iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78820

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

Development of a Springless Suspension System Using Bevel Gear Mechanism

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Abstract: Suspension systems are fundamental to vehicle performance, ensuring ride comfort, stability, and safety by mitigating vibrations caused by road irregularities. Traditional suspension systems depend on springs and dampers, which are susceptible to fatigue, deformation, and maintenance challenges over prolonged use. This paper presents the design and development of a springless suspension system utilizing a bevel gear mechanism.

The proposed system operates by converting vertical wheel displacement into rotational motion, thereby redistributing impact energy and minimizing direct transmission of shocks to the vehicle frame. A functional prototype incorporating bevel gears, DC motors, and an Arduino-based control unit with Bluetooth communication was developed. Experimental evaluation under simulated uneven surface conditions demonstrates improved smoothness, reduced shock transmission, and stable operation.

The study validates the feasibility of a gear-based suspension mechanism and highlights its potential for low-speed vehicles, robotic platforms, and experimental applications. Future enhancements involving damping integration and analytical modeling can further improve performance.

Keywords: Springless Suspension, Bevel Gear Mechanism, Shock Absorption, Mechanical Motion Conversion, Vehicle Dynamics

I. INTRODUCTION

Suspension systems are critical for maintaining vehicle stability and ensuring passenger comfort. They isolate the vehicle body from road-induced disturbances and maintain tire contact with the ground. Conventional suspension systems employ springs and dampers, which absorb and dissipate energy through elastic deformation and viscous damping.

However, these systems suffer from several drawbacks, including:

- Fatigue failure due to cyclic loading
- Wear and tear over prolonged operation
- Limited adaptability to varying road conditions
- Increased maintenance requirements

To address these limitations, alternative suspension mechanisms have been explored. One such approach is the springless suspension system, which eliminates traditional springs and instead utilizes mechanical or electromagnetic principles for shock absorption.

In this work, a bevel gear-based suspension system is proposed, where vertical motion is converted into rotational motion. This method enables energy redistribution without relying on elastic components, thereby reducing fatigue-related failures and maintenance.

II. LITERATURE REVIEW

Extensive research has been conducted on gear mechanisms and alternative suspension systems. Bevel gears are widely used in power transmission between intersecting shafts and are known for their efficiency and reliability. Studies on bevel gear geometry and stress analysis provide insights into load distribution and durability.

Magnetic suspension systems have been proposed as springless alternatives; however, they require complex control systems and high energy consumption. Gear-based suspension mechanisms have also been investigated for their ability to convert linear motion into rotational motion, thereby reducing shock transmission.

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Despite these developments, most studies remain theoretical or focus on individual components rather than complete system implementation. There is a clear need for experimental validation of a practical springless suspension system using bevel gears, which forms the basis of this research.

III. METHODOLOGY

The methodology adopted in this work follows a systematic approach:

1) Problem Identification: Analysis of limitations in conventional suspension systems
2) Concept Development: Designing a springless mechanism using bevel gears
3) Component Selection: Selection of gears, motors, and control components
4) Prototype Fabrication: Assembly of mechanical and electrical systems
5) Control Integration: Implementation of Arduino-based control
6) Experimental Testing: Evaluation under simulated conditions
7) Performance Analysis: Observation and comparison of results

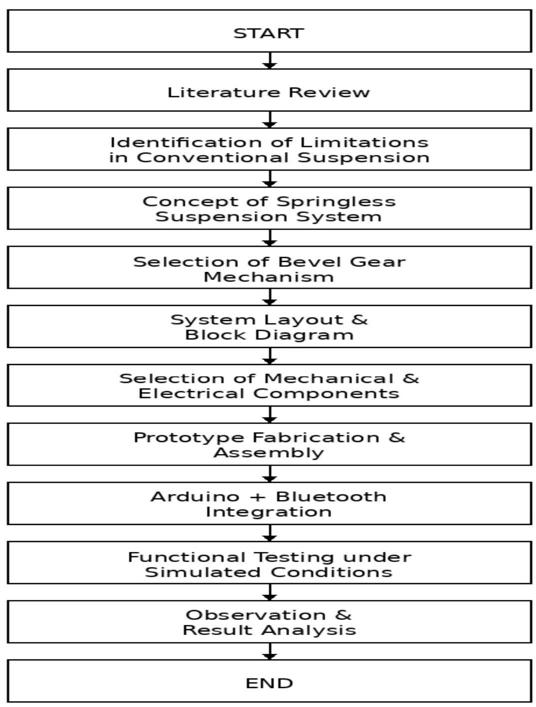

Fig. 1 Methodology Flowchart

IV. SYSTEM DESIGN

The proposed system consists of three main subsystems:

A. Mechanical Subsystem

Includes bevel gears, shafts, wheels, and supporting frame. The bevel gears are arranged at 90° to facilitate motion conversion.

B. Electrical Subsystem

Consists of DC motors, power supply, and motor driver module (L298N) for driving the gears.

C. Control Subsystem

Arduino UNO microcontroller is used for controlling motor operation, with Bluetooth communication enabling wireless control.

Table I: System Components

Subsystem	Components
Mechanical	Bevel gears, shafts, wheels
Electrical	DC motor, power supply
Control	Arduino UNO, Bluetooth

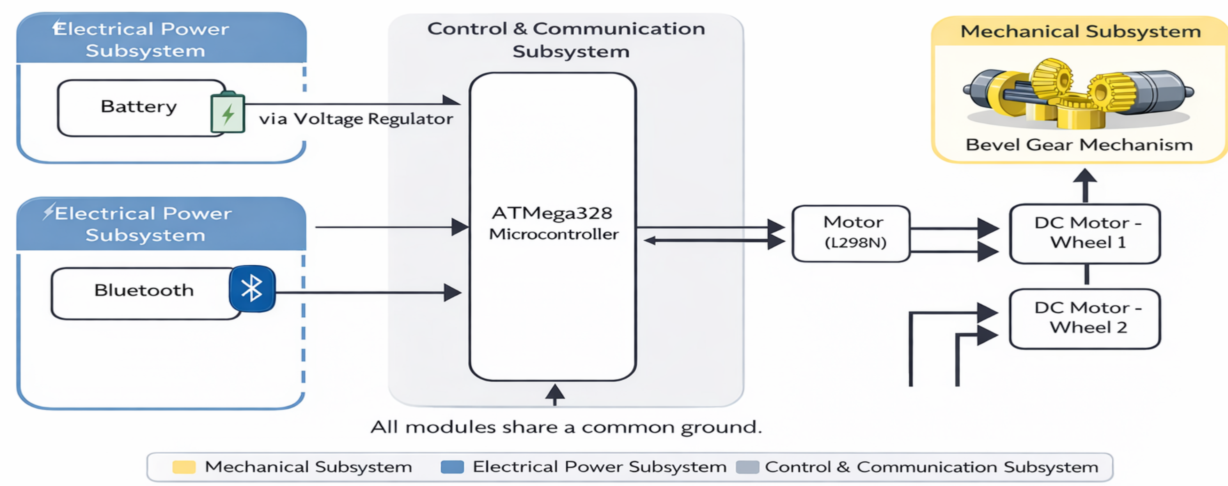

Fig. 3.3 System block diagram of bevel gear-based springless suspension prototype

Fig. 2 System Block Diagram

V. WORKING PRINCIPLE

The working principle is based on mechanical energy transformation. When the wheel encounters an uneven surface, vertical displacement occurs. This displacement is transmitted to the bevel gears through shafts. The gears convert this linear motion into rotational motion, which redistributes the impact energy.

Unlike conventional systems, where energy is absorbed through spring compression, the proposed system dissipates energy through controlled rotational movement. This reduces sudden shock transmission and improves system stability.

VI. EXPERIMENTAL SETUP

The prototype was fabricated using locally available components and mounted on a rigid frame. The system includes:

- Bevel gear assembly
- DC motors (60 RPM)
- Arduino UNO controller
- Bluetooth module

Testing was conducted by simulating uneven road conditions using artificial bumps. Key parameters observed include:

- Wheel displacement
- Gear rotation
- Frame stability
- Shock transmission

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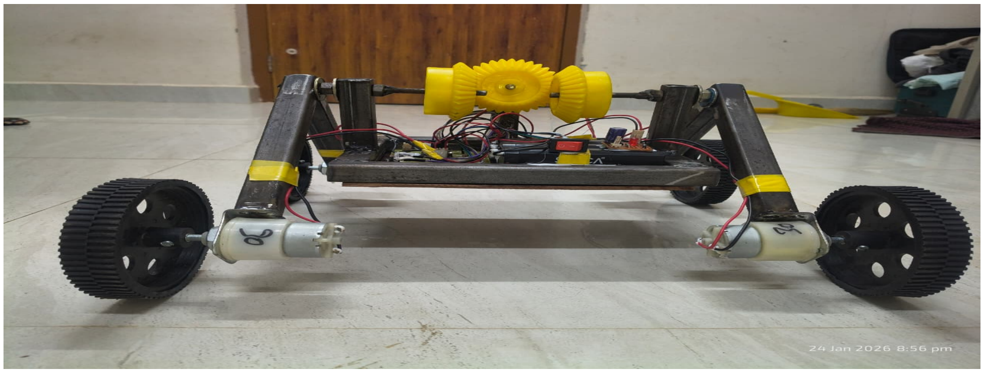

Fig. 3 Experimental Setup of Prototype

VII. RESULTS AND DISCUSSION

A. *Shock Absorption Performance*

The system demonstrated a noticeable reduction in sudden jerks. The conversion of vertical motion into rotational motion resulted in smoother energy dissipation.

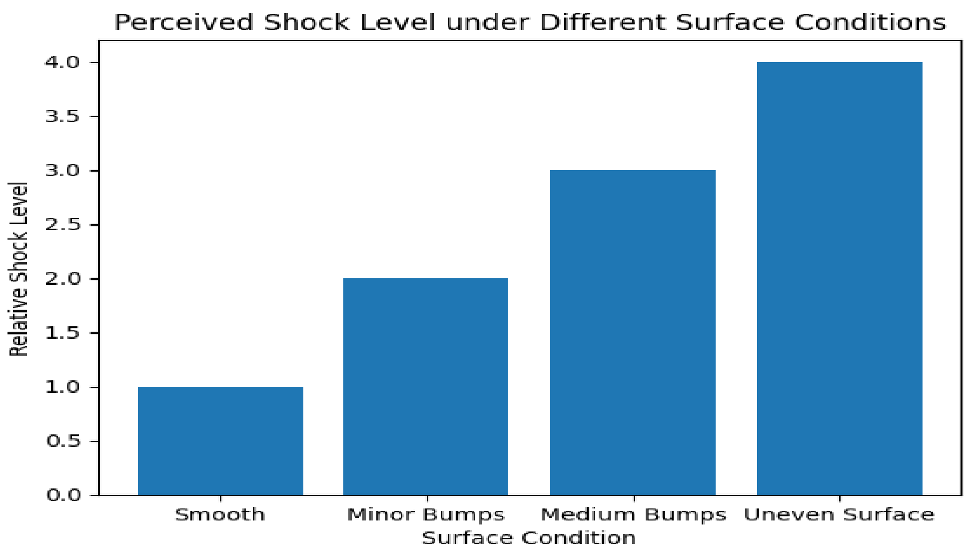

Fig. 4 Shock Level vs Surface Condition

B. *Gear Response*

- Smooth meshing of gears
- No mechanical locking
- Balanced load distribution

C. *Stability Analysis*

The supporting frame exhibited minimal vibration, indicating stable system behavior.

D. *Energy Redistribution Insight*

The bevel gear mechanism acts as an energy redistribution system, converting impact forces into rotational energy. This reduces localized stress and enhances durability.

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VIII. COMPARISON WITH CONVENTIONAL SUSPENSION

Table II: Performance Comparison

Parameter	Conventional	Proposed
Shock absorption	Spring-based	Gear-based
Maintenance	High	Low
Fatigue	High	Low
Damping	High	Moderate
Complexity	Low	Moderate

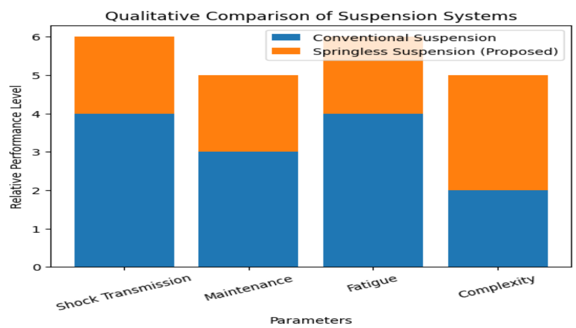

Fig. 5 Comparative Analysis Graph

IX. CONCLUSION

The developed springless suspension system successfully demonstrates the feasibility of using bevel gears for shock absorption. The system effectively converts vertical displacement into rotational motion, reducing shock transmission and improving stability.

The results validate the concept at a prototype level, indicating potential for applications in low-speed vehicles and experimental platforms. Further enhancements can improve performance for real-world applications.

X. FUTURE WORK

- Integration of damping elements
- Finite Element Analysis (FEA) for stress evaluation
- High-speed and load testing
- Sensor-based adaptive control
- Optimization for commercial vehicles

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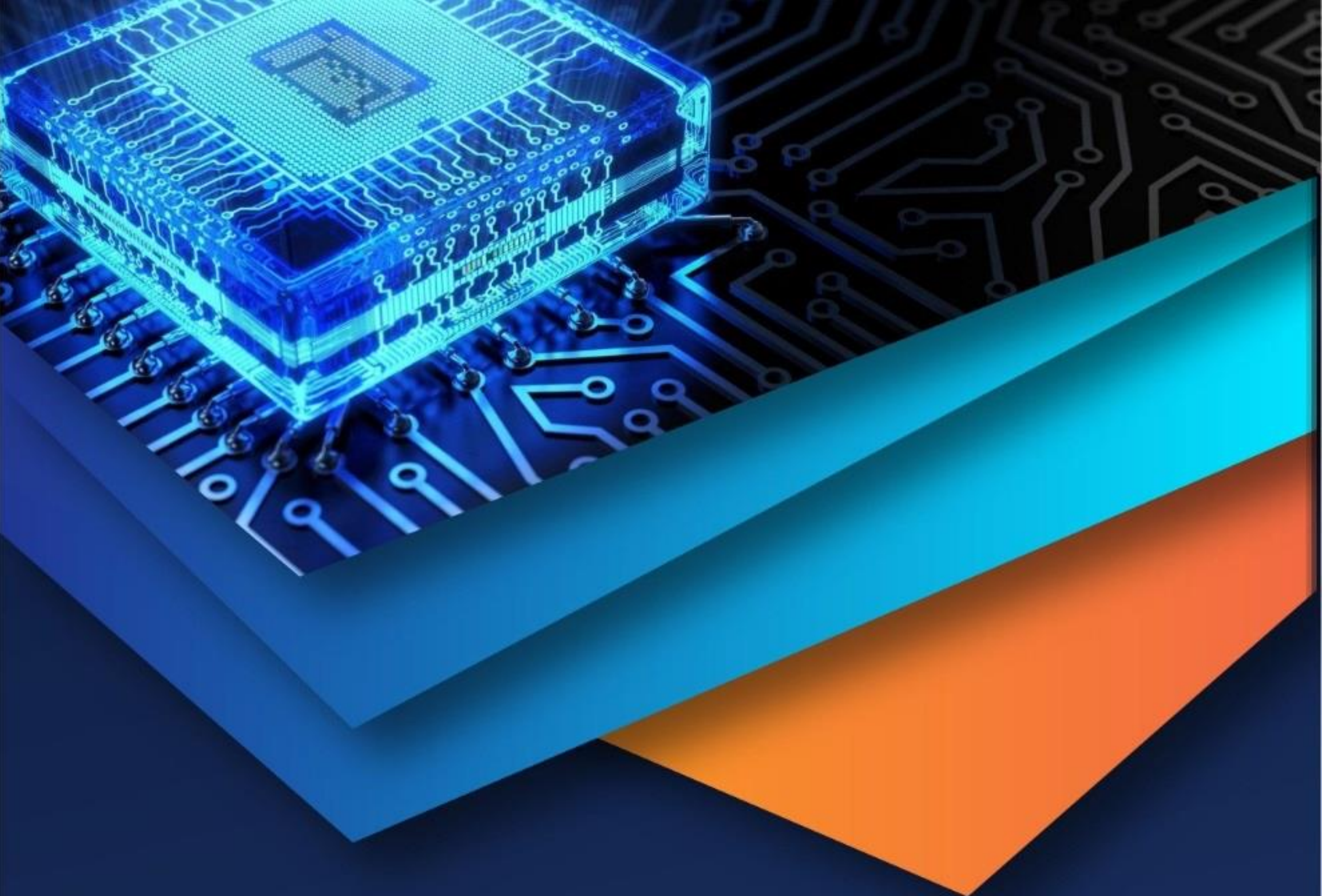

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