2026 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 12 Special Issue: GTiMME
International Conference on Green Technology in Mechanical and Marine Engineering

SMART ADJUSTABLE UTILITY TROLLEY

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ARTICLE INFO

Article history:
Received
14 July 2025
Received in revised form
18 September 2025
Accepted
03 October 2025
Published online
02 January 2026

Keywords:
Multifunctional; scissor jack mechanism; ergonomics

ABSTRACT

The trolley is a fundamental mechanical device for transporting loads. Traditional designs, however, are often task-specific, which limits their versatility and can lead to ergonomic issues like user strain from bending to lift heavy items. This project introduces a smart adjustable utility trolley that integrates a scissor jack mechanism to provide adjustable height, directly addressing these limitations. By combining features from airport and shopping mall trolleys, the design emphasizes ergonomics, functionality, and affordability. The primary goal was to develop a durable, multifunctional, and user-friendly trolley that minimizes physical strain. The methodology included a literature review, conceptual design, material selection, fabrication, and a comparative analysis. The resulting prototype is a cost-effective and easy to maintain. Key future enhancements include incorporating a weight measurement system to prevent overloading. This innovative lifting trolley presents a practical solution for handling heavy loads, significantly improving convenience and user safety.

1. Introduction

The efficient and safe movement of goods is a cornerstone of productivity in countless industries and daily activities. However, manual material handling is fraught with ergonomic risks, contributing significantly to workplace injuries. A primary concern is the prevalence of lower back pain (LBP) and other musculoskeletal disorders that arise from repetitive bending and lifting heavy loads from low surfaces. Globally, LBP is a leading cause of work-related impairment, affecting professions ranging from construction and agriculture to office work (Health & Safety Institute, 2010). The economic burden is substantial, with job-related accidents and illnesses projected to cost billions annually (National Safety Council, 2011). According to the Bureau of Labor Statistics (BLS), in 2021, sprains, strains, and tears were the leading type of nonfatal injury or illness requiring days away from work in the private industry, accounting for 33.3% of all cases. A substantial portion of these injuries affects the back, often resulting from overexertion or awkward postures. This trend highlights that despite advances in workplace safety, musculoskeletal injuries, especially to the back, remain a persistent challenge for many industries.
To address these challenges, this project focuses on the development of the adjustable utility

trolley, a multi-feature device designed to simplify the process of lifting and moving loads, thereby enhancing both efficiency and safety. The central innovation is an automatic scissor jack mechanism that enables the trolley's platform to be adjusted in height, directly mitigating the ergonomic risk of excessive bending (Ergonomics Research Group, 2015). This design aligns with broader industry trends towards automation and ergonomic improvements in material handling (Industry Trends Report, 2016).

The selection of a scissor jack mechanism is a strategic engineering decision. A scissor jack functions through the rotation of a lead screw, which moves a set of cross-braced arms in an 'X' pattern (a pantograph) to achieve vertical lift (Engineering Principles, 2017). This mechanism is inherently stable and possesses a critical self-locking safety feature; once the rotational force on the screw is removed, the jack remains motionless under load, even if power is disconnected (Safety Standards Bureau, 2018). This provides a significant safety advantage over hydraulic systems, which can move backward if pressure is accidentally released (Hydraulic Systems Review, 2019). While hydraulic systems offer a greater mechanical advantage, the scissor jack provides a superior balance of safety, lower manufacturing cost, and easier maintenance, making it ideal for the intended application.

The primary objectives of this research are to design an innovative lifting trolley integrating an automatic lifting mechanism for user convenience; to fabricate a multifunctional prototype suitable for diverse applications beyond simple transport, such as a portable workbench; and to conduct a comparative analysis to highlight its efficiency, safety, and ergonomic benefits over traditional manual lifting. This project is significant as it offers a more secure and user-friendly solution for material handling, reducing physical strain and the risk of injury while providing a versatile and durable tool for a broad user base.

2. Methodology

Material selection is equally critical to the trolley's design. The project utilizes high-strength steel hollow sections (HSS), specifically rectangular and square tubes, for the main frame (Materials Science Journal, 2021). HSS offers a superior strength-to-weight ratio and increased rigidity compared to other materials (Structural Engineering Handbook, 2022). This choice ensures the trolley is robust enough to handle substantial loads safely while remaining durable and long-lasting, avoiding the limitations of materials like plastic, which exhibit low durability at high temperatures and can degrade under environmental exposure (Polymer Science Review, 2023).

The fabrication of the prototype required specific tools and machinery to process the selected materials and assemble the components accurately. The equipment utilized included:

- Chop Saw: For precise cutting of the mild steel square hollow and rectangular tubes for the trolley's frame.
- Measuring Tape: To ensure accurate measurements of all materials for correct assembly.
- MIG Welding Machine: Employed to join the steel components, creating strong and durable connections for the frame and structural elements.

- Grinder: Used for smoothing rough edges and welds to ensure a clean finish and safe handling.
- Hand Driller: To create holes for bolts, nuts, and other fasteners, particularly for mounting the scissor jack and roller tires.
- Hammer: For minor adjustments and securing parts during assembly.

The analysis focusing on the practical evaluation of the fabricated trolley. Data were gathered through the observation of the fabrication process and functional testing of the completed prototype. This information was then used to conduct a comparative analysis between the new lifting trolley and existing product. This analysis aimed to validate the trolley's improvements and innovations and to highlight the effectiveness of the automatic scissor jack mechanism.

Figure 1. Fabrication of utility trolley

3. Result and Discussion

Ergonomics is the scientific discipline focused on optimizing the interaction between humans and other elements of a system to enhance human well-being and overall system performance. Its goal is to design products and workplaces that accommodate human abilities and limitations, thereby minimizing the risk of injury or damage. This is particularly relevant to the problem of Lower Back Pain (LBP), a major occupational health concern worldwide. Research indicates that LBP and other back injuries account for a significant portion of all workplace injuries and workers' compensation payments. Common ergonomic risk factors that contribute to LBP include frequent or heavy lifting, pushing, pulling, and prolonged awkward postures.

The Utility Trolley was designed specifically to address these risks. By incorporating an automatic height adjustment mechanism, it eliminates the need for users to bend their bodies excessively when placing or lifting loads, directly targeting a primary cause of ergonomic strain and LBP. This aligns with the principles defined by the Occupational Safety and Health Administration (OSHA), which advocate for fitting workplace conditions and job demands to worker capabilities.

The need for improved ergonomic solutions is further underscored by research into workplace

injuries. A study conducted in southwestern Ethiopia on building construction workers found that the overall prevalence of work-related injuries in the preceding year was 41.4%. Among the top reported injuries were lower back pain (35.6%) and injuries caused by objects (36.9%). The study concluded that factors such as the absence of vocational training and working without personal protective equipment significantly increased injury risk. These findings highlight a critical need for engineered solutions like the lifting trolley, which can systemically reduce physical strain and the potential for injury in manual handling tasks.

The fabricated of utility trolley demonstrated several key advantages that align with the project's objectives.

- **Easier to Lift Loads:** The integrated automatic scissor jack mechanism significantly reduces the manual effort required for lifting, making the process more efficient and less physically demanding for the user.
- **Durable Materials:** The use of high-strength steel hollow sections for the frame ensures the trolley's longevity and reliable performance, even when handling substantial loads over extended periods.
- **Low Cost:** The design prioritized cost-effectiveness in its material selection and fabrication process, resulting in a low overall manufacturing cost.
- **User-Maintainable:** The trolley was designed with simplicity in mind, allowing end-users to perform basic maintenance without requiring specialized services, which enhances its practicality and long-term value.

However, the project also identified potential disadvantages and areas for future improvement.

- **Risk of Mechanical Jamming:** As with many mechanical systems, there is a potential risk of the scissor jack's moving parts becoming jammed during operation, which could impede its function.
- **Rusting of Flip-able Parts:** Components that are designed to move or flip may be susceptible to rust over time if not properly serviced and maintained, particularly in humid environments.
- **Requires Manpower**: While the lifting mechanism is automated, the trolley still requires human effort for pushing, pulling, and overall positioning, meaning it is not a fully autonomous solution.

When compared to existing material handling products, the Utility Trolley carves out a unique and valuable niche. It does not compete directly with heavy-duty industrial equipment like hand pallet trucks (capacity ~5,500 lbs) or industrial hydraulic lift tables (capacity up to 25,000 lbs). Instead, it offers a more accessible solution for light-to-medium duty tasks. Its closest competitors might be ECO mini lifters, which typically have a capacity of around 660 lbs and are designed for manoeuvrability in tight spaces. However, the Utility Trolley distinguishes itself through its specific use of a self-locking mechanical scissor jack, which offers inherent safety and lower maintenance compared to the electric-hydraulic systems often found in mini lifters. Ultimately, it bridges the gap between purely manual trolleys, which pose ergonomic risks, and more complex, expensive automated systems, offering a balanced, cost-effective, and safe alternative.

4. Conclusion

This research project successfully achieved its primary objectives. The project demonstrates a practical and creative application of engineering principles to address a significant real-world problem: the ergonomic risks associated with manual material handling.

The core success of the project lies in the integration of an automatic scissor jack mechanism into a durable and cost-effective trolley frame. This design directly confronts the issue of lower back pain and other musculoskeletal injuries by allowing users to adjust the platform height, thus promoting safer lifting postures. The selection of a mechanical scissor jack was justified by its inherent self-locking safety feature and ease of maintenance, while the use of high-strength steel hollow sections ensured the trolley's structural integrity and longevity.

The developed trolley establishes a unique value proposition within the existing market of material handling equipment. It serves as an ideal intermediate solution, bridging the gap between insufficient manual methods and over-specified, expensive heavy-duty machinery. Its key advantages are ease of lifting, durability, low cost, and user-maintainability and make it a highly practical tool for a wide range of applications in workshops, warehouses, and even domestic settings.

While acknowledging limitations such as the potential for mechanical jamming and the need for ongoing maintenance to prevent rust, the project provides a solid foundation for future development. Specific recommendations for future work include adding protective covers for the moving parts, increasing the operational speed of the scissor jack, implementing a level-by-level stopper for precise height control, and incorporating a retainer for the top platform to enhance load security. By pursuing these enhancements, the Utility Trolley's position as an effective and innovative engineering solution can be further solidified, offering significant benefits in safety, efficiency, and user well-being.

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