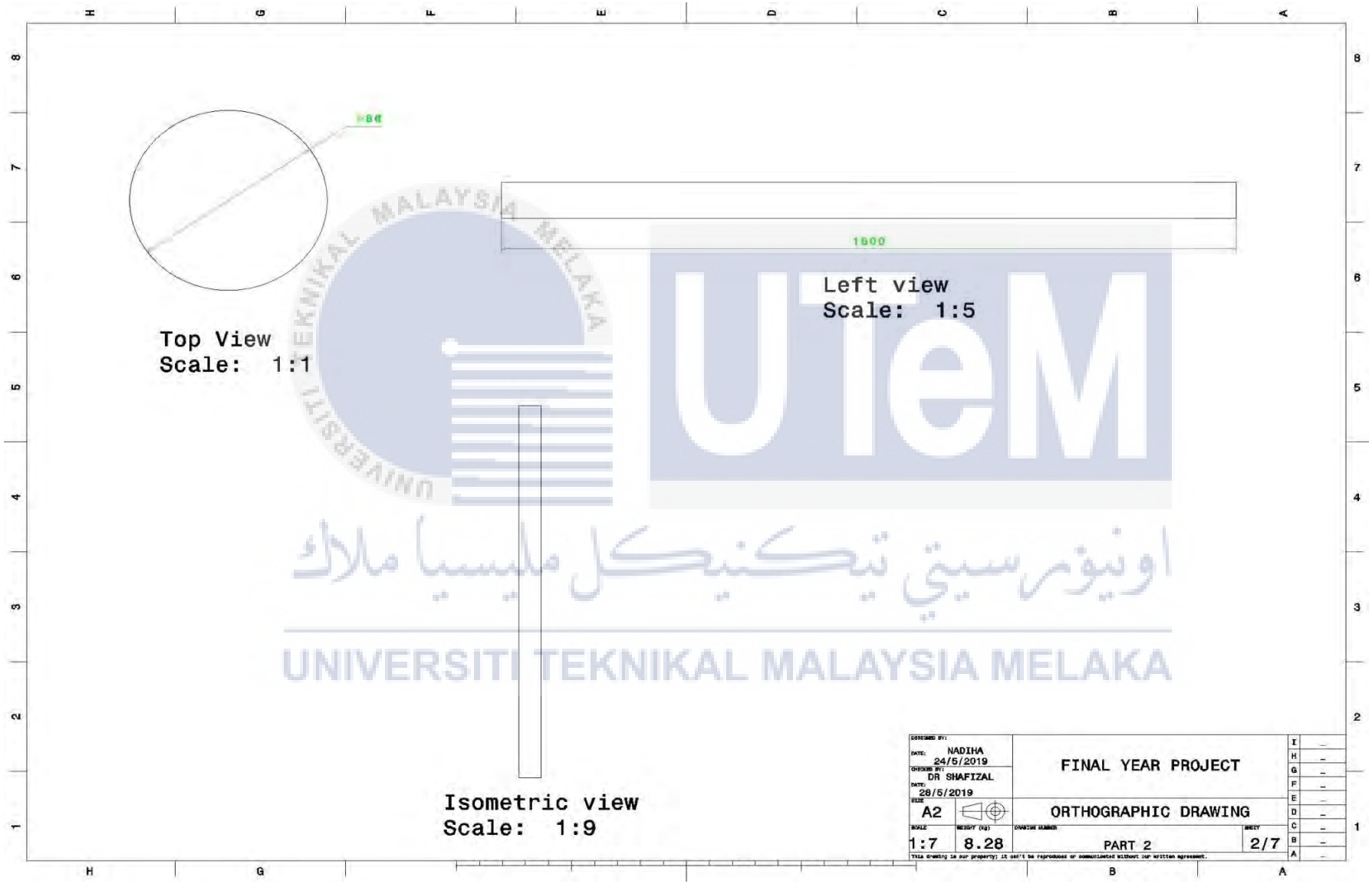
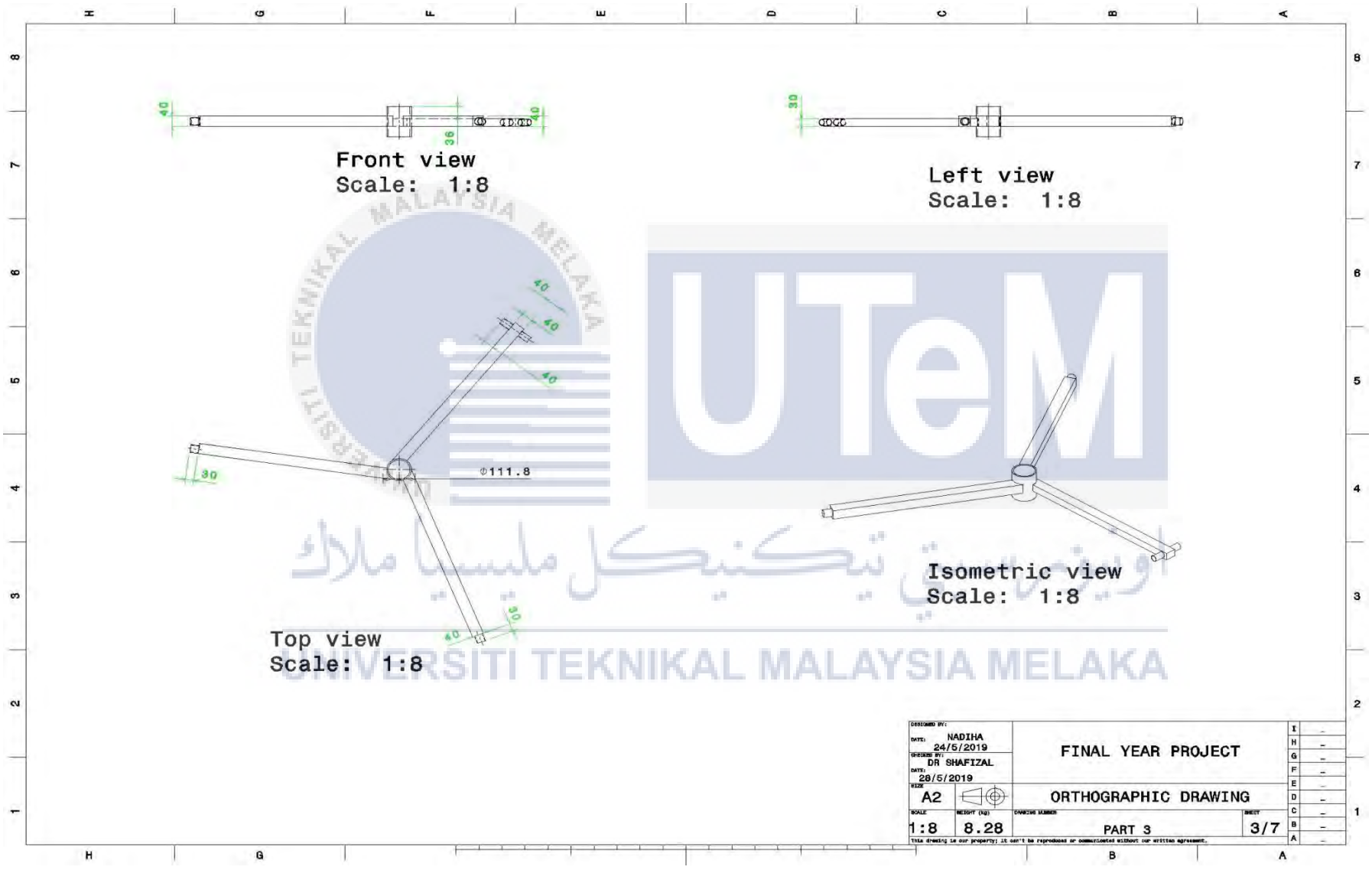
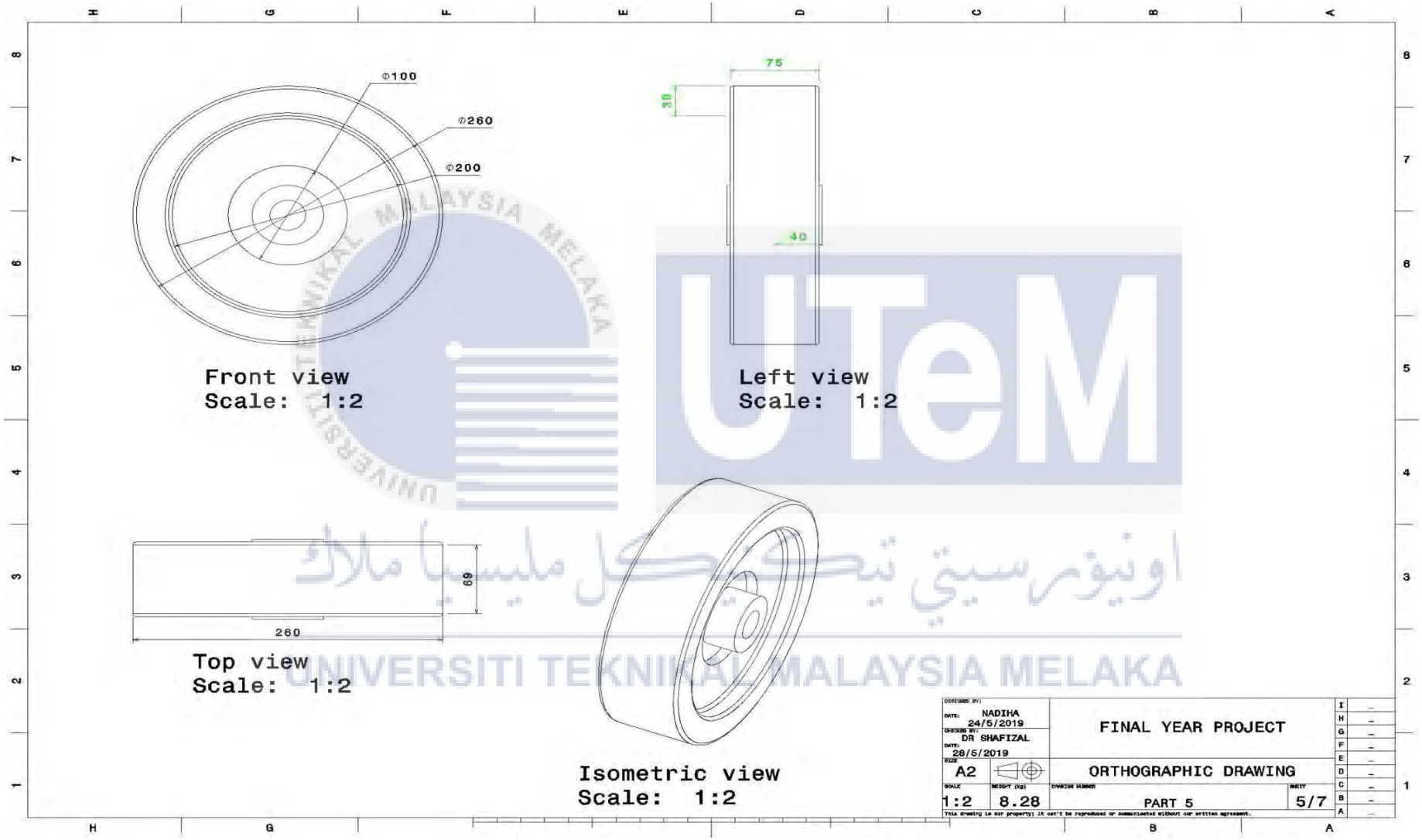
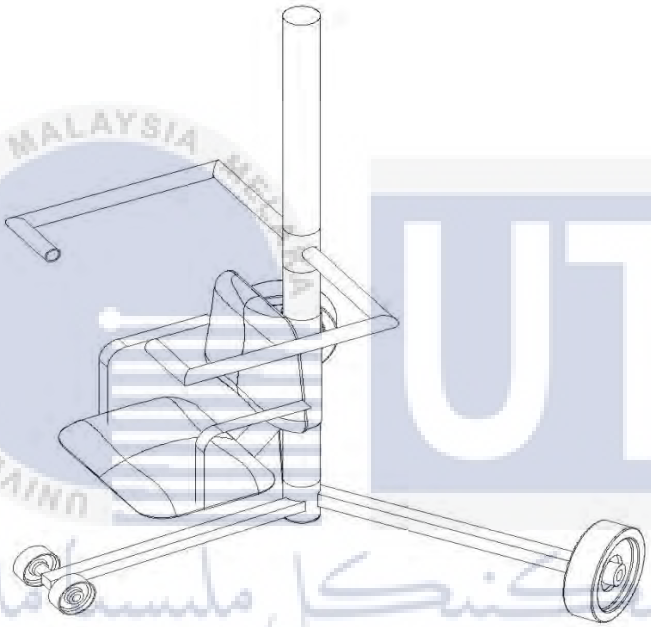
APPENDIX











Isometric view
Scale: 1:7

DESIGNED BY: NADIHA DATE: 24/5/2019 CHECKED BY: DR SHAFIZAL DATE: 28/5/2019		FINAL YEAR PROJECT	
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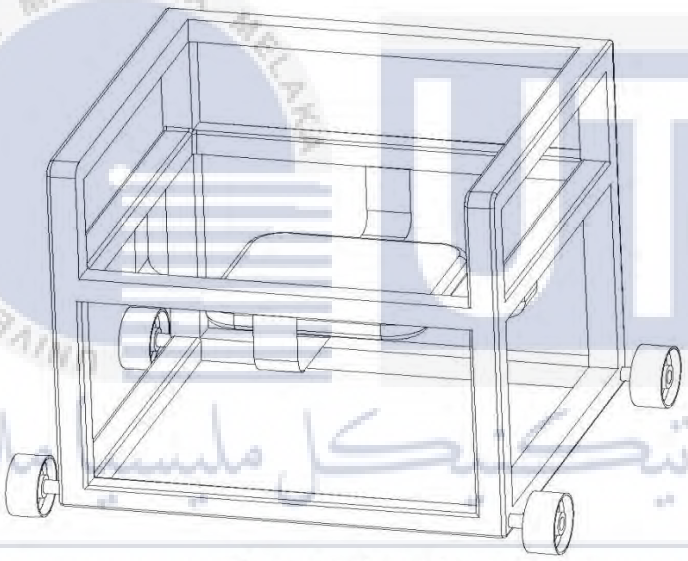
SCALE: 1:7	WEIGHT (Kg): 8.28	DRAWING NUMBER: PART 6	SHEET: 6/7



Isometric view
Scale: 1:4

DESIGNED BY: NADIHA DATE: 24/5/2019		FINAL YEAR PROJECT	
CHECKED BY: DR SHAFIZAL DATE: 28/5/2019			
SIZE: A2		ORTHOGRAPHIC DRAWING	
SCALE: 1:4	WEIGHT (Kg): 8.28	DRAWING NUMBER: PART 7	SHEET: 7/7

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Gantt Chart for Final Year Project 1

NO	TASK	WEEK														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Introduction Detail Discussion with sv Problem Statement Objective Scope															
2	Review literature Work Literiture Review (journal, book) Finding additional information/ knowledge															
3	Methodology Design theproduct SimulationWork PredictionResult															
4	Report Writing															

Gantt Chart for Final Year Project II

NO	TASK	WEEK														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Product Design Selection															
2	Produce detailDesign															
3	Analysis for design															
4	Report PSM2															