

Program: <b>Diploma in Automobile Engineering / Mechanical Engineering</b>	
Course Code: <b>6051A</b>	Course Title: <b>Electric and Hybrid Vehicles</b>
Semester: <b>6</b>	Credits: <b>4</b>
Course Category: <b>Program Elective</b>	
Periods per week: <b>4 (L:4, T:0, P:0)</b>	Periods per semester: <b>60</b>

### Course Objectives:

- To understand general aspects of Electric and Hybrid Vehicles
- To understand basic design considerations of EVs.
- To select the suitable electric propulsion systems.
- To select required energy storage and charging devices.

### Course Pre-requisites:

Topic	Course code	Course name	Semester
Knowledge on basic Automobile Engineering		Basic Automobile Engineering	2
Knowledge on Automobile electrical and electronics systems		Automobile Electrical and Electronic systems	4

### Course Outcomes:

CO <sub>n</sub>	Description	Duration (Hours)	Cognitive level
CO1	Summarize the general aspects of Electric and Hybrid Vehicles	12	Understanding
CO2	Outline the basic design considerations of Electric vehicles.	16	Understanding
CO3	Identify various drive trains in Electric vehicles and Hybrid electric vehicles	14	Understanding
CO4	Select the required energy storage and charging devices for Electric and Hybrid vehicles	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		

## Course Outline

On completion of the course student will be able to:

Module Outcomes	Description	Duration (Hours)	Cognitive level
CO1	<b>Summarize the general aspects of Electric and Hybrid Vehicles (EHV)</b>		
M1.01	Explain the need for hybrid and electric vehicles	1	Understanding
M1.02	Illustrate the components and working principle of electric and hybrid electric vehicles	3	Understanding
M1.03	Summarize the different configurations of electric vehicles and hybrid vehicles	4	Understanding
M1.04	Compare petrol, diesel, hybrid and electric vehicles	2	Understanding
M1.05	Summarize the advantages and disadvantages of hybrid and electric vehicles	1	Understanding
M1.06	Outline the Government policies and schemes related to Electric vehicles	1	Understanding

### Contents:

Need for hybrid and electric vehicles, Historical background. Social and environmental importance of hybrid and electric vehicles.

Main components and working principles of electric and hybrid vehicles.

Different configurations of Electric Vehicles (EV) – 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.

Comparative study of EV and conventional vehicles, Differences between complete EV and Hybrid vehicles. Life cycle assessment of electric vehicles.

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.

<b>CO2</b>	<b>Outline the basic design considerations of Electric vehicles</b>		
M2.01	Infer the design requirements for electric vehicles	3	Understanding
M2.02	Summarize the performance of electric vehicles during acceleration, coasting, moving up and down a hill	5	Understanding
M2.03	Identify the various types of motors used in electric vehicles	3	Applying
M2.04	Explain the principle of operation and characteristics of DC motor drives, Induction motor drives, Permanent Magnet motor drives and Switched reluctance motor drives.	5	Understanding
	Series Test – I	1	
<p><b>Contents:</b>  <b>Design requirement for electric vehicles-</b> Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistances, Performance of electric vehicles- acceleration, coasting, moving up and down a hill. Tractive Effort and Transmission Requirement, Transmission efficiency, energy consumption.</p> <p><b>Motor drive Technologies:</b> Electric propulsion unit - Classification of EV Motors, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switched reluctance motor drives.</p>			
<b>CO3</b>	<b>Identify various drive trains in Electric Vehicles and Hybrid Electric Vehicles</b>		
M3.01	Outline the power electronics converters used in electric and hybrid vehicles	2	Understanding
M3.02	Explain control systems for EV	2	Understanding
M3.03	Identify various drive trains in Electric Vehicles and Hybrid Electric Vehicles	2	Applying
M3.04	Illustrate the drive train configurations in Electric vehicles and Hybrid Electric Vehicles	3	Understanding
M3.05	Illustrate regenerative braking and hybrid braking	2	Understanding
M3.06	Outline the service and maintenance of EV components	3	Understanding

**Contents:**

**Power electronics related to EV** - Rectifiers, Inverters, DC/DC converters, and Power Split devices for Hybrid Vehicles.

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

**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.

The architecture of hybrid vehicle drive train – Series hybrid, Parallel hybrid, Series-Parallel hybrid, and Complex hybrid.

Braking system in electric and Hybrid vehicles, Regenerative braking, Hybrid braking.

Maintenance, repairing, and services, Troubleshooting faults in different EV components (Motor, drive train, battery, etc.).

<b>CO4</b>	<b>Select the required energy storage and charging devices for Electric and Hybrid vehicles</b>		
M4.01	Identify the various energy storage requirements in electric and hybrid vehicles	2	Applying
M4.02	Illustrate the construction and working of various batteries used in electric and hybrid vehicles	5	Understanding
M4.03	Illustrate the basic principle of Ultra capacitors, Ultrahigh-speed Flywheel and Hybridization of energy storages,	3	Understanding
M4.04	Illustrate the operation of Fuel cells	2	Understanding
M4.05	Explain various Battery charging Technologies and Battery management systems.	4	Understanding
	Series Test – II	1	

**Contents:**

Energy storage requirements in electric and hybrid vehicles. Definition of various Battery Parameters. Different types of batteries – Lead Acid, Nickel-based, Sodium based, Lithium-based, Metal Air based. Battery charging, Quick Charging devices. Ultra-capacitors – Features and basic principle. Ultrahigh-speed flywheel-based energy storage. Hybridization of different energy Storages. Fuel Cells- basic principle and operation, Types of Fuel Cells.

Battery Management System, Battery charging technologies: Methods of battery charging – Onboard and offboard charging, Domestic charging infrastructure, Public charging infrastructure, Fast charging station, Battery swapping station,

## Text / Reference

T/R	Book Title/Author
T1	Jack Erjavec, Jeff Arias, “Hybrid, Electric and Fuel-cell Vehicles”, Cengage Learning India Pvt Ltd. New Delhi.
R1	C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
R2	S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
R3	M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
R4	T. Denton, “Electric and Hybrid Vehicles”, Routledge.
R5	Iqbal Hussein, “Electric and Hybrid Vehicles Design Fundamentals”, CRC Press
R6	A.K. Babu, Electric & Hybrid Vehicles, Khanna Publishing House, New Delhi (Ed. 2018)

## Online Resources

Sl.No	Website Link
1	<a href="https://nptel.ac.in/courses/108/103/108103009/">https://nptel.ac.in/courses/108/103/108103009/</a>
2	<a href="https://nptel.ac.in/courses/108/106/108106170">https://nptel.ac.in/courses/108/106/108106170</a>
3	<a href="https://www.youtube.com/watch?v=3E1SXG7VkQk&amp;list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr&amp;index=2">https://www.youtube.com/watch?v=3E1SXG7VkQk&amp;list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr&amp;index=2</a>
4	<a href="https://www.youtube.com/watch?v=V004WUdpHeA&amp;list=PL8qPObng38fHB4nP oBOA411ujmriiq_1E">https://www.youtube.com/watch?v=V004WUdpHeA&amp;list=PL8qPObng38fHB4nP oBOA411ujmriiq_1E</a>
5	<a href="https://www.sciencedirect.com/science/article/pii/S2095756420300647">https://www.sciencedirect.com/science/article/pii/S2095756420300647</a>
6	How does an Electric Car work?   Tesla Model S <a href="https://www.youtube.com/watch?v=3SAxXUIre28">https://www.youtube.com/watch?v=3SAxXUIre28</a>
7	Tesla Model 3's motor - The Brilliant Engineering behind it <a href="https://www.youtube.com/watch?v=esUb7Zy5Oio">https://www.youtube.com/watch?v=esUb7Zy5Oio</a>
8	Understanding the Honda Hybrid E-Drive <a href="https://www.youtube.com/watch?v=QLUIExAnNcE">https://www.youtube.com/watch?v=QLUIExAnNcE</a>
9	Toyota Hybrid System <a href="https://www.youtube.com/watch?v=jNuixuVhc5E">https://www.youtube.com/watch?v=jNuixuVhc5E</a>
10	BMW Electric Drive HOW IT'S MADE - Interior BATTERY CELLS Production Assembly Line <a href="https://www.youtube.com/watch?v=xvaQMTcckSg">https://www.youtube.com/watch?v=xvaQMTcckSg</a>