GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering Syllabus

Subject Code: 3726410

Subject Name: Hydrogen Fuel Based Vehicles

WEF Academic Year :	2023 - 24
Semester :	2
Category of the Course :	Program Elective

Prerequisite: NA
Objective:

The objective of this course is to understand the concept of Hydrogen Gas vehicles Technologies , properties of Hydrogen Gas , Fuel Cell Technologies, testing and Comparison with different fuel cell vehicles.

Teaching and Examination Scheme:

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

Sr. No.	Content	Total Hrs
1	**INTRODUCTION:** Introduction to hydrogen fuelled vehicles, hydrogen internal combustion engine vehicles, hydrogen fuel cell vehicles, advantages, limitations, future, current status.	**04**
2	**HYDROGEN:** Properties of hydrogen, energy content, hazards, global status of supply and demand, methods of hydrogen production, storage and distribution. Hydrogen for vehicles, purity of hydrogen for fuel cell vehicles, raw material for hydrogen production. Thermo-chemical cycles for hydrogen production, fundamentals for electrolysis of water.	**12**
3	**HYDROGEN FUEL-CELL VEHICLES:** Operating Principles of Fuel Cells: Electrode potential and current–voltage curve, fuel and oxidant consumption, fuel cell system characteristics, fuel cell technologies like proton exchange membrane fuel cells, alkaline fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells, direct methanol fuel cells. Hydrogen Storage: compressed hydrogen, cryogenic liquid hydrogen, metal hydrides, hydrogen production, steam reforming, auto thermal reforming. PEM Fuel Cell vehicles, components, trains, flow diagram of fuel cell vehicle working system, controls, performance of vehicles, comparison with petrol and diesel vehicles, infrastructure available and required. Current status, strategies for commercialisations, future production by automotive industries, statistics and case studies.	**16**
4.	**HYBRID ELECTRIC VEHICLES:** Hybrid electric vehicles, electric motors, auxiliary power units, generators, energy storage systems, regenerative braking, control systems.	**07**

5.	**EVALUATION OF HYDROGEN VEHICLES:** Power density and durability in fuel cell vehicles, test and evaluation of hydrogen fuel cell vehicles, comparison of hydrogen combustion engine vehicles and fuel cell vehicles.	**06**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**25**	**30**	**15**	**5**	**5**

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 the above table.

Reference Books:

1. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, CRC Press, 2018.
2. "Hydrogen Electrical Vehicles", Mehmet Sankır, Nurdan Sankir, Wiley, 2023
3. "Hydrogen Fuel Cells for Road Vehicles (Green Energy and Technology)", Pasquale Corbo, Fortunato Migliardini, Ottorino Veneri, Springer, 2011.
4. "Electric, Hybrid, and Fuel Cell Vehicles", Amgad Elgowainy, Springer, 2021.
5. "Fuel Cell Systems Explained", J Larminie, A L Dicks, 2nd Edition, Wiley, 2013.
6. "Principles of Fuel Cells", X Li, Taylor and Francis, 2005.

Course Outcomes:

S. No	CO STATEMENT	Bloom's taxonomy level	Marks % weightage
CO1	To relate the Properties of Hydrogen Gas and Fuel Cell Technology in Hydrogen Fuel-Cell Vehicles.	**Remember L1 , Understand L2**	**30%**
CO2	Analyze the different types of membranes used in Hydrogen Fuel Cell Vehicles.	**Remember L1 , Understand L2, Analyze L4, Create L6**	**30%**
CO3	To discover the Evaluation of Hydrogen Fuel Cell Vehicles.	**Remember L1 , Understand L2, Evaluate L5**	**20%**
CO4	To infer the concepts of Hybrid Electric Vehicles.	**Remember L1 , Understand L2, Evaluate L5**	**20%**

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1						1	1
CO2	3	2	2	2		1						2
CO3	3	1			1		2	1		2	1	
CO4	3	1	2	2			1					

1:Slight (Low) 2:Moderate(Medium) 3:Substantial(High) :None

Suggestive List of Experiments:

1. To study different types Hydrogen Fuel cells for vehicles.
2. To study about properties of Hydrogen Gas used in Vehicles.
3. To study different methods of hydrogen gas production.
4. To study function and working of components used in PEM Fuel cell vehicles.
5. To study working system of Fuel Cell Vehicle.
6. To study the infrastructure facility available at national and international level for hydrogen based vehicles.
7. To study evaluation of hydrogen vehicles.
8. To study about different methods of testing of fuel cell.
9. To study the control system and breaking of hybrid electric vehicles.
10. To study about different case studies of Hydrogen Fuel Cell Vehicles.

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