DESIGN AND FABRICATION OF FOUR-WHEEL STEERING MECHANISM

Dr. Y. Ramamohan Reddy[1] Aman S[2] Misba P[3] Eshwar S[4] Hafriz D[5] Harsha A[6]

[1]Associate professor, Department of Mechanical Engineering, Srinivasa Ramanujan Institute of Technology, Ananthapuramu, Andhrapradesh. (yrammohanreddy@gmail.com)

[2,3,4,5,6] Students, Department of Mechanical engineering, Srinivasa Ramanujan Institute of Technology, Ananthapuramu, Andhra Pradesh.

Abstract:

The primary goal of the Design and Fabrication of Four-Wheel Steering Mechanism is to create a simple yet effective four-wheel steering system that improves vehicle control and manoeuvrability. Conventional cars often only feature front-wheel steering, limiting their turning radius and agility. This concept provides a solution to this restriction by incorporating a four-wheel steering mechanism that allows both the front and back wheels to actively participate in steering. These days, the issue of increased street mobility has made vehicle treatment more difficult. As a result, there is a need to develop an alternative mechanism for easy vehicle steering. When a vehicle is in a congested or limited region, a better turning response is desired, or we may wish the car to drive with less movement. This four-wheel steering system is made of mild steel and employs a linkage system, in which the front and back wheels are linked together so that both wheels turn at the same time. There are numerous benefits to using a four-wheel steering system, including the ability to drive the vehicle more precisely, particularly when cornering, parking, or traveling in narrow locations.

Keywords: Four-wheel steering, Fabrication, Steering, Stability, Mechanism.

I. INTRODUCTION

The evolution of automotive technology has witnessed continuous advancements aimed at enhancing vehicle performance, safety, and manoeuvrability. One such innovative feature is the Four-Wheel Steering (4WS) mechanism, which introduces steering control to all four wheels of a vehicle.[1] Lohith, K., S. R. Shankapal, and H. Monish Gowda. "Development of four-wheel steering system for a car." *SASTech-Technical Journal of RUAS* 12.1 (2013): 90-97. Traditionally, vehicles are equipped with front-wheel steering systems, but the incorporation of 4WS offers numerous benefits, including improved stability, reduced turning radius, enhanced handling, and increased safety.[2] PADWAL, PRANITA, et al. "Four-Wheel Steering Mechanism-Review." *JournalNX* 4.10 (2017): 1-4. Four-wheel steering (4WS) is a vehicle control system that allows all four wheels to be steered in response to driver input, enhancing stability. Four-wheel steering gives an extra level of control by allowing the back wheels to turn, in contrast to conventional two-wheel steering systems that only guide the front wheels.[3] Vanamala, Uma Maheshwar. *An innovative design concept of four-wheel steering mechanism for an automobile*. No. 2013-01-2845. SAE Technical Paper, 2013. This novel device is intended to enhance a car's handling qualities, especially in low-speed situations and when performing tight turns.[4] Kolekar, Mr Aniket, et al. "Review on Steering Mechanism." (2017). This comes in two primary varieties: passive and active. In passive systems, the steering angle and vehicle speed, among other variables, control how the rear wheels, which are mechanically connected to the front wheels, turn. This design improves low-speed agility, which makes parking and navigating through crowded locations easier. [5] Rehan, Ansari, et al. "Design & Synthesis of Four-Wheel Steering Mechanism." *International Refereed Journal of Engineering and Science* 6.4 (2017): 17-20. Conversely, active systems provide a greater degree of adaptability to various driving situations by using electronic control to independently steer the rear wheels. In order to evaluate variables like vehicle speed, steering input, and lateral acceleration and modify the rear wheel angles appropriately, these systems frequently use sensors and algorithms. Increased stability is one of the main advantages of four-wheel steering, particularly while lane changing and cornering at high speeds.[6] Bhishikar, Saket, et al. "Design and simulation of 4-wheel steering system." *International Journal of Engineering and Innovative Technology* 3.12 (2014): 351-367. The car performs better overall when the rear wheels are driven in the same direction as the front wheels at higher speeds. This makes the car more responsive and stable. Furthermore, the ability to turn the rear wheels in the opposite direction of the front wheels minimizes the turning radius, making the vehicle more agile while navigating tight places or parking at reduced

speeds. Four-wheel steering systems can increase a vehicle's complexity and cost despite their benefits.[7] Singh, Bhupendra Pratap, et al. "Advanced four-wheel steering system." *International Journal of Research in Engineering & Advanced Technology [IJIERT]* 3.2 (2015). Equipment and specific knowledge may be needed for maintenance and repairs. Additionally, the steering reaction may feel different from conventional two-wheel steering systems, thus the driver must adjust. Four-wheel steering will probably be improved considerably more as technology develops, providing even more accurate control and helping to improve automobile performance and safety. [8] Shadab, Alam, et al. "Four Wheel Steering System." (2018).

Widely used two-wheel steering system lags in stability during high speeds, lane changing becomes a difficult task, it also faces problem while parallel parking. Since the front wheels are over burden, as engine is placed at frontier position, due to these front tyres wear out quickly. As wheels are overburdened, it tends to under steer. [9] Whitehead, John C. "Four wheel steering: Maneuverability and high speed stabilization." *SAE Transactions* (1988): 668-679. While a heavy front provides adequate starting torque on wet roads, in all other conditions torque from a front wheel steer vehicle is inferior to a rear wheel steer vehicle. This is due to non-uniform weight distribution. The rear end of a front wheel steer vehicle is considerably lighter than its front end, which means the rear tyres do not grip the road very well. Since steering and engine power is handled by the front wheels, the latter sometimes tends to compromise the former. The force generated front the engine, sometimes tends to pull the either to the right or to the left.[10] Shekh, Mubina, O. P. Umrao, and Dharmendra Singh. "Kinematic Analysis of Steering Mechanism: A Review." *Proceedings of International Conference in Mechanical and Energy Technology: ICMET 2019, India*. Springer Singapore, 2020. This is referred to as torque steering. According to news published in The Economic Times dated 28.dec.2016 which clearly stated that India ranks first in Road deaths in the world, where India accounts for 10 percent of global road accidents with more than 1.46 lakh fatalities annually, highest in world. By research done by NPTEL, Bank Bazar, Low man law firm mechanical failure that causes road accidents reports steering system to be on third position. Mumbai-Pune expressway road accident study conducted by JP Research India concluded top contributing factors influencing occurrence of accidents.

II. DESIGN AND FABRICATION

Visualizing a design on paper is a fundamental and essential stage in the creative process. It serves as the canvas for initial ideas, allowing designers to quickly sketch and explore different concepts. The tangible nature of paper provides a hands-on experience that fosters creativity and allows for rapid iteration. This method not only aids in refining design elements but also acts as a powerful tool for effective communication. Hand-drawn sketches offer a clear and immediate way to convey ideas to clients and team members, aligning everyone's vision before moving into digital or more detailed phases of the design process. In essence, visualizing on paper is a dynamic starting point that sets the foundation for successful design execution. Below are some of the references of the rough designs on the paper we came up with before going to the next step i.e. designing on CAD (Computer Aided Drafting)

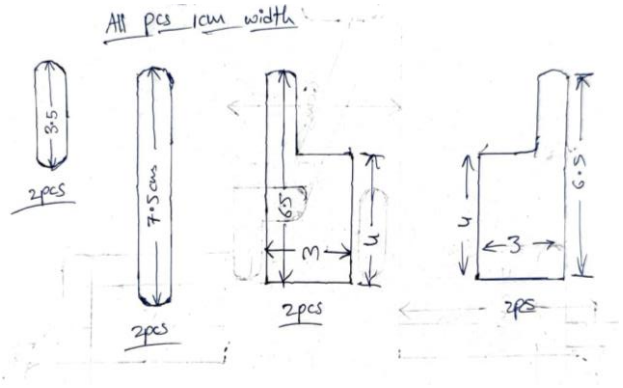

Figure 1. Rough sketch of links

The preliminary illustration depicts the integral components involved in the construction of a four-wheel steering mechanism. Specifically, the initial figures showcase the linkage parts that play a crucial role in this system. The last two pieces highlighted in the depiction are poised to establish a connection with the wheels. These final components are designed to actively engage with the wheels, effectively translating the applied force from the other links into rotational motion. In essence, these last two pieces act as the intermediaries, responding to the forces exerted on them by the other components and translating that energy into the desired movement of the wheels. The careful integration of these elements in the four-wheel steering mechanism is paramount to achieving synchronized and responsive steering, enhancing the overall manoeuvrability and control of the vehicle.

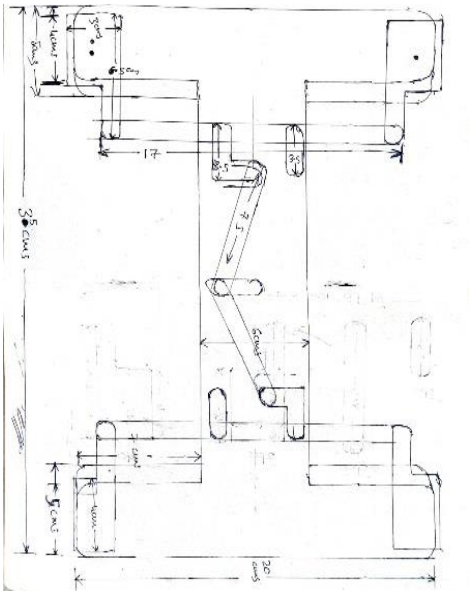

Figure 2. Final Rough Sketch

The initial figure provides a comprehensive representation of the chassis intended for use in our project, offering detailed insights into its shape, design, and dimensions. This visual depiction serves as a foundational reference for the fabrication process, outlining the structural framework that will form the backbone of our project. The figure not only showcases the overall silhouette of the chassis but also captures the intricate design elements that contribute to its functionality. By presenting the dimensions, this visual aid plays a crucial role in ensuring precision during the fabrication phase, acting as a guide for the accurate assembly of the chassis components. The clarity provided by this visual reference is instrumental in aligning the fabrication team with the project specifications, promoting consistency and reliability in the construction of the chassis for our endeavor.

3D Modelling of the design:

The 3D drawings for the four-wheel steering mechanism were meticulously created using Computer-Aided Design (CAD) software, specifically CATIA. This sophisticated software played a crucial role in transforming initial rough sketches into detailed and accurate representations of the mechanical components that constitute the steering system. The design process began with the collection of conceptual sketches, which served as the foundation for the 3D modelling. CATIA's intuitive interface and robust modelling tools allowed the designers to translate these rough ideas into a digital format. Each component of the steering mechanism, including linkages, joints, and support structures, was carefully modelled to ensure precision and adherence to design specifications. CATIA's parametric modelling capabilities were instrumental in making the design adaptable to changes and iterations. This feature allowed designers to modify dimensions, angles, and other parameters seamlessly, facilitating the optimization of the four-wheel steering mechanism for optimal performance. The software's ability to create assemblies enabled the integration of individual components, providing a comprehensive view of how the entire system would function cohesively. Moreover, CATIA's rendering capabilities allowed for the creation of realistic visualizations of the four-wheel steering mechanism. These visualizations played a crucial role in the

design review process, providing stakeholders with a clear and vivid understanding of the final product before the fabrication phase. On ce the 3D models were finalized, they served as the basis for generating detailed engineering drawings. These drawings, created with precision and accuracy, included all necessary dimensions, and annotations required for the fabrication process. CATIA's drafting tools facilitated the creation of these detailed drawings, ensuring that the fabrication team had the essential information needed to bring the design to life. In summary, the utilization of CATIA in the design process was pivotal to the success of the project. The software's capabilities not only allowed for the transformation of rough sketches into intricate 3D models but also streamlined the design iteration process and facilitated effective communication between the design and fabrication teams. The result is a well-conceived and precisely engineered four-wheel steering mechanism ready for fabrication and testing.

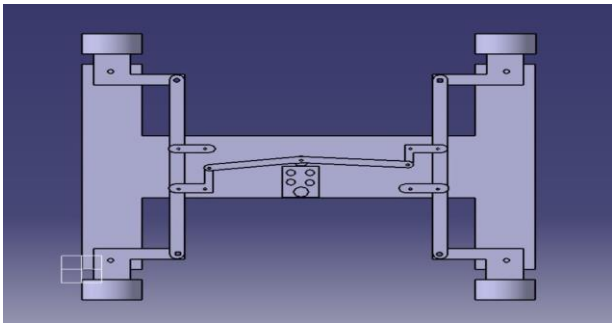

Figure 3. Top view of the model

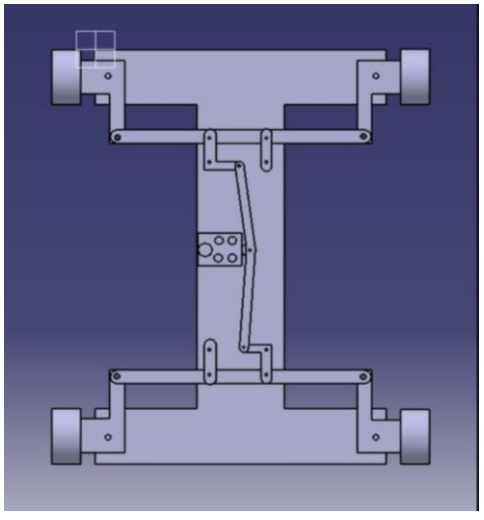

Figure 4. Top view

The top views of the four-wheel steering project provide a comprehensive visual representation of the entire steering mechanism. This includes various linkages and their interconnections, which are essential for coordinating the steering of all four wheels simultaneously. Linkages are mechanical connections that transmit motion and force between different parts of a system. In this project, the linkages are crucial elements that enable the synchronized steering of all four wheels. They are likely designed to convert the rotational motion generated by the steering mechanism into the lateral movement required to turn each wheel. The top view reveals the arrangement and positioning of the linkages, showing how they are connected to each other and to other components within the system. This layout is meticulously designed to ensure proper coordination and synchronization of the steering action across all four wheels. The depiction of the wheels in the top view provides insight into their positioning relative to each other and to the vehicle's chassis. Proper wheel placement is essential for achieving stability, maneuverability, and optimal performance during steering maneuvers. The placement of motors responsible for operating the linkages is also visible in the top view. These motors play a crucial role in translating the driver's steering inputs into mechanical motion, which in turn adjusts the orientation of the wheels accordingly.

Through the visual representation, one can infer how the motors interact with the linkages to control the steering of all four wheels simultaneously. This operation is likely based on a sophisticated control system that interprets input signals and coordinates the movement of the linkages to achieve the desired steering angles for each wheel.

Fabrication:

We have opted to use an 18-gauge mild steel metal sheet for fabricating our prototype. This choice offers several advantages, Mild steel is known for its strength and durability, making it suitable for withstanding various stresses and impacts. The material's strength ensures that the prototype can withstand the forces exerted on it during operation or testing without deforming or breaking easily. Despite being robust, mild steel is relatively lightweight compared to other metals, which is advantageous for portability and handling. Mild steel is often more affordable compared to other metals, contributing to cost efficiency in prototype fabrication. we have considered the dimensions of the prototype to ensure clarity in understanding how the links control the front and rear wheels simultaneously, as well as ensuring portability. This involves: By designing the prototype with dimensions that allow for easy visualization of how the links operate, you make it simpler for observers to understand the mechanism behind controlling both sets of wheels concurrently. Ensuring that the dimensions are comprehensible to everyone implies that the prototype's design is user-friendly and accessible to a wide audience, facilitating communication and collaboration in development or demonstration. Dimensional considerations extend to making the prototype portable, meaning it can be easily transported or moved from one location to another. This enhances its practicality and usability for testing or showcasing purposes. Components of the fabrication consists the I-shaped base frame, crafted from cold rolled mild steel, embodies crucial attributes: durability, strength, and lightweight construction. This material selection ensures the base frame can withstand the rigors of operational demands while maintaining structural integrity over time. Its robust nature enables it to support all the intricate components of the mechanism without succumbing to deformation or failure. Despite its formidable strength, the base frame remains remarkably light, easing transportation, installation, and handling processes. Furthermore, cold rolled mild steel's inherent resistance to corrosion enhances the longevity of the base frame, ensuring sustained performance even in challenging environmental conditions. Its malleability facilitates precise fabrication, allowing for the creation of a meticulously designed component tailored to the specific requirements of the mechanism. Additionally, the cost-effectiveness of mild steel makes it an economically viable choice, providing an optimal balance between quality, performance, and affordability. Overall, the I-shaped base frame, forged from cold rolled mild steel, stands as a cornerstone of stability, durability, and functionality within the mechanism's architecture.

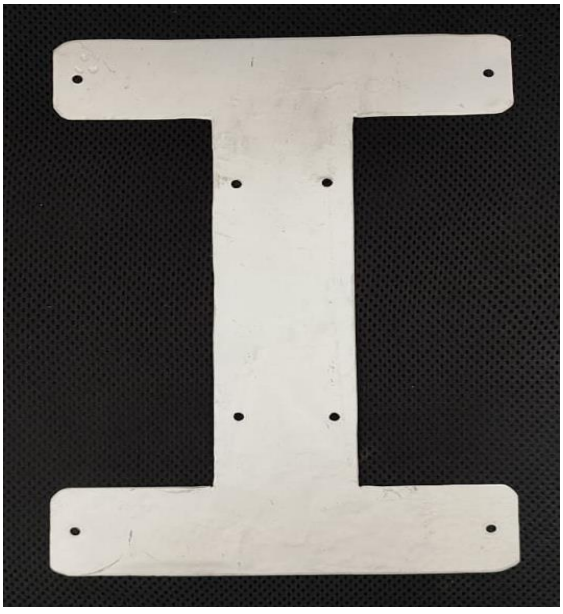

Figure 4. I shaped base frame

The linkages, crucial components within the mechanism's steering system, are crafted from cold rolled cast iron sheet, albeit with a slightly thinner gauge of 20 instead of 18. Despite the slight reduction in gauge, the cold rolled cast iron sheet maintains sufficient strength to support the demands of steering all four wheels simultaneously. The precise fabrication and assembly of the linkages allow for seamless connection, enabling synchronized steering across all wheels. By coordinating the movement of all four wheels, the linkages contribute to the stability and responsiveness of the mechanism, whether traversing rugged terrain or navigating tight spaces. Overall, the linkages, meticulously crafted from cold rolled cast iron sheet with a gauge of 20, serve as integral components in the steering system, ensuring coordinated movement and enhancing the overall performance and functionality of the mechanism. We have used a 300-rpm dc motor in this project to automatically operate the linkages and steer all the four wheels at the same time. These motors are simple DC Motors featuring gears for the shaft for obtaining the optimal performance characteristics. They are known as Center Shaft DC Geared Motors because their shaft extends through the center of their gearbox assembly. These standard size DC Motors are very easy to use. A two-way toggle switch is a type of electrical switch commonly used in circuits to control the flow of electricity. It is called a "two-way" switch because it has two possible positions that it can be toggled between. In a typical two-way toggle switch setup, there are three terminals: one common terminal and two traveller terminals. When the switch is toggled to one position, the common terminal is connected to one of the traveller terminals, and when toggled to the other position, the common terminal is connected to the other traveller terminal. This arrangement allows electricity to flow through the circuit when the switch is in either position, completing the circuit and turning the light or other electrical device on, and breaking the circuit to turn it off. Wheels are essential components of transportation and mobility, acting as basic instruments for moving across varied terrains and situations. These circular devices, which are frequently mounted on axles, are intended to reduce friction between a moving object and the surface it traverses, allowing for smoother and more efficient motion. From the solid wheels of ancient carts to the pneumatic tires of modern automobiles, the evolution of wheel technology has been inextricably linked with human progress. Wheels are ubiquitous throughout sectors and applications, whether as casters for furniture movement, spoked wheels for bicycle performance, or large earthmoving tires for heavy machines. Beyond their practical utility, wheels represent invention and inventiveness, representing humanity's never-ending drive for increased mobility and efficiency.

III. RESULTS AND DISCUSSION

The final assembly shows how a four-wheel steering mechanism linkage will look like after assembling all the parts together and how it will function showcasing the working of four-wheel steering. The links relate to the help of nuts and screws on the I shaped base frame. The four wheels are attached to the links with the help of a freely rotating wheel coupler. The DC motor is connected to the 2-way toggle switch and the middle link. To operate the motor, a 12V battery is connected along with a switch to control the power supply. When the power is supplied to the motor from the battery through the toggle switch, the motor will rotate and the links connected in series to the motor and wheels will turn the wheels in one direction, with the help of a toggle switch we can steer the wheels in both the directions.

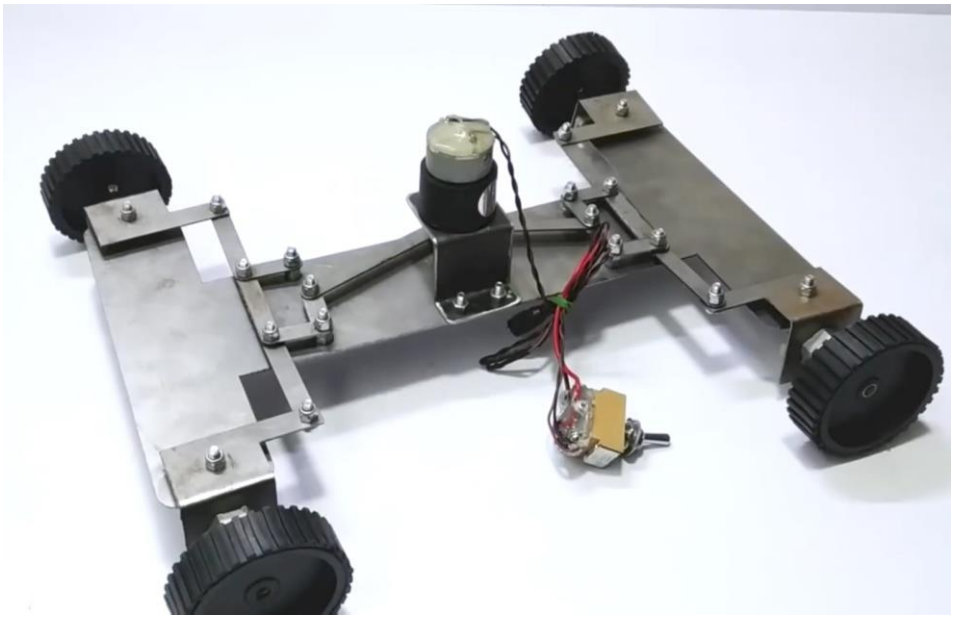

Figure 6. Final assembly

A four-wheel steering mechanism provides unique ideas for improving vehicle dynamics and manoeuvrability. Unlike typical two-wheel steering systems, which solely control the front wheels, four-wheel steering uses technology to allow the back wheels to turn in tandem with the front. This innovative technique tackles numerous major issues with traditional steering configurations. Primarily, the four-wheel steering system excels in addressing the intricacies of low-speed manoeuvrability. Negotiating tight spaces and parking in urban environments becomes markedly more effortless as the rear wheels pivot in the opposite direction to the front wheels. This intricate choreography substantially reduces the turning radius, providing a heightened level of agility crucial for navigating confined spaces with finesse. Moving beyond the realm of low-speed scenarios, the system's prowess extends to higher speeds, where it becomes a stalwart contributor to stability and superior handling. The rear wheels can pivot in tandem with the front wheels, bolstering the vehicle's stability during rapid lane changes and high-speed manoeuvres. This translates to a driving experience imbued with heightened confidence and control, particularly when faced with challenging road conditions or emergency situations. Beyond the realms of manoeuvrability and stability, the four-wheel steering mechanism emerges as a linchpin in optimizing overall vehicle performance. By intelligently distributing the steering load across all four wheels, the system enhances traction and control, particularly evident during cornering. This meticulous load distribution translates into improved grip, effectively mitigating the risk of understeer or oversteer tendencies. The net result is a vehicle that boasts heightened responsiveness and handling precision, elevating the driving experience to new levels of sophistication. In summation, the four-wheel steering mechanism represents a paradigm shift in automotive engineering, offering a holistic and nuanced approach to vehicle dynamics. From the finesse required in low-speed scenarios to the demands of high-speed stability and the intricacies of cornering, this innovative technology seamlessly addresses these challenges, redefining the expectations associated with conventional steering systems.

CONCLUSION

In conclusion, the design and fabrication of the four-wheel steering mechanism project has proven to be a significant endeavor with promising outcomes. Through meticulous planning, innovative design considerations, and precise fabrication techniques, our team has successfully developed a system that enhances the maneuverability and stability of a four-wheeled vehicle. The integration of four-wheel steering introduces a futuristic shift in traditional vehicle dynamics, providing advantages in terms of reduced turning radius, improved handling, and enhanced safety. Our project aimed not only to conceptualize and design the mechanism but also to bring it to fruition through careful fabrication and assembly processes. Throughout the project, we encountered and overcame various challenges, such as optimizing the linkage system, ensuring synchronization between front and rear wheels, and addressing potential issues related to control and

feedback. The successful implementation of this project opens possibilities for future applications in both commercial and automotive sectors. The technology developed can be further refined and adapted for different vehicle types, contributing to advancements in the field of transportation. The insights gained from this project can also serve as a foundation for future research and development in the quest for more efficient and dynamic vehicle systems. In essence, the design and fabrication of the four-wheel steering mechanism project not only demonstrates our engineering prowess but also underscores our commitment to pushing the boundaries of conventional automotive design. The knowledge and experience gained from this project will undoubtedly pave the way for future innovations in vehicle

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