

GUJARAT TECHNOLOGICAL UNIVERSITY



Program Name: Diploma Engineering

Level: Diploma

Branch: Automobile Engineering

Subject Code : DI05002011

Subject Name : Automotive Green Hydrogen Vehicle

w. e. f. Academic Year:	2026-27
Semester:	5 th
Category of the Course:	PCC

Prerequisite:	---
Rationale:	This course has been structured to deliver a well-rounded and experiential learning experience in Green Hydrogen Technology, specifically aimed at Diploma Automobile Engineers. The rationale for its design is to connect traditional automotive engineering foundations with the fast-evolving landscape of hydrogen-powered transportation. As the global shift toward sustainable and zero-emission mobility gains momentum, there is an urgent need for professionals trained in emerging energy systems and cutting-edge vehicle technologies.

Course Outcome:

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

No	Course Outcomes	RBT Level
01	Explain the concept of green hydrogen and its importance in clean energy.	R & U
02	Demonstrate working of hydrogen-gasoline dual-fuel systems and fuel-switching techniques used in automotive applications.	U & A
03	Identify the components of Fuel Cell Electric Vehicles (FCEVs).	U & A
04	Apply appropriate diagnostic tools, testing procedures, and data interpretation techniques for evaluating the performance and faults in H ₂ -ICE and Fuel Cell Electric Vehicles (FCEVs).	R & U
05	Assess the safety protocols, design features, and regulatory compliance aspects of hydrogen-powered vehicles.	R & U

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				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.	Introduction to Green Hydrogen 1.1 Basics of Hydrogen, Physical and Chemical Properties of Hydrogen. 1.2 Introduction to Green Hydrogen, Application of Green Hydrogen 1.3 Comparative Analysis of Alternative Fuels (Biofuel, Alcohol, etc.) with Green Hydrogen: Advantages and Disadvantages 1.4 Hydrogen Production Technologies and Color Code Classification <ul style="list-style-type: none">• Electrolyzer systems• Different types of Electrolyzes<ul style="list-style-type: none">- Polymer Electrolyte Membrane (PEM)- Alkaline electrolysis (AE)- Solid Oxide Electrolysis (SOEC) 1.5 Critical Aspects and Challenges in the Production, Storage, Transportation, and Distribution of Green Hydrogen 1.6 Utilization of Renewable Energy (Solar, Wind, Hydro) for Automotive Green Hydrogen Generation through Electrolysis 1.7 Study of compatibility analysis of hydrogen fueled vehicle in commercial, passenger vehicle. 1.8 Types of hydrogen vehicles <ul style="list-style-type: none">• Fuel Cell Electric Vehicle Technology (FCEV)• Hydrogen-Internal Combustion Engine (H₂-ICE)• Comparison of FCEV vs H₂-ICE 1.9 Role and responsibilities of a Diploma Automobile engineer in Automotive Green Hydrogen Technology	08	16%
2.	Hydrogen-Internal Combustion Engine (H₂-ICE) 2.1 Basics of Hydrogen-Internal Combustion Engine 2.2 Properties of hydrogen relevant to combustion:	10	24%

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	<ul style="list-style-type: none">● Flammability limits● Auto ignition temperature● Flame speed● Density and energy content <p>2.3 Modification in Components of H₂-ICE</p> <ul style="list-style-type: none">● Piston● Combustion chamber● Injectors● Fuel supply system● Intake and exhaust valves <p>2.4 Hydrogen Storage & Supply System</p> <ul style="list-style-type: none">● High-pressure tanks (Type I, Type II, Type III, Type IV)● Pressure regulators● Hydrogen leak sensors <p>2.5 Pollution control methods</p> <ul style="list-style-type: none">● Exhaust Gas Recirculation (EGR)● Water injection● Lean-burn operation <p>2.6 Dual-Fuel and Hybrid Hydrogen Systems</p> <ul style="list-style-type: none">● Hydrogen-only / H₂-enriched mode● Gasoline (or CNG)-only mode● Hydrogen + gasoline/CNG dual-fuel systems● Fuel Switching: Manual vs. Automatic● Engine combustion control strategies and ECU mapping● Advantages and limitations of dual-fuel mode		
3.	<p>Fuel Cell Electric Vehicle Technology (FCEV)</p> <p>3.1 Basic of Fuel Cell Electric Vehicle Technology (FCEV) and powertrain layout of FCEV</p> <p>3.2 Components of FCEV</p> <ul style="list-style-type: none">● Fuel cell, Types of fuel cell & Comparison<ul style="list-style-type: none">- Proton Exchange Membrane Fuel Cell (PEMFC)- Solid Oxide Fuel Cell (SOFC)- Alkaline Fuel Cell (AFC)- Phosphoric Acid Fuel Cell (PAFC)● Fuel cell stack components<ul style="list-style-type: none">- Membrane Electrode Assembly (MEA)- Bipolar plates	10	24%

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	<ul style="list-style-type: none"> - Flow field channels ● Hydrogen Storage System ● Power Electronics & Energy Management <ul style="list-style-type: none"> - DC-DC boost converter - Power Control Unit (PCU) - DC-DC converters ● Battery <ul style="list-style-type: none"> - Li-ion ● Motors <ul style="list-style-type: none"> - Permanent magnet synchronous motor (PMSM) ● Air & Thermal Management Systems <ul style="list-style-type: none"> - Air processing system - Thermal management system ● Refueling & External Connections <p>3.3 Integration of a fuel cell with an electric motor and a battery</p> <p>3.4 Vehicle Performance</p> <ul style="list-style-type: none"> ● Driving modes and power delivery ● Acceleration and torque characteristics ● Regenerative braking ● Range and efficiency 		
4.	<p>Diagnosis and Testing in Hydrogen vehicle (H₂-ICE & FCEV)</p> <p>4.1 Diagnosis and Testing in H₂-ICE</p> <ul style="list-style-type: none"> ● Engine Diagnosis and Tester ● Fuel System Integrity & Consumption Testing <ul style="list-style-type: none"> - Leak Detection Methods - Fuel Flow Measurement - Injector & Rail Diagnostics ● Combustion Diagnostics & Instrumentation <ul style="list-style-type: none"> - Pressure Sensing - Knock & Misfire Detection ● Hydrogen Storage Tank Testing Methods, Testing Validity, Life of Hydrogen Storage Tanks. ● Fuel Switch Monitoring & ECU Calibration Checks <p>4.2 Diagnosis and Testing in FCEV</p> <ul style="list-style-type: none"> ● Hydrogen fuel tank testing Procedure ● Hydrogen Leak & Combustion Detection Systems 	09	20%

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	<ul style="list-style-type: none"> ● Fuel Cell Stack Characterization & Durability <ul style="list-style-type: none"> - Baseline stack testing - Accelerated Stress Tests (ASTs) - Degradation Mechanisms Study ● Electrochemical & Failure Diagnostics <ul style="list-style-type: none"> - Electrochemical Impedance Spectroscopy (EIS) - Limiting Current / Crossover Current (LSV) testing - Cathode Gas-Diffusion Layer (GDL) & Flow Field Diagnosis - Gas Contaminant Poisoning ● Hydrogen System Testing <ul style="list-style-type: none"> - Coolant & Thermal Management - Hydrogen Purity & Pressure Regulation - Fueling Valve Safety Diagnostics ● Power Electronics, Battery & Motor Diagnostics <ul style="list-style-type: none"> - DC-DC Boost & Inverter Testing - Battery diagnosis - Motor / Gearbox Diagnostics 		
5.	<p>Safety precaution in a Hydrogen Vehicle</p> <p>5.1 Safety Precaution in Operational Safety</p> <ul style="list-style-type: none"> ● Types of Safety (powered and non-powered vehicles) ● Fuelling and Defueling Protocols. ● On-board Leak Detection and Management ● High-Voltage System Safety <p>5.2 Safety Precaution (Maintenance and Repair Safety</p> <ul style="list-style-type: none"> ● Workshop and Facility Requirement (Ventilation, Hydrogen Detection Systems, Ignition Source Control) ● Pre-Maintenance Procedures (Lockout/Tagout (LOTO), Purging and Defueling, Static Electricity Control) <p>5.3 Safety Precaution in Emergency Response</p> <ul style="list-style-type: none"> ● First Responder Training ● Driver and Operator Procedures (In-vehicle Alarms, Post-accident Actions) ● Post-Incident Management <p>5.4 Safety precaution in the Storage of Hydrogen</p> <p>5.5 Crash Test of Hydrogen vehicle NCAP (UN Regulation No 134, Indian regulation ECE R134)</p> <p>5.6 Type approval in a Hydrogen vehicle</p>	08	16%
	Total	45	100

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Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
40	40	20	-	-	-

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) Books:

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Hydrogen and Fuel Cells: Emerging Technologies and Applications	Bent Sørensen	Academic Press / Elsevier publication 2018, ISBN 0081007086
2	Hydrogen Fuel: Production, Transport, and Storage	Ram B. Gupta	CRC Press 2008, ISBN 9781420045772
3	Fuel Cell Vehicles: Technologies and Development	M. R. Islam, A. A. Oni	Wiley publication, 2015 ISBN 9781119575105
4	Hydrogen-Powered Vehicles	Michael Frank Hordeski	Fairmont Press , 2015, ISBN 9780881735151
5	Automotive Fuel and Emissions Control Systems	James D. Halderman	Pearson publication, 2015, ISBN 9780132542929
6	Hydrogen and Fuel Cell: Fundamentals, Technologies and Applications	Detlef Stolten, Bernd Emonts	Wiley-VCH publication, 2010, ISBN 9783527318428
7	Hydrogen in Automotive Engineering: Principles and Applications	Ali Emadi, Mehrdad Ehsani	Springer Nature Publication
8	Fuel Cell Technology Handbook	Gregor Hoogers (Ed.)	CRC Press , ISBN 9780849308772
9	Handbook of Hydrogen Energy	S.A. Sherif, T.N. Veziroglu, E.K. Stefanakos	CRC Press Publication, 2018

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10	Alternative Fuels and Advanced Vehicle Technologies	Richard Folkson (Ed.)	Woodhead Publishing / Elsevier 9780857095220
11	Electric and Hybrid Vehicles: Technologies, Modeling and Control	Amir Khajepour, M. Saber Fallah	Wiley Publication, ISBN: 9781118341513
12	ISO 19880 Series (Hydrogen Fueling Stations)	ISO	-

(b) Open source software and website:

1. <https://nptel.ac.in>
2. <https://swayam.gov.in>
3. <https://vlab.co.in>
4. <https://hydrogeneurope.research.eu/publications-2/>
5. <https://www.hydrogen.energy.gov/>
6. <https://www.iphe.net/>
7. <https://mnre.gov.in/en/hydrogen/>
8. <https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024>
9. <https://www.irena.org/Publications/2024/Jul/Green-hydrogen-strategy-A-guide-to-design>
10. <https://www.irena.org/Publications/2024/Apr/International-co-operation-to-accelerate-green-hydrogen-deployment>
11. <https://www.irena.org/Publications/2022/May/Innovation-Trends-in-Electrolysers-for-Hydrogen-Production>

Suggested Course Practical List:

Sr. No	Practical Outcomes (PrOs)		Unit No.	Approx. Hrs. required
1	Study and Comparison of Green, Blue, and Grey Hydrogen Production Techniques.	Any one	I	04
2	Case Study: Application of Green Hydrogen in Automotive Sector.		I	04
3	Identify, locate & constructional and functional details of Hydrogen Internal Combustion engine.	Any Two	II	06
4	Perform Combustion investigation for Port fuel injection test rig using Hydrogen as fuel source.		II	04

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5	Experimental Study on Emission Parameters of Hydrogen as a Fuel in IC Engines.		II	04
6	Study of Hydrogen Storage Technologies: Compression, Liquefaction, and Solid-State Methods		II	04
7	Identify, locate & constructional and functional details of Fuel cell Electric Vehicle.	Any Two	III	04
8	Interpret safety precaution to be taken during Safety precaution to be taken in handling and maintenance of FCEV		III	04
9	Hands-On Study of Fuel Cell Components and Safety Systems in FCEVs		III	04
10	Study of Powertrain Architecture and Component Layout of a Fuel Cell Electric Vehicle (FCEV)		III	04
11	Combustion Diagnostics in Hydrogen Engines using Pressure and Knock Sensors	Any one	IV	04
12	Engine Diagnostic Testing using OBD Scanner for H ₂ -ICE Systems.		IV	04
13	Diagnostic Testing using Scanner for Fuel cell Electric Vehicle Systems.		IV	04
14	Demonstration of Safe Fuelling and Defuelling Procedures in Hydrogen Vehicles	Any one	V	04
15	Demonstration of Safety precaution in operation, handling and maintenance in Hydrogen Vehicles		V	04
	Total Hrs.	07		28

List of Laboratory/Learning Resources Required:

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Study & Comparison of Green, Blue, Grey Hydrogen Production Techniques Engine model in working condition <ul style="list-style-type: none">● Electrolysis demo unit (small-scale)● Color code charts● Multimedia or simulation software	1,2

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2	Identify Components of Hydrogen Internal Combustion Engine (H ₂ -ICE). <ul style="list-style-type: none">● H₂-ICE cut section / model● Charts showing modification	1&2
3	Combustion Investigation for Port Fuel Injection using Hydrogen. <ul style="list-style-type: none">● Port fuel injection test rig● Hydrogen gas supply with regulators● Combustion chamber rig	1,2
4	Experimental Study on Emission Parameters of Hydrogen in IC Engines. <ul style="list-style-type: none">● Emission analyzer (NO_x, CO, HC)● Exhaust gas collection unit● H₂-ICE test engine	2
5	Study of Hydrogen Storage Technologies. <ul style="list-style-type: none">● Sample tanks (Type I-IV)	2,3
6	Identify Components of Fuel Cell Electric Vehicle (FCEV) <ul style="list-style-type: none">● FCEV model / cut section● Fuel cell stack model● Training board for FCEV layout	1,3,4
7	Safety Precautions in Handling and Maintenance of FCEV. <ul style="list-style-type: none">● Safety gear (PPE kit)● Safety signage● Hydrogen leak detectors● Safety SOP charts	1,2,3,4,5
8	Combustion Diagnostics in H ₂ Engine using Pressure/Knock Sensors. <ul style="list-style-type: none">● Pressure sensors● Knock sensor setup● Data acquisition system● PC with analysis software	4,5
9	Engine Diagnostic Testing using OBD Scanner for H ₂ -ICE. <ul style="list-style-type: none">● OBD-II / CAN scanner● H₂-ICE-compatible test vehicle or simulator	4

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10	Safety Demo in Operation, Handling, Maintenance of Hydrogen Vehicles. <ul style="list-style-type: none">● Fire extinguisher (suitable for gas fire)● Earthing system demo● First-aid kit● SOP kit	1,5
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Suggested Project List:

Make a few FCEV or H ₂ -ICE components / their model using suitable material like thermocol/wood/ plastic.
Select any FCEV and H ₂ -ICE, search information on any system from website and prepare report for the same.
Collect the data of different types of Hydrogen vehicles and writes a report on it.
Observe the hydrogen vehicle on different fuel basis and identify their different parts.
Prepare methods of hydrogen production techniques and state benefits of green hydrogen.
Draw neat sketch of power train for FCEV and H ₂ -ICE.
Prepare PPT or Poster presentation on different type of hydrogen vehicle along with colour code of hydrogen.
Collect the data of different types of Advance hydrogen engines and writes a report on it.
Case study of different hydrogen vehicle and prepare a report on it.

Suggested Activities for Students: If any

Beyond classroom teaching and learning, the following co-curricular activities are recommended to enhance the achievement of learning outcomes in this course on Green Hydrogen Technology. These activities are designed to deepen students 'understanding of green hydrogen production technologies, safety practices, policy frameworks, and real-world applications.

Students are encouraged to undertake these activities individually or in groups. At least one activity from the following should be carried out.:

1. Poster-Making Activity:
Create a colourful poster explaining the hydrogen colour classification (grey, blue, green, etc.) with examples and illustrations.
2. Component Identification:

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Identify and label basic components of an electrolyzer or fuel cell system using images, charts, or physical models.

3. **Field Visit / Virtual Tour:**

Visit a renewable energy plant (solar/wind) or participate in a virtual tour of a green hydrogen production or fuel cell facility to observe technologies in action.

4. **Group Presentation on Hydrogen Process and its Applications:**

Prepare and deliver a presentation on industrial applications of green hydrogen (e.g., steel, ammonia, and mobility), highlighting current trends and potential.

5. **Case study of different Hydrogen vehicle available:**

Prepare a case study report of Automobile Vehicle available in market and do comparative analysis of them.

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