iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: V Month of publication: May 2025

DOI: https://doi.org/10.22214/ijraset.2025.69779

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Design and Fabrication of Electric Wheel Chair for Disabled People

Saravanakumar M[1], Nagaraj A[2]
Department of Mechanical Engineering, PSG Polytechnic College, Coimbatore

Abstract: This paper presents the design and fabrication of an electric-powered wheelchair aimed at improving mobility and independence for individuals with physical disabilities. The system features a motorized lifting mechanism to assist in vertical transitions, such as from a bed to a restroom, minimizing the need for caregiver assistance. A dynamic model based on nonlinear differential equations was developed to simulate motion and analyze system behavior under varied surface conditions. A modified Proportional-Integral-Derivative (PID) controller is integrated to provide adaptive response based on user load and terrain. The system is implemented using a microcontroller-based platform, with real-time experimental results validating performance, stability, and user safety. The proposed design offers a practical and user-centric solution for addressing common limitations in existing wheelchair systems.
Keywords: Electric wheelchair, dynamic modeling, PID control, lifting mechanism, assistive device, mobility aid, adaptive control.

I. INTRODUCTION

A wheelchair is a mobility device designed to assist individuals with impaired walking ability due to physical disability, aging, or illness. Wheelchairs are available in various configurations, including manually propelled, motor-assisted, or caregiver-operated versions. Electric-powered wheelchairs, in particular, utilize motors for propulsion and are typically controlled using a joystick mounted on the armrest. These systems provide enhanced mobility and autonomy for users who cannot operate manual wheelchairs or who require mobility over extended distances.

However, existing wheelchair designs present several limitations. Conventional models offer limited assistance during daily activities such as defecation, often requiring manual intervention from caregivers. Patients must be lifted, undressed, and repositioned, which can be uncomfortable and undignified—especially in emergency situations. Furthermore, traditional backrest designs can lead to repetitive strain injuries during prolonged use, and fixed armrests hinder easy transfer between the wheelchair and other surfaces such as beds or vehicles.

To address these issues, this paper proposes the design of a power wheelchair equipped with a lifting mechanism to facilitate vertical movement. Such a feature enhances user independence and safety during transfers from higher to lower surfaces, such as from a bed to a restroom. Additionally, the proposed design takes into account the dynamic interaction between the wheelchair and the surface, as slipping becomes a concern when operating under uneven or low-friction conditions, particularly with the combined weight of the chair and user.

This study focuses on developing a dynamic model for an electric-powered wheelchair with an integrated lifting function, emphasizing control and stability during motion over adverse surfaces. The objective is to enhance the ergonomic and functional aspects of wheelchair use by addressing issues related to patient safety, comfort, and ease of transfer.

II. LITERATURE SURVEY

Numerous studies have explored electric wheelchairs and their adaptability to various user needs and terrains. Traditional wheelchairs, while cost-effective, require physical effort, leading to strain and discomfort. Electric wheelchairs address this by offering motorized movement controlled via joysticks or remote systems.

P. Swapna et al. [1] designed a joystick-controlled mobility aid with DC motors and included GPS/GSM integration for location tracking. Y. Mori et al. proposed a wheelchair with a folding body and lifting function for assisting caregivers during patient transfers. T. Makino et al. introduced a multifunctional electric wheelchair that can transform into a portable bed and bath lift. C. Gopinath et al. highlighted the challenges faced by attendants in transferring patients, proposing a wheelchair-stretcher hybrid to improve hospital workflows.

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Yoshikazu Mori et al. [2] developed a wheelchair integrated with a lifting mechanism to assist caregivers in transferring patients both indoors and outdoors. This design targets users with severe upper and lower limb disabilities who require physical assistance during daily activities, such as moving from a bed to a wheelchair or using the restroom. The wheelchair and lift are powered by individual motors, and the design allows rear access to beds or toilets due to front-positioned wheels and a foldable seat. The frame can also be folded during lifting, making it suitable for use on public roads. The study presented both the conceptual design and experimental validation of the prototype, confirming its effectiveness.

Taira Makino et al. [3] proposed a multifunctional care support system aimed at reducing caregiver burden for bedridden patients. The system comprises an electric wheelchair that can recline into a portable bed, a lift mechanism for patient transfers, and a mobile vinyl bathtub supported by an aluminum frame. The study also introduced a mobile robot with a built-in portable toilet that can be positioned beneath the wheelchair. The robot is equipped with an omni-directional movement system to navigate narrow spaces and includes an autonomous cleaning mechanism. This system enhances the efficiency and comfort of caregiving tasks such as bathing and incontinence care.

C. Gopinath et al. [4] focused on the growing need for advanced mobility aids in India due to the increasing number of disabled individuals. They identified the challenges caregivers face in transferring patients between wheelchairs, stretchers, and beds. To address this, the authors proposed a wheelchair-stretcher hybrid, designed to improve patient mobility and support medical personnel in Indian healthcare facilities. The proposed solution highlights the importance of ergonomic and functional design in mobility devices.

III. COMPONENTS AND ITS DESCRIPTIONS

A. Hydraulic Bottle Jack

Bottle jacks are a type of hydraulic jack designed to operate in a horizontal position. They work by applying hydraulic pressure to push against a lever, which lifts the main arm. Due to their longer handles, bottle jacks provide greater lift per stroke compared to standard hydraulic jacks. Their compact horizontal design allows use in confined spaces and offers efficient leverage. These jacks are widely used in search and rescue operations, particularly following earthquake damage, and have become standard equipment in fire departments and rescue units. In addition to lifting, they are also suitable for spreading, bending, pushing, pressing, and straightening tasks. With electrically welded bases and cylinders, bottle jacks are built for durability and can operate in upright, angled, or horizontal orientations.

Fig 1 Hydraulic Jack

Table 1.1: Hydraulic jack specification

Lift Capacity (tons)	2
Min. Lift Height (mm)	178
Max. Lift Height (mm)	292
Ram Travel (mm)	114
Screw Top Adjustment (in.)	17/8
Operation	Manual
Dimensions L x W x H (mm)	89 x 92 x 178

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B. DC Motor

A DC motor is an electrical machine that converts direct current (DC) electrical energy into mechanical energy. When the field coil is energized, a magnetic field is produced in the air gap, directed radially across the armature. The magnetic flux enters the armature from the North pole and exits through the South pole. Conductors on either side of the armature experience equal and opposite forces, generating a torque that causes rotation.

Fig 2 DC Motor

Table 3.2: Specification of dc motor

Motor type	775
Operating voltage	6~20v DC. (Nominal 12v DC)
No Load speed	12,000 RPM @ 12v
Rated current	1.2A @ 12v
Torque	79Ncm @ 14.4v
Overall size	98 × 42 mm

C. Battery

A battery is a device that stores chemical energy and converts it to electrical energy. The chemical reactions in a battery involve the flow of electrons from one material (electrode) to another, through an external circuit. The flow of electrons provides an electric current that can be used to do work. It is lead acid battery, 12V, 7A and weighs 2.5 kg.

Fig 3 Battery

D. Square bars

Square bars are commonly used in construction and fencing due to their strength and versatility. They can be easily drilled, cut, or welded to meet specific requirements. In this project, mild steel rods are used for frame construction. Mild steel, also known as low carbon steel, contains approximately 0.05% to 0.25% carbon by weight. Unlike high carbon steel, which can contain up to 2.5% carbon, mild steel has low carbon content and does not include significant amounts of other elements, making it a non-alloy steel. It is widely used in the manufacturing of machinery and automotive components due to its affordability, ease of machining, good weldability, and adequate mechanical strength. These properties make it ideal for applications such as frames and structural panels.

Fig 4 Square Bar

E. Nylon Wheels

Nylon is a synthetic material that belongs to the polyamide family. While some polyamides occur naturally, like silk, nylon is man-made. It is produced by a chemical reaction between amino and carboxylic acid molecules, along with added fibers. Nylon offers excellent mechanical properties, making it a popular choice for wheel applications, especially in the castor wheel industry.

Fig 5 Nylon Wheel

IV. DESIGN OF THE PROJECT

Wheelchairs are designed with a variety of features to accommodate the diverse needs of users. These features include the overall length, weight, frame type, seat configuration, wheel and caster type, armrests, footrests, axle position, and the propulsion mechanism. Each of these elements plays a crucial role in determining the wheelchair's usability and effectiveness for the individual.

According to the World Health Organization (WHO), the design of a wheelchair should be based on several key factors:

- The physical needs and conditions of the user
- The environment in which the wheelchair will be used (e.g., indoor, outdoor, rough terrain)
- The materials and technologies available in the region where the wheelchair is produced and used

These factors ensure that the wheelchair is functional, comfortable, and appropriate for the user's lifestyle and surroundings.

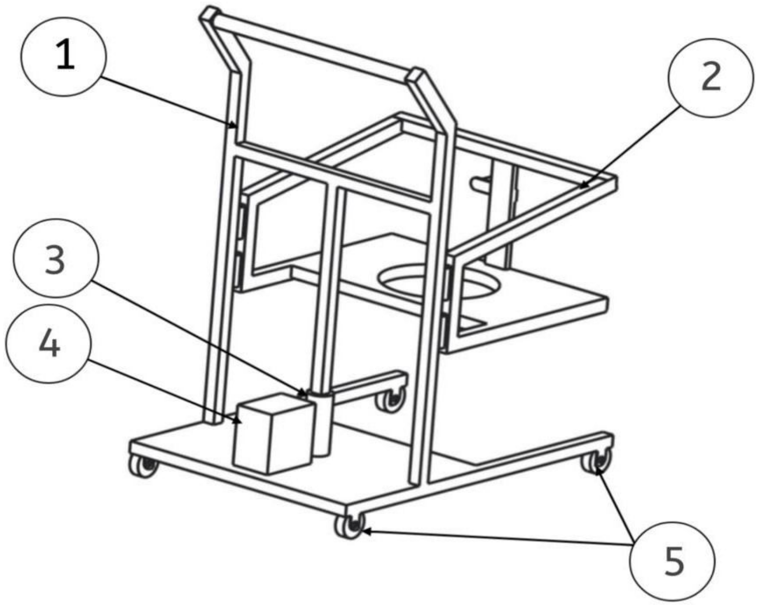

Fig 6 Electric Wheel Chair

1-Frame, 2-Seat, 3-Hydarulic Jack, 4-Motor, 5-Wheel

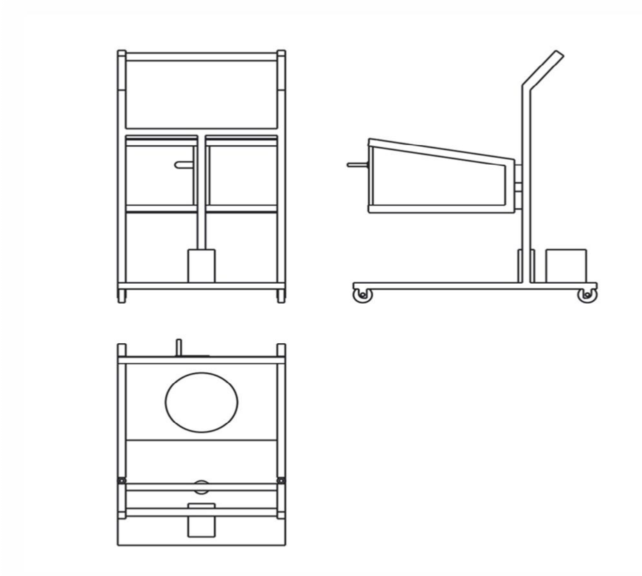

Fig 7 Orthographic views of Electric Wheel chair

V. WORKING PRINCIPLE

The electric wheelchair is first positioned near the location where the physically challenged or elderly person is seated. The user is then safely transferred onto the wheelchair. The seat height can be adjusted for user comfort and alignment using an electrically operated hydraulic jack. The lifting action is achieved through a hydraulic jack, which is powered by a linear pumping mechanism. This pumping action is automated using a DC motor as the prime mover. According to Pascal's Law, the pressure applied to the hydraulic fluid within the container is distributed equally in all directions, causing the piston to move upward and raise the seat. Once the user reaches the destination, such as a bed or restroom surface, the seat height is adjusted to minimize the gap between the wheelchair and the surface. This ensures a smooth and safe transfer. If the seat height needs to be lowered, the release lever on the hydraulic jack is engaged. This allows the piston to return to its original (lower) position, adjusting the seat accordingly.

VI. TESTING

Testing electric wheelchairs involves evaluating their functionality and overall performance. While testing standards may vary based on manufacturers and regulatory requirements, the following aspects were considered during the testing of the developed electric wheelchair:

A. Compressive Testing

Compressive testing is the counterpart of tensile testing and is conducted using a compressive or universal testing machine. The material sample is placed between two plates that apply a compressive force until the material fractures. This method is commonly used for brittle materials such as cement and brick. For ductile materials, compressive testing may be less accurate, as these materials tend to undergo plastic deformation instead of breaking. The results are generally measured in pounds per square inch (psi) or pascals (Pa).

B. Performance Testing Results

1) Maximum stroke length of the hydraulic jack: 100 mm
2) Lifting speed of the hydraulic jack: 40 mm/min
3) Time to reach full lift height: 2 minutes 30 seconds
4) Lifting capacity of the hydraulic jack: 2 tons
5) Load capacity of the frame: 120–150 kg
6) Frame stress of the electric chair: 20,800 Pa
7) Yield stress of the frame material: 250 MPa
8) Compressive strength of the frame material: 400 MPa

VII. ADVANTAGES AND APPLICATIONS

A. Advantages

1) The wheelchair features an adjustable seat height, ensuring comfort, adaptability, and safety for the user. Height adjustments can be easily made using a lever mechanism.
2) It is easier to operate compared to a manual wheelchair, especially for users with limited physical strength.
3) The use of this electric wheelchair can significantly enhance the user's daily life and independence.
4) The power lift feature simplifies everyday activities by enabling smooth height adjustment.
5) This wheelchair allows users to raise their eye level to match others, making social interactions more natural and engaging.
6) It enhances the ability of individuals with disabilities to perform routine tasks with greater ease and confidence.
7) The wheelchair offers customizable features to improve user comfort and overall usability.
8) The lifting function supports both the physical and mental well-being of users by providing ergonomic posture and greater autonomy.
9) It is suitable for use on various types of surfaces, including flat and inclined (sloped) areas.

B. Applications

1) It can be used to transfer elderly or disabled individuals safely.
2) Enables smooth movement in sloped or uneven areas.
3) Allows easy height adjustments to transfer users to different levels, such as beds, chairs, or restrooms.
4) Assists in moving users to and from restrooms with minimal effort.
5) Provides consistent support for both indoor and outdoor use.
6) Helps users transfer comfortably between chairs, beds, and dining tables.
7) Facilitates pick-up and drop-off of users from vehicles without requiring physical effort from the user.
8) Ensures safe movement in slippery areas, such as tiled floors in buildings.
9) Enhances outdoor activity by reducing physical strain on both the user and the caregiver.
10) Suitable for use in various indoor environments such as homes, offices, hospitals, restaurants, and more.

VIII. CONCLUSION

In this project, we proposed a novel electric wheelchair equipped with a lifting mechanism designed specifically for users with disabilities affecting both upper and lower limbs. The system facilitates smooth and secure transfers to and from beds or toilet seats, thanks to an innovative wheel arrangement that differs from that of conventional wheelchairs. Additionally, the foldable frame associated with the lifting mechanism enables this wheelchair to be safely operated on public roads. Experimental results demonstrated that the wheelchair provides excellent manoeuvrability—comparable to a forklift—and is capable of climbing a 100 mm step and functioning effectively on uneven surfaces, including restrooms. It is designed for users who can maintain a seated posture and can also assist in lifting users from a lying position. While the system offers several advantages, practical use may be influenced by individual physical conditions and restroom configurations. Nonetheless, the proposed design represents a significant step toward improving mobility and autonomy for physically challenged individuals.

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