

# Prototype of Self Balancing Bicycle

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## ABSTRACT

**This project presents the design and development of a self-balancing bicycle prototype utilizing a mechanical gyroscopic stabilization system. The entire structure, including the chassis, wheel rims, and body, is 3D printed using PETG material, while the tires are fabricated using flexible TPU filament for enhanced grip and cushioning. The key innovation in this prototype lies in its mechanical gyroscope-based balancing mechanism, where a high-speed 1400 KV BLDC drone motor spins a horizontal wheel mounted on a pivoting platform. When the bicycle tilts to either side, the gyroscopic wheel tilts forward or backward respectively, generating a gyroscopic precession force that restores balance. This system allows the bicycle to maintain upright stability without requiring digital feedback control. Directional control is achieved using a servo motor attached to the front fork, allowing the bicycle to turn left or right. For propulsion, a 60 RPM BO motor drives a small roller wheel in contact with the rear tire, enabling forward and reverse motion. The entire system is powered by two lithium-ion cells and controlled using a NodeMCU microcontroller, with an L298N motor driver regulating the rear motor. This project demonstrates an effective and low-cost approach to self-balancing vehicle design, combining mechanical principles with minimal electronics, and offers a platform for further development in autonomous or rider-assistive bicycle technologies.**

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## 1. INTRODUCTION

This project presents a self-balancing bicycle prototype that uses a mechanical gyroscopic stabilization system to stay upright. Unlike advanced electronic balancing systems that rely on sensors and complex control algorithms, this design uses the basic physics principle of gyroscopic precession to maintain balance in a simpler and more cost-effective way. The entire bicycle frame, wheel rims, and chassis are 3D printed using PETG, chosen for its strength and durability. The tires are printed with TPU, a flexible material that provides better grip and rubber-like properties. The main balancing component is a high-speed rotating gyroscope mounted on top of the chassis.

It is powered by a 1400 KV BLDC motor. The gyroscope is placed on a pivot mechanism that allows it to tilt forward and backward. When the bicycle tilts to one side, the gyro tilts in a specific direction, creating a gyroscopic reaction force that helps bring the bicycle back to its upright position. This system balances the bicycle automatically without electronic feedback. For steering, a servo motor is attached to the front fork and controlled by a NodeMCU microcontroller. Propulsion is achieved using a 60 RPM BO motor connected to a rubber roller that drives the rear tire. An L298N motor driver controls the motor's direction and speed. The system is powered by two lithium-ion batteries. The NodeMCU controls steering and movement and also allows for future upgrades such as wireless control or autonomous features. Overall, this prototype combines mechanical design, electronics, and 3D printing to create a simple, low-cost self-balancing bicycle. It demonstrates how fundamental physics principles can be applied to solve real-world engineering problems.

## 2. METHODOLOGY

The methodology used in this project follows a systematic design and implementation approach. First, the principle of gyroscopic precession was selected as the core balancing mechanism instead of complex sensor-based PID control. A detailed CAD model of the bicycle frame, chassis, and gyroscopic assembly was designed. The structural components were fabricated using 3D printing with PETG material, while TPU was used for flexible tires. Next, the mechanical assembly was completed, including mounting the BLDC motor-driven gyro wheel on a pivot mechanism. The electronic components such as NodeMCU, L298N motor driver, servo motor, and ESC were integrated into the system. Proper electrical connections and power distribution using lithium-ion batteries were established. The NodeMCU was programmed to control steering and rear-wheel motion. The gyroscopic motor speed was calibrated using an ESC and

servo tester. Finally, the prototype was tested under different tilt conditions, and adjustments were made to optimize balancing performance and system stability.

### 3. OBJECTIVES

**To design and fabricate** a lightweight self-balancing bicycle prototype using 3D printing technology (PETG and TPU materials).

**To implement mechanical gyroscopic stabilization** using a high-speed BLDC motor to maintain balance through gyroscopic precession.

**To develop a steering mechanism** using a servo motor for controlled left and right directional movement.

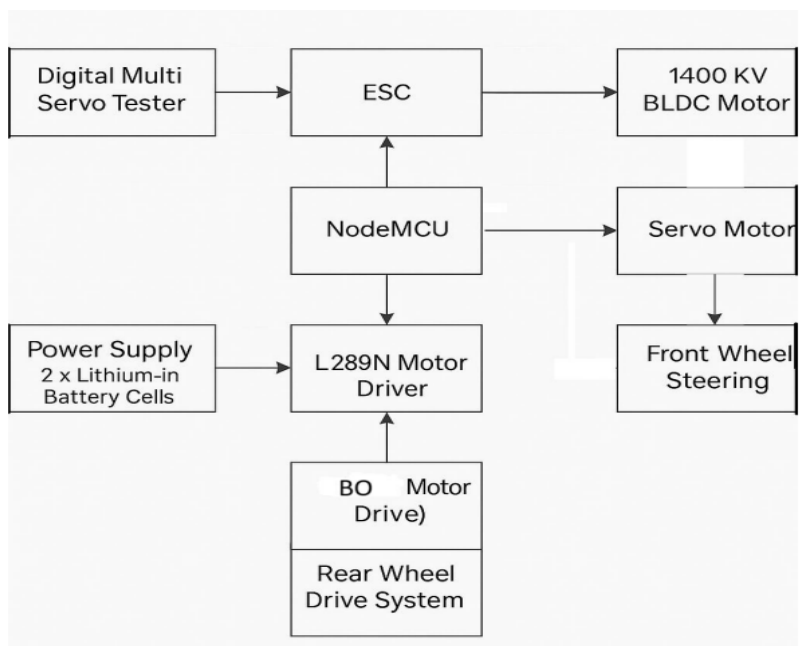
**To provide propulsion control** using a 60 RPM BO motor with an L298N motor driver for forward and reverse motion.

**To integrate a NodeMCU microcontroller** for coordinating motor control and overall system operation.

**To create a low-cost, educational, and scalable prototype** that can be enhanced with future features like wireless control or sensor-based feedback.

### 4. BLOCK DIAGRAM

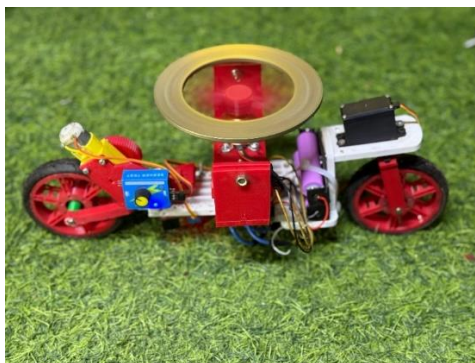
The block diagram represents the overall architecture of the self-balancing bicycle system. It shows the lithium-ion battery supplying power to the NodeMCU, motor driver, servo motor, and BLDC motor with ESC. The NodeMCU acts as the main controller, sending control signals to the steering servo and propulsion motor driver. The BLDC motor drives the gyroscopic wheel to provide stabilization. Together, these interconnected blocks illustrate how power and control flow within the system to achieve balancing and movement.



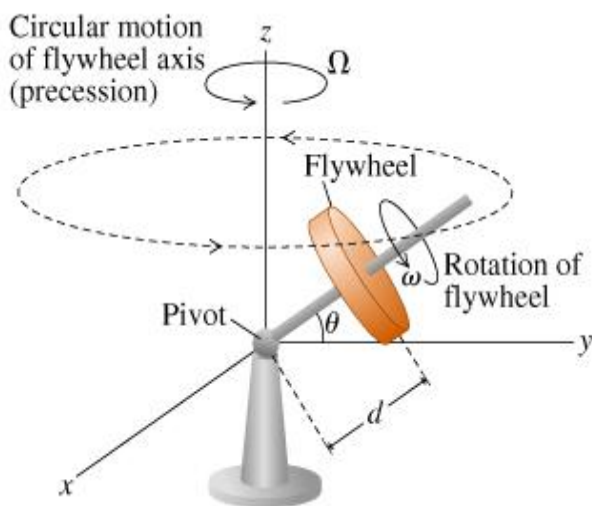
### 5. LITERATURE-REVIEW.

In this project, the literature review focuses on existing studies about self-balancing bicycles, gyroscopic stabilization, and two-wheeled vehicle safety. It examines earlier research papers, technical journals, and online resources to understand how balancing systems have been designed and implemented. For example, research published by IEEE discusses the development of self-balancing robots using gyroscopic principles. Studies from the International Journal of Advanced Robotic Systems explain the design of two-wheeled self-balancing vehicles using sensors and control algorithms. These references help in understanding both mechanical and electronic balancing techniques. The literature review also compares different approaches such as control moment gyroscopes, IMU sensor-based systems, and PID-controlled mechanisms. It highlights the advantages and disadvantages of complex electronic systems versus simpler mechanical methods. By reviewing previous work, the project identifies gaps where a low-cost and mechanically driven solution can be developed. This section provides theoretical background and technical knowledge necessary for designing the prototype. It justifies the selection of a mechanical gyroscopic stabilization system instead of a fully sensor-based control system. Overall, the literature review builds a strong foundation for the project by connecting past research with the current design and innovation.

### 6. COMPONENTS



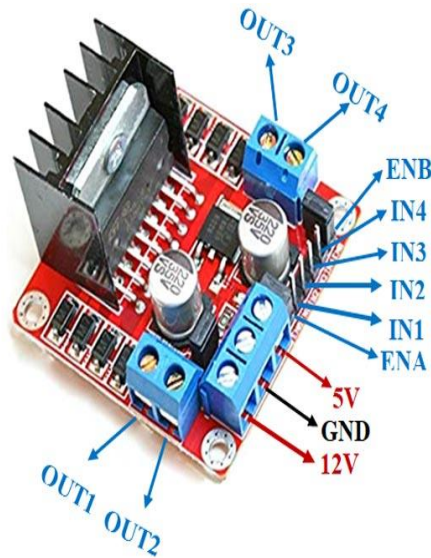
This image shows the complete self-balancing bicycle prototype with all integrated components. The frame is 3D printed using PETG for strength and durability, while TPU tires provide flexibility and grip. The front section includes the steering servo motor, and the rear section contains the propulsion motor. The gyroscopic unit is mounted on the chassis for stabilization. This image gives a clear understanding of the mechanical structure and overall system layout.



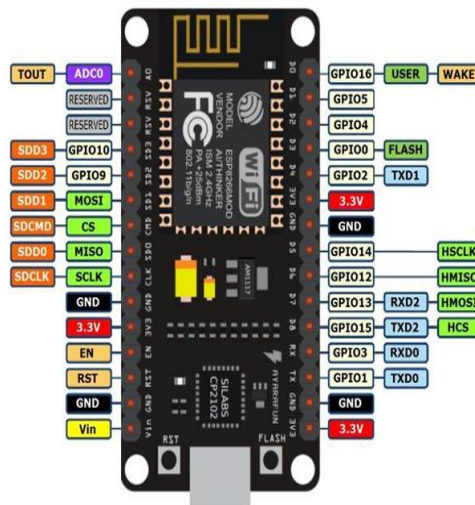
This image illustrates the working principle of the gyroscopic stabilization system. A high-speed rotating flywheel driven by a BLDC motor is mounted on a pivot. When the bicycle tilts to one side, the gyroscope tilts forward or backward. Due to gyroscopic precession, a reactive torque is generated perpendicular to the tilt direction. This restoring torque helps bring the bicycle back to its upright position, enabling automatic balancing motor driving a rotating flywheel mounted on a pivot. When the bicycle tilts, the gyroscope produces a precession effect that generates a restoring torque. This torque helps maintain the upright position of the bicycle, enabling automatic mechanical stabilization.



A **Digital Multi Servo Tester (ESC Tester)** is used to generate PWM signals to test and control servo motors and electronic speed controllers (ESCs). It allows manual adjustment of motor speed or servo position without using a microcontroller. In this project, it is used to control and calibrate the BLDC motor speed for the gyroscopic stabilization system.



The **L298N Motor Driver Module** is used to control the speed and direction of DC motors using an H-bridge circuit. It receives control signals from the Node MCU and drives the BO motor for forward and reverse movement. The module can handle higher current loads and provides stable motor operation in the system



The **Node MCU (ESP8266 Microcontroller)** acts as the main control unit of the system. It processes control signals and sends commands to the servo motor and L298N motor driver for steering and propulsion. It also offers built-in Wi-Fi capability, allowing future upgrades like wireless control or IoT integration

## 7. RESULTS

The prototype successfully achieved partial self-balancing using the gyroscopic stabilization method. • The gyro wheel was effective in reducing tilt when the bicycle leaned to one side, showing that the gyroscopic force played a key role in stability. • The steering and drive systems operated correctly under manual and programmed control. • Overall movement and response time were within acceptable limits, though further tuning may improve balance at lower speeds.

## 8. APPLICATION

The self-balancing bicycle prototype showcases innovative gyroscopic stabilization and basic automation, making it useful in various real-world and educational scenarios. The following are some potential applications

1. Smart Commuting Solutions
2. Autonomous Delivery System
3. Research and Educational Purposes

4. Robotics and AI Development
5. Two-Wheeler Safety Enhancement

## 9. FUTURE SCOPE

1. Full-Scale Model Development
2. Wireless Control and Automation
3. Advanced Balancing Techniques
4. Improved Power and Charging System
5. Obstacle Detection and Navigation

## CONCLUSION

The self-balancing bicycle prototype successfully demonstrates the use of mechanical gyroscopic stabilization to maintain balance. By utilizing the principle of gyroscopic precession, the system achieves real-time stability without relying on complex sensor-based control algorithms. The integration of 3D printed components, BLDC-driven gyro mechanism, Node MCU control, and motor driver circuits results in a compact and cost-effective design. The prototype proves that mechanical physics concepts can be effectively applied to solve balancing challenges. Furthermore, the system provides a strong foundation for future enhancements such as sensor feedback, wireless control, and autonomous navigation.

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  - d. BO 60 RPM Geared Motor.
  - e. Digital Multi Servo Tester for ESC Calibration.