ANNEXURE I

TABLE 1: MODULE WISE COURSE CONTENT AND OUTCOME				
S. No.	**MODULE NAME**	**MODULE CONTENT**	**MODULE LEARNING OUTCOME**	**DURATION (HRS)**
1	**Fundamentals of Battery Technology**	Introduction to Electric Vehicles Historical perspective	Trace the historical development of electric vehicles and identify key milestones.	9 Hrs
		Types of EVs (BEV, PHEV, HEV, FCEV) Advantages and disadvantages of EVs EV Powertrain Components Electric motor types (AC induction, DC brushless, PMDC) Power electronics converters (inverters, rectifiers, DC-DC converters) Battery technologies (Li-ion, Ni-MH, etc.) Vehicle Dynamics and Control Vehicle dynamics principles (longitudinal and lateral dynamics) Traction control systems Stability control systems Regenerative braking	Distinguish between different types of electric vehicles (BEV, PHEV, HEV, and FCEV) based on their powertrain configurations and energy sources. Analyze the environmental, economic, and social benefits and drawbacks of electric vehicles. Recognize the major components of an electric vehicle powertrain, including electric motors, power electronics converters, and battery technologies. Develop the fundamental concepts of vehicle dynamics and the role of control systems in ensuring vehicle stability and performance. Evaluate the energy efficiency benefits of regenerative braking systems in electric vehicles.	

2	**Modelling of 2/3 Wheeler**	EV 2/3Wheeler Architecture 2/3 Wheeler vehicle Dynamics Calculation 2/3 Wheeler vehicle Energy Calculation Design of Specification Simulink Modeling of 2/3 Wheeler Performance Estimation of 2/3 Wheeler	Vehicle dynamics modeling and simulation Vehicle stability and handling characteristics Control strategies for steering, braking, and acceleration Energy consumption modeling and estimation Powertrain efficiency optimization Design considerations for 2/3-wheeler EVs	9 Hrs
			Component selection and sizing Vehicle weight distribution and balance Use of simulation tools (e.g., MATLAB/Simulink) Model development for vehicle dynamics, powertrain, and control systems Simulation-based analysis and optimization	
3	**Battery Management System (BMS)**	Introduction to Battery Management Systems (BMS) Definition and purpose of a BMS in energy storage systems Overview of BMS applications in electric vehicles, grid storage, and portable devices Importance of BMS for safety, performance, and battery lifespan. Typical BMS architecture: centralized,	Voltage, current, and temperature sensing and their importance in BMS operation. Methods for accurate data acquisition and monitoring in real-time Importance of data logging for performance analysis and predictive maintenance. Compare the Environmental Impact of EVs and Traditional Vehicles	9 Hrs

		modular, and distributed systems Key components: sensors, microcontrollers, thermal management systems, and communication interfaces Role of the Battery Control Unit (BCU) in system-level management and decision-making.	Conduct well-to-wheel analysis to compare the full lifecycle emissions of EVs and traditional vehicles. Identify factors influencing the environmental impact of EVs, such as electricity source, battery technology, and vehicle weight. Assess the potential environmental benefits of EVs in reducing greenhouse	
			gas emissions and air pollution. Techniques for estimating SOC, SOH, and SOP, including coulomb counting, voltage-based, and model-based methods Factors affecting the accuracy of estimation and strategies to improve reliability Role of these estimations in optimizing battery usage and preventing failures	

4	**EV Design and Engineering**	Vehicle Platform Design Chassis and body design considerations Aerodynamics and weight optimization Thermal Management Systems Battery thermal management Power electronics cooling Electrical System Design Wiring harness design Fuse and relay protection Safety and Reliability Safety standards and regulations Fault diagnosis and recovery Cybersecurity	Analyze the factors influencing vehicle platform design, including chassis and body considerations. Evaluate the impact of aerodynamics and weight optimization on vehicle performance and energy efficiency. Design effective thermal management systems for batteries and power electronics to ensure optimal performance and longevity. Design wiring harnesses and implement fuse and relay protection systems to ensure the safety and reliability of the electrical system. Understand and apply relevant safety standards and regulations to EV design and manufacturing.	9 Hrs

			Develop strategies for diagnosing and addressing faults in EV systems. Protect EVs from cybersecurity threats and implement measures to safeguard sensitive information.	
5	**EV Manufacturing Technology**	Assembly Line Operations: Vehicle assembly sequence Quality control checks at each assembly stage Integration of components (battery, motor, power electronics) Testing and Validation: Performance testing (range, acceleration, top speed) Durability testing (vibration, thermal cycling, etc.) Safety testing (crash tests, fire safety) Regulatory compliance testing	Explain the assembly sequence of electric vehicles and identify key assembly stages. Apply quality control checks at different stages of the assembly process to ensure product quality. Integrate critical components such as batteries, motors, and power electronics into the vehicle assembly. Evaluate the performance of electric vehicles in terms of range, acceleration, and top speed. Assess the durability of EVs through vibration and thermal cycling tests. Conduct safety tests, including crash tests and fire safety tests, to meet regulatory standards. Ensure that EVs meet all relevant regulatory requirements.	9 Hrs

ANNEXURE II

TABLE 2: OVERALL COURSE LEARNING OUTCOME ASSESSMENT CRITERIA AND USECASES			
LEARNING OUTCOME	**ASSESSMENT CRITERIA**	**PERFORMANCE CRITERIA.**	**USECASES**
Explore and apply fundamental principles of electric vehicle technology. Design and develop a 2-wheeler EV powertrain system. Simulate and analyze the performance of an EV powertrain. Validate the performance of an EV prototype through testing and experimentation	Demonstrate a comprehensive skilling of electric vehicle technology, including components, systems, and their interactions. Apply engineering principles and design tools to design and develop a 2-wheeler EV powertrain. Identify and solve complex engineering problems related to EV powertrain design and optimization. Conduct experiments, analyze data, and interpret results to validate the performance of an EV prototype.	**Powertrain Design:** Design a suitable powertrain system for a 2-wheeler EV, considering factors like motor power, battery capacity, and transmission type. **Simulation Modeling:** Develop accurate simulation models of the EV powertrain using appropriate software tools. **Performance Analysis:** Analyze the simulated performance of the EV in terms of range, efficiency, and acceleration. **Prototype Validation:** Build and test a 2-wheeler EV prototype to validate the design and simulation results.	Design and Development of a 2-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation

Explore and apply fundamental principles of electric vehicle technology. Design and develop a 3-wheeler EV powertrain system.	Demonstrate a comprehensive understanding of electric vehicle technology, including components, systems, and their interactions.	**Powertrain Design:** Design a suitable powertrain system for a 3-wheeler EV, considering factors like motor power, battery capacity, and transmission type.	Design and Development of a 3-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation

Simulate and analyze the performance of an EV powertrain. Validate the performance of an EV prototype through testing and experimentation	Apply engineering principles and design tools to design and develop a 3-wheeler EV powertrain. Identify and solve complex engineering problems related to EV powertrain design and optimization. Conduct experiments, analyze data, and interpret results to validate the performance of an EV prototype.	**Simulation Modeling:** Develop accurate simulation models of the EV powertrain using appropriate software tools. **Performance Analysis:** Analyze the simulated performance of the EV in terms of range, efficiency, and acceleration. **Prototype Validation:** Build and test a 3-wheeler EV prototype to validate the design and simulation results.	

Demonstrate and apply fundamental principles of electric vehicle technology. Design and develop a 4-wheeler EV powertrain system. Simulate and analyze the performance of an EV powertrain. Validate the performance of an EV prototype through testing and experimentation	Demonstrate a comprehensive perception of electric vehicle technology, including components, systems, and their interactions. Apply engineering principles and design tools to design and develop a 4-wheeler EV powertrain. Identify and solve complex engineering	**Powertrain Design:** Design a suitable powertrain system for a 4-wheeler EV, considering factors like motor power, battery capacity, and transmission type. **Simulation Modeling:** Develop accurate simulation models of the EV powertrain using appropriate software tools. **Performance Analysis:** Analyze the simulated performance of	Design and Development of a 4-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation
	problems related to EV powertrain design and optimization. Conduct experiments, analyze data, and interpret results to validate the performance of an EV prototype.	the EV in terms of range, efficiency, and acceleration. **Prototype Validation:** Build and test a 4-wheeler EV prototype to validate the design and simulation results.	

Calculate the factors affecting EV powertrain efficiency. Analyze and identify potential efficiency improvement areas in a 2-wheeler EV. Develop and implement strategies to optimize EV powertrain efficiency.	Demonstrate knowledge of energy loss mechanisms in EV powertrains. Analyze powertrain components and systems to identify inefficiencies. Propose and evaluate strategies to improve powertrain efficiency. Conduct experiments and data analysis to validate efficiency improvements.	Calculate and analyze the efficiency of different powertrain components (motor, inverter, battery, transmission). Identify major sources of energy loss, such as resistive losses, switching losses, and mechanical losses. Propose and implement strategies to reduce losses and improve overall efficiency, such as motor control techniques, thermal management, and lightweight design. Conduct experiments to measure the impact of optimization strategies on powertrain efficiency.	Efficiency Analysis and Optimization of a 2-Wheeler Electric Vehicle Powertrain
Calculate the factors affecting EV powertrain efficiency. Analyze and identify	Demonstrate knowledge of energy loss mechanisms in EV powertrains.	Calculate and analyze the efficiency of different powertrain components (motor, inverter, battery, transmission).	Efficiency Analysis and Optimization of a 3-Wheeler Electric

potential efficiency improvement areas in a 3-wheeler EV. Develop and implement strategies to optimize EV powertrain efficiency.	Analyze powertrain components and systems to identify inefficiencies. Propose and evaluate strategies to improve powertrain efficiency. Conduct experiments and data analysis to validate efficiency improvements.	Identify major sources of energy loss, such as resistive losses, switching losses, and mechanical losses. Propose and implement strategies to reduce losses and improve overall efficiency, such as motor control techniques, thermal management, and lightweight design. Conduct experiments to measure the impact of optimization strategies on powertrain efficiency.	Vehicle Powertrain
Calculate the factors affecting EV powertrain efficiency. Analyze and identify potential efficiency improvement areas in a 4-wheeler EV. Develop and implement strategies to optimize EV powertrain efficiency.	Demonstrate knowledge of energy loss mechanisms in EV powertrains. Analyze powertrain components and systems to identify inefficiencies. Propose and evaluate strategies to improve powertrain efficiency. Conduct experiments and data analysis to validate efficiency improvements.	Calculate and analyze the efficiency of different powertrain components (motor, inverter, battery, transmission). Identify major sources of energy loss, such as resistive losses, switching losses, and mechanical losses. Propose and implement strategies to reduce losses and improve overall efficiency, such as motor control techniques, thermal management, and lightweight design. Conduct experiments to measure the impact of optimization strategies on	Efficiency Analysis and Optimization of a 4-Wheeler Electric Vehicle Powertrain

		powertrain efficiency.	

Understand the design considerations for in-wheel hub motor fixtures. Utilize CAD software to design and model mechanical fixtures. Apply manufacturing techniques to fabricate the designed fixture.	Demonstrate knowledge of mechanical design principles and manufacturing processes. Design a suitable fixture for the in-wheel hub motor, considering factors like weight, strength, and vibration isolation. Analyze the design for potential failures and optimize the design for performance. Fabricate the fixture using appropriate manufacturing techniques and assemble it with the motor.	Create a detailed 3D CAD model of the fixture. Conduct FEA to analyze the stress distribution and structural integrity of the fixture. Select appropriate manufacturing processes (e.g., machining, 3D printing) for the fixture components. Fabricate the fixture components and assemble them into a complete unit.	Design and Fabrication of a Mechanical Fixture for In-Wheel Hub Motor
Understand the principles of mechanical power transmission systems. Design a suitable transmission system for a 2-wheeler EV. Analyze the performance of the designed transmission system.	Knowledge and Understanding: Demonstrate knowledge of gear design, belt drive systems, and chain drive systems. Design Skills: Design a transmission system that meets the specific requirements of a 2-wheeler EV. Analysis Skills: Analyze the performance of the transmission	Transmission System Selection: Select an appropriate transmission type (belt, chain, or gear) based on factors like efficiency, cost, and noise. Gear Ratio Calculation: Calculate the required gear ratios to achieve desired vehicle performance. CAD Modeling and Design: Create detailed 3D CAD models of the	Design and Development of a Mechanical Transmission System for a 2-Wheeler Electric Vehicle

	system in terms of efficiency, noise, and vibration. Practical Skills: Fabricate and assemble the transmission system.	transmission components. Fabrication and Assembly: Fabricate and assemble the transmission system, ensuring proper alignment and lubrication.	
Understand the principles of lithium-ion battery technology. Design and assemble a 7S5P battery pack. Implement a Battery Management System (BMS) for battery safety and performance.	Knowledge and Understanding : Demonstrate knowledge of battery chemistry, cell characteristics, and safety considerations. Design Skills: Design a battery pack considering factors like cell selection, configuration, and thermal management. Practical Skills: Assemble the battery pack and integrate a BMS. Problem-Solving Skills: Troubleshoot and resolve issues related to battery pack assembly and testing.	Cell Selection: Select appropriate lithium-ion cells based on capacity, voltage, and discharge rate. Battery Pack Configuration: Design and assemble a 7S5P battery pack, ensuring proper cell balancing and wiring. BMS Integration: Integrate a BMS to monitor and control battery voltage, current, and temperature. Safety Considerations: Implement safety measures, such as thermal runaway protection and overcharge/overdi scharge prevention.	Design and Assembly of a 7S5P Lithium-ion Battery Pack
Understand the specific requirements of a 3-wheeler EV	Knowledge and Understanding : Demonstrate knowledge of	Transmission Type Selection: Select an appropriate transmission type	Design and Development of a Mechanical

transmission system. Design and select suitable components for the transmission system. Analyze the performance of the designed transmission system.	gear design, belt drive systems, and chain drive systems, especially for 3-wheeler applications. Design Skills: Design a transmission system that meets the specific power and torque requirements of a 3-wheeler EV. Analysis Skills: Analyze the performance of the transmission system in terms of efficiency, noise, vibration, and durability. Practical Skills: Fabricate and assemble the transmission system, ensuring proper alignment and lubrication.	(belt, chain, or gear) based on vehicle load, terrain, and efficiency considerations. Gear Ratio Calculation: Calculate the required gear ratios to achieve desired vehicle performance and optimize efficiency. CAD Modeling and Design: Create detailed 3D CAD models of the transmission components, considering factors like stress, fatigue, and wear. Fabrication and Assembly: Fabricate and assemble the transmission system, ensuring proper alignment, lubrication, and sealing.	Transmission System for a 3-Wheeler Electric Vehicle
Understand the specific requirements of a 4-wheeler EV transmission system. Design and select suitable components for	Knowledge and Understanding : Demonstrate knowledge of gear design, belt drive systems, and chain drive systems, especially for	Transmission Type Selection: Select an appropriate transmission type (belt, chain, or gear) based on vehicle load, terrain, and	Design and Development of a Mechanical Transmission System for a 4-Wheeler Electric Vehicle

the transmission system. Analyze the performance of the designed transmission system.	4-wheeler applications. Design Skills: Design a transmission system that meets the specific power and torque requirements of a 4-wheeler EV. Analysis Skills: Analyze the performance of the transmission system in terms of efficiency, noise, vibration, and durability. Practical Skills: Fabricate and assemble the transmission system, ensuring proper alignment, lubrication, and sealing.	efficiency considerations. Gear Ratio Calculation: Calculate the required gear ratios to achieve desired vehicle performance and optimize efficiency. CAD Modeling and Design: Create detailed CAD models of the transmission components, considering factors like stress, fatigue, and wear. Fabrication and Assembly: Fabricate and assemble the transmission system, ensuring proper alignment, lubrication, and sealing.	
Understand the factors affecting the efficiency of EV transmission systems. Analyze the efficiency of various transmission types (belt, chain, gear).	Knowledge and Understanding : Demonstrate knowledge of mechanical power transmission systems and their losses. Analytical Skills: Analyze the efficiency of different transmission	Efficiency Modeling: Develop a model to simulate the efficiency of the transmission system under various operating conditions. Experimental Testing: Design and conduct experiments to measure the input	Efficiency Analysis of a 2-Wheeler Electric Vehicle Transmission System

Propose strategies to improve transmission system efficiency.	components (gears, bearings, belts, chains). Problem-Solving Skills: Identify and address inefficiencies in the transmission system. Experimental Skills: Conduct experiments to measure power losses and efficiency.	and output power of the transmission system. Loss Analysis: Identify and quantify the major sources of power loss, such as frictional losses, mechanical losses, and windage losses. Efficiency Optimization: Propose and evaluate strategies to improve transmission efficiency, such as lubrication optimization, gear design improvements, and material selection.	
Understand the key performance metrics of electric vehicle powertrains. Develop test procedures to evaluate powertrain performance. Analyze and interpret powertrain performance data.	Knowledge and Understanding: Demonstrate knowledge of EV powertrain components, their interactions, and performance metrics. Experimental Skills: Design and conduct experiments to measure powertrain performance. Data Analysis Skills: Analyze and interpret	Test Plan Development: Develop a comprehensive test plan to evaluate powertrain performance metrics, such as acceleration, top speed, range, and energy efficiency. Data Acquisition and Analysis: Use appropriate instrumentation and data acquisition techniques to collect data on motor speed, torque, voltage,	Performance Evaluation of an Electric Vehicle Powertrain

	experimental data to evaluate powertrain performance. Problem-Solving Skills: Identify and troubleshoot issues that may affect powertrain performance.	current, and temperature. Performance Metrics Calculation: Calculate key performance metrics, such as motor efficiency, inverter efficiency, and overall vehicle efficiency. Performance Optimization: Identify areas for improvement in powertrain performance and propose optimization strategies.	
Understand the principles of electric vehicle conversion. Design and select suitable components for a 2-wheeler EV conversion. Integrate the new components into an existing 2-wheeler vehicle.	Knowledge and Understanding: Demonstrate knowledge of electric vehicle components, power electronics, and battery technology. Design Skills: Design a suitable electric powertrain for the 2-wheeler vehicle, considering factors like weight distribution, motor placement, and battery location.	Component Selection: Select appropriate components, such as motor, controller, battery, and charger, based on vehicle specifications and performance requirements. Vehicle Modification: Modify the vehicle's frame and body to accommodate the new components, ensuring proper weight distribution and structural integrity. Wiring and Integration: Wire the electric components,	Retrofitting of 2-Wheeler Electric Vehicle

	Practical Skills: Install and wire the electric powertrain components, ensuring proper integration with the existing vehicle. Problem-Solving Skills: Troubleshoot and resolve issues that may arise during the conversion process.	ensuring proper connections and insulation. Performance Testing: Test the converted vehicle's performance, including range, speed, acceleration, and braking.	

TABLE 3: LIST OF FINAL PROJECTS (15 PROJECTS THAT COMPREHENSIVELY COVER ALL THE LEARNING OUTCOME)	
SL. NO.	**Industry Use Case**
1	Design and Development of a 2-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation
2	Design and Development of a 3-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation
3	Design and Development of a 4-Wheeler Electric Vehicle: Powertrain Design, Simulation, and Validation
4	Efficiency Analysis and Optimization of a 2-Wheeler Electric Vehicle Powertrain
5	Efficiency Analysis and Optimization of a 3-Wheeler Electric Vehicle Powertrain
6	Efficiency Analysis and Optimization of a 4-Wheeler Electric Vehicle Powertrain
7	Design and Fabrication of a Mechanical Fixture for In-Wheel Hub Motor
8	Design and Development of a Mechanical Transmission System for a 2-Wheeler Electric Vehicle
9	Design and Assembly of a 7S5P Lithium-ion Battery Pack
10	Design and Development of a Mechanical Transmission System for a 3-Wheeler Electric Vehicle

11	Design and Development of a Mechanical Transmission System for a 4-Wheeler Electric Vehicle
12	Communication and Monitoring of a 7S5P Lithium-ion Battery Pack
13	Efficiency Analysis of a 2-Wheeler Electric Vehicle Transmission System
14	Performance Evaluation of an Electric Vehicle Powertrain
15	Retrofitting of 2-Wheeler Electric Vehicle

ANNEXURE III

TABLE 4: COURSE ASSESSMENT RUBRICS (TOTAL MARKS: 70)				
ASSESSMENT CRITERIA	**DESCRIBE THE CRITERIA OF THE BELOW CATEGORY PERFORMANCE**			**TOTAL MARKS**
	FAIR	**GOOD**	**EXCELLENT**	
Knowledge and understanding	Recalls key definitions and concepts.	Explains concepts in a clear and concise manner.	Applies concepts to solve problems and answer questions in a comprehensive and insightful manner.	20
Application and Analysis	Attempts to apply learn to solve problems, even if the solution is not entirely accurate.	Applies knowledge to solve problems correctly, demonstrating a clear understanding of the concepts involved.	Critically analyzes problems, identifies relevant concepts, and applies knowledge to develop creative and effective solutions.	25
Evaluation and Synthesis	Identifies relevant information from various sources.	Analyzes and critiques information from various sources, identifying strengths and weaknesses.	Synthesizes information from various sources to form well-founded arguments and evidence-based conclusions.	15
Communication Skills	Presents information in a clear and organized manner, but may lack detail or clarity.	Presents information in a clear, concise, and well-organized manner, using appropriate language and terminology.	Presents information in a clear, concise, and well-organized manner, using sophisticated language and terminology to engage the audience.	10

Category	**Assessment Criteria**	**Performance Levels**	**Weightage (Marks)**
Practical Skills Proficiency	Demonstrates ability to perform job-specific tasks effectively, using relevant tools, techniques, or methodologies	Good, Fair, Excellent	20
Technical Knowledge Application	Applies theoretical concepts to practical scenarios with accuracy	Fair, Good, Excellent	10

	and relevance		
Project Execution	Completes assigned projects or use cases demonstrating innovation, thoroughness, and skill application relevant to industry standards.	Fair, Good, Excellent	30
Communication and Reporting	Clearly presents findings, solutions, or project outcomes using professional communication and documentation standards (e.g., reports, presentations).	Fair, Good, Excellent	10

Level	Description
Fair (50%-64%)	Recalls basic definitions and concepts but struggles with application. Attempts to apply knowledge but often makes mistakes or lacks depth in analysis. Identifies some relevant information but struggles to analyze and synthesize it effectively. Presents information in a basic manner, lacking clarity and organization.
Good (65%-79%)	Explains concepts clearly and concisely, demonstrating a solid understanding. Applies knowledge to solve problems correctly, but may lack critical thinking and innovative solutions. Analyzes information effectively and identifies key points. Presents information clearly and concisely, using appropriate language and terminology.
Excellent (80%-100%)	Applies concepts to solve complex problems creatively and insightfully. Critically analyzes information, identifies underlying assumptions, and develops innovative solutions. Synthesizes information from multiple sources to form well-founded arguments and evidence-based conclusions. Presents information in a clear, concise, and engaging manner, using sophisticated language and terminology.