ERGONOMIC DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN THE CLASSROOM

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This report is submitted
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DECLARATION

I declare that this project entitled “ERGONOMIC DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN THE CLASSROOM” is the result of my own work except as cited in the references.

Signature : 

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Date :26.08.2020

SUPERVISOR'S DECLARATION

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

Signature : .....

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Date : 26.8.2020

DEDICATION

I dedicate this project to my beloved parents and family members, lecturers and friends that always give me encouragement, love, moral supports and pray for my success throughout this Final Year Project.

ABSTRACT

Children who are suffering from disabilities experience learning difficulties and need some extra care. Cerebral palsy (CP) is classified as one of the physical disabilities that occur among children. Children with physical disabilities most likely have difficulties in moving from one place to another. Although there are many aid tools that available in Malaysia to help them in their daily life, children with physical disabilities still have problem in moving around freely like other normal children. Therefore, the purpose of this project is introducing and develop an ergonomic walking chair to help them performing their daily life much easier. This new mechanism of walking chair also help them in rehabilitation for their own good. The process of this project started with an observation at Pusat Pemulihan Dalam Komuniti (PDK) to look closely for their difficulties in their daily life. House of Quality been produced to convert the customer requirement into engineering characteristics based on the observation. Then, Morphological Chart been made to translate it into some conceptual designs. In addition, final design was selected among the conceptual designs using Weighted Decision Matric. After that, 3D model of the final design was produced by using Solidworks 2016. Analysis and simulation been carried out to make sure the product design is safe to be use. The simulation and stress analysis has been running in the software to determine the safety of factor of the product. This mechanism of the product is far the most convenient for children with physical disabilities in Malaysia to use for their daily task and low maintenance.

ABSTRAK

Kanak-kanak yang menderita akibat kecacatan mengalami masalah pembelajaran dan memerlukan penjagaan yang lebih. Cerebral palsy (CP) diklasifikasikan sebagai salah satu daripada kecacatan fisikal yang terjadi dalam kalangan kanak-kanak. Walaupun telah banyak alat bantuan yang telah wujud di Malaysia untuk membantu dalam urusan harian mereka, kanak-kanak yang mengalami kecacatan fisikal masih mempunyai masalah dalam bergerak sekeliling mereka dengan bebas seperti kanak-kanak normal yang lain. Oleh sebab itu, tujuan projek ini ialah memperkenalkan dan mencipta sebuah kerusi berjalan yang ergonomik untuk memudahkan urusan harian mereka. Mekanisme baharu ini juga dapat membantu mereka dalam rehabilisasi untuk kebaikan mereka. Proses kerja dalam projek ini dimulakan dengan pemerhatian di Pusat Pemulihan Dalam Komuniti (PDK) untuk melihat lebih dekat kesusahan yang dihadapi dalam urusan harian mereka. House of Quality dikeluarkan untuk menukarkan permintaan pelanggan kepada karakter kejuruteraan berdasarkan pemerhatian yang telah dibuat. Kemudian, Morphological Chart dibuat untuk menterjemahkannya kepada beberapa reka bentuk konsep. Tambahan lagi, reka bentuk akhir dipilih berdasarkan reka bentuk konsep menggunakan Weighed Decision Matric. Kemudian, model 3D reka bentuk akhir dibentuk menggunakan Solidwork 2016. Analisis and simulasi dibuat untuk memastikan reka bentuk selamat untuk digunakan. Simulasi and analisis tekanan dijalankan dalam aplikasi untuk menentukan factor keselamatan produk. Setakat ini, mekanisme produk ini adalah yang paling senang untuk kanak-kanak dengan kecacatan fisikal di Malaysia menggunakannya untuk urusan harian mereka dan rendah dari segi kos penyelenggaraan.

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WHO	World Health Organization
OKU	Orang Kelainan Upaya
CAD	Computer Aided Design
CP	Cerebral Palsy
GMFCS	Gross Motor Function Classification System
HOQ	House of Quality
FEA	Finite Element Analysis
PSM	Projek Sarjana Muda
UTeM	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Introduction

The ‘Projek Sarjana Muda’ (PSM) also known as Final Year Project (FYP) is one of the major requirement subject which needed the student to do academic research based on Mechanical Engineering course. The knowledges that has been learned in Mechanical Engineering course such as design engineering, mathematical engineering, sustainability and safety have been used for this project. This chapter explaining about the importance and basis of the project such as background, problem statement, objectives, and scope.

Ergonomics Design of Walking Chair for Disable Children in classroom is the title of the research project for this PSM. Disable person or also known as ‘Orang Kelainan Upaya’ (OKU) can occur to both children and adult and they are part of the community in Malaysia. It is a disorder which may limit someone’s mobility functions, or mental sensory to complete their task in the same way as a normal person. They may need assisting tools so they can overcome this obstacles.

1.2 Background of the project

Children with disabilities have difficulties in learning in their classroom so they need extra care or known as special educational needs. It is the process of educating the student in

some way that addresses their special needs and individual differences. Generally, this includes systematically monitored ordering and individually organized of teaching procedures, accessible settings, and adapted appliances and materials.

Special children need to go to school as normal children too. In Malaysia, they start their early school in pre-school and then they go to primary school and after that is secondary school. Usually pre-school begin when children reach age more than five years old while primary school a year later. For disabled children they can start their primary school at the age of six until 14 years old. On the other hand, secondary school can be start at the age of 13 until 19 years old. They must be certified as special children by medical practitioners and can take care of themself without the help of others and according to the academic stream, after completion of pre-school, special education children may enter primary school. Special children that follow national curriculum may sit for formal examination such as UPSR, PT3, SPM and STPM as normal students in Malaysia.

Nowadays, there are many successful people around the globe and most of them are normal student. There only a few of them are from disabled students. Normal student basically have no problem in their studies and also get opportunity to pursue into higher education level while disabled student do not. Disabled student have many barrier for them to move freely in the classroom and this factor really effect their learning process, they should be provided with friendly environment and appropriate tools for them to move freely with or without assistance from others.

This project focus on children with Cerebral Palsy (CP). There is approximately 2-3 per 1000 live birth may get CP which can be considered CP is the most cause of childhood physical disability. Activity limitations and reduced participation is the result from abnormal fine and

gross motor functioning from CP. Musculoskeletal disorder, including spasticity, contractures and bony deformities may be experience by the people with CP (O'Connell et al., 2019).

CP could be one of the permanent movement disorder that appear in early childhood. Various sign and symptoms are shown among the people over time. Usually the symptom are poor coordination, stiff muscles, weak muscles, and tremors. They might have problems with their sensation, vision, hearing, swallowing, and speaking. Babies with cerebral palsy may not roll over, sit, crawl or walk as early as normal babies at their age. Person with CP may use higher energy expenditures, impaired mobility, and reduce autonomy because of movement and gait disorders. Over time, the degeneration of ligaments and cartilage and even immobility may result from spasticity and contractures in patients with CP (Tsitlakidis, Horsch, Schaefer, & Westhauser, 2019).

The main objective of this project is to design and develop an appropriate walking chair for disabled children so they can move freely in friendly environment classroom layout and ergonomically to suit their needs. For this design of application, it is specialized for the disabled children with CP and the design also must be suitable with the classroom based on their needs and the classroom space. It is also to create an appropriate environments to increase their involvement and participation in the classroom. The designing of ergonomics analysis in this project might improve the design facilities of workstation and the environments to maximize the involvement of the student and minimize their risk of harm.

1.3 Problem statement:

Children with disabilities deserve the right learning environment with their level of ability. The lack of facilities at school and high school level for disabled people has caused these people not to live a comfortable and perfect life like other citizens or students.

In the early years, the appearance of problem behavior could put this children on adverse development trajectories. This could be true with the early externalization of the behavior, which could lead to continued problems and poor academic performance(Fauth, Platt, & Parsons, 2017).

Special kids need an appropriate learning environment suited to their disabilities. The lack of institution in providing suitable facility for them make them experiencing difficulties in their learning. Furthermore, some institutions are not concerned with providing them with facilities for them to continue their learning. It is so tough for disabled children to pursue their study in higher education. Besides, because of this condition, some of the higher institutions refuse their request to continue their education in their institution. Moreover, available assistive tools available now does not give appropriate functions for those unlucky children.

In this centuries, the level of awareness of management toward providing enough and friendly facilities for disabled people still in low state. Therefore, this study should be conduct to give a chance for disable children to study comfortably in their classroom by providing ergonomic walking tool for them and then spread the awareness in providing the learning facilities that meets the needs of disabled people among the public. It also help the communities to be more alert in giving those unlucky children with suitable tools for them pursue their studies

into higher level of education. This study also give more opportunities for those children and hopes for them to feel like a normal students out there.

1.4 Objective:

1. To design and develop an appropriate walking chair for disabled children to move freely in friendly environment classroom.

2. To evaluate an ergonomic analysis, stress analysis and safety for the users.

1.5 Scope of the project

The outlined scopes of the project are:

1. Understand and study the problems that always occur among the disabled children in Malaysia.
2. Study the classroom environment that fulfills the safety requirement for disabled student.
3. Study and develop suitable walking aid used for the student with physical disabilities.
4. Design, develop and analysis the selected design by using Computer Aided Design (CAD) software and analytical software.

1.6 Organization of Report

This report explain detail on how to achieve the objectives in this project which is designing the chair for disable children. First chapter introduces the background, problem statement, objectives and the scopes of the project.

Chapter two gives the information for literature review of this study. The information will be extract from the journals and other sources from the internet.

Third chapter will explain more about the methodology for this case study. The method used are interview and observation at Pusat Pemulihan dalam Komuniti (PDK). Furthermore, this chapter also focus on the conceptual design. There are three conceptual design proposed for this project and this chapter explain briefly the designs and the methods used to choose the best concept. It also explain the details of the best design. The characteristic and functionality of the design was analyzed in this chapter.

Chapter 4 is result and discussion for this project. Two analysis were carried out which are structural analysis and ergonomic analysis.

Chapter 5 is the conclusion for this project. The recommendation also were provided for the future work on this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, it will discuss more about the issues relating to children with disabilities (OKU). This will include the definition of disabled people and their facilities requirements. This is important in order to study their needs properly and conduct this study precisely. The categories of disabilities and their types also been identified so this information will be useful for the reasonable facilities that should be propose to this group.

There are things that must be consider so that they can be independent to perform their daily tasks as normal students. The considerations will be mention in this chapter. Furthermore, some facilities that had been used to this century also been discuss in this chapter. Several previous studies that connected to this subject of the study been highlighted in this chapter. The information about this case study can be archive through trusted websites, journal, and books.

2.2 Disabled People

Basically, disabled people (OKU) is the people with any condition that makes it harder for a person to do certain activities or interact with the world around them. Physical, intellectual, developmental, mental, cognitive, sensory, or a combination of multiple factors can be these conditions or impairments. Impairments that cause disability can occur at birth or during the

lifetime of an individual. According World Health Organization (WHO), disabilities is a comprehensive term covering impairments, activity limits and participation constraints. Disability is a defect in the body's function or structure; a limitation of activity is a challenge faced by an individual while performing a task or action; restricting participation is a problem that a person encounters when engaging in life situations. Therefore, disability is not just a health issue. It is a complex phenomenon that reflects the interaction between the characteristics of the body of a person and the characteristics of the society in which he or she lives (WHO, 2018). In order to overcome the challenges faced by people with disabilities, intervention is required to eliminate environmental and social barrier.

Categories of forms of disability include multiple physical and mental impairments that may hamper or diminish the capacity of an individual to perform his or her activities. Such impairments could affect the person's condition to do their daily tasks. Mobility and physical impairments is one of the disability categories. This category include people with varying types of physical impairments such as upper and lower limbs disability, manual dexterity and disability in co-ordination with different organ of the body. Statistical reports have clearly shown that a certain group of people with physical disabilities have become less effective on the labor market. The discrimination between people with disabilities (75%) and people with disabilities (44%) is a harsh reality of our modern civilization in terms of the employment rate of working-age people (Protim, Abdullah, Pritom, & Chowdhury, 2019). Mobility deficiency can be either an inborn or acquired with age condition problem. It might also be a disease's effect. Individual with a broken bone also fall into this disability category.

Spinal cord disability or spinal cord injury (SCI) also one of forms disability categories. This disability means that spinal cord damage that induces temporary or permanent changes in

its function. Loss of muscle function, sensation, or autonomic function in the body parts served by the spinal cord below the injury level are the symptoms of this disability. SCI refers to spinal cord or cauda equine that been insult caused by vertebra fracture of dislocation with or without an open wound track. Approximately 14 percent for spinal injury cases suffer from SCI, most of it are mono-segmental. SCI occurs frequently in people aged between 30-40 years. The mortality rate of SCI patients was higher that of age-group controls(Huang et al., 2019). Injury can occur at any level of the spinal cord and can result in complete injury, with total loss of sensation and muscle function of incompleteness, which means that some nervous signals can travel past the cord injured area. The symptoms differ, from the numbness to paralysis to incontinence, depending on the location and extent of the injury. There is also a wide range of long-term results, from full recovery to permanent tetraplegia (also known as quadriplegia) or paraplegia. Muscle atrophy, pressure sores, infections, and breathing problems are complication for SCI patients. The injury in most cases occurs from physical trauma such as car accidents, gunshot wound, falls, or sport injuries, but it may also result from non-traumatic causes such as infection, poor blood flow, and tumors. SCI can be broken down into two phases; primary and secondary injury. The destruction of the spinal cord and its surrounding vascular tissues after mechanical trauma leads to local edema, ischemia, hypoxia, which are the causes of primary injury. The main causes of secondary injury are derived from primary injury which is ischemia and hypoxia, which triggers invasion of inflammatory cells and apoptosis and necrosis of neurons (Fan, Liao, Tian, & Nie, 2019).

Hearing disability or hearing loss is an inability to hear partially or completely. Hearing loss affects millions of people worldwide and is estimated to be the fourth leading disability cause worldwide. The World Health Organization (WHO) had estimated that there were 360

million people worldwide living with disability hearing-loss in 2008 and over 466 million people with disabling hearing-loss in 2018. Hearing impairments are bound expected to affect the communication and cognitive performance of individuals, thus reducing their quality of life and increasing their difficulty in developing social networks. Furthermore, besides the difficulty and practical difficulties caused by hearing impairment, people with hearing impairment are more likely to suffer injury because they cannot receive alerts adequately and a timely manner(Wu, Yeh, Huang, & Lee, 2020).

Hearing loss can occur in one or both ears. Hearing problems can affect the ability to learn spoken language in children and can create problems with social interaction and at work in adults. In their everyday life experiences, all children benefit from rich and varied linguistic input from caregivers while learning spoken language. Children with hearing impairment are a clinical group that is vulnerable for delayed or atypical language development, including weak language skills and vocabulary knowledge (Kristensen, Sundby, Hauge, & Löfkvist, 2019). In some cases, hearing loss can result in loneliness in some people, especially older people. Hearing loss can be caused by number of factors, including; genetics, ageing, noise exposure, certain infections, complications of birth, ear trauma, and certain medications or toxins. Chronic ear infections are common condition that results in hearing loss. Many infections during pregnancy, such as cytomegalovirus, syphilis, and rubella, can also contribute to hearing loss in the infant. Hearing loss is diagnosed when hearing test finds that in at least one ear of the person cannot hear 25 decibels. Hearing loss can be graded as mild (25-40 dB), medium (41-55 dB), moderate-severe (56-70 dB), extreme (71-90 dB) or profound (greater than 90 dB). There are three major types of hearing loss; conductive hearing loss, sensory hearing loss, and mixed hearing loss.

Visual impairment, also known as vision impairment or vision loss, is a reduced ability to see to a degree that usually causes problems that cannot be fixed anymore by usual means, such as glasses. The term blindness is used for the condition for the complete or almost completely vision loss. Uncorrected refractive errors (43%), cataracts (33%), and glaucoma (2%) are the most common causes of visual impairment worldwide. Among all that, cataracts are the most common cause of blindness. Refractive errors include near- sightedness, far-sightedness, presbyopia, and astigmatism. Certain disorder that may cause this disability may include age-related macular degeneration, diabetes retinopathy, corneal clouding, childhood blindness, and a variety of infections. It is difficult for visually impaired people to operate in unfamiliar environments or volatile conditions. Such challenges limit their independence and increase the gap between them and the population with a normal sighted. To adapt into this particular condition, they are likely to change their lives, restricting their actions to prevent mistakes and frustrations. They often have to be taken to places several times before they know all the important details of the particular path by heart, using complementary senses in the case of severe visual disabilities. They may have difficulty finding their way home in unknown places or avoiding physical barriers under less controlled circumstances (Chessa et al., 2016).

Another disability is cognitive or learning disabilities. It is a brain disability which causes problems in interpreting or processing information and can be caused by variety of factors. Person with cognitive impairment have more trouble with one or more types of mental tasks than average person. Some cognitive impairments have some kind of basis in the individual's physiology. In the case of traumatic brain injury and genetic disorder, the link between a person's physiology and mental processes is most apparent, but even the more subtle cognitive problems are often focused on the brain's structure or chemistry. Learning impairment

make it difficult for children to acquire the necessary knowledge and skills not only in elementary school, but often at all educational levels. Throughout adulthood, profound disability can hinder individuals throughout their job choices and also have a secondary effect on work and personal relationships due to their effects on the individual's psyche. (Juklová, 2012). This type of impairment should get official clinical diagnosis in which a person fits certain criteria as defined by a professional such as psychologist and pediatrician. The word learning disability used identifies a category of disabilities characterized by poor development of specific academic, linguistic and speech skills. Learning impairment categories include reading (dyslexia), arithmetic (dyscalculia) and writing (dysgraphia). A person with a severe cognitive impairment will need assistance with almost every aspect of everyday life. Person with this disability have difficulty performing specific types of skills or completing tasks if left alone or if taught in conventional ways to figure things out.

Psychological disorder or mental disorder also one of disabilities impairment. Psychological disorder is a condition where the patient experience abnormal thought, feeling, and behavioral state. The causes of this disability often are unknown. Mental disorder are usually defined by a combination of the actions, feeling, perceiving, or thinking of an individual. Mental disorder is one of the mental health aspect. Results showed that mean psychological disorders in students with educational issues is higher than normal students (Salehyan, Mousatabatabaee, & Rajabpour, 2013).Common mental disorder include bipolar disorder, depression, dementia, schizophrenia and other psychoses.

2.3 Facilities

Facilities can be defined as a building or equipment or services that are provided for a particular purpose. For this case of study, the particular purpose focused on is a place where student can get education or classroom. The needed to provide a good facilities to student is a necessary and important to many peoples. Major problems faced by children with physical disabilities who are trying to complete their formal education centers around structural barriers prevent them to access to conventional and special education facilities. Some current special education experts recommend that children with physical disabilities have as many opportunities as possible for independent behavior as possible. Existing building can be modified or new structures can be designed to provide a greater degree of independence than in contemporary buildings. This structure frequently makes the system more available to physically normal people too with temporary disabilities and the elderly, and can also promote ease movement throughout the facility.

Facilities and supports for people with disabilities should be offer directly by government or another social services to allow people with disabilities to participate in society and community life. Facilities allowing the use of public building without assistance to anyone who may feel uncomfortable due to temporary or permanent disability or even external circumstances. Public transport also one of facilities needed by disabled people. The inefficiency of accessibility in public transport terminal has contributed to inconvenience and restricts the free movement of many disabled people. This is one of major barriers to full participation of people with disabilities in society (Hassan, Soltani, Sham, & Awang, 2012).

It is important for consideration in improving and provide efficient and necessary facilities for disabled people in a nation as Malaysia in this modern century. Malaysia is one of developing country in the world that should acknowledge special children and capable to educate many disabled person that could create more harmony and prosperity in the society. Many experts agreed that disabled person achieve better than normal students in schools. This achievements had open many eyes in the world to give proper facilities and education for disabled people to pursue more in their life. Government in every nation must propose good quality facilities and take fast action in order to produce more educated people and boost them to survive in the society. Physical environment play important role in creating safe and comfortable environment to the society. This influenced teachers and students in spreading healthy communication and help students to improve more in their education.

2.3.1 Classroom design

The correlation between classroom layout and learning outcomes is more than simple conjecture. Cautious planning of classroom layout is important in every school and some basic features of efficient design are common to all types of students. For this particular case study is for disabled children. Since students have to spend a lot of time in the classroom, it should be a welcoming place and warm to raise student morale. In addition, the layout of classroom will enhance students' learning experiences with special needs. Changing certain core elements of the layout classroom will improve learning outcomes by 16 percent (Barrett, Davies, Zhang, & Barrett, 2015).

Nevertheless, there are some factors that need to be addressed for this children with disabilities. Such modifications can differ depending on the nature of the conditions they are

and the ages of them. One of the aspect must be consider is the range of movement available to people with physical disabilities. It involve mobility restrictions occurring from specific physical conditions as well as those resulting from restraint in a prosthetic or orthotic device such as a wheelchair. These criteria influence the distance the distances between objects and the position height.

The second major factor is the strength of the person with physical disabilities. Generally, it can be assumed that people with physical disabilities have less physical strength compare to normal people. The architecture of certain units, particularly those moving such as doors, the weight involved and the complexity of the movement required (push and pull) should be take into account. The considerations also include the material used in the construction, or with mechanical devices such as hinges which can decrease the physical strength needed for manipulation.

The scale of classroom spaces in a school in which students with disabilities are included should be greater than in a conventional school. There must be enough space in the classroom for maneuvering wheelchairs, for walking with crutches, additional equipment and wheelchair storage where the child can comfortable sit on a chair. It has been suggested that at least one third more space is need for students with physical impairment compared to children without disabilities.

2.4 Physical disabilities

Physical disability can be defined as an impairment of the physical function, mobility, agility or the stamina of a person. The reasons people have this disability can be categorized into two which are hereditary or congenital and acquired condition. Hereditary is the condition where a person has been born with or acquired a physical disability due to inherited genetic disorders due to inherited genetic disorders, or suffered from birth injury, or has muscle problems issues. Meanwhile for the acquired condition is where physical disability caused by an accident, disease or illness, or as a side effect from medical condition. This disability cause the person having functional loss. Due to the loss of functional, the individual may experience the inability to perform normal body movements such as mobility and walking, standing and sitting, use their arms and hands and muscle control.

Children with physical disability most probably having hard time in the society. The increased risk of depression was associated with physical disability of children or long-term health problems, and the correlation between physical disabilities of children and long-term health problems and depression are partly mediated by experiences of childhood maltreatment (Wang et al., 2019). There are less likely people with disabilities to be physically active and joining school activity based on past study (Vasudevan, Vang, & Fernandez-baca, 2019). Social environment and lacking of proper facilities provided by authorities limit participation and opportunities for the people with disabilities. Facilities still lacking for the access of people with disabilities giving more difficulty engaging in physical activities (Rimmer, Padalabalanarayanan, & Malone, 2017).

There are two major categories which are musculoskeletal disability (MSDs) and neuromuscular disability. MSDs is an injuries or discomfort in the musculoskeletal system of humans, including muscles, nerves, bones, nerves, ligaments, tendons and structures supporting limbs, neck and back. This category can result from sudden exertion such as uplift something heavy or they may arise from repeatedly stressing the same movements, or from repeated exposure to pressure, vibration, or uncomfortable posture. MSDs can affect many different parts of the body including the upper and lower back, chest, shoulder, and limbs such as arms, legs, feet, and hands. Types of muscular skeletal disability are muscular dystrophy, loss or deformity of limbs, and osteogenesis imperfecta.

On the other hand, neuromuscular disability is a specific term which includes many diseases and ailments that influence the functioning of the muscles, whether directly, voluntary muscle pathologies, or indirectly, nerve pathologies or neuromuscular junction. This disability result in muscle weakness and fatigue that progress over time. Neuromuscular disorders affect the muscles and their direct control of the nervous system which the problems with the central nervous control may cause spasticity or paralysis, depending the location and the problem's nature. Many neuromuscular disorders have signs that begin in infancy, while others may develop in adolescence or even adulthood. Examples of this categories are cerebral palsy, poliomyelitis, spina bifilda, head injury, spinal cord injury.

There are few technologies that been used for physical disabilities for this modern era globalization. Assistive technologies are those arrangements and tools that aim to easier the life of people with physical disabilities by removing their barriers and improving their physical and mental capabilities. This can increase their optimism, mood and quality of their life. Some example of assistive technologies are crutches, walking stick, and wheelchair.

2.4.1 Cerebral palsy

Cerebral palsy (CP) is a group of disorder affecting the ability of a person to move and maintain balance and posture. CP is the most common disability happen to be found during childhood. Cerebral means being brain-related. Palsy means muscle weakness or problems. CP is caused by abnormal brain development or brain damage that affects the ability of an individual to control their muscles. CP affects people in different ways, depending on the area of the nervous system affected and severity of injury. Sometimes resulting in postural control failing that may interfere with the interaction of a child in important developmental context (Mônika et al., 2019). Postural control involves sensorimotor and musculoskeletal system with two behavioral objectives: postural alignment and flexibility to maintain balance. Postural orientation includes the active control of the body's alignment and muscle tone, and balance involves coordinating sensorimotor technique to maintain the body center of mass during disturbances in postural stability. CP is generally cause by injury to developing brain before or during birth, caused by decreased in blood supply and oxygen lacking.

The challenge of maintaining postural control in individual with CP is due to changes in sequence of muscle activation, slowness and re-adjustment of anticipatory and compensatory postural adjustments and inefficient adaptation of postural responses to tasks and environmental requirements. There are four type cerebral palsy which are spastic cerebral palsy, dyskinetic cerebral palsy, ataxic cerebral palsy and mixed cerebral palsy.

Spastic cerebral palsy is the most common type of CP. Person with spastic CP have increasing in muscle tone. This condition makes their muscle tense and stiff and their movements can be awkward as the result. Usually CP is defined by body parts are affected. Spastic diplegia or diparesis is where the muscle mostly weak in the legs, with the arms less

affected or not affected at all. This would make them having difficulty in walking because tight hip and leg muscles cause their legs to pull together, turn inwards, and cross at the knees. Spastic hemiplegia or hemiparesis is the type of CP that affecting only one side of person's body and the arm is the most probably affected than the leg. Spastic quadriplegia or quadriparesis is the most profound form type of spastic CP because it affects all limbs, the face and trunk. Children with diplegia have bigger impairment of motor control in the lower extremity than upper extremity. In addition, children with hemiplegia have motor disorders in one have of the body, they show significant physical changes with minimal postural adjustment of lower extremities (Ali, Awad, & Elassal, 2019). Patient with this CP mostly cannot walk and have other addition developmental disabilities such as seizures, intellectual disability, hearing, speech and problems with vision.

The second largest group of CP is dyskinetic cerebral palsy (DCP), with high rates among born at term and among children with normal birth weight. DCP has lower gross motor function than any other types of CP (Leiva et al., 2019). Person who has Dyskinetic cerebral have trouble in controlling their hands, arms, feets, and legs movement and result in difficulty for sitting and walking action. Their movements can be too slow and writhing or rapid and jerky and unpredictable. The face and tongue are sometimes affected, and they have difficulties in speaking, sucking and swallow. Their muscle tone can be vary because of this type of CP.

Ataxic is the least common of syndromes, most of these babies have normal birth weights and early prenatal origin of the condition (Miller, 1990).Ataxic cerebral palsy is the condition patients having difficulties with coordination and balance. They may shaky and unsteady when walking. For quick movements or movements that need a lot of control such

writing, they might have hard times. When they reach something, they might have difficulties in controlling their arms and hands.

Mixed cerebral palsy is the type of CP that have more than one type of CP. The most famous and usually found is spastic-dyskinetic CP.

The gross motor function of cerebral palsy children and young people can be divided into 5 different levels using a tool called the Gross Motor Function Classification System (GMFCS) as shown in Figure 2.1. GMFCS examines movement like sitting, walking and using mobility devices. It is useful because it gives a clear description of the present motor function of a child for parents and clinicians. It also helps in the awareness of what tools or mobility aids a child may need in the future, such as crutches, wheelchairs or walking frames. Generally speaking, an infant or young person over the age of 5 will not raise their level of GMFCS, so if, for instance, a child is rated at a level IV at age 6 then it is possible that they will need to use a mobility tool for their lifetime.

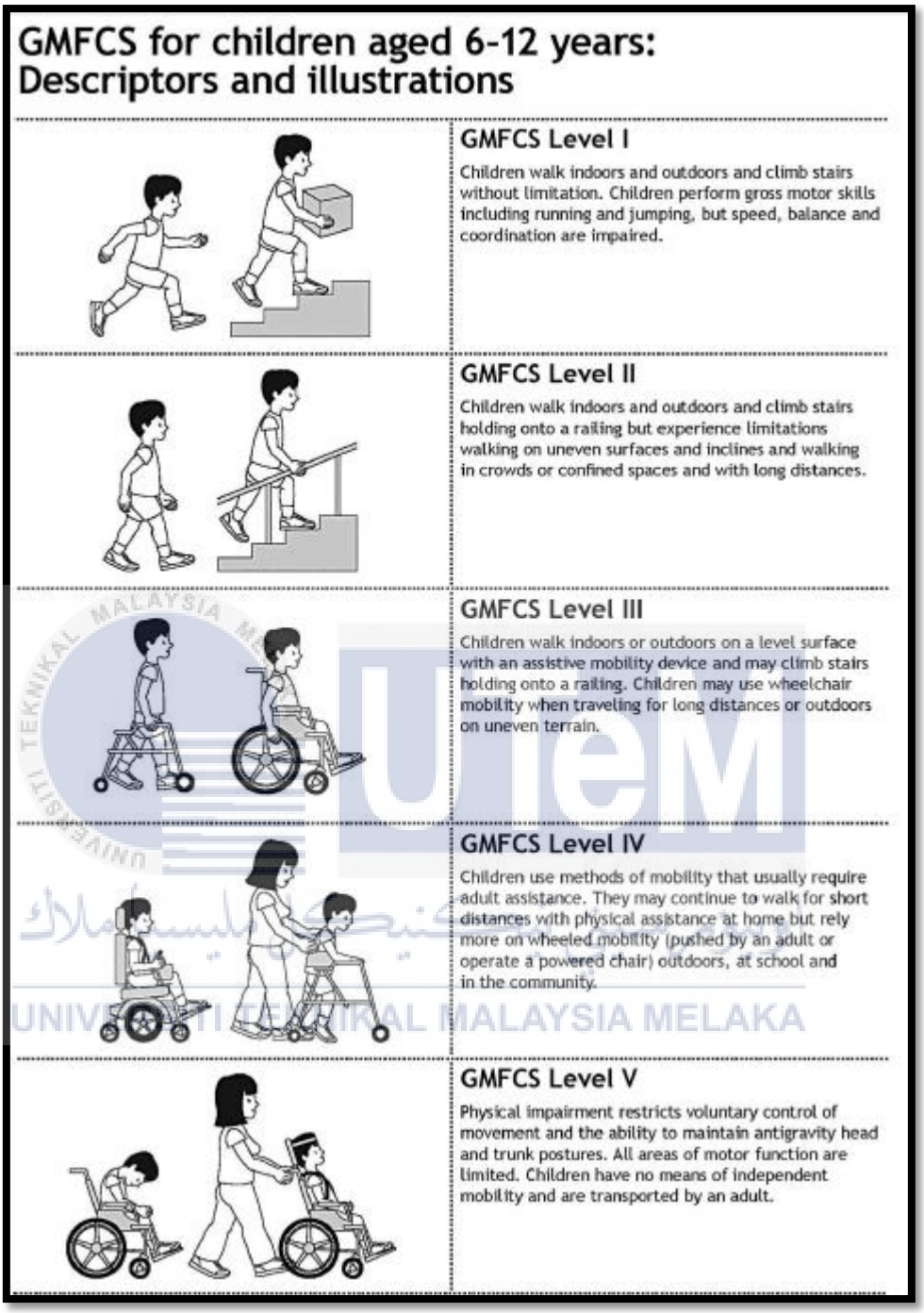


Figure 2.1: GMFCS to classify how a child with cerebral palsy mobilises and are classified according to age.

(Source: Wimalasundera & Stevenson, 2016)

2.4.2 Walking stick

Postural balance is the ability to stabilize the body and keep the body in equilibrium after body after body segments. The basic motor skill should be learned at an early age and necessary for daily routine and physical activities (Oliver, 2017). Postural control is important in children as it provides a basis to support them in moving their arms and legs smoothly. A child with good postural control may maintain a seated position without fatigue. Many factors can directly affects the ability of individual to maintain good posture, stability, and balance. These include the natural aging process, physical disabilities and other symptom of many chronic medical conditions. External aids could be used to give more physical support and help in maintain proper postural balance for the people

Walking stick also known as cane is an assistive cane to aid physical disabilities people in mobility. A cane can help in distribute weight from weak or painful lower leg, improve strength and stability by supporting the base and provide tactile ground information to improve balance. Children with physical disabilities having difficulties in walking since they had hard time moving their body compared to normal people. Variety of walking assistive technologies were available to this group to help in giving them proper support and motivate them to pursue higher in their life.

Usually people with disabilities or injuries, or older adults who are at risk of falling down might use mobility aids as walking sticks as their preference. Assistive canes are useful for people who have problems balancing and who might at risk of falling. The inability to maintain balance can increase the risk of falling. Walking stick can maintain good posture and better balance to people and this will reduce the risk of falling.

2.4.3 Wheelchair

Wheelchair is basically a combination of a chair and wheels used to aid people with difficulty in walking or due to illness, injury or disability. Generally it is used for people who are physically disabled such as elder people and children who unable to walk (Kumar, H.S., Ranjan, & Ahamed, 2012). Wheelchair can comes in variety of sizes and formats in order to meet the specific need of the users. The most popular use wheelchair are powered wheelchairs and manually propelled wheelchairs. Powered wheelchairs or powerchairs are a chair where the propulsion provided by batteries and electric motors while manually powered wheelchairs was used by the wheelchair user by moving the wheelchair with their own hands or by pushing the attendant from the back. Figure 2.2 shows the basic nomenclature of a rigid frame wheelchair.

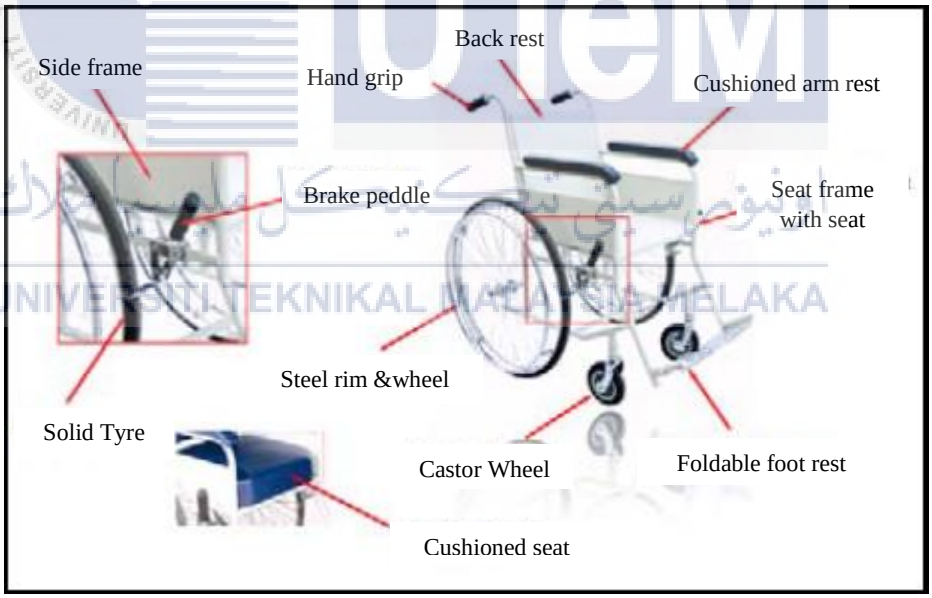


Figure 2.2: Nomenclature of a rigid frame wheel chair

(Source: Kumar et al., 2012)

A self-propelled manual wheelchair usually comes with a frame, bench, one or two footrests and four wheels which are two caster wheels at the front and two large wheels at the back. Separate seat cushion will also usually available. They offer complete independence, so they are ideal for people disabled people who want to be less likely burden other people. The larger rear wheels generally have quite smaller push-rims projected just beyond the tire, allowing the user to move the chair by without needed them to grasp the tire. Manual wheelchairs usually have brakes bearing on the rear wheel tires, but these are only parking brakes and in-motion braking provided directly on the push-rims by the user's palms.

Other type of wheelchair is manual attendant-propelled wheelchairs. It is basically same as self-propelled manual wheelchair. The difference between them is the diameter of the wheels which are smaller diameter wheels at both front and rear compared to self-propelled manual wheelchair. The person standing at the back and push the handles for controlling the wheelchair. Usually the brakes were provided for the attendant and the user such a foot or hand operated parking brake.

For the powered wheelchair, it is an electric powered wheelchair and also can be called powerchair. The wheelchair comes with batteries and electric motor into the frames. It could be operated by the attendant or self-controlled by the user. The remote usually placed on the armrest or the upper back of the frame as a small joystick. For users who cannot used the manual joystick, there are many other options such as head switches, chin-operated joystick, sip-and-puff controller or other specialists controls that could allow independent operation of the wheelchair. The batteries provided could travelled quite far away and ranges over 10 miles or 15 km for the fully charges batteries.

Mobility scooters also one of the type of wheelchair which sharing same features as powered wheelchair. The mobility scooters might not be considered only for disabled people because it is getting much popularity among normal people and include in different market segment. Small scooter generally have three wheeled with a basic seat at the rear as the platform, with a control tiller at front. Meanwhile, the bigger scooters often have four wheel and more substantial seat provided.

Another type of scooter is single-arm drive wheelchairs. One-arm or single arm drive wheelchair can be control by the user using only one arm. There is a large wheel on the same side as the arm used. The product mostly in the market usually have a smaller rim connected to the wheel on the opposite side by an inner concentric axle. The chair can be moved forward and backward in a straight line when both hand rims are grasped together.

2.5 Ergonomic

Ergonomic is the scientific discipline that focused on the understanding between the human and other elements of the interaction in the system and the profession applies theory, concepts, information and development of the methods in order to improve human well-being and overall system efficiency. It is a scientific discipline that incorporates expertise from any other knowledge such as physiology, anatomy, engineering, statistic and psychology. This method applied to ensure the designs achieved and match the strengths and abilities of the people and at the same time reducing the impact of their weakness.

Instead of asking people to adapt to the available design that requires them to work in unpleasant, stressful or dangerous manner, ergonomist and experts in human factors are seeking

to understand more to understand how the product, environment or process can be designed to suit the people who in needed. People do notice the bad design and often did not notice the good one. Good design give more comfortable used and less likely being complain about their qualities. Bad design might usually being noticed as unperfected product because of lack of ergonomic design in it and incredibly frustrating.

Many product nowadays studied and applied ergonomic design in their product such as backpack for children in the school. The design being proposed by the studies by (Amin, Akbari, & Noroddin, 2018) and examined the effects of school backpack design to the student. Their research was designed on the basis of the personal experiences by the student and observations of the students as a result of using backpacks. The design of the bag based on anthropometric characteristic to supplied more ergonomic design for the children.

2.6 Ergonomic design of a wheelchair

The study of the ergonomics in wheelchair is the relationship of the aspects of vehicle mechanic of the wheelchair and the physical condition of the user. Ergonomically design in wheelchair can reduces the strain caused by the product use by the user in a long duration. (Kumar et al., 2012).

Ergonomic seats are described as flexible seats that give more comfortable adapt and convenient to the morphology of their user (Chaléat-valayer et al., 2019). Basically the wheelchair must be lightweight and precisely designed to support the body along with its natural contour. Weight, height, proportion and temperature preferences are human factors that should be taking into account to help reduce or avoid pressure points and pain.

The use of wheelchair that suitable for the individual characteristics and need of a user will make them more independent and increase their sense of involvement and better quality of life. Some configuration on the wheelchair can be more comfortable and efficient can improve the range of motion, rolling resistance and system stability for the wheelchair for the better used. system stability and quality of mobility are two interrelated variables because of the enhancing one of it could affects the other (Medola et al, 2014).

The configuration of the wheelchair can affect and impact the propulsion efficiency and wheelchair drivability. One of the configuration is the backrest height. The backrest configuration can impact the trunk support and upper limbs' range of motion (ROM). These aspects are counter posed when one considers the two extreme situations which is while a higher backrest provides more support, it limits the extension of the shoulder, which is particularly unwanted, as it is necessary to grip the wheel's hand rims later when starting to push a wheelchair. Lower backrests, on the other hand, allow the upper limbs to move freely, but there is minimal back support and posterior stability. Furthermore, Lower backrest allows higher ROM shoulder and higher push angle and push time, reducing the push speed. As the seat layout depends on the physical characteristics of the user, the most effective solution seems to be the use of anatomical references.

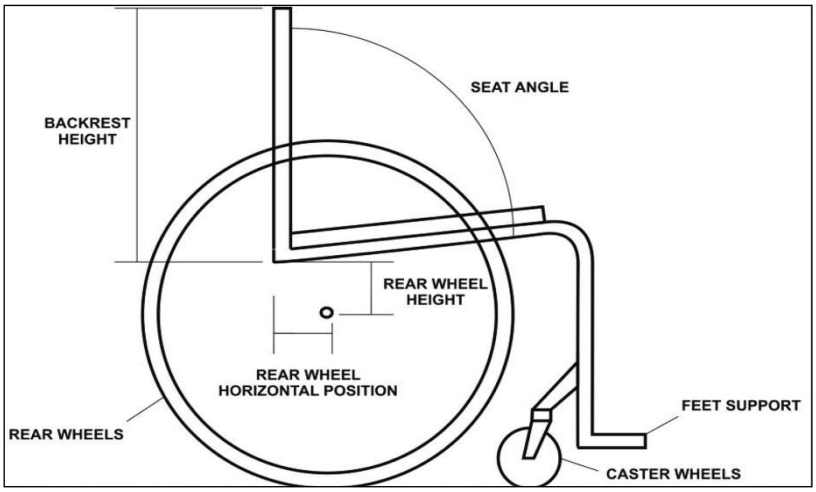


Figure 2.3: Wheelchair configuration

(Source :Medola et al., 2014)

Other configuration is seat and backrest angle. Reclining the seat angle is a common way of improving the sitting balance and functional reach of a user, but it also affects manual propulsion biomechanics. On the other hand, the use of straight angles of the seat is associated with pain in the shoulder.

Figure 2.4: Elbow angle (α) as a reference for the optimal vertical position of the rear wheels

(Source :Medola et al., 2014)

Wheel type is the configuration that needed to take into consideration for wheelchair user. The rear wheel design plays a major role in the mass and vibration transmission of the system. From a technical point of view, heavier wheels make it more difficult to start moving from a standing position. In fact, since the back wheels are on the outer side of the body, the weight significantly affects the system's rotational inertia. Rear wheels have traditionally been made in either steel or plastic. Most recently, in order to create lightweight tires, carbon fiber has been used. Carbon fiber wheels decrease the transmission of vibration to the body of the user in addition to weight reduction. This is highly advantageous because vibration can cause discomfort, nausea, dizziness, tiredness and even muscle hypertonicity and pain.

Next configuration is the leg and foot support. The implications of improper placement of the foot and leg support are felt in relation to the seat control pressure, user comfort and balance, maneuverability and wheelchair mechanical parameters. The tension on the seat interface tends to rise when the foot support is too low, as the weight of the legs and feet pushes down the thighs and compresses them against the floor. Since the feet are not supported properly, gravity makes the knees fall forward, making it easier in shortening the calf muscles. Furthermore without appropriate anterior aid for the feet, it becomes an unstable and dangerous task to move forward. The horizontal range between the leg and foot and the rear wheels defines the mass distribution and the total length of the wheelchair and, therefore, the inertia of the system. The variables directly impacted by the placement of the leg and foot support are the center of mass, balance, rolling resistance and the moment of inertia of the system.

Hand rim design is another configuration that should be consider for the wheelchair user. Using a manual wheelchair involves the hands repeatedly pushing or breaking the wheels on the hand rim. Such manual forces impose significant loads on the upper limbs, since the system's

inertial properties include the chair mass and the user's weight (Curimbaba et al., 2015). The small size of modern hand rims results in two main problems which are increasing the stress on the surface of the hands when contact with the hand rim and decreasing in mechanical efficiency due to the inability to support the hand rim with the whole hand, which requires additional muscle contraction to balance the hands on the rim. Greater diameter of the hand rims showed higher efficiency and lower physiological costs.

Using the comfortable wheelchair can improve the lifestyle of the user and be more active. The more convenient the wheelchair, the more likely the user going to be able to drive it smoothly. Biomechanics of manual propulsion, process stability, seat pressure and user experience of comfort and drivability can be optimized. Good wheelchair promotes a good posture that decreases pain in the neck, shoulders and back in particular. Once the wheelchair is comfortable, the user just going to be more likely to go out there. Never having to worry about any discomfort will let them stay out and about.

2.7 Summary of chapter 2

This chapter stated the literature review used for this project. The literature review help student to gain more knowledges and information from the all trusted resources in order to understand more regarding the research study. This chapter discuss more past studies based on the disabled people, mobility devices and ergonomic. The physical disabilities and Cerebral Palsy disease was explain in detail and more specific in this chapter. The information from literature review based on data from previous journal and internet.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is specific process or techniques used for implementation of the project. The chapter will explain in detail the approach used during the analysis and the procedure required to complete the research project report. Methodology is important as it explain in detail the sequences and the flow of methods used during this project.

First thing to begin and set out the Final Year Project in University Teknikal Malaysia Melaka is by proposing the project titles to the Supervisor of the university. Then, the Supervisor will explain in detail the basis of the project such as objective, scope and others related things connected to the study. After that, the project's progress began with finding what customer requirement is based on the project's tittle. The information's finding is based on the interview and observation being held. The location of the finding information this project research is at Pusat Pemulihan Dalam Komuniti (PDK).

The research continue with reading Literature Review. The Literature Review finding based on the source from journal, websites and other sources that related the study of the research. The literature review help the student get proper information regarding the studies of the research. Furthermore, it can assist student to understand more about the research.

The conceptual design was illustrated by the use of customer needs information after sufficient information was collected. This project required at least three conceptual designs which are an improvement design from the older version and more convenient for the user.

After that, the process continues by aiming to choose the most suitable design for the user. The conceptual design being produced based on the literature review. Morphology Chart must be take into consideration, which a few designs in conceptual design being choose. Detail design was based on morphology chart. Then one of the best conceptual would be selected as the final design. Lastly, the structure of final design of this project will be analyze. The flow of this project being shown in Figure 3.1.

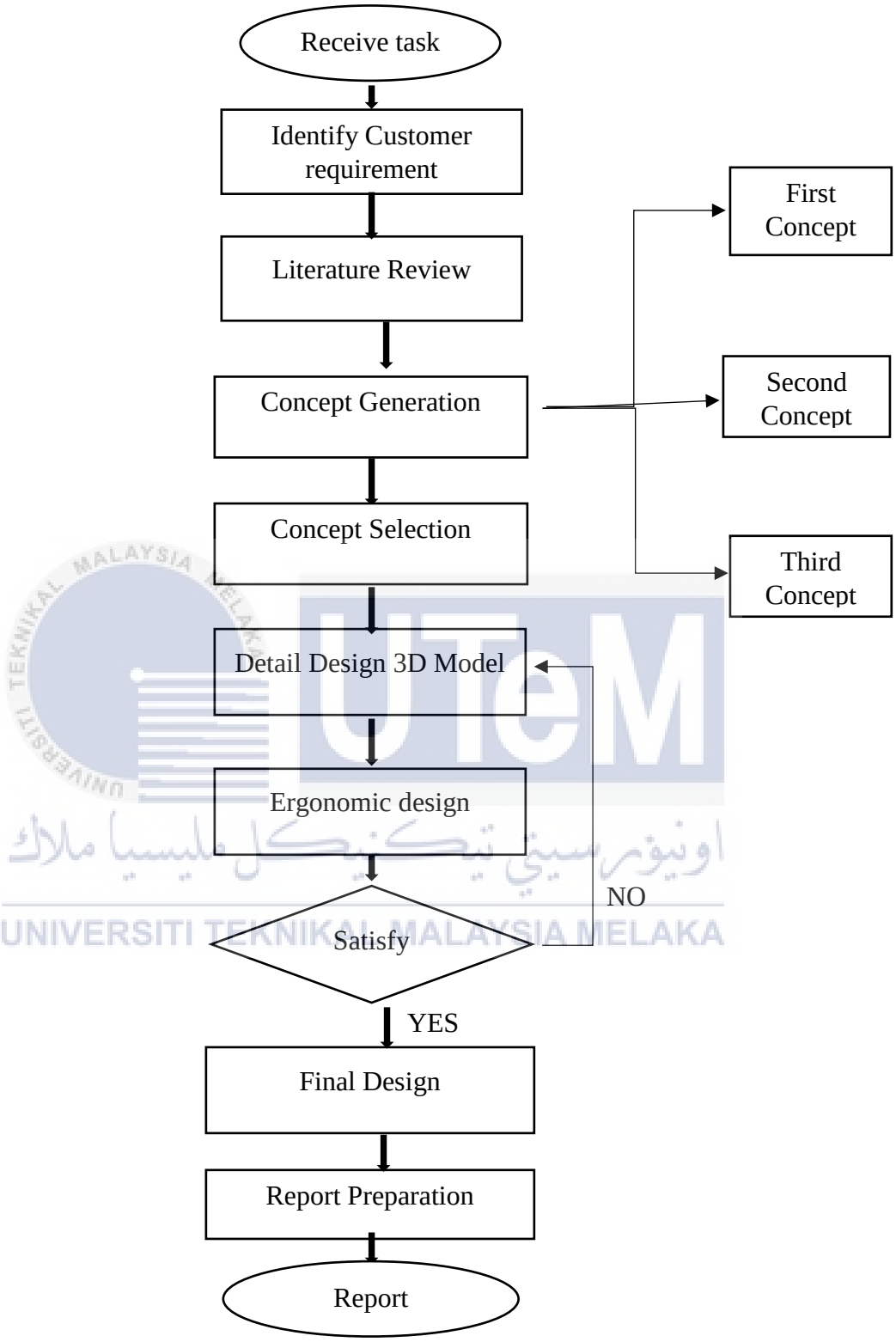


Figure 3.1: Flow Chart of Project Outline

3.2 Identify customer needs

There are many consideration that have to be make in order to designing survey tools. The goals of identifying the customer need are to make sure the product designed fulfil the customer requirement. In addition, it will expose the hidden needs and preparation of facts based on the product specification. The customer requirement also help in developing common understanding between the customer and development team.

Customer requirement is very important because it include the involvement of customer in development of product. The product specification must meet the customer requirement in order to be more successful product design and meet the target market.

Concept generation, concept selection and development of product specification must be related to customer requirement that been gathered. There are few steps to identifying customer needs. First step is gathering information as customer statement. Then, change the information in terms of customer need. Third, put the data gathered into the hierarchy such as primary, secondary and tertiary. After that, creating the relative important of the needs. Last step is reflection of the result and the process

In this project, there are two methods had been used to identifying customer requirement to make sure the project develop according to the plan. First method is by interviewing the headmaster of the Pusat Pemulihan Dalam Komuniti (PDK). The second method is by observation at the related PDK.

3.2.1 Result from observation

The main focus for this research is on the disabled children with physical disabilities. Pusat Pemulihan Dalam Komuniti (PDK) is selected as the place for observation to complete the project's aim. The PDK's goal is to encourage the local community regarding an attentiveness, autonomy and sense of responsibility in rehabilitating people with disabilities (OKU). The project is specific to the classroom facilities used. The PDK classroom is shown in Figure 3.2. Home-based, Centre-based, and Centre-Home-based PDK concept.

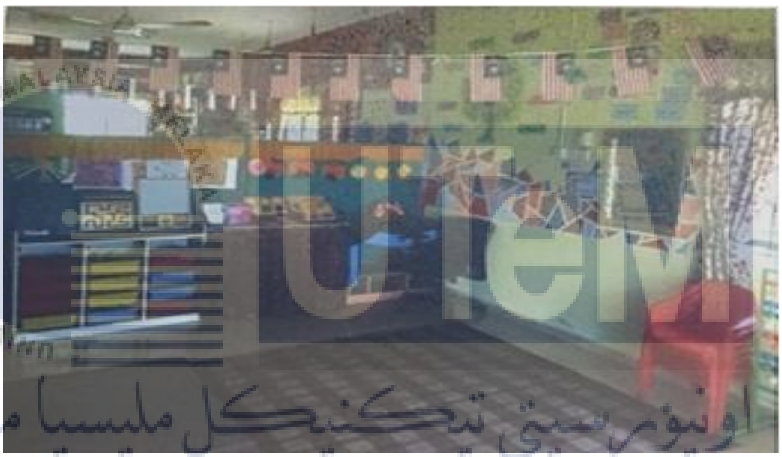


Figure 3.2: Classroom at PDK

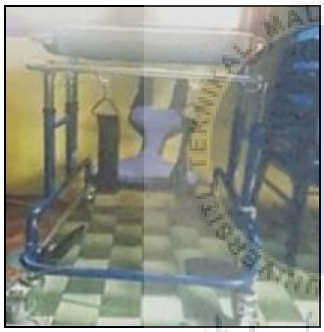
(Source: Bakri, 2019)

Based on the observation at the PDK, the major problem that been identify is the limited physical movement in almost in everything in their life. Their disabilities put a barrier between them to be active as normal children. Their problem related to movement, posture, eating, communication and reflex movement.

There are few facilities that have been supplied to the disabled children based on the observation. Nevertheless, the facilities are not ergonomic enough. The classroom design and

facilities used for the physical disabilities children need to be enhance in term of daily used of the children.

The basis of PDK does not focus solely on education Children with disabilities are taught to be more confident and to be able to manage their daily routine on their own. On the other hand, children with Cerebral Palsy at PDK do have their own classrooms. The teachers trained this specific physical disability to walk on their own. Figure 3.3 shows the facilities been used to trained the children for walking practice activity. This standing chair can be used for children and adolescent.



a) Front View

b) Side View

c) Top View

Figure 3.3**:** Available standing Chair at PDK

(Source: Bakri, 2019)

3.2.2 Result from survey

Based on the headmaster statement, there are three student with Cerebral Palsy in this PDK. The main problem that they face daily is difficulties to move freely. The voice of customer come out from the headmaster of the school after a few question was interviewed. Table 3.1 was produced after the observation and interview being held at Pusat Pemulihan Dalam Komuniti (PDK).

Table 3.1**:** List Of Customer Requirement and Technical Voice

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

3.3 Benchmarking

There are some aspects of the mobility device product that would provide a competitive edge over the current available products in Malaysia. Firstly the functionality of the product as mobility device. The product functionality include the effectiveness of the products to help patient with physical disabilities to walk independently on their own. The product that want to be proposed have the higher score to aid physical disabilities to be more independent. In addition, the mechanism used can help people with physical disabilities for rehabilitation on their own.

Portability of the device also higher than wheelchair and walking frame. The tyres and small dimension of the product increase the product portability. Furthermore, the product also less in weight compare to available wheelchair. On the other hand, the product is affordable and less likely become a burden to buy for aiding physical disabilities in mobility. Table 3.2 shows the scores between the suggested walking device product, wheelchair and walking frame with wheels.

Table 3.2**:** Benchmarking the mobility devices in Malaysia

Aspect	**Types of mobility devices available in Malaysia**		
	New design walking device product	Wheelchair 	Walking frame with wheels 
	Score		
Functionality	5	3	4
Portability	4	3	1
Light weight	4	1	5
Affordability	4	1	5

3.4 House of Quality

House of quality or also regarded as Quality Functional Deployment (QFD) is used for customer requirement conversion into engineering requirement. It is very necessary and yet so strong that it combines the customer's input into it.

Figure 3.4 shows the how of House of Quality been produced based on customer requirement. The progression of HOQ start with the voice of customer requirement on the design. Since the design for the children, the design must be light weight and easy to handle.

The product should also portable to easier the product to be carry anywhere. The product must be ergonomic for convenient use of the user and safe to be use for a long time period. In addition, the design should be offer for affordable price to meet the target market. The attractive design most probably will get attention as it is an added value to the design.

HOQ can be defined as customer requirement and the engineering characteristic relationship based on Figure 3.4. One of the customer requirement is the product must be easy to handle. In order to create a design that easy to be used, the weight and stability of the product must be taken seriously to create the design. The structure of the product also influence the quality of the product. Next customer requirement is performance. The performance is the most critical thinking involve in the making of a product. The performance most probably related to the weight, structure of mechanism and yield strength. The stability of the product and type of the material should be connected to get better performance.

Portability of the product should be take into consideration also. The weight and dimension of the product played an important role as to make sure the product is portable. Moreover, the product could be a better lightweight product if the type of material properly choose. It also linked to the stability of the product. Besides, the product must be easy for maintenance, but it require a production cost involvement more.

Size of the product is one of the important part in customer requirement. Dimension and stability of the product influence more to the size of the product. For the stability and durability, the yield strength, production cost and type of material influence more for this particular customer requirement. Moreover, to make sure the design is attractive, the production cost related more on the product.

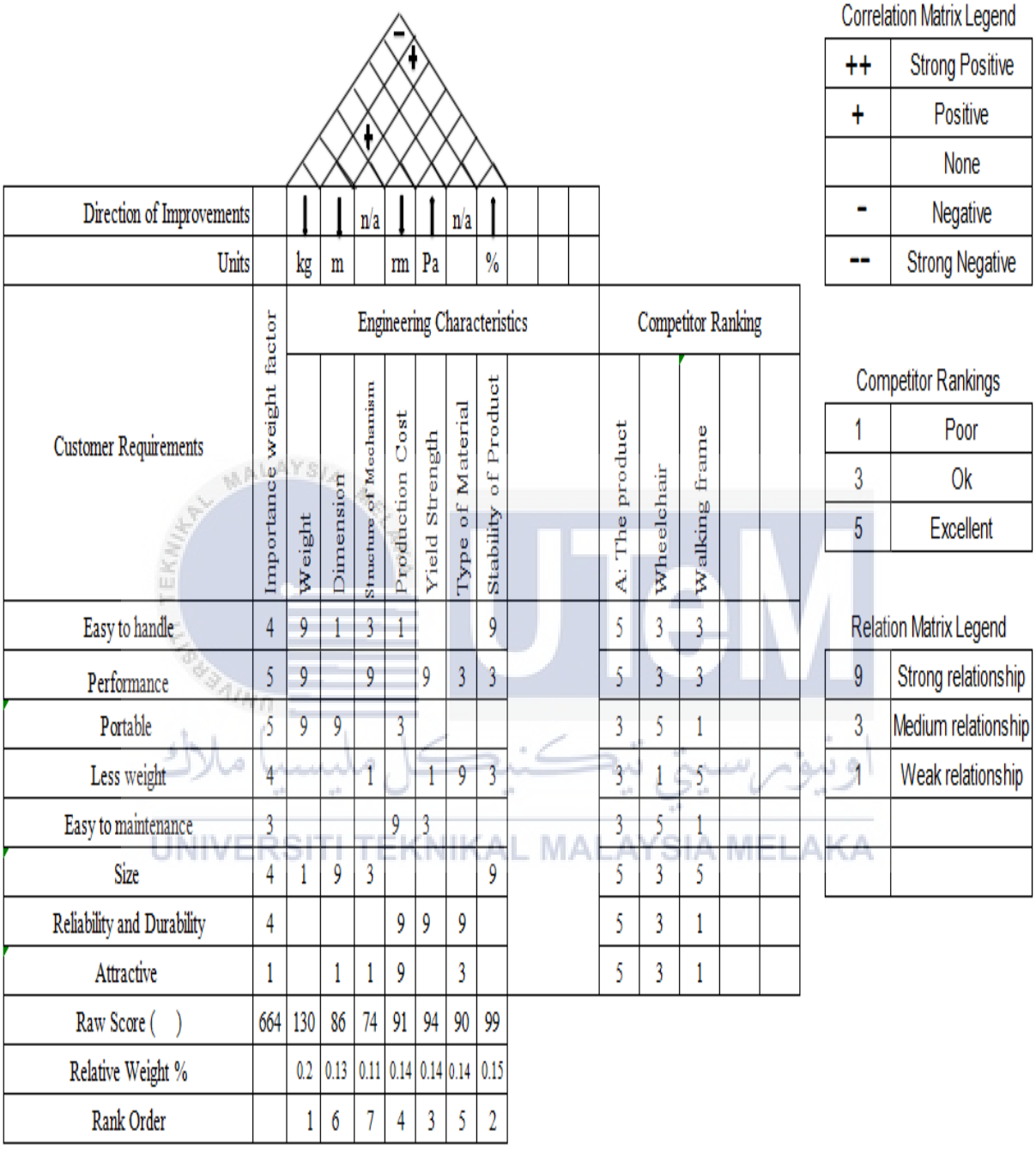


Figure 3.4**:** House of Quality

3.5 Product Design Specification

Identify, find and compile all the data is the aim of design process preparation to decide if product development is safe to use and produce the right investment and reach the target market. The product design specification was create as a compilation of the planning process. The important information regarding the product was included in the product design specification. It was the outcome of the product based on the customer requirement.

The selected final design is based on customer requirements and gave the user a good balance. Although, the student with Cerebral Palsy is physically disabled, they still need to get an opportunity to move freely and independently. The product was design to provide an assistive aid to help them to be more independent in the classroom. Table 3.3 shows the background of walking device selected:

Table 3.3: Background of walking device

Potential	I. The walking device is easy to handle and use. II. The design is portable, attractive and stable
Material	I. Material used is safe for the environment II. Material used is durable and less likely to rusty III. Good quality material and suitable for operation
Lifetime Product	I. Long lasting
Ergonomic Product	I. Easy to move freely II. Excellent stability for the user III. Easy to handle as a walking aid
Environment	I. The walker was design eco-friendly to the environment. II. Energy saving and sustainability product
Manufacturing	I. The process of manufacturing not exceed RM1000.

Safety	I.	Analysis was made before used to prevent any harm to user
	II.	Warning sign is clear to be read and clear.
Quality	I.	Follow all the customer requirement
	II.	Follow the standard product specification
	III.	Improvement product from other available walking aid
Safety	I.	Unique design
	II.	Attractive colour
Criteria that need for consideration	I.	Product Design
	II.	Material Selection
	III.	Control Mechanism

3.5.1 Target Product Design Specification

The target product design was produced as Table 3.4.

Table 3.4: Target Product Design Specification

Customer Requirement	Target Product Design Specification
Easy to use and handle	I. The product design is simple and easy to be use II. Include an adjustable seat III. Manually operates IV. Eco-friendly Design to the classroom environment
Durability	I. The material used is high strength and do not rust easily
Portability	I. The tyres make the walking device can be move to anywhere II. Some part can be fold to reduce the size and carry to any place

The final concept design will be evaluated and selected based on the target design specification on Table 3.4 and meet the customer requirement. The device must be easy to be handle because the target user is people with physical disabilities. The design is simple to use

and attractive to attract the children with physical disabilities utilize the device for their daily used. Furthermore, the concept design can be easily transported to anywhere by manually push it into any place and with a reliable tyre provided with it.

3.6 Detail Design and Analysis.

After the final concept design been choose, the design will be put into 3D detail design. The 3D detail design created using one of the Computer Aided Design (CAD) software which is Catia V5 R16. The CAD is a technology that is widely used this day to produce a design in the computer based on the real model in the reality world. This CAD design is an important process for analyzing process and development of the product. There are two types in modelling of CAD which are two-dimensional and three-dimensional diagram. The graphic model in CAD gives more information regarding the engineering design for the analyzing process.

The walking device has been designed part by part in the CAD process and will then be fully assembled to create a full product design model. The specific measurements used are based on the standard design scale. The assembled design will be used for analysis data. The full concept design will undergo the stress analysis for Von-misses Stress and safety factor analysis.

3.7 Selection of Material

The material selection one of the most important task during this research. It is one of the step of design process. Choosing the proper material for the product will decreasing production cost while meeting the target of product performance. In addition, the better the

quality of the material, the better the performance of the product. Each material have their own properties and specific advantages regarding their price, durability and strength.

After the 3D model have been create in CAD, the selection of material method will be used for data analysis. From this process, the value of Elastic 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: Solidwork software)

Material	Young Modulus (N/m^2)	Poisson Ratio	Density (kg/m^3)	Yield Strength (N/m^2)
Aluminium	6.9×10^{10}	0.36	2950	0.95×10^{8}
Mild Steel	2.05×10^{11}	0.3	7850	2.5×10^{8}
Stainless steel	1.93×10^{11}	0.27	8000	1.7×10^{8}

The advantages and disadvantages of those material is explain in the Table 3. 6. The comparison were made for the choosing the proper material and most appropriate material for the structure design of the walking device in this project.

Table 3.6: Comparison between the Materials

Types of Material	Advantages	Disadvantages
Aluminium	• Strong • Lightweight	• High cost • Difficult to weld
Mild Steel	• Affordable • Easy to weld	• Low tensile strength
Stainless Steel	• Strong • High strength	• High cost • Difficult to handle

3.8 Theoretical Calculation

Factor of safety also known as safety factor can be defined as a system used for expressing the strength of the product that it needs for intended load. Basically, the minimum value of the safety factor is 1. In this project, for the value less than 1 it should be declare as failed since it cannot support load more than the target. The simplest equation of safety factor have been illustrated in **Equation 3.1**

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

Equation 3.1 where;

FS = Factor of Safety

Syt = Yield Tensile Strength

$\boldsymbol{\sigma Von\ misses}$ = Maximum of Material Stress

3.9 Concept Generation

The design will be explain in more details and with the schematic diagram provided. All concept design been proposed followed all the customer requirement that have been discuss. The conceptual design will be analyze before choosing the most properly used for target market. For this project, the final design will be choose specifically more focused on the physical disabilities children. The children with physical disabilities such as Cerebral Palsy cannot walk properly on their own. They really need an assistive aid to help them walk in more comfortable way and less likely need help from others. The walking aid device will help them to move freely and more independent.

Creative idea generation is an intuitive way to proceed to a feasible design solution. In this project, there are three design were proposed. All design must fulfils the customer requirement that have been discuss in previous chapter. The customer requirement have been gathered by interviewing and observation.

There are few characteristics that all design concept need to have regarding their functionality, safety and engineering requirement. The functionality of the product is a mobility device for physical disabilities children and also acting as a rehabilitation device for them to walk. The project focused on children with Cerebral Palsy with GMFCS in level II and level III. In this particular level of GMFCS, the children still have their ability in walking, but they need an assistive aid for them to performing it. The device also can help them to walk in more proper ways and comfortable. The product is design for indoor purpose. The children can use the device to performing indoor activities such as learning in the classroom as normal people. The device should be one of their motivation tools in performing their daily life and be more active. The

walking device also could be carried anywhere as a portable device and easily be handling by them.

Furthermore, the safety is one of the most important thing in development of the product. Some criteria must be follow by all the conceptual design to meet the safety requirement. One of the criteria is the stability of the product before and during operated. Next criteria is the type of the material used. The material of the product should be environmentally friendly and non-toxic to the user. Moreover, the edges in the product should be pay attention since the user of the product is children.

In engineering requirement, the material used must be strong and durable for the used in a long time period. The product also must be easily to maintenance. Besides, the cost of the product should be affordable and not too expensive to be buy as mobility device purpose. The Table 3.7 shows the ranges of ages, weight and height of target user.

Table 3.7: The ranges of target user

Ages	Weight (kg)	Height (cm)
5-12	15-45	80-130

3.9.1 Morphological chart

Morphological chart is the tool used to represent and discuss all relationships in multidimensional problems. It can generate product design ideas from a collection of components which can fulfill the same purpose as a new product. Figure 3.5 shows morphological chart for designing the new product of walking device.

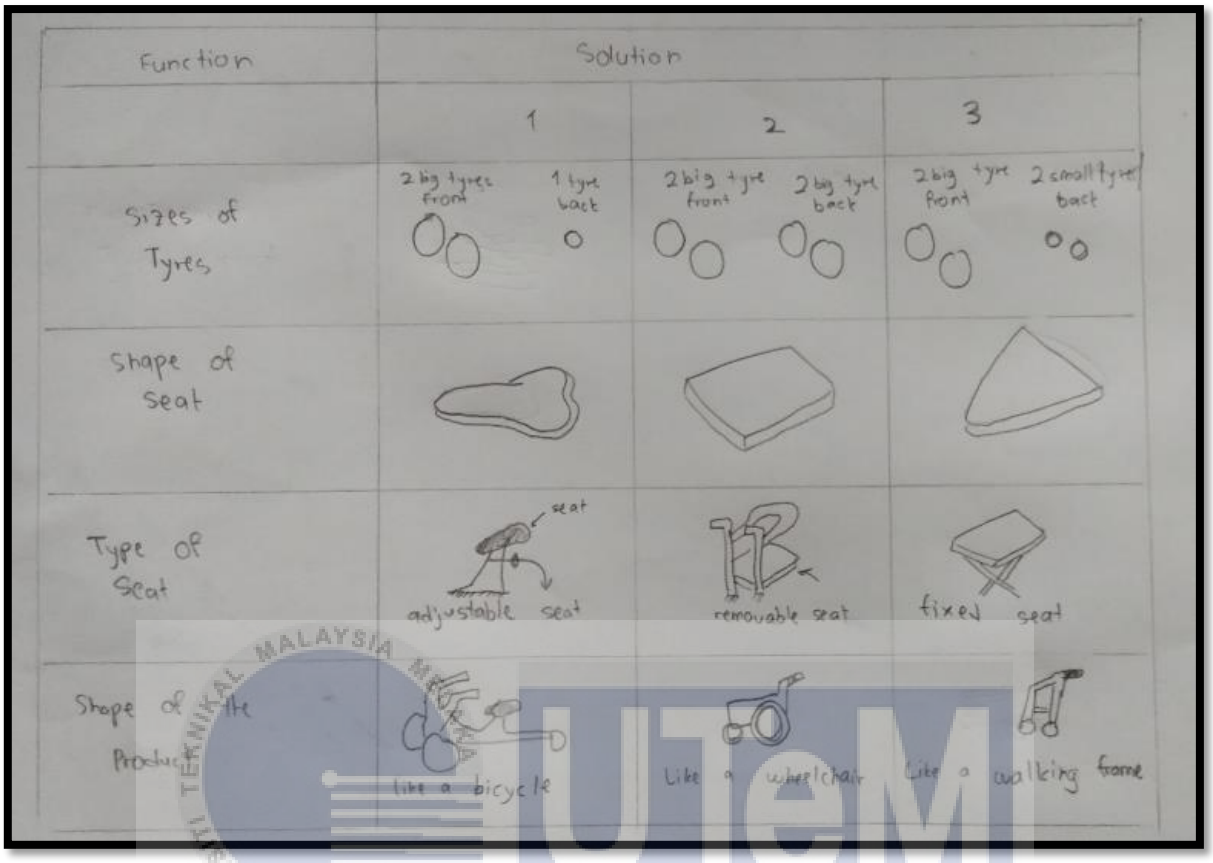


Figure 3.5: morphological chart for the new product design

Three conceptual designs were designed using morphological chart. All the layout is combined and chosen by consideration of customer requirement for fulfilling the objective of the project.

3.9.2 Concept design A

Table 3.8: Morphological chart chosen for first concept

Size of tyre	Shape of the seat	Type of seat	Shape of the product
1	1	1	1

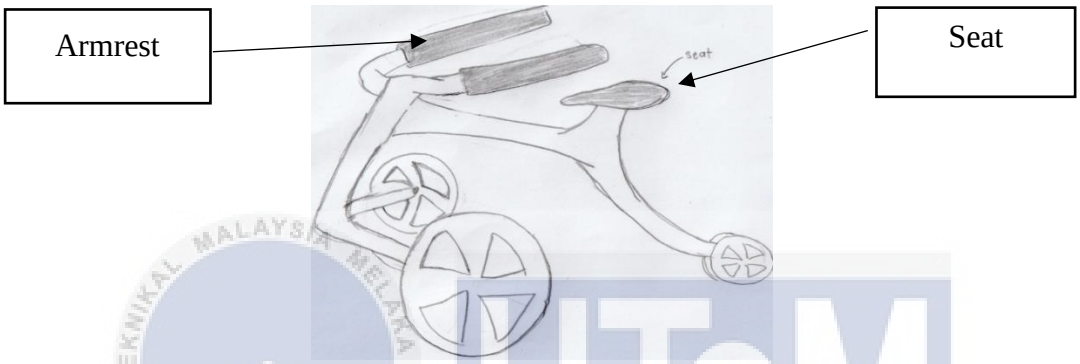


Figure 3.6: First concept design

The first conceptual design is an attractive design structure. The design provide an armrest for supporting the upper limbs of the user for comfortable used. It help the user to walk in a proper way while resting their arm at the armrest. The seat is adjustable for appropriate height of the user.

There are two big tyres at the front intended for receiving the force acting by the user. The tyres also give better performance by absorbing most of the vibration acting on it. Two big tyre at front side by side and a tyre at the back give a proper balance for the product. The product offer a simple design yet a benefit device for children used.

3.9.3 Concept design B

Table 3.9: Morphological chart chosen for first concept

Size of tyre	Shape of the seat	Type of seat	Shape of the product
2	2	3	2

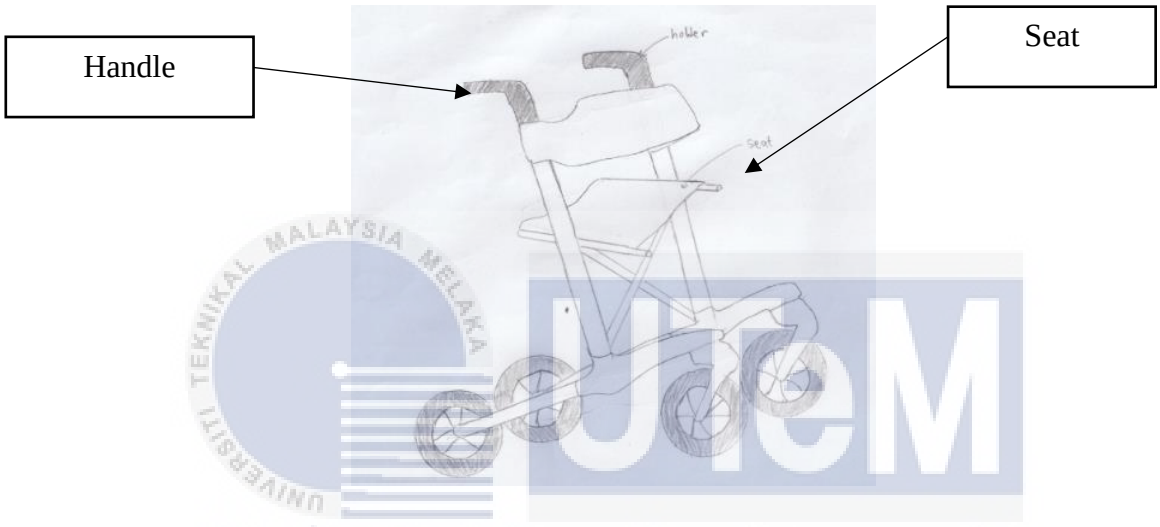


Figure 3.7: Second concept design

Second concept design offer a walking chair design with a backrest used for resting the user back. The user can seat and rest their back in more comfortable way. The design allow an attendant to push the user using the handles provided. The design comes with four tyre to give more balance for the user and the stability of the design.

The user can hold the handle by themselves in a standing position for walking purpose. The user should able to walk by maintaining their body by using this device. This design also help the user to move freely by performing walking independently.

3.9.4 Concept design C

Table 3.10: Morphological chart chosen for third concept

Size of tyre	Shape of the seat	Type of seat	Shape of the product
2	2	3	3

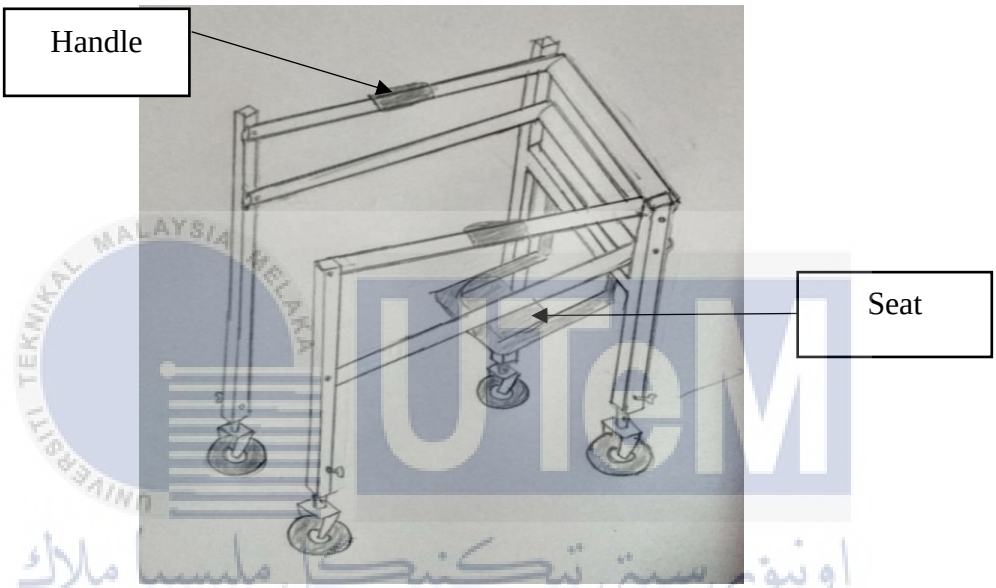


Figure 3.8: Third concept design

The figure 4.4 show the third concept design. The design is easy to handle. An attendant can push and pull the user to anywhere when the user in seating position. The user can relax in more comfortable with the cushion on the seat and wide seat with the square shape seat. The seat can be fold up when user want to walk and fold down when user want to seat. Moreover, this design is foldable which will reducing the size of the product and make it much easier to be carry anywhere and use it anytime.

The seat is fixed but the height of the product can be change by adjusting the bolt and nut locating at the tyre holder. There are two big tyres at the front and two at the back for

balancing the user when they walk. This concept help to balance the user's body mass within the base of the support for increased stability and security.

3.10 Concept Evaluation and Selection

Concept evaluation involves comparisons and decision making. It is about determining which ideas have the greatest potential to become a successful product.

3.10.1 Weighted Decision Matrix

To select the best conceptual design, the tool used is weighted decision matrix which is shown in the table 3.11 below.

Table 3.11: Weighted decision matrix table

Design criteria	Weight factor	Concept A		Concept B		Concept C	
		R	W	R	W	R	W
Attractive	0.05	4	0.2	2	0.10	3	0.15
Easy to Use	0.15	2	0.3	3	0.45	4	0.6
Portability	0.20	3	0.6	3	0.60	4	0.8
Size	0.10	2	0.2	3	0.30	3	0.3
Weight	0.05	2	0.1	4	0.20	3	0.15
Safety	0.30	3	0.9	2	0.60	4	1.2
Low maintenance	0.15	2	0.3	3	0.45	3	0.45
Total	1		2.6		2.7		3.65

From the evaluation, the highest weighted rating falls to conceptual design C (figure3.8) with a total score of 3.65. This conceptual design score highest in safety, and the reason for that it is ergonomics.

There is no sharp edges in this design and the seat is cover with comfortable and soft cushion. Another highest weighted rating is easy to use. The design is much easier to be use with foldable seat and easy to be handle by the user. The design help to balance the body mass of the user and increasing their stability. Moreover, the size is not too big and not a burden for the user. Portability also is highest for the conceptual design C. The design much easier to be carry and move to another places. This design can be foldable into smaller size and make it more

convenient to the user. In addition, the weight of this design is not too heavy and it help the user to move the product effortlessly.

3.11 Design

New design of walking aid for children with cerebral palsy has been introduced (figure 3.9). The new concept and the characteristics of the walking aid design agreed with the requirement and the needs of those children. They can move more freely and has an option to rest their limbs anywhere they want. The new concept design make the children feel more convenient and more independent in doing their daily task. The mechanism in the new concept design is the better version than other assistive walking aid and looks more appealing and ergonomic.

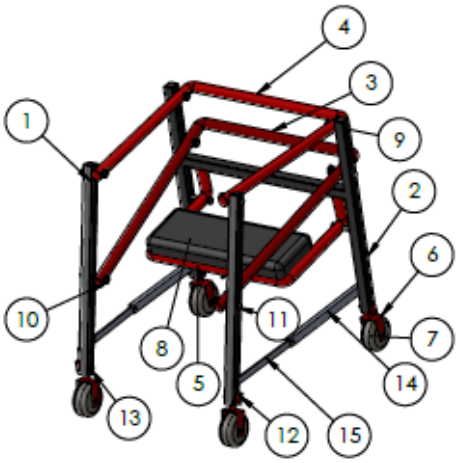
Figure 3.9: New design of walking aid

The new concept design is foldable. The mechanism in the design allow the user to fold parts at bolts connection at the main body and turn it into a smaller size and increase the portability of the tool. In addition, the main parts of the design is hollow to minimize the weight

of the product. Figure 3.10 shows that the seat is also foldable .This function is important to ensure the user can use the walking aid for walking rehabilitation and rest their limbs afterwards by sitting on the cushion seat.

Figure 3.10: foldable seat in the design

Figure 3.11 below shows the new design for assistive walking tools have 15 different items combined including bolts and nuts. The main parts of the design consist of six important parts which are two parts of square hollow bar, tyre holders and tyres, square hollow bar H shape, the seat with the cushion and two parts circular rods at the bottom and top of the design. The height of the product can be change for the user preferences. It can be adjust by inserting the bolt type 2 into the desired hole at the tyre holder (figure 3.11).



ITEM NO.	DESCRIPTION	QTY.
1	Square Hollow Bar	2
2	Square Hollow Bar H Shape	1
3	Circular Hollow Rod bottom	1
4	Circular Hollow Rod top	1
5	Seat	1
6	Tyre holder	4
7	Tyre	4
8	Cushion	1
9	Bolt 60mm	6
10	Nut	8
11	Bolt 70mm	4
12	Bolt Type 2	4
13	Nut for Type 2 bolt	4
14	Connector 1	2
15	Connector 2	2

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

name
drawn mūhd farisi

BILL OF MATERIAL OF WALKING CHAIR

Assem1

A4

Figure 3.11: bill of material of the new concept design

3.11.1 Square hollow bar

The design consist of two parts of square hollow bars to maintain the stability of the products. The hollow bars locate at the front of the product which are right and left side (figure 3.11). The parts include the square hollow bars, bolts and nuts, tyre holder and tyre, and bolts type 2 and nuts (figure 3.12).

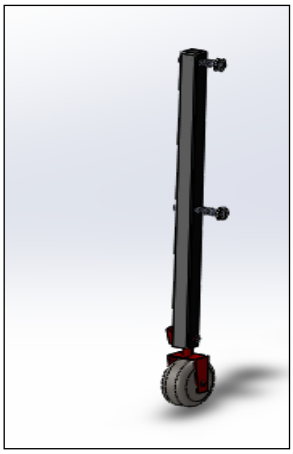


Figure 3.12: Square Hollow Bar

3.11.2 Tyre Holder and Tyre

The height of the product could be increase using the available bolt (figure 3.13). The user can remove the bolt and nut easily and put it into other holes locate at the tyre holder. There are three holes locate at the tyre holder for three different height available according the user's conveniences. In addition, the tyres can be rotate 360 degree and this helps the user to move freely anywhere they want easily. There are four tyres provided in this product.

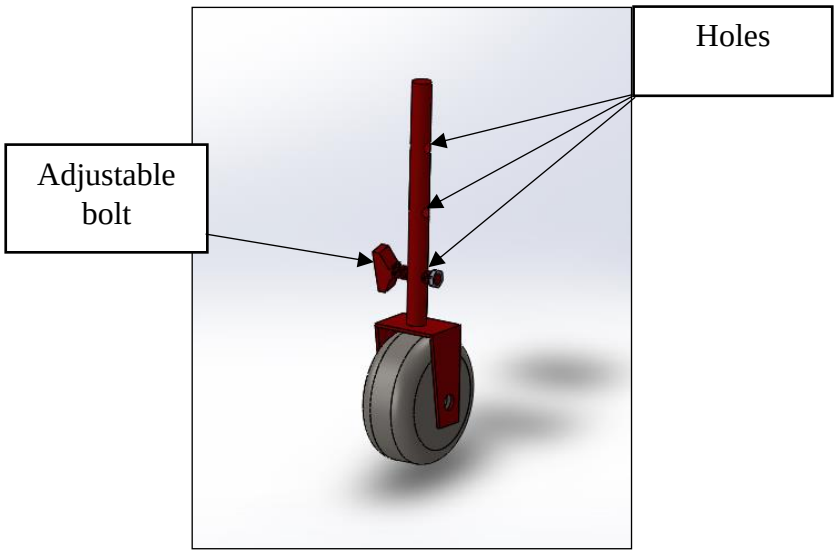


Figure 3.13: Tyre holder with holes

3.11.3 Square Hollow Bar H Shape

Figure 3.14 shows that two square hollow bars join together by one bar connecting them at the middle. It is located at the back of product design. This part play important role in supporting the most of the user weight and balance the body mass. The connected bar at the middle use to hold the force by the user when they sit on the seat (see figure 3.9). Moreover, there are two small rods used to grip the seat part. The rods are made of tough and sturdy material of steel to keep the seat in it position and help it grip the position of the seat when it fold. This parts also consist of two adjustable bolt and two tyre holders.

Figure 3.14: Square Hollow Bar H Shape

3.11.4 Seat

The seat hold most of the pressure when the user seat on it**.** Figure 3.15 shows there is soft leather cushion to decrease the pressure taken by the seat. It also give the user more comfortable seat and more relaxing condition.

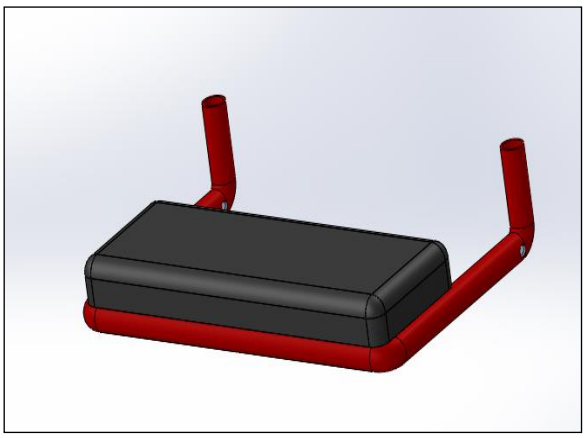


Figure 3.15: Seat

Figure 3.16 shows that two bolt attached to connect the cushion and the seat tightly and neatly. The seat can be moved upward when the user want to perform walking action for rehabilitation or downward when they want to rest their back or legs.

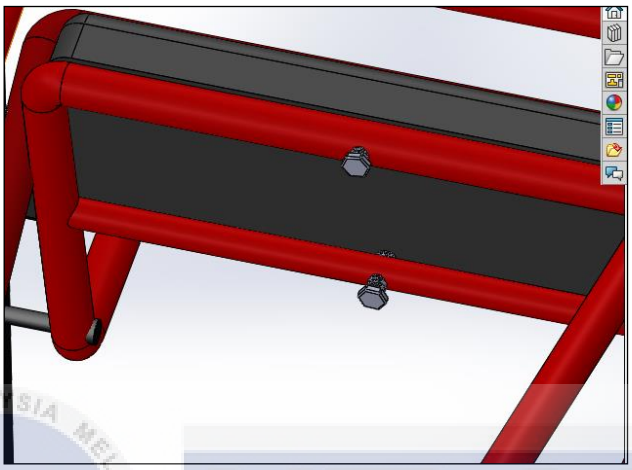


Figure 3.16: bottom side of the seat

3.11.5 Circular rods

Two rods at the top and the bottom of the design is the essentials parts (figure 3.17). The top part used to balance the product and balance the mass of the user at the middle. It also used for the user to grip while they walking using this product. Furthermore, an attendant can push the user while sit by holding this part at the back.

The bottom part hold the product in position and keep the balance of the product when use by the user. This part also help to support the weight of the user while they walk or sit. Both of the part attached at the two squared hollow bars at the front and squared hollow bar H shape at the back using bolts and nuts.

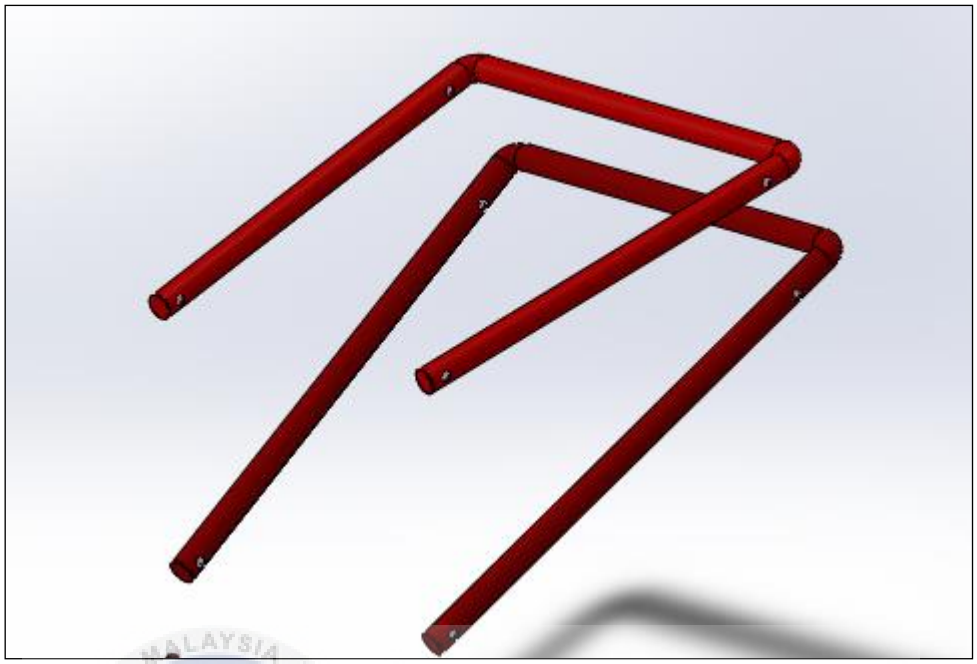


Figure 3.17: Circular Rods

CHAPTER 4

RESULT AND ANALYSIS

4.1 Analysis of Product

This chapter will explain more about the analysis being made to test the ergonomic and reliability of the product. The analysis being is Finite Element Analysis (FEA) and being run in Solidwork. FEA is usually perform to reduce the number of physical prototypes and run virtual experiments to optimize the designs. Finite Element Analysis (FEA) is the simulation of a physical phenomenon using a numerical mathematical technique called the Finite Element Method, or FEM. It is also one of the main concepts used for the simulation software development.

Two parameter has been consider to perform the FEA task. First, the selection of the material and second is force distribution. In this study, the material selection for this assistive walking tool are mild steel, stainless steel, and aluminium. Each material used in analysis determine the stress von misses, strain and factor of safety of the product

Figure 4.1 shows that the maximum force acting on the seat is 45kg from the weight of the user or $45 \times 9.8 = 441N$. The maximum weight of the product is assume as 20 kg or 196N. The total force acting which is 441N + 196N = 637N will be distribute on four tyre holders equally. Total force acting on each tyre holder is 637N/4 = 159.25N downward as shown in figure 4.2.

Figure 4.1: Force acting on the seat

Figure 4.2: Force acting on the tyre holder

When user performing walking action, they will use most of the force on the top part which is the hollow rod. The maximum force that the product can take is assume 441N or 220.5N each on the both left and right side due to user grip the part as shown in figure 4.3.

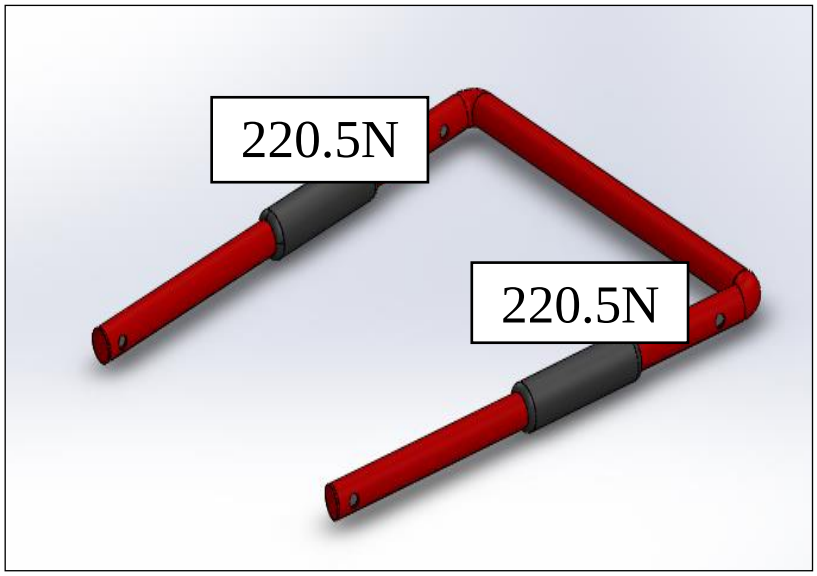


Figure 4.3: Force on top part

4.1.1 Presure on the seat

Maximum mass of children, m= 45kg

Radius of tyre holder= 12mm=0.012m

Pressure=mass/Area

Area,$A = 4 \times \pi r^2$

P = mg/$(4 \times \pi r^2)$

= (45×9.8)/($4\pi(0.012)^2$)

=243.706kPa

4.2 Mild steel

Mild steel is a low carbon steel type. Carbon steels are metals containing a small amount of carbon (maximum 2.1 percent) that improves pure iron properties. The carbon content varies according to steel specifications. The table 4.1 below shows the properties of mild steel material.

Table 4.1: Properties of mild steel material

Material	Mild steel
Yield strength (N/m^2)	2.5x 10^8
Thermal expansion(N/m^2)	1.17 x 10^5
Density(kg/m^3)	7850
Poisson Ratio	0.3
Young Modulus (N/m^2)	2.05 x 10^{11}

4.2.1 Seat

Using the mild steel material properties, the analysis can be calculated to get von misses stress. The load applied on the seat is 441N and it affecting the whole seat as shown in figure 4.4. The maximum stress on this part is 146.3MPa. Figure 4.5 shows the displacement of the seat when the load applied. The maximum resultant displacement is 9.274 x 10^{-1}mm.

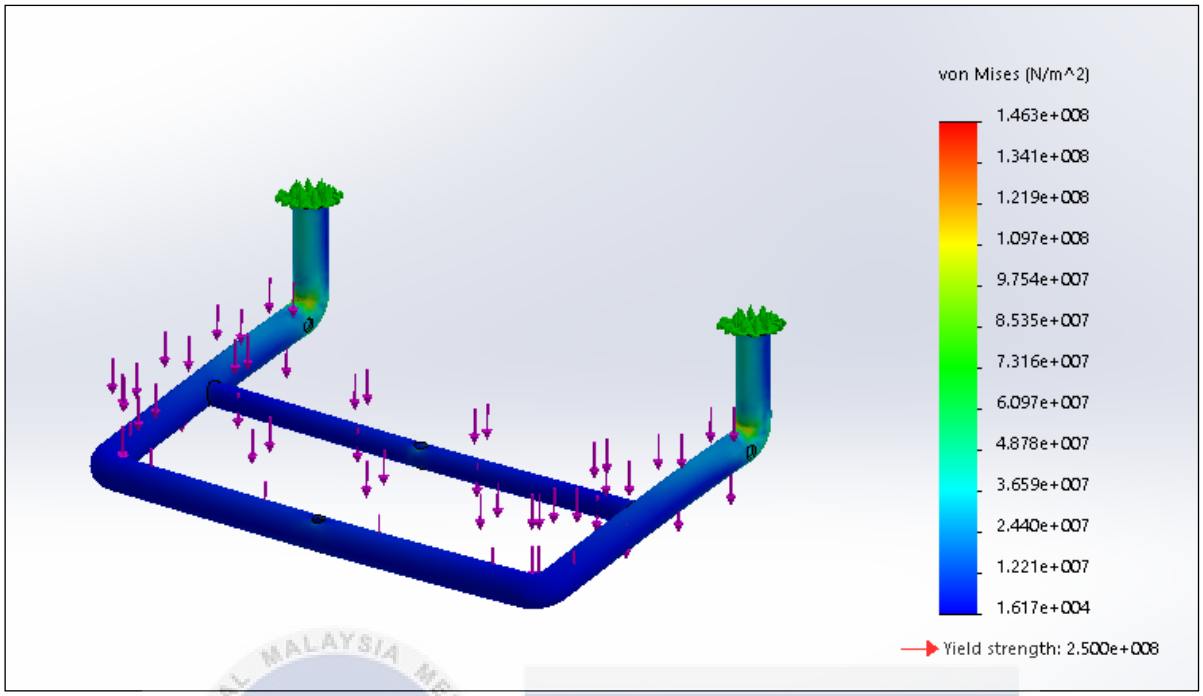


Figure 4.4: Von misses stress of the seat

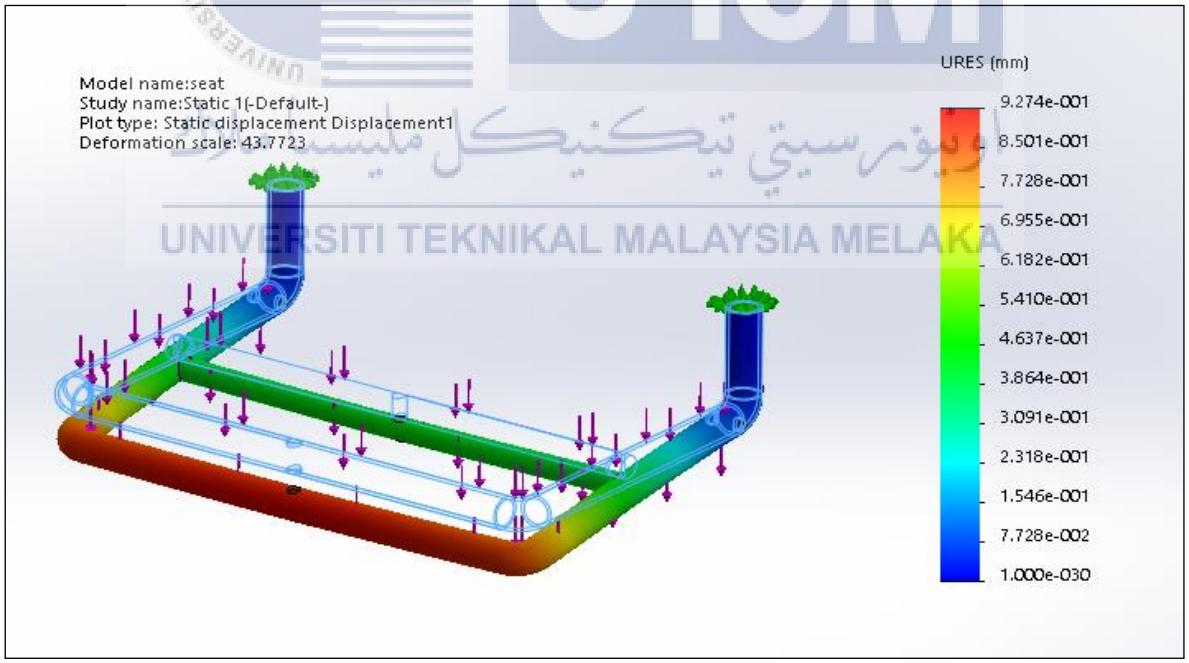


Figure 4.5: Displacement of the seat

4.2.2 Tyre Holder

The load applied on each of the tyre holder is 159.25N. The force include the weight of the user and the weight of product. The maximum Von misses stress using mild steel material for this part is 21.15MPa as shown in figure 4.6 below. Figure 4.7 shows the deformation of the material. The maximum of resultant displacement is 2.342 x 10^{-3}mm.

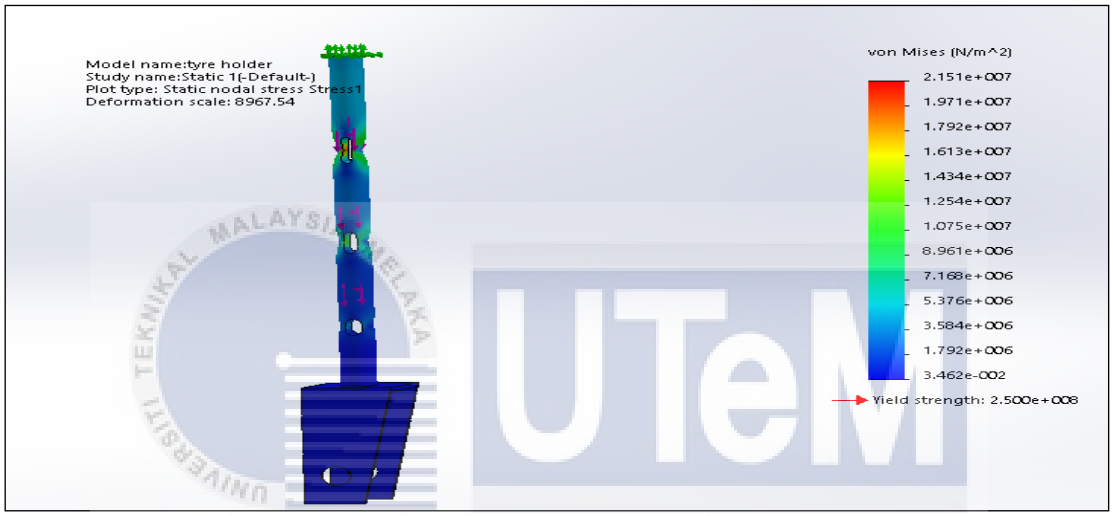


Figure 4.6: Von misses stress of the tyre holder

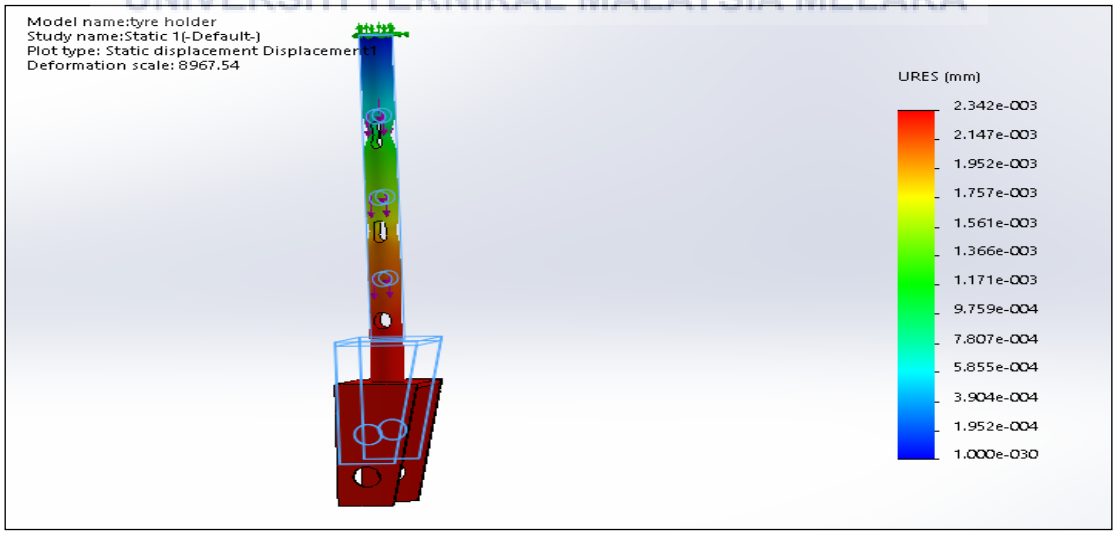


Figure 4.7: Displacement of the tyre holder

4.2.3 Top Part of Circular Rod

The top part play important role when the user want to walking for rehabilitation using this product. The applied load on this part is 220.5N on the left and the right side respectively. The maximum von misses stress on this product is 105.6MPa as shown in figure 4.8. The maximum resultant displacement is 12.24x 10^{-1}mm as shown in figure 4.9.

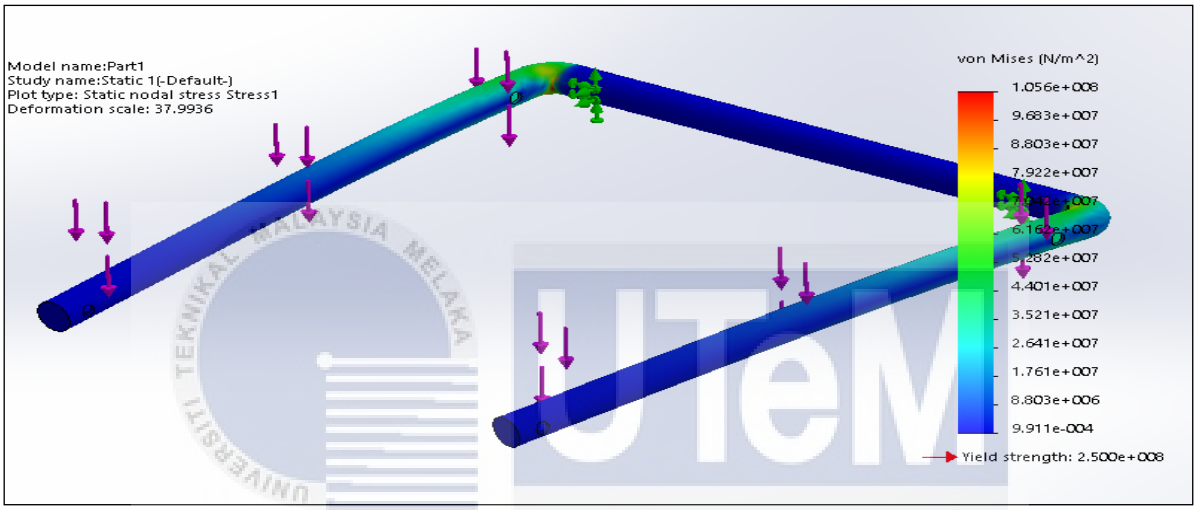


Figure 4.8: Von misses stress of the top part

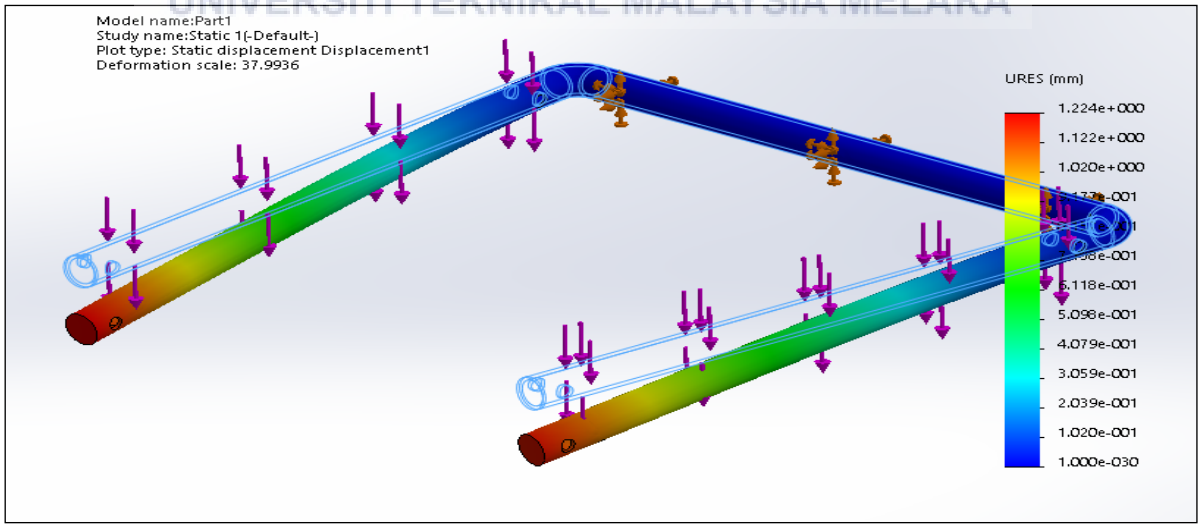


Figure 4.9: Displacement of the top part

4.2.4 Square Hollow Bar H-shape

This part hold the impact of the force acting on the seat which is the force from the user weight. This part is important as it hold still the seat when the user sit on it or when the user fold the seat upward. Load applied for this part is 441N. The maximum von misses stress on this product is 29.74MPa as shown in figure 4.10. The maximum resultant displacement is 4.29x 10^{-2}mm as shown in figure 4.11.

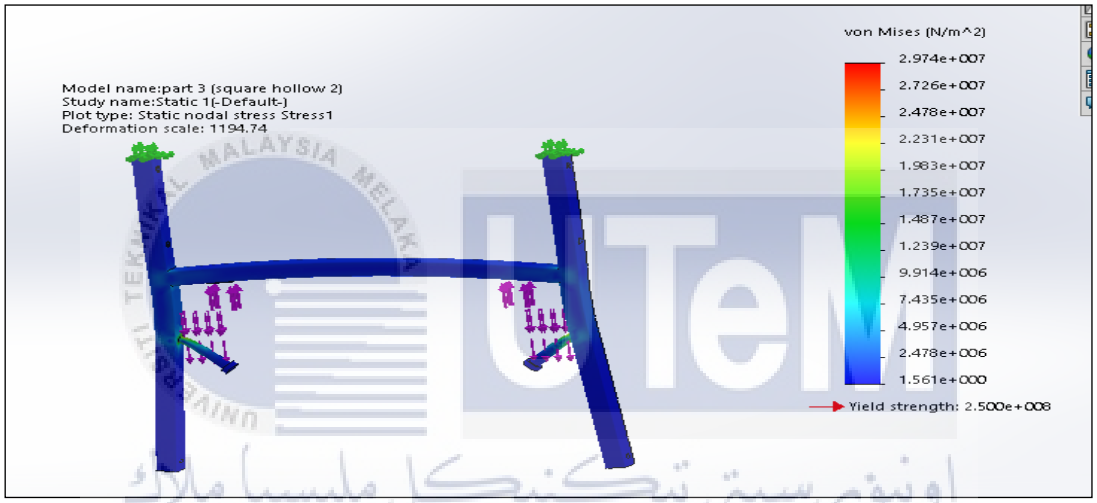


Figure 4.10: Von misses stress of the square hollow bar H-shape

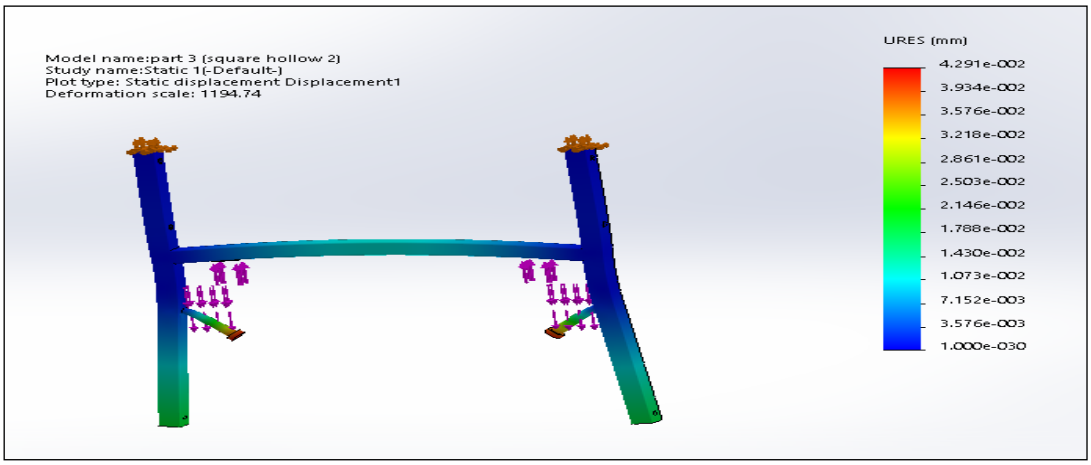


Figure 4.11: Displacement of the square hollow bar H-shape

4.3 Stainless steel

Stainless steel is a family of iron-based alloys containing a composition that prevents iron from rusting and offers heat-resistant properties of at least 11 per cent chromiu. Table 4.2 below shows the properties of the stainless steel material.

Table 4.2: Properties of Stainless steel

Material	Stainless steel
Yield strength	1.7x 10^8
Thermal expansion(N/m^2)	0
Density(kg/m^3)	8000
Poisson Ratio	0.27
Young Modulus (N/m^2)	1.93 x 10^{11}

4.3.1 Seat

The force acting on this part is 441N. The maximum von misses stress using stainless steel material is 143.6Mpa as shows in figure 4.12. Figure 4.13 shows the displacement of the seat when the load applied. The maximum resultant displacement is 9.897x 10^{-1}mm.

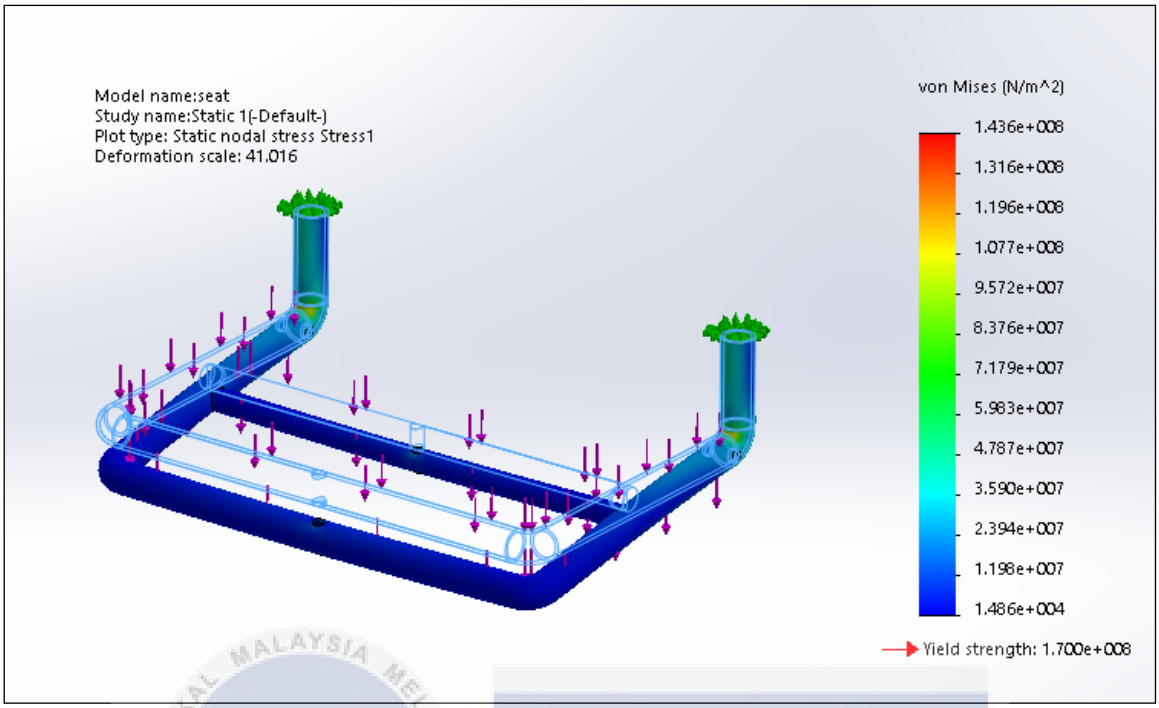


Figure 4.12: Von misses stress of the seat

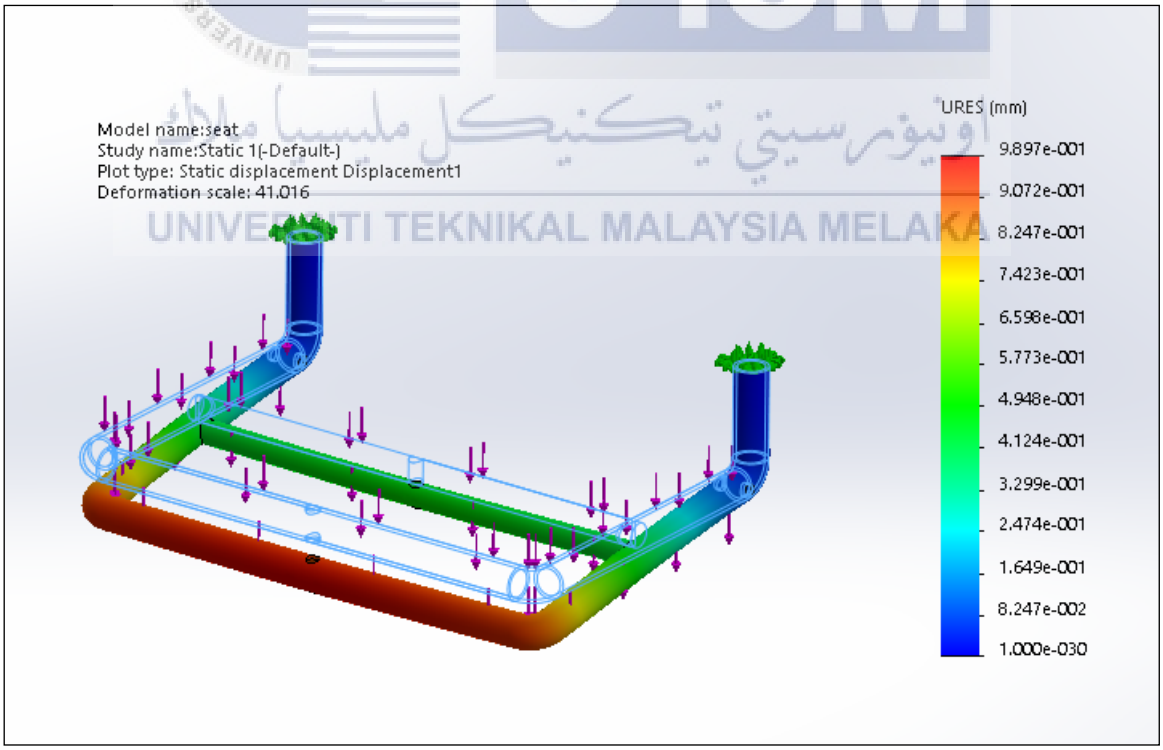


Figure 4.13: Displacement of the seat

4.3.2 Tyre holder

The force acting on this part is 159.25N. The maximum von misses stress using stainless steel material is 21.56Mpa as shown in figure 4.14. Figure 4.15 shows the maximum resultant displacement is 2.493x 10^{-3}mm.

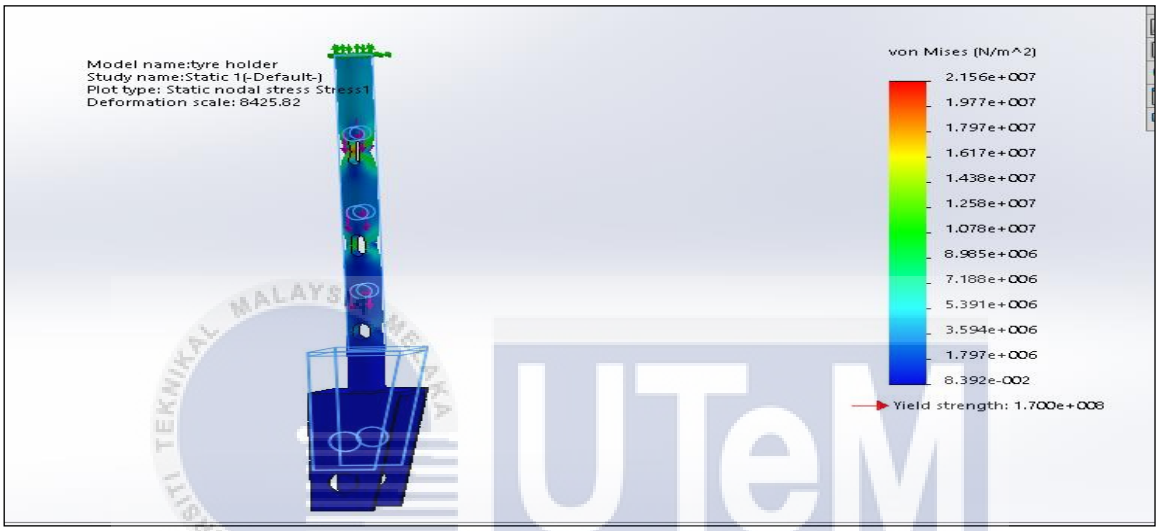


Figure 4.14: Von misses stress of the tyre holder

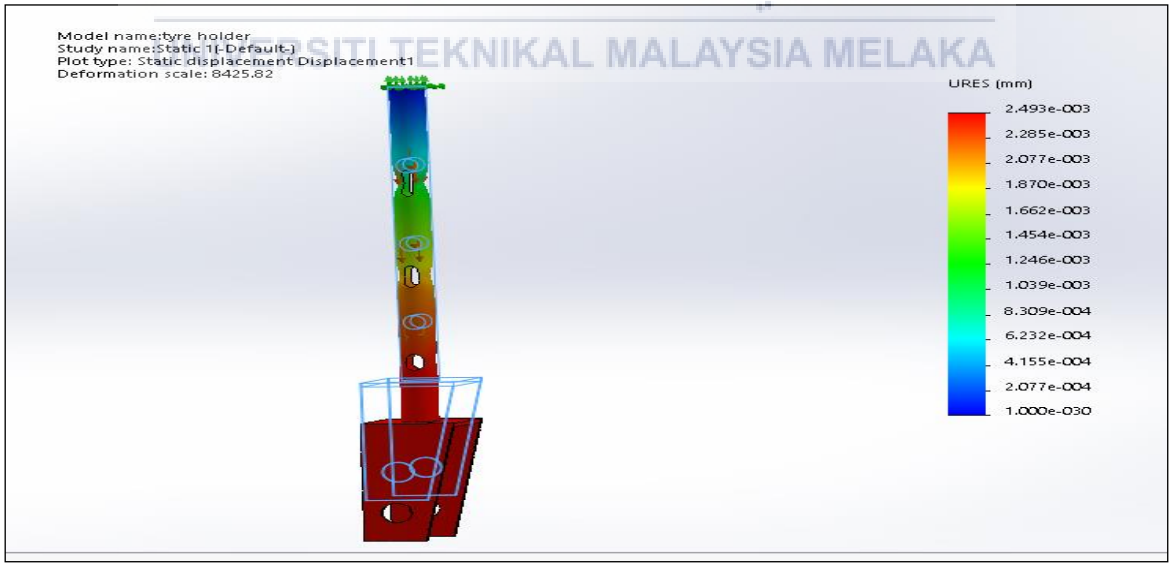


Figure 4.15: Displacement of the tyre holder

4.3.3 Top Part of circular hollow rod

The top part play important role when the user want to walking for rehabilitation using this product. The applied load on this part is 220.5N on the left and the right side respectively. The maximum von misses stress on this product is 106.8MPa as shown in figure 4.16. The maximum resultant displacement is 12.980x 10^{-1}mm as shown in figure 4.17.

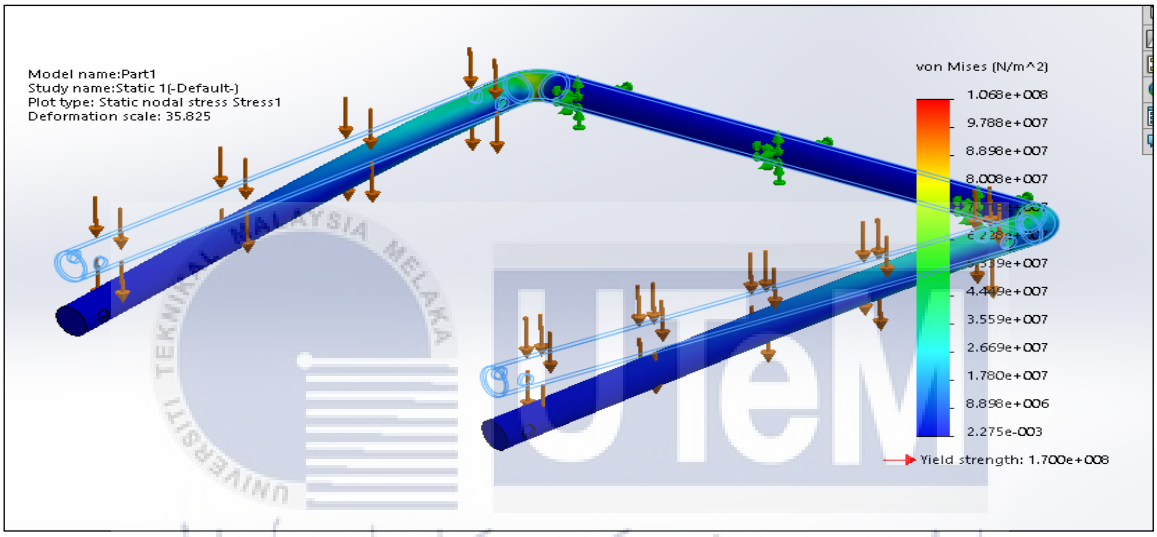


Figure 4.16: Von misses stress of the top part

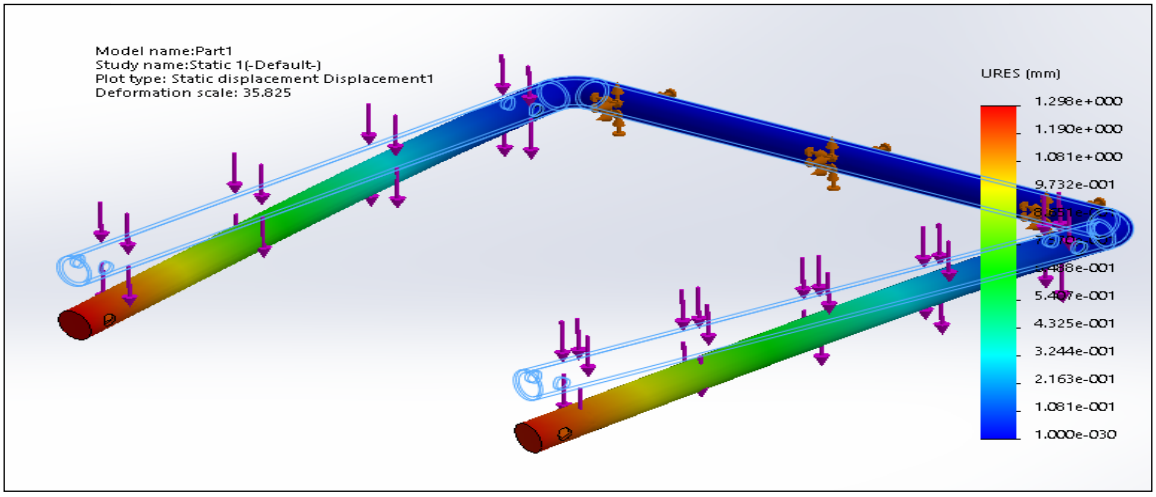


Figure 4.17: Displacement of the top part

4.3.4 Square Hollow Bar H-shape

This part hold the impact of the force acting on the seat which is the force from the user weight. Load applied for this part is 441N. The maximum von misses stress on this product is 30.21MPa as shown in figure 4.18. The maximum resultant displacement is 4.602x 10^{-2}mm as shown in figure 4.19.

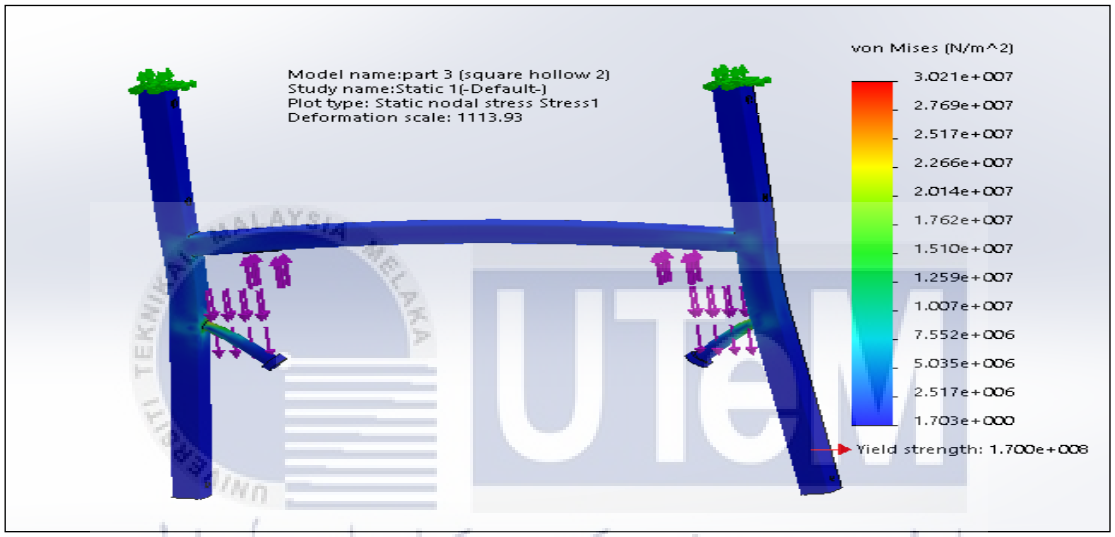


Figure 4.18: Von misses stress of the square hollow bar H-shape

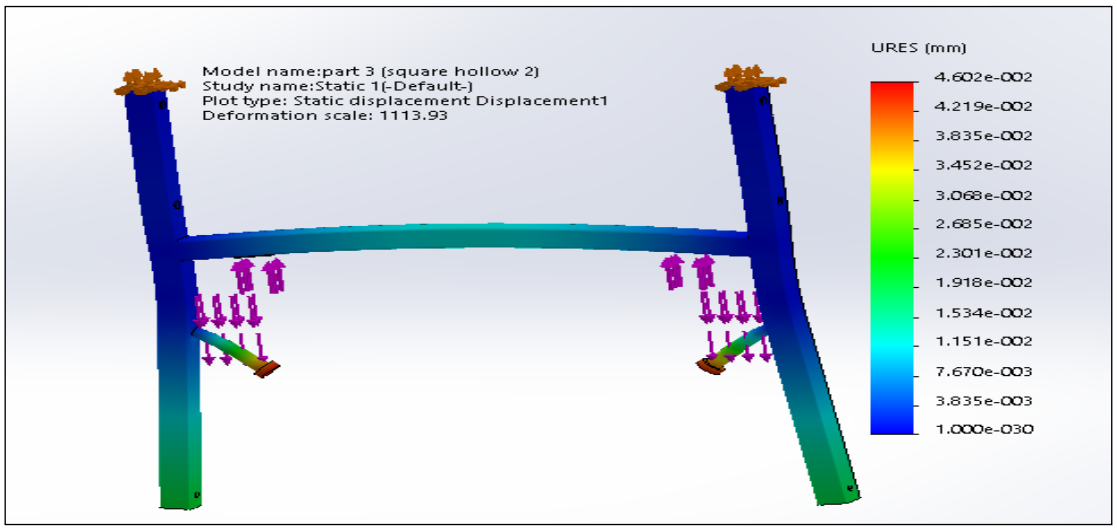


Figure 4.19: Displacement of the square hollow bar H-shape

4.4 Aluminium

Aluminium is a lighter and shows a reliable material against corrosion. Table 4.3 below shows the properties of the aluminium material.

Table 4.3: properties of aluminium

Material	Aluminium
Yield strength(N/m^2)	0.95x 10^8
Thermal expansion(N/m^2)	24 x 10^{-6}
Density(kg/m^3)	2950
Poisson Ratio	0.36
Young Modulus (N/m^2)	6.9 x 10^{10}

4.4.1 Seat

The force acting on this part is 441N. The maximum von misses stress using stainless steel material is 152.7Mpa as shows in figure 4.20. Figure 4.21 shows the displacement of the seat when the load applied. The maximum resultant displacement is 27.20x 10^{-1}mm.

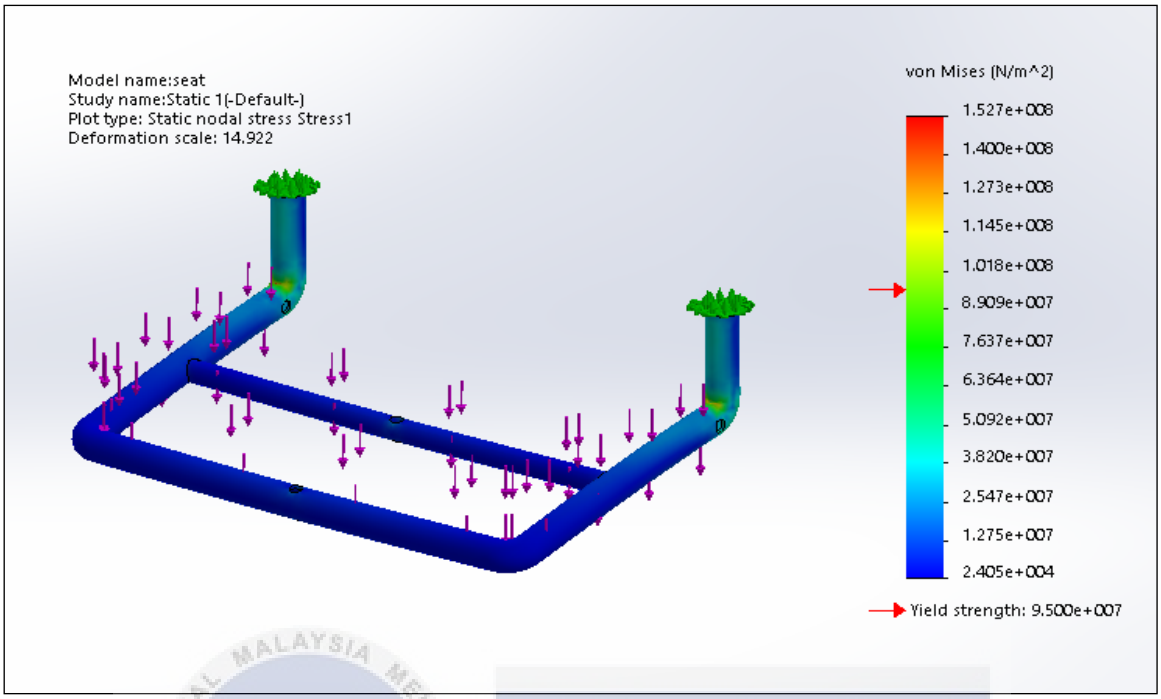


Figure 4.20: Von misses stress of the seat

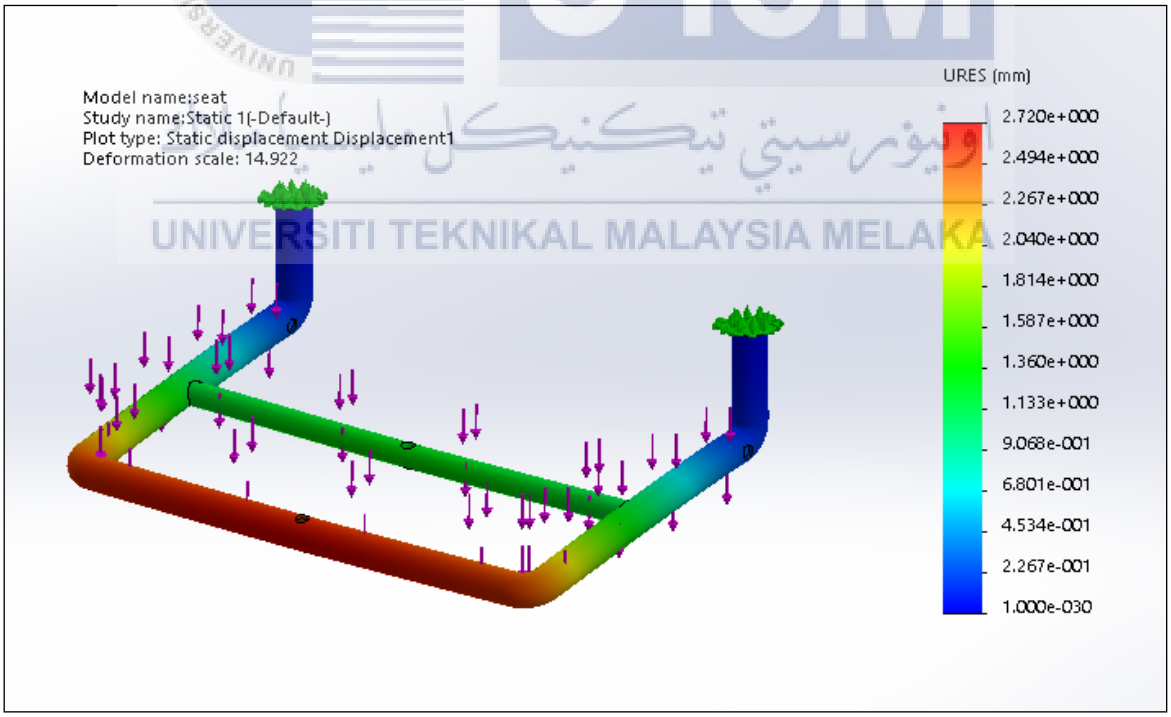


Figure 4.21: Displacement of the seat

4.4.2 Tyre holder

The force acting on this part is 159.25N. The maximum von misses stress using stainless steel material is 21.43Mpa as shown in figure 4.22. Figure 4.23 shows the maximum resultant displacement is 6.923x 10^{-3}mm.

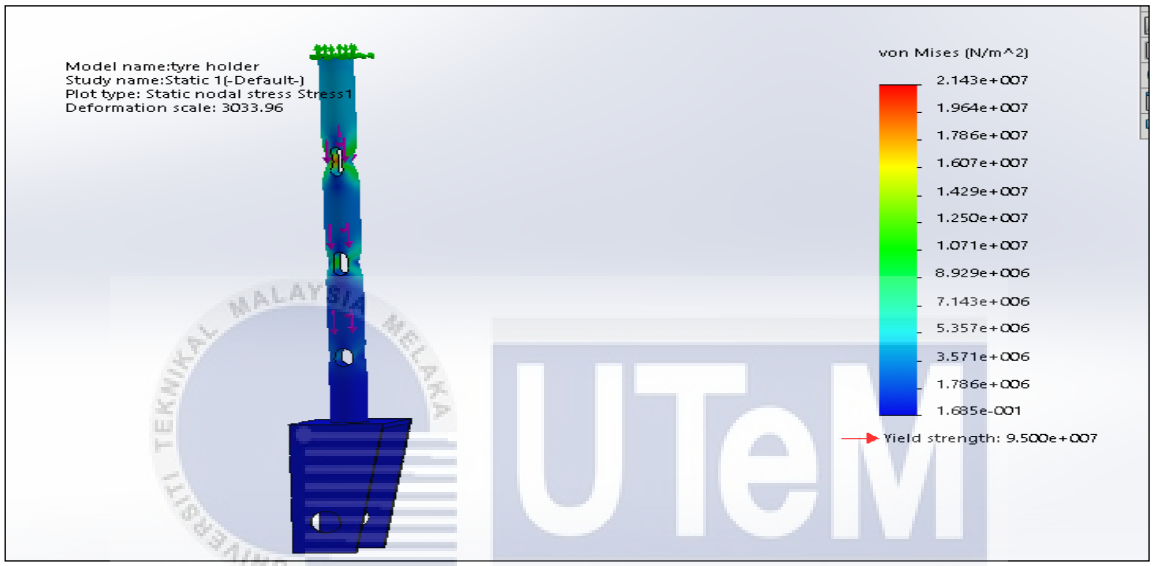


Figure 4.22: Von misses stress of the tyre holder

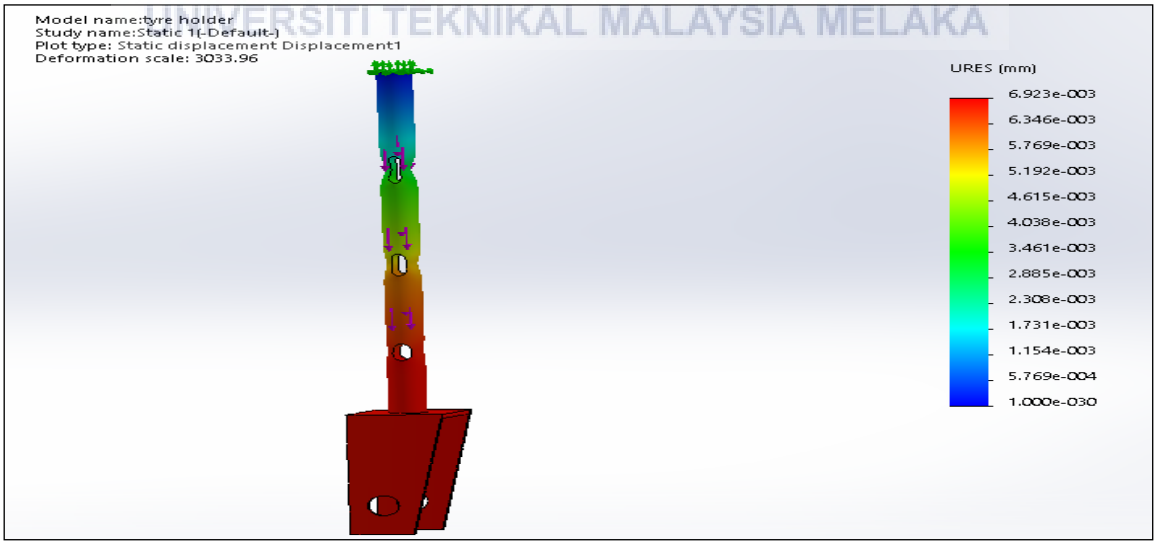


Figure 4.23: Displacement of the tyre holder

4.4.3 Top Part of circular hollow rod

The top part play important role when the user want to walking for rehabilitation using this product. The applied load on this part is 220.5N on the left and the right side respectively. The maximum von misses stress on this product is 103.5MPa as shown in figure 4.24. The maximum resultant displacement is 36.420x 10^{-1}mm as shown in figure 4.25.

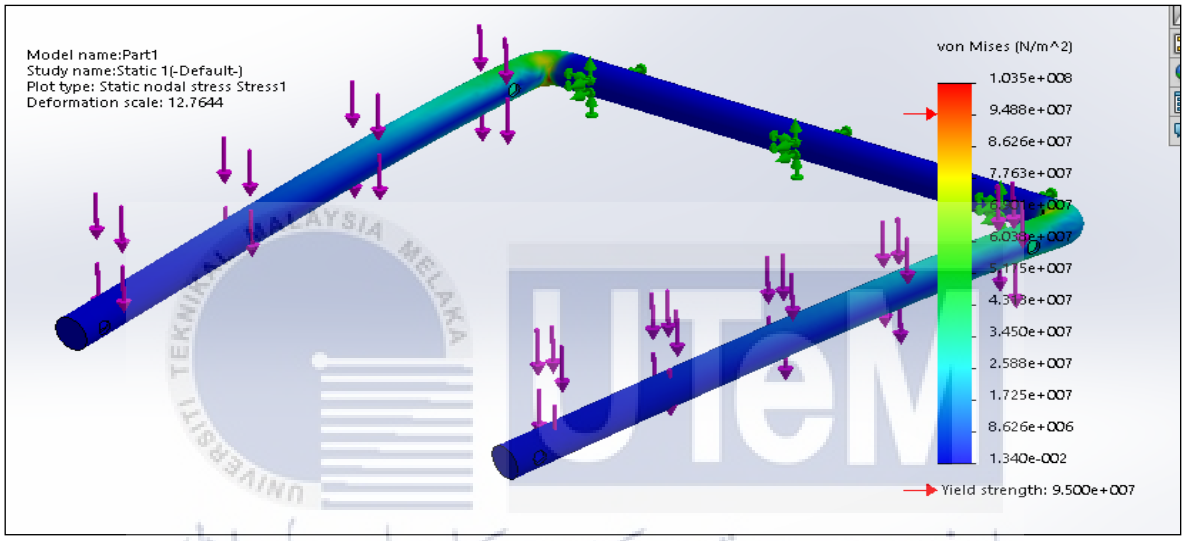


Figure 4.24: Von misses stress of the top part

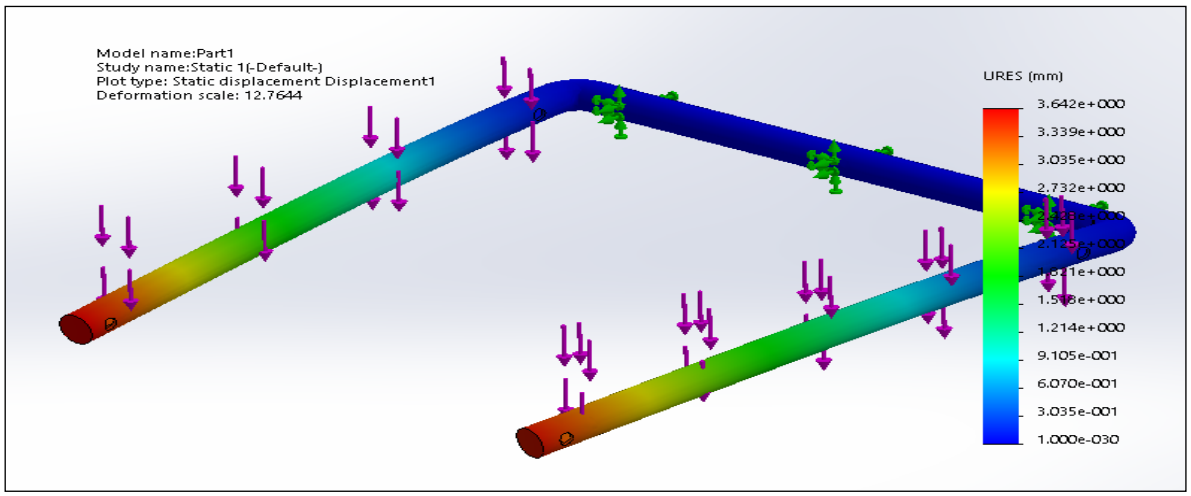


Figure 4.25: Displacement of the top part

4.4.4 Square Hollow Bar H-shape

This part hold the impact of the force acting on the seat which is the force from the user weight. Load applied for this part is 441N. The maximum von misses stress on this product is 28.73MPa as shown in figure 4.26. The maximum resultant displacement is 12.43x 10^{-2}mm as shown in figure 4.27.

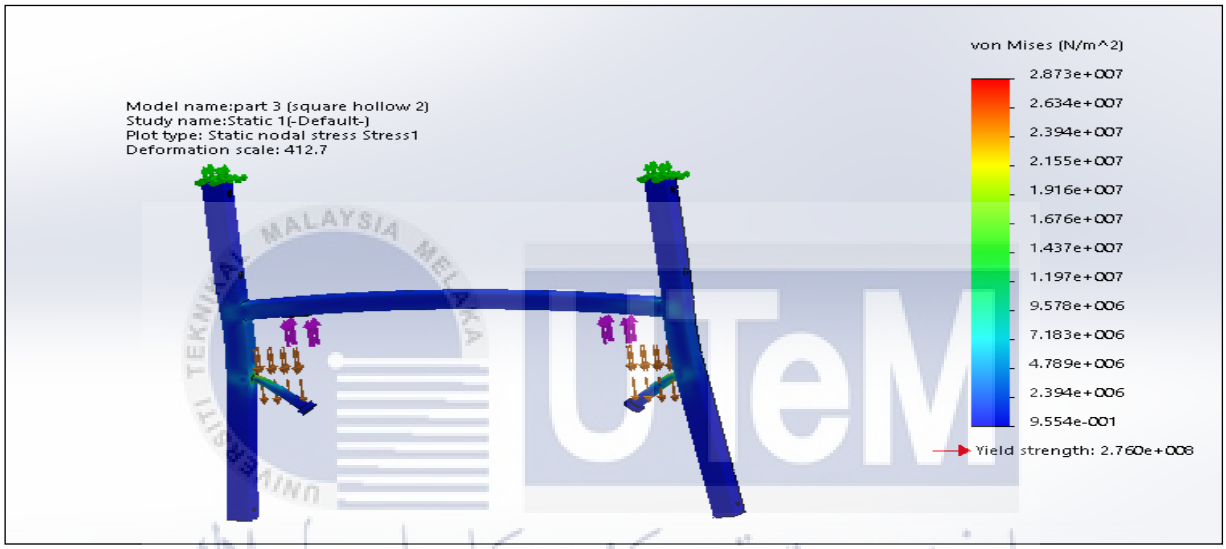


Figure 4.26: Von misses stress of the square hollow bar H-shape

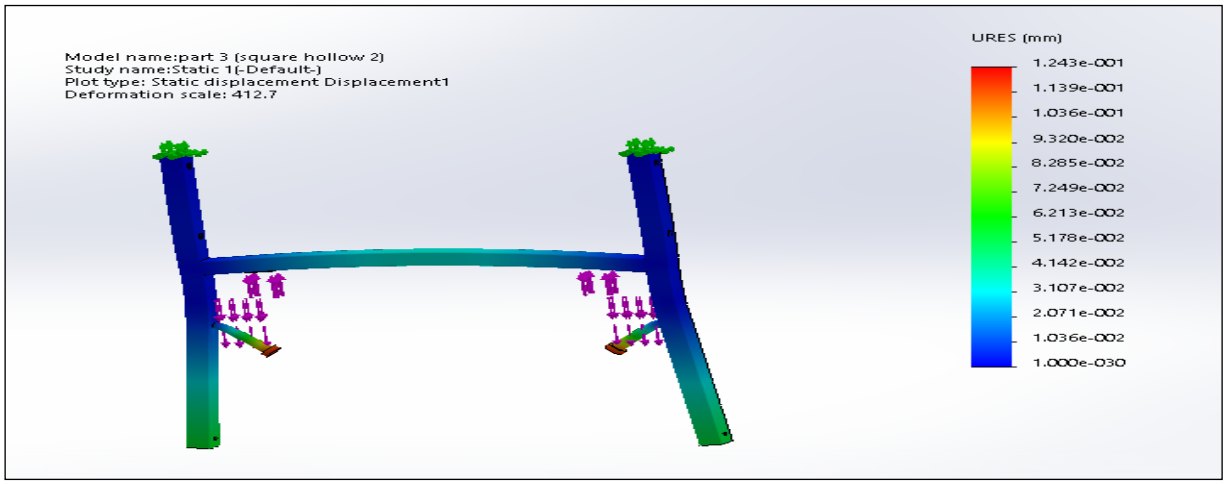


Figure 4.27: Displacement of the square hollow bar H-shape

4.5 Factor of safety

Factor of safety can be calculate using the equation 3.1.This equation can determine Safety factor of all parts that been analyze. One example below show the calculation to find safety factor for material mild steel, seat part.

$$\text{Factor of Safety} = \frac{\text{Syt}}{\sigma\text{Von Misses}} \quad \textbf{(Equation 3.1)}$$

Yield tensile strength, Syt = 2.5x 10^8 Pa

Von misses strength, σVon Misses = 1.463x 10^8 Pa

Factor of safety $= \frac{2.5\text{x } 10^8}{1.463\text{x } 10^8}$

= 1.70

The values for factor of safety from the calculation been record into table 4.4, table 4.5, table 4.6 and table 4.7 below.

Table 4.4: Factor of safety of seat part

Material	Yield strength (N/m^2)	Maximum stress (N/m^2)	Factor of safety
Mild steel	2.50x 10^8	1.463x 10^8	1.70
Stainless steel	1.70x 10^8	1.436x 10^8	1.18
Aluminium	0.95x 10^8	1.527x 10^8	0.62

Table 4.5: Factor of safety of tyre holder part

Material	Yield strength (N/m^2)	Maximum stress (N/m^2)	Factor of safety
Mild steel	2.50x 10^8	0.2151x 10^8	11.62
Stainless steel	1.70x 10^8	0.2156x 10^8	7.88
Aluminium	0.95x 10^8	0.2143x 10^8	4.43

Table 4.6: Factor of safety of circular hollow rod top part

Material	Yield strength (N/m^2)	Maximum stress (N/m^2)	Factor of safety
Mild steel	2.50x 10^8	1.056x 10^8	2.37
Stainless steel	1.70x 10^8	1.068x 10^8	1.59
Aluminium	0.95x 10^8	1.035x 10^8	0.92

Table 4.7: Factor of safety of square hollow bar H-shape part

Material	Yield strength (N/m^2)	Maximum stress (N/m^2)	Factor of safety
Mild steel	2.50x 10^8	0.9740x 10^8	2.57
Stainless steel	1.70x 10^8	0.3021x 10^8	5.63
Aluminium	0.95x 10^8	0.2873x 10^8	3.31

4.6 Structural Analysis

Table 4.4, 4.5, 4.6, and 4.7 shows the values of safety factor for each critical part using different types of material. To determine the critical parts is safe to be use, the factor of safety must be more than one.

Based on the table 4.4 and table 4.6 above, the safety factor for the aluminium material are low than one. This condition happen because the material has the lowest value of the yield strength. Aluminium should be the ideal material in terms of its advantages which are good conductor of electricity and low density that could lead the material becomes less weight. However, the safety of the user must be on top of priority, which make this material must be reject at all cost.

Referring to the factor of safety from selective material, mild steel is the most suitable material to use. Furthermore, mild steel is the most affordable material compare to stainless steel and aluminium. Mild steel also one of the long lasting material and strong enough to withstand any external pressure acting on it. In addition, the density of mild steel is lower than stainless steel which mean material from mild steel is lighter.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will summarize the results that have been obtained from simulation and analysis in the previous chapter and the conclusion for this project. In addition, several recommendations will be discuss in order to improve design of the product.

5.2 CONCLUSION

The design and simulation for an ergonomic walking chair for disabled children is complete and the objectives of this project were accomplished. The new concept of walking chair can be use by the disabled children with cerebral palsy with Gross Motor Function Classification System (GMFCS) in level II and level III for rehabilitation and move freely in their classroom. Based on survey at PDK, an analysis called House of Quality was carried out and engineering characteristics were defined as priorities for the design. Three conceptual designs were drawn from the information in the House of Quality, and then one final conceptual design was selected using weighted decision matrix analysis.

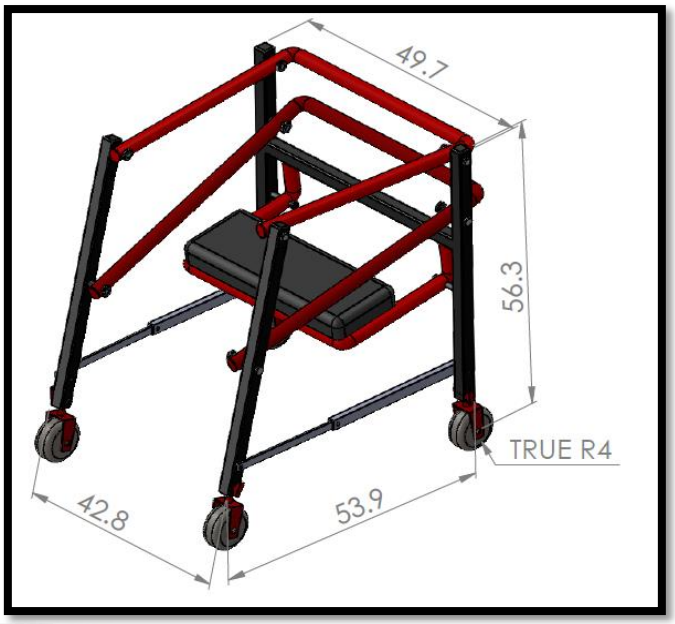


Figure 5.1: Dimension for Walking Chair (unit in cm)

The design are fully utilized and can be used as market developing to help children with disabilities to own an ergonomic walking chair in performing their daily tasks and for their own benefits. Figure 5.1 shows the dimension for the walking chair. The walking chair is suitable for the user with height between 80 and 130 cm. The height of the walking chair is adjustable by removing the bolt at the tyre holder and insert it into other holes on it. The height can be increase by 4 cm for suitability of user and their comfort.

The simulation and analysis of the product design are running through the Solidworks 2016 software. The product design was proved that it can function well and safe to be use based on the analysis outcome from the software. There are four parts that have been determined as the critical force acting on them which are seat part, tyre holder, top part of circular rod and square hollow bar H-shape. In addition, there are three materials that been tested which are mild steel, aluminium, and stainless steel. Based on the analysis, with maximum load of 45 kg

applied, stainless steel and mild steel is the safe material that could be use because the product safety of factor obtained is more than one. However, mild steel is the most suitable material that should be use by considering the advantages of the material.

5.3 RECOMMENDATION

The fabrication of the product design cannot be done during this COVID-19 pandemic so the real picture of the product design into real life situation cannot be interpret. A proper fabrication should be made in order for this project enable to prove it marketability among other walking aid tools. In addition, some changes can be made when this product being tested by the user according with their suitability and comfort.

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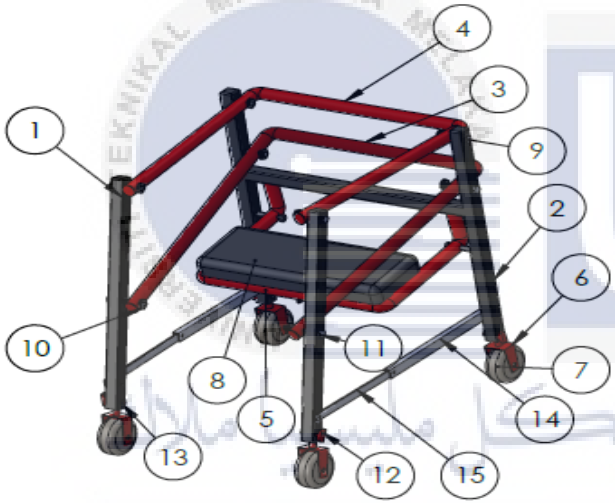
APPENDICES

APPENDIX A



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3	Circular Hollow Rod bottom	1
4	Circular Hollow Rod top	1
5	Seat	1
6	Tyre holder	4
7	Tyre	4
8	Cushion	1
9	Bolt 60mm	6
10	Nut	8
11	Bolt 70mm	4
12	Bolt Type 2	4
13	Nut for Type 2 bolt	4
14	Connector 1	2
15	Connector 2	2

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REVISION

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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A4

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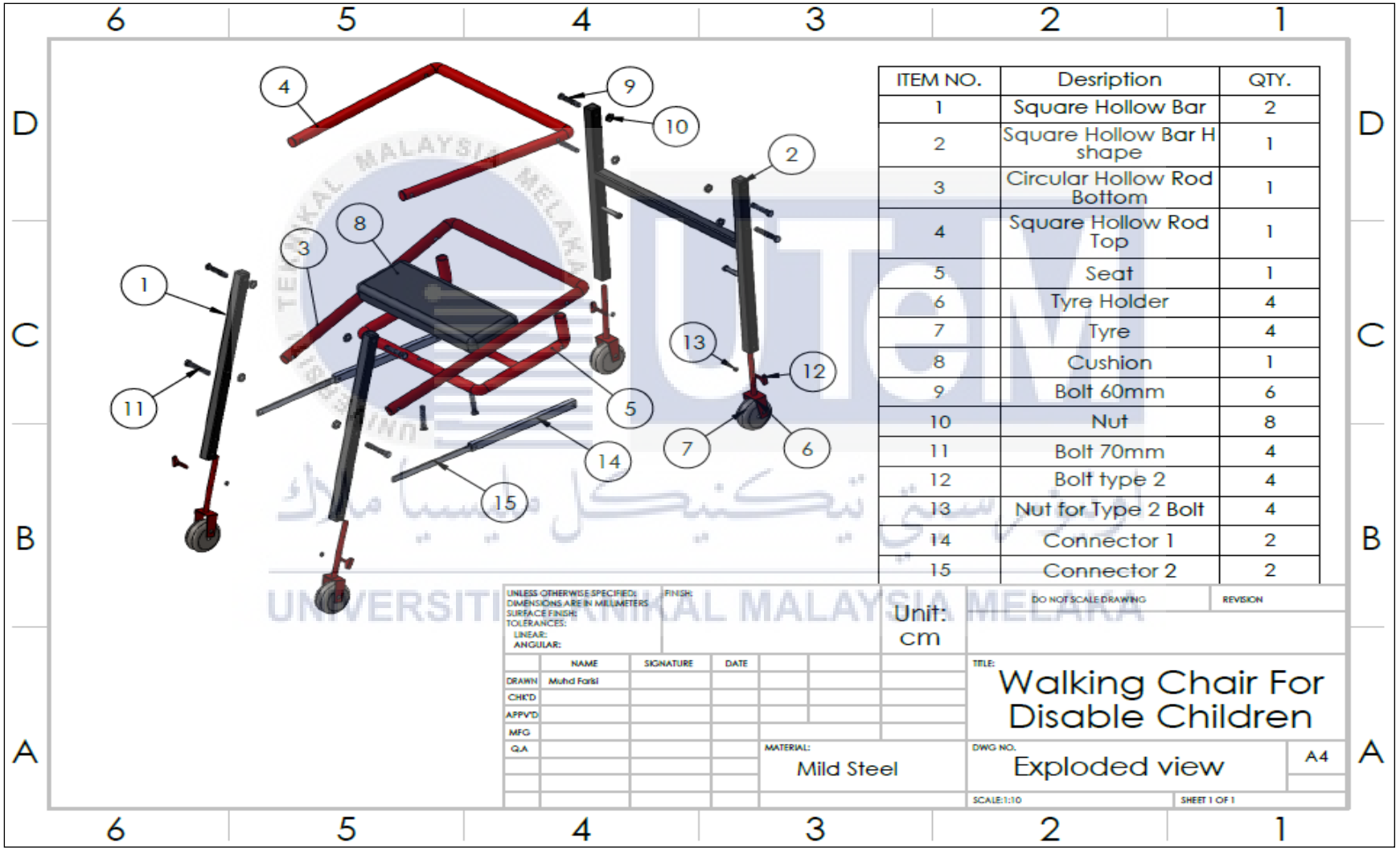
SHEET 1 OF 1

APPENDIX B



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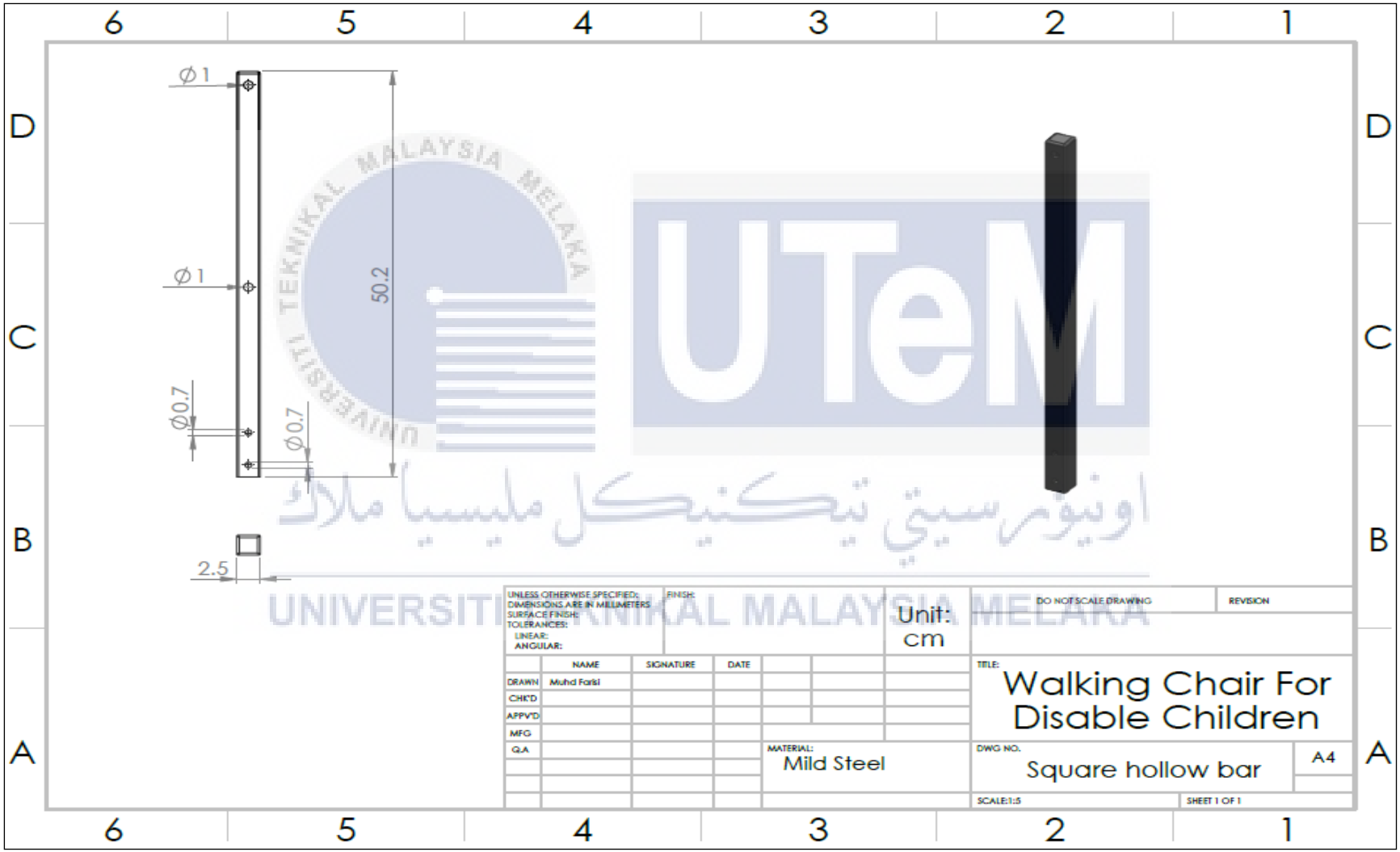

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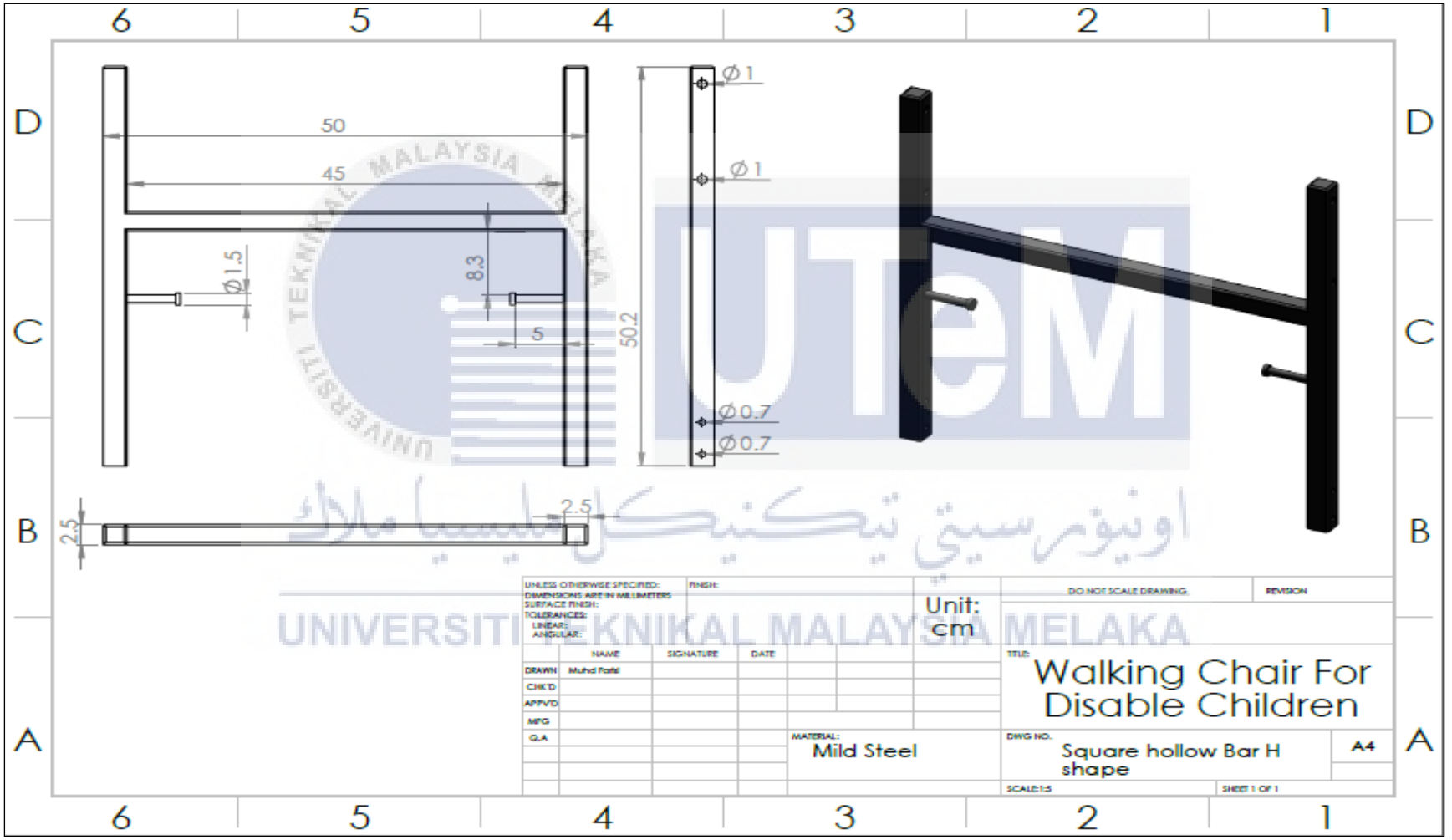

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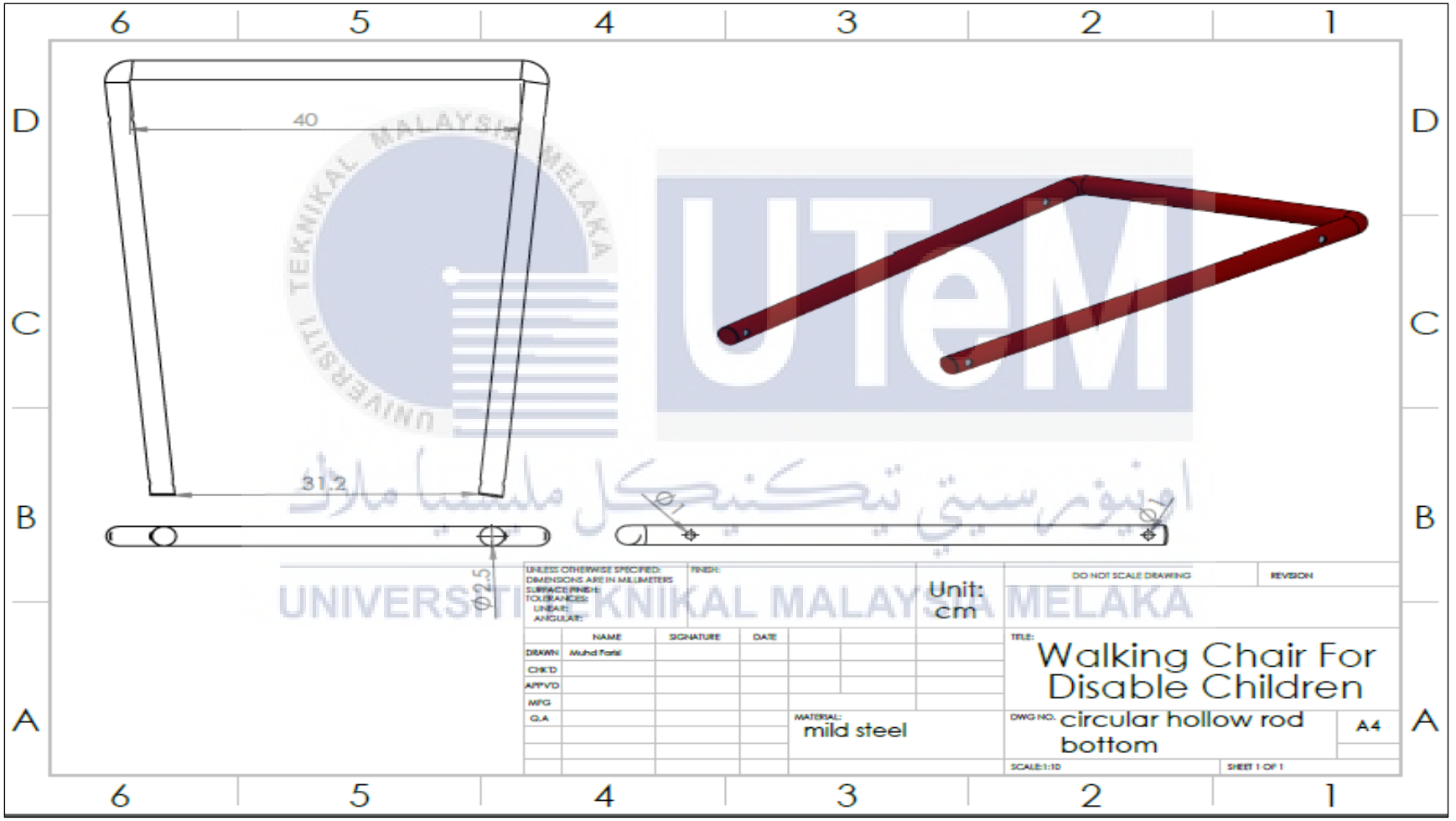

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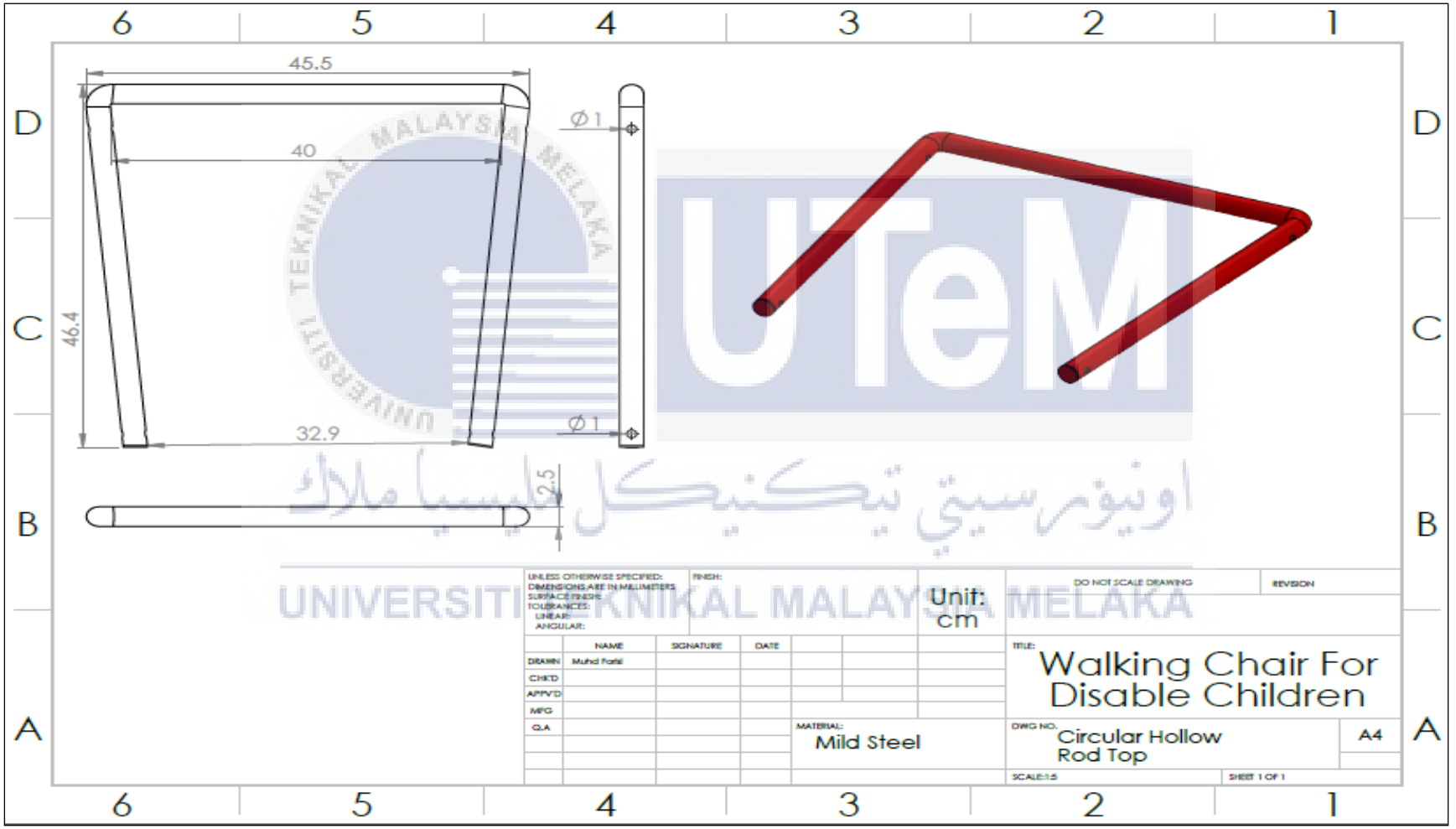

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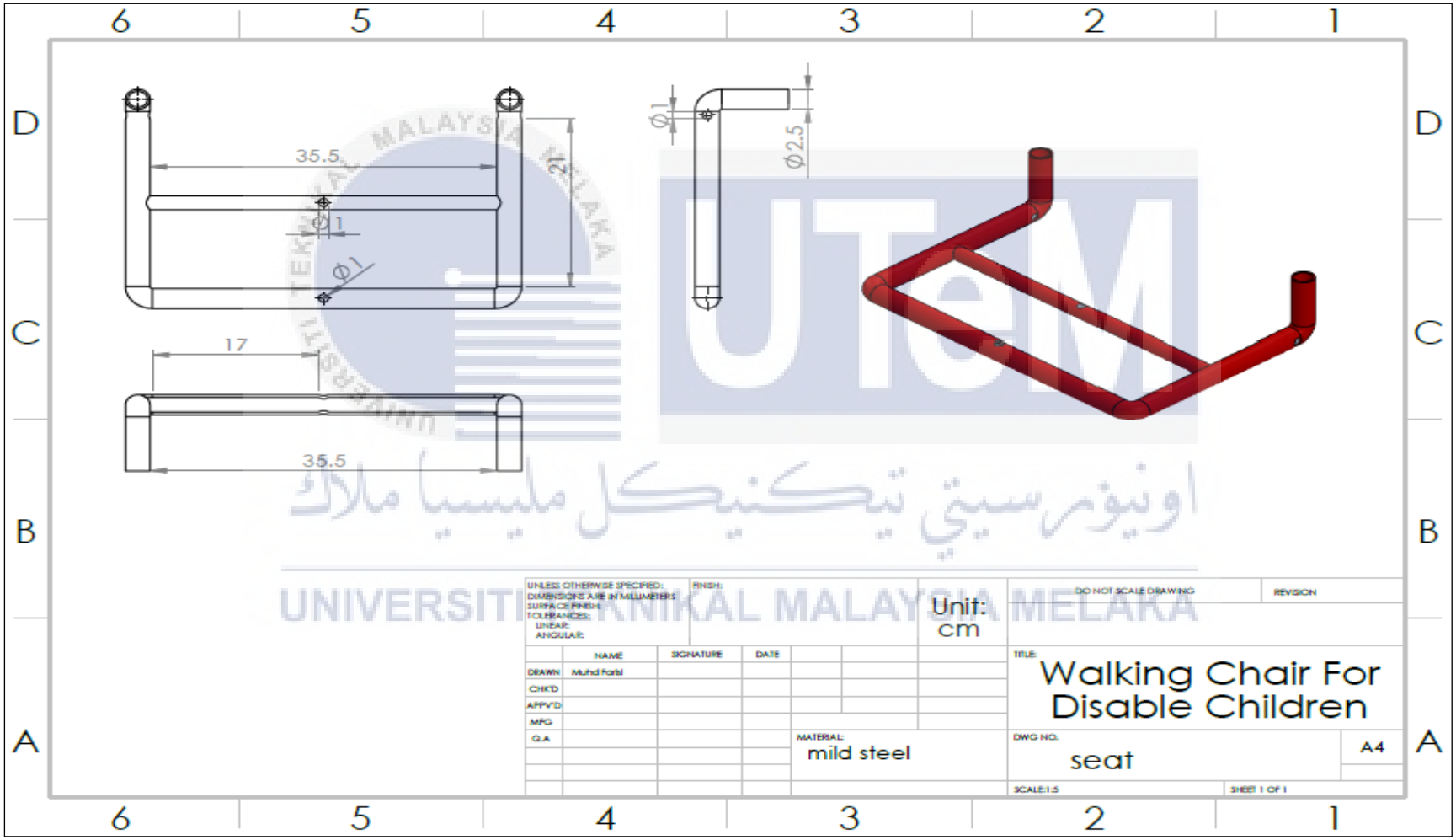

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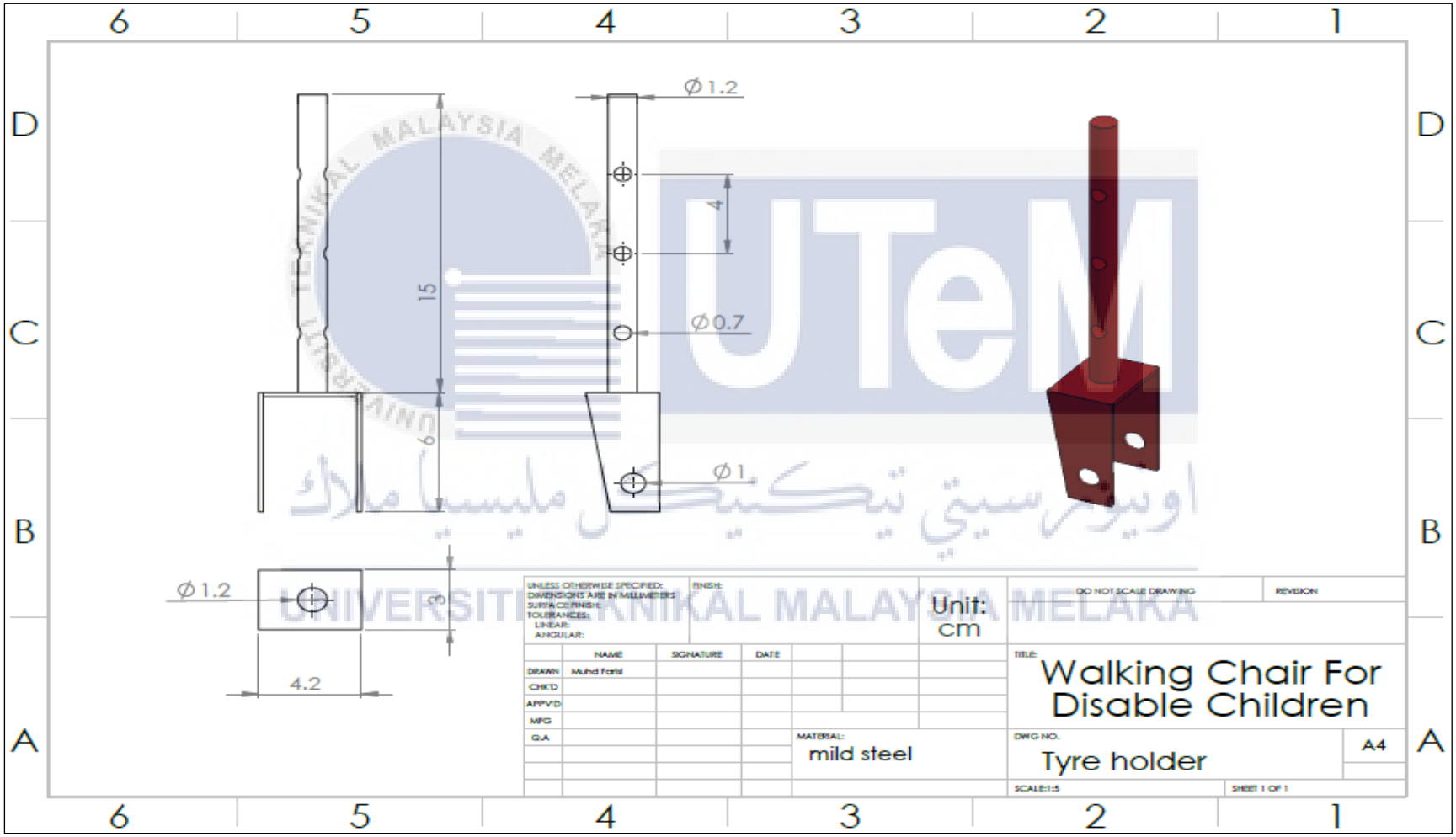
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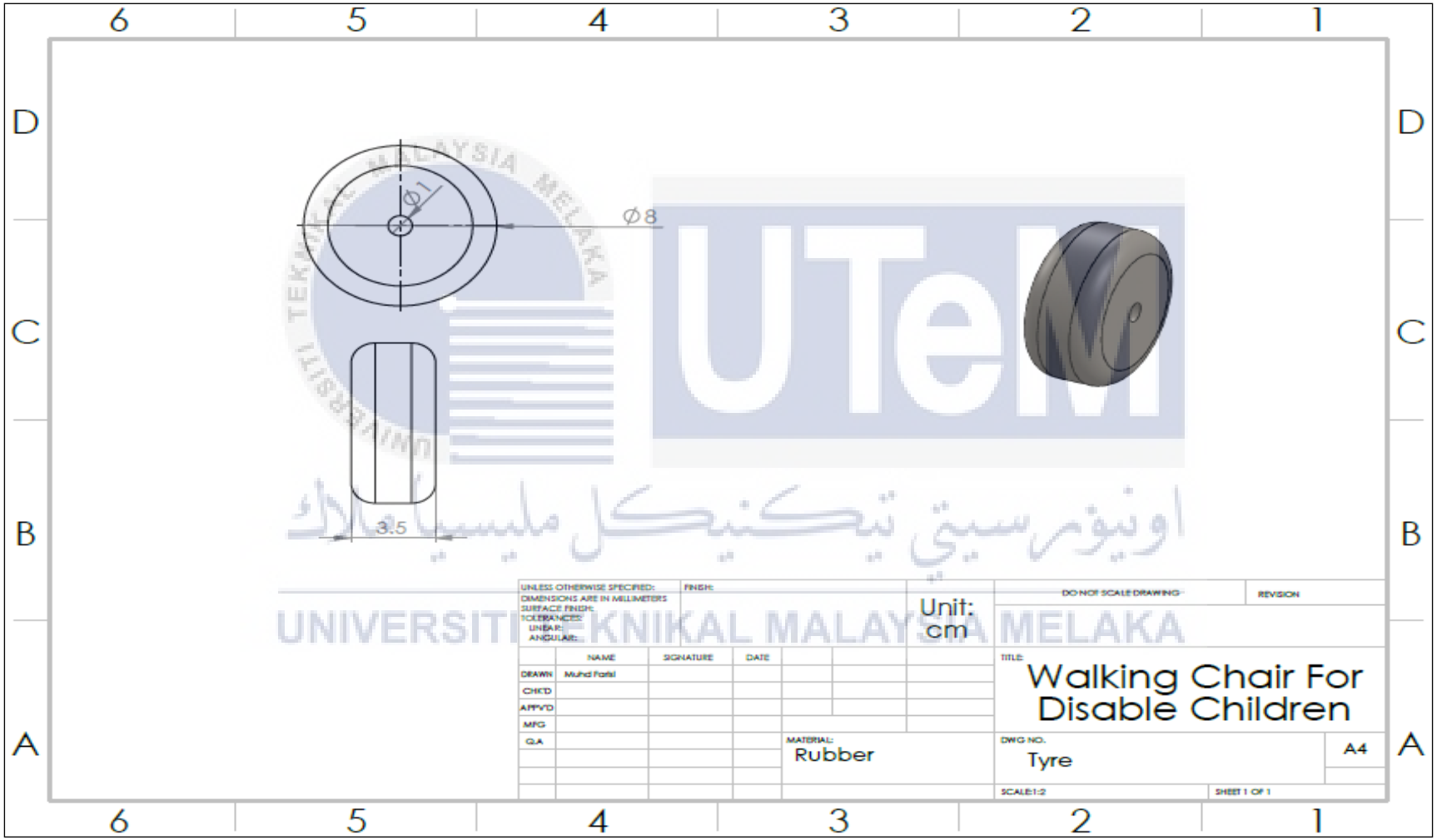
APPENDIX I



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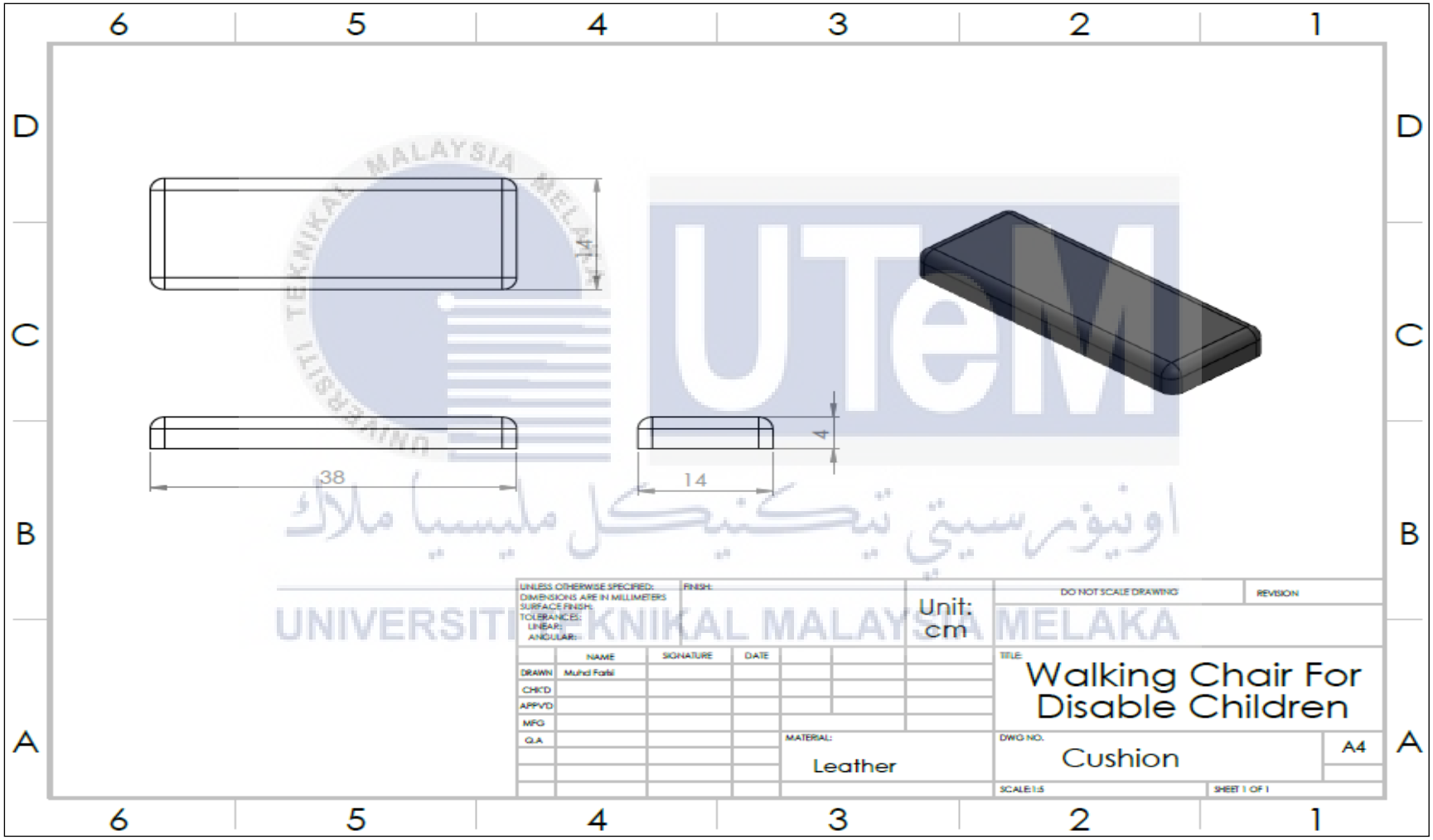
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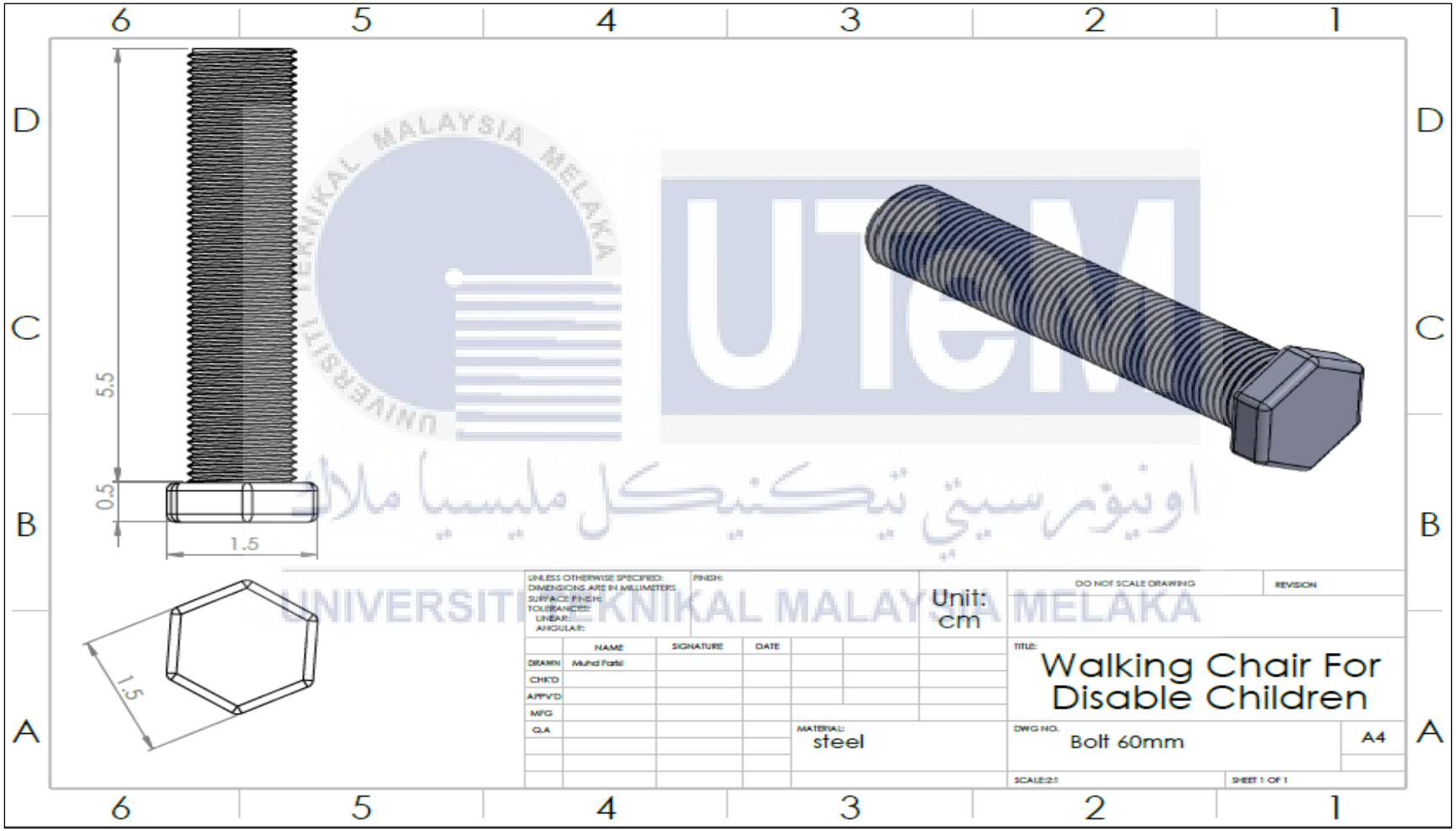
APPENDIX K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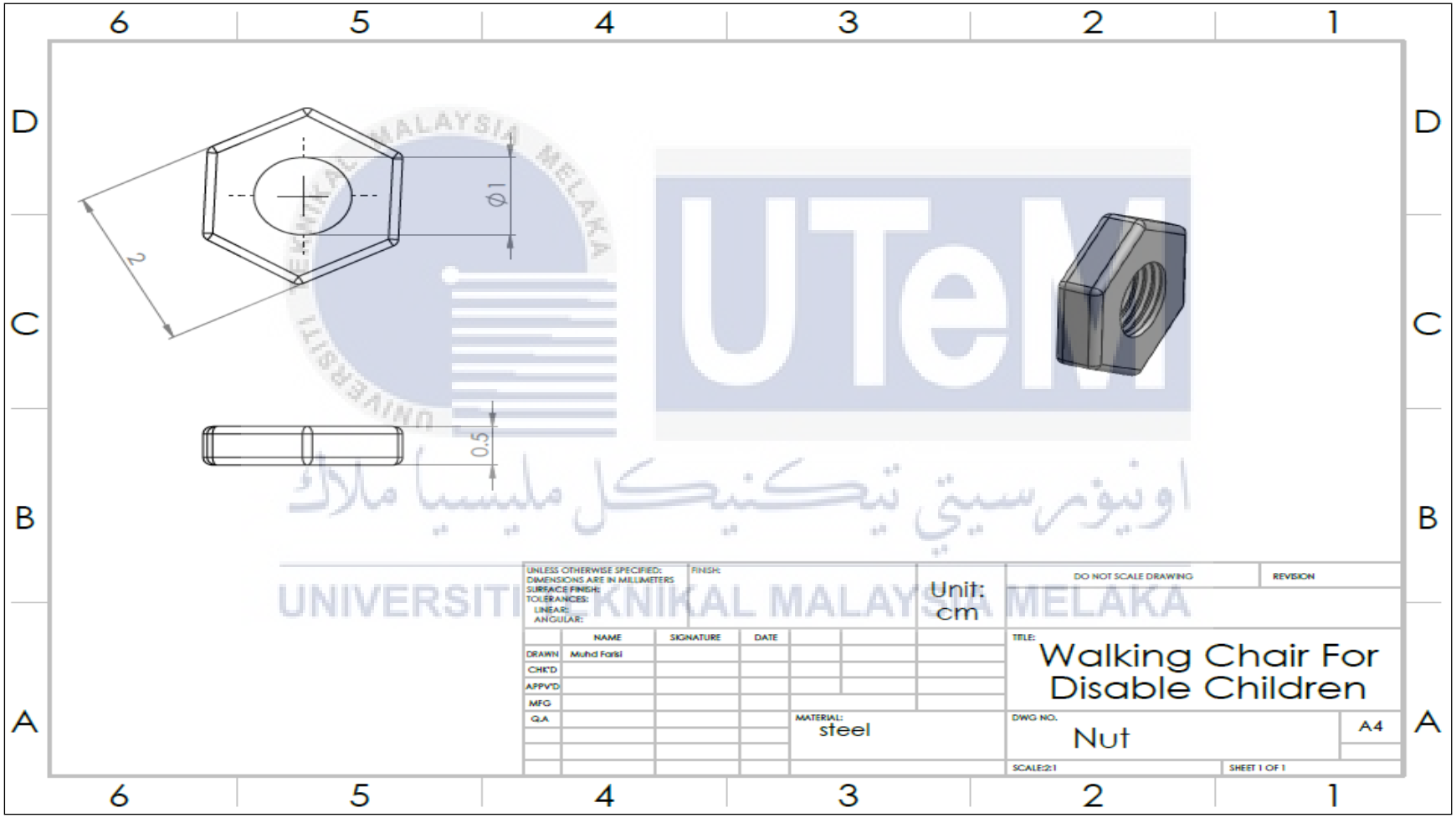
SHEET 1 OF 1

APPENDIX L



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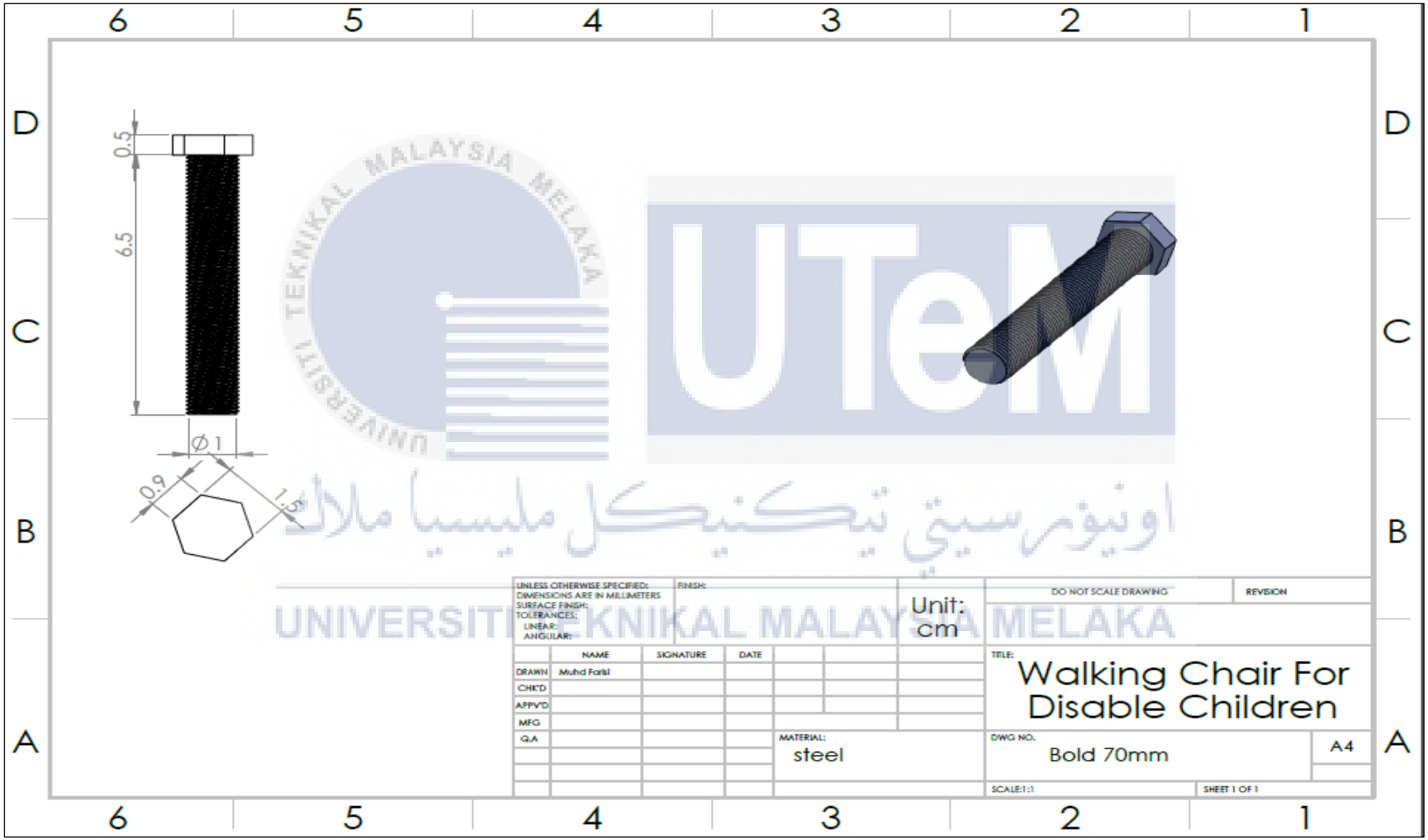

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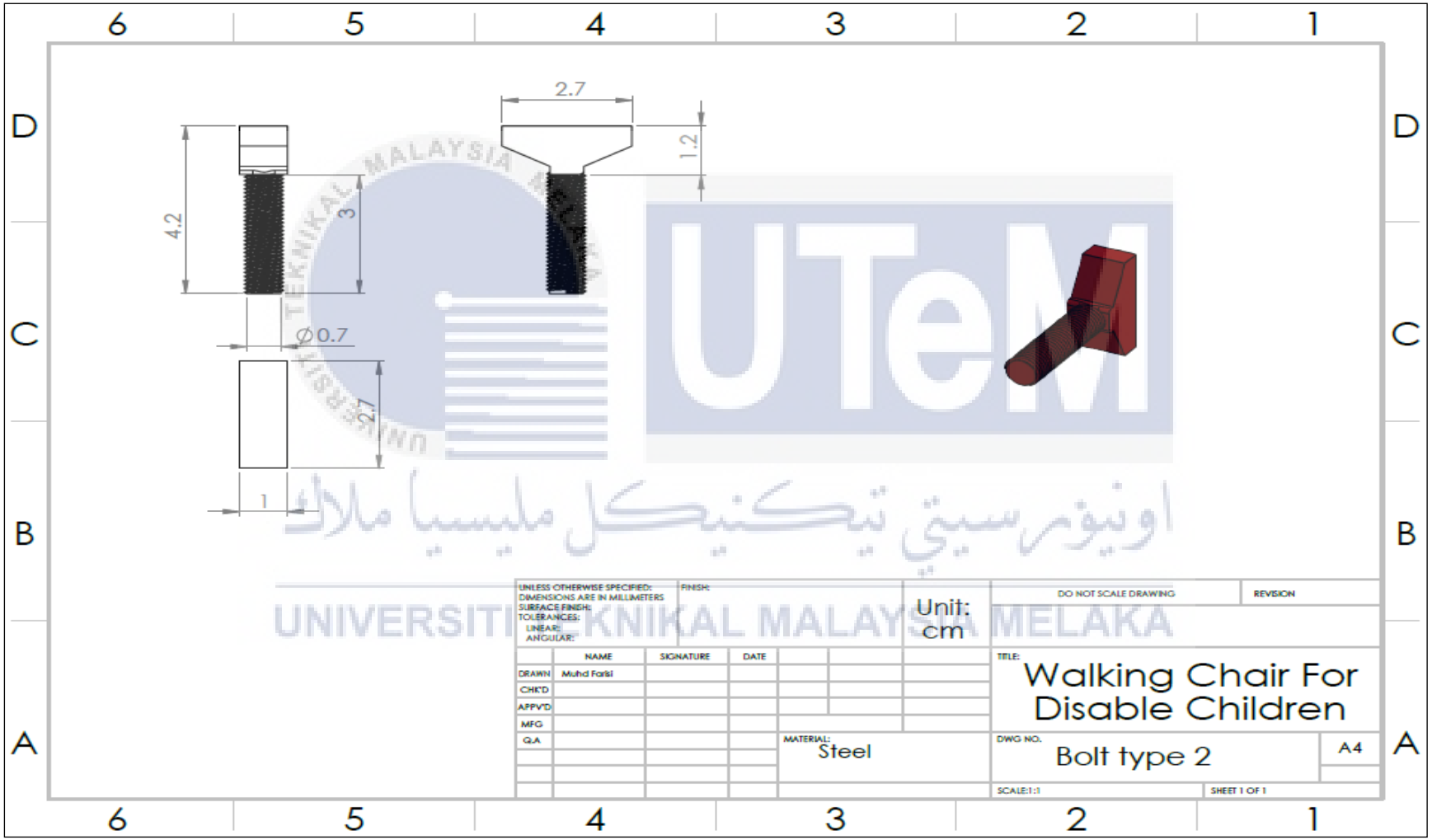

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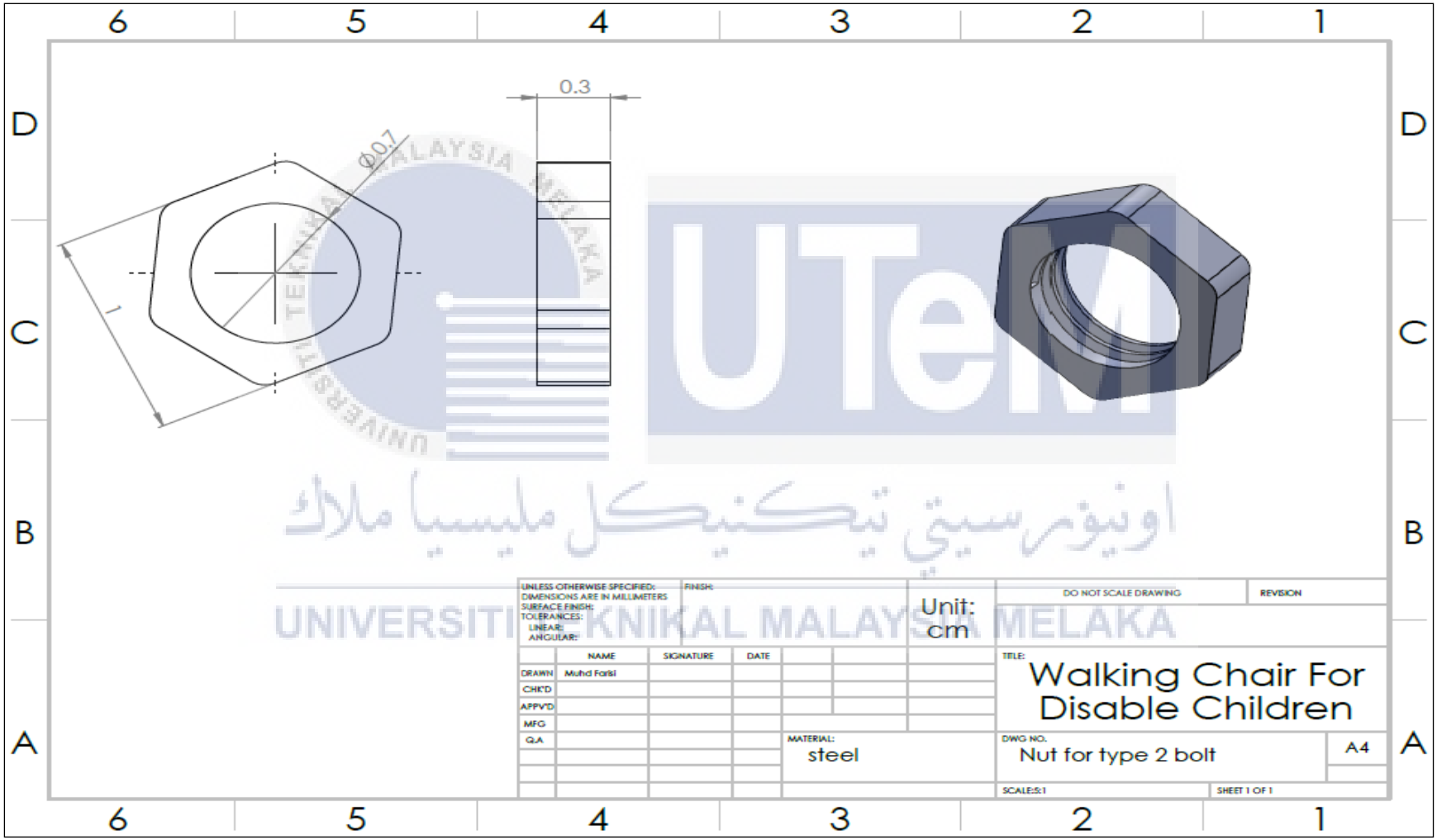

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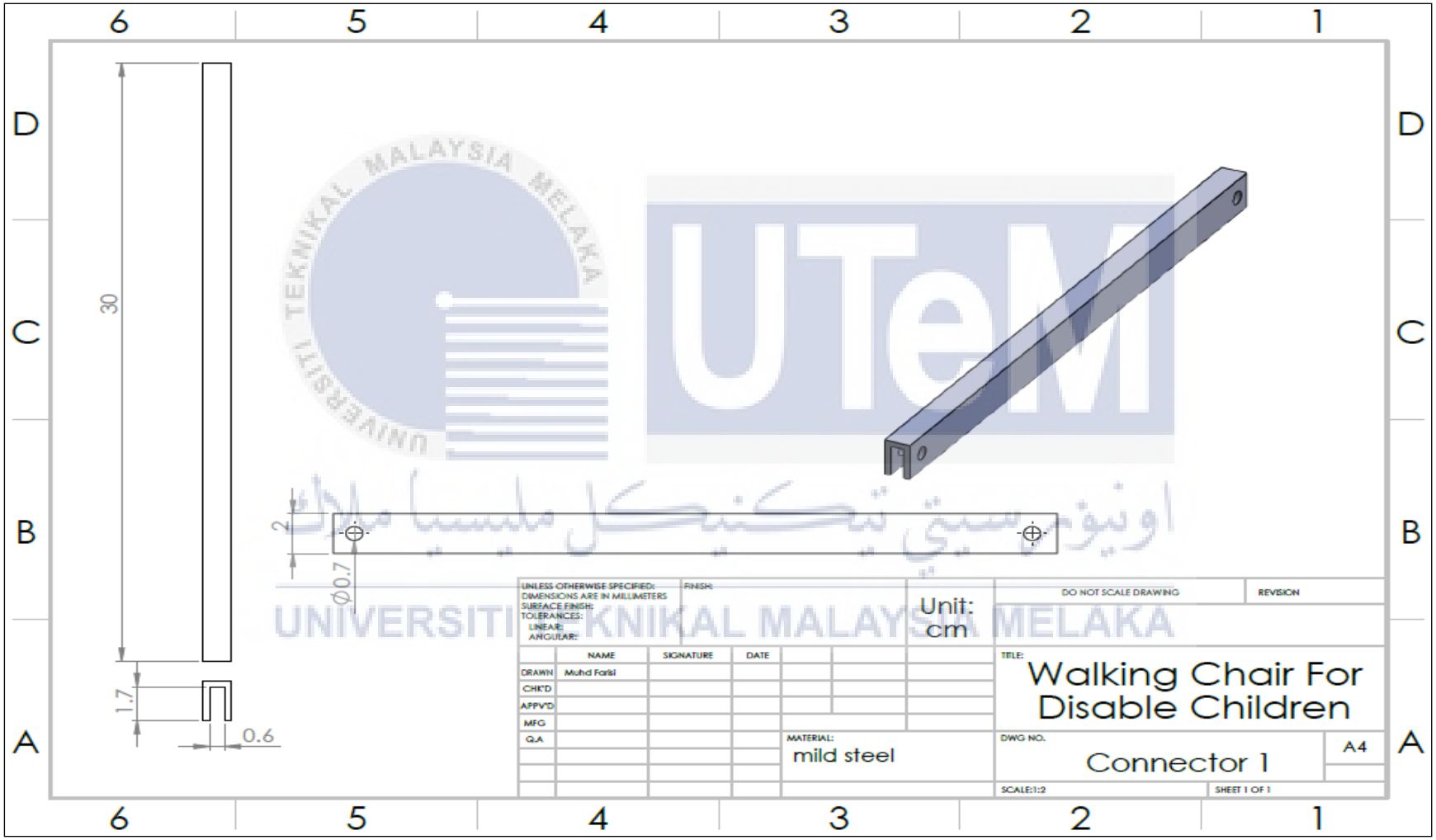

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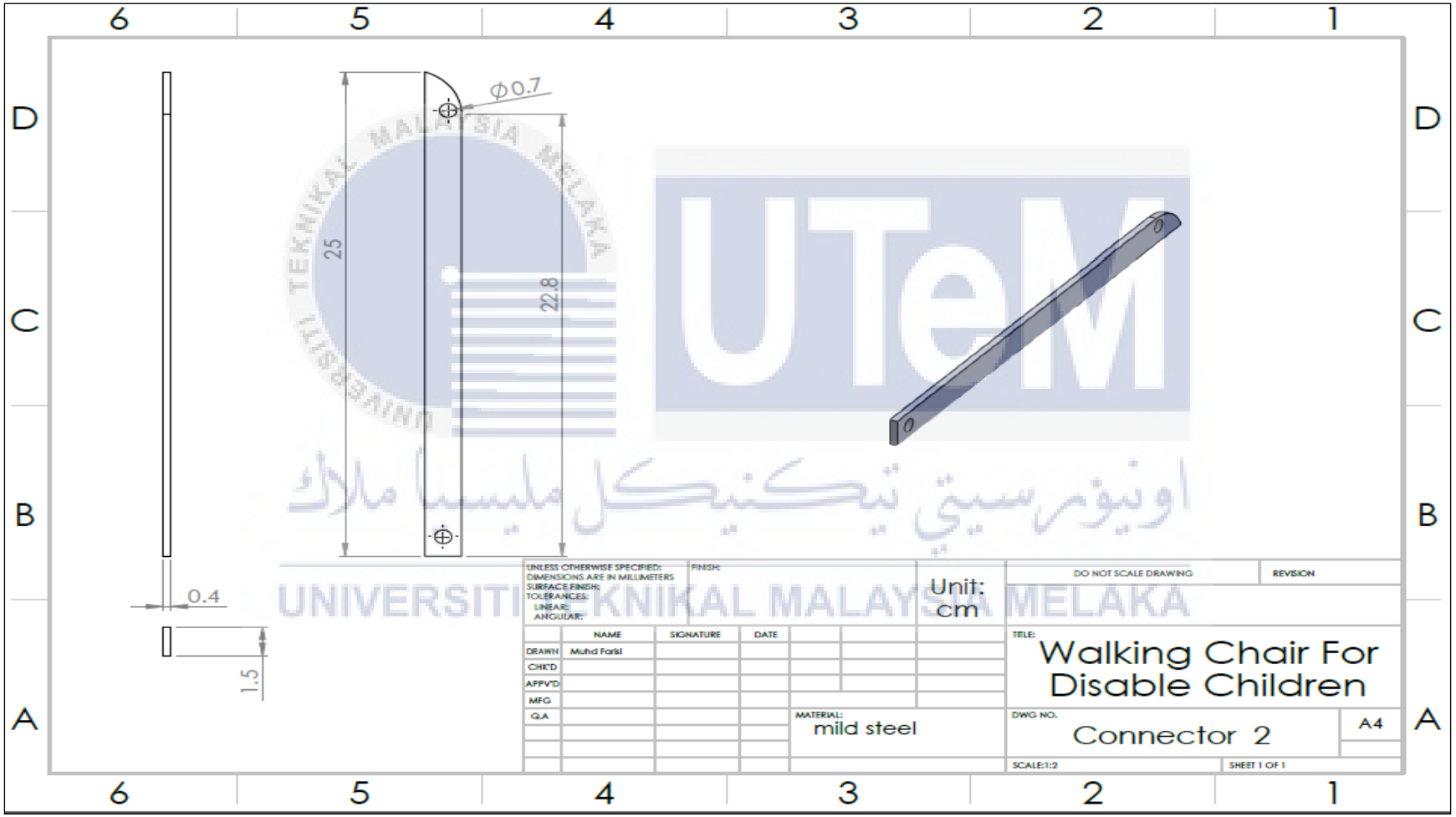
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APPV'D
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mild steel
TITLE:
Walking Chair For Disable Children
DWG NO.
Connector 2
A4
SCALE:1:2
SHEET 1 OF 1