<table>
<tr><td colspan="3">Devi Ahilya Vishwavidyalaya, Indore, India
Institute of Engineering & Technology</td><td colspan="4">III Year B. Tech (Mechanical Engineering)
(Full Time)</td></tr>
<tr><td>Course Code & Name</td><td colspan="6">Instructions Hours per Semester and Credits</td></tr>
<tr><td rowspan="3">5RMPE5: Hybrid Electric Vehicle</td><td colspan="2">Classroom Instruction (CI)</td><td>Lab Instruction (LI)</td><td>Term Work (TW) and Self Learning (SL)</td><td>Total no. of Hours Per semester</td><td>Total Credits (Total Hours/30)</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>TW+SL</td><td rowspan="2">120</td><td rowspan="2">4</td></tr>
<tr><td>20</td><td>10</td><td>20</td><td>70</td></tr>
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Course Learning Objectives:

1. To understand the need for evolution and classification of Hybrid Electric Vehicles.
2. To study HEV architecture and powertrain components.
3. To understand energy storage systems and electric drives used in HEVs.
4. To analyze energy management strategies and regenerative braking.
5. To evaluate HEV performance and future technologies.

Prerequisite(s): Internal Combustion Engine, Basic Electrical Engineering, Basic Electronic Engineering

COURSE CONTENT

UNIT-I

Introduction: History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (Internal Combustion Engines (ICE) & others), Fuel Cell Electric Vehicles (EV), and Solar Powered Vehicles. Introduction to HEV, Benefits and challenges. about engines and their types.

UNIT-II

Introduction, Construction and Working of HEV: Social and environmental importance of hybrid and electric vehicles, Vehicle powertrain fundamentals ICE, motor/generator, transmission, Power electronics, Series, Parallel, Series-Parallel architectures, Power flow and operating modes Comparative analysis.

UNIT-III

Energy Storage Systems: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE).

UNIT-IV

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Introduction to various charging techniques and schematic of charging stations.

UNIT-V

Performance Evaluation and Future Trends: Performance parameters, Hybridization factor, Integration of ICE and electric propulsion, Applications, AI-assisted energy management overview, Recent developments and case studies.

Course Outcomes:

CO. No.	CO	POs
CO1	Explain fundamentals and classification of HEVs.	PO1, PO11
CO2	Analyze different HEV architectures and powertrains.	PO2, PO3
CO3	Select suitable energy storage systems and electric drives.	PO3, PO5
CO4	Analyze energy management and regenerative braking strategies.	PO2, PO4, PO7
CO5	Evaluate HEV design and emerging technologies.	PO4, PO9, PO10

Books Recommended:

[1]. James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd. 2003.
[2]. 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.
[3]. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
[4]. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

CO-PO-PSO Relationship

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2	PS O3
5RMPE5 .CO1	3	2	-	-	-	-	2	-	-	-	-	3	3	3
4RMPC3 .CO2	3	3	2	-	1	-	2	-	-	-	-	3	3	2
4RMPC3 .CO3	3	2	3	1	2	-	2	-	-	-	-	3	3	2
4RMPC3 .CO4	3	3	2	2	2	-	3	-	-	-	-	3	3	2
4RMPC3 .CO5	2	3	2	1	2	-	3	1	-	-	-	3	3	3

List of Lab/Practical Assignments:

1. To Study Electric and Hybrid Vehicles: Identification and classification of EVs and HEVs.
2. To Study Hybrid Drive-train Topologies: Series, Parallel, and Series-Parallel configurations.
3. To Simulate Hybrid Drive-train using MATLAB/Simulink or equivalent software.
4. To Study Performance Analysis of Conventional vs Hybrid Powertrains.
5. To Study Battery Characterization: Charging/discharging cycles, efficiency, and thermal behavior.
6. To Study Fuel Cell Operations and Efficiency Testing.
7. To Compare Supercapacitor and Flywheel Storage Systems: Comparative analysis.

8. To Study the different Electric Motor and ICE for HEV applications.
9. To Study Implementation of Energy Management Strategies in HEVs using simulation tools.
10. To Study Charging Techniques and Charging Station Layouts.
