

Staircase Climbing Trolley

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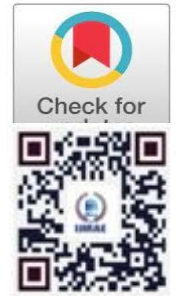
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Abstract: The transportation of heavy loads across staircases remains a significant challenge in domestic and industrial environments. Conventional trolleys are limited to flat surfaces, often requiring excessive manual effort and posing safety risks when used on stairs. This paper presents the design and development of a staircase climbing trolley incorporating an innovative wheel mechanism, such as a tri-wheel assembly, to enable smooth and stable movement over steps. The proposed system focuses on enhancing load capacity, user safety, and operational efficiency while maintaining a cost-effective design. The structural framework and ergonomic considerations are optimized to minimize human effort and reduce the risk of injuries. Experimental analysis demonstrates improved performance compared to traditional trolleys in terms of stability and ease of handling. The developed trolley offers a practical solution for applications in logistics, health care, and household material handling in multi-level environments.

INTRODUCTION

The movement of heavy loads is a common requirement in various environments such as residential buildings, warehouses, hospitals, and commercial facilities. While conventional trolleys are effective on flat surfaces, they face significant limitations when used on staircases. In many situations, manual lifting is required to transport goods across different levels, which increases physical strain, reduces efficiency, and raises the risk of accidents and injuries. To address these challenges, staircase climbing trolleys have been developed as a practical solution for vertical transportation. These trolleys are equipped with specialized wheel mechanisms, such as tri-wheel or rotating wheel assemblies, which allow smooth navigation over steps. The design ensures better stability, load distribution, and ease of operation compared to traditional methods. This work focuses on the design and development of a cost-effective and user-friendly staircase climbing trolley. The primary objectives include reducing human effort, enhancing safety, and improving the overall efficiency of load handling. By incorporating ergonomic and mechanical innovations, the proposed system aims to provide a reliable solution for transporting goods in multi-level environments. Navigation and obstacle avoidance, making it suitable for educational purposes and small-scale industrial applications. Material handling is a critical aspect in both domestic and industrial sectors, where the efficient movement of goods directly impacts productivity and safety. Although conventional trolleys are widely used for transporting loads on flat surfaces, they become ineffective when dealing with staircases and uneven terrains. In such cases, manual lifting is often employed, which not only requires significant physical effort but also increases the chances of fatigue, musculoskeletal injuries, and accidental drops. With the rapid growth of urban infrastructure, multi-storey buildings have become increasingly common, creating a strong need for efficient load transportation systems that can operate across different levels. Existing solutions, such as elevators or ramps, are not always available or feasible in all situations, especially in small-scale industries and residential settings. This highlights the necessity for a simple, portable, and cost-effective alternative. The staircase climbing trolley addresses these challenges by incorporating a specialized wheel mechanism, such as a Tri-Star wheel assembly, which enables smooth and continuous movement over steps. This mechanism ensures better load distribution and stability while climbing, thereby reducing the effort required by the user. Additionally, the ergonomic design of the trolley enhances user comfort and control during operation. This project focuses on the design, fabrication, and analysis of a staircase climbing trolley that is efficient, durable, and easy to use. The proposed system aims to minimize human effort, improve safety, and increase operational efficiency. By providing a practical and economical solution, the staircase climbing trolley can be effectively utilized in applications such as logistics, delivery services, hospitals, and household material handling level environments.

LITERATURE REVIEW

Several researchers have explored different mechanisms and designs to improve the efficiency of load transportation over staircases. Early studies primarily focused on manual handling techniques, highlighting the physical strain and high risk of injuries associated with lifting heavy loads across steps. These findings emphasized the need for mechanical assistance devices to enhance safety and reduce human effort. One of the most widely adopted solutions is the tri-wheel or star wheel mechanism, which allows continuous rolling motion over stair edges. Studies on Tri-Star wheel assemblies have demonstrated improved stability and reduced effort compared to conventional two-wheel trolleys. Researchers have also analysed the optimal wheel size, angle, and material to enhance performance and durability during stair climbing operations. In addition to passive mechanisms, some advanced designs incorporate motorized systems with electric drives and sensors to automate the climbing process. While these systems offer higher efficiency and ease of use, they tend to be expensive, complex, and less suitable for small-scale or household applications. Therefore, many studies suggest that manually operated designs remain more practical in terms of cost and maintenance. Ergonomic considerations have also been a major focus in recent research. Proper handle design, load distribution, and frame structure significantly influence user comfort and control. Lightweight materials such as aluminium alloys have been recommended to improve portability without compromising strength. Despite these advancements, there remains a need for a cost-effective, simple, and efficient staircase climbing trolley that balances performance, durability, and ease of use. This project aims to build upon existing research by developing an optimized design that addresses these key limitations and provides a practical solution for real-world applications. The problem of transporting loads over staircases has been addressed by various researchers through different mechanical and automated solutions. Early approaches mainly relied on manual lifting, which studies have shown to cause significant physical strain, fatigue, and a high risk of musculoskeletal injuries. This led to the development of assistive devices aimed at reducing human effort and improving safety.

EXISTING SYSTEM

The problem of transporting loads over staircases has been addressed by various researchers through different mechanical and automated solutions. Early approaches mainly relied on manual lifting, which studies have shown to cause significant physical strain, fatigue, and a high risk of musculoskeletal injuries. This led to the development of assistive devices aimed at reducing human effort and improving safety. One of the most commonly researched mechanisms is the Tri-Star (three-wheel) arrangement. Research has also focused on optimizing parameters such as wheel diameter, spacing, and frame geometry to achieve better stability and smoother climbing performance. In addition to mechanical designs, motorized and automated stair-climbing trolleys have been proposed. These systems typically use electric motors, gear drives, and sometimes sensor-based control systems to facilitate movement

DIS ADVANTAGES:

- Conventional trolleys cannot be used on staircases
- Causes physical strain and fatigue
- High risk of injuries and accidents
- Time-consuming and inefficient
- High

PROPOSED SYSTEM

Block Diagram



The system shown in the figure represents a staircase climbing trolley designed for efficient transportation of loads across staircases. The structure consists of a rigid metallic frame that provides strength and durability for carrying heavy materials. A handle is provided at the top to ensure proper grip and control during operation, while a flat base platform supports the load. The key feature of this trolley is the tri-wheel mechanism mounted on either side.

Each set consists of three wheels arranged in a triangular configuration, which enables the trolley to climb stairs smoothly. When the trolley encounters a step, the wheel assembly rotates, allowing one wheel to lift on to the next step while the others provide support and balance. This continuous rotational movement eliminates the need to manually lift the entire load. The design improves stability and reduces the physical effort required by the user. It also minimizes the risk of slipping and ensures safer handling of heavy objects. Due to its simple construction and effective mechanism, the staircase climbing trolley is suitable for applications in material handling, delivery services, warehouses, and residential use. The system illustrated in the figure represents a staircase climbing trolley specifically designed to facilitate the movement of heavy loads across staircases and uneven surfaces. The trolley is constructed using a robust metallic frame that ensures high strength, durability, and the ability to withstand significant loads during operation. The top portion consists of an ergonomically designed handle, which provides better grip, control, and ease of maneuverability for the user. The bottom section includes a flat load-bearing platform that securely holds the materials during transportation. The most significant feature of this design is the incorporation of a tri-wheel mechanism on both sides of the trolley. Each wheel assembly consists of three wheels arranged in a triangular configuration and mounted on a rotating frame. This innovative mechanism enables the trolley to climb stairs efficiently. When the trolley reaches a step, the wheel assembly rotates about , allowing one wheel to rise and rest on the next step while the remaining wheels maintain balance and support. This results in a smooth and continuous climbing motion, eliminating the need for lifting the entire load manually. Furthermore, the design ensures improved load distribution and enhanced stability during operation, reducing the chances of tipping or slipping. The trolley also minimizes the physical effort required by the user, thereby reducing fatigue and the risk of injuries. Compared to conventional trolleys, this system provides greater efficiency, safety, and convenience, especially in multi-level environments.

ADVANTAGES:

- Easily moves loads on staircases
- Reduces manual effort and fatigue
- Improves safety during load handling

V. CONCLUSION

In conclusion, the staircase climbing trolley provides an effective and practical solution for transporting heavy loads across staircases and uneven surfaces. The use of a tri-wheel mechanism enables smooth and continuous movement, significantly reducing the need for manual lifting and minimizing physical strain. The design ensures improved stability, safety, and ease of operation compared to conventional trolleys.

VI. FUTURE ENHANCEMENT

The staircase climbing trolley can be further improved by incorporating advanced features to enhance its performance and usability. One of the major enhancements includes the integration of a motorized mechanism with a rechargeable battery system to enable automatic stair climbing with minimal human effort. The use of lightweight materials such as aluminum alloys can reduce the overall weight of the trolley while maintaining its strength and durability. Improvements in wheel design, along with the addition of anti-slip and shock-absorbing features, can provide smoother and safer operation, especially when handling delicate goods. Furthermore, the inclusion of an efficient braking system and an adjustable handle can improve user safety and comfort. The design can also be modified to be foldable for easy storage and portability. In addition, incorporating smart features such as sensors and load monitoring systems can further enhance the efficiency and functionality of the trolley, making it more suitable for modern material handling applications. Advanced wheel configurations can be developed to handle different types of staircases with varying dimensions and surfaces. Additionally, implementing a locking mechanism for wheels can provide better control during loading and unloading. The system can also be designed to be more compact and modular, allowing easy assembly and disassembly. These enhancements would improve the versatility and adaptability of the trolley in different working conditions.

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