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THE DESIGN OF AN ERGONOMIC WHEELCHAIR

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Abstract

A broad spectrum of health conditions and impairments can result in mobility difficulties, including amputation, arthritis, cerebral palsy, poliomyelitis, muscular dystrophy, spinal cord injury, spina bifida, stroke, and older people with mobility challenges. Assistive technology tools like wheelchairs have demonstrated a significant impact on disabled people's ability to participate independently and be independent in their environment. People with disabilities should have access to accessible mobility devices and be able to participate in their communities. Hence, the burden of care is reduced, as is the need for formal support services. The ergonomic wheelchair has been designed to enable people with disabilities to become mobile, remain healthy, and participate fully in community life. A mobile lifestyle establishes a person's ability to learn, communicate, interact, earn a living, and participate in the community. Wheelchair users should be able to move around effectively if the wheelchair is comfortable and meets their specific needs. The ability to adjust a wheelchair to meet a user's needs varies depending on the type of wheelchair. Ideally, wheelchairs should be available in a wide range of sizes and can be adjusted easily, for instance, adjusting the height of the seat and inclination of the backrest. Thus, this project focuses on designing an ergonomic wheelchair to suit users' needs and abilities. A solid modeling computer-aided design (Solid Work Software) and specific mathematical and engineering calculations are applied to provide the best adjustment levels according to the users' capabilities.

Keywords: Mobility devices; mobility difficulties; assistive technology; ergonomic; inclination

1.0 INTRODUCTION

Wheelchairs are frequently used as assistive devices by people with mobility impairments like those with spinal cord injuries and muscular dystrophy to get around. Wheelchair mobility opens up new opportunities for wheelchair users in terms of education, employment, social interaction, and healthcare access. In addition, a good quality wheelchair contributes to the users' physical health by reducing problems such as pressure sores, progress in deformity, and improving respiration and digestion. To ensure optimum mobility, wheelchair users need a wheelchair that fits them correctly and meets their specific needs. It is estimated that about 1% of the total population, or 10% of people with disabilities (65 million people worldwide), require a wheelchair.

There are indications that only a minority of those in need of wheelchairs have access to them, and of these, very few have access to an appropriate wheelchair [2].

2.0 EXPERIMENTAL

Product Architecture

Figure 1 depicts a schematic diagram, and Figure 2 depicts the prototype's geometric layout. The diagram is used to determine the connections and relationships between the prototype's components. The interaction between modules are:

a) Lock the wheel to avoid accidents or slips.
b) Control the movement of the product with a handle.
c) Add wheels for moving in different directions.

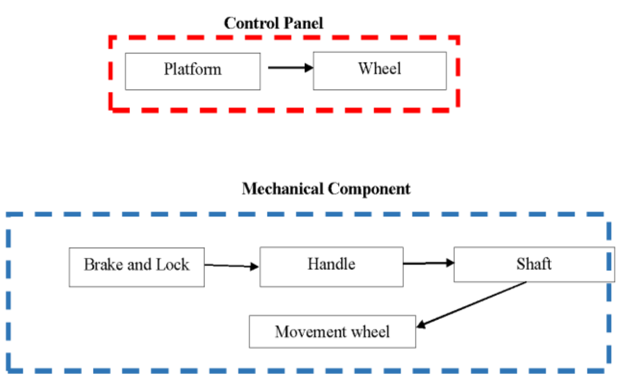


Fig. 1. Schematic Diagram

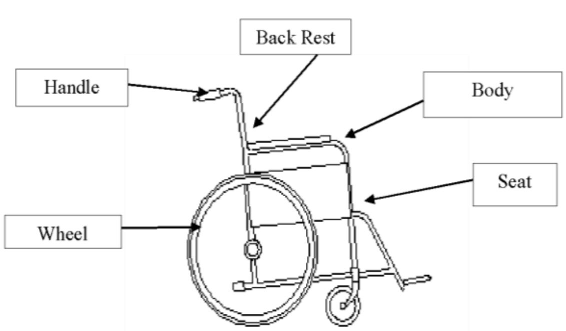


Fig. 2. Geometric Layout

Wheelchairs are undoubtedly a highly beneficial assistive tool when they meet individual and environmental needs, have balanced biomechanical principles, are safe, durable, accessible, maintainable, and reasonably priced in the country [3]. A wheelchair can open up a whole new world for consumers, moving them from exclusion to participation in all community activities, sports, and recreation, all of which lead to independence, better health, and a higher quality of life. [4], [5], [6].

Engineering Calculation

1. Pressure Analysis

The effect of a force can varies dramatically depending on the area where it is applied [7]. A force applied to a 1 mm2 area, for example, has a pressure 100 times greater than the same force applied to a 1 cm2 area. Pressure (P) is defined as the normal force, F, per unit area, A ,over which the force is applied, or

$$F_{net} = ma \quad (1)$$

It is defined as the force *dF* exerted by a fluid over an infinitesimal area *dA* containing a point, resulting in:

$$p = \frac{dF}{dA} \quad (2)$$

Pressure, although a vector, is a scalar. Pressure is a scalar of the quantity because it is defined as the magnitude of the force acting perpendicularly to the surface area.

$$1 \text{ Pa} = 1 \text{ N/m}^2 \quad (3)$$

As Newton's Law of Neutral Gravitation states, the force of attraction between objects is known as Neutral Gravitation. In the case of objects relatively close to Earth, it is called gravity, and the equation is :

$$F = mg \quad (4)$$

F = force pulling object towards the Earth
m= mass of the object
g = acceleration due to gravity, constantly (9.81 m/s^2)

Given that, Length = 800mm and Width = 300mm, and the mass exerted upon the product is, m= 70kg. The pressure exerted on the product will be determined using Figure 3 which the Free Body Diagram.

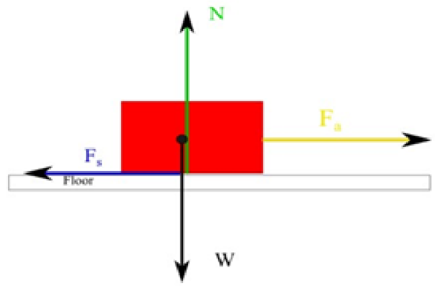


Fig. 3. Free Body Diagram

$$F = mg$$
$$F = (70)(9.81)$$
$$F = 686.7N$$

$$A = (800)(300)$$
$$A = 240000mm \approx 240m^2$$

$$P = \frac{F}{A}$$
$$P = \frac{686.7N}{240m^2}$$
$$P = 2.861N/m^2$$

2. Force Analysis

In Newton's second law of motion, there is a close relationship with Newton's first law of motion. In other words, it explains the cause-and-effect relationship between motion and force. Newton's second law of motion provides a quantitative basis for calculating what happens when forces act.

The acceleration of a system is directly related to and inversely proportional to its mass and is also directly proportional to the external force acting on the system. Equation (4) uses the unit of force F_{net} = ma to express mass, length, and time in terms of the three basic units of force.

Given that the acceleration of the system is, a= 0.2m/s2, and the mass of 64 kg. Force, F applied on the product will be determined.

$$F = ma$$
$$m = 64kg$$
$$a = 0.2m/s^2$$
$$F = (64)(0.2)$$
$$F = 12.8N$$

Engineering Analysis

1. Computer Aided Engineering (CAE)

In engineering analysis, the most crucial part of this wheelchair is the sustainability of the seat. This is because the seat must accommodate the highest load which is the weight of a person sitting on it. The load applied as discussed during engineering analysis on the product is based on Newton's Second Law: Force (F) acting on an object is equivalent to mass (m) of an object time its gravitational acceleration (g), or F=ma, the conducted weight was 686.7N.

According to von Mises' case study and simulation, the product came up with 3 characteristics which were Stress and Strain, N/m2, and displacement, m.

Through the simulation of stress analysis as shown in Figure 4, it was concluded that 7.310e + 004 (N/m^2) is the maximum stress limit for the seat. It was also concluded that its Yield Strength has an amount of 9.237e + 006 (N/m^2).

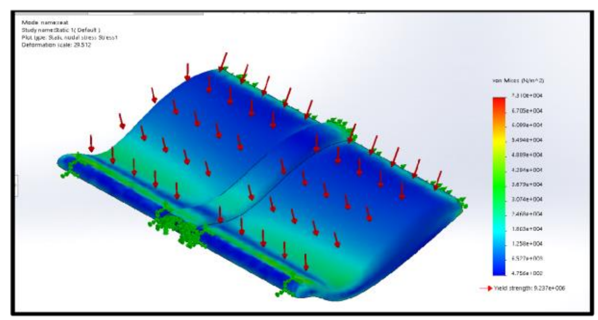


Fig. 4. 1. Computer Aided Engineering (CAE

Configuration Design

Configuration design establishes the shape and general dimension of components. The first step of configuring the design is by doing a simple sketch of parts. Several sketches are required to determine all available alternatives. There are factors that need to be considered during sketching like the function, material selection, and manufacturing method.

a) Function: Are the shapes able to execute the function correctly?
b) Material Selection: Are the materials able to support the user?
c) Manufacturing Method: How to manufacture the parts? How much cost and time needed?

List of Parts

Table 1 shows which parts are purchased and which are custom-made. As a result, it facilitates differentiation by parts, and gives a better understanding of costs summed up.

Table 1. Purchase and Custom Parts

Purchase	Custom
Wheel	Body design
Body material	Seat
Handle	Footrest
	Wheel lock
	Backrest
	Screw Height Mechanism

Parts Dimension: Custom Parts

Table 2 shows detailed description of each part. The selection of these parts is an important design process before manufacturing it.

Table 2. Description of parts

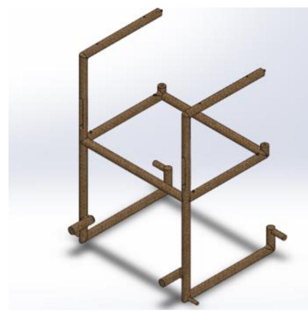
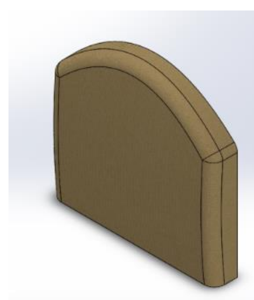
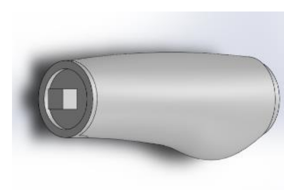
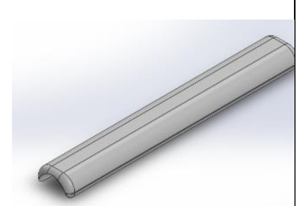
Part	Diagram	Dimension (in cm)	Function
Body		Length: 80 Width: 50 Height: 90	Strong to support user
Seat		Length: 70 Width: 30 Height: 15	Avoid user from moving
Back rest		Length: 45 Width: 15 Height: 50	Cover back body
Tyre		Diameter = 25 Width = 4	-More grip
Handle		Length: 80 Height: 20 Radius: 2.5	-Help user to control easier

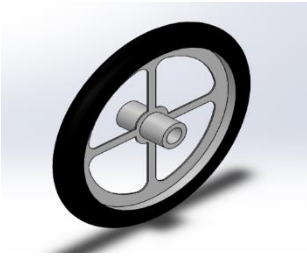
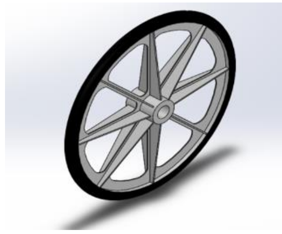
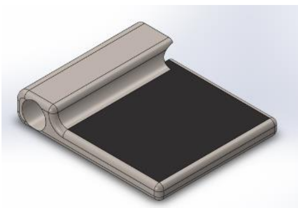
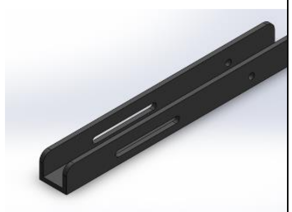
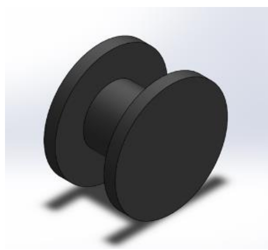
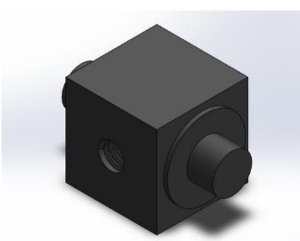
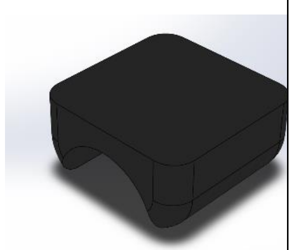
3.0 RESULTS AND DISCUSSION

Manufacturing Detail

An overview of the dismantling of the wheelchair is given in Table 3. The Lower Part Body was welded into an E-shaped body and mated with the Seat Handle. The process of mating was done by attaching both cylindrical fasteners with a diameter of 10mm to a hole of 10mm in diameter. Backseat and then was stitched to the Seat Handle. Armrests were attached at the hands of the Lower Part Body with a "Lego-type mechanism". Both Small Wheels and Big Wheels were attached on the shafts beneath the Lower Part Body. The attached parts were moved by a gearing mechanism.

Table 3. Parts of the Wheelchair

 Lower Body Part	 Seat Handle
 Backseat	 Handle
 A curved Seat	 Armrest

 Small Wheel	 Big Wheel
 Foot Rest	 Main head
 The Arm of Height Adjuster	 Fastener for Height Adjuster
 The Middle Block of Height Adjuster	 The Grip
 The Middle Part of Height Adjuster	 The Arms formed an "X

The Small Wheels were positioned at the front side of the Lower Part Body whilst the Big Wheels were positioned at the back side of the Lower Part Body. Foot rests were inserted at the bottom-front side of the Lower Part Body. For the main component, the main Head is related to its Arm. The Arm is then replicated and connected to one another. The Arms were then connected with a Fastener. Steps 9 and 10 were repeated until the Arms formed an "X". Another Head for Height Adjuster was inserted to complete both top and bottom of the Height Adjuster by using the same Fastener.

Middle Blocks were inserted in the middle between the Arms and connected with a Fastener. To complete the assembly, the Grips were inserted at the bottom of the Height Adjusted. Subsequently, the Middle Part Screw was inserted through the Middle Blocks and mated with a screw of metric die M24x2.0. This whole assembly is mainly a Screw Height Mechanism to increase the height of the subjected area. The Screw Height Mechanism was then attached to the Lower Part of Body. Finally, the Seat was placed on top of Screw Height Mechanism to ensure the whole functionality of the product as shown in Figure 4.

Figure 4. Whole assembly boby of ergonomic wheelchair.

Recommendation

Future recommendations will include improving the selected material and rethinking the process to make it better to handle a higher load without breaking. Steel or metal, for example, would be improved if necessary. The task of developing a product that is lightweight and strong will require further research since it will need to be tested on various loads.

Thus, the product's purpose is to make it easier for the wheelchair user to transfer from bed to wheelchair seat or vice versa. It is recommended to include a compartment for storing some essential items, such as medicines, diapers, etc. It is convenient to carry personal items since the wheelchair is the defining point of their lives.

Accordingly, the wheelchair will need to be equipped with some motors to move automatically. Therefore, if no one else is nearby, the user does not need anyone to push them when they want to move somewhere.

4.0 CONCLUSION

Creating full awareness of a wheelchair service's personal needs benefits customers and people alike. In this case, all elements are crucial in providing a comprehensive wheelchair service. All people should understand the importance of handling and providing an appropriate wheelchair throughout the necessary practices. An individual with physical disabilities that result in incapacity to ambulate or ambulation in which endurance is restricted is a candidate for powered or manual mobility. These people can therefore benefit from assisted ambulation and wheelchair accessibility. With a few adjustments and modifications, a wheelchair can achieve greater functionality, i.e., greater mobility for better daily performance. In engineering and architecture, success requires technical expertise, a good understanding of construction, and an understanding of manufacturing processes.

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