GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: PG
Branch: Electrical Engineering
Course / Subject Code: ME01000201

Course / Subject Name: Electric and Hybrid Vehicles

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Basic knowledge of power electronics, electrical machines and their control.
Rationale:	The objective of this course is to provide basic understanding of the upcoming technology of electric and hybrid vehicles and to provide exposure to different aspects like sizing, design and control of drives used for hybrid and electric vehicle.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
01	Identify various configuration of Electric and hybrid vehicles	R
02	Understand the Basics of electric and hybrid vehicles, Tractive effort, vehicle performance	U
03	Estimate the size of electrical motors, batteries and power electronic converters for EV and HEV application	N
04	Evaluate energy management concepts for EV	E
05	Apply strategies for control of EV and HEV using electric motors, power electronics controllers, regeneration	A

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per RBT-Revised Bloom's Taxonomy)

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA (M)	PA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drivetrains on energy supplies, Basics of vehicle performance, Vehicle Power Plant and Transmission Characteristics, Mathematical models to describe vehicle performance	8	18
2.	Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis. Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis	6	13
3.	Introduction to electric components used in hybrid and electric vehicles, Configuration, Optimization and control of 1. DC Motor drives 2. Introduction Motor drives 3. Permanent Magnet Motor drives 4. Switch Reluctance Motor drives, DC-DC and DC-AC Converters for EV and HEV Applications	9	20
4.	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	6	13
5.	Matching the electric machine and the internal combustion engine (ICE), Design principle of HEV, Drive cycle and its detailed analysis, Sizing the propulsion motor, sizing the power electronics,	9	20
6.	Fundamentals of regenerative braking, brake System of EV and HEV, Control Systems and ECU for the EV and EHV, Energy management system and their strategies, Communications, Supporting subsystems Vehicle to grid and grid to vehicle	7	16
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**25**	**20**	**25**	**10**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Reference Books:

1. M. Ehsani, Y. Gao, S. Gay and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, CRC Press, 2005
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
3. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
4. C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, OXFORD University Press, 2001.
5. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles Principles And Applications With Practical Perspectives, Wiley Publication, 2011.
6. E. Karden, S. Ploumen, B. Fricke, T. Miller and K. Snyder, "Energy storage devices for future hybrid electric vehicles," J. Power Sources, vol. 168, no. 1, pp. 2–11, 2007
7. Michael Nikowitz, "Advanced Hybrid and Electric Vehicles: System Optimization and Vehicle Integration", Springer International Publishing, 2016.
8. James Larminie and John Lowry "Electric Vehicle Technology Explained", John Wiley and Sons, 2nd ed., 2014.
9. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018

(b) Open source software and website:

1. E-materials available at the website of NPTEL- **https://archive.nptel.ac.in/courses/108/103/108103009/**
2. MATLAB (Trial version): Software is useful for simulation and analysis of electrical systems

Suggested Course Practical List:

1. Aerodynamics, rolling resistance and tractive efforts of vehicle
2. Drive cycles & experimental techniques
3. Characterization of power, torque and efficiency for EV/HEV over drive cycle
4. Power flow in EV/HEV power train during charging, V2G feeding, motoring and braking
5. Forward & backward motoring and regenerative braking of EV/HEV consisting of multiple motor drives
6. Control methods of DC-DC and DC-AC converters for electric motors over complete drive cycle of

EV/HEV

7. Familiarization of Electric Vehicle Control Modules
8. Estimation of fuel economy
9. Batteries
10. Systems integration
11. EV and HEV modeling

List of Laboratory/Learning Resources Required:

1. MATLAB and CARSIM simulation software.
2. Micro controllers as supported by above software to perform experiment with HIL simulation in software.
3. Set of Electric motor with DC-DC controllers and DC-AC converters.
4. Other necessary instruments, kits and apparatus are to be provided for conducting the above practical.

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