GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170216
Semester – VII

Subject Name: Electric, Hybrid and Fuel cell Vehicles

Type of course:
Prerequisite: Nil

Rationale: This course goes deeper into the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc. Each topic will be developed in logical progression with up-to-date information.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
1	**Introduction:** History of electric, hybrid and fuel cell vehicles, environmental and social importance of fuel cell, electric and hybrid vehicles. **Electric Drive-trains**: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis **Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. **Fuel cell Drive-trains**: Basic concept of fuel cell vehicle, introduction to fuel cell drive-train topologies.	**06**
2	**Energy Storage:** 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, Hybridization of different energy storage devices. **Batteries:** Lead-acid battery, Nickel-based batteries, Metal/air batteries Sodium-β batteries, lithium batteries, Evaluation of batteries, Battery parameters and measurement Introduction and working of ultra-capacitor and high-speed flywheels.	**09**
3	**Electric Propulsion**: Introduction to electric motors, power electronics and control strategies used in electric propulsion, Configuration and control of DC and BLDC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of permanent magnet motor and switched reluctance motors. Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor and energy storage.	**09**

4	**Fuel cell Technology**: fuel cell characteristics, alkaline fuel cell, proton exchange membrane fuel cell, direct methanol fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, fuel cell model, hydrogen storage systems	**08**
5	**EV Auxiliaries:** Battery characteristics and chargers, battery indication and management, temperature control units, power steering units, auxiliary power supplies, regenerative braking systems	**06**
6	**Communications, supporting subsystems:** In vehicle networks- CAN, 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	**07**
	Total	**45**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**30**	**20**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011
2. C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, Oxford University Press,2001
3. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
4. Fuel Cell Handbook by EG &G Technical Services, Inc.Seventh Edition
5. Ali Emadi, Mehrdad Ehsani, John M. Muller, "Vehicular Electric Power Systems", Marcel Dekker, Inc., 2004.
6. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011
7. Hoogers, G., Edr. "Fuel Cell Technology Handbook", CRC Press, Washington D. C., 2003
8. Larminie, J. and Dicks, A., "Fuel Cell Systems Explained" John Wiley & Sons, Ltd., New York, 2001.

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Course Outcomes: Students will be able to maintain and repair vehicle with application of various hand tools, special purpose tools, power tools and service equipment. Student will able to manage and run automobile workshop or service station.

Sr. No.	CO statement	Marks % weightage
CO-1	Illustrate various Architectures related to Hybrid Drive train, electric drive train and fuel cell vehicle	10
CO-2	Choose proper energy storage systems for vehicle applications	25
CO-3	Design and choose electric propulsion for vehicle	25
CO-4	Describe different types of Fuel cells, its operation, and performance	20
CO-5	Identify various communication protocols and technologies used in vehicle networks.	20

Term Work:
The term work shall be based on the topics mentioned above.

List of Experiments:
1. Study of wiring layout of electric vehicle.
2. Study of various topologies of hybrid vehicle.
3. Study of Batteries used for electric vehicles.
4. Study of electric propulsion system.
5. Study of Battery parameters and Testing of batteries for electric vehicle.
6. Study of fuel cells and their characteristics.
7. Dismantling, Assembling and study of electric scooter.
8. **Case Studies**: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Major Equipment:
1. Multi-meter
2. Electric scooter
3. Lithium-ion battery
4. Lead acid battery
5. BLDC motor, induction motor, permanent magnet motor
6. Cut section of BLDC motor, induction motor, permanent magnet motor
7. Mechanic tool kit

List of Open-Source Software/learning website:

1. http://nptel.ac.in/
2. http://npti.in/default.aspx
3. https://www.youtube.com/