ROHINI
COLLEGE OF ENGINEERING & TECHNOLOGY
(AUTONOMOUS)
Approved By AICTE & Affiliated to Anna University
NBA Accredited for All Eligible B.E/B.Tech Programs | NAAC Accredited with A+ Grade
Near Anjugramam - Kanyakumari Main Road, Palkulam, Variyoor P.O.-629401, Kanyakumari Dist, Tamil Nadu.

Minor Course

ELECTRIC VEHICLES

Curriculum & Syllabus

(2024-2025 Admitted Students Onwards)

CREDIT INFO		
Sl.No	**Category**	**Credits**
1	Minor Courses	18

CREDIT DISTRIBUTION

Course Category	Credit/Semester								No. of Credits
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	
Minor Courses	**-**	**-**	**-**	**-**	**6**	**6**	**6**	**-**	**18**

MINOR COURSES						
ELECTRIC VEHICLES						
Sl.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	24EE581	Electric Vehicle Architecture	3	0	0	3
2	24EE582	Hybrid Vehicle Technology	3	0	0	3
3	24EE583	Electric Vehicle Charging Infrastructure and Smart Energy Management	3	0	0	3
4	24ME581	Battery Management Systems	3	0	0	3
5	24ME582	Design of Motor and Power Converters for Electric Vehicles	3	0	0	3
6	24ME583	Automotive Electronics and Embedded Systems	3	0	0	3

Course Code:	24EE581	Course Title:	ELECTRIC VEHICLE ARCHITECTURE
Credits:	3	L – T – P	3-0-0
Pre-requisite: Electric Circuits, Electrical Machines, Electron Devices and Circuits / Fundamentals of Electrical and Electronics Engineering / Fundamentals of Electrical Engineering			

Course Objectives:

- To understand the architecture and components of modern electric vehicles.
- To analyze electric propulsion systems, energy storage technologies and power electronics used in EVs.
- To explore EV charging infrastructure, battery management systems and vehicle communication networks.
- To study advanced EV technologies including connected, autonomous, and intelligent transportation systems.
- To develop practical skills in EV design, simulation, diagnostics, and performance evaluation.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industry Case Studies
2. Simulation-Based Learning using MATLAB/Simulink
3. Project-Based Learning
4. Industry Expert Sessions
5. Flipped Classroom Approach
6. Problem-Based Learning
7. EV Component Demonstrations
8. Smart Mobility Case Studies

UNIT I – INTRODUCTION TO ELECTRIC VEHICLE ARCHITECTURE	[9 hours]
Evolution of transportation and electrification, Types of Electric Vehicles: BEV, HEV, PHEV, FCEV, EV architecture and system-level design, Vehicle dynamics and performance requirements, EV subsystems and integration, Electric mobility ecosystem, Standards and regulations for EVs, Software defined Vehicles (SDV), Digital Twin concepts in EV design, AI-enabled vehicle monitoring, Real-world EV case studies.	

UNIT II – ELECTRIC PROPULSION SYSTEMS AND POWER ELECTRONICS	[9 hours]
Electric traction requirements, DC Motors, BLDC Motors, PMSM Induction Motors, Motor selection and sizing, Inverters and converters for EVs, Motor controllers and drive systems, Regenerative braking systems, Power electronic converters, AI-based motor control systems.	

UNIT III – BATTERY TECHNOLOGY AND ENERGY MANAGEMENT SYSTEMS	[9 hours]
Energy storage requirements for EVs, Lithium-ion, Solid-State, Sodium-ion batteries, Battery pack design and configuration, Battery Management System (BMS), State of Charge (SOC) estimation, State of Health (SOH) monitoring, Thermal management systems, Battery safety and protection.	

UNIT IV – EV CHARGING INFRASTRUCTURE AND VEHICLE COMMUNICATIONS	[9 hours]
EV charging standards and protocols, AC and DC charging systems, Fast charging technologies, Wireless charging concepts, Vehicle-to-Grid (V2G) technology, Vehicle communication networks (CAN, LIN, Ethernet), Charging station architecture, Smart grid integration.	

UNIT V – INTELLIGENT ELECTRIC VEHICLES AND FUTURE MOBILITY SOLUTIONS	[9 hours]
Connected Electric Vehicles, Autonomous and Assisted Driving Systems, Artificial Intelligence in EVs, Predictive Maintenance, Cyber security in EVs, Fleet Management Systems, Smart Mobility and Transportation, Sustainability and Life Cycle Assessment of EVs.	

Course Outcomes:
On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Analyze and evaluate electric vehicle architectures and subsystem integration for real-world transportation applications.	**K4**
CO2	Apply electric propulsion system design principles to select suitable motors, converters, and drive systems for EV applications.	**K3**
CO3	Design battery packs and implement battery management strategies to enhance EV performance, safety, and reliability.	**K3**
CO4	Develop EV charging infrastructure solutions and vehicle communication systems for smart mobility ecosystems.	**K3**
CO5	Design intelligent electric vehicle solutions incorporating AI, IoT, V2X communication, and predictive maintenance technologies.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	1	-	1	-	-	1	-	-	1	2	1	-
CO2	3	2	1	-	1	-	-	1	-	-	1	2	1	-
CO3	3	2	1	-	1	-	-	1	-	-	1	2	1	-
CO4	3	2	1	-	1	-	-	1	-	-	1	2	1	-
CO5	3	2	1	-	1	-	-	1	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	50	100	40
	CIE – II	100			
	MCQ	20	10		
	Skill Assessment - I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	48	80	64
Analyze	32	-	16
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2018.
2. Build Your Own Electric Vehicle,Seth Leitman ,Bob Brant, McGraw Hill, Third Edition 2013.
3. The Electric Vehicle Conversion Handbook: How to Convert Cars, Trucks, Motorcycles, and Bicycles -Includes EV Components, Kits, and Project Vehicles Mark Warner, HP Books, 2011.

Reference Books:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017.
2. Heavy-duty Electric Vehicles from Concept to Reality, Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, Elsevier Science, 2021.
3. Electric Vehicles Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevi kumar Padmanaban, Jens Bo Holm-Nielsen Springer, 2020.
4. Hybrid Electric Vehicles: A Review of Existing Configurations and Thermodynamic Cycles, Rogelio Leon , Christian Montaleza , Jose Luis Maldonado , Marcos Tostado-Veliz and Francisco Jurado, Thermo, 2021, 1, 134–150. https://doi.org/10.3390/thermo1020010.

Web Links and Video Lectures (E-Resources):

1. https://www.youtube.com/watch?v=wypbLRe9xUg
2. https://youtu.be/Q_1RmmQgDGk?si=VS54qVvv0kyMvsnM
3. https://www.youtube.com/live/KytCYJq8ATA?si=Oin5rpc87CKFNvQw
4. https://youtu.be/61VupMVdIK8?si=4b9y1BXMd6I-GawF
5. https://youtu.be/2F1dn64V4Vc?si=mYqF6DU0LlYwnu_y

Suggested Skill Activities:

1. Comparative analysis of popular EV architectures and preparation of a technical report.
2. Identification and study of major EV components using virtual EV platforms and simulation tools.
3. Selection and sizing of traction motor for a specified electric vehicle application.
4. Design a battery pack configuration for an electric two-wheeler or four-wheeler
5. Design a conceptual EV charging station for a smart city application.
6. Mini project on simulation and performance evaluation of a smart electric vehicle system.
7. Develop an AI-enabled predictive maintenance model for EV battery or motor systems.
8. Develop a real-time fault detection system to identify battery, motor, and inverter failures and improve vehicle reliability.

Course Code:	**24EE582**	**Course Title:**	**HYBRID VEHICLE TECHNOLOGY**
Credits:	**3**	**L – T – P**	**3-0-0**
Pre-requisite:			**Electrical Machines I, Electrical Machines II**

Course Objectives:

To impart knowledge on the

- To understand the fundamentals, architecture, and operating principles of hybrid electric vehicles (HEVs).
- To analyze hybrid powertrain components, energy storage systems, and energy management strategies.
- To evaluate hybrid vehicle performance, fuel economy, emissions, and sustainability aspects.
- To study advanced hybrid technologies, intelligent control systems, and connected mobility solutions.
- To develop practical skills in modeling, simulation, diagnostics, and optimization of hybrid vehicle systems.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industry Case Studies
2. MATLAB/Simulink-Based Simulations
3. Project-Based Learning
4. Problem-Based Learning
5. Industry Expert Talks
6. Flipped Classroom Sessions
7. Component Demonstrations and Teardowns
8. Hybrid Vehicle Performance Analysis Workshops

UNIT I – INTRODUCTION TO HYBRID ELECTRIC VEHICLE	**[9 hours]**
Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	

UNIT II – HYBRID POWERTRAIN COMPONENTS AND ELECTRIC DRIVES	**[9 hours]**
Internal Combustion Engine (ICE) integration in hybrid vehicles, Electric Motors: BLDC, PMSM, Induction Motors, Generators and Traction systems, Power Electronic Converters and Inverters, Hybrid transmission systems, Regenerative braking systems, Powertrain integration and control, Thermal Management of Propulsion Systems.	

UNIT III – ENERGY STORAGE SYSTEMS AND ENERGY MANAGEMENT	[9 hours]
Energy storage requirements in hybrid vehicles, Battery technologies: Lithium-ion, Solid-State, Sodium-ion Batteries, Ultracapacitors and Fuel Cells, Battery pack configuration and sizing, Battery Management System (BMS), State of Charge (SOC) and State of Health (SOH) estimation, Hybrid Energy Storage Systems (HESS), Energy management strategies.	

UNIT IV – HYBRID VEHICLE CONTROL, PERFORMANCE AND EMISSIONS	[9 hours]
Supervisory control strategies, Rule-based and optimization-based energy management, Vehicle performance analysis, Fuel economy assessment, Emission reduction techniques, Drive cycles and vehicle testing, Real-time monitoring and diagnostics, Hybrid vehicle standards and safety requirements.	

UNIT V – CONNECTED HYBRID VEHICLES AND FUTURE MOBILITY SYSTEMS	[9 hours]
Intelligent Hybrid Vehicles, Connected and Autonomous Hybrid Vehicles, Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Communication, Internet of Vehicles (IoV), Predictive Maintenance Systems, Cyber security in Hybrid Vehicles, Fleet Management and Smart Transportation, Sustainability and Life Cycle Assessment.	

Course Outcomes:

On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Analyze and evaluate various hybrid vehicle architectures and operating strategies for sustainable transportation applications.	**K4**
CO2	Apply hybrid powertrain design principles to select and integrate propulsion system components for improved vehicle performance.	**K3**
CO3	Design and implement energy storage and battery management solutions for efficient hybrid vehicle operation.	**K3**
CO4	Develop energy management and control strategies to optimize fuel economy, emissions, and system efficiency in hybrid vehicles.	**K3**
CO5	Design intelligent hybrid vehicle solutions incorporating AI, IoT, V2X communication, and predictive maintenance technologies for future mobility systems.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3	3	-	-	1	-	-	1	-	-	1	2	1	-
CO2	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO3	3	2	1	-	1	-	-	1	-	-	1	2	1	-
CO4	3	2	1	-	1	-	-	1	-	-	1	2	1	-
CO5	3	2	1	-	1	-	-	1	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	50	100	40
	CIE – II	100			
	MCQ	20	10		
	Skill Assessment - I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	**2**	
Remember	10	10	10
Understand	10	10	10
Apply	48	80	64
Analyze	32	-	16
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Sebastian E. Gay and Ali Emadi, 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles,' CRC Press, Second Edition, 2018.
2. Tom Denton and Hayley Pells, 'Electric and Hybrid Vehicles,' Routledge Publication, Third Edition, 2024.
3. Chris Mi, M. Abul Masrur and David Wenzhong Gao, 'Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,' Wiley Publication, Second Edition, 2017.

Reference Books:

1. James Larminie and John Lowry, 'Electric Vehicle Technology Explained,' Wiley Publication, Second Edition, 2012.
2. Ali Emadi, 'Fundamentals of Hybrid Electric Vehicles,' CRC Press, 2015.
3. Wei Liu, 'Hybrid Electric Vehicle System Modeling and Control,' Wiley-IEEE Press, 2013.
4. K. T. Chau, 'Electric Vehicle Machines and Drives,' Wiley Publication, 2015.
5. Sheldon S. Williamson, 'Energy Management Strategies for Electric and Hybrid Vehicles,' Springer Publication, 2013.

Web Links and Video Lectures (E-Resources):

1. NPTEL – Hybrid Electric Vehicles
2. NPTEL – Electric Vehicles Part 1
3. NPTEL – Electric Vehicles Part 2

Suggested Skill Activities:

1. Selection and sizing of electric drive components for a hybrid passenger vehicle.
2. Performance analysis of electric motor drives and regenerative braking systems through simulation.
3. Battery charging-discharging analysis and SOC estimation using simulation tools.
4. Design a hybrid energy storage system for a specified hybrid vehicle application.
5. Simulation of hybrid vehicle energy management strategies using standard drive cycles.
6. Analyze fuel economy and emission performance under different drive cycles.
7. Develop a predictive maintenance framework for hybrid vehicle batteries or powertrain systems.
8. Mini project on intelligent hybrid vehicle monitoring and diagnostics using IoT and AI tools.
9. Modelling and efficiency analysis of DC, induction and PMSM motor drives.
10. Estimation of EV range under standard driving cycles such as UDDS and WLTP.
11. Design and analysis of battery–supercapacitor hybrid energy storage systems.
12. Development of energy management algorithms for HEVs using MATLAB.
13. Case study analysis of electric two-wheelers, three-wheelers and four-wheelers available in India.
14. Mini project on design of e-rickshaw with suitable motor and energy storage system.
15. Performance analysis of regenerative braking systems in EVs.
16. Preparation of technical reports and presentations on recent EV technologies and standards.

Course Code:	**24EE583**	**Course Title:**	**ELECTRIC VEHICLE CHARGING INFRASTRUCTURE AND SMART ENERGY MANAGEMENT**
Credits:	**3**	**L – T – P**	**3-0-0**
Pre-requisite: Basic Electrical Engineering, Electric Vehicle Technology, Renewable Energy Systems			

Course Objectives:

- Understand the architecture, standards, and operation of electric vehicle charging infrastructure for residential, commercial, and public applications.
- Design and evaluate AC/DC charging systems, battery swapping stations, and smart charging networks for efficient energy utilization.
- Apply smart energy management techniques by integrating renewable energy sources, energy storage systems, and Vehicle-to-Grid (V2G) technologies.
- Develop intelligent charging solutions using IoT, Artificial Intelligence, cloud computing, and communication protocols for real-time monitoring and control.
- Design sustainable, secure, and standards-compliant EV charging infrastructure to address real-world challenges in electric mobility and smart cities.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Blended Mode of Learning
3. Project based Learning
4. Experiential Learning
5. NPTEL and Other Videos
6. Smart Class Room
7. Flipped Class

UNIT I – ELECTRIC VEHICLE CHARGING FUNDAMENTALS AND STANDARDS	**[9 hours]**
Evolution of EV Charging Infrastructure – Charging Ecosystem – EV Supply Equipment (EVSE) – Charging Levels (Level 1, Level 2, Level 3) – AC Charging – DC Fast Charging – Ultra-Fast Charging – Pantograph Charging – Battery Swapping – Wireless Charging – Conductive and Inductive Charging – Charging Standards (IEC 61851, IEC 62196, ISO 15118, CCS, CHAdeMO, GB/T, Bharat AC001 & DC001, NACS) – Charger Selection and Sizing – Public, Residential and Fleet Charging Infrastructure.	

UNIT II – CHARGING POWER ELECTRONICS AND STATION DESIGN	[9 hours]
Power Electronic Converters for EV Chargers – AC-DC Rectifiers – DC-DC Converters – Bidirectional Chargers – On-board Chargers (OBC) – Off-board Chargers – Modular Charging Systems – High-Power Charging – Solid-State Transformers – Transformerless Chargers – Protection Systems – Earthing – Load Calculations – Cable Sizing – Thermal Management – Charging Station Layout and Design – Reliability and Maintenance.	

UNIT III – SMART ENERGY MANAGEMENT AND GRID INTEGRATION	[9 hours]
Smart Grid Fundamentals – Distributed Energy Resources – Renewable Energy Integration – Solar PV Powered Charging Stations – Wind Energy Integration – Battery Energy Storage Systems (BESS) – Microgrids – Load Forecasting – Demand Response – Peak Load Management – Vehicle-to-Grid (V2G) – Vehicle-to-Home (V2H) – Vehicle-to-Building (V2B) – Energy Management Systems (EMS) – Smart Metering – Power Quality – Grid Stability.	

UNIT IV – CONNECTED CHARGING, IoT AND INTELLIGENT ENERGY MANAGEMENT	[9 hours]
Internet of Things (IoT) for EV Charging – Smart Charging Algorithms – Open Charge Point Protocol (OCPP) – Open Automated Demand Response (OpenADR) – MQTT Communication – Cloud-Based Charger Management – Mobile Applications – Artificial Intelligence for Charging Optimization – Machine Learning for Load Prediction – Blockchain for Energy Trading – Cybersecurity in Charging Infrastructure – Digital Twin for Charging Networks – Edge Computing.	

UNIT V – FUTURE MOBILITY, SUSTAINABILITY AND EV INFRASTRUCTURE PLANNING	[9 hours]
EV Charging Network Planning – GIS-Based Charger Location Optimization – Fleet Electrification – Public Transport Electrification – Charging Economics – Business Models – Government Policies and Incentives – Carbon Footprint Analysis – Lifecycle Assessment – Circular Economy – Second-Life Batteries – Green Hydrogen Integration – AI-Based Smart Cities – Industry 5.0 – Future Trends in Electric Mobility.	

Course Outcomes:

On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Interpret the EV charging infrastructure by selecting appropriate charging technologies, standards, and power electronic converters for residential, commercial, and public applications.	**K2**
CO2	Develop smart charging stations integrated with renewable energy sources, battery energy storage systems, and intelligent energy management strategies.	**K3**
CO3	Apply Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H), and demand response techniques to improve grid stability and energy efficiency.	**K3**
CO4	Integrate IoT, Artificial Intelligence, cloud computing, communication protocols, and digital twin technologies for intelligent monitoring, optimization, and cybersecurity of EV charging networks.	**K3**
CO5	Design sustainable, economically viable, and standards-compliant EV charging ecosystems that address real-world challenges in electric mobility, smart cities, and clean energy transition.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	2	1	1	-	1	-	-	1	-	-	1	2	1	-
CO2	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO3	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO4	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO5	3	2	1	-	1	-	-	1	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	50	100	40
	CIE – II	100			
	MCQ	20	10		
	Skill Assessment - I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	2	
Remember	10	10	10
Understand	42	10	26
Apply	32	32	32
Analyze	16	48	32
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. Gregory L. Plett, Battery Management Systems, Volumes I–III, Artech House.
2. James Larminie and John Lowry, Electric Vehicle Technology Explained, 2nd Edition, Wiley.
3. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition, CRC Press.
4. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.
2. Chris Mi, M. Abul Masrur, and David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley.
3. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley.
4. Ali Keyhani, Smart Power Grid, Springer.
5. IEC 61851 – Electric Vehicle Conductive Charging Systems.
6. ISO 15118 – Road Vehicles – Vehicle-to-Grid Communication Interface.
7. IEC 62196 – Plugs, Socket-Outlets, Vehicle Connectors and Inlets.
8. SAE J1772 – Electric Vehicle Conductive Charging Coupler.
9. IEEE 2030.1.1 – Smart Grid Interoperability.

Web Links and Video Lectures (E-Resources):

1. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee134
2. https://www.coursera.org/learn/creating-ev-charging-hubs-innovative-design
3. https://www.udemy.com/course/charging-infrastructure-for-electric-vehicles
4. https://www.youtube.com/watch?v=sp0IPWvqNfM
5. https://www.elevify.com/en/courses/transportation-automotive-and-logistics/automobiles/ev-charging-course-9c5ca

Skill Activities

Students shall complete **any FIVE** of the following:

1. Design a public EV charging station for a commercial complex.
2. Develop a solar-powered EV charging system with battery storage.
3. Simulate Vehicle-to-Grid (V2G) operation using MATLAB/Simulink.
4. Build an IoT-enabled EV charging monitoring system using ESP32 and MQTT.
5. Configure an OCPP-compliant charging station and cloud dashboard.
6. Develop an AI model for charging demand forecasting and load optimization.
7. Perform energy auditing and optimization of an EV charging station.
8. Design a smart charging algorithm for fleet charging applications.
9. Create a digital twin model of a charging station for predictive maintenance.
10. Prepare a GIS-based charging infrastructure plan for a smart city or College campus.

Course Code:	24ME581	Course Title:	BATTERY MANAGEMENT SYSTEMS
Credits:	3	L – T – P	3-0-0
Pre-requisite: Electric Circuits, Engineering Chemistry, Electron Devices and Circuits			

Course Objectives:

- Understand the chemistry, characteristics, performance, and safety requirements of batteries used in electric vehicles and energy storage systems.
- Design Battery Management Systems (BMS) for monitoring, protection, balancing, and optimization of battery packs.
- Apply embedded systems, sensors, communication protocols, and power electronics for intelligent battery management.
- Integrate Artificial Intelligence (AI), Machine Learning (ML), Digital Twin, and Internet of Things (IoT) technologies for battery diagnostics and predictive maintenance.
- Develop sustainable, reliable, and industry-compliant BMS solutions for electric mobility, renewable energy, and smart grid applications.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Blended Mode of Learning
3. Project based Learning
4. Experiential Learning
5. NPTEL and Other Videos
6. Smart Class Room
7. Flipped Class

UNIT I – BATTERY TECHNOLOGIES AND ENERGY STORAGE SYSTEMS	[9 hours]
Introduction to Electrochemical Energy Storage – Battery Fundamentals – Cell Construction – Battery Chemistry – Lead Acid, Nickel Metal Hydride, Lithium-ion, Lithium Polymer, Lithium Iron Phosphate (LFP), Sodium-ion, Solid-State Batteries – Battery Characteristics – Capacity, C-rate, Energy Density, Power Density, Cycle Life, Efficiency – Battery Pack Configuration – Battery Manufacturing Process – Recycling and Circular Economy – Applications in Electric Vehicles, Grid Energy Storage, Consumer Electronics and Aerospace.	

UNIT II – BATTERY MANAGEMENT SYSTEM ARCHITECTURE AND PROTECTION	[9 hours]
Battery Management System Overview – Centralized, Modular and Distributed BMS Architectures – Cell Voltage Monitoring – Current Measurement – Temperature Monitoring – Battery Protection – Overcharge, Over-discharge, Overcurrent, Short Circuit, Thermal Runaway Detection – State of Charge (SOC) Estimation – State of Health (SOH) Estimation – State of Power (SOP) – Battery Fault Diagnosis – Functional Safety (ISO 26262).	

UNIT III – CELL BALANCING, CHARGING TECHNOLOGIES AND COMMUNICATION SYSTEMS	[9 hours]
Passive and Active Cell Balancing – Charge Equalization Techniques – Battery Charging Methods – Constant Current-Constant Voltage (CC-CV) Charging – Fast Charging – Wireless Charging – Opportunity Charging – Battery Swapping – Thermal Management Systems – Liquid Cooling – Air Cooling – Phase Change Materials – Battery Communication Protocols – CAN, CAN FD, LIN, SPI, I²C, UART, Ethernet – Cloud Connectivity – OTA Firmware Updates.	

UNIT IV – INTELLIGENT BATTERY MANAGEMENT USING AI, IoT AND DIGITAL TWIN	[9 hours]
AI and Machine Learning for Battery Analytics – Predictive Maintenance – Remaining Useful Life (RUL) Prediction – Deep Learning for Fault Detection – Digital Twin for Battery Simulation – IoT-enabled Battery Monitoring – Cloud-Based Battery Analytics – Edge Computing – Big Data Analytics – Cybersecurity in Battery Systems – Blockchain for Battery Traceability – Smart Fleet Battery Management.	

UNIT V – ADVANCED BATTERY MANAGEMENT APPLICATIONS AND FUTURE TRENDS	[9 hours]
Battery Management for Electric Vehicles – Hybrid Electric Vehicles – Fuel Cell Hybrid Systems – Renewable Energy Storage – Microgrids – Vehicle-to-Grid (V2G) – Vehicle-to-Home (V2H) – Second-Life Batteries – Battery Recycling Technologies – IEC, ISO and AIS Standards – Sustainability and Carbon Neutrality – Industry 5.0 – AI-assisted Battery Design – Quantum Battery Research – Solid-State Battery Management.	

Course Outcomes:

On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Design battery packs and battery management system architectures suitable for electric vehicles and stationary energy storage applications.	**K2**
CO2	Develop intelligent algorithms for battery monitoring, protection, cell balancing, and charging to improve safety and performance.	**K3**
CO3	Integrate embedded controllers, sensors, communication protocols, and cloud platforms for real-time battery diagnostics and remote monitoring.	**K4**
CO4	Apply Artificial Intelligence, Machine Learning, IoT, and Digital Twin technologies for battery health estimation, predictive maintenance, and lifecycle optimization.	**K3**
CO5	Develop sustainable, standards-compliant Battery Management Systems that address real-world challenges in electric mobility, renewable energy, and smart grid applications.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	2	1	1	1	1	-	-	1	-	-	1	2	1	-
CO2	3	2	1	2	1	-	-	1	-	-	1	2	1	-
CO3	3	2	2	2	1	-	-	1	-	-	1	2	1	-
CO4	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO5	3	2	1	-	1	-	-	1	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	50	100	40
	CIE – II	100			
	MCQ	20	10		
	Skill Assessment - I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	2	
Remember	10	10	10
Understand	42	10	26
Apply	32	64	48
Analyze	16	16	16
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House, 2010.
2. Gregory L. Plett, Battery Management Systems, Volume I: Battery Modeling, Artech House, 2015.
3. Gregory L. Plett, Battery Management Systems, Volume II: Equivalent Circuit Methods, Artech House, 2016.
4. Gregory L. Plett, Battery Management Systems, Volume III: Battery State Estimation, Artech House, 2015.

Reference Books:

1. Jiuchun Jiang, Fundamentals and Applications of Lithium-Ion Batteries in Electric Drive Vehicles, Wiley, 2015.
2. Rui Xiong, Battery Management Algorithms for Electric Vehicles, Springer, 2020.
3. Karim Abdel-Malek, Electric Vehicle Technology Explained, Wiley, Latest Edition.
4. Chris Mi, M. Abul Masrur, and David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications, Wiley.
5. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley.
6. IEC 62660 – Secondary Lithium-Ion Cells for Electric Vehicles.
7. ISO 26262 – Road Vehicles – Functional Safety.
8. IEC 61508 – Functional Safety of Electrical/Electronic Systems.
9. SAE J2464 – Electric and Hybrid Vehicle Battery Safety Testing.

Web Links and Video Lectures (E-Resources):

1. Introduction to battery-management systems, Gregory Plett, University of Colorado, https://www.coursera.org/learn/battery-management-systems
2. Electric Vehicle Battery Management System, Udemy, https://www.udemy.com/course/battery-and-battery-management-system-design-simulation
3. Battery and Battery Management Systems, eMobility Academy, https://emobility.academy/course/bms/
4. Battery and Battery Management Systems, ASDC, https://courses.asdc.org.in/course/battery-and-battery-management-systems-bms-course
5. Battery Management Systems (BMS) and Pack Design, TU Delft, https://www.edx.org/learn/engineering/delft-university-of-technology-battery-pack-design-and-management-systems

Skill Activities:

Students shall complete **any FIVE** of the following activities:

1. Design a Battery Management System for an electric two-wheeler.
2. Develop a State of Charge (SOC) estimation algorithm using MATLAB or Python.
3. Implement passive and active cell balancing using simulation tools.
4. Develop an IoT-enabled battery monitoring dashboard using ESP32 and MQTT.
5. Analyze battery thermal behavior using simulation software.
6. Build a cloud-based battery monitoring system using ThingsBoard or Azure IoT.
7. Develop an AI model for battery fault detection or Remaining Useful Life (RUL) prediction.
8. Configure CAN communication between a BMS controller and an electric vehicle simulator.
9. Perform lifecycle assessment and recycling analysis of lithium-ion batteries.
10. Design a smart charging and battery swapping management system for electric vehicles.

Mini Project:

Students shall solve one real-world problem such as:

- Smart Battery Management for Electric Vehicles
- AI-Based Battery Health Prediction
- IoT-Enabled Battery Monitoring System
- Battery Thermal Management for Fast Charging
- Smart Charging Station with Cloud Connectivity
- Digital Twin of an EV Battery Pack
- Battery Swapping Management System
- Renewable Energy Battery Storage Controller
- Fleet Battery Monitoring and Analytics
- Battery Recycling and Second-Life Management Platform

Course Code:	24ME582	Course Title:	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES
Credits:	3	L – T – P	3-0-0
Pre-requisite:			Electron Devices and Circuits, Control Systems

Course Objectives:

Upon successful completion of the course, students will be able to:

1. Understand the design principles, characteristics, and selection criteria of electric traction motors used in electric and hybrid electric vehicles.
2. Design and analyze power electronic converters, inverters, and charging systems for EV propulsion and auxiliary applications.
3. Apply simulation tools and embedded control techniques to optimize motor drive performance, efficiency, thermal management, and reliability.
4. Integrate emerging technologies such as wide bandgap semiconductor devices, AI-based control, digital twins, and Vehicle-to-Grid (V2G) systems into EV powertrain design.
5. Develop energy-efficient, standards-compliant electric propulsion systems capable of addressing real-world challenges in electric mobility and sustainable transportation.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Blended Mode of Learning
3. Project based Learning
4. Experiential Learning
5. NPTEL and Other Videos
6. Smart Class Room
7. Flipped Class

UNIT I – ELECTRIC VEHICLE POWERTRAIN AND TRACTION MOTOR REQUIREMENTS	[9 hours]
Electric Vehicle Architecture – Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Fuel Cell Electric Vehicles (FCEV) – EV Powertrain Components – Vehicle Dynamics – Tractive Effort – Drive Cycle Analysis (WLTP, FTP-75, IDC) – Motor Selection Criteria – Torque-Speed Characteristics – Efficiency Maps – Thermal Limits – NVH Considerations – Standards and Safety Requirements.	

UNIT II – DESIGN OF ELECTRIC TRACTION MOTORS	[9 hours]
Electromagnetic Design Fundamentals – Design Specifications – Magnetic and Electric Loading – Torque Density – Efficiency Optimization – Thermal Design – Cooling Techniques – Design and Performance Analysis of: Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors (BLDC), Induction Motors (IM), Switched Reluctance Motors (SRM), Axial Flux Permanent Magnet Motors (AFPM), Synchronous Reluctance Motors (SynRM). Finite Element Analysis (FEA) of Motors – Materials Selection – Rare Earth Magnet Alternatives – Fault-Tolerant Motor Design.	

UNIT III – DESIGN OF POWER CONVERTERS AND MOTOR DRIVES	[9 hours]
Power Semiconductor Devices – Si, SiC MOSFETs, GaN Devices – DC-DC Converters (Buck, Boost, Bidirectional, Interleaved) – Voltage Source Inverters – Multilevel Inverters – Soft Switching Techniques – PWM Strategies – Space Vector PWM – Regenerative Braking – On-board Chargers (OBC) – Fast DC Chargers – Converter Thermal Management – EMI/EMC Considerations – Reliability and Protection.	

UNIT IV – CONTROL, OPTIMIZATION AND INTELLIGENT DRIVE SYSTEMS	[9 hours]
Motor Control Strategies – Field Oriented Control (FOC) – Direct Torque Control (DTC) – Sensorless Control – Vector Control – Embedded Motor Controllers – DSP and FPGA-Based Drive Systems – AI-Based Motor Control – Machine Learning for Efficiency Optimization – Predictive Maintenance – Digital Twin for Powertrain Simulation – Model Predictive Control (MPC) – Cybersecurity in EV Power Electronics.	

UNIT V – ADVANCED EV PROPULSION SYSTEMS AND FUTURE TRENDS	[9 hours]
Integrated Motor Drives – E-Axle Systems – Vehicle-to-Grid (V2G) – Vehicle-to-Home (V2H) – Wireless Power Transfer – Dynamic Wireless Charging – Ultra-Fast Charging – Solid-State Transformers – AI-Based Energy Management – Digital Twin-Based Powertrain Design – Industry 5.0 in EV Manufacturing – Circular Economy – Sustainable Materials – Recycling of Motors and Power Electronics – International Standards (IEC, ISO, AIS, SAE).	

Course Outcomes:

On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Design electric traction motors that satisfy torque, efficiency, thermal, and performance requirements for diverse electric vehicle applications.	**K3**
CO2	Develop high-efficiency power converters and inverter systems for electric vehicle propulsion, charging, and regenerative braking.	**K3**
CO3	Apply advanced control algorithms, embedded platforms, and communication protocols to optimize EV motor drive performance and reliability.	**K3**
CO4	Integrate AI, digital twin, wide bandgap semiconductor technologies, and intelligent energy management techniques into modern EV propulsion systems.	**K3**
CO5	Develop sustainable, industry-compliant electric powertrain solutions that address real-world challenges in electric mobility, energy efficiency, safety, and grid integration.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO2	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO3	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO4	3	2	1	1	1	-	-	1	-	-	1	2	1	-
CO5	3	2	1	1	1	-	-	1	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	50	100	40
	CIE – II	100			
	MCQ	20	10		
	Skill Assessment – I	40	40		
	Skill Assessment – II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	70	70	70
Analyze	-	-	-
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. Krishnan R., Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press.
2. James Larminie and John Lowry, Electric Vehicle Technology Explained, 2nd Edition, Wiley.
3. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition, CRC Press.
4. Ned Mohan, Tore M. Undeland, and William P. Robbins, Power Electronics: Converters, Applications, and Design, Wiley.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.
2. Austin Hughes and Bill Drury, Electric Motors and Drives, 5th Edition, Elsevier.
3. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson.
4. Issa Batarseh and Ahmad Harb, Power Electronics: Circuits, Devices and Applications, Springer.
5. Chris Mi, M. Abul Masrur, and David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley.
6. IEC 61851 – Electric Vehicle Conductive Charging System.
7. ISO 26262 – Road Vehicles – Functional Safety.
8. SAE J1772 – Electric Vehicle Charging Interface.
9. IEC 60034 – Rotating Electrical Machines.

Web Links and Video Lectures (E-Resources):

1. https://youtu.be/HcwJKKG_LYY?si=99ZKgw4aBpcK9r2P
2. https://youtu.be/viNhv2tlUYM?si=cRdLfGB3iwxJeSzC
3. https://youtu.be/M88fk35108k?si=c8NpFNNNtncLtAsv
4. https://youtu.be/fgKE6FWdLXU?si=dm3eSq5Q54itmY61
5. https://youtu.be/B5HNlJDjM64?si=IDThd0s5SDcBvhou

Suggested Skill Activities:

1. Design a PMSM for an electric two-wheeler using electromagnetic design software.
2. Develop a bidirectional DC-DC converter for EV battery charging.
3. Simulate an SVPWM-controlled inverter using MATLAB/Simulink.
4. Implement Field Oriented Control (FOC) for a BLDC or PMSM drive.

5. Analyze the performance of SiC and GaN devices in high-frequency EV converters.
6. Develop a regenerative braking strategy for an electric vehicle.
7. Create a digital twin model of an EV powertrain.
8. Design a thermal management system for an EV traction motor.
9. Develop an AI-based predictive maintenance model for motor drive fault diagnosis.
10. Design a Vehicle-to-Grid (V2G) bidirectional charging interface.

Mini Project

Students shall solve one real-world engineering problem such as:

- High-Efficiency Electric Two-Wheeler Drive System
- AI-Based Motor Fault Diagnosis
- Smart Regenerative Braking Controller
- Digital Twin of an Electric Powertrain
- Bidirectional EV Charger for V2G Applications
- SiC-Based High-Efficiency Traction Inverter
- Wireless Charging System for Electric Vehicles
- Integrated E-Axle Drive Design
- Smart Thermal Management of EV Motors
- Intelligent Motor Drive Health Monitoring System

Course Code:	**24ME583**	**Course Title:**	**AUTOMOTIVE ELECTRONICS AND EMBEDDED SYSTEMS**
Credits:	**3**	**L – T – P**	**3-0-0**

Course Objectives:

1. Understand the architecture and operation of modern automotive electronic systems used in electric and intelligent vehicles.
2. Design embedded hardware and software solutions for automotive control applications using automotive-grade microcontrollers.
3. Develop sensor and actuator interfacing techniques for vehicle monitoring, diagnostics, and control.
4. Implement automotive communication protocols and cybersecurity mechanisms for connected vehicles.
5. Design intelligent automotive embedded systems integrating AI, IoT, Edge Computing, and functional safety principles to solve real-world mobility problems.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. NPTEL and Other Videos
3. Smart Class Room
4. Field visit
5. Project based learning
6. Industrial Visit

UNIT I – FUNDAMENTALS OF AUTOMOTIVE ELECTRONIC SYSTEMS	**[9 hours]**
Evolution of Automotive Electronics, Conventional vs Electric Vehicle Electronics, Electronic Control Units (ECU), Automotive domain architecture, Distributed Vehicle Electronics, Vehicle electrical architecture (12V, 48V and High Voltage systems), Automotive sensors, Position sensors, Speed sensors, Current sensors, Voltage sensors, Temperature sensors, IMU, Hall Effect sensors, Automotive actuators, Power Electronics in EVs, Introduction to AUTOSAR, Industry Case Study: Electronic architecture of Tesla, Hyundai Ioniq 5 and Tata Nexon EV.	

UNIT II – AUTOMOTIVE EMBEDDED SYSTEMS DESIGN	[9 hours]
Automotive microcontrollers: ARM Cortex-M, Infineon AURIX, NXP S32K, Renesas RH850: Embedded C Programming, Real-Time Operating Systems (RTOS), Interrupt handling, Timers, ADC/DAC, PWM generation, Memory management, Embedded software development lifecycle, Automotive software architecture, Functional Safety (ISO 26262).	

UNIT III – VEHICLE SENSORS, ACTUATORS AND COMMUNICATION NETWORKS	[9 hours]
Automotive sensor integration: Battery Monitoring Sensors, Wheel Speed Sensors, Torque Sensors, Steering Sensors, Tire Pressure Monitoring System (TPMS), Camera, Radar, LiDAR. Vehicle Actuators: BLDC Motor Controller, Steering actuator, Brake actuator, Cooling system, HVAC controller. Automotive Networks: CAN, CAN FD, LIN, FlexRay, Automotive Ethernet, MOST, SPI, I2C, UART. Vehicle Diagnostics: OBD-II, UDS Protocol	

UNIT IV – EMBEDDED CONTROL SYSTEMS FOR ELECTRIC VEHICLES	[9 hours]
Embedded control of Battery Management System, Motor Controller, DC-DC Converter, On-board Charger, Regenerative Braking, Thermal Management System, Charging Control Unit, Vehicle Control Unit (VCU): Energy optimization, Fault detection, Embedded diagnostics, Predictive maintenance, OTA (Over-the-Air) software updates, Digital Twin for automotive electronics.	

UNIT V – INTELLIGENT AUTOMOTIVE EMBEDDED SYSTEMS	[9 hours]
Artificial Intelligence in automotive electronics, Machine Learning for predictive diagnostics, IoT-enabled connected vehicles, Edge AI, Cybersecurity for vehicles, Secure boot, Hardware Security Module (HSM), Vehicle-to-Everything (V2X), Software Defined Vehicles (SDV), Autonomous driving electronics, Future automotive architectures, Industry 5.0 applications.	

Course Outcomes:

On completion of the course, the student will have the ability to

CO No.	Course Outcomes	Highest Cognitive Level
CO1	Model automotive electronic architectures by selecting suitable sensors, actuators, ECUs, and embedded hardware for electric vehicle applications.	**K3**
CO2	Develop embedded software using automotive microcontrollers and RTOS to implement real-time vehicle control systems.	**K3**
CO3	Integrate automotive communication protocols and diagnostic systems to enable reliable data exchange and fault detection in modern vehicles.	**K4**
CO4	Identify embedded control solutions for battery management systems, motor controllers, charging systems and energy management in electric vehicles.	**K3**
CO5	Develop intelligent automotive embedded applications using AI, IoT, Edge Computing, cybersecurity, and V2X technologies to address real-world smart mobility challenges.	**K3**

COs and POs/PSOs Mapping:

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3	2	2	2	2	-	-	2	-	-	1	2	1	-
CO2	3	2	2	1	2	-	2	2	-	-	1	2	1	-
CO3	3	2	2	2	1	-	2	-	-	-	1	2	1	-
CO4	3	2	2	2	2	-	2	2	-	-	1	2	1	-
CO5	3	2	2	2	1	-	2	2	-	-	1	2	1	-

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Assessment Pattern:

Bloom's Category	Continuous Internal Examination		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	64	64	64
Analyze	16	16	16
Evaluate	-	-	-
Create	-	-	-

Text Books:

1. William B. Ribbens, *Understanding Automotive Electronics: An Engineering Perspective*, 9th Edition, Butterworth-Heinemann, 2023.
2. Nicolas Navet and Francoise Simonot-Lion, *Automotive Embedded Systems Handbook*, 2nd Edition, CRC Press, 2021.
3. Ronald K. Jurgen, *Automotive Electronics Handbook*, McGraw-Hill Education, Latest Edition.

Reference Books:

1. Frank Vahid and Tony Givargis, Embedded System Design, 3rd Edition, Wiley, 2020.
2. Tammy Noergaard, Embedded Systems Architecture, 3rd Edition, Elsevier, 2021.
3. Jack Ganssle, The Art of Designing Embedded Systems, 3rd Edition, Newnes, 2022.
4. Ulrich Kiencke and Lars Nielsen, Automotive Control Systems, 3rd Edition, Springer, 2021.
5. David Ward and John Webster, Automotive Embedded Electronics and Mechatronics, SAE International, Latest Edition.
6. Robert Bosch GmbH, Bosch Automotive Handbook, 11th Edition, Wiley, 2023.Tom Denton, “Automotive Electrical and Electronics Systems,” Third Edition, 2004, SAE International
7. William Ribbens, "Understanding Automotive Electronics - An Engineering Perspective," 7th Edition, Elsevier Butterworth-Heinemann Publishers, 2012.

Web Links and Video Lectures (E-Resources):

1. https://www.udemy.com/course/automotive-electronics-t
2. https://www.coursera.org/learn/introduction-to-automotive-embedded-systems
3. https://www.youtube.com/playlist?list=PLr3K3SCZV7DbrYggMwkBAop3VtjLANMGg
4. https://www.youtube.com/playlist?list=PLTndtixj8kK3ebawbU_-vbcGxGzJtj36E
5. https://www.youtube.com/watch?v=pHCBOLidXOY

Suggested Skill Activities:

1. Develop an embedded controller for an automatic headlight system.
2. Build a CAN-based communication network between two ECUs.
3. Design an IoT-enabled vehicle health monitoring system.
4. Implement Battery Monitoring using voltage and temperature sensors.
5. Develop an embedded predictive maintenance dashboard using vehicle sensor data.
6. Mini Project: Develop a Smart Embedded Automotive System for an Electric Vehicle using sensors, ARM controller, CAN communication, and IoT dashboard.