RAJALAKSHMI ENGINEERING COLLEGE
(AN AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY)
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

MINOR DEGREE IN ELECTRIC VEHICLES

S. NO	COURSE CODE	COURSE NAME	Category	L	T	P	C
1	MEE1901	Energy Systems and Design of Electric Vehicles	PC	3	0	0	3
2	MEE1902	Fundamentals of Automotive Technology	PC	3	0	0	3
3	MEE1903	Charging Systems for Electric Vehicles	PC	2	0	2	3
4	MEE1904	Power Converters and Motors for Electric Vehicles	PC	2	0	2	3
5	MEE1905	Control of Electric Vehicles	PC	2	0	2	3
6	MEE1906	Grid Integration of Electric Vehicles	PC	3	0	0	3

Subject Code	Subject Name	Category	L	T	P	C
MEE1901	ENERGY SYSTEMS AND DESIGN OF ELECTRIC VEHICLES (Theory Course)	PC	3	0	0	3

Objectives:

- To impart knowledge on basics of electric and hybrid vehicles
- To provide knowledge on batteries fir traction application
- To learn the concepts of fuel cell and their application in EV and HEV
- To understand the design fundamentals of electric and hybrid vehicles
- To learn about the effects of electromagnetic interference and testing

UNIT-I INTRODUCTION **9**

Electric vehicles – need, types, advantages, challenges - Hybrid vehicle – advantages, disadvantages, architecture and energy flow– series, parallel, series-parallel, micro, mild, full and plugin hybrid. - Drive train for hybrid and electric vehicles-Hybrid vehicle operating modes. Electronic control system for EV & EHV. Power flow control.

UNIT-II EV & HEV BATTERIES **9**

Targets and properties of batteries for EV and HEV. Construction, working principle and properties of Li-Po battery, Li ion battery, Nickel Metal Hydride Battery, Sodium Sulphur Battery and Aluminium Air Battery. Basics of battery management – Battery capacity calculation , size and weight estimation.

UNIT-III FUEL CELLS **9**

Operation principles of fuel cells – Electrode potential and current-voltage curves. Types – Proton exchange membrane fuel cells, alkaline fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells, direct methanol fuel cells. Fuel cell hybrid drive train. Control strategy. Power design of fuel cell system - Fuel cell characteristic curves- Energy flow in FCEV – Case study – Toyota Mirai

UNIT-IV EV & HEV DESIGN FUNDAMENTALS **9**

Forces acting on a vehicle – Aerodynamic, rolling and gradient resistance. Tractive effort and vehicle speed calculation, estimation of power, range, and energy consumption, Sizing of power train components in Electric and hybrid electric drive. Maximum speed of the vehicle. Gradeability. Vehicle fuel economy estimation in a hybrid drive.

UNIT-V ELECTROMAGNETIC INTERFERENCE AND TESTING **9**

EMI–significance and control techniques. SAE Automotive EMC standards – SAE J551- SAE J 1113 – Test methodology- Safety checklist (AIS 038). – significance of isolation resistance - measurement of isolation resistance – water tests motor power test (AIS 041) – chassis dynamometer– Energy consumption test (AIS 039) – battery testing (AIS 048) –Range test (AIS 040).

Contact Hours : 45

Course Outcomes: On completion of the course, the students will be able to

- explain about the global pollution, emission standards and modern drive train technology options
- describe about various traction batteries, their performance and perform capacity and size estimation.
- explain about different fuel cell and their suitability for electric and hybrid vehicle application.
- compute the various resistances and can estimate the performance parameters for the vehicle.
- elucidate the testing standards and electromagnetic interference and suppression techniques for electric vehicles.

Text Book (s):	
1	Tom denton. " Electric and Hybrid Vehicles" Routledge Publications, 2016
2	Connor, Paul., Bailey, Robert (Bob) D., Rand, D A J., Dell, R M. Understanding Batteries. United Kingdom: Royal Society of Chemistry, 2007.
3	Iqbal Hussain. "Electric and Hybrid Vehicles Design Fundamentals". CRC Press, 2013
Reference Books(s) / Web links:	
1	MehrdadEhsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell Vehicles", CRC press, 2017
2	Electric Vehicles: The Benefits and Barriers. Croatia: IntechOpen, 2011.
3	Goodarzi, G. Abas., Hayes, John G.. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles. United Kingdom: Wiley, 2018.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	1	-	3	3	2	-	1	-	2	3	3	2
CO 2	3	1	1	-	-	3	3	2	-	1	-	2	3	-	2
CO 3	3	1	1	-	-	3	3	2	-	1	-	2	3	-	2
CO 4	3	2	2	1	-	2	3	2	-	1	-	2	3	-	2
CO 5	3	2	2	1	-	2	2	2	-	1	-	2	3	-	2
Average	**3**	**1.6**	**1.6**	**1**	-	**2.6**	**2.8**	**2**	-	**1**	-	**2**	**3**	**3**	**2**

Subject Code	Subject Name(Theory Course)	Category	L	T	P	C
MEE1902	**FUNDAMENTALS OF AUTOMOTIVE TECHNOLOGY**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To learn about the types of chassis layout and drivetrain systems
- To understand the basics of front axle types and steering system
- To know about the loads acting on rear axles and the various types of tyres and wheels of an automobile.
- To learn the fundamentals of suspension system
- To impart the basic knowledge on brake systems

UNIT-I	**LAYOUT, FRAME AND DRIVE LINE**	9

Basic construction of vehicles, Types of Chassis layout with reference to Power Plant location and drive, various types of frames, forces acting on a vehicle, introduction to automotive engines- gasoline and diesel, Universal Joints, Constant Velocity Universal Joints, Principle and Constructional details of gear box and differential unit.

UNIT-II	**FRONT AXLE AND STEERING SYSTEM**	9

Types of Front Axles and Stub Axles, Front Wheel Geometry. Condition for True Rolling Motion. Ackerman 's and Davis's Steering Mechanisms, Steering Linkages, Different Types of Steering Gear boxes, Slip Angle, effects of Over–Steer and Under–Steer, Electric Power Steering

UNIT-III	**REAR AXLES, WHEELS, RIMS AND TYRES**	9

Construction of rear axles, Types of Loads acting on rear axles, Full –Floating, Three–Quarter Floating and Semi–Floating Axles, Multi axle vehicles and its types. Construction of Wheels and Rims, Types of Tyres and their constructional details. Optimisation of wheels and selection of tyres

UNIT-IV	**SUSPENSION SYSTEM**	9

Requirement of Suspension System, Types of Suspension Springs, Constructional details and characteristics of Single Leaf, Multi–Leaf spring, Coil and Torsion bar Springs, Rubber,Pneumatic and Hydro – elastic Suspension Spring Systems, Independent and dependent Suspension System, Shock Absorber and its types, anti-roll bar for stability of electric vehicles.

UNIT-V	**BRAKE SYSTEMS**	9

Need for Brake systems, Stopping Distance, Time and Braking Efficiency, Effect of Weight Transfer during Braking, Classification of brakes, Braking Torque, drum brake and disc Brake Theory, Types and Construction of Hydraulic Braking System, Mechanical Braking System, Power–Assisted Braking System,

	Total Contact Hours	**:**	**45**

Course Outcomes:

At the end of the course the student will be able to

●	the steering geometry and derive the condition for true rolling motion of an automobile
●	the knowledge about the working of transmission and components of driveline system.
●	select the appropriate type of rear axle for a given vehicle and know about the various types of wheels and tires.
●	possess knowledge about the deployment of appropriate type of springs for vehicles.
●	realize the importance of braking systems in a vehicle

Text Book(s):	
1	Kirpal Singh, "Automobile Engineering Vol.1", Standard Publisher Distributors, 14th Edition, 2017.
2	Fundamentals of Automotive Technology. United States: Jones & Bartlett Learning, 2017.
3	Restoule, Martin., Erjavec, Jack., Playter, Al. Automotive Technology: A Systems Approach. Australia: Nelson Education Limited, 2006.
Reference Books(s) / Web links:	
1	Erjavec, Jack., Thompson, Rob. Automotive Technology: A Systems Approach. United States: Cengage Learning, 2014.
2	Duffy, James E.. Modern Automotive Technology. United States: Goodheart-Willcox Company, 2004.
3	VanGelder, Kirk T.. Fundamentals of Automotive Technology: Principles and Practice. United States: CDX Automotive, Jones & Bartlett Learning, 2013.

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	1	-	-	1	-	-	-	1	1	2	3	3	2
CO 2	3	2	1	-	-	1	-	-	-	1	1	2	3	-	2
CO 3	3	2	1	-	-	1	-	-	-	1	1	2	3	-	2
CO 4	3	2	1	-	-	1	-	-	-	1	1	2	3	1	2
CO 5	3	2	1	-	-	1	-	-	-	1	1	2	3	2	2
Average	**3**	**2**	**1**	-	-	**1**	-	-	-	**1**	**1**	**2**	**3**	**2**	**2**

Subject Code	**Subject Name(Lab Oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
MEE1903	**CHARGING SYSTEMS FOR ELECTRIC VEHICLES**	**PC**	**2**	**0**	**2**	**3**

Objectives:

●	To impart knowledge on general physical mechanism and standards for EV charging systems
●	To expose the concept of battery management systems
●	To familiarize the estimation methods for different battery parameters
●	To teach the concept of wireless power transfer in EVs 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.		
	Contact Hours	**30**

List of Experiments			
1	To find the SOH and SOC of the given battery.		
2	To simulate the thermal characteristics of a cell.		
3	To simulate the primary battery monitoring system.		
4	To simulate the charging system of the given battery for a specified time period.		
5	To simulate the charging system of the given battery fed from Photovoltaic panel.		
		Contact Hours	**15**
		TOTAL CONTACT HOURS : 45	
Course Outcomes: On completion of the course, the students will be able to			
●	comprehend the general physical mechanism of EV charging systems and standards		
●	realize the functions of basic battery management system		
●	estimate the different parameters of the battery		
●	analyse the different types of wireless power transfer		
●	realize the challenges and problems associated with the use of various energy sources for EV charging systems.		
Text Book (s):			
1	Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration", Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021		
2	Battery Management Algorithm for Electric Vehicles, Rui Xiong Springer; 1st ed. 2020 edition (8 October 2019)		
3	Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles , Chitra A. (Editor), Sanjeevikumar Padmanaban (Editor), Jens Bo Holm-Nielsen (Editor), S. Himavathi (Editor), Wiley-Scrivener; 1st edition (18 September 2020)		
Reference Books(s) / Web links:			
1	Mobile Electric Vehicles Online Charging and Discharging , Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016		
2	Alicia Triviño-Cabrera ,José M. González-González,José A. Aguado, Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach, Springer Publisher 2019		
3	Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban,Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 2020		

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3
CO 2	3	3	3	3	3	3	3	1	3	2	3	3	3	2	3
CO 3	3	3	3	3	3	3	3	1	3	2	3	3	3	2	3
CO 4	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3
CO 5	3	3	3	3	3	3	3	1	3	2	3	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1.8**	**3**	**2**	**3**	**3**	**3**	**2**	**3**

Subject Code	**Subject Name(Lab Oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
MEE1904	**POWER CONVERTERS AND MOTORS FOR ELECTRIC VEHICLES**	**PC**	**2**	**0**	**2**	**3**

Objectives:		
●	To familiarise the different types of DC - DC Power Converters used in Electric Vehicles	
●	To provide knowledge on different types of Inverters used in Electric Vehicles	
●	To inculcate knowledge on the construction, principle of operation and design of Induction and PMBLDC Motors	
●	To impart knowledge on construction, principle of operation and design of Synchronous Reluctance Motor and Permanent Magnet Synchronous Motor	
●	To learn the construction, principle of operation and design of Switched Reluctance Motor and Axial Flux Motor	
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, Isolated DC- DC Converters: Flyback Converter, Forward Converter- Modes of Operation and Analysis.		
UNIT-II	**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.		
UNIT-III	**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-IV	**PERMANENT MAGNET SYNCHRONOUS MOTOR**	6
PMSM Motor – Construction and types of PMSM - EMF and torque developed, Torque - Speed Characteristics Phasor diagram, Braking methods.		
UNIT-V	**AXIAL FLUX MOTOR**	6
Axial Flux Motor - Constructional features, Principle of operation, Torque developed and Speed Control. Introduction to Raxial motor.		
	Contact Hours : 30	

	List of Experiments
1.	Simulation of Buck converters with R and RL loads
2.	Simulation of Boost converters with R,RL and RLE loads
3.	Simulation of SPWM inverter with Induction Motor load
4.	Design of PMSM Motor using Matlab
5.	Study of PMBLDC motor/PMSM motor using 'Motor solve' - software
	Contact Hours : 15
	Total Contact Hours : 45
Course Outcomes: On completion of the course, the students will be able to	
●	choose and design the appropriate DC - DC Power Converter and Inverter for Electric Vehicle applications
●	design and analyse the Induction Motor
●	design and analyse the Permanent Magnet Synchronous Motor
●	design and analyse PMBLDC motor
●	perform simulation of different types of power converters and motors used in Electric Vehicles using Matlab.
Text Book (s):	
1	Jananardanan, Special electrical machines, Prentice hall India,2013
2	Philip T Krein, Elements of Power Electronics, Oxford university press,2003
3	Venkataratnam, Special electrical machines, Oxford university press,2021
Reference Books(s) / Web links:	
1	M.H.Rashid, Power electronics, Pearson,2014
2	Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, BhimireddyPrathap Reddy, Wiley,2021
3	Theodore wildi, Electrical machines and drives,pearson,2015

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 2	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 3	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 4	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 5	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**3**	**2**	**3**	**3**	**3**	**2**	**3**

Subject Code	Subject Name(Lab Oriented Theory Course)	Category	L	T	P	C
MEE1905	CONTROL OF ELECTRIC VEHICLES	PC	2	0	2	3

bjectives:

- To impart knowledge on different control schemes applied to Induction Motors.
- To provide knowledge on different methods of control of synchronous reluctance motors.
- To familiarize the different control techniques for PMBLDC motor.
- To inculcate knowledge on the various control schemes applied to permanent magnet synchronous motors.
- To teach the different control methods applicable for switched reluctance 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, Sensorless 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.

Contact Hours	**:**	**30**

List of Experiments

1	Testing of v/f controller for Induction motor
2	Speed control of PMDC motor
3	Speed control of BLDC motor
4	Speed of control of SRM motor
5	Testing of PMSM motor

Lab Contact Hours	**:**	**15**
Total Contact Hours	**:**	**45**

Course Outcomes: On completion of the course, the students will be able to

- To choose the appropriate control scheme for the speed control of Induction Motors
- To apply the suitable control method for the speed control of synchronous reluctance motors
- To select the appropriate control scheme for the control of PMBLDC motor
- To realize the suitable control scheme for the control of permanent magnet synchronous motors and switched reluctance motors
- To realize the speed control of various motors used in Electric Vehicles using Matlab/Simulink software tool.

Text Book (s):

1. Kenjo, T and Naganori, S “Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003. 8.
3. R.Krishnan, “Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications” CRC Press, 2001.

Reference Books(s) / Web links:

1. Miller, T.J.E. “Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.
2. B.K. Bose, “Modern Power Electronics & AC drives”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
3. VedamSubrahmanyam, "Electric Drives: Concepts & Applications", 2nd Edition, Mcgrahill

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	1	1	1	3	2	3	3	3	2	3
CO 2	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3

CO 3	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 4	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 5	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**1.8**	**1.8**	**1**	**3**	**2**	**3**	**3**	**3**	**2**	**3**

Subject Code	**Subject Name(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
MEE1906	**GRID INTEGRATION OF ELECTRIC VEHICLES**	**PC**	**3**	**0**	**0**	**3**

Objectives:

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

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 EVs, 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 EVs on environment.

UNIT-V	**MANAGEMENT OF EVs**	**9**

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

Total Contact Hours	**:**	**45**

Course Outcomes: On completion of the course, the students will be able to

- analyse the methods of energy exchange between storage element to power system grid.
- realise the benefits of V2G
- analyse the technical and regulatory challenges related to V2G
- comprehend the impact of EV and V2G on power grid
- realize the concept of management of EVs.

Text Book (s):

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor; Jesus Fraile-Ardanuy, IET 2020

Reference Books(s) / Web links:

1. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015
2. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019
3. https://www.iec.ch/technical-committees-and-subcommittees#tclist

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	-	3	3	3	3	2	3	3	3	3	2

CO 2	3	3	3	3	-	3	3	3	3	2	3	3	3	3	2
CO 3	3	3	3	3	-	3	3	3	3	2	3	3	3	3	2
CO 4	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2
CO 5	3	3	3	3	-	3	3	3	3	2	3	3	3	3	2
Average	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**2**