# Design and Fabrication of an Electric Bike with Smart Suspension

, Shubham Wagh[1], Renuka Ranpise[2], Shraddha Halnor[3], Vedant Varule[4]

Prof. Sarika Lugade[5], Prof. Mrunali Yadav[6] Prof. Bhavna Ingole[7] Dr. Usha Pawar[8] Prof. Trupti[9]

*[1]Shubham Wagh, Mechanical Department, Datta Meghe College Of engineering*
*[2]Renuka Ranpise, Mechanical Department, Datta Meghe College Of engineering*
*[3]Shraddha Halnor, Mechanical Department, Datta Meghe College Of engineering*
*4Vedant Varule, Mechanical Department, Datta Meghe College Of engineering*
*[5]Prof. Sarika Lugade, Mechanical Department, Datta Meghe College Of engineering*
*[6]Prof. Mrunali, Mechanical Department, Datta Meghe College Of engineering*
*[7]Prof. Bhavna Ingole, Mechanical Department, Datta Meghe College Of engineering*
*[8]Dr. Usha Pawar, Mechanical Department, Datta Meghe College Of engineering*
*[9]Prof. Trupti, Mechanical Department, Datta Meghe College Of engineering*

---------------------------------------------------------------------***---------------------------------------------------------------------

**Abstract -** This project introduces the design and development of a budget-friendly yet innovative electric bike (e-bike) tailored to improve user experience while keeping affordability in mind, particularly for the Indian market. With the growing need for sustainable transport solutions, this e-bike incorporates a unique smart suspension system that allows each of its two rear wheels to move independently, enabling a tilt of up to 30 degrees. This feature enhances stability, maneuverability, and comfort, making the bike well-suited for both city commuting and light off-road use.To keep manufacturing costs low, conventional fork shock absorbers have been replaced with spring-based shock absorbers, offering a practical balance between cost-effectiveness and functionality. The bike's design has also been carefully crafted to ensure it remains visually appealing and competitive in the market. Furthermore, a built-in safety feature mandates that the rider wear a helmet before the bike can be started, encouraging responsible riding habits.
This report explores the technical aspects, design choices, and cost-efficient strategies used in developing this e-bike. By incorporating advanced features while prioritizing rider comfort, the project aims to deliver an e-bike that caters to modern users' needs while promoting a greener approach to transportation. The insights from this study could also serve as a foundation for future innovations in e-bike technology, especially in emerging markets.

***Key Words***: *Electric bike, e-bike, smart suspension, independent wheel movement, 30-degree tilt, stability, maneuverability, urban commuting, off-road capability, cost-effective, spring shock absorbers, affordability*

## 1.INTRODUCTION

The rise of electric bicycles (e-bikes) marks a major shift in personal transportation, especially in cities. With urbanization and increasing concerns about pollution and traffic, the demand for sustainable and efficient transport is growing. In India, where bicycles and scooters dominate, e-bikes offer a compelling alternative by blending electric mobility with cycling benefits.

This project focuses on designing a cost-effective e-bike for the Indian market, addressing affordability challenges that often limit adoption. Many e-bike models are expensive, making them inaccessible to a large population. By integrating innovative design features and cost-saving strategies, this project aims to create an economical yet practical e-bike.
A key aspect of the design is a **smart suspension system** that allows each wheel to move independently. This enhances ride comfort and enables a **30-degree tilt**, improving stability on turns and rough terrain. The use of **spring shock absorbers** instead of traditional fork shocks further enhances comfort while keeping costs low.
Beyond performance, aesthetics play a crucial role in the bike's appeal. A modern, striking design makes it stand out, attracting younger riders who prioritize both function and style. Additionally, safety is a top priority, with a **helmet detection feature** that prevents the bike from starting unless the rider wears a helmet, reinforcing responsible riding habits.
This report explores the technical specifications, design choices, and cost-effective approaches taken in developing this e-bike. By merging advanced technology with practical solutions, this project aims to contribute to India's electric mobility sector, fostering a more **sustainable and accessible** future for personal transport.

### 1.1 Objectives :

The primary objective of this project is to design and develop a cost-effective and efficient electric bicycle (e-bike) tailored for the Indian market. The focus is on creating a sustainable transportation solution that addresses affordability, performance, and user comfort while promoting the shift towards eco-friendly mobility.

To achieve this, the project aims to:

1. Develop an **affordable** e-bike by implementing cost-efficient design and manufacturing techniques without compromising quality and durability.
2. Enhance **ride comfort and stability** by incorporating an advanced suspension system capable of handling diverse road conditions, including urban streets and uneven terrains.

3. Optimize **battery performance** to ensure longer travel ranges and reduced charging times, making the e-bike a practical alternative to traditional fuel-powered two-wheelers.

4. Integrate **aesthetic and ergonomic design elements** to make the e-bike visually appealing while ensuring ease of use for a wide range of riders.

## 2. LITERATURE SURVEY

### 2.1 Design and Development of Energy Regenerating Electric Two-Wheeler

Authors: Pratik Jaywant Ahire, Ninad Jeevan Deshpande, Abhishek Trimbakrao Khiste

Around 200 Million two wheelers are running on Indian road as on today. The conventional fuel with uncontrolled cost and pollution has created the hazards to the environment. The economies of developing countries like India are also depended upon the cost of fuel as it is consumed in huge amount daily. Most of the transportation is dependent on the conventional fuel like petrol and diesel. The electric bikes in India have been introduced in 1990s but it was not very popular due to the low performance of battery and less mileage per charging. The performance of electric vehicles has improved now with the new charging and battery technologies developed. Authors have proposed the implementation of energy regenerating electric bike in this paper. A prototype is designed, developed and presented in this paper.

### 2.2 Design and Development of Modern Electric Bike

Authors: Prathamesh Nigam, Deepak Sahu, Dr. Anil M. Bisen

The number of automobiles on the roads throughout the globe is increasing at a staggering rate year by year, but the dependence on oil-based fuel grows almost unchecked. Due to this, electric vehicles come into the picture as an alternative. Need for an affordable and efficient mode of transport created a growing demand for Electric Bikes in India too, and this project is taken as an opportunity, rather a challenge to design and develop the best in a class electric bike for the quotidian commute. An electric bike is a two-wheeler propelled exclusively by an electric motor, which is powered by an onboard dedicated battery pack providing it with the required traction energy. The electric bike has an electrical motor with an intelligent controller and a battery pack connected via efficient cabling systems and monitoring instruments in place of an engine and other supporting components of a fuel run bike. Also, the use of electric bikes will cause less environmental pollution and keep our surroundings lively. This project presents a study on the design and development process of a smarter, affordable, and safer electric bike achieved by comprehensive market research, studying the existing options to find what a customer desires, the challenges faced by them and benchmarking our design to meet industry standards

### 2.3 Design and Implementation of a Low-Cost Electric Bike for Domestic Purposes

Authors: Omkar H. Pokharkar, Kshitij R. Lalsare, Anuja S. Mohite, Shamkumar B. Chavan

The aim of this research work is to design and implement a low cost electric bike to use for day to day activities, to analyze the mileage of the bike for every charging per hour. **Method:** Initially the model of Hbridge driver circuitry is created to drive the BLDC motor in Proteus simulation software. PWM pulses are fed to H-bridge driver circuitry and response of the BLDC motor is studied. The speed control mechanism of BLDC motor driver is studied in simulation. Then the H-bridge converter circuitry is designed and developed to drive the BLDC motor. The assembly of BLDC motor and tyre is selected which act as rear wheel. The system is designed around Arduino microcontroller. Lithium ion battery is used to supply power. Program is developed for Arduino Uno microcontroller to generate PWM pulses which are fed to H-bridge driver. The performance of the BLDC motor driver is analyzed. After precise control of the motor and tyre assembly, the other subsystems like speedometer, indicator, accelerator, horn, braking system etc. are developed and tested. Motor controller and status monitoring controller acts in coordination due to which in any faulty or abnormality situation both interacts with each other to take necessary action. Finally the mechanical assembly and chassis is designed and developed. **Findings:** The bike developed in this work is found to be useful for day to day domestic uses. The maximum speed of 40km/ hr is achieved and upon charging for nearly 3 hours it travels around 70km.

### 2.4 Design and Modeling of E-Bike

Authors: Mahesh Palavalasa, R. S. R. Krishnam Naidu, Gayathri Garrepalli, Annapoorna Pinninti, Sai Ganesh Appalabathula, Sudheer Kumar Kalyana, Srinivas Molli, Uma Shankar Narem

This project details about the Electric Bike which runs on the battery thereby providing voltage to the motor. This project compromises with design and fabrication of Electric Bike which makes use of Electric energy as the primary source and solar energy, if possible, by attaching solar panels. It also highlights on the design aspects of the bike. There is a provision for a charging the battery by ejecting it from the main system. The electrical power generated which is used to run the bike can give better fuel economy compared to conventional vehicle, better performance and also causes less pollution. The project is to design a feasible yet highly adaptable E-bike. As the number of motor vehicles on the roads throughout the world increases at staggering rate each year, the dependence on oil-based fuel grows almost unchecked. The increased use of non-renewable fossil fuels brings with it environmental problems such as: the “greenhouse effect”, health problems for city delivers and concern over the stability of fuel supply. To move away from this dependence on oil, a vast amount of money is being spent on the development of electrical vehicles (EVs) that may be produced. This project presents a study of electrical motorcycle design. The aim of this study is to investigate how to design a simple, cost-effective model of electrical motorcycle with intelligent control system. This can be implemented by removing the internal combustion engine, the exhaust system and other unnecessary components from the motorcycle and replaced by an electrical motor, an intelligent controller.

## 3. DESIGN OF ELECTRIC BIKE

### 3.1 Limitation of Exiting system or research Gaps

**For Suspension System :**

**1. Limited Adjustability in Traditional Rear Suspension**

- **Current Limitation**: Conventional suspension systems, such as mono-shock or twin-shock setups, have limited adjustability when it comes to dynamic load distribution and ride height for different terrains (especially off-road) or rider preferences.

- **Research Gap**: There's a lack of suspension systems designed to automatically adjust based on terrain or the rider's weight, particularly to enhance the comfort and safety of disabled individuals.

**2. Inadequate Tilt Mechanisms**

- **Current Limitation**: Traditional motorcycles lack advanced rear suspension designs that allow the bike to tilt safely and controlled, especially during slow-speed manoeuvres or when stationary, which is crucial for stability.

- **Research Gap**: There's minimal research or focus on integrating a suspension that supports controlled tilting, especially for riders with limited mobility or strength. The challenge is to offer tilt support without compromising balance or ride dynamics.

**3. Accessibility and Balance Issues for Disabled Riders**

- **Current Limitation**: Existing motorcycles are designed primarily for able-bodied individuals, and the rear suspension doesn't offer any support for those who have difficulty balancing or seating themselves. Current designs don't cater to mounting/dismounting ease or balance aids.

- **Research Gap**: Very little research is available on adaptive suspension systems that improve accessibility for disabled riders, making it easier for them to mount without external assistance, balancing aids, or modifications that don't compromise performance.

**4. Off-Road Comfort**

- **Current Limitation**: Conventional suspension systems offer limited travel and shock absorption in off-road scenarios, leading to discomfort, particularly on uneven surfaces. This becomes more pronounced for disabled riders who might already have limited physical capacity to adapt to sudden shocks.

- **Research Gap**: While off-road bikes focus on long suspension travel, there is a gap in developing rear suspensions that intelligently adapt to off-road conditions while maintaining comfort, particularly for disabled riders, without making the bike unwieldy or heavy.

**5. Weight and Energy Efficiency**

- **Current Limitation**: Adding complex features like tilt mechanisms or adaptive suspension can increase the weight of the bike, affecting energy efficiency and handling, particularly in electric or fuel-efficient models.

- **Research Gap**: There's a need to explore lightweight materials or energy-efficient designs for adaptive suspension systems that can offer tilting and increased comfort without sacrificing the bike's performance or increasing fuel consumption significantly.

## 4. METHODOLOGY OF PROJECT

1. **Research and Literature Review:**

- Objective: To understand the current limitations of motorcycle suspension systems and safety features.
- Action Steps:
  - Conduct a review of existing rear suspension systems, focusing on their performance in tilting, stability, and off-roading capabilities.
  - Analyse the challenges faced by disabled riders in mounting and balancing motorcycles.
  - Research helmet detection systems currently used for motorcycles or similar vehicles.
  - Identify the research gaps related to tilt-enabled suspensions, comfort during off-roading, and helmet enforcement systems for bikes.

**2.System Design and Specification:**

Objective: To design an innovative rear suspension system that tilts and assists disabled riders, along with a helmet detection system.

Action Steps:

- Design the rear suspension system:
  - Develop CAD models of the rear suspension that allows a tilt angle of up to 30 degrees.
  - Calculate the forces and loads acting on the suspension when tilting and during off-road rides.
  - Integrate mechanisms that assist disabled riders in safely mounting the bike without the need for balance.
- Technical specifications:
  - Define the materials for the suspension system, ensuring they can withstand off-road conditions while remaining lightweight.

3.**Simulation and Analysis of the Suspension System:**

Objective: To evaluate the performance of the suspension system under various conditions.

Action Steps:

- Use simulation software (e.g., SolidWorks, Fusion 360) to simulate:
  - Tilting at different angles (up to 30 degrees).
  - Dynamic analysis for stability during off-road conditions.
- Perform stress and strain analysis on the suspension components to ensure they can handle the forces during operation.
  - Analyse the mechanical behaviour when the system is under full load, especially focusing on the points where disabled riders interact with the system.

4. **Prototype Fabrication:**

Objective: To build a functional prototype of the suspension system and integrate it with the motorcycle.

Action Steps:

- Fabricate the rear suspension system, ensuring the materials and design meet the performance requirements.
- Implement tilt-assist mechanisms for disabled riders, which may include additional support features like motorized stabilizers.
- Install the helmet detection system and integrate it with the motorcycle's ignition system.

5. **Testing and Validation:**

Objective: To test the functionality of the suspension system and helmet detection system in real-world scenarios.

Action Steps:

- Conduct stability and tilt angle tests on the rear suspension to verify the system's ability to handle different terrain (urban and off-road).
- Test the comfort provided by the suspension during off-roading, measuring vibration damping and shock absorption.
- Simulate conditions for disabled riders, testing the ease with which they can mount the bike and stabilize it without needing balance.
- Perform extensive tests on the helmet detection system to ensure it works consistently and reliably under different real-world conditions (e.g., weather, distance between helmet and bike).
- Evaluate the bike’s performance in both manual and automated tilt modes.

6. **Cost Analysis and Optimization:**

Objective: To evaluate the cost-effectiveness of the system and optimize it for affordability.

Action Steps:

- Perform a cost-benefit analysis comparing the materials and technologies used in the suspension system with more traditional options.
- Evaluate the cost of integrating the tilt-assist mechanism for disabled riders.
- Analyze the costs of developing the helmet detection system, focusing on sensor technology and installation expenses.
- Refine the design and materials based on cost assessments to ensure affordability without compromising performance.

7. **Refinement and Improvements:**

Objective: To refine the design based on feedback from testing and cost analysis.

Action Steps:

- Modify the suspension design if testing reveals areas for improvement, particularly regarding comfort, tilt range, and performance.
- Re-evaluate the helmet detection system for false positives/negatives and improve its accuracy.
- Conduct additional simulations or small-scale tests to ensure all safety features and comfort parameters are optimized.
- Finalize the system design, ensuring all features (tilting, comfort, disabled access, helmet safety) work harmoniously.

8. **Documentation and Reporting:**

Objective: To compile all findings and methodologies into a comprehensive project report.

Action Steps:

- Document the entire design process, from research and development to prototype fabrication and testing.
- Include detailed technical specifications, CAD drawings, and simulation results for the rear suspension and helmet detection systems.
- Provide insights into cost analysis, showing how the project strikes a balance between performance and affordability.
- Highlight areas for future research, such as improving the helmet detection technology or enhancing tilt capabilities for extreme off-roading.

## 5. LIST OF COMPONENTS

1. **Frame**
Material : Aluminium Alloy 6160
Advantages of 6061 Aluminum Alloy

- Lightweight: 1/3rd the weight of steel.
- Corrosion Resistance: Ideal for outdoor use.
- High Strength-to-Weight Ratio: Strong enough to handle motor torque.
- Good Weldability: Can be welded using TIG welding.

Cost : 1500-2000 Rs.

2. **Battery**
Capacity : 48V ( 10AH :
Power Output : 500W
Cost : 5000 rs

3. **Electric Motor**
**Type:** Brush motor
**Power:** 250W
**Voltage:** 24V
**Efficiency:** ~85–90%
**Cost:** 3000

4. **Motor Controller**
**Type:** Square wave
**Power Rating:** 24V 500W
**Cost:** 1500 Rs

5. **Throttle & Display**

**Type:** Twist Throttle
**Display:** LCD or LED with Speed, Battery Level, Trip Data
**Cost:** ₹1,200 Rs

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

**6. Suspension**

Front: Telescopic Fork
Rear: Hydraulic or Spring Suspension
Cost: 1500

**7. Wheels & Tires**

Size: 16", 18", or 26"
Type: Tubeless/Tubed
Cost: ₹3,000 Rs

**8. Chain or Belt Drive**

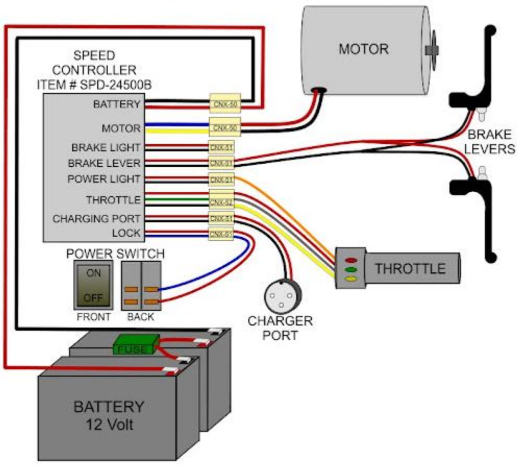
(if Mid-Drive Motor)
Type: Chain (Steel) / Belt (Kevlar)
Cost: ₹1000

**9. Additional Accessories**

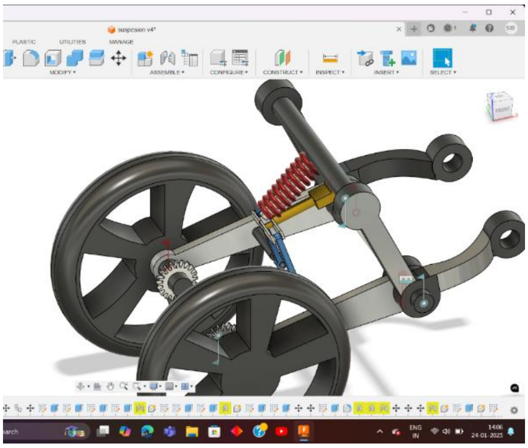
Headlights, Indicators, Horn: ₹1,500 – ₹4,000
Side Stand, Mudguard, Footrest: ₹1,500 – ₹3,000

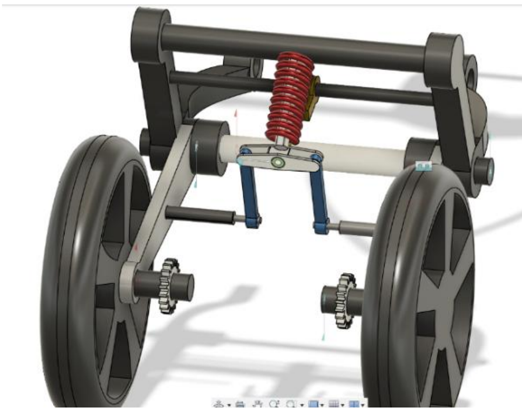
## 6. SCHEMATIC DIAGRAM AND CAD MODEL

6.1 Schematic Diagram




6.2 Cad Model





6.3 Dimensions

| Parameter | Electric Bike Dimensions |
|---|---|
| Length (mm) | 2020 – 2048 mm (Balanced size) |
| Width (mm) | 740 mm (Between 726 – 785 mm) |
| Height (mm) | 1105 mm (Between 1103 – 1110 mm) |

| | |
|---|---|
| Wheelbase (mm) | 1280 mm (Between 1270 – 1285 mm) |
| Ground Clearance (mm) | 170 mm (Between 160 – 180 mm) |
| Kerb Weight (kg) | 45 – 60 kg (without battery) |
| Seat Height (mm) | (Between 790 – 799 mm) |

## 7. MATERIAL SELECTION

**Material Selection for Electric Bike Fabrication**
The selection of appropriate materials plays a crucial role in the performance, durability, and overall efficiency of an electric bike. Various components require different materials based on strength, weight, and cost considerations. Below is a detailed material selection for each critical part of the electric bike.

1. **Frame Material**
**Selected Material:** 6061 Aluminum Alloy
**Reasons for Selection:**

- **Lightweight:** Aluminum alloy is significantly lighter than steel, reducing the overall weight of the bike and improving battery efficiency.
- **Corrosion Resistance:** Unlike steel, aluminum does not rust, making it ideal for long-term use.
- **Good Strength-to-Weight Ratio:** 6061-T6 aluminum provides excellent mechanical properties while keeping the frame lightweight.
- **Weldability:** This alloy is easy to weld using TIG (Tungsten Inert Gas) welding, which ensures strong joints.

**Specifications:**

- **Type:** 6061-T6 Aluminum Alloy
- **Density:** 2.7 g/cm³
- **Yield Strength:** 276 MPa
- **Ultimate Tensile Strength:** 310 MPa
- **Weight Requirement:** ~5-7 kg (including wastage)

2. **Battery Enclosure**
**Selected Material: Plastic**
**Reasons for Selection:**

- **Lightweight:** A plastic battery casing keeps weight minimal while offering good protection.
- **Impact Resistance:** Polycarbonate (PC) is highly impact-resistant, ensuring the battery remains safe from external shocks.
- **Heat Resistance:** PC and ABS have good heat resistance, preventing overheating issues.

**Specifications:**

- **Type:** Polycarbonate (PC) or ABS Plastic
- **Density:** 1.2 g/cm³
- **Melting Point:** ~260°C

3. **Suspension System (Rear Shock Absorbers)**
**Selected Material: High-Strength Steel (Chromoly 4130) & Aluminum Alloy**

**Reasons for Selection:**
**High Load Capacity:** Chromoly steel is strong enough to handle shocks and rough terrain.
**Fatigue Resistance:** The material can withstand repeated stress without failure.
**Aluminum for Rear Shock Absorbers:** Lightweight and corrosion-resistant, improving ride comfort.

**Specifications:**
**Type:** Chromoly 4130 Steel (Front Fork), 7075 Aluminum Alloy (Rear Shock)
**Yield Strength (Steel):** 435 MPa
**Yield Strength (Aluminum):** 503 MPa

## 8. DESIGN CALCULATIONS

Load Capacity and Structural Analysis of the Electric Bike
**1. Frame Material and Strength Analysis**
The bike frame is made of 6061 Aluminum Alloy, which has:

- Yield Strength (σ_y): 276 MPa
- Ultimate Tensile Strength (σ_ut): 310 MPa
- Density (ρ): 2.7 g/cm³

**Using Aluminum Tubular Frame (assumed tubing dimensions):**

- Outer Diameter (D): 50 mm
- Wall Thickness (t): 3 mm
- Frame Weight (W_f): ≈ 8–10 kg

**Weight Distribution & Load Capacity**
The weight distribution consists of:

- Frame: 8–10 kg
- Motors (2x): 4–6 kg
- Battery: 8–12 kg
- Suspension System: 3–5 kg
- Wheels & Tires (2 Rear, 1 Front): 12–14 kg

**Total Estimated Bike Weight (W_b):**
$Wb=(8+10)+(4+6)+(8+12)+(3+5)+(12+14)=45-57$ kg

**Maximum Load Capacity (Rider + Passenger + Cargo)**
Based on frame strength and suspension capacity, the total load capacity is estimated using:
$F=\sigma y\times AF$
where A is the cross-sectional area of the frame tubing.
For 6061 aluminum tubing:
$A=\pi\times(D^2-(D-2t)^2)/4$

$A=\pi\times(50^2-44^2)/4=460.76\ mm^2$

**Total force supported by the frame:**
$F=276\times460.76\approx127.2$ kN

**Assuming safety factors and dynamic loads, the bike can withstand:**

$P_{max}$=150−180 kg (Rider+Passenger+Cargo)

**2. Tilt and Stability Analysis**
The bike is designed to tilt up to 30°, which improves stability in turns and off-road conditions.

- Center of Gravity (CoG) Calculation
- Height of CoG (h): 650 mm (estimated based on seat height and rider positioning).
- Wheelbase (L): 1300 mm (average for stability).
- Rear Wheel Track Width (W_t): 500 mm (distance between rear wheels).

Condition for Stability in a Turn:
$\theta=\tan^{-1}(Wt/2h)$

$\theta = \tan^{-1}(500 / 2\times650) = \tan^{-1}(0.3846)\approx21°$

**This means the bike remains stable up to 21° naturally; beyond that, suspension and dynamic tilt control help stabilize it up to 30°.**

**3. Passenger Seating Capacity**
Seat Length: 700 mm
Rider + Passenger Seating Area:

- Rider: 350 mm
- Passenger: 350 mm

Each seat section can accommodate an average 75 kg person, so a rider + 1 passenger (max 150 kg) setup is recommended.

**4. Rear Wheel Independent Rotation Analysis**
The separate rear wheels with independent motors allow:

- Better cornering and maneuverability.
- Increased traction on rough terrain.
- Stability even if one wheel loses grip.

Each rear wheel is powered by an individual Brush motor with a torque of ~50 Nm per wheel.

**Total Torque Output:**
$T_{total}=2\times50=100$ Nm

**Acceleration Calculation (Newton's Second Law):**
$F=T / r$
**Assuming wheel radius of 300 mm (0.3 m):**
$F=100 / 0.3=333.3$ N

**Maximum Theoretical Acceleration:**
$a = F / m=333.3 / 150=2.22\ m/s^2$

**5. Suspension System Calculation**
Using spring suspensions on each rear wheel, we calculate required stiffness:
$F=kx$

Where:

- k = Spring Stiffness (N/mm)
- x = Maximum Compression (mm)
- F = Load on Each Wheel

**Estimated load on each rear wheel:**
F=(Rider+Passenger+BikeWeight) / 2=(150+50) / 2=100 kg=980N

**If maximum suspension travel is 50 mm:**
$k=980 / 50=19.6$ N/mm

So, a spring stiffness of ~20 N/mm is suitable for a stable ride.

## 8. CONCLUSIONS

In this project, an **electric bike** was successfully designed and optimized, focusing on **affordability, functionality, and performance**. The key objective was to create a **cost-effective** yet **reliable** electric bike while maintaining essential features such as **independent rear-wheel motors, a tilting mechanism for better stability, and a durable frame structure**.
To achieve the **target budget of ₹30,000**, several **strategic modifications** were made, including the use of **steel tubing for the swingarms**, **lower-power hub motors**, and a **lead-acid battery instead of lithium-ion**. These adjustments significantly reduced costs without compromising the **core functionality and ride experience**.
The **mechanical disc braking system** provided a cost-efficient **yet effective stopping power**, while **smaller steel rims with tube tires** further contributed to affordability. Despite these changes, the bike still offers **decent performance, stability, and durability**, making it an **ideal solution for urban commuting and off-road riding**.
This project demonstrates that with **careful component selection and engineering decisions**, an electric bike can be fabricated within a **limited budget** while maintaining **structural integrity, safety, and efficiency**. Future improvements could involve **upgrading to lithium-ion batteries** for better range and **hydraulic brakes** for enhanced stopping power.
In conclusion, this **electric bike design** presents a **practical and innovative** approach to sustainable mobility, offering a balance between **cost-effectiveness, performance, and rider safety**.

## ACKNOWLEDGEMENT

I at this moment acknowledge all those who directly or indirectly helped me draft this project report. It would not have been possible for me to complete the task without their help and guidance.

First, I would like to thank my guide Prof. Sarika V. Lugade And Prof. Mrunali for the valuable guidance in completing my project. I thank the Head of the Department Dr. Usha C. Pawar and department faculty members for the moral support to complete the project. My heartfelt gratitude to the principal Dr. P. A. Dode, for the opportunity given to do the project work. Finally, I thank our library staff for assisting me in getting the right source of information.

Last but not least; I am thankful to the University of Mumbai for offering the project in the syllabus. I must mention my hearty gratitude towards my family, other faculty members, and friends who supported me with the project.

## REFERENCES

1. Chan, C.C., Wong, Y.S., Bouscayrol, A., Chen, K.: Powering Sustainable Mobility: Roadmaps of Electric, Hybrid, and Fuel Cell Vehicles. Proc. IEEE 95(4) (2007) 704–718
2. Ehsani, M., Gao, Y., Emadi, A.: Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design. 2nd edn. CRC Press, Boca Raton (2009)
3. Husain, I.: Electric and Hybrid Vehicles: Design Fundamentals. 2nd edn. CRC Press, Boca Raton (2010)
4. Miller, J.M., Kaminski, M., Zhu, L.: Propulsion System Design for Electric and Hybrid Vehicles. SAE Int. J. Alt. Power. 1(1) (2012) 48–59
5. Chau, K.T., Wong, Y.S.: Overview of Power Management in Hybrid Electric Vehicles. Energy Convers. Manag. 43(15) (2002) 1953–1968