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EXPLORATORY PROJECT REPORT
ON

DESIGN OPTIMIZATION OF MOTORIZED WHEELCHAIRS

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We thank you all for your encouragement, advice, and support.

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ABSTRACT

This project aimed to improve the mobility of people with special needs by developing a low-cost, motorized wheelchair through the repair and modification of an existing wheelchair. The project encountered various challenges, such as designing an effective steering and braking system. In response, the team developed a novel steering system that utilizes a push-pull cable and incorporates scrap material and an old wheelchair to keep costs low. The steering system was designed and built in-house and is a developing technique that offers a low-cost alternative to traditional steering systems. The project's main focus was on making the product affordable while delivering high results. Overall, this project represents a small yet valuable effort towards improving the quality of life for individuals with special needs.

INTRODUCTION

Wheelchairs are essential mobility aids for people with disabilities, allowing them to move around and perform daily activities with greater ease and independence. However, conventional wheelchairs often have design limitations that can make their use challenging, especially in certain environments or for individuals with specific needs. As such, there is a growing demand for improved wheelchair designs that can provide better comfort, functionality, and accessibility for users.

The aim of this project report is to present the design optimization of a wheelchair, with the goal of enhancing its performance and user experience. The report will detail the various design considerations that were taken into account, including ergonomics, material selection, structural design, and manufacturability. The report will also review the different simulation and testing methods used to validate the design changes and evaluate the resulting performance improvements.

Through this project, we hope to demonstrate the importance of optimizing wheelchair designs to meet the needs of users better and provide greater independence and mobility. The optimized wheelchair design presented in this report can serve as a foundation for future wheelchair innovations and advancements, ultimately improving the lives of those who depend on them.

KIRAN FOUNDATION VISIT

During our visit to the Kiran Foundation, we had the opportunity to observe the equipment used by individuals with disabilities, including both wheelchairs and tricycles. We noted several advantages and disadvantages of each and identified areas where they can be improved.

The tricycle offers lots of space in the seating area, and its parts can be easily replaced. Additionally, the user has the freedom to pedal and steer with their hands. However, we also identified several disadvantages, including the lack of a differential, which can make it challenging to navigate on uneven terrain. The tricycle is also bulky and not portable, and the braking system is inefficient.

Furthermore, there is no clutch or handbrake, and excess space is unnecessary. Additionally, dismounting the tricycle requires a certain level of leg mobility, making it unsuitable for those with spine injuries.

To improve the tricycle, we recommend eliminating the entire front component and providing steering and braking facilities adjacent to the chair. Using lighter materials can also reduce the overall weight of the device, making it easier to transport. Additionally, making it foldable can enhance its portability.

Similarly, while the wheelchair has several advantages, including allowing people with mobility impairments to move around independently and providing comfortable seating, we also identified some disadvantages.

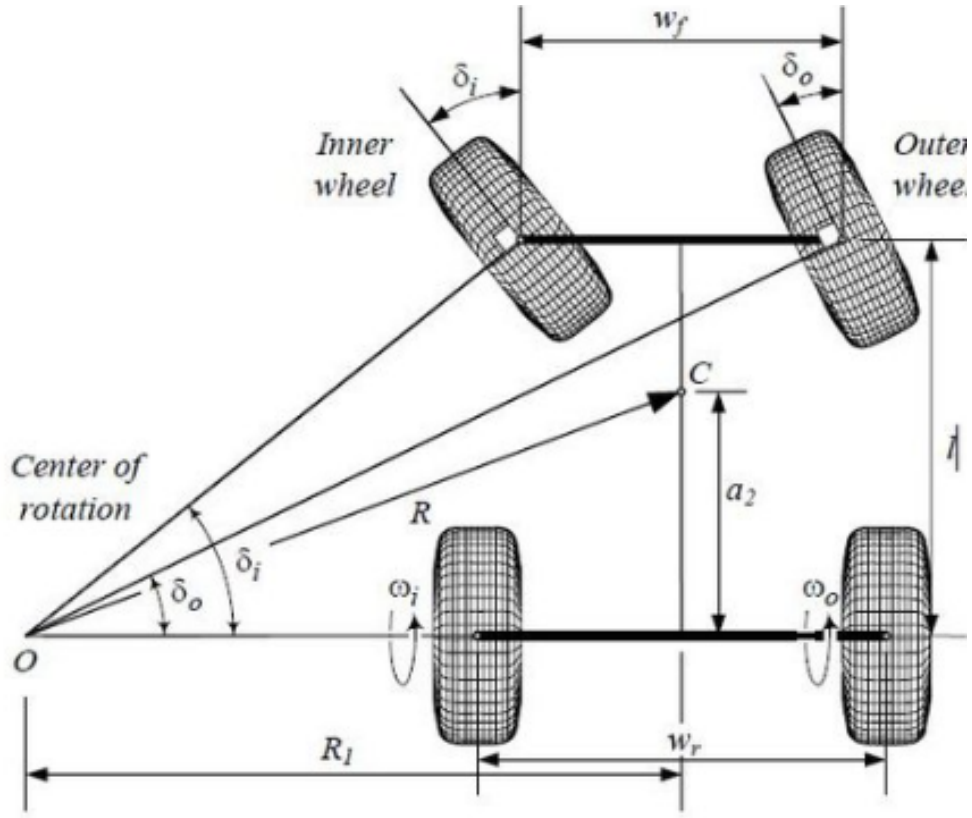
Specifically, the lack of a steering mechanism can make it challenging for users. Users must stop one side of the wheel with their bare hand and turn the other, requiring extra effort. Furthermore, wheelchairs can be difficult to maneuver in tight spaces and require upper body strength to self-propel.

To improve the wheelchair, we recommend enhancing the design to improve maneuverability, especially in tight spaces. Incorporating better suspension can also provide smoother rides over rough terrain. Adjustable features can prevent pressure sores, and using less expensive materials without compromising on quality can make it more affordable. Innovative features, such as a detachable or foldable backrest, can also enhance portability.

ACKERMANN STEERING MECHANISM

The Ackermann steering mechanism is a type of steering system that is commonly used in four-wheeled vehicles such as cars and trucks. The mechanism is designed to allow the wheels to turn at different angles maintaining proper geometry to provide accurate steering.

How the Ackermann Steering Mechanism Works



The Ackermann steering mechanism is designed to provide accurate steering control by ensuring that both the front wheels of a vehicle follow a circular path when turning. When a vehicle makes a turn, the inside wheel follows a tighter turn radius than the outside wheel. The difference in the turn radius is compensated for by the Ackermann steering mechanism, which ensures that both wheels are turned at the correct angle to follow their respective circular paths.

The mechanism typically consists of a steering wheel, a steering column, and two steering arms that are connected to the front wheels of the vehicle. The steering wheel is used to turn the steering column, which in turn rotates the two steering arms. The steering arms are connected to the front wheels of the

vehicle through tie rods and ball joints, which allow the wheels to turn independently of each other.

When the steering wheel is turned, the steering column rotates the steering arms, causing the front wheels to turn at an angle. The angle of the wheels is determined by the geometry of the steering system, which is designed to ensure that the inside wheel turns at a sharper angle than the outside wheel.

The Ackermann steering mechanism is designed to maintain a constant angle between the wheels and the vehicle's body during turns. This ensures that the vehicle maintains its stability and balance while turning.

Why is the Ackermann Steering Mechanism not Suitable for Two-Wheeled Vehicles such as Wheelchairs ?

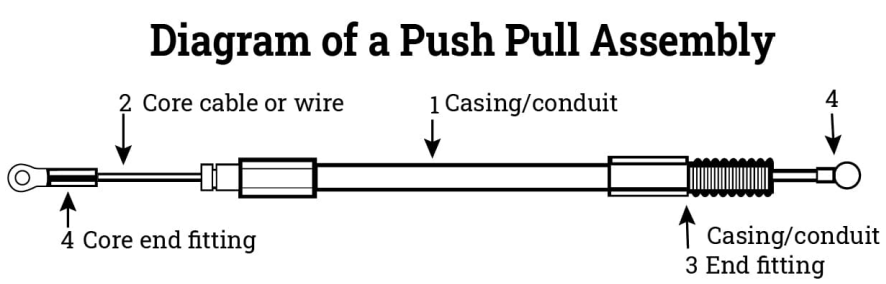
While the Ackermann steering mechanism works well for four-wheeled vehicles, it is not well-suited for use in two-wheeled vehicles such as wheelchairs. The primary reason for this is that the Ackermann steering mechanism assumes that the two wheels are fixed in position relative to each other. In a two-wheeled vehicle, such as a wheelchair, this is not the case as the wheels are free to move independently.

Furthermore, in a two-wheeled vehicle, the Ackermann steering mechanism can cause a phenomenon known as "oversteering." This occurs when the inside wheel turns more sharply than the outside wheel, causing the vehicle to turn too sharply and potentially tip over.

As a result, two-wheeled vehicles such as wheelchairs typically use a different type of steering mechanism, such as a single front-wheel caster or a two-wheel steering system that allows both wheels to turn at the same angle. These steering systems are designed to provide greater stability and control for the user, while also minimizing the risk of tipping over.

PUSH-PULL CABLE MECHANISM

A push-pull cable is used to transmit precision control of mechanical motion. They consist of an inner cable made of twisted steel wire that travels from the bike's control levers on the bar to the brakes through an outer sleeve. Some of the inner wires may not be entirely covered by the outer cables, which terminate in 'stops' fastened to the frame.



Two of the most common uses of this device in our day-to-day life are the throttle cable in a two-wheeler and the braking system of a bicycle.

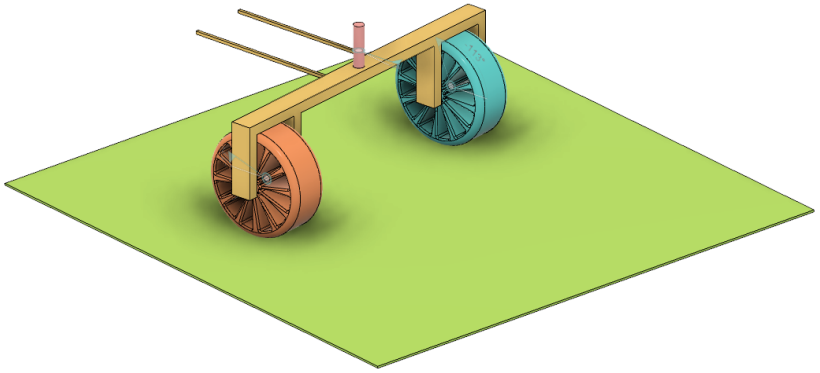
In a motorcycle push/pull throttle, the push cable works in tandem with a throttle return spring to close the throttle plates while the pull cable opens the throttle plates.

In a bicycle, both ends of the inner cable are secured. The inner cable is dragged through the outer cable when the bike's brake levers are pulled, which activates the brake caliper.

For our requirements, the idea is to have the steering wheel assembly rotated around a shaft passing through its center, actuated by two pull cables. Movement of the steering wheel assembly will cause the wheelchair to move in a particular direction, allowing it to turn without needing a differential.

SIMULATION AND TESTING METHODS

Having only a vague idea of how our steering assembly should function, we started by creating a CAD model in order to be able to understand better how the assembly should look and the components required. Having a minimalistic design was the aim, as the main idea was to make a low-cost product. We created a rough model for the assembly within the bounds of our limited knowledge of Autodesk Fusion 360 and the software's features.



Once the requirements were identified, the next step was to test out the working of our idea. We performed the same in two steps: testing with a styrofoam block and a rectangular wooden rod. The choice of using a rectangular wooden rod over a circular one was made considering that it is easier to drill a hole on a plate than a rod, and the scrap for the same was also available more readily.

First, the push-pull cables' action and direction of turning were checked on a styrofoam block. Since the push mechanism is actually just a spring to return the valve (in a motorcycle engine) to its original position (i.e., closed valve), our mechanism needed to rely on the pull action. To provide a better user experience, it is important that the wheelchair turns in the same direction (right or left) as the side of the handle that the user pushes. With this consideration,

the decision was made to have the pull cables in a cross position, i.e., a cable connecting the left side of the handle to the right side of the steering rod and vice versa.

Next, the thought process was that the weight of a metal block is much greater than the weight of styrofoam, so the need was to test with a block that would require more force to move. Considering the ease of availability and preparing the test sample, we chose to use wood for our testing. The functioning of the cables with wood was as per the requirements, so we decided to go forward with the plan and collected the scraps for our use.

MATERIAL SELECTION AND MANUFACTURING PROCESSES

Material selection is a critical aspect of any engineering project, and it is especially important when designing a product such as a wheelchair. The choice of materials can have a significant impact on the performance, durability, and cost of the product. In our project, we have chosen to use mild steel and wood, and have neglected other materials such as cast iron, stainless steel, and aluminum.

Why is Mild Steel and Wood used ?

Mild steel is a popular material for wheelchair frames because it is strong, durable, and relatively inexpensive. It can be easily welded and formed into complex shapes, making it ideal for custom wheelchair designs. Mild steel has a high tensile strength and can withstand heavy loads without deforming or breaking. It is also resistant to corrosion and can be painted or coated to enhance its appearance and durability.

Wood is another material that can be used in wheelchair construction, particularly for the wheelchair's seat and backrest. Wood is strong, lightweight, and has good shock-absorbing properties, making it comfortable for users. It can also be easily shaped and finished to provide a custom fit and improve the wheelchair's aesthetics.

Why are other materials not selected ?

The decision to neglect other materials such as cast iron, stainless steel, and aluminum may be based on several factors. For example, cast iron is heavy and difficult to form into complex shapes, making it less suitable for wheelchair frames. Stainless steel and aluminum are more expensive than mild steel and may not provide significant benefits in terms of performance or durability in a wheelchair design.

When selecting materials for our project, it is important to consider the specific requirements and constraints of the application, such as weight, strength, durability, and cost. By carefully evaluating these factors and selecting the most suitable materials, we can optimize the performance and cost-effectiveness of our wheelchair design.

Manufacturing Process

The wheelchair is an essential mobility aid for people with disabilities. However, traditional wheelchair designs have certain limitations that can impact the user's comfort, safety, and functionality. As engineers, our goal is to use our skills and expertise to design and modify products that can improve the quality of life for people with disabilities.

Our story of performing design optimisation of the wheelchair starts with-

(i) Bringing Wheelchair from IMS BHU for Design Modification

To address those above limitations, we wrote an application to IMS BHU requesting their collaboration to modify their existing wheelchair design.

After we wrote an application to IMS BHU requesting their collaboration to modify their existing wheelchair design, they provided us with a standard wheelchair for us to use as a baseline for our modifications.

The wheelchair provided to us by IMS BHU was a standard, manual wheelchair. It had two large rear wheels and two smaller front casters for stability and maneuverability.

(ii) Cleaning and Furnishing the Wheelchair

One of the first steps we took was to clean and sanitize the wheelchair thoroughly. We used a mild soap and water to clean the frame, upholstery, and wheels. This helped to remove any dirt, dust, or other debris that may have accumulated on the wheelchair.

During our evaluation of the wheelchair, we found that several spokes on the rear wheels were damaged and needed to be replaced. We ordered new spokes and replaced the damaged ones ourselves. This helped to ensure that the wheelchair was safe and functional for its intended purpose.

(iii) Axle formation For Steering Mechanism

As part of our project to modify the wheelchair, we wanted to replace the smaller front casters with a steering mechanism. This required the fabrication of a custom axle to accommodate the steering mechanism.

Process for Axle Formation:

To create the axle, we first took a rectangular mild steel rod and cut it to the required length using a cutting tool. We then used a grinding tool to smooth out both ends of the rod to ensure a snug fit within the wheel hubs.

Once the ends of the rod were smooth, we proceeded to create the axle formation. This involved shaping the ends of the rod to accommodate the mounting of the steering mechanism. We used a combination of cutting and grinding tools to create the desired shape, ensuring that the ends were symmetrical and properly aligned.

After the axle formation was complete, we tested the fit of the axle within the wheel hubs. We made adjustments as necessary to ensure a tight and secure fit, as this was critical for the proper function of the steering mechanism.

(iv) Push-Pull Cable Attachment

Now we wanted to install a steering mechanism that would allow for improved maneuverability. To do this, we attached a push-pull cable to the axle rod using a wooden block.

Process for Attaching the Push-Pull Cable:

To begin, we created a U-shaped slot and attached it to the back of the wheelchair frame using screws and bolts. We then performed drilling over the slot to ensure a secure connection.

Next, we created a wooden block in the shape of a U that was designed to ease the steering handling by person hand's movement. We attached this block to the U-shaped slot using screws and bolts.

To connect the push-pull cable to the axle rod, we passed the cable through the U-shaped wooden block and secured it in place using a cable clamp. We ensured that the cable was properly tensioned, as this was critical for the proper function of the steering mechanism.

Once the push-pull cable was attached, we tested the steering mechanism to ensure that it was functioning properly. We made adjustments as necessary to ensure smooth and precise steering.

(v) Final Work-Welding

We needed to install a steering mechanism that required welding the axle rod to the wheelchair frame. This was a critical step in 'ensuring that the wheelchair would function properly and be safe to use.

Process for Welding the Axle Rod to the Wheelchair Frame:

To begin, we measured and marked the points on the frame where the axle rod needed to be attached. We then used a grinder to remove any rust or debris from these areas to ensure a clean welding surface.

Next, we placed the axle rod into position and secured it in place using clamps. We then used a welder to weld the axle rod to the wheelchair frame at the marked points. We made sure to use the appropriate welding techniques and settings to ensure a strong and secure weld.

Once the welding was complete, we inspected the welds to ensure that they were free from defects or irregularities. We also tested the steering mechanism to ensure that it was functioning properly and that the welds were holding up under stress.

CONCLUSION AND FUTURE ASPECTS

Conclusion:

In conclusion, our project to modify the wheelchair with a new steering mechanism was a success. We were able to design and implement a steering mechanism using mild steel and wood materials that were both cost-effective and efficient. Our team was able to overcome challenges such as time constraints and the need for welding by using innovative solutions such as push-pull cables and wooden blocks.

The modified wheelchair is now safer and more efficient for people with disabilities, allowing them greater mobility and independence. We are proud to have contributed to this project and hope to continue improving the lives of people with disabilities through engineering innovation.

Future Aspects:

While our modifications have improved the functionality of the wheelchair, there are still areas for further improvement. In the future, we could explore using different materials such as aluminum or titanium to reduce the weight of the wheelchair and make it more portable.

Additionally, we could further optimize the steering mechanism by exploring alternative designs or adding electronic controls to improve the precision of the steering. We could also explore ways to improve the ergonomics and comfort of the seating area for the user.

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