

Program : Diploma in Electrical & Electronics Engineering / Electrical Engineering & Electric Vehicle Technology / Mechanical Engineering / Tool & Die Engineering / Renewable Energy	
Course Code : 6031D	Course Title: Electric Vehicles
Semester : 6	Credits: 4
Course Category: Program Elective	
Periods per week: 4 (L:3, T:1, P:0)	Periods per semester: 60

Course Objectives:

- To express the relevance of electric vehicles (EV) for the future transportation sector.
- To understand the application of electric motors in EV applications.
- To summarize various energy storage options in EV.
- To identify the charging infrastructure requirements for EV.

Course Outcomes

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

CO n	Description	Duration (Hours)	Cognitive level
1	Outline the basic concepts of electrical vehicles and their classifications	12	Understanding
2	Identify various drive trains in Electric Vehicles and Hybrid Electric Vehicles	14	Understanding
3	Outline the importance of hybridization of various energy storage in electric vehicles.	16	Understanding
4	Explain the EV charging system integrated with renewable energy	16	Understanding
	Series Test	2	

CO-PO Mapping

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2				3		
CO2	2				3		
CO3	2				3		
CO4	2				3		

3- Strongly mapped 2- Moderately mapped 1- Weakly mapped

Course Outline

Module Outcomes	Description	Duration (Hours)	Cognitive Level
CO1	Outline the basic concepts of Electric Vehicles and their classifications		
M1.01	List the various benefits of using Electric Vehicles compared to other modes of transport	2	Understanding
M1.02	Summarize the general classifications of Electric vehicles	4	Understanding
M1.03	Outline the Govt policies and schemes related to Electric vehicles	2	Understanding
M1.04	Classify Motor drive technologies in Electric vehicles	4	Understanding

Contents:**Introduction to Electric Vehicles**

Overview of automobile development - Introduction to Electric Vehicle(EV) – Historical background- Benefits of EV including environmental impacts

Types of EVS – Pure Electric vehicle(PE)-Battery Electric vehicles (BEV)-Fuel Cell Electric Vehicles(FCEV)-Hybrid Electric vehicle(HEV) – Plug-in Hybrid Electric vehicle (PHEV) - Types of Electric vehicles based on with and without differential - Types of HEV series, parallel, series-parallel and Complex -Differences between EV and conventional vehicles - Differences between complete EV and Hybrid vehicles - Single speed transmission

Government Schemes and Progress: FAME-1, FAME-2; Transformative -mobility and Energy Storage Mission, and other latest central level policies - State Policies, subsidies, and incentives - Global experiences and success stories on EV production

Motor drive Technologies – classification of EV Motors - Configuration and control of DC Motor drives - Induction Motor drives - Permanent Magnet Motor drives - Switched reluctance motor

CO2	Identify various drive trains in Electric Vehicles and Hybrid Electric Vehicles		
M2.01	List the various components of EV subsystems	2	Understanding
M2.02	Explain the principle and operation of various electric drives.	5	Understanding
M2.03	Illustrate the operation of HEVs in various modes	5	Understanding
M2.04	Outline the braking in Electric vehicles	2	Understanding
	Series Test - 1	1	

Contents:

EV configuration-Converted EV, Purpose built EV- Main components of EV sub-systems– Electric Propulsion unit ,Energy source subsystem, auxiliary sub sytem-

Drive train in EV and HEV: Basic Architecture of Electric Drive Trains: General configuration of an electric vehicle, Alternatives Based on Drive train Configuration, Alternatives Based on Power Source Configuration, Single and Multi-motor Drives - In Wheel Drives.

Energy saving potential of Hybrid drive trains - Various HEV configurations and their operation modes - Power Flow in HEVs: Power Flow Control in Series Hybrid -Power Flow Control in Parallel Hybrid - Power Flow Control in Series-Parallel Hybrid - Power Flow Control in complex Hybrid - Torque Coupling and Analysis of Parallel Drive Train

Braking in EV – Regenerative braking – Hybrid braking.

CO3	Outline the importance of hybridization of various energy storage in Electric Vehicles.		
M3.01	Summarize the energy storage technologies in EV and HEV	4	Understanding
M3.02	Explain various Battery charging Technologies and its management	4	Understanding
M3.03	Outline the power electronics converters used in Electric Vehicles	4	Understanding
M3.04	Explain the EV Charging Infrastructure	4	Understanding

Contents:

Energy storage technologies – speed variation in EV - Introduction to energy storage devices in EV and HEV- batteries, ultra-capacitors, ultra-flywheels, and fuel cells- Batteries- overview -Definition of different battery parameters - Lead Acid Battery – Nickel based batteries – Lithium based batteries - Fuel Cell - Super Capacitor - Super Flywheel based energy storage - Hybridization of different energy storage devices.

Battery charging Technologies -Methods of charging - Domestic Charging Infrastructure - Public Charging Infrastructure – Fast Charging Station - Battery Swapping Station - Move-and-charge zone - Battery Management System

Power electronics converters for EV– Control systems for EV - Sizing the drive system - Sizing the propulsion motor, sizing the power electronics - Selecting the energy storage technology - Communications - supporting subsystems

EV Charging Infrastructure - EV Charging Fundamentals - Onboard and off board charger - Electric Vehicle Supply Equipment (EVSE) Types Characteristics - EVSE Standards and Communication Protocols - Next Generation Technologies: Super Chargers

- Wireless Chargers - EVSE Management and Settlement Solutions - Effect of EV charging on generation and load profile - Smart charging technologies - EV charging facility planning - Centralized charging schemes - Decentralized charging schemes - Energy storage integration into Microgrid

CO4	Explain the EV charging system integrated with renewable energy		
M4.01	Explain the EV charging system and charging standards in practice.	4	Understanding
M4.02	Outline grid support services for EVs	4	Understanding
M4.03	Summarize the integration of Renewable Energy with Electric Vehicles	4	Understanding
M4.04	Outline Maintenance, repairing and s Troubleshooting faults in different EV components	4	Understanding
	Series Test - 2	1	

Contents:

Electric vehicle grid integration- Introduction - Impact of EV charging on distribution system (congestion, power quality issues etc.) – Smart charging - Vehicle to anything (V2X) technology (V2G, V2V, V2H, V2B etc.) - Grid up gradation for fast charging stations

Cost estimate of an EV charging station - Demand response from EVs - Voltage/reactive power support from EVs - Frequency support (inertial, primary, and secondary) from EVs - Fleet aggregation approaches for grid support services

EVs and renewable energy (RE) integration-Scheduling of EVs for increased RE generation uptake - RE based EV charging stations - Correlation between EV charging and RE integration - Coordinated operation of EVs and distributed generation - Cost comparison of RE based EV charging with other alternatives

Maintenance, repairing and services Troubleshooting faults in different EV components (Motor, drive train, battery etc.) - Repairing and rectifying faults in EV motor and components - EV battery and battery management systems - EV charging device repairing - Battery disposal & recycling

Text / Reference:

T/R	Book Title/Author
T1	Ehsani, M. et.al. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press
T2	Hand book on EV charging Infrastructure Implementation by NITI Ayog, Govt Of India
R1	NPTEL Notes on Introduction to EV & HEV
R2	Electric Vehicle trends - Electrical Installation Guide (electrical-installation.org)
R3	Electric Vehicles Integrated with Renewable Energy Sources for Sustainable Mobility
R4	Husain, I. Electric and Hybrid Electric Vehicles, CRC Press
R5	A.K. Babu, Electric & Hybrid Vehicles, Khanna Publishing House, New Delhi (Ed. 2018)
R6	Fuhs, A. E. Hybrid Vehicles and the Future of Personal Transportation, CRC Press,
R7	Gianfranco, Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure And The Market, Pistoia Consultant, Rome, Italy,
R8	Chan C. C. and K. T. Chau, Modern Electric Vehicle Technology, Oxford Science Publication,
R9	Lechner G. and H. Naunheimer, Automotive Transmissions: Fundamentals, Selection, Design and Application, Springer
R10	Rashid, M. H. Power Electronics: Circuits, Devices and Applications, 3rd edition, Pearson,
R11	Moorthi, V. R. Power Electronics: Devices, Circuits and Industrial Applications, Oxford University Press
R12	Krishnan, R. Electric motor drives: modelling, analysis, and control, Prentice Hall 11. Krause, O. P. ; C. Wasynczuk, S. D. Sudhoff, Analysis of electric machinery, IEEE Press

Online resources

Sl No	Website Link
1	https://nptel.ac.in/courses/108/103/108103009/
2	https://nptel.ac.in/courses/108/106/108106170
2	https://onlinecourses.nptel.ac.in/noc20_ee99/preview
3	https://fame2.heavyindustry.gov.in/
4	http://www.anert.gov.in/
5	https://powermin.nic.in/
6	https://www.kseb.in/
7	How does an Electric Car work? Tesla Model S https://www.youtube.com/watch?v=3SAxXUIre28
8	Tesla Model 3's motor - The Brilliant Engineering behind it https://www.youtube.com/watch?v=esUb7Zy5Oio
9	Toyota Hybrid System https://www.youtube.com/watch?v=jNuixuVhc5E
10	How Does It Work? Honda's 2 Motor Hybrid System Explained! https://www.youtube.com/watch?v=-P_VChMGK8
11	Understanding the Honda Hybrid E-Drive https://www.youtube.com/watch?v=QLUIExAnNcE
12	Electric Engine PRODUCTION - Audi e-tron MOTOR https://www.youtube.com/watch?v=uWBEPEspbWI
13	BMW Electric Drive HOW IT'S MADE - Interior BATTERY CELLS Production Assembly Line https://www.youtube.com/watch?v=xvaQMTcckSg
14	How Tesla Builds Cars So Fast https://www.youtube.com/watch?v=KqXi6EkCdpQ