Teacher and Trainer Guide

1 – Introduction

This guide is prepared for the Sustainable Life Sustainable Vocational Education Project conducted within the scope of the KA220-VET – Cooperation partnerships in vocational education and training program, funded by the European Union under the Erasmus+ Key Action 2, 1st term program for the year 2022.

Key Action 2, Cooperation among organisations and institutions, includes Cooperation Partnerships (KA-220) under the Collaboration for Partnerships activity, offering opportunities for participating institutions/organizations to gain international collaboration experience and enhance institutional capacity development. The aim is to increase the capacities of institutions and organizations through collaborative partnerships in vocational education, share experiences, generate innovative intellectual outputs, and enhance the quality of education and learning at the European level.

The overall aim of our project is to enhance students' skills and qualifications in the maintenance and repair of electric bicycles within the field of vocational education and training. The project is designed to update vocational education content in line with contemporary requirements and to train the needed intermediate staff.

The specific objectives of our project are to enhance the knowledge and skills of vocational education students in the field of electric micromobility vehicles; increase their employability in this area; produce up-to-date educational materials for vocational education teachers to deliver lessons; and create training modules covering the production, service, maintenance, and repair processes of electric bicycles.

2 – Guide Structure and Content

This guide has been prepared to provide practical support to trainers in the implementation of the educational modules of the Sustainable Life Sustainable Vocational Education project. The guide was developed by subject matter experts (module authors).

In the preparation of the guide, principles of adult education and interactive education based on active participation were followed and attention was given to ensure that all training sessions were aligned accordingly.

The guide consists of three main components:

- Identifying Target Group
- Training Modules
- Instructor-specific Guide

and the topics of the instructor-specific guide are determined as follows:

  - Introduction to Electric Bicycles, Advantages, Prejudices
  - Public Area Usage, Integration with Public Transportation, and Transporting the Bicycle

- Personal Protective Measures and Selection of Protective Equipment, Spare Kits, Accessories
- Road Conditions and Traffic, Hazards Encountered in Traffic
- Legal Regulations
- Basic Functions, Speed and Balance
- Control Mechanisms, Braking and Gear Systems
- Periodic Maintenance, Cleaning, Proper Use and Charging of Batteries

3 – Designing Education for Target Group

The main stakeholders of the Education:

- Students enrolled in high schools that provide education in fields related to electricity, machinery, and electric bicycles, with the potential to create expertise in these areas
- Teachers in vocational high schools providing education in fields related to electricity, machinery, and employment areas associated with electric bicycles.
- Public institutions and municipalities responsible for transportation
- Universities, researchers, and academicians engaged in studies in the field of electric vehicles and electric bicycles
- Small and medium-sized enterprises (SMEs) operating in the production, repair, and maintenance of electric bicycles.
- Private vocational training institutions

It is recommended to assess participants' current levels of knowledge and their expectations from the training as you prepare for the education. While some participants may already have knowledge about electric bicycles, others may have less familiarity with the subject.

You can conduct an analysis of participants' prior knowledge and training needs. This analysis can be done by asking some participants questions or instructing them to fill out the form provided in Appendix X.X.

You can also create a supportive environment where participants can learn from each other.

By customizing the Education according to the specific needs and contexts of each target group, you can maximize the impact and relevance of the education programs:

1. Students Enrolled in High Schools

Inspire Passion: Emphasize the exciting potential and innovation in the field of electric bicycles and related technologies. Encourage students to explore their passion and curiosity.

Real-World Relevance: Connect theoretical concepts to real-world applications. Discuss current industry trends, job opportunities, and the impact their expertise can have on the future of transportation.

2. Teachers in Vocational High Schools

Pedagogical Approach: Discuss effective teaching methods for vocational education, such as hands-on learning, project-based assignments, and industry collaborations.

Continuous Learning: Emphasize the importance of staying updated on industry advancements and integrating practical, industry-relevant examples into their teaching.

3. Public Institutions and Municipalities Responsible for Transportation

Societal Impact: Illustrate how the adoption of electric bicycles can contribute to sustainable and efficient transportation, reducing environmental impact and enhancing public health.

Policy Considerations: Discuss the role of public institutions in shaping policies that support the integration of electric bicycles into transportation systems.

4. Universities, Researchers, and Academicians

Research Opportunities: Highlight the exciting research opportunities in the field, from technological advancements to social and environmental impact studies.

Interdisciplinary Collaboration: Encourage collaboration between researchers from different disciplines to address complex challenges associated with electric vehicles and bicycles.

5. Small and Medium-Sized Enterprises (SMEs):

Innovation and Adaptability: Stress the importance of continuous innovation and adaptability in the rapidly evolving field of electric bicycles. Discuss strategies for SMEs to stay competitive and contribute to industry growth.

Skill Development: Emphasize the role of education in developing the skilled workforce necessary for SMEs to thrive.

6. Private Vocational Training Institutions

Industry Alignment: Discuss the importance of aligning training programs with industry needs and standards. Encourage flexibility and responsiveness to emerging trends.

Partnerships: Explore opportunities for private vocational training institutions to collaborate with industry partners, ensuring that programs remain relevant and effective.

Remember to tailor the messaging to the specific goals and characteristics of each group, and foster an environment that promotes curiosity, collaboration, and a passion for learning.

4 – Training Modules

Module 1. History of Electric Bicycles: In this module, the invention of the first electric bicycle, subsequent developments, obtained patents, and their fundamental technical specifications are explained. Following this, electric bicycle types based on control systems and motors are summarized. The next section lists the advantages and disadvantages of electric bicycles, and finally, the operational principles of electric bicycles are discussed.

Module 2. Electrical Theory and Its Components: This module offers an essential exploration of electrical basics and components crucial for electric bicycle maintenance and repair. It covers voltage, current, resistance, and power fundamentals, and dives into the use of key electrical components, circuit reading, AC/DC current differentiation, and safety practices. The module combines theory with hands-on learning to equip participants with practical skills for sustainable transportation technology.

Module 3. Direct Current Principles: This module, covers key aspects of e-bike electrical systems:

- Ohm's Law and power calculations: Essential for understanding current, voltage, resistance, and power consumption in e-bike components.
- Components like batteries, motor controllers, electric motors, throttle or pedal sensors, display units, and wiring: Their connections and roles in the system.
- Battery types: Lithium-ion and lead-acid, with lithium-ion being more common due to higher energy density and longer lifespan.
- Motor controllers: Regulate power flow from the battery to the motor, ensuring smooth acceleration and speed control.
- Electric motors: Hub or mid-drive, converting electrical energy into mechanical motion for propulsion.
- Control methods: Throttle-based or pedal-assist, offering different levels of rider control over power output.
- Display units: Providing real-time data on speed, battery level, and assist mode for enhanced rider experience.
- Wiring and connectors: Ensuring reliable power transmission and minimizing electrical faults.
- DC motor connections: Involving phase connections to the motor controller and battery connections for power supply.

Understanding and optimizing these components and connections are crucial for achieving optimal performance, efficiency, and rider experience in e-bikes.

Module 4. Battery Technologies in Electric Vehicles: The training module offers a comprehensive overview of various battery technologies that are crucial to the development and operation of electric vehicles (EVs). It begins by discussing the need for electric energy storage (EES), highlighting its significance in bridging the gap between renewable energy production and consumption. The module covers the structure, function, and working principles of batteries, including detailed insights into lead-acid, nickel-cadmium (NiCd), nickel-metal hydride (NiMH), lithium-ion (Li-ion), lithium-ion polymer (LiPo), lithium iron phosphate ($LiFePO_4$), and lithium-sulfur (Li-S) batteries. It explains the characteristics, charging and

discharge cycles, safety and maintenance considerations, environmental implications, and future prospects of each battery type. Additionally, it delves into battery management systems (BMS) and modeling methods, essential for maximizing performance and lifespan of batteries in EVs. This holistic approach to battery technologies not only educates on current solutions but also explores innovative advancements shaping the future of electric mobility.

Module 5. Electric Motors Used in Bicycles: This module covers various aspects of electric motors used in bicycles, from their fundamental principles to practical applications. It explores the structures and power transmission of AC and DC motors, focusing particularly on the widespread use of brushless DC motors in bicycles and different motor connection types. Additionally, it discusses how speed control is achieved in electric bicycles and how motor speed is adjusted mechanically and electronically. This module provides a foundational understanding to enhance the performance and efficiency of electric bicycles.

Module 6. Structural Features of Elctric Bicycles: This module delves into the structural features of electric bicycles, elucidating their design elements and functional components. It begins by introducing electric bicycles as environmentally friendly, convenient means of transportation, highlighting their basic components and operational mechanisms. The discussion then progresses to body designs and mechanical connections, emphasizing the importance of materials like aluminum for frames and robust spokes for wheel stability. Subsequently, powertrains and pedal assemblies are explored, detailing pedal support, gear systems, and the role of electric motors in propulsion.

The module further investigates braking systems, distinguishing between various types such as V-brakes, hydraulic disc brakes, and the innovative regenerative braking system, which harnesses kinetic energy for battery charging. Lighting and warning systems are also examined, with a focus on LED technology for enhanced visibility and safety. Lastly, display circuits are discussed, highlighting their role in monitoring speed, battery charge, and other vital parameters for an optimal riding experience.

Module 7. Legal Regulations About Electric Bicycles: The module covers legal regulations pertaining to electric bicycles, emphasizing their safe integration into traffic. It outlines rules for driving on highways, following traffic lanes, and adhering to speed limits, alongside licensing requirements based on power ratings and maximum speeds. Ethical guidelines stress safety measures such as wearing helmets, obeying traffic signals, and maintaining safe distances.

Furthermore, it explores the role of electric bicycles in urban transportation and environmental sustainability efforts, highlighting their potential for short-distance travel in congested areas. Challenges such as traffic safety and infrastructure development are discussed, along with the importance of social awareness campaigns and regulatory measures to ensure their effective integration into urban transportation systems.

In summary, the module provides insights into the legal framework, ethical considerations, and potential benefits of electric bicycles in promoting sustainable urban mobility.

Module 8. Periodic Maintenance and Service of Electric Bicycles

This module focuses on the skills needed for periodic maintenance of electric bicycles, covering daily, weekly, monthly, and annual maintenance tasks. It aims to equip users with the ability to detect and fix malfunctions related to the electric motor, mechanical system, charging system, and warning/display system.

Key areas covered include:

1. Maintenance schedules for different intervals.
2. Electric motor failures and solutions.
3. Mechanical system failures and troubleshooting.
4. Charging system malfunctions and solutions.
5. Warning and display system malfunctions and diagnostics.

Practical maintenance tips are provided for tasks such as battery care, chain maintenance, tire care, and brake maintenance. The module emphasizes the importance of regular maintenance to ensure the smooth operation and longevity of electric bicycles.

4.1 – History of Electric Bicycles

4.1.1 – Module Summary

Objective of the Module	• To narrate the historical development of electric bicycles and the technological evolution leading to contemporary usage standards • To raise awareness on how the use of electric bicycles is influenced by describing the types of electric bicycles, current usage standards, legal regulations, and government policies • To develop analytical thinking skills through the examination of historical patents, designs, and improvements • To explain that electric bicycles are sustainable means of transportation by considering their costs and environmentally friendly effects • To explain legal classifications and regulations along with safety standards
Topics	• The history of electric bicycles, developments up to the present, technical aspects, motor designs, and power sources • Current usage standards • Types of electric bicycles • Advantages and disadvantages of electric bicycles

	• Operation principles of e-bikes
Method	• Slides • In-class discussion • Summary
Exercises	• Test questions
Notes	• Introduction to Electric Bicycles • Prejudices about Electric Bicycles • Usage Habits in Cities, Countries, and Worldwide
Duration	• 135 min.

4.1.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (5 min.)
- Presentation of Main Topics (75 min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Sample Patent (15 min.)
- Sharing Participants' Experiences (10 min.)
- Conclusion (10 min.)

Introduction (5 min.)

It is recommended to start with a brief introduction providing an overview of the module's objectives and main components.

Presentation of Main Topics (75 min.)

For groups unfamiliar with electric bicycles, it is advisable to start with an introduction that provides basic information and explains the fundamental components of electric bicycles supported by slides (See: Appendix 1.1). Following this, the historical development of electric bicycles, current usage standards, types of electric bicycles, and the advantages and disadvantages of electric bicycles are expected to be discussed.

Discussion, Questions, and Answers (20 min.)

In addition to the questions participants may ask after the presentation, the instructor can also encourage discussion by posing some questions. Sample questions could include:

- What can be done to promote the use of electric bicycles when considering their contributions to sustainable transportation and environmental benefits?
- Considering the current technology of electric bicycles, what is the most innovative discovery in the historical development of electric bicycles, and who made it?
- What is the level of awareness about electric bicycles in your city, and what role does cycling play in public transportation?

Examination of a Sample Patent (15 min.)

To prepare participants for topics to be examined in subsequent modules, it is recommended to conduct a review of a patent that also bears traces of technological advancements foundational to current usage standards.

Participants Share Their Experiences (10 min.)

After the course, participants are expected to ask questions related to the module and share their own experiences about electric bicycles. The instructor may

also encourage participants to share their existing knowledge about electric bicycles and their own opinions on the advantages and disadvantages of electric bicycles.

Conclusion (10 min.)

After the completion of topics, the instructor summarizes the subjects, also addressing the goals of the training, and concludes the session.

4.1.2.1 – Adjusting the Duration of the Training

The instructor can increase or decrease the duration of the module according to the training. The duration may vary depending on participants' expectations. Following the presentations, during the discussion questions section, participants can be divided into small groups to present their suggestions. Later, these suggestions can be communicated by the instructor to all participants for further discussion.

4.1.3 – Main Topics of the Module

As is done with all modules, it is important to review the fundamental headings before delivering this module to the participants. The essential headings outlined below assist the instructor in preparation and summarizing the topic.

The History of Electric Bicycles and Contemporary Usage Standards

The history of electric bicycles dates back to the late 19th century. The first prototypes of electric bicycles emerged with the development of electric motors and batteries. However, these initial examples were heavy, expensive, and impractical vehicles. Significant patents are provided between pages 1 and 6 of the training module.

In the 1930s, the use of electric bicycles became widespread. During this period, especially in some countries like China, people started to prefer electric bicycles for daily transportation. However, the popularity of these vehicles worldwide was still limited. On the other hand, while the Second World War temporarily halted the development of electric bicycles, the interest in electric vehicles increased again with the emergence of the fuel crisis.

In the 1970s, American chemist M. Stanley Whittingham discovered the concept of intercalation electrodes and, despite not being able to commercialize his invention, created the first rechargeable lithium-ion battery based on a titanium disulfide cathode and a lithium-aluminum anode. American materials scientist and solid-state physicist John Goodenough further developed this work in 1980 by using lithium cobalt oxide as a cathode. The first prototype of the modern lithium-ion battery with a carbon anode, commercialized in 1991 by the team led by Yoshio Nishi at Sony and Asahi Kasei, as a replacement for lithium metal, was developed in 1985 by Akira Yoshino. This marked a turning point for the development of modern electric vehicles and the first hybrid cars.

With the onset of the 2000s, electric bicycles began to be widely used worldwide. Increasing concerns about the sustainability of urban transportation have boosted the popularity

of electric bicycles. Many companies are currently developing various models for use in urban transportation.

The history of electric bicycles has been shaped by technological advancements, making them one of the first vehicles that come to mind when the concept of 'Sustainable Transportation' is mentioned in today's world.

Types of Electric Bicycles

The current usage standards are explained in section 1.1.2 of the module. The operating principle of electric bicycles before 1990 differs from the current operating principle of electric bicycles. In examples prior to 1990, mechanical pedal power was augmented by the electric motor, whereas in contemporary electric bicycles, pedal power is converted into electrical energy and transmitted to the motor. The electric motor comes into play additionally when needed.

Advantages and Disadvantages of Electric Bicycles

Advantages and disadvantages of electric bicycles are listed and examined in this section. By providing real-world examples based on these advantages and disadvantages, you can make the topic more engaging and help students enhance their critical thinking skills.

Highlighting that electric bicycles are more efficient and environmentally friendly compared to traditional transportation vehicles, you can raise awareness among students about sustainable transportation.

Some electric bicycle models have a regenerative braking system that can convert kinetic energy into electrical energy during braking. By explaining this concept, you can emphasize energy savings and environmentally friendly features.

Operation Principles of Electric Bicycles

Electric bicycles fundamentally operate by utilizing electrical energy. It is important to briefly explain to students what electrical energy is, how it is generated, and how it is stored.

Electric bicycles use an electric motor to convert electrical energy into mechanical energy to turn the bicycle's wheel. Explaining the internal structure and operating principles of the motor with visuals can be effective in conveying the concept to students. *(See: Module 5, page x)*

Electric bicycles generally feature a control system that manages how the rider operates the bicycle. It controls aspects such as speed, brakes, and other functions. It is important to explain to students how these control systems affect the performance of the bicycle. Detailed information can be found in training *module 1.2.*

Emphasizing how the electric bicycle's battery is charged and utilized can help students understand the continuity of bicycle usage. Detailed information can be found in modules 4.1 and 4.2 *(page x).*

4.1.4 – Slides That Can Be Used in Module 1 Presentation

The slides prepared for Module 1 can be found in Appendix 1.1 (CD).

4.1.5 – Notes for Module 1

Introduction to Electric Bicycles

Equipped with an electric motor and a rechargeable battery, electric bicycles offer users the option to manually pedal or use the electric motor assistance. This functionality makes electric bicycles versatile, catering to users with different physical abilities and various transportation needs. Electric assistance not only increases travel distance but also breaks down barriers for individuals who find traditional biking challenging, making uphill climbs more manageable.

Preconceptions about Electric Bicycles

Despite their advantages, unfair prejudices exist regarding electric bicycles. Some individuals claim that electric bicycles promote laziness or lack the eco-friendly appeal of traditional bicycles. However, studies indicate that electric bicycle users often cover longer distances and ride more frequently than traditional cyclists, debunking the myth of reduced physical activity. Moreover, modern electric bicycles are designed with "sustainability" in mind, incorporating efficient motors and eco-friendly battery technologies.

Global Adoption of Electric Bicycles

Globally, electric bicycles are becoming popular for practical and sustainable urban transportation. Cities are demonstrating a shift towards green transportation options by implementing bike-sharing programs that include electric bicycles. Countries with well-developed cycling infrastructure, such as the Netherlands and Denmark, have embraced electric bicycles as a key component of their transportation systems.

Ongoing technological advancements, such as improvements in battery technology and motor efficiency, have contributed to the increased range and performance of electric bicycles.

Growing environmental awareness and a desire for eco-friendly transportation options have contributed to the acceptance of electric bicycles as a green alternative to traditional vehicles.

In conclusion, electric bicycles hold promise as a solution to urban mobility challenges, shaping the future of transportation by providing a sustainable and accessible alternative. They have the potential to play a significant role in promoting healthier lifestyles and contributing to the creation of a more sustainable planet.

Note: You can also discuss with your students during the class by conducting your own research on the usage habits and integration with public transportation of electric bicycles in your country.

Notes:

4.2 – Electrical Theory and Its Components

4.2.1 – Module Summary

Objective of the Module	• To introduce the fundamental concepts of electrical theory crucial for understanding electric bicycles and their components. • To provide a solid foundation in electrical components and circuit design, enabling students to analyze and troubleshoot electric bicycle systems. • To enhance practical skills in handling electrical components, fostering safety and efficiency in electric bicycle maintenance and repair. • To explore the impact of electrical innovations on the sustainability and performance of electric bicycles.
Topics	• Basic electrical principles including voltage, current, resistance, and power. • Components of electrical circuits (resistors, capacitors, inductors, diodes, transistors) and their roles in electric bicycles. • Reading and interpreting circuit diagrams and electrical schematics. • Distinction between AC and DC currents, with an emphasis on DC for electric bicycles. • Electrical safety measures and best practices in the context of electric bicycles
Method	• Interactive lectures supplemented with multimedia presentations to cover theoretical concepts. • Hands-on laboratory exercises for practical experience with electrical circuits. • Group discussions to facilitate the understanding of complex topics. • Case studies and real-world examples to link theory with practice.
Exercises	• Quiz questions to reinforce theoretical knowledge. • Practical assignments involving the assembly and analysis of electrical circuits. • Projects focused on diagnosing and fixing common electrical issues in electric bicycles.

Notes	• Foundational Clarity • Engagement Through Analogies. • Interactive Component Exploration • Application-Centric Learning • Circuit Diagram Literacy • DC Emphasis with Safety in Mind • Safety as a Priority • Real-World Problem-Solving
Duration	• 135 min.

4.2.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (10 min.)
- Presentation of Main Topics (75 min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Sample Component (20 min.)
- Sharing Participants' Experiences (15 min.)
- Conclusion (10 min.)

Introduction (10 min.)

Start with a concise introduction outlining the objectives and the structure of the module. Highlight the importance of understanding electrical theory for anyone working with electric bicycles and other electric vehicles. Mention that the module will cover fundamental electrical concepts, components, and safety measures, aiming to build a solid foundation for diagnosing and repairing electric bicycles.

Presentation of Main Topics (75 min.)

1. **Fundamental Electrical Concepts (15 min.)**: Begin with basic electrical principles such as voltage, current, resistance, and power. Use simple analogies and visuals to explain Ohm's Law and the power equation, ensuring participants grasp these foundational concepts.
2. **Components of Electrical Circuits (20 min.)**: Introduce common electrical components (resistors, capacitors, inductors, diodes, transistors) and their functions. Utilize diagrams and real component examples to illustrate how each part fits into electric bicycle circuits.
3. **Reading Circuit Diagrams and Electrical Schematics (15 min.)**: Teach participants to interpret circuit diagrams, focusing on symbols and notations relevant to electric bicycles. Incorporate interactive elements by having participants attempt to read basic schematics in small groups.
4. **DC vs. AC Currents (10 min.)**: Explain the difference between direct and alternating current, emphasizing the significance of DC in electric bicycles. Use visuals to depict how DC is used in battery-powered devices.
5. **Electrical Safety (15 min.)**: Stress the importance of safety when working with electrical systems. Discuss personal protective equipment, emergency procedures, and best practices for electrical work, particularly in the context of electric bicycle maintenance and repairs.

Discussion, Questions, and Answers (20 min.)

Encourage an interactive discussion by posing the following questions:

- "Why do electric bicycles primarily use DC instead of AC?"
- "How do the components of an electric circuit contribute to the overall functionality of an electric bicycle?"
- "What are some key safety measures to consider when working with electric bicycles?"

Encourage participants to share their thoughts and questions, facilitating a deeper understanding of the content presented.

Examination of a Sample Component (20 min.)

Choose a critical electrical component of electric bicycles, such as the battery or motor controller. Demonstrate its role within the system, how to safely handle it, and discuss common issues and troubleshooting tips. This hands-on demonstration will help solidify theoretical knowledge through practical application.

Participants Share Their Experiences (15 min.)

Invite participants to share any experiences they have had with electric bicycles, focusing on electrical aspects. This can include troubleshooting they've performed, interesting modifications, or observations on usage patterns. This segment will foster community learning and provide real-world context to the theoretical knowledge acquired.

Conclusion (10 min.)

Summarize the key points covered in the module, emphasizing the relevance of electrical theory and safety in the maintenance and operation of electric bicycles. Encourage participants to continue exploring and practicing the concepts learned, highlighting any follow-up resources or sessions available. Close by reiterating the importance of sustainable transportation solutions like electric bicycles in today's world.

4.2.2.1 – Adjusting the Duration of the Training

Adjusting the duration of the "Electrical Theory and Its Components" training module is essential for meeting participant needs and ensuring that all learning objectives are thoroughly covered. Tailor each session's length based on the participants' familiarity with the subject matter, their engagement levels, and feedback received. Focus on balancing comprehensive coverage of critical topics with interactive elements like discussions and hands-on activities to maintain interest and facilitate learning. Regularly review and refine the session durations based on observations and participant feedback to optimize educational outcomes and keep the module dynamic and responsive to learner needs.

4.2.3 – Main Topics of the Module

1. Introduction to Fundamental Electrical Principles

Objective: To establish a foundational understanding of electrical concepts.

Content: Detailed explanations of voltage (electric potential difference), current (rate of charge flow), resistance (opposition to current), and power (rate of doing work or transferring energy). Use real-world analogies to illustrate these concepts, such as water flow in pipes for current and voltage.

Activities: Interactive simulations and experiments to visualize and measure voltage, current, and resistance using basic components.

2. Electrical Components and Their Functions

Objective: To identify and understand the roles of various electrical components within circuits.

Content: In-depth exploration of resistors (limiting current flow), capacitors (storing electrical energy), inductors (storing energy in a magnetic field), diodes (allowing current to flow in one direction only), and transistors (amplifying or switching electronic signals). Discuss the significance of each component in regulating and controlling electrical circuits, particularly in electric bicycle systems.

Activities: Hands-on assembly of simple circuits to demonstrate the function of each component. Use multimeters to measure component behavior in different circuit configurations.

3- Circuit Diagrams and Electrical Schematics

Objective: To enable the reading and interpretation of electrical schematics.

Content: Instruction on the symbols and notations used in circuit diagrams, focusing on their relevance to electric bicycles. Techniques for tracing circuit paths and understanding the layout and connection of components.

Activities: Group exercises where trainees practice drawing and interpreting schematic diagrams of circuits commonly found in electric bicycles.

4- Direct Current (DC) vs. Alternating Current (AC)

Objective: To differentiate between AC and DC and understand their applications.

Content: Explanation of AC and DC, highlighting the characteristics and uses of each type of current. Discuss why DC is preferred for electric bicycles and the role of batteries and converters.

Activities: Demonstrations using both AC and DC sources to power simple devices, illustrating the practical differences and safety considerations.

5- Electrical Safety

Objective: To emphasize the importance of safety in electrical work.

Content: Discussion on electrical hazards and the importance of using personal protective equipment (PPE). Guidelines for safe handling of electrical components, emergency response to electrical incidents, and maintenance of a safe working environment.

Activities: Role-playing scenarios to practice safety procedures and PPE use. Safety audits of electric bicycle components to identify potential hazards.

6- Practical Application in Electric Bicycles

Objective: To apply theoretical knowledge to the practical aspects of electric bicycles.

Content: Examination of electric bicycle systems, focusing on the electrical circuitry that powers motors, controls, and battery management systems. Troubleshooting common electrical problems, from battery issues to motor faults.

Activities: Diagnostic exercises using actual electric bicycles or simulators to identify and repair electrical faults. Design projects where trainees propose modifications or improvements to existing electric bicycle electrical systems.

By covering these topics in detail, trainers will be equipped with a comprehensive understanding of the electrical theory necessary for electric bicycle technology. This preparation will facilitate the creation of engaging and informative lessons that not only convey essential theoretical knowledge but also provide practical skills and safety awareness, crucial for vocational education in sustainable transportation.

4.2.4 – Slides That Can Be Used in Module 2 Presentation

The slides prepared for Module 2 can be found in Appendix 2.1 (CD).

4.2.5 – Notes for Module 2

Foundational Clarity: Emphasize the importance of a clear understanding of basic electrical principles. Before delving into complex topics, ensure participants have a solid grasp of voltage, current, resistance, and power.

Engagement Through Analogies: Use relatable analogies to simplify complex electrical concepts. This approach helps participants better visualize and comprehend the foundational principles of electricity.

Interactive Component Exploration: Highlight the significance of hands-on experiences with electrical components. Encourage active participation in labs to demystify the functions and applications of resistors, capacitors, inductors, diodes, and transistors.

Application-Centric Learning: Link theoretical knowledge to real-world applications, specifically focusing on electric bicycles. Discuss how various components are utilized in e-bikes to enhance understanding and relevance.

Circuit Diagram Literacy: Stress the importance of being proficient in reading and interpreting circuit diagrams. This skill is crucial for troubleshooting and understanding the electrical systems of electric bicycles.

DC Emphasis with Safety in Mind: Underline the predominance of DC in electric bicycles and portable devices. Address the specific safety considerations necessary when working with DC and AC currents to prevent accidents.

Safety as a Priority: Ensure that electrical safety is a recurring theme throughout the module. From the use of personal protective equipment to emergency procedures, instilling a safety-first mindset is paramount.

Real-World Problem-Solving: Foster an environment where participants are encouraged to apply their knowledge to solve practical problems. Use diagnostics and repair exercises on actual electric bicycles or simulators to bridge theory with practice.

Notes:

4.3 – Direct Current Principles

4.3.1 – Module Summary

Objective of the Module	• To know the laws of direct current, Ohm's law, Joule's law. • Knowing the elements of a direct current electric circuit, their role and characteristic sizes. • To know how they can be connected in a circuit - series, parallel and mixed. • To know and apply the effects of electric current (method of medium voltage currents). • To apply electric battery testing methods. • To apply methods of testing DC motors.
Topics	• Direct Current (DC) Circuit Measurements and Calculations • Direct Current Source Connections • Direct Current Motor Connections
Method	• Slides • In-class discussion • Summary
Exercises	• Test questions
Notes	• Introduction to direct current circuits • Knowledge of circuit elements, connection types and measurement of physical quantities • Methods of testing the electric battery and the direct current motor.
Duration	• 120 min.

4.3.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (5 min.)
- Presentation of Main Topics (35 min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Sample Component (40 min.)
- Sharing Participants' Experiences (10 min.)
- Conclusion (10 min.)

Introduction (5 min.)

Electric bikes work mainly by using electricity. Electric bicycles use direct current circuits. In this module we present theoretical information about direct current. Students will know the laws that explain the operation of the circuit, the main components and the characteristic quantities of a direct current circuit. In this chapter, we will delve into the fundamental concepts and principles behind the electrical systems of e-bikes. As the popularity of e-bikes continues to grow, understanding the DC principles specific to these innovative modes of transportation becomes increasingly important.

Electric bikes, with their electric powered motors, have revolutionized the way we commute and explore our surroundings. At the heart of any e-bike is a DC system that powers its motor, providing an extra boost that makes cycling effortless and enjoyable. By understanding the principles of DC, we can unlock the potential of these remarkable machines and gain insight into their operation, efficiency and autonomy.

Presentation of Main Topics (35 min.)

Throughout this chapter, we will explore the key components of the DC system in electric bicycles, focusing on the battery, motor controller, and motor. We will examine the evolution of battery technology and the dominance of lithium-ion batteries in e-bikes, given their superior performance, reliability and energy density. By understanding the specifications and characteristics of these batteries, we can optimize performance and maximize the range of e-bikes.

We will also study the principles of voltage, current and power in the context of electric bicycle DC circuits. By understanding these fundamental concepts, we can analyze the relationships between battery capacity, voltage, and battery life. Furthermore, we will explore the effects of resistance, load and terrain on the performance and efficiency of e-bikes, allowing us to make informed decisions when choosing and operating these vehicles.

Additionally, we'll delve into the charging and discharging processes of e-bike batteries, highlighting best practices to extend battery life and optimize performance. By understanding the intricacies of these processes, we can ensure the longevity and reliability of our e-bike power supply.

Throughout this chapter, we'll focus on safety considerations, guiding you on best practices when working with electric bike DC components. By the end of this chapter, you will have a comprehensive understanding of DC principles specific to electric bicycles. You will gain the knowledge and skills to analyze, troubleshoot and optimize the performance of the DC system in your e-bike. So let's embark on this enlightening journey into the principles of direct current for electric bikes!

It is important to explain to students that Ohm's Law is the fundamental principle behind the electrical systems of e-bikes. Identifying the physical quantities: intensity, voltage, resistance and the related means of measurement, we will be able to analyze and optimize the performance of the DC system in the electric bicycle.

It is important for students to understand the correlation of the current-voltage ratio with the way of connecting the electric resistors: series, parallel, mixed and the electrothermal effect of the electric current, the heat released by the conductor when the electric current passes (Joule's Law).

A DC circuit requires a voltage source to generate a potential difference across the circuit. The voltage source provides the energy needed to push electrical charges through the circuit.

Common examples of DC voltage sources include batteries and DC power supplies.

For a good operation of electric bicycles, it is good that the battery(s) are charged to the nominal parameters, to present safety in operation to avoid possible dangers (accidents). For this it is important that students know how to measure electromotive voltage (voltage drop at the battery terminals) with a multimeter or tester.

DC motors are used to set electric bicycles in motion. Moving the bicycle on flat, sloped or rough terrain involves identifying the operating modes of the DC motors.

Discussion, Questions, and Answers (20 min.)

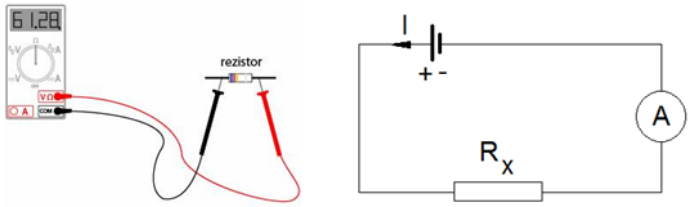
In addition to the questions that the participants can ask after the presentation, the instructor can also encourage the discussion by asking some questions. Examples of questions might include:

- Technical operating characteristics are also written on the electric bicycle nameplate. How do you determine the electrical power of the battery?
- How can you determine the internal resistance of the electric bicycle dc motor?
- Does temperature affect the resistance of the electric circuit in the electric motor?
- Can the direct voltage sources be connected in parallel? under what conditions?
- How can the speed of a direct current motor be regulated?

Examination of a Sample Component (40 min.)

Demonstration of one or more components (battery, electrical switch, resistor, etc.) in the classroom is recommended.

Ohm's law - practical applications



No.	Properties of Materials and Equipment	Units
1	Multimeter	1pcs
2	Cables black	1pcs
3	Cables red	1pcs
4	Rezistance	3 Ω
5	Battery	36V

The tables related to the study are given below.

Table 3.1: Table of Measurements

No	Voltage U(V)	rezistance R(Ω)	current I(A)	power P(W)

Participants Share Their Experiences (10 min.)

After the course, participants are expected to ask questions related to the knowledge presented and share their own experiences with electrical circuits. The instructor may also encourage participants to share their existing knowledge of electric motors or electric batteries.

Conclusion (10 min.)

By following these safety precautions, you can enjoy the benefits of e-bikes while ensuring a safe and enjoyable riding experience. After completing the topics, the instructor summarizes the topics, also addressing the training objectives, and concludes the session.

4.3.2.1 – Adjusting the Duration of the Training

The instructor can increase or decrease the duration of the module depending on the preparation. The duration may vary depending on the expectations of the participants. Following the presentations, during the discussion question section, participants can be divided into small groups to present their suggestions. Later, these suggestions can be communicated by the instructor to all participants for further discussion.

4.3.3 – Main Topics of the Module

- Direct Current (DC) Circuit Measurements and Calculations
- Direct Current Source Connections
- Direct Current Motor Connections

4.3.4 – Slides that can be used in the presentation of Module 3

- Powerpoint Presentation
- Work platform

4.3.4 – Slides That Can Be Used in Module 3 Presentation

- power-point presentation

- work platform

4.3.5 – Notes for Module 3

Electric bikes use DC circuits. The basic elements of an electric bike are the DC electric motor and the Li-ion battery. Ohm's Law is the fundamental principle behind the electrical systems of electric bicycles. By identifying the physical quantities: intensity, voltage, resistance and the related means of measurement, we will be able to analyze and optimize the performance of the DC system in the electric bicycle.

The voltage-current ratio, the connection method of the electric resistors: series, parallel, mixed and the electro thermal effect of the electric current, the heat released by the conductor when the electric current passes (Joule's Law), the electric power, are important elements to take into account for a good operation of the electric bicycle. To determine these parameters, the correct use of measuring tools is obvious.

Notes:

4.4 – Battery Technologies in Electric Vehicles

4.4.1 – Module Summary

Objective of the Module	• Understand Electric Energy Storage Needs: Introduce electric energy storage (EES) systems, emphasizing their necessity in the modern energy landscape, particularly in supporting renewable energy sources by capturing excess energy during peak times and releasing it when production is low, thereby ensuring a consistent energy supply. • Explore Battery Types and Functions: Provide a comprehensive overview of different battery technologies used in electric vehicles, including their structure, functions, and working principles. This section delves into the specifics of Lead-Acid, Nickel-Cadmium, Nickel Metal Hydride, Lithium-Ion, Lithium-Ion Polymer, and Lithium Iron Phosphate batteries, highlighting their advantages, applications, and limitations. • Highlight Safety, Maintenance, and Environmental Impacts: Address operational safety, maintenance practices, and the environmental implications of battery use in electric vehicles. This includes discussing the proper handling of batteries, the importance of a Battery Management System (BMS), recycling and disposal considerations, and the role of batteries in promoting sustainability. • Discuss Future Trends and Innovations in Battery Technology: Examine anticipated advancements and future directions in battery technology and their potential impacts on electric vehicles and the broader energy sector. Focus on emerging technologies such as solid-state batteries and gravity-based storage solutions, and consider their implications for electric vehicle performance, safety, and environmental sustainability. • Introduce Battery Modeling Methods: Cover the significance of battery modeling in electric bicycles, exploring various modeling techniques that predict battery behavior. This includes theoretical, empirical, and electrical circuit models, as well as models for assessing the State of Charge (SoC) and State of Health (SoH). The objective is to equip students with the knowledge

	to design, maintain, and troubleshoot electric bicycle systems effectively.
Topics	• Electric Energy Storage Need • The Structure, Functions, and Working Principles of Batteries • Lead-Acid (Pb-Acid) Batteries • Nickel-Cadmium (NiCd) Batteries • Nickel Metal Hydride (NiMH) Batteries • Lithium-Ion (Li-ion) Batteries • Lithium-Ion Polymer (LiPo) Batteries • Lithium Iron Phosphate ($LiFePO_4$) Batteries • Lithium Sulfide (Li-S) Batteries • Battery Management System • Battery Modeling Methods
Method	• Slides • In-class discussion • Summary
Exercises	• Test questions
Notes	• N/A
Duration	• 270 min.

4.4.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (15 min.)
- Presentation of Main Topics (155 min.)
- Discussion, Questions and Answers (40 min.)
- Examination of a Sample Component (30 min.)
- Sharing Participants' Experiences (15 min.)
- Conclusion (15 min.)

Introduction (15 min.)

It is recommended to start with a brief introduction providing an overview of the module's objectives and main components.

Presentation of Main Topics (155 min.)

Start With an Overview: Begin with a brief introduction to the importance of battery technologies in the context of electric vehicles and renewable energy storage.

Progress Logically: Follow the structure you've prepared, starting with basic concepts before moving on to more complex topics. This ensures the audience builds on their understanding step by step.

Explain Terminology: When introducing new terms or concepts, take the time to explain them clearly. Use analogies or comparisons to make complex ideas more relatable.

Utilize Visual Aids: Use your prepared visuals to support key points, making sure to explain all parts of diagrams or graphs to your audience.

Encourage Participation: Invite questions or comments throughout the presentation, not just at the end. This keeps the audience engaged and allows you to address misunderstandings immediately.

Summarize Key Points: At the end of the presentation, recap the major takeaways to reinforce learning and ensure clarity on the essential concepts of battery technologies in electric vehicles.

Provide Additional Resources: Offer further reading materials or resources for those interested in deeper exploration of the topics covered.

Discussion, Questions, and Answers (40 min.)

To effectively discuess the module "Battery Technologies in Electric Vehicles" to learners, follow these structured steps. This approach ensures a comprehensive and

engaging learning experience, covering the technical aspects, real-world applications, and future trends in battery technology.

- **Introduction**

Objective Setting: Begin by outlining the learning objectives, emphasizing the importance of understanding battery technologies in the context of electric vehicles (EVs), including their role in renewable energy integration, operational safety, and environmental impact.

Pre-assessment: Conduct a brief pre-assessment to gauge learners' existing knowledge about electric energy storage and battery technologies. This will help tailor the session to the audience's level.

- **Electric Energy Storage Need**

Interactive Presentation: Use visuals (charts, graphs) to explain the need for electric energy storage, focusing on the intermittency of renewable energy sources and how batteries help stabilize energy supply.

Group Discussion: Encourage a group discussion on why energy storage is pivotal for the modern grid and electric vehicles, referencing specific figures and examples from the module.

- **Types and Functions of Batteries**

Case Study Analysis: Present case studies on different battery technologies (Li-ion, Lead-Acid, NiCd, etc.), discussing their structure, functions, and applications in EVs. Highlight their advantages and limitations.

Hands-On Activity: Organize a small lab activity or simulation where learners can experiment with basic components of a battery (anode, cathode, electrolyte) to understand electrochemical reactions.

- **Safety and Environmental Impact**

Guest Speaker or Video: Invite an expert or play an educational video on operational safety and maintenance of storage systems in EVs, including the role of the Battery Management System (BMS).

Debate: Facilitate a debate on the environmental and economic implications of energy storage systems, prompting learners to consider recycling, lifecycle, and the transition to sustainable energy solutions.

- **Future Directions**

Research Project: Assign a research project or presentation on future directions in electric energy storage, encouraging learners to explore advancements in battery technologies, solid-state batteries, and the role of microgrids in EV charging infrastructure.

Virtual Field Trip: If possible, organize a virtual tour of a facility specializing in advanced battery manufacturing or an EV production plant to provide practical insights into how the concepts learned are applied in the industry.

- **Recap and Assessment**

Quiz or Test: Conduct a quiz or test to assess the learners' understanding of the module, covering key concepts, technologies, and their implications for the future of transportation and energy storage.

Feedback Session: End with a feedback session, discussing the key takeaways, answering any remaining questions, and providing additional resources for further study.

- **Additional Tips**

Interactive Tools: Utilize interactive tools such as quizzes, flashcards, and e-learning modules to reinforce learning.

Real-World Applications: Wherever possible, connect theoretical knowledge with real-world applications to highlight the relevance of battery technologies in everyday life and the future of electric mobility.

This structured approach ensures that learners not only grasp the technical aspects of battery technologies in EVs but also understand their broader implications for sustainability, safety, and future innovations.

Examination of a Sample Component (30 min.)

It is recommended to show and discuss a type of battery in the class to illustrate the topic.

Participants Share Their Experiences (15 min.)

After the module, participants are expected to ask questions related to the module and share their own experiences.

Conclusion (15 min.)

After the completion of topics, the instructor summarizes the subjects, also addressing the goals of the training, and concludes the session.

4.4.2.1 – Adjusting the Duration of the Training

The instructor can increase or decrease the duration of the module according to the training. The duration may vary depending on participants' expectations. Following the presentations, during the discussion questions section, participants can be divided into small groups to present their suggestions. Later, these suggestions can be communicated by the instructor to all participants for further discussion.

4.4.3 – Main Topics of the Module

Electric Energy Storage Need

Introduction and Rising Need: Explores the significance of Electric Energy Storage (EES) systems, emphasizing their role in stabilizing the grid by capturing excess renewable energy during peak times and releasing it when production is low.

Types of Storage Systems: Covers various EES systems, including chemical (batteries), mechanical (flywheels, pumped hydro), electrostatic (capacitors), and thermal storage.

Batteries as Cornerstone: Highlights batteries as pivotal EES devices, with discussions on different types, including lead-acid, lithium-ion, and flow batteries.

Beyond Batteries: Discusses alternative storage technologies like pumped hydro storage, flywheels, and thermal storage.

Importance in Modern Grids: Focuses on the role of energy storage in enhancing grid stability, integrating renewable energy, and improving power quality.

Specifics for Electric Vehicles: Delves into determining storage needs for EVs, including operational safety, maintenance, environmental, and economic implications, and future directions.

The Structure, Functions, and Working Principles of Batteries

Basic Components and Types: Describes battery fundamentals, including anode, cathode, and electrolyte, and the distinction between primary and secondary batteries.

Chemical Reaction and Lithium-ion Preference: Explains electrochemistry in batteries, focusing on why lithium-ion batteries are preferred for electric bicycles due to their high energy density and longevity.

Capacity, Voltage, and BMS: Covers battery capacity and voltage basics, the importance of Battery Management Systems (BMS), and maintenance and safety best practices.

Future of Battery Technology: Looks into future innovations like solid-state batteries.

Lead-Acid (Pb-Acid) Batteries

Introduction and Chemistry: Provides an overview of lead-acid batteries, their components, underlying chemistry, and types.

Characteristics and Applications: Discusses their characteristics, charging and discharge cycles, safety, maintenance, environmental considerations, and specific applications in electric bicycles.

Future Prospects: Considers ongoing research and future improvements.

Specific Battery Types (NiCd, NiMH, Li-ion, LiPo, $LiFePO_4$, Li-S)

Each section introduces a specific battery type, detailing its introduction, basic components, working mechanism, characteristics, charging and maintenance, safety precautions, environmental implications, and future outlook. Also, their application in electric bicycles and specific considerations for each battery type are highlighted.

Battery Management System

Core Functions and Importance: Explains the functions of a BMS in electric bicycles, including cell balancing, voltage and temperature monitoring, and ensuring safety and prolonged battery life.

Components and Advanced Features: Details the components of a BMS and explores advanced features like data logging and predictive maintenance.

Battery Modeling Methods

Purpose and Types of Models: Discusses the significance of battery modeling in predicting battery behavior and reviews various modeling methods, including theoretical, empirical, and electrical circuit models, as well as models for State of Charge (SoC) and State of Health (SoH).

Future Trends: Considers the impact of advancements in machine learning and AI on future battery modeling techniques.

This module provides a comprehensive overview of battery technologies in electric vehicles, focusing on their types, functions, importance in EVs, and the future direction of these technologies.

4.4.4 – Slides That Can Be Used in Module 4 Presentation

The slides prepared for Module 4 can be found in Appendix 4.1 (CD).

Notes:

4.5 – Electric Motors Used In Bicycles

4.5.1 – Module Summary

Objective of the Module	• To explain the structures, types and control methods of AC and various DC motors. • To give information about the parts that make up electric motors and their structural differences and the characteristics of their working classes. • To give information about Power Transmission and Control in Electric Motors • To give general information about the connection types of direct current motors. • To give general information about how to check and change the speed of direct current motors.
Topics	• Working Logic of Electric Motors • Parts of Electric Motors • Power Transmission and Control in Electric Motors • Direct Current Motor Connections • Number of revolutions of direct current motors
Method	• Lecture, Q&A • Slides presentation video • In-class discussion • Summary
Exercises	• Test and section questions
Notes	• The development of Electric Bicycle motors
Duration	• 150 min.

4.5.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (5 min.)
- Presentation of Main Topics (60min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Sample Component (15 min.)
- Sharing Participants' Experiences (10 min.)
- Conclusion (10 min.)

Introduction (5 min.)

It is recommended to make a brief introduction by giving summary information about the usage targets of electric motors and the main components.

Presentation of Main Topics (60 min.)

A basic knowledge of the history and structures of electric motors should be conveyed at the listener's level of understanding and without boring them. It is advisable to make an introduction decorated with visuals related to the development of engines, their types and connections. In this module, it is expected to explain the development and use of motors used in electric bicycles.

Discussion, Questions, and Answers (20 min.)

In the period after the basic topics are explained, in the form of questions and answers, in addition to the questions to be asked by the participants, the trainer can encourage the discussion by asking some questions. Example questions might be as follows:

- By giving examples of the usage areas of electric motors around the world, how should alternative projects to electric motors and energy efficiency be?
- What are the differences between AC and DC motors?
- What do you mean by reducers?
- What are the terms torque and cadence?
- What are the methods used for PWM control?

Examination of environmental designs (15 min.)

Considering the environmental possibilities in which the subjects will be processed, the applications should be made in the most efficient way. In order to prepare for these processes and the next modules, subject models should be selected from understandable types. Variations should be made as much as possible to make the applied experiments more understandable. A detailed examination will be made by considering the conditions and designs required for this.

Participants Share Their Experiences (10 min.)

Finally, upon completion of the module, trainees are expected to ask questions about the module and share their own experiences with electric motors.

Conclusion (10 min.)

After the completion of the lesson, the trainer summarizes the topics and closes the session, mentioning the objectives of the training.

4.5.2.1 – Adjusting the Duration of the Training

The trainer can increase or decrease the duration of the module based on the flow. The duration may vary depending on the expectations of the participants. After the presentations, in the discussion questions section, the participants can divide into small groups and present their own suggestions. These suggestions can then be conveyed by the trainer to all participants for discussion

4.5.3 – Main Topics of the Module

Explaining the main topics of the module to the trainees will facilitate the explanation of the topics. The key topics outlined below help the trainer prepare and summarize the topic.

Working logic of Electric Motors

The structures, types and control methods of AC and various DC motors are described in section 5.1 of the module. In this regard, teachers are directed to the learning process from simple to difficult by referring to the theoretical work of motors and their structures and working systems.

This topic should be explained and explained with examples of the following topics:

• The structures and differences of AC and DC motors should be briefly explained.

• The issue of universal motors should be explained and Speed controls and change of speed direction of universal motors should be briefly explained.

• Brushed and Brushless The types and usage areas of DC motors should be briefly explained and their advantages and disadvantages should be mentioned.

• Stepper and Servo motors should be briefly explained and the places where they are used should be compared.

Parts of Electric Motors

Within the information described in section 5.2 of the module, information about the components that make up electric motors and their structural differences and the characteristics of their operating classes should be given.

The information should start as asynchronous and synchronous and end with DC motors and include illustrative figures.

Power Transmission and Control in Electric Motors

It is described in section 5.3 of the module.

The topic of couplings and reducers should be briefly explained.

AC and DC motor speed and speed control should be briefly explained.

Stepper and servo motor control circuits should be briefly mentioned.

Direct Current Motor Connections

This topic is described in section 5.4 of the module. General information should be given about the connections of direct current motors. At the same time, since DC motors used in electric bicycles are also explained in this module, application methods should be briefly mentioned.

Therefore:

- The advantages and disadvantages of mid-drive motors should be briefly described.
- The gear hub motor structure should be briefly explained with its advantages and disadvantages.
- The content, advantages and disadvantages of the motor structure in direct drive systems should be briefly described.
- The advantages and disadvantages of the wheel friction motor system should be briefly described.

Number of revolutions of direct current motors

Module 5 provides general information on how to check and change the speed of DC motors. Based on this:

- The issue of speed control in brushed DC motors should be briefly explained.
- The first basic information should be given for the engine to start back and forth.
- Speed control with brushless DC motor circuit should be briefly described.

4.5.4 – Slides That Can Be Used in Module 5 Presentation

The slides prepared for Module 5 can be found in Appendix 5.1 (CD).

4.5.5 – Notes for Module 5

The development of electric bicycle motors

Electric bicycles are a type of bicycle used by the rider pedaling thanks to the developed pedal structure. In this type of bicycle, the progress of the bicycle is ensured by using electrical energy. The first studies on electric bicycles were put forward in the 1890s with US patent documents. ***On*** December 31, 1895, Ogden Bolton Jr. received U.S. Patent 552.271 with a "rear wheel-mounted, 6-pole, brushed, and commutator direct current (DC) hub motor" with a battery-powered system. This bike, which did not have a gear, had a current of 10 amperes from a 10-volt battery.

Ogden Bolton Jr. In 1897, two years after the patent was declared***, Hosea W. Libbey*** invented the U.S. Patent 596,272 patented bicycle with dual electric motors. The engine of this

bicycle was located on the mirror arm axle. The same model was developed and later reinvented by the "Giant Lafree e-bikes" at the end of the 1990s.

Mathew J. Steffens, on the other hand, patented a bicycle with a rear-wheel drive system in 1898 using a drive belt on the outside of the wheel. By 1899, ***Schnepf*** had developed the U.S. Patent 627.066 drive electric bicycle called the "roller wheel" with a frictional rear wheel.

Political and economic developments in the 21st century have closely affected the nations of the world. Industrialization and, accordingly, mechanization have shown themselves in every field. With the developing technology, many products have become more useful and robust. Bicycles are one of these products. These products, which are economical and environmentally friendly, have started to be produced and developed in different forms as of this century. In particular, electric bicycles have started to be produced as more useful and high-performance environmentally friendly vehicles. As of the end of the 1990s, torque sensors and power controls have been developed. In Japan, in 1997**,** ***Takada Yutky*** applied for a patent for the device he developed.

In 1992, ***Vector Services*** Limited designed and launched the Zike e-bike. The bike has "NiCd batteries and an 850 g permanent-magnet motor".

Japanese automotive company Yamaha produced one of the first prototypes of electric bicycles in 1989.

In 1993, he invented pedal-assisted ones. In the period from this date to 2004, production increased by around 35%.

In 1997, American automobile mogul Lee Iacocca founded EV Global Motors, which produced the E-bike SX. After this period, e-bikes started to become widespread in the USA. After this period, electric bicycles were manufactured using bulky lead-acid batteries. Newer models, on the other hand, are lighter and produced using high-capacity NiCd, NiMH and Li-ion batteries. Although their performance varies, the speed and range of Li-ion batteries are greater than other batteries.

In 2007, it is known that 10-20% of the bicycles used in China are electric bicycles.

https://elektriklimotor.com.tr/elektrikli-bisiklet-in-tarihi/

Notes:

4.6 – Structural Features of Electric Bicycles

4.6.1 – Module Summary

Objective of the Module	• Will be able to explain the body structure of electric bicycles aerodynamically. • Will know the basic properties of the materials used in the body structure of electric bicycles. • Will know the mechanical parts of electric bicycles by their names and features and will be able to disassemble and assemble them.
Topics	• Body Designs of electric bicycles, • Types of trunks • Elements that enable operation
Method	• Lecture, Q&A • Application • Slides presentation video • In-class discussion • Summary
Exercises	• Test questions • Skill Practices
Notes	• The importance of electric bikes.
Duration	• 120 min.

4.6.2 – Sequence of Training

For this training module, the following framework is suggested:

- Introduction (5 min.)
- Presentation of Main Topics (60 min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Sample Component (15 min.)
- Sharing Participants' Experiences (10 min.)
- Conclusion (10 min.)

Introduction (5 min.)

It is recommended to give a brief introduction in which a summary information is given about the objectives and main components of the module. The structures of electric bicycles should be briefly mentioned.

Presentation of Main Topics (60 min.)

For groups that do not know about the body structures of electric bicycles, it is recommended to make an introduction that gives basic information and explains the basic components of electric bicycles with slides. Then, it is expected to explain the historical development of electric bicycles, current usage standards, electric bicycle body types, advantages and disadvantages of body structures of electric bicycles.

Discussion, Questions, and Answers (20 min.)

In addition to the questions that the participants will ask after the presentation, the trainer can also encourage discussion by asking some questions. Example questions might be as follows:

- Discuss what distinguishes electric bikes from other battery-powered vehicles.
- How the body structures of electric bicycles have changed over the years. Discuss it in class by searching it on the internet.
- Think of the main features of the batteries as the place on the bicycle frame and discuss where the ideal location might be.
- Discuss the difference between mountain biking and urban cycling with examples.

Review of Sample Patent (15 min.)

In order to prepare the participants for the issues that will be examined in later models, it is recommended that they examine a patent that also contains traces of technological development that form the basis of today's standards of use.

This patent can be electric bicycle in foldable body structure.

Participants Share Their Experiences (10 min.)

After the module, trainees are expected to ask questions about the module and share their own experiences about the body structures of electric bicycles. The trainer may also ask participants to share their current knowledge of the body structures of electric bicycles and their own ideas on the advantages and disadvantages of electric bicycles.

Conclusion (10 min.)

After the completion of the topics, the trainer summarizes the topics and closes the session, also touching on the objectives of the training.

4.6.2.1 – Adjusting the Duration of the Training

The trainer can increase or decrease the duration of the module based on the flow. The duration may vary depending on the expectations of the participants. After the presentations, in the discussion questions section, the participants can divide into small groups and present their own suggestions. These suggestions can then be conveyed by the trainer to all participants for discussion.

4.6.3 – Main Topics of the Module

As with all modules, it is important to review the basic topics before transferring this module to the trainees. The key topics outlined below help the trainer prepare and summarize the topic.

History of Body Structures of Electric Bicycles and Today's Usage Standards

This is described in Module 6.1. An electric bicycle is an extremely simple, convenient, economical and ergonomic means of transportation. In recent years, a new generation of electric bicycles has been produced as environmentally friendly. It provides convenience to the user by eliminating the difficulty of pedaling at heavy loads and especially on slopes

The electric bicycle frame is called "Frame". Carbon, steel, aluminium, titanium. It can be made of different materials such as. In terms of durability, aluminum and carbon frames are mostly preferred on bicycles. One of the biggest features of aluminum frames is that they are light and absorb impacts. Today, carbon fiber frames are quite common, and they are much stiffer and much lighter than aluminum. Due to this feature, the mountain Carbon frames are more preferred in bicycles and road bikes.

Electric Bicycle Body Types

Today's usage standards are described in section 6.2 of the module. The standard body structure is fixed. Foldable bicycle is a type of bicycle that can be easily folded to

take up less space in order to be used in the first and last parts of a long journey, and can be easily opened and ridden when it arrives. There are also two-wheeled bicycles called scooters or "kick bikes", which are ridden without a seat, by pressing close to the ground with one foot and pushing the ground with one foot. They are suitable for shorter and non-hilly paved distances.

Materials That Make Up Electric Bicycles

This topic is covered in Module 6.3. The basic parts that make up an e-Bike:

- Indicator
- Gear levers (right and left)
- Battery
- Pedals
- DC motor (brushless)
- Saddle
- Wheels (front and rear)
- Disc brake
- Connection cables
- Rims (front and rear) and anchors
- Protective materials and body bars
- Sensors (speed, cadence, torque, etc.)
- Lighting headlights
- Chains and gears
- It can be said as a chain box (team).

4.6.4 – Slides That Can Be Used in Module 6 Presentation

The slides prepared for Module 6 can be found in Appendix 6.1 (CD).

4.6.5 – Notes for Module 6

• The Importance of Electric Bicycles

Electric BicycleNew technologies in motor and battery (eg.Ni-MH) has started to make the bicycle more attractive by bringing price and ease of use. That's why longer distances have become accessible by bicycle without sweating. In addition, the reasons such as offering a freer, more social, healthier, more cost-effective, and more environmentally friendly option instead of a sedentary journey in the car in congested traffic have made the electric bicycle more attractive. The electric motor can be placed in the front wheel hub, rear wheel hub, or between the pedals for more stability. The battery in which the electrical energy is stored may be hidden in the frame or mounted on it. The motor increases the comfort of the driver by helping the pedal power with the energy it receives from the battery. In order to comply with the restrictions imposed by the law on bicycle speed and engine power and to ease of use, devices that measure speed and pedal power in electric bicycles and adjust the rate of motor assistance may also be part of the system.

Notes:

4.7 – Legal Regulations About Electric Bicycles

4.7.1 – Module Summary

Objective of the Module	• To explain what are the rules that electric bicycle users should pay attention to. • To inform you about the conditions required to be a conscious user. • To teach the requirements for a license to drive an electric bicycle. • To apply knowledge about user ethics required when using an electric bike. • To comprehend issues such as road, environment, warning signs designed for electric bicycles. • To explain the role of electric bicycles in environment, sustainability and urban transportation.
Topics	• Considerations when using an electric bicycle • License to drive an electric bicycle • The ethics of using an electric bike • Electric Bicycle Frame and Design Environmental sustainability and the role of electric bikes in urban transport
Method	• Lecture, Q&A • Slides presentation video • In-class discussion Summary
Exercises	• Test questions
Notes	• Introduction to the use of electric bicycles • Electric bike ethics • The role of the electric bicycle in the city, country and around the world
Duration	• 120 min.

4.7.2 – Sequence of Training

The following framework is recommended for this training module:

- Introduction (5 min.)
- Presentation of Main Topics (75 min.)
- Discussion, Questions and Answers (20 min.)
- Examination of a Regulation (15 min.)
- Sharing Participants' Experiences (10 min.)
- Conclusion (10 min.)

Introduction (5 min.)

It is recommended to make a brief introduction by giving summary information about the objectives and main components of the topics.

Presentation of Main Topics (75 min.)

Since electric bicycles are land vehicles, a number of legal regulations have been introduced regarding their use in traffic. It is recommended to make an introduction in which these regulations are supported and explained. In this module, it is expected that the laws and rules that need to be known in the use of electric bicycles will be discussed and explained.

Discussion, Questions, and Answers (20 min.)

In the period after the basic topics are explained, in the form of questions and answers, in addition to the questions to be asked by the participants, the trainer can encourage the discussion by asking some questions. Example questions might be as follows:

- What should be considered when using electric bicycles in city traffic?
- According to the power and speed reached by electric vehicles per hour, it has imposed obligations such as helmets, license plates, registration, driver's licenses. Accordingly, What should be the driver's license class required for electric bicycles?
- What is the distance between two vehicles moving one after the other in the same lane on the highway?
- What should be the power of the electric bicycle that can be used without a license and license plate?

Examination of Environmental Designs (15 min.)

In order to prepare for the next modules, methods that promote environmentally friendly transportation, policies that aim to increase the use of pedestrian, bicycle and public transportation types, and implement improvements for these types will be examined. In various world cities, various project packages and designs that support these policies will be examined in detail in line with the unique social and physical characteristics of the cities.

Participants Share Their Experiences (10 min.)

Finally, upon completion of the module, trainees are expected to ask questions about the module and share their own experiences with the use of electric bicycles. The trainer may also ask the participants to share their current knowledge about electric bicycles and their ideas about shared rental urban bicycle applications.

Conclusion (10 min.)

After the completion of the educational course, by mentioning the objectives of the training Summarizes the topics and closes the session.

4.7.2.1 – Adjusting the Duration of the Training

The trainer can increase or decrease the duration of the module based on the flow. The duration may vary depending on the expectations of the participants. After the presentations, in the discussion questions section, the participants can divide into small groups and present their own suggestions. These suggestions can then be conveyed by the trainer to all participants for discussion.

4.7.3 – Main Topics of the Module

As with all modules, it is important to review the basic topics before transferring this module to the trainees. The key topics outlined below help the trainer prepare and summarize the topic.

Considerations When Using an Electric Bicycle

The points to be considered for the use of cargo bikes or driver bicycles in city traffic should be summarized. This topic is described in section 7.1 of the module. The following rules should be explained and explained with examples:

- It should drive on the right side of the highways.
- The right lane should be followed.
- Loads to be placed on the bicycle must be carried in the bicycle trunk.
- Loads that will disturb the balance or affect the width of the bicycle should not be carried.
- The bike must be driven with both hands, except for right and left signaling.
- Appropriate hand signal should be given in turns.
- Before entering the main road, you should get off the bike and check the road.
- Electric bicycles must be used within speed limits. Excessive speed should be avoided.

- Sudden braking should be avoided on icy roads, in snowy and heavily rainy weather.
- When cycling in a group, sudden movements should be avoided as much as possible.
- When using an electric bicycle, the following distance of 30 cm should be maintained.

Following Distance within the Group

Definitions should be explained with emphasis. In this topic, the concept of following distance will be explained as follows:

The distance between two vehicles that are moving one after the other in the same lane on the highway is called the following distance. On urban and out-of-town tours, the following distance should be maintained with the cyclist in front as much as possible

License to Operate an Electric Bicycle

It is described in section 7.2 of the module. As the use of electric bicycles, electric motorcycles, electric scooters has increased on the highways recently, there has been a need for traffic regulations for life safety. As a result, according to the power and speed of electric vehicles per hour, obligations such as helmet, license plate, registration, driver's license will be mentioned.

The Ethics of Using Electric Bikes

7.3. By giving students world examples of ethics in the use of electric bikes, you can make the topic more attractive and help them develop their thinking skills.

You can raise awareness of students about sustainable transportation by giving examples about the fact that electric bicycles should be realized within the framework of certain rules.

Electric Bicycle Frame & Design

With the 2000s, electric bicycles have been widely used around the world. Growing concerns about the sustainability of urban transportation have increased the popularity of electric bikes. Many companies are developing various models to be used in urban transportation today.

In line with the information described in section 7.4 of the module, students should be asked about their opinions on different environmental designs and evaluation and brainstorming should be created in the classroom.

Environmental Sustainability and the Role of Electric Bicycles in Urban Transportation

The history of electric bicycles has been shaped by technological developments and has become one of the first vehicles that come to mind when the concept of "Sustainable Transportation" is mentioned. These are strategies that, on the one hand, promote the use of non-motorized modes of transport, while at the same time trying to

reduce the use of motorized modes of transport. According to this strategy, electric and flat bicycle stations are installed in cities for rent.

The subject described in section 7.2 of the module should be elaborated and visuals related to electric bicycle charging stations should be shared. Research assignments can be given on the technical specifications of charging stations.

4.7.4 – Slides That Can Be Used in Module 7 Presentation

The slides prepared for Module 7 can be found in Appendix 7.1 (CD).

4.7.5 – Notes for Module 7

- **Introduction to the use of electric bicycles**

The electric bicycle, which is becoming more and more widespread, is a mixed product. The bicycle, which is a human-powered and environmentally friendly type of transportation, is supported by an environmentally friendly electric motor and preserves its environmentally friendly feature to a great extent. With the support of the electric motor, the limits in the use of the bicycle are stretched, the area of effect is expanded, and comfort and convenience are provided. By reducing the negative effects of inclined areas, which are the most important restriction in the use of the bicycle, fatigue and sweating and fatigue caused by slope and distance are reduced. This change, especially when combined with shared rental urban bicycle (bike share) applications, electric bicycles constitute a serious alternative to automobile use and become one of the most important types of transportation in the cities of the future.

- **Electric bike ethics**

The physical separation of the electric bicycle, which has started to move away from pedestrian features, from pedestrians and motor vehicles in traffic becomes more necessary. This new species, which differs from pedestrians and motor vehicles, poses new risks to pedestrians and themselves, as it is as naïve and fragile as pedestrians and bicycles, but faster and stronger than non-motorized types. Moreover, the environmental impact of aging battery waste, which is an unsolved problem of electric bicycles, is a negative dimension that should not be overlooked. Taking into account all the positive and problematic features of this new mode of transportation, new policies should be created and implemented in order to use it in urban transportation. The creation of policies and projects related to electric bicycles has started since the beginning of the two millenniums and policies and rules have been defined in many countries.

- **The role of the electric bicycle in the city, country and around the world**

Among the users of electric bicycles and vehicles, weak, naïve and fragile users such as the disabled, the elderly, children, pregnant women, mothers with children are primarily evaluated. Pedestrian transportation and cyclists, including all of these users, need to be protected and taken care of, as they do not have a negative impact on the environment, on the contrary, they are adversely affected by the pollution created by vehicles. It is necessary to protect these species from the crushing, polluting, damaging effects of motor vehicles and especially automobiles.

Notes:

4.8 – Periodic Maintenance and Service of Electric Bicycles

4.8.1 – Module Summary

Objective of the Module	• To be able to perform daily, weekly and monthly maintenance of electric bicycles. • To be able to detect and fix electric motor malfunctions, • To be able to diagnose and repair mechanical system malfunctions, • To know and repair charging system malfunctions, warning and display system malfunctions, • To be able to perform general maintenance of electric bicycles.
Topics	• Daily, weekly, monthly and annual maintenance • Electric motor malfunctions • Mechanical system failures • Charging system malfunctions • Warning and display system malfunctions
Method	• Lecture, Q&A • Application • Slides presentation video • In-class discussion Summary
Exercises	• Test questions • Skill Practices
Notes	• Examining the Electric Bicycles General Fault Table • Methods of servicing and maintenance of electric bicycles • Precautionary measures
Duration	• 150 min.

4.8.2 – Sequence of Training

The following framework is recommended for this training module:

- Entrance (5 min.)
- Presentation of Main Topics (45 min.)
- Discussion, Questions and Answers (20 min.)
- Applications related to the detection of electric bicycle malfunctions (40 min.)
- Trainees share their experiences (30 min.)
- Result (10 min.)

Entrance (5 min.)

It is recommended to give a brief introduction in which a summary information is given about the objectives and main components of the module. Monthly maintenance on electric bicycles, the necessity and purpose of the procedures performed in weekly maintenance should be emphasized.

Presentation of Main Topics (45 min.)

The two most important elements of electric bicycles are their mechanical and electronic components. These components need periodic maintenance. Electric bicycle repair and maintenance services are not as common as automobile services. Therefore, users should have the ability to perform periodic maintenance of their own bicycles.

In this module, which aims to maintain and repair brake systems, pedals, electric motor and charging unit and to inform about periodic maintenance, it is expected to gain competencies that can do these maintenance on your own.

Applications should be made by following the order of work and operations to be done in daily, weekly, monthly and annual maintenance of electric bicycles, and students should be provided with skills.

Discussion, Questions, and Answers (min.)

In addition to the questions that the participants will ask after the presentation, the trainer can also encourage discussion by asking some questions. Example questions might be as follows:

- What type of battery is usually used in electric bicycles?
- At what maintenance time is the replacement of brake pads carried out?
- Electric bicycles can cause a number of problems in charging systems depending on the usage situation and the user. What are these problems?
- What are the procedures to be done in daily, weekly, monthly and annual maintenance of electric bicycles?
- What are the warning indicators on electric bicycles?

- Describe the brake maintenance in the order of operation.
- Introduce the measuring and adjusting tools used during maintenance.

Applications related to the detection of electric bicycle malfunctions (40 min.)

Just like any other vehicle, electric bikes require regular maintenance to function optimally. Neglecting regular maintenance can lead to significant problems that may require costly repairs. Routine maintenance will also extend the life of your electric bike and minimize the chances of accidents. For this, work and process steps for maintenance applications will be monitored.

During the course of the lesson, the batteries, cables, controllers, fuses and connectors of a sample electric bicycle will be checked for signs of damage. Components will be tested one by one to isolate the root cause of the problem. Defective components will be repaired or replaced as needed.

The procedures to be done for daily, weekly, monthly and annual maintenance of electric bicycles will be explained practically and students will be given hand skills.

Participants Share Their Experiences (30 min.)

Upon completion of the module, trainees are expected to ask questions about the module and share their own experiences with the maintenance of electric bikes. The trainer may ask the participants to discuss their current knowledge about the maintenance and repair of electric bicycles and possible mechanical failures and solutions that may be encountered in electric bicycles.

Conclusion (10 min.)

After the completion of the topics, the trainer summarizes the topics and closes the session, also touching on the objectives of the training.

4.8.2.1 – Adjusting the Duration of the Training

Since the priority in this module is the evaluation of practice and manual skills, the training period can be extended. Flexibility in training can be achieved as different skills are required on each electric bike for maintenance and repair.

In applications such as mechanical maintenance, repair and measurement, students can be divided into groups. Each of these groups can do different practices and monitor the development of the educational group.

4.8.3 – Main Topics of the Module

As with all modules, it is important to review the basic topics before transferring this module to the trainees. The key topics outlined below help the trainer prepare and summarize the topic.

Daily, weekly, monthly and annual maintenance

In the subject described in section 8.1 of the module, the following topics will be emphasized;

Just like any other vehicle, electric bikes require regular maintenance to function optimally.

Neglecting regular maintenance can lead to significant problems that may require costly repairs.

Routine maintenance will also extend the life of your electric bike and minimize the chances of accidents.

Regular maintenance and quick repairs can prevent problems that could damage your bike's battery, motor, and other components.

Daily, weekly, monthly and annual maintenance applications will be made on electric bicycles.

Electric motor malfunctions

It is proposed to give the subject of electric motor failures described in section 8.2 of the module with the demonstration and application method. Examining and measuring electric bicycle motors and determining what their malfunctions are should be concluded by both skill and discussion. The possible malfunctions of the electric motor should be examined in a table and recorded in the notes section.

Mechanical system failures

Mechanical system failures in section 8.3 of the module should be explained using the demonstration and application method. Possible mechanical failures that may be encountered in electric bicycles and their solutions should be explained by comparing the table given in the module. Mechanical failures should be recorded in the notes section.

Charging system malfunctions

Electric bicycles can cause some problems in charging systems depending on the usage situation and the user. General charging system malfunctions should be detected on a sample bicycle and the identified faults should be recorded in the notes section. In addition, the hand and measuring instruments to be used will be available in the application environment.

Warning and display system malfunctions

Warning indicators on electric bicycles provide information to the user about driving. Although this information is the same for most electric bikes, explain the indicators on the bike in your practice workshop in practice. Perform the measurement process in module 8.5 with measuring instruments and write the results in the notes section.

4.8.4 – Slides That Can Be Used in Module 8 Presentation

The slides prepared for Module 6 can be found in Appendix 8.1 (CD).

4.8.5 – Notes for Module 8

- ## Examining the Electric Bicycles General Fault Table

Checking and Adjusting Tire Pressure	Check it regularly. Keep the pressure at the manufacturer's recommended levels.
Cleaning and lubricating the drivetrain	Keep the chain and sprockets clean and lubricated to maximize performance and prevent wear.
Inspection and Tightening of Bolts and Fasteners	Regularly inspect all bolts and fasteners. Tighten if necessary to prevent damage and ensure safety.
Replacing the Brake Pads and Adjusting the Brakes	Brake pads wear out over time and should be replaced as soon as they become too thin. The correct setting is essential to ensure that your bike can stop safely and quickly.

- ## Methods of servicing and maintenance of electric bicycles

Troubleshooting Common Issues

Identifying and Correcting Electrical System Problems

Check batteries, cables, controllers, fuses, and connectors for signs of damage. Test individual components to isolate the root cause of the problem. Repair or replace defective components as needed.

Diagnosing and Resolving Battery Problems

Perform regular battery maintenance, such as charging and balancing. Test battery voltages and internal resistance. Replace the battery if necessary to restore performance.

Handling Motor and Controller Failures

Test the motor and controller connections for signs of wear and damage. Check the electrical controls and sensors to see if they are working properly. Replace or repair as needed to restore power and performance.

- ## Precautionary measures

From worn chains to broken spokes, there are many problems that can occur with the mechanical components of e-bikes. Checking for wear and making repairs at the first signs can prevent the need for costly replacements down the road.

Before working on electrical systems, use the appropriate tools, follow manufacturer recommendations, and take safety precautions, such as turning off the power. Always work in a well-lit, well-ventilated area.

Notes:

5 – Instructor Specific Guide

5.1 – Introduction to Electric Bicycles, Advantages, Prejudices

5.1.1 – Introduction to Electric Bicycles

Electric bicycles, commonly known as e-bikes, represent a revolutionary shift in personal transportation. Combining traditional cycling with electric assistance, these vehicles have gained substantial popularity for their eco-friendly nature and practicality.

In the ever-evolving landscape of transportation, electric bicycles (e-bikes) stand out as a beacon of innovation, offering a dynamic fusion of traditional cycling and cutting-edge electric technology. As we embark on this educational journey, it's essential to recognize the transformative impact that e-bikes have on personal mobility and the broader landscape of urban transportation.

The idea of electrically assisted bicycles dates back to the late 19th century, but recent advancements in battery technology, motor efficiency, and a growing emphasis on sustainability have propelled e-bikes into the spotlight. These vehicles seamlessly integrate electric power with human pedaling, offering riders an enhanced and accessible mode of commuting.

Over the past decade, the global popularity of e-bikes has surged, with riders from various demographics embracing this eco-friendly alternative. This surge is not merely a trend; it represents a shift in how we perceive and engage with personal transportation. E-bikes are no longer niche gadgets but integral components of a sustainable and interconnected urban mobility ecosystem.

As urban areas grapple with issues of traffic congestion, air pollution, and the need for sustainable transportation solutions, e-bikes emerge as a practical and efficient answer. They provide a harmonious blend of exercise and electric assistance, making cycling an attractive option for individuals of all fitness levels and ages.

In the context of our educational endeavors, understanding electric bicycles is not just about mastering the mechanics of a modern vehicle; it's about equipping our students with the knowledge to navigate a world increasingly shaped by sustainable practices. As educators, we play a pivotal role in fostering awareness and appreciation for innovations that can positively impact our communities and the environment.

Throughout this educational module, we will explore the intricate details of electric bicycles from the mechanics of their electric motors to the societal impacts of their widespread adoption. Our discussions will delve into the advantages these vehicles offer, as well as the prejudices and challenges they face in various communities.

As we embark on this exploration of electric bicycles, let us keep in mind their potential to redefine not only how we move but also how we perceive and contribute to a greener and more sustainable future. Our journey begins with a deeper understanding of these innovative vehicles, and together, we can inspire a new generation to embrace the possibilities they bring to the landscape of transportation.

5.1.2 – Advantages

As we embark on the exciting journey of exploring electric bicycles with our students, it's crucial to highlight the enchanting advantages that make these innovative vehicles a compelling choice for sustainable transportation:

Eco-Friendly Commuting

Imagine commuting without leaving a trace. E-bikes are the epitome of eco-friendly transportation, emitting zero emissions and contributing to a cleaner, greener planet. Our rides become acts of environmental stewardship.

Effortless Mobility

E-bikes effortlessly blend pedal power with electric assistance, making our daily commutes and rides a breeze. No sweat, no stress—just smooth, enjoyable journeys. It's the magic of technology enhancing our mobility.

Health and Wellness

Contrary to misconceptions, e-bikes don't replace effort; they enhance it. The pedal-assist feature encourages physical activity at our own pace, promoting a healthier lifestyle. It's not just a ride; it's a holistic well-being experience.

Time Efficiency

Time is precious, and e-bikes understand that. They navigate through traffic seamlessly, reducing commute times and providing us with more moments to cherish. It's not just a mode of transport; it's a time-saving companion.

Cost-Effective Travel

Say goodbye to fuel costs and expensive commutes. E-bikes are not just environmentally friendly; they're pocket-friendly too. Share with your students about the savings they accumulate as they adopt this cost-effective method of travel.

Empowering Independence

With e-bikes, we reclaim our independence. Whether it's conquering hills effortlessly or extending our commuting range, these vehicles empower us to explore more, opening doors to new adventures and possibilities.

Fun and Enjoyable Rides

As we discuss the fun aspect of e-bikes, let's introduce students to various e-bike models designed for specific purposes, such as urban commuting, off-road adventures, or leisurely weekend rides. This variety ensures that there's an e-bike suited for every preference and style.

In our upcoming sessions, let's ignite curiosity and excitement by unraveling these enchanting advantages. By showcasing the magic of e-bikes, we aim to inspire a newfound appreciation for sustainable and delightful transportation.

5.1.3 – Prejudices

Perceived Lack of Exercise

One prevalent prejudice is the belief that e-bikes result in a lack of physical exercise. It's essential to emphasize that e-bikes are designed to assist rather than replace human effort. The pedal-assist feature encourages physical activity, making cycling accessible to a broader range of individuals with varying fitness levels. Engage students in discussions about the health benefits of e-bikes. Illustrate scenarios where individuals, regardless of fitness levels, can enjoy the advantages of cycling while incorporating electric assistance as needed. Encourage them to view e-bikes as tools that promote both exercise and inclusivity.

Range Anxiety

Another common misconception is 'range anxiety' - the fear of running out of battery during a ride. Reassure students that advancements in battery technology have significantly extended the range of e-bikes. Share real-world examples of users successfully completing long journeys, highlighting the practicality and reliability of modern e-bike batteries.

Perception of Cheating

There's a common perception that using an e-bike is 'cheating' compared to traditional cycling. Challenge this notion by emphasizing that e-bikes are not about competition but about creating an inclusive and accessible mode of transportation. Discuss the diverse user base, from avid cyclists to those rediscovering the joy of biking through e-bikes.

Encourage students to embrace the diversity of e-bike users. Share anecdotes of individuals with varying needs, such as commuters, recreational riders, and those overcoming physical challenges, all benefiting from the electric assistance that e-bikes provide. In doing so, we redefine the narrative from 'cheating' to 'inclusive mobility.

Regulatory Uncertainty

Concerns about unclear regulations are valid and contribute to prejudices. Equip students with knowledge about the regulatory landscape surrounding e-bikes. Encourage them to stay informed about local laws and promote responsible e-bike riding within established guidelines. Discuss how regulations may vary by region and the importance of riders understanding and adhering to local laws.

5.2 – Public Area Usage, Integration with Public Transportation and Transporting the Bicycle

5.2.1 – Public Area Usage

One of the remarkable features of electric bicycles is their adaptability to public spaces. E-bikes are designed for urban environments, enabling riders to navigate crowded streets, bike lanes, and public areas with ease. Public area usage of electric bicycles can take various forms, and it largely depends on local regulations, infrastructure, ancd community preferences.

Bike-sharing Programs: Many cities around the World have implemented bike-sharing programs that include electric bicycles. These programs allow individuals to reng e-bikes at designated locations, promoting a convenient and eco-friendly mode of transportation.

In Ankara, public transport authority EGO, initiated the "MeHub" project under the EIT Urban Mobility call in 2022. This project focuses on integrating a connected micromobility infrastructure into public transportation. In the initial phase, they have commenced testing an electric bicycle-sharing system with 25 electric bicycles. Additionally, within the scope of the “SMART Ankara” Project, 408 electric bicycles will be integrated into public transportation.

Bike Lanes and Infrastructure: The growing popularity of e-bikes has led to increased considerations for bike-friendly infrastructure. Cities may develop dedicated bike lanes, bike-sharing stations, and charging points for e-bikes to encourage their use and ensure safety.

Commute and Last-Mile Transportation: E-bikes are often used for commuting and last-mile transportation. Many people use them to cover short distances between public transportation stops and their final destinations. This helps reduce traffic congestion and provides a sustainable alternative to traditional commuting methods.

Regulations and Policies: The use of e-bikes in public areas is subject to local regulations and policies. These may include speed limits, helmet requirements, and restrictions on where e-bikes can be ridden. Different regions may categorize e-bikes differently, with some considering them as regular bicycles and others as motorized vehicles.

Tourism and Recreation: In tourist destinations, e-bikes are sometimes used for guided tours or personal exploration. They offer a convenient and environmentally friendly way for tourists to explore scenic areas and historical sites.

Challenges and Considerations: Public area usage of e-bikes also raises some challenges, such as the need for proper infrastructure, charging facilities, and clear regulations. Safety concerns, especially regarding speed differences between e-bikes and traditional bicycles, pedestrians, or other vehicles, may also need to be addressed.

5.2.2 – Integration with Public Transportation

The integration of electric bicycles (e-bikes) with public transport is gaining popularity as cities seek sustainable and efficient transportation solutions. This integration offers several benefits and addresses common challenges associated with the "last mile" problem, where commuters face difficulties getting to and from public transport hubs. Some key aspects of the integration of e-bikes with public transport are:

First and Last Mile Connectivity: E-bikes provide an excellent solution for the first and last mile of a commuter's journey. Commuters can use e-bikes to travel between their homes and public transport stations (such as bus stops or train stations), bridging the gap that may be inconvenient or too far to walk.

Reduced Congestion and Emission Levels: Integrating e-bikes with public transport can contribute to reduced congestion and lower emission levels. By encouraging commuters to use e-bikes for short distances, cities can alleviate traffic congestion and decrease the environmental impact of transportation.

Bike-Sharing Programs: Public transport agencies often collaborate with bike-sharing programs that include e-bikes. This allows commuters to easily access e-bikes at or near public transport stations, making it a seamless and convenient experience.

Multi-Modal Ticketing Systems: Some cities have implemented integrated ticketing systems that cover both public transport and bike-sharing services, including e-bikes. This simplifies the payment process for commuters and promotes the use of multiple modes of transportation within a single journey.

Bike Parking Facilities: Public transport hubs may provide secure and convenient bike parking facilities, including charging stations for e-bikes. This infrastructure encourages commuters to use e-bikes as part of their overall journey.

Awareness and Education: Public transport agencies often run awareness campaigns and educational programs to inform commuters about the benefits of integrating e-bikes into their daily transportation routines. This includes information on how to use e-bikes safely and in compliance with local regulations.

Infrastructure Planning: Cities may need to plan and develop infrastructure that supports the integration of e-bikes with public transport. This includes the creation of bike lanes, bike-sharing stations, and adequate parking facilities.

Regulations and Policy Support: Clear regulations and policies regarding the use of e-bikes in conjunction with public transport can facilitate smooth integration. This may involve defining rules for transporting e-bikes on certain types of public transport (e.g., buses or trains).

The integration of electric bicycles with public transport not only enhances the overall transportation system but also promotes a more sustainable and flexible urban mobility landscape. As with any integration effort, collaboration between various stakeholders, including public transport agencies, local governments, and bike-sharing operators, is essential for success.

5.2.3 – Transporting the Bicycle

Transporting an e-bike, especially for daily commuting, can be a consideration for individuals who need to combine multiple modes of transportation or face challenges riding the e-bike for the entire journey. Some common methods and considerations for transporting e-bikes are:

Public Transport

Buses and Trains: Some public transport systems allow passengers to bring e-bikes on buses or trains like EGO's. General Directorate of EGO has mounted bicycle racks on 480 buses within the scope of the SMART Ankara Project. Metro cars have also been made suitable for bicycle transport, and 1290 meters of bicycle ramps have been installed at 34 metro stations to facilitate the transportation of bicycles on stairs.

Folding E-Bikes: Folding e-bikes are a convenient option for commuting as they can be easily folded and carried onto public transport. Many folding e-bikes are compact and lightweight, making them suitable for storage during transit.

Bike Racks

Car Bike Racks: If commuting involves a car, bike racks mounted on the car's roof, trunk, or hitch can be used to transport e-bikes. It's crucial to ensure that the chosen rack is compatible with the weight and dimensions of the e-bike.

Bike Racks on Public Transport: Some buses and trains are equipped with bike racks, allowing commuters to secure their e-bikes for the duration of the journey.

Personal Vehicles

Carrying Inside Vehicles: Depending on the size of the vehicle, e-bike owners may choose to transport their e-bikes inside cars or other personal vehicles. This may involve folding the seats down or removing the front wheel for easier accommodation.

E-Bike Design

Removable Batteries: Some e-bikes have removable batteries, allowing commuters to take the battery with them while leaving the bike securely locked. This can make the e-bike lighter and more manageable when transporting.

Bike Trailers

Cargo Trailers: Some e-bike owners use cargo trailers specifically designed for bikes to transport their e-bikes. These trailers attach to the back of the bike and can carry additional cargo, including the e-bike itself.

E-Bike Trailers: There are trailers specifically designed for e-bikes that allow for towing the e-bike with another bicycle.

5.3 – Personal Protective Measures and Selection of Protective Equipment, Spare Kits, Accessories

In the realm of electrical work, particularly when dealing with electric bicycles and similar technologies, the importance of personal protective measures cannot be overstated. The foundation of safety in this field is built upon a thorough understanding and application of protective measures tailored to the specific risks involved. When working with electric bicycles, this includes the risk of electric shock, burns from hot components, and injuries from moving parts. To mitigate these risks, the selection of appropriate personal protective equipment (PPE) is crucial. This typically encompasses insulated gloves and safety glasses as basic essentials. Insulated gloves protect against electric shock and should be rated for the voltages one might encounter. Safety glasses shield the eyes from potential sparks or debris resulting from electrical work or mechanical adjustments.

Beyond the basics, the use of flame-resistant clothing can protect against burns, while sturdy, non-conductive footwear ensures additional safety from electric shock, especially in environments where the risk is heightened. For tasks that involve the potential for flying debris or particles, face shields offer an added layer of protection. It's also important to equip oneself with a well-thought-out selection of tools and accessories that are specifically designed for electrical work. These tools, often insulated to protect against electrical shock, include screwdrivers, pliers, wire strippers, and multimeters, among others.

Moreover, keeping a spare kit of essential components and accessories—such as fuses, wires, connectors, and terminals—readily available can significantly enhance safety and efficiency. This ensures that repairs and maintenance can be conducted without unnecessary delays, reducing the temptation to use makeshift solutions that could compromise safety. Additionally, investing in a comprehensive first-aid kit equipped to handle electrical burns and injuries is a critical safety measure for immediate response to accidents.

In essence, the proactive selection of protective equipment, along with a strategic approach to maintaining a kit of spares and accessories, forms a critical backbone for safety in the maintenance and repair of electric bicycles. This not only safeguards the technicians working on these vehicles but also enhances the overall reliability and safety of the electric bicycles themselves.

5.4 – Road Conditions and Traffic, Hazards Encountered in Traffic

Injuries in traffic accidents on highways are a significant and urgent public health crisis worldwide, and the frequency of these accidents continues to remain high in many countries. According to the World Health Organization's 2023 Global Road Safety Report, the number of deaths in road accidents reached up to 1.19 million in 2021.

According to the same report, only one-fifth of the world's roads meet the basic safety requirements for cyclists and pedestrians, and only 0.2% of them have dedicated lanes for bicycles.

More than half of the deaths occur among vulnerable road users such as pedestrians, motorcyclists, and cyclists. Approximately one-third of the deaths are comprised of occupants of four-wheeled vehicles *(1):*

Four-wheeled vehicle occupants	%30
Pedestrians	%23
Motorcyclists and users of 2-3 wheeled vehicles	%21
Cyclists	%6
Other (vehicles carrying more than 10 passengers and heavy vehicles, etc.)	%20

An important issue with the increasing popularity of electric bicycles, due to their time-saving, economic, and environmentally friendly nature, is ensuring road traffic safety.

(1) WHO, Global Status Report on Road Safety, 2023 (https://iris.who.int/bitstream/handle/10665/375016/9789240086517-eng.pdf)

5.5 – Legal Regulations

Today, the use of electric land vehicles is increasing. These vehicles are often also seen as electric scooters and electric bicycles. Since electric bicycles are land vehicles, a number of legal regulations have been introduced regarding their use in traffic. With the regulation prepared by the General Directorate of Highways (KGM), the use of bicycles has been linked to the law. The purpose of this regulation is to determine the procedures and principles regarding the planning, design and construction of bicycle paths and bicycle parking stations in order to ensure that the bicycle can be used for purposes such as transportation, navigation and sports. The use of electric bicycles has made it mandatory to apply certain rules for the safety of ourselves and the environment. As the use of electric bicycles, electric motorcycles, electric scooters have increased in recent times on the highways, there has been a need for regulations in traffic for life safety. As a result, according to the speed of electric vehicles in power and hour, it has brought obligations such as helmets, license plates, registrations and licenses. Electric bicycles, scooters, motorcycles, e-Bikes with a power of 0.249 kW (249 W) and vehicles with less engine power can be used without a license and license plate. No license plates are required for electric bicycles. A license plate is required for electric motorcycles (mopeds). However, according to the new practice, traffic insurance is not sought. According to the law enacted in Turkey in 2016, license and license plate obligation has been introduced for all vehicles operating with 250 W and higher electric motors. Vehicles such as electric bicycles, electric scooters, electric motorcycles must be registered by applying to the Traffic Registration Branch if they have a capacity of 250 W or higher. According to this regulation, electric bicycles are included in the scope of the M class driver's license. The minimum age for an electric bike, electric scooter, electric motorcycle license is set at 16.

5.6 – Basic Functions, Speed and Balance

5.6.1 Basic Functions

Depending on the terrain on which you are going to travel with them, but also depending on the special functionalities that electric bicycles include can be:

a)Electric mountain bikes

Electric Mountain Bikes or e-MTBs are an optimal option for those who love pedaling on rugged mountain terrain. They usually have more powerful engines and more autonomy to give you the assistance you need when going up or down slopes.

b)Fat bike electric bikes

Electric fat bikes are recognized by their thick wheels, specially designed to traverse even the most inaccessible areas. They are especially suitable if you plan to go out by bike in the winter as well, as they have a good grip on snow, sand and more.

c)Electric road bikes

For road cyclists, who love to feel the burn in their legs after pedaling, an electric road bike seems like something unimaginable. However, such a variant is extremely useful if you put more value on the journey than on the final destination. When you're not focusing on the effort you put into pedaling, you can pay more attention to the scenery that greets you.

d)Hybrid or trekking electric bikes

We could say that the hybrid electric bike (trekking) offers you the best of both worlds. You have both the strength of an e-MTB and the versatility of a road bike, so you can use the bike in the most diverse situations. Most of the time, e-bikes of this kind are preferred by those who commute, but would also like to go out on the weekend for a ride with the same bike.

e)Folding electric bikes

For folding bikes, the most important aspect is flexibility. They are intended for short distance rides, especially for commuting. Their usefulness is given by the ease with which they can be transported and stored.

f)Electric city bikes

The main benefit of electric city bikes is the increased comfort of each ride. Because the emphasis is not on speed, but on adapting to traffic and the experience itself, these e-bikes are suitable for quiet, relaxed rides with no effort on your part.

5.6.2. Speed

As mentioned above, the only real requirement for a bike to be considered e-bike is the use of an electric motor. As such, there are many different types with many different uses. They are often separated into three main categories:

Type 1: Electric bikes with pedal assist

The first and most common type of e-bike is one that helps the rider reach a certain speed. The motor starts to help power the rear wheel and stops when a certain speed is reached. This type of bike is meant to help with what is generally considered the most difficult part of cycling – acceleration.

Type 2: Assist when pedaling and when you want it

Some e-bikes have pedal assist as well as manual start on demand. This means you can use a throttle to manually power the bike. Engine power determines the amount of coupling and speed you can achieve.

Type 3: Only support when you want it

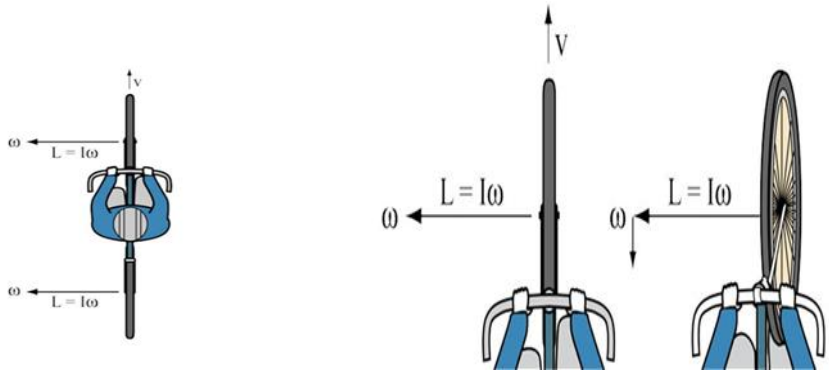
Some bikes only offer assistance when you want it. These bikes are relatively rare and in fact hardly qualify as bikes. To still be considered an e-bike, it must have the option to pedal manually.

• **Class 1**: electric bicycles with pedal assistance, without acceleration, with a maximum assisted speed of approx. 25km/h (20mph US)

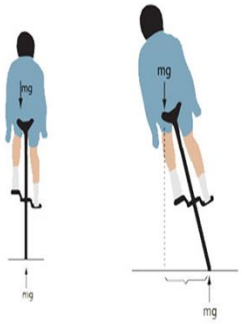
• **Class 2**: electric bicycles with pedal assistance, without acceleration, with a maximum assisted speed of approx. 45km/h (25mph US).

5.6.3. Balance

Two physicists, J. Lowell and H.D. McKell, published in 1982 in the American Journal of Physics a very interesting and detailed study on why a cyclist manages to keep his balance. In short, the bicycle does not behave like a body moving due to its inertia, but like a gyroscope, thanks to the kinetic moment generated by the wheel, which stabilizes the whole bicycle. At the same time, it is this gyroscopic behavior that helps to change direction, and not the handlebars.



After demonstrating that the motion of the wheel creates a kinetic moment, Lowell and McKell established the gyroscopic nature of this component of the bicycle. In turn, this kinetic moment is subjected to centrifugal force, which is the real element that provides stability to the bicycle in motion. So, not inertia and not velocity are the critical factors for balance.



The change in direction (the yaw) is directly related to this gyroscopic motion and, translationally, to the centrifugal force. A bicycle that is held perpendicular to the ground will go straight. Even if there is a temptation to blame this on inertia, it is the centrifugal force that makes this possible. As proof, if you tilt the bike to the left, then the whole bike will turn to the left, even though the handlebars are straight.

5.7 – Control Mechanisms, Braking and Gear Systems

5.7.1 Control Controllers

Control mechanisms in electric bicycles consist of controllers, brake, and gear systems. The general control system is the basic control device used to start, run, move forward and backward, control speed, stop, and control other electronic devices of the electric bicycle. It is like the brain of the electric bicycle and an essential part of it. Currently, electric bicycles, electric two-wheeled motorcycles, electric three-wheeled bicycles, electric three-wheeled motorcycles, electric four-wheeled vehicles, electric cars, etc. fall within this scope. The system is structurally of two types. The first structure is where the control system is separate from the display. In this case, the main structure is close to the battery and enclosed. It is generally protected from shocks. Connections with the motor are usually shorter. The second structure integrates the display and control part, which is protected by a plastic box and mounted in the middle of the handlebar. It is in a waterproof structure and located far from the battery and motor. The main task of the controller: It has a silent design. It has a current control mechanism, thus extending the battery life by controlling the motor current. It ensures the flawless operation of the system by obtaining the necessary information for the bicycle through various sensors. Controls such as road and range information, battery status, and position of illumination signals and speed limitations are provided from here. https://www.hotebike.com/tr/do-you-know-the-function-of-electric-bicycle-controller

There are two different types of controllers designed to fit brushed or brushless motors. Brushless motors are becoming more common as the cost of controllers continues to decrease. Controllers for brushless motors: E-bikes require high starting torque, so models using brushless motors typically have Hall sensor commutation for speed and angle measurement. The electronic controller assists as a function of sensor inputs, vehicle speed, and required force. Controllers typically allow for input through a potentiometer or Hall Effect twist grip (or thumb-operated crank lever) for precise speed control, closed-loop speed control for precise speed adjustment, protection logic circuitry for overvoltage, overcurrent, and thermal protection. For pedal-assist bicycles,

there is a combined magnet ring disc with a series of pulses proportional to pedal rotation frequency on the crankshaft, along with a Hall sensor. The controller uses pulse width modulation to adjust power to the motor. Sometimes support for regenerative braking is provided, but it rarely limits energy recovery with braking and low bicycle mass. Controllers for brushed motors: Brushed motors are also used in e-bikes but are less common due to their lower inherent efficiency. However, controllers for brushed motors are much simpler and cheaper as they do not require Hall sensor feedback and are typically designed as open-loop controllers. Some controllers can regulate multiple voltages. https://tr.wikipedia.org/wiki/Elektrikli_bisiklet

5.7.2 Brakes

What is a bicycle brake?

Brakes provide stopping power for your bicycle, allowing you to slow down safely and in a controlled manner. This is due to the force of friction. To stop something faster, you need to increase the friction force.

Brake systems:

V-brake: V-brakes work with a metal wire cable. When the brake is applied, the power transferred to the brake cables is transmitted to the brake pads, and the pads stop the wheel with friction force. It is economical, easy to find spare parts for, durable, trouble-free, and practical to maintain. Therefore, it is one of the most commonly used systems. Over time, as V-brakes wear out, they gradually become misaligned, resulting in a weak and soft feel in the brake lever. To realign the brake pads, align them flat against the rim while the brakes are open and make readjustments.

Disc Brake: There are two types of disc brakes: Mechanical and Hydraulic disc brakes.

Mechanical disc brake: In a mechanical disc brake (also known as cable disc brakes), a metal wire cable is used instead of hydraulic fluid. When the brake is applied, the brake lever pulls the cable, squeezing the brake pads against the disc.

• It requires less muscle power than V-brakes. It provides tighter braking.

• It is less affected by rainy weather and dirt surfaces.

A slight touch of the disc to your brake pads and the accompanying squealing/squeaking noise may bother you. In serious cases, your brakes will slow you down with each pedal stroke, and your pads will wear quickly and unevenly.

Adjusting Mechanical Disc Brakes

Unlike hydraulic disc brakes, mechanical disc brakes do not self-align, so periodic adjustments of brake pads and cable tension are necessary to

compensate for wear. Tools required to align a single-piston mechanical disc brake:

• Allen wrench torque tool (typically 4mm, 5mm, or 6mm)

• Rubber band

• Stiff card (old greeting card or business card)

Step 1: Wrap the brake cable adjustment screw all the way; there will be one on the brake lever and one on the caliper (depending on the model).

Step 2: Pull the inner fixed brake pad away from the rotor (i.e., toward the wheel spoke closest) inside.

Step 3: Slightly loosen the bolts that attach the caliper's main body to the frame/fork/adapter.

Step 4: Slide the caliper body until the disc rotor passes through the center of the gap in the caliper (not between the pads).

Step 5: Carefully tighten the caliper body bolts.

Step 6: Wind the fixed pad back towards the rotor until you hear it lightly touch as the wheel turns, then wind it back with small increments until it runs silently.

Step 7: Loosen the cable compression screw on the caliper lever.

Step 8: Insert the card piece between the outer brake pad and the disc rotor

Step 9: Use a rubber band to keep the caliper lever in the 'open' position.

Step 10: Pull and then release the brake cable slightly from the lever.

Step 11: Remove the rubber band and card piece.

Step 12: Open the cable drum adjuster until the bite point on the brake lever feels comfortable.

Hydraulic Disc Brake: Hydraulic disc brakes operate with hydraulic fluid. When the brake is applied, the brake lever pumps hydraulic fluid to the brake caliper, squeezing the pads against the disc.

• It does not require muscle power. It provides tight braking.

• It is not affected by rainy weather and dirt surfaces, making it more advantageous for riding in muddy areas.

Adjusting Hydraulic Disc Brakes

Once installed, hydraulic disc brakes self-center; this means periodic adjustments of the brake pads are not necessary. When you pull the brake lever, fluid will be pumped from the master cylinder to the brake caliper, pushing the pistons toward the rotor. If the brake pads are slightly off-center, the pad that touches the rotor first will be stopped in place, and the other will reach it effectively. When both pads are firmly against the rotor, both pistons/pads will release from the rotor at the same time when the brake lever is released. However, initially, proper alignment of the caliper is still necessary to ensure that the pads make equal contact with the disc without any friction.

Step 1: Wrap the barrel adjusters all the way; there will be one on the brake lever and one one on the caliper (depending on the model).

Step 2: Pull the inner fixed brake pad away from the rotor (i.e., toward the wheel spoke closest) inside. This is the fixed pad.

Step 3: Slightly loosen the bolts that attach the caliper's main body to the frame/fork/adapter.

Step 4: Slide the caliper body until the disc rotor passes through the center of the gap in the caliper (not between the pads). Step 5: Carefully tighten the caliper body bolts.

Step 6: Wind the fixed pad back towards the rotor until you hear it lightly touch as the wheel turns, then wind it back with small increments until it runs silently.

Step 7: Loosen the cable compression screw on the caliper lever. Step 8: Insert the card piece between the outer brake pad and the disc rotor.

Step 9: Use a rubber band to keep the caliper lever in the 'open' position. Only a slight movement is required.

Step 10: Pull and then release the brake cable slightly from the lever.

Step 11: Remove the rubber band and card piece.

Step 12: Open the cable drum adjuster until the bite point on the brake lever feels comfortable. https://www.elektrikliaraclar.info/elektrikli-bisikletler-nasil-calisir

5.7.3 Gears (Transmission) on Electric Bicycles

It is a common misconception that gears are not necessary on electric bicycles. While they provide a throttle and pedal assistance to help you get started, there are times when you may want to use gears on your electric bike, especially when planning to ride short distances on flat roads. In most cases, pedal assistance will provide you with

enough power to reach your destination. However, there are scenarios where switching your electric bike to low pedal assistance and using gears can be more effective.

Can Pedal Assistance Replace Gears?

While pedal assistance is a great feature offered by electric bikes, there are several reasons why using gears instead is preferred.

1. Motor size: If you're trying to climb a steep hill but your electric bike's motor is small, your pedal assist system may not provide enough power. Using gears will require a bit more effort, making it much easier to manage climbing the hill. While pedal assistance can help you reach the top of the hill, it will be a much slower process.
2. Battery life: Since electric bikes rely on a battery to keep them powered and functioning properly, you may need to find a way to extend your battery life depending on the distance you plan to ride. By pedaling along with the bike's motor, you can reduce the amount of power used from the battery. Having gears that facilitate more efficient pedaling will make these battery savings even more significant.

How to Use Gears on an Electric Bike?

Using gears on an electric bike is very similar to using them on a regular bike. The lower the number of gears, the easier it is to pedal. The gear number is directly related to how hard the motor needs to work. The lower the gear, the more the electric bike relies on the battery. When you set the gear to a higher number, you'll need to pedal more, which will extend your battery life.

The handlebars on the electric bike control the gears and pedal assist system. In most cases, there is a gear shifter on the right handlebar that allows you to adjust the mechanical gear level, making it easier or harder to pedal the bike. On the left handlebar, the power level of the pedal assist system is adjusted by determining how much of the bike's battery power is being used.

How to Determine Which Gears to Use?

Choosing the right gears can sometimes be a bit tricky and will vary depending on the situation. However, there are some tips you can use to decide which gear to use.

If you're standing still, use one of the lower gears since it's more appropriate for the speed at which you're moving. When climbing uphill, a lower gear is used since more effort is required to pedal. Then, when transitioning to the other side, a higher gear should be selected since you'll likely be moving at a higher speed. www.hotebike.com/blog/

5.8 – Proper Use and Charging of Batteries

In the module section on "Proper Use and Charging of Batteries," it's crucial for instructors to guide students through the critical aspects of battery management in electric vehicles. This includes emphasizing the role of electric energy storage (EES) in smoothing out the intermittency of renewable energy sources and explaining how batteries capture and store excess energy for later use. Instructors should delve deeply into the specific characteristics, charging protocols, and maintenance requirements of various battery types including Lead-Acid, Nickel-Cadmium, Nickel Metal Hydride, Lithium-Ion, Lithium-Ion Polymer, and Lithium Iron Phosphate.

Educators need to highlight the importance of adhering to manufacturer-specific guidelines for charging and discharging batteries to optimize performance and longevity. They should explain the significance of a Battery Management System (BMS) in monitoring battery health, ensuring safety, and enhancing efficiency. Additionally, discussions should cover the environmental impacts of battery disposal and the importance of recycling to promote sustainability.

Practical demonstrations or simulations on battery charging and handling should be integrated into the session to provide hands-on learning experiences. This approach will help students not only understand the theoretical aspects but also acquire practical skills necessary for managing and troubleshooting battery systems in electric vehicles effectively.

Lastly, instructors should encourage a participatory learning environment by inviting questions and facilitating discussions around the maintenance practices and safety protocols, ensuring students can apply their knowledge effectively in real-world scenarios. This comprehensive instruction aims to equip learners with the necessary skills to navigate the evolving landscape of battery technology in electric vehicles confidently.

5.9 – Periodic Maintenance, Cleaning

The two most important elements of electric bicycles are mechanical and electronic components. These components need periodic maintenance. Electric bike repair maintenance services are not as common as car services. Therefore, mostly users should have the ability to perform periodic maintenance of their own bicycles. It is the repair equipment that should be present in electric bicycles and does not take up space.

It consists of a set of keys, a charger and a tire inflation apparatus. It is designed to be easily removed when needed and to eliminate the fault urgently. The biggest difference between an electric bike and a regular bike is the battery. Most electric bikes use a lithium-ion battery of the same type used in a cell phone and laptop. These batteries should be kept away from extreme temperatures. On electric bicycles, the information to the warning indicator is given by the electro control unit (brain). In case of malfunction of the electric bike on the indicator, error codes are read through the display. Sensor malfunctions are often seen on the warning and warning screen. The electric bicycle brain sends a 5 V signal to the sensors. The sensors are controlled by voltmeter. The voltmeter should be connected to the minus (-) end from the brain with the tips coming from the sensors and the 4.5-5 V value should be read. A low value means sensor failure.