IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

Advancing Stair-Climbing Mechanisms: A Dual-Mobility Robotic Approach for Cleaning Applications

Mr. Shaikh M. L.
Dean Marketing
VACOE, Ahmednagar

Abstract: *Stairs are part of the architecture infrastructure of a building, and thus challenges for how to clean stairs are plenteous, primarily in multistorey buildings. Conventional stair climbing robots mainly aim at climbing the stairs and are unable to serve effective cleaning along the stair surface. Our research introduces an alternative solution which is to develop a stair-climbing platform including lateral wheels for a holistic and automated stair cleaning.*

A unique design in wheels utilizing a conjugate profile to provide stable stair climbing and omni-directional motion using lateral rollers is introduced in the project. This kind of compound moving system guarantees the ability of vertical climbing and horizontal covering every stair step and it evidently improves the cleaning efficiency.

The approach is based on conceptual design, mathematical modeling, CAD prototyping with SolidWorks, structure and motion analysis using ANSYS, MATLAB and validation of the performance through physical prototypes and sensor measurement.

Based on a thorough literature review we indicate a void in current solutions that involve single-sided mobility and lack of a high level of automation. The latter limitations are both overcome in the developed system by including intelligent cleaning functionalities, flexible mechanics and affordable materials making it a potential product for home and industrial needs.

This interdisciplinary investigation is likely to advance smart mobility solutions and facilitate "Make in India" efforts and also pave the way for patentable technologies on clocked maintenance systems. The ultimate result is an independent, effective and versatile robotic solution for stair cleaning that makes stair cleaning hands free.

Objectives: -

1. Design and optimize the stair-climbing wheel based on step profile.
2. Integrate lateral motion wheels to enable cleaning of each stair surface.
3. Develop a motorized system to control stair ascent and lateral movement.
4. Analyze power, torque and efficiency of the system.
5. Validate performance through simulations and prototype testing..

Keywords: architecture infrastructure

I. INTRODUCTION

1.1 Introduction

Staircases are a fundamental design element in nearly all multi-story structures, serving as an important pathway for vertical transit and as emergency escape routes when the situation calls for it. Staircases also tend to pose considerable hindrances to accessibility and maintenance. The mobility-impaired, service robots or load-hauling equipment cannot safely traverse stairs, whereas sweeping large or multi-story structures by hand is both time- and energy-consuming. Current stair-climbing equipment and cleaning devices fulfil these requirements individually stair climbers are

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

generally only designed for climbing up but don't provide stability on the way down and cleaning devices can't consistently deliver results on stairs, particularly at corners and edges that are hard to reach.

The proposed project presents a solution in one: an automated stair mobility and cleaning system featuring a specially designed conjugate profile wheel with a fully automatic cleaning mechanism. The conjugate profile wheel is made to match exactly with the geometry of every stair step, allowing for maximum contact between the surfaces. This fit greatly minimizes slippage, maximizes traction and enhances balance, whether going up or coming down. In contrast to standard wheels that barely touch the surface of the stairs, the conjugate structure provides stability even under weight or when scrubbing.

Apart from stability, the system also boasts lateral mobility to enable it to progress laterally over each step. This feature guarantees full surface coverage, such as edges and corners, which are usually left untouched by common cleaning techniques. Cleaning is entirely automatic, with sensors for measuring dirt and debris levels and adaptive brushes or suction units for adjusting to various types of stair materials like stone, tile, carpenter wood. It may also be provided with a water spray or cleaning fluid for thorough cleaning in heavy traffic zones, working either on schedule or on demand.

The system offers a number of benefits over traditional systems. Its better grip and balance ensure safety in climbing stairs, whereas the side-to-side cleaning motion guarantees that no area of the step remains untouched. Automation cuts down on labour needs and improves efficiency, making it highly suitable for large-scale public or commercial buildings. The system can be designed for different stair configurations and can be used in offices, shopping canters, hospitals, railway stations, airports, schools and colleges and other public places.

In operating, the device first navigates the staircase using step-detection sensors and the conjugate profile wheel for smooth and controlled movement. At each step, the sideways mobility mechanism is activated and positions the cleaning tools across the tread width for thorough cleaning. The cleaning intensity is then adjusted based on the surface type and the amount of dirt accumulation through pressure sensors. Debris collected is onboarded in a bin for easy disposal.

In the future, the system has tremendous scope for expansion, such as artificial intelligence for route optimization of cleaning wireless communication for remote operation and monitoring, solar-powered charging for power savings and attachments to perform specific tasks like disinfecting, polishing or snow removal.

1.2 Problem Statement

Staircase cleaning can be a major task especially in high-rise buildings. The existing techniques are insufficient time-consuming and difficult. The fact that traditional stair-climbing wheels are only designed to move up and down significantly limits their functionality and makes them inappropriate. The goal of this research is developing new type of stair-climbing wheel that can also travel horizontally in order to address this issue.

A unique profile that increases stability and decreases slippage will be included in the design. Cleaning will be considerably more efficient this wheel's capacity to move laterally cleaning every inch of the steps while maintaining a smooth sliding.

The study will explore the best possible wheel design choose lightweight material develop mathematical models for accurate sizing construct prototypes is state-of-the-art manufacturing techniques. The goal is to create an adaptable and efficient automated stair cleaning solution that solves the limitations of traditional stair-climbing wheels.

1.3 Justification

The proposed design incorporates small horizontal wheels on the stair-climbing platform to enable lateral movement allowing the clean each stair surface effectively. This innovation will contribute:

- Reducing manual cleaning method
- Enhancing cleaning efficiency and consistency
- Expanding the application of stairclimbing platforms beyond mobility solution.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

II. LITERATURE REVIEW

Various types of stair-climbing robots have been studied for delivery cleaning surveillance and rescue. Traditional cleaning robots. According to the review performed with sensor-based navigation and smart control systems to maximize the coverage area & obstruction avoidance. Unfortunately, multi-surface robotic cleaners especially those optimized for staircases are not widely available in the market.

The research study entitled "Curved-Spoke Tri-Wheel Mechanism for Fast Stair-Climbing" is aimed at improving the mechanical capability of robots to climb stairs efficiently and quickly through a specially developed tri-wheel system with curved spokes. The mechanism can manage vertical movement between steps by turning the wheels in a way that simulates walking over obstructions. The major strength of this research is its simplicity and stability in stair climbing which makes it appropriate for stair navigation in mobile robots or assistive devices.

Nonetheless, this work fails to meet some key limitations when the context is applied to real- world use such as stair cleaning. To begin with the mechanism is mechanical without any automation or intelligence there is no lateral (sideways) movement provision which is important in accessing the entire surface area of wide stairs in cleaning operations.

"The Synthesis of a Segmented Stair-Climbing Wheel" by Mostyn et al. (2018), a segmented wheel mechanism was synthesized to facilitate smooth and stable stair climbing. The design successfully reduced vibration and ensured ground contact which made it appropriate for mobility-oriented robots.

Yet the research does not include lateral movement or functional uses such as cleaning. By contrast the suggested research combines lateral wheel movement and an automated cleaning system, expanding the functionality of stair-climbing robots from mobility to useful maintenance functions. This increased functionality makes the system more useful and relevant to actual service environments.

In this paper the researchers aimed at improving the ability of stair climbing for wheel-based mobile robots through the amendment of conventional wheel mechanisms. They used a tri- wheel mechanism, where three small wheels are fixed in a triangular configuration on a rotating central spindle. The design allows the robot to climb stairs through the rotation of the overall tri-wheel mechanism, allowing the robot to step over the edges of stairs smoother and with less energy expenditure.

On the other hand, the research proposed here seeks to surpass mere stair climbing by incorporating lateral wheel movement for better maneuverability and including a cleaning mechanism for stair surface upkeep. Although the tri-wheel system in the given paper works well for vertical climbing, it is not horizontally adaptable and functionally integrated for operations such as cleaning. The new design includes a hybrid mobility system that accommodates both vertical (climbing stairs) and lateral (sideways motion) movement and is thus better suited for real-world applications such as indoor robotic stair cleaning.

In the current study titled "Innovative Stair Climber Using Associate Mechanism," the authors suggest a stair-climbing robot based on an associate mechanism that is primarily focused on locomotion over staircases with the aid of a specifically designed linkage system. The mechanism involves the integration of multiple wheels with an interesting orientation that facilitates smooth navigation across the stairs with a focus on mechanical efficiency and lesser energy consumption. Their design does not utilize complicated electronics and instead tends towards a mechanically based design, making it lighter and more appropriate for applications requiring lightness and minimizing control complexity.

The other hand, however, has the research work entitled "Design & Development of a Stair Climbing with Lateral Wheel Integration for Automated Stair Cleaning" presenting not just the stair-climbing function but also integrating lateral travel through the use of special wheels, along with an incorporated cleaning function. This makes the system more functional in both navigation and utility since it seeks to automate the cleaning of stairs. In contrast to the previous work that is limited to climbing capability through an associate linkage the present proposal widens its functionality to incorporate automated cleaning, perhaps through suction or brush- based cleaning systems. The lateral wheel integration concept enables the robot to travel sideways along every step, improving its cleaning coverage and minimizing blind spots.

Whereas the previous paper highlights mechanical innovation via a low-cost and low- complexity climbing design the new system is geared towards a multi-functional solution

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

involving mechanical movement, intelligent navigation (potentially using sensors) and task- specific modules such as cleaning units. This reflects a definitive progression in the problem space from mere traversal to intelligent and task-specific automation.

Accordingly, the envisaged work draws inspiration from the concept of associate mechanism in climbing but progresses it with the inclusion of lateral motion and automated cleaning method, providing a more comprehensive and applicable solution for actual real-world domestic or business stair cleaning assignments.

"Cleaning Robots: A Review of Sensor Technologies and Intelligent Control" The above paper generically explains cleaning robots employing a wide range of intelligent sensors and control algorithms. The paper identifies automation, detection of obstacles and mapping of area but is deficient in having a specific mechanism to climb stairs or move sideways. However, your project covers this mobility shortfall through planned combined lateral and climbing motion within stairs.

"Design and Implementation of Floor Cleaning Robot Using IoT." This project emphasizes flat-surface cleaning with control based on IoT for real-time monitoring. But it cannot deal with staircases. Your project addresses this by incorporating a specially adapted wheel system for cleaning stairs as well as facilitating lateral motion—plugging an important gap in mobility and multi-surface capability.

"Design of Low Power Triangle Type Stair Cleaning Machine "This design does aim at stairs with a triangle-shaped frame but doesn't have lateral wheel integration and is meant for single- direction motion only. Your work builds upon this by introducing lateral movement, improving the maneuverability, coverage area and overall cleaning effectiveness of the robot.

"Ensuring Area Coverage and Safety of a Robotic Vacuum Cleaner "The research addresses navigation, safety and full area coverage on flat floors with multiple sensors. It ignores stair cleaning or non-linear movement. Your suggested system integrates area coverage and mobility tailored to stairways with lateral adjustments, widening real-world application.

"Staircase Cleaning Robot: Design Considerations and Case Study "This research is directly applicable to your subject, with emphasis on the design problem of staircase robots. It does not have sophisticated mobility like lateral movement and the solution is more mechanical without automation integration in multi-direction control. Your project extends this by solving mobility and cleaning accuracy with an integrated wheel system for vertical and lateral movements.

2.1 Comparative Study: Advancing Stair-Climbing Mechanisms

The comparative analysis of previous research clearly highlights that most stair-climbing mechanisms are limited to unidirectional movement—primarily designed for ascending stairs. These systems effectively handle vertical navigation but lack the ability to perform lateral movement which is essential for thorough cleaning of each stair step.

Our proposed solution addresses this limitation by introducing a wheel design that enables both climbing and lateral movement. By incorporating omni wheels onto a specially contoured wheel profile designed to align with the curve of the stair surface we enable smooth sideways motion while the robot is on a step. This feature allows the cleaning mechanism to cover the entire width of each step, ensuring complete and efficient cleaning.

Unlike earlier approaches that focused only on climbing, our design offers a comprehensive stair-cleaning solution with integrated lateral mobility. The addition of lateral movement into the stair-climbing mechanism transforms the system into a more practical and intelligent cleaning robot for real-world applications

Table: Comparative Study: Advancing Stair-Climbing Mechanisms: -

Research Work / Title	Main Focus	Mobility Type	Lateral Movement	Limitations in Context of Stair Cleaning
Curved-Spoke Tri-Wheel Mechanism for Fast Stair-Climbing	Efficient stair climbing using curved spoke tri-wheel design	Vertical climbing only	No lateral movement	Lacks automation, lateral movement, and cleaning capability
The Synthesis of a Segmented Stair-Climbing Wheel (Mostyn	Smooth and stable stair climbing with	Vertical climbing	No lateral	Does not provide lateral movement or cleaning

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

et al., 2018)	segmented wheel design	only	movement	
Innovative Stair Climber Using Associate Mechanism	Mechanical linkage for smooth stair climbing	Vertical climbing only	No lateral movement	Focuses only on climbing and lacks cleaning
Design and Development of a Stair Climbing with Lateral Wheel Integration for Automated Stair Cleaning	Climbing combined with lateral wheel movement and cleaning	Vertical and lateral climbing	Has lateral movement	Basic cleaning integration and limited navigation features
Cleaning Robots: A Review of Sensor Technologies and Intelligent Control	Intelligent navigation and cleaning on flat surfaces	Flat-surface movement only	No lateral movement	No stair-climbing capability
Design and Implementation of Floor Cleaning Robot Using Internet of Things	Internet of Things based control for flat surface cleaning	Flat-surface movement only	No lateral movement	Cannot climb stairs
Design of Low Power Triangle Type Stair Cleaning Machine	Triangle frame for stair cleaning	Vertical climbing only	No lateral movement	One-directional movement with poor coverage
Ensuring Area Coverage and Safety of a Robotic Vacuum Cleaner	Coverage and safety for flat floors	Flat-surface movement only	No lateral movement	Not designed for stairs
Staircase Cleaning Robot: Design Considerations and Case Study	Mechanical design for stair cleaning	Vertical climbing only	No lateral movement	Lacks lateral motion and advanced automation

2.2 Comparative Study with Tri-Wheel Profile Mechanism: -

Fig.1 Unidirectional Stair-Climbing Tri-wheel.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

2.3 Comparative Study with logarithmic spiral profile mechanism: -

Fig.2 3- lobed Unidirectional

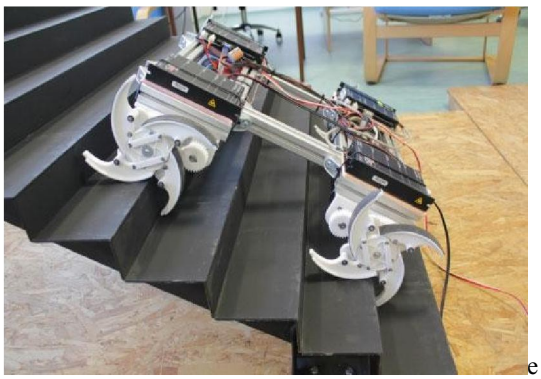


Fig.3 4- lobed Unidirectional

"The comparative study reveals that the wheel's limitation is its ability to move only in one direction that is climbing only."

2.4 Identified Gaps

- The limitation of the wheel can only climb but there is gap of the lateral movement.
- Most existing designs focus on stair mobility rather than cleaning.
- Lack of automated cleaning mechanisms in stair-climbing platforms.
- Innovation need for lateral wheel integration for effective surface cleaning.

III. MOTIVATION

3.1 Novelty of the Proposed System

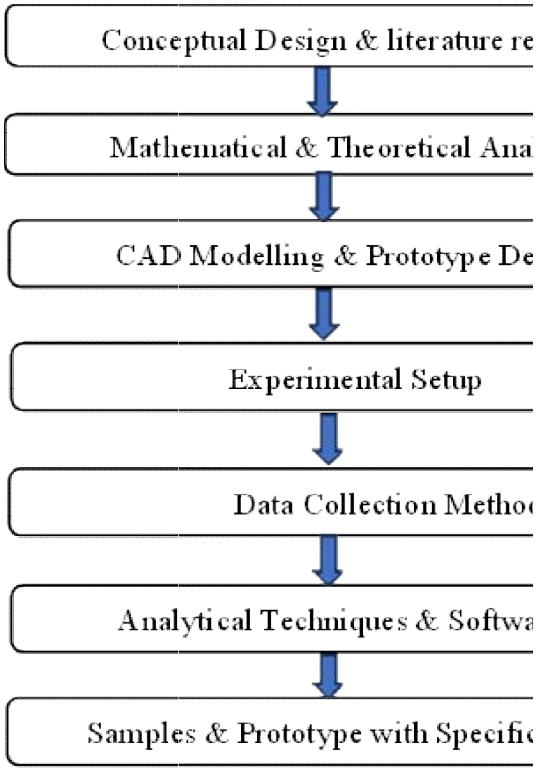
- First-ever combination of stair-climbing mobility and lateral cleaning.
- Independent lateral movement system for surface coverage and dirt removal.
- Adaptable to various staircase sizes and materials.

3.2 Benefits of the Research to National and International Scenario:

This research offers a novel stair-climbing and lateral-moving wheel mechanism with significant national and international impact. Nationally, it supports affordable mobility solutions for the elderly and differently-abled, promotes "Make in India" innovation, and boosts MSME involvement. Internationally, it contributes to accessible design, enhances research in mobility engineering, and opens avenues for patenting, global collaboration, and sustainable product development.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

3.3 Methodology



IV. EXPERIMENTATION/ IMPLEMENTION

(CASE STUDY 1&2)

A) WHEEL 1 (CASE 1): - Conceptional design Using Solid Work Software

By using conjugate profile wheel type

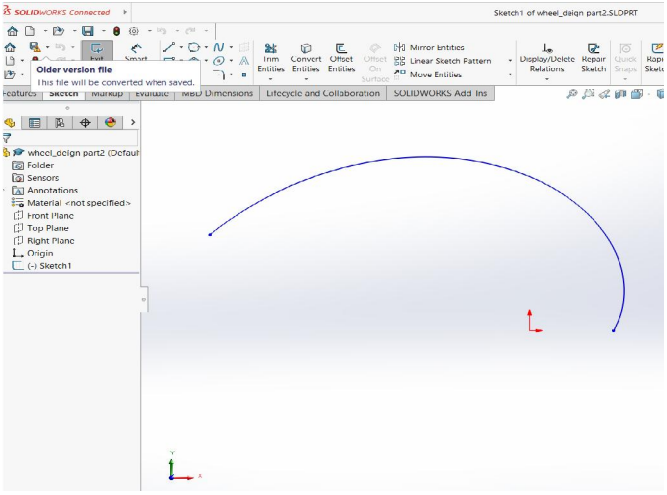


Fig.4.1 Step1: - To identify curve (wheel 1 case 1)

DOI: 10.48175/IJARSCT-28735

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

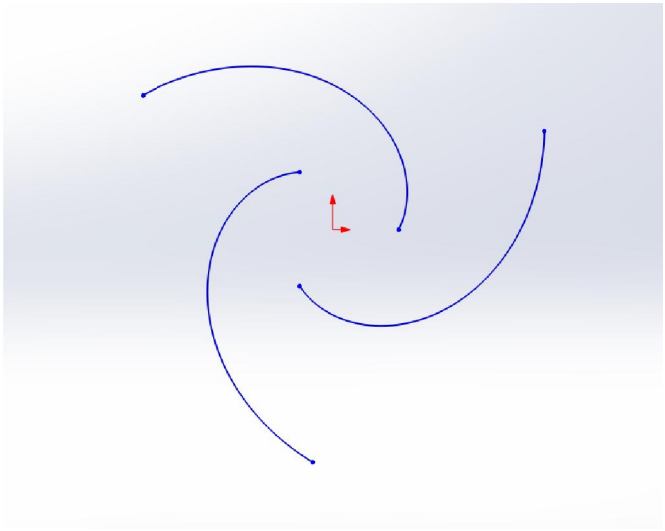


Fig.4.2 Step 2: - 3-lobed curve (wheel 1 case 1)

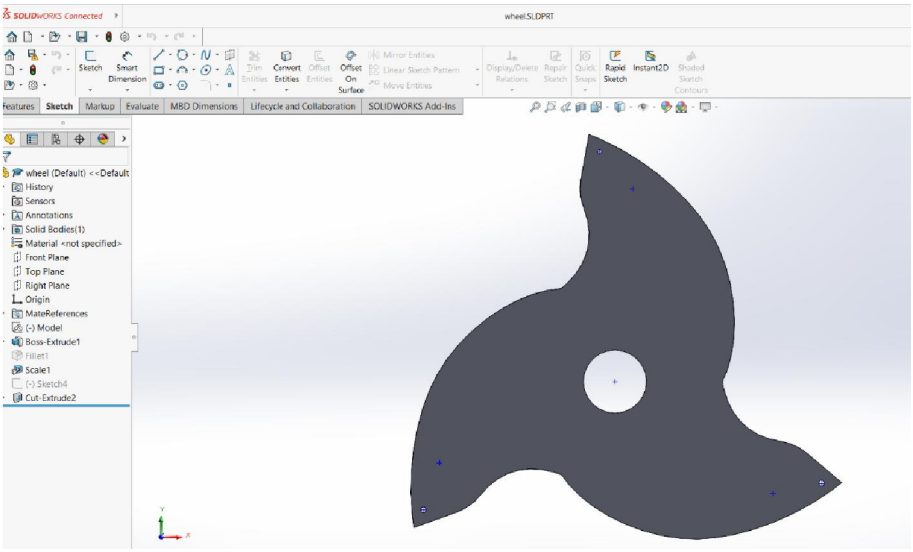


Fig.4.3 Step 3: - solid wheel part (wheel 1 case 1)

DOI: 10.48175/IJARSCT-28735

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

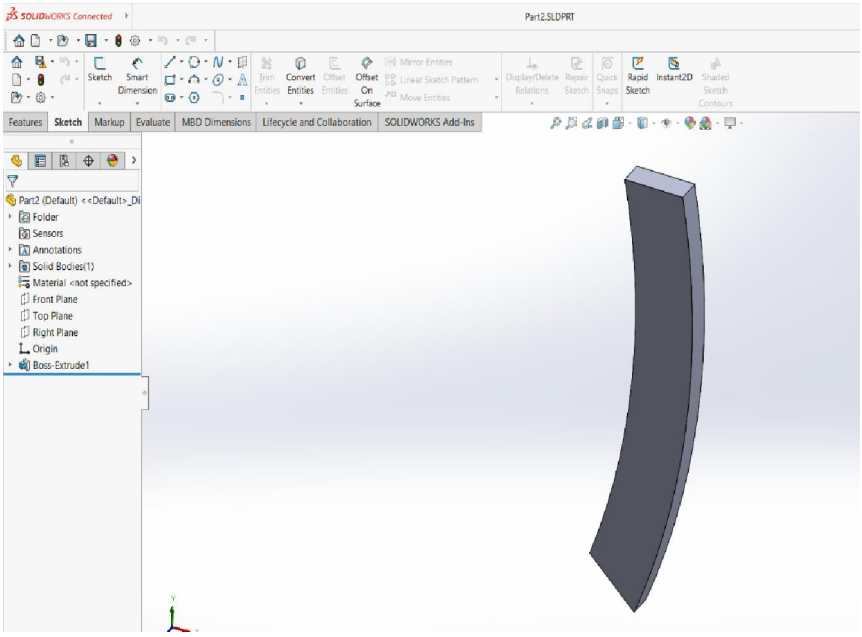


Fig.4.4 Step 4: - Wheel component 1 to adjust the movement (wheel 1 case 1)

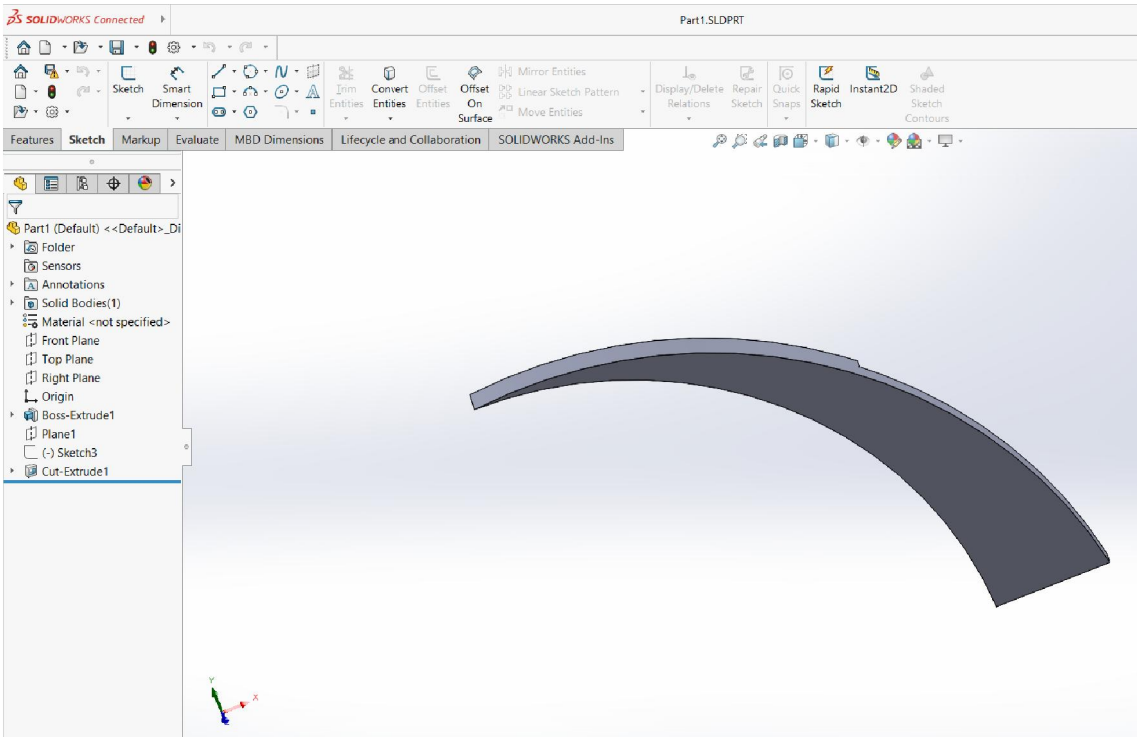


Fig.4.5 Step 5: - Wheel component 2 to adjust the movement (wheel 1 case 1)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

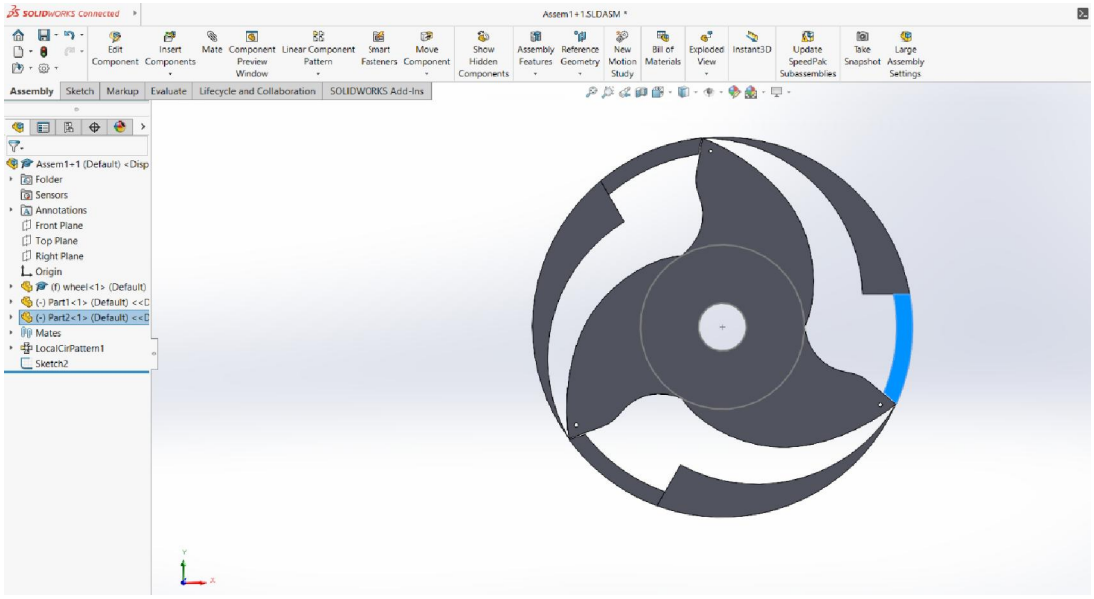


Fig.4.6 Wheel Assembly Position-1 to adjust the movement (wheel 1 case 1)

DOI: 10.48175/IJARSCT-28735

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

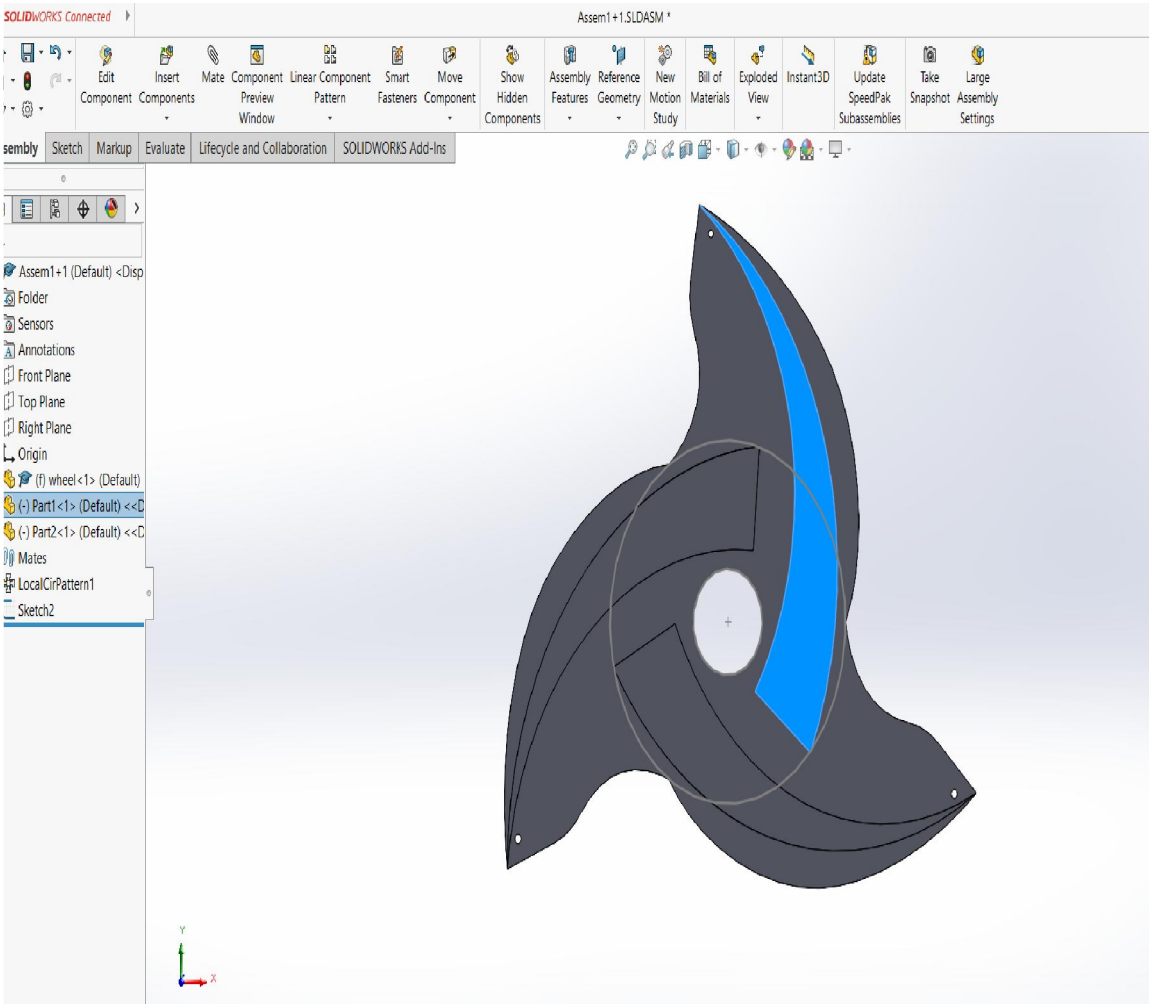


Fig.4.7 Wheel assembly position-2nd to adjust the movement (wheel 1 case 1)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

B) WHEEL 2: - Conceptional design Using Solid Work Software

By using Logarithmic spiral profile wheel type

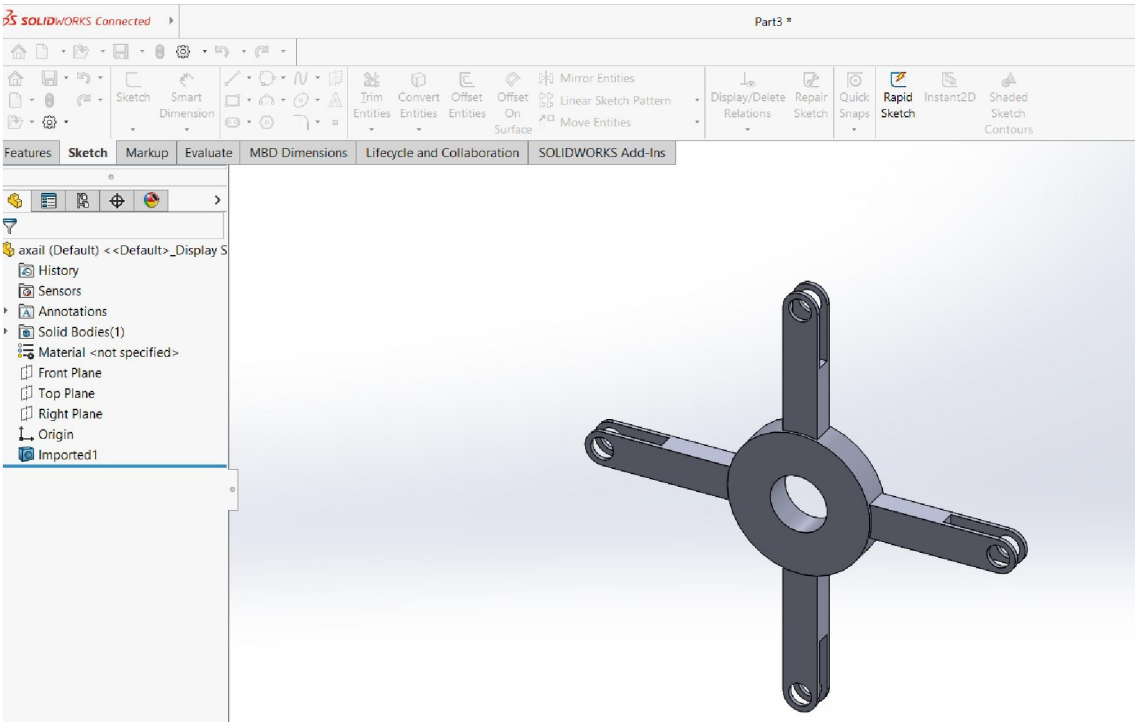


Fig.4.8 Step 1: - to prepare wheel component (wheel 2 case 2)

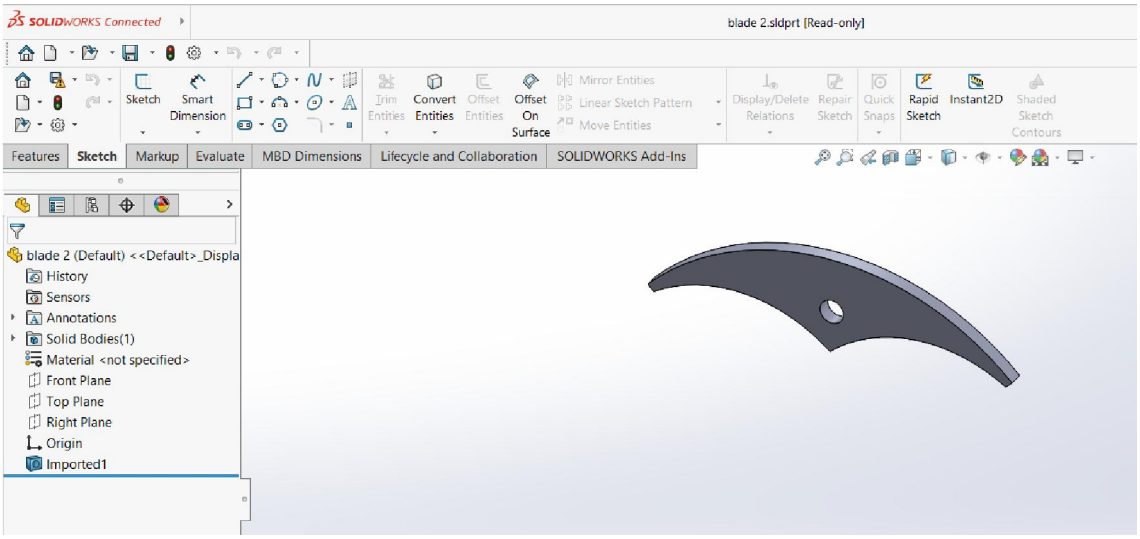


Fig.4.9 Step 2: - to prepare wheel component 2 (wheel 2 case 2)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

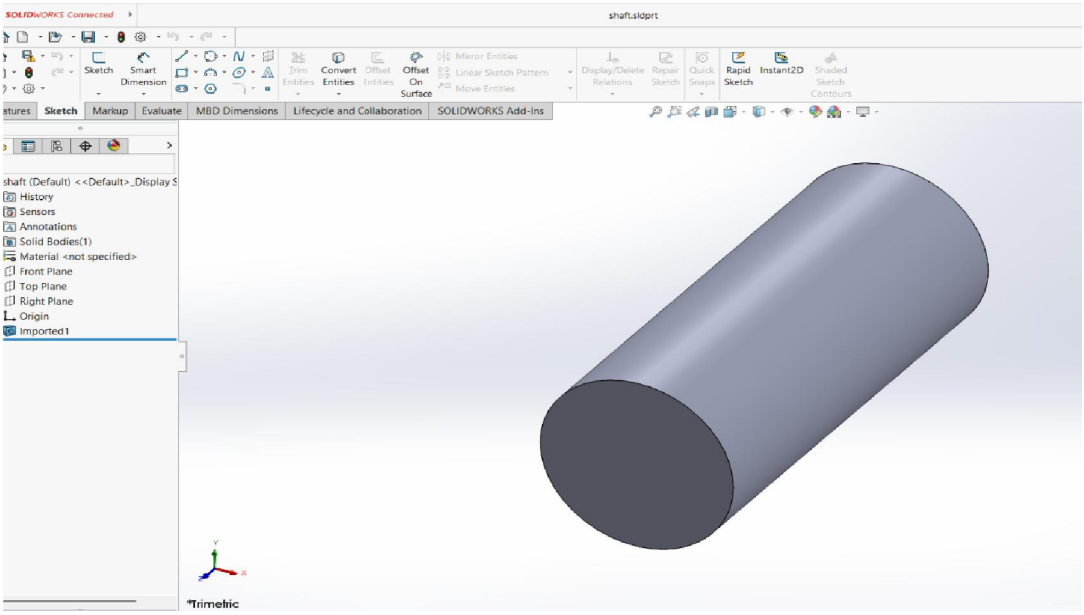


Fig.4.10 Step 3: - to prepare wheel component 3 (wheel 2 case 2)

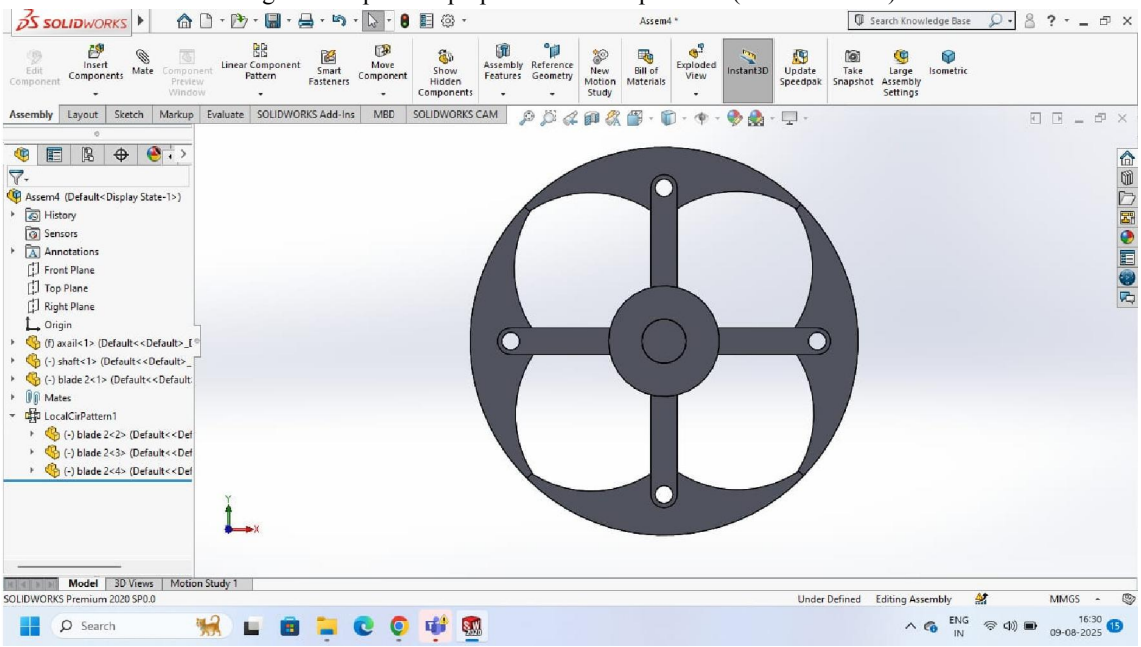


Fig.4.11 Wheel 2 position 1st Assembly (wheel 2 case 2)

DOI: 10.48175/IJARSCT-28735

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

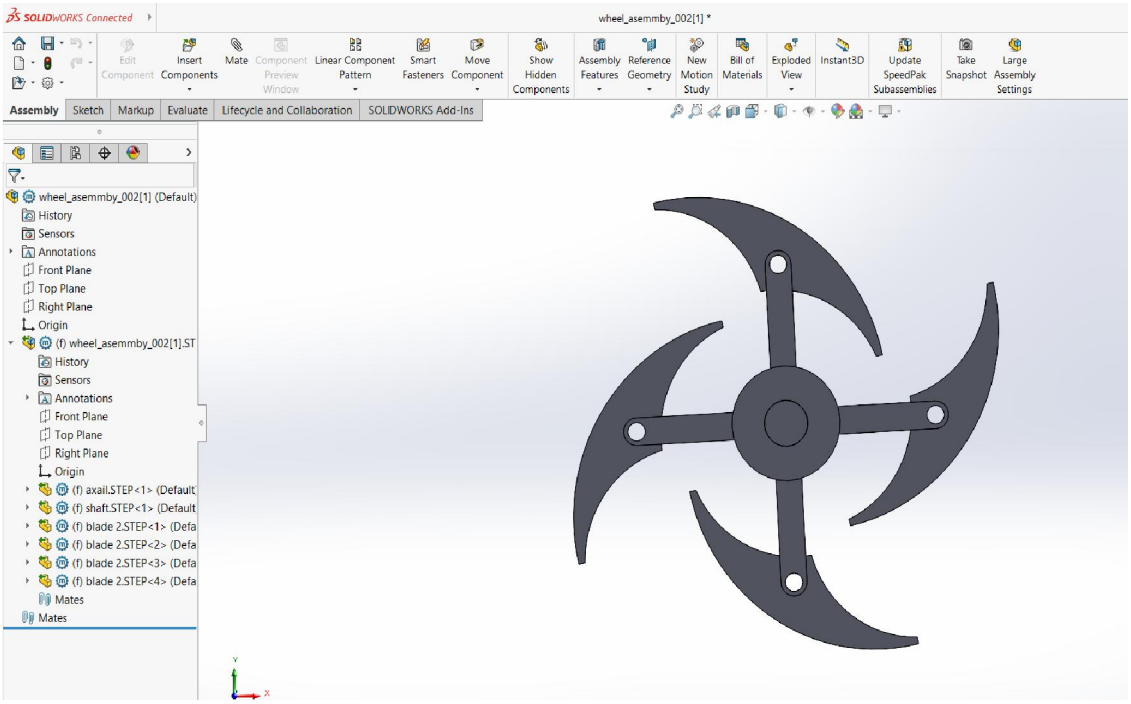


Fig.4.12 Wheel 2 position 2nd Assembly (wheel 2 case 2)

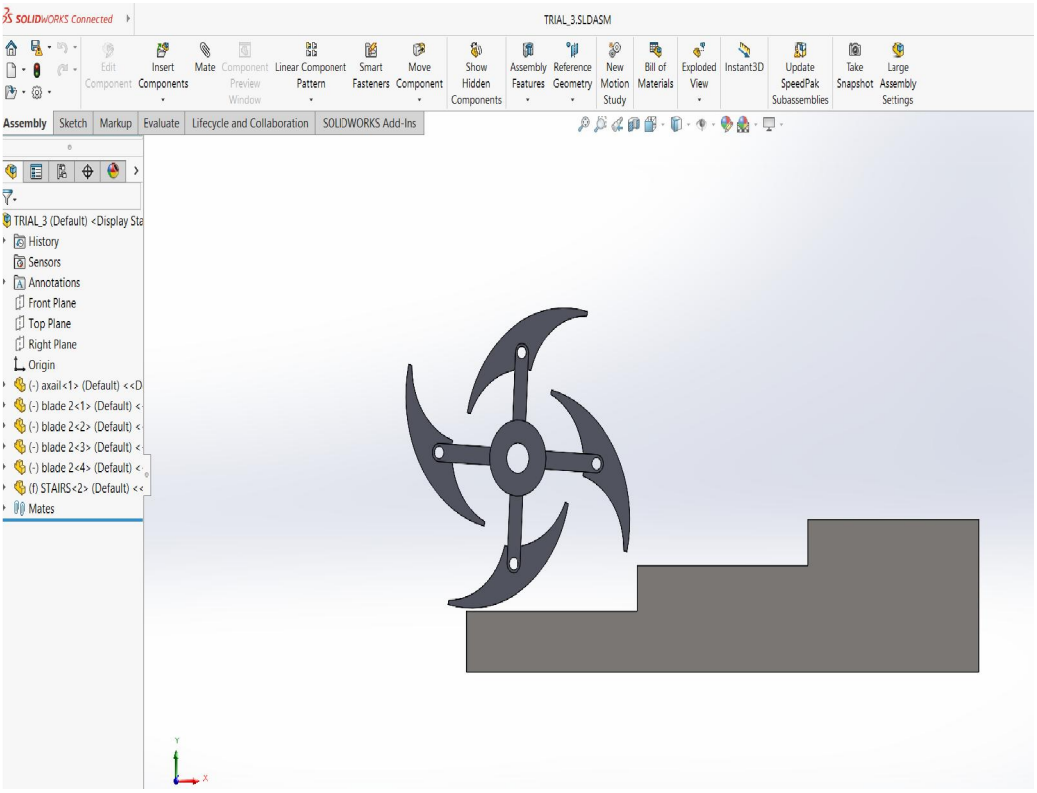


Fig.4.13 Wheel & Stair case Assembly (wheel 2 case 2

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, August 2025
Impact Factor: 7.67

V. CONCLUSION

1. Looking back at the work from January to June 2025, we've built a really solid foundation for our new stair-climbing robot that can also move sideways.
2. We took a good look at existing robots and found they mostly struggle to clean stairs thoroughly because they only move in one direction and aren't very automated.
3. To fix these issues, we came up with a dual-mobility system. We designed and modeled it in SolidWorks, using specially shaped wheels—conjugate and logarithmic spiral profiles—that let the robot climb stairs and move sideways smoothly.
4. This integrated setup helps the robot cover every step really well, making cleaning more accurate, stable, and efficient.
5. We've already run some initial simulations and built prototypes, and the results look promising.
6. This project not only advances smart mobility and automation but also supports national efforts like "Make in India," aiming to create scalable, affordable tech for both homes and industries.

REFERENCES

[1] Kim, Y., Kim, J., Kim, H. S., & Seo, T. (2019). Curved-spoke tri-wheel mechanism for fast stair-climbing. IEEE Access, 7, 173766–173773. https://doi.org/10.1109/ACCESS.2019.2956163
[2] Mostyn, V., Krys, V., Kot, T., Bobovsky, Z., & Novak, P. (2018). The synthesis of a segmented stair-climbing wheel. International Journal of Advanced Robotic Systems, 15(1). https://doi.org/10.1177/1729881417749470
[3] Dinesh Kumar, S., Muthuramalingam, T., & Rajasekaran, P. (2016). Modification of a wheel type stair climber. International Journal of Engineering Research and Technology, 5(10), 340–343.
[4] Modak, G. S., & Bhoomkar, M. M. (2016). Innovative low-cost stair climbing mechanism. Frontiers of Mechanical Engineering, 11, 299–310. https://doi.org/10.1007/s11465-016-0374- 1
[5] Cleaning Robots: A Review of Sensor Technologies and Intelligent Control Tapus, A., Pintaric, L., & Matuško, J. (2022). Cleaning robots: A review of sensor technologies and intelligent control. Robotics and Autonomous Systems, 152, 104052. https://doi.org/10.1016/j.robot.2022.104052
[6] Design and Implementation of Floor Cleaning Robot Using IoT Kumar, D., Singh, A., Sinha, P., & Rani, K. (2020). Design and implementation of floor cleaning robot using IoT. International Journal of Scientific & Engineering Research, 11(5), 189–193.
[7] Design of Low Power Triangle Type Stair Cleaning Machine Shinde, P. A., & Gohad, S. V. (2019). Design of low power triangle type stair cleaning machine. International Journal of Scientific Development and Research (IJSDR), 4(6), 261– 264.
[8] Ensuring Area Coverage and Safety of a Robotic Vacuum Cleaner Priyadarshini, M., & Sankar, P. (2021). Ensuring area coverage and safety of a robotic vacuum cleaner. International Journal of Advance Research, Ideas and Innovations in Technology, 7(3), 320–323.
[9] Staircase Cleaning Robot: Design Considerations and a Case Study Zeeshan, M., Reddy, M. D. R., & Manikandan, R. (2020). Staircase cleaning robot: Design considerations and a case study. International Research Journal of Engineering and Technology (IRJET), 7(5), 2454–2457.
[10] Alas pure, R., Barmase, C., Chambhare, S., Mandhre, M., G., Y., & Joshi, Y. (2016). Fabrication of stair climbing wheel mechanism: Alternate for lifting goods. International Research Journal of Engineering and Technology (IRJET), 3(4). https://doi.org/10.13140/RG.2.1.3716.0569
[11] Gangadia, H., Shukla, H., Patel, S., Jani, M., Upadhyay, R., & Ishan, F. (2015). Design and modeling of stair climbing trolley. SARJAN, 4, 62.
[12] Kim, Y., Son, D., Shin, J., & Seo, T. (2023). Optimal design of body profile for stable stair climbing via tri-wheels. International Journal of Precision Engineering and Manufacturing, 24(12), 2291–2302. https://doi.org/10.1007/s12541-023-00887-4

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, August 2025 Impact Factor: 7.67

[13] Gao, X., Cui, D., Guo, W., Mu, Y., & Li, B. (2017). Dynamics and stability analysis on stairs climbing of wheel–track mobile robot. International Journal of Advanced Robotic Systems, 14(4). https://doi.org/10.1177/1729881417720783

[14] Quaglia, G., Nisi, M., Franco, W., & Bruzzone, L. (2017). Dynamic simulation of an electric stair-climbing wheelchair. International Journal of Automation Technology, 11(3), 472–480. https://doi.org/10.20965/ijat.2017.p0472

[15] Honarmandi, P., Peters, E., & Tang, N. (2024). Design and prototype a stair-climbing wheelchair. Journal of Engineering and Science in Medical Diagnostics and Therapy, 7(4), 041001. https://doi.org/10.1115/1.4064599