DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING	
Name of the Minor Degree	Electric Vehicles
Department Offering the Minor Degree	Electrical and Electronics Engineering
Eligible Departments	ECE, CSE, IT, Mech., Civil, AIDS, Cyber Security

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDEE01	Basics of Electric Vehicles	2	0	2	4	3
2	U23MDEE02	Electric Vehicle Architecture	3	0	0	3	3
3	U23MDEE03	Power Converters and Motors for Electrical Drives	2	0	2	4	3
4	U23MDEE04	Energy Storage Systems in Electric Vehicles	2	0	2	4	3
5	U23MDEE05	Control of Electric Vehicles	2	0	2	4	3
6	U23MDEE06	Integration of Plug in Electric Vehicles	3	0	0	3	3

TOTAL CREDITS :18

Approved

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U23MDEE01	BASICS OF ELECTRIC VEHICLES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To understand the different configurations of EV.
- To understand the basics of battery charging in EV.
- To understand the different motors used in EV.

UNIT I **HISTORY OF ELECTRIC VEHICLES** **6**

Introduction-Electric Vehicles – Promotion year of EV, Basic Types of Electric Vehicles, Advantages and Disadvantages.

UNIT II **DRIVE TRAIN OF ELECTRIC VEHICLES** **6**

Introduction to Battery Electric vehicles-Hybrid Electric Vehicles-Types-Plug In Hybrid EV-Basic Architecture.

UNIT III **EV CONFIGURATIONS** **6**

Introduction – EV Configuration Basic Architecture-Single and Multi-Motor Drives-Construction and working of the drives.

UNIT IV **ENERGY STORAGE IN EV** **6**

Overview of different types of Batteries-Parameters of batteries-Concept of Battery Charging-Fuel Cell Concept-Basic working and operation of batteries.

UNIT V **ELECTRIC VEHICLE MOTORS** **6**

Introduction to Electric Motors –AC Motors-permanent magnet motors-Series wound motors-Shunt wound motors-Brushless DC Motors-Basics and working-Regenerative Braking.

30 PERIODS

PRACTICAL EXERCISES

Using SCILAB/MATLAB Simulation Software

1 Simulation of Basic Models of EV.
2 Design and Simulation of different EV Configurations.
3 Simulation of Different energy storage systems in EV.
4 Simulation of any two motors in EV.
5 Simulate the torque speed characteristics of BLDC motor used in EV.

30 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

1 S Sujatha, B Senthilkumar, "A Text Book on Electric Vehicle Technology", 1st Edition, Scientific International Publishers, 2024.
2 Yimin Gao, Stefano Lango, "Modern Electric Hybrid & Fuel Cell Vehicles", 2nd Edition, CRC Press, 2021.

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REFERENCES:

1 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, "Electric Vehicles Modern Technologies and Trends", 1st Edition, Springer, 2021.

2 Arvind J Bosale, S S Raghuvanshi, Amit R Patil, "Fundamentals of Hybrid and Electric Vehicles", 1st Edition, Khanna Publishers, 2024.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/108/105/108105058/

2 https://onlinecourses.nptel.ac.in/noc21_ge04/preview

3 https://archive.nptel.ac.in/courses/108/105/108105061/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the Basics of Electric Vehicles.

CO2 Explain the different types of Electric Vehicles..

CO3 Design an EV Configuration drives.

CO4 Describe the concept of energy storage in EV.

CO5 Explain the Concept of different motors used in EV.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	1	1	1	-	-
CO2	2	2	1	1	1	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	2	2	1	1	1	-	-	1	1	1	-	-

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U23MDEE02	ELECTRIC VEHICLE ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the structure of Electric Vehicle, Hybrid Electric Vehicle, Plug in Hybrid EV
- To understand about the EV conversion components, specifications for EV.
- To model and simulate all types of DC motors.

UNIT I **VEHICLE ARCHITECTURE AND SIZING** **(7+2 Skill) 9**

Electric Vehicle History, and Evolution of Electric Vehicles. Series, Parallel and Series parallel Architecture, Micro and Mild architectures. Mountain Bike - Motorcycle-Electric Cars and Heavy Duty EVs. -Details and Specifications.

UNIT II **VEHICLE MECHANICS** **(7+2 Skill) 9**

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.

UNIT III **POWER COMPONENTS AND BRAKES** **(7+2 Skill) 9**

Powertrain Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV powertrain sizing, HEV Powertrain sizing, Examples.

UNIT IV **HYBRID VEHICLE CONTROL STRATEGY** **(7+2 Skill) 9**

Vehicle supervisory control, Mode selection strategy, Modal Control strategies.

UNIT V **PLUG-IN HYBRID ELECTRIC VEHICLE** **(7+2 Skill) 9**

Introduction-History-Comparison with electrical and hybrid electrical vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/ Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Simulation using MATLAB or SCILAB)

1 Group Seminar on Electric Vehicle History and EV Architecture.

2 Assignment on vehicle mechanics.

3 Quiz on power components and brakes.

4 Surprise test on hybrid vehicle control strategy.

5 Simulation of plug in hybrid vehicles.

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TOTAL : 45 PERIODS

TEXT BOOKS:

1 Shashank Arora, Alireza Tashakori, Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, "Heavy-duty Electric Vehicles from Concept to Reality", 2nd Edition, Elsevier Science Publishers, 2021.

2 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban , "Electric Vehicles Modern Technologies and Trends", 12th Edition, Springer, 2021.

REFERENCES:

1 G C Karg, "Utilization of Electric Power and Electric Traction", 2nd Edition, Khanna Publishers, 2021.

2 C L Wadhwa,"Generation Distribution and Utilization of Electrical Energy", 3rd Edition, New Age International Publishers, 2021.

3 H Partab, "Art and Science of Utilization of Electrical Energy", 4th Edition, Dhanpat Rai Publishers, 2021.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/108/105/108105058/

2 https://onlinecourses.nptel.ac.in/noc21_ge04/preview

3 https://archive.nptel.ac.in/courses/108/105/108105061/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize suitable electric drives for different applications in electric traction.

CO2 Design various illumination systems for energy saving.

CO3 Explain the utilization of electrical energy for heating and welding purposes.

CO4 Summarize the effective usage of solar and wind energies for various electrical applications.

CO5 Explain the electric connection for any domestic appliance like refrigerator, battery charging circuit for a specific household application.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	3	3	3	3	1	-	-	1	1	1	-	-
CO3	2	2	1	1	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE03	POWER CONVERTERS AND MOTORS FOR ELECTRICAL DRIVES	L T P C
		2 0 2 3

COURSE OBJECTIVES:

- To impart knowledge on different types of DC-DC Power Converters used in Electric Vehicles.
- To impart knowledge on construction, working and design of Induction and PMBLDC Motors, Permanent Magnet Synchronous Motors, and Axial Flux Motors
- To provide knowledge on different types of Inverters used in Electric Vehicles

UNIT I POWER CONVERTERS FOR ELECTRIC VEHICLES 6

Introduction to Components of Electric Vehicles, Non-Isolated DC-DC Converter: Boost Converter, Buck Converter Buck-Boost Converter, and Isolated DC- DC Converters: Fly back Converter, Forward Converter- Modes of Operation and Analysis.

UNIT II INDUCTION MOTOR AND PMBLDC MOTOR 6

Induction motor - Construction and operation, torque and power equation, Torque-Speed Characteristics, Braking methods.PMBLDC Motor - Constructional features, Operating principle, EMF and torque developed, Torque-Speed Characteristics.

UNIT III PERMANENT MAGNET SYNCHRONOUS MOTOR 6

PMSM Motor – Construction and types of PMSM - EMF and torque developed, Torque - Speed Characteristics - Phasor diagram, Braking methods

UNIT IV AXIAL FLUX MOTOR 6

Axial Flux Motor - Constructional features, Principle of operation, Torque developed and Speed Control. Introduction to axial motor.

UNIT V INVERTERS FOR ELECTRIC VEHICLES 6

Introduction to H Bridge Inverter, Three Phase Voltage and Current source inverters - operation and analysis. Modulation techniques for VSI – SPWM, SVPWM.

30 PERIODS

PRACTICAL EXERCISES

Using SCILAB/MATLAB Simulation Software

1 Simulation of DC-DC Power Converters used in Electric Vehicles.

2 Simulation of Inverters for Electric Vehicles.

3 Simulation of PMBLDC motors.

4 Simulation of Axial Flux Motors.

5 Simulation of PMSM motors.

30 PERIODS

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TOTAL : 60 PERIODS

TEXT BOOKS:

1 Jigneshkumar P Desai, "Special Electrical Machinery", 1st Edition, John Wiley & Sons, 2023.

2 L Ashok Kumar, S Albert Alexander, "Power Converters for Electric Vehicles", 1st Edition, CRC Press, 2021.

REFERENCES:

1 Simmi P Burman, "Special Electrical Machines", 1st Edition, S K Kataria & Sons, 2023.

2 Atif Iqbal, Shaikh, "Electrical Machines Fundamentals with Numerical Solutions using MATLAB/SIMULINK", 1st Edition, John Wiley &Sons, 2021.

3 Md Rabiul Islam, Rakibuzzaman Shah, "Emerging Power Converters for Renewable Energy and Electric Vehicles: Modelling Design and Control", 1st Edition, CRC Press, 2021.

ONLINE RESOURCES:

1 https://onlinecourses. nptel.ac.in/noc25_ee33/preview

2 https://innovationspace.ansys.com//courses/learning-track.

3 https://onlinecourses.nptel.ac.in/noc22_ee33/preview

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the operation of power converters used in Electric Vehicles.

CO2 Explain the working of Induction Motors and PMBLDC Motors.

CO3 Design Permanent Magnet Synchronous Motors.

CO4 Comprehend the working of Axial Flux Motors.

CO5 Explain the operation of inverters used in Electric Vehicles

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	2	2	1	1	-	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	-	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE04	ENERGY STORAGE SYSTEMS IN ELECTRIC VEHICLES	L T P C
		2 0 2 3

COURSE OBJECTIVES:

- To impart knowledge on general physical mechanism and standards for EV charging systems and battery management systems
- To familiarize the estimation methods for different battery parameters and wireless power transfer in EV and its standards
- To provide knowledge on renewable energy powered EV charging systems.

UNIT I **EV CHARGING METHODS AND STANDARDS** **6**

Introduction- Building Blocks of EV charging station, Types of battery chargers – Slow, rapid and DC fast chargers - Charging technologies- Conductive charging - Need for inductive charging of EV - Inductive charging – International standards and regulations - Indian standard IS 17017-part-1,2,23-25;

UNIT II **BATTERY MANAGEMENT SYSTEMS** **6**

Significance of Battery Management Systems - Functions of the Battery Management System – Topology of the BMS - Methods of Battery Management - Introduction to IoT based Battery Monitoring System.

UNIT III **BATTERY STATE ESTIMATION** **6**

Single Cell – Series and Parallel combination of Batteries - Characteristic Parameters: State of Charge (SoC), Depth of Discharge (DoD) and State of Health (SoH) – Estimation methods of SoC and SoH - Ampere-hour integral.

UNIT IV **WIRELESS POWER TRANSFER FOR EVs** **6**

Introduction – Types of Wireless Charging - Inductive, Magnetic Resonance and Capacitive - Benefits of WPT - Standards for EV Wireless Chargers, SAE J2954, IEC 61980, ISO 19363.

UNIT V **EV CHARGING USING RENEWABLE ENERGY SYSTEMS** **6**

Introduction – EV charging systems for residential and commercial buildings - solar PV system – wind energy conversion systems - charging infrastructure with hybrid solar PV, wind and battery.

30 PERIODS

PRACTICAL EXERCISES

Use any Renewable energy kit /open source platform

1 Determine the SOH and SOC of the given battery.
2 Simulate the thermal characteristics of a cell.
3 Simulate the primary battery monitoring system.
4 Simulate the charging system of the given battery for a specified time period
5 Simulate the charging system of the given battery fed from Photovoltaic panel.

30 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

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1 Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, "Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration", 1st Edition, Springer, 2021.

2 Rui Xiong, "Battery Management Algorithm for Electric Vehicles", 1st Edition, Springer, 2021.

REFERENCES:

1 Chitra A, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, S Himavathi, "Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles", 1st Edition, John Wiley&Sons, 2021.

2 Alicia Trevino,-Cabrera, José M González-González, José A. Aguado, " Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach", 1st Edition, Springer, 2021.

3 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, "Electric Vehicles Modern Technologies and Trends", 1st Edition, Springer, 2021.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/113/105/113105102/

2 https://www.dqindia.com/iit-madras-offers-free-online-course-electric-vehicles-can-completed-12-weeks/

3 https://archive.nptel.ac.in/courses/108/106/108106182/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Comprehend the general physical mechanism of EV charging systems and standards

CO2 Design basic battery management system.

CO3 Evaluate the different parameters of the battery.

CO4 Analyze the different types of wireless power transfer.

CO5 Explain the challenges and problems associated with the use of various energy sources for EV charging systems.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	3	3	3	3	1	-	-	1	1	1	--	-
CO3	3	3	2	3	1	-	-	1	1	1	-	-
CO4	3	3	1	2	1	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE05	CONTROL OF ELECTRIC VEHICLES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To impart knowledge on basics control strategy on power converter and different control schemes applied to Induction Motors
- To provide knowledge on different methods of control of synchronous reluctanc Motors
- To familiarize the different control techniques for PMBLDC motor and axial flux motors.

UNIT I **CONTROL OF POWER CONVERTERS** 6

Need for Closed Loop Control – Voltage Mode Control (VMC) – Current Mode Control (CMC) – Advantages of CMC over VMC –Cascade Control Strategy – Condition for implementing Cascade Control Strategy - Introduction to fixed and variable frequency PWM methods.

UNIT II **CONTROL OF INDUCTION MOTOR** 6

d-q Model, Scalar Control - v/f Control, Voltage Fed Inverter Control, Current Fed Inverter Control, Direct torque control.

UNIT III **CONTROL OF PERMANENT MAGNET BRUSHLESS DC MOTORS** 6

Control of PMBLDC Motor using 3-pulse Converter and 6 pulse Inverter, Structure of controller, Closed loop Current Mode Control - Microcontroller based implementation of PMBLDC Drive. Control of E-bike

UNIT IV **CONTROL OF PERMANENT MAGNET SYNCHRONOUS MOTORS** 6

Self-control, v/f control, Direct Torque control, Vector control, Sensor less control, Microcontroller based PMSM Drive.

UNIT V **CONTROL OF AXIAL FLUX MOTORS** 6

Current Control Schemes- Hysteresis and PWM control - Embedded control of axial flux motor.

30 PERIODS

PRACTICAL EXERCISES:

Use any open source platform

1 Simulate the Testing of v/f controller for Induction motor

2 Simulate the Speed control of PMDC motor

3 Simulate the Speed control of BLDC motor

4 Simulate the Speed of control of SRM motor

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5 Simulate the Testing of PMSM motor

30 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1 Rolf Isermann," Automotive Control: Modelling and Control of Vehicles" 1st Edition, Springer Berlin, Heidelberg, 2021.

2 Per Enge, Nick Enge, Stephen Zoepf, "Electric Vehicle Engineering", 1st Edition, Tata McGraw Hill Publishers, 2021.

REFERENCES:

1 João Pedro F, Trovão, Minh Cao Ta," Electric Vehicle Efficient Power and Propulsion Systems", 1st Edition, Multidisciplinary Digital Publishing Institute(MDPI), 2022.

2 Kundan Kumar, Ambrish Devanshu, Sanjeet K. Dwivedi," Electric Vehicle Propulsion Drives and Charging Systems",1st Edition, CRC Press, 2024.

3 Raj Kamal, "Embedded Systems", 4th Edition, Tata McGraw Hill, 2020.

ONLINE RESOURCES:

1 https://www.embitel.com/motor-control-solution-for-electric-vehicle-drivetrain

2 https://onlinecourses.nptel.ac.in/noc24_ee30/preview

3 https://onlinecourses.nptel.ac.in/noc25_ee33/preview

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the concept of power converters.

CO2 Describe the control of induction motors.

CO3 Design permanent magnet brushless DC Motors.

CO4 Explain the concepts of permanent magnet synchronous motors and axial flux motors.

CO5 Design various motors used in electric vehicles.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	1	1	1	-	-
CO2	2	2	1	1	1	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	3	3	3	3	1	-	-	1	1	1	-	-

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U23MDEE06 INTEGRATION OF PLUG IN ELECTRIC VEHICLES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge on energy exchange between storage element and power grid and benefits of V2G
- To learn the challenges in V2G integrated power system , impacts of EV and V2G on the power grid
- To familiarize the management of EV

UNIT I INTRODUCTION TO G2V AND V2G 9

Introduction to power grid and smart grid. Definition of G2V and V2G - History and Development of V2G. Incorporating V2G for EV, Types of storage: Short-term and Long-Term.

UNIT II BENEFITS OF V2G 9

Benefits of V2G. Technical Benefits: Storage Superiority and Grid Efficiency - Economic Benefits: EV Owners and Societal Savings - Environment and Health Benefits: Sustainability in Electricity and Transport.

UNIT III CHALLENGES IN V2G 9

Technical Challenges- Effect of Battery Degradation, Conversion Efficiency of EV Charger. The Economic and Business Challenges of V2G - Evolving Nature of V2G Costs and Benefits. Introduction to Regulatory Challenges and Frameworks.

UNIT IV IMPACT OF EV AND V2G ON POWER GRID 9

Impact of Electric Vehicles on power quality issues - Load management using Renewable Energy Sources and EVs. Impacts of EV on environment.

UNIT V MANAGEMENT OF EV 9

Introduction to Machine to Machine (M2M) communication- M2M in distributed energy management systems - M2M communication for EV - Overview of cloud-based energy management service for Electric vehicles - Data loggers for EV. - Charging Station Discovery Selection and Status Server (CDSSS).

45 PERIODS

TEXT BOOKS:

1 Nand Kishor, Jesus Fraile-Ardanuy, "Electric Vehicle Integration with the Smart Grid", 1st Edition, Springer, 2020.

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2 Mohammad Saad Alam, Mahesh Krishnamurthy," Electric Vehicle Integration in a Smart Micro grid Environment", 1st Edition, CRC Press, 2021.

REFERENCES:

1 Lance Noel, Gerardo Zarazua de Rubens, Johannes Kester, Benjamin K Sovacool, " Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility", 1st Edition, Palgrave Macmillan, 2019.

2 Rajiv Singh, Sanjeevikumar Padmanaban," Cable Based and Wireless Charging Systems for Electric Vehicles: Technology and Control, Management and Grid Integration", 1st Edition, Springer, 2021.

3 Rather Z, Nath A, "Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global Review, India's Gap Analyses and Way Forward", 1st Edition, Elsevier, 2021.

ONLINE RESOURCES:

1 https://onlinecourses.nptel.ac.in/noc25_ee79/preview

2 https://onlinecourses.nptel.ac.in/noc23_ee60/preview

3 https://archive.nptel.ac.in/courses/108/106/108106182/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Describe the methods of energy exchange between storage elements to power system grid

CO2 Explain the benefits of V2G

CO3 Analyze the technical and regulatory challenges related to V2G

CO4 Comprehend the impact of EV and V2G on power grid

CO5 Describe the concept of management of EV

CO PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	1	-	-	-	-	-
CO2	2	2	1	1	-	-	1	-	-	-	-	-
CO3	3	3	1	2	-	-	1	-	-	-	-	-
CO4	2	2	1	1	-	-	1	-	-	-	-	-
CO5	2	2	1	1	-	-	1	-	-	-	-	-

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