Semester: V		
HYBRID ELECTRIC VEHICLES		
Course Code: 16G5B06		**CIE Marks: 100**
Credits: L:T:P: 4:0:0		**SEE Marks: 100**
Hrs: 44		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to,

1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3	Analyze various electric drives suitable for hybrid electric vehicles.
4	Discuss different energy storage technologies used for hybrid electric vehicles and their control.
5	Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

UNIT-I	
Introduction: Sustainable Transportation, A Brief History of HEVs, Why EVs Emerged and Failed, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs. **Hybridization of the Automobile:** Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).	09 Hrs
UNIT-II	
HEV Fundamentals: Introduction, Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics. **Plug-in Hybrid Electric Vehicles:** Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology. **Power Electronics in HEVs:** Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.	09 Hrs
UNIT-III	

Batteries, Ultracapacitors, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	08 Hrs
UNIT-IV	
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors. **(only functional treatment to be given)**	09Hrs
UNIT-V	
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. **Energy Management Strategies:** Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	09Hrs

Course Outcomes: After completing the course, the students will be able to	
1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles.
3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology
4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.

Reference Books:	
1.	Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2nd Edition, 2003.
2.	James Larminie, John Lowry, "Electric Vehicle Technology", Wiley publications, 1st Edition, 2003.
3.	B D McNicol, D A J Rand, "Power Sources for Electric Vehicles", Elsevier publications, 1st Edition, 1998.
4.	Seth Leitman, "Build Your Own Electric Vehicle" MC Graw Hill, 1st Edition, 2013.

In case of a course having only theory, the following minimum guidelines may be followed.

Continuous Internal Evaluation (CIE) (Theory – 100 Marks)	
Evaluation method	Marks
Quiz -1	10
Test -1	50
Quiz -2	10
Test -2	50
Quiz -3	10
Test -3	50
Assignment	10
Final evaluation, quiz 10+10+10=30 + Test 50+50+50=150 (Reduced to 60) + Assignment 10 = 100	

Semester End Evaluation Theory (100)	
Part- –A Objective type questions	**20**
Part –B There should be five questions from five units. Each question should be for maximum of 16 Marks. The **UNIT-1**, **UNIT-4** and **UNIT-5** should not have any choice. The **UNIT-2 and UNIT-3** should have an internal choice. Both the questions should be of the same complexity in terms of COs and Bloom's taxonomy level.	**80**
Total	**100**

Note: The faculty teaching the course may adapt additional methods for evaluation within the total maximum marks.

	What		**To whom**	**Frequency of conduction**	**Max Marks**	**Evidence**	**Contribution to Course Outcome**		
Direct	CIE	Quiz	Students	Three	30	Answer Scripts	80%	100%	90%
		Test		Two	60				
		Assignment		2 phases	10	Reports			

	SEE	Semester End Examination		End of every semester Consisting of Part-A and Part-B	100	Answer Scripts	20%		
Indirect	Course End Survey		Students	End of course		Questionnaire Based on COs	10%		

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**3**	**2**	**2**	**1**	**1**	**3**	**-**	**-**	**-**	**-**	**-**
CO2	**3**	**3**	**2**	**2**	**3**	**-**	**3**	**-**	**-**	**-**	**-**	**-**
CO3	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**-**	**-**	**-**	**-**	**-**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**-**	**-**	**-**	**-**	**-**

High-3: Medium-2: Low-1