



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

w. e. f. Academic Year:	2025-26
Semester:	4 th
Category of the Course:	Professional Elective - II

Prerequisite:	Basic knowledge of physics (electricity and energy), simple chemistry concepts like electrolysis and reactions, and a general awareness of renewable energy sources.
Rationale:	Fuel cells are becoming an important technology for clean and efficient power generation. They can provide electricity for vehicles, industries, and portable devices while producing water as the main by-product, making them environmentally friendly compared to conventional fossil fuels. Studying this subject will help diploma students understand how fuel cells work, the different types available, and their applications in real life. It will also introduce hydrogen as a clean fuel and explain its importance in the future energy transition. This prepares them for opportunities in the growing field of hydrogen and fuel cell technologies, which are vital for achieving sustainable energy solutions.

Course Outcomes:

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

No	Course Outcomes	RBT Level*
01	Explain the working principle and components of different types of fuel cells.	R, U
02	Compare fuel cells with conventional batteries.	R, U
03	Describe the materials used in fuel cells and their performance characteristics.	R, U
04	Understand hydrogen production, storage, and safety considerations for fuel cells.	U
05	Apply knowledge to basic practical setups and projects on fuel cells.	U, A

**Revised Bloom's Taxonomy (RBT)*



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

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.	Unit 1: Introduction to Fuel Cell Technology <ul style="list-style-type: none"> Principle & working of a fuel cell Fuel cell components: Membrane, electrodes, bipolar plates, gas diffusion layers Types of fuel cells: AFC, PEMFC, DMFC, SOFC, MCFC, PAFC Comparison of Battery vs Fuel Cell Low- and high-temperature fuel cells Simple performance evaluation (fuel consumption vs power output) 	12	27%
2.	Unit 2: Fuel Cell Reactions and Performance <ul style="list-style-type: none"> Basics of fuel cell thermodynamics and kinetics (simplified) Electrode reactions, activation and ohmic losses (conceptual) Overvoltage, efficiency, polarization curve (basic understanding) Fuel cell system design – stack arrangement, air/fuel supply, cooling Applications of different fuel cells (transport, stationary power, portable devices) 	10	21%
3.	Unit 3: Hydrogen in Fuel Cell Technology <ul style="list-style-type: none"> Hydrogen as a fuel – physical and chemical properties (lightest element, high energy per unit mass, clean fuel). Role of hydrogen in reducing greenhouse gas emissions. Hydrogen Economy – concept, future potential, and challenges. Hydrogen production Methods: <ul style="list-style-type: none"> Electrolysis of water (basic principle, efficiency). Natural gas reforming (steam reforming, partial oxidation), Coal gasification (with CCS), 	12	27%



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

	<ul style="list-style-type: none"> ○ Renewable-based hydrogen, ● Emerging methods: photo-electrochemical, microbial hydrogen production (basic introduction). ● Hydrogen applications in: Fuel cells for EVs (cars, buses, trains), Power generation (stationary fuel cells, microgrids), Portable devices (electronics, backup systems). 		
4.	<p>Unit 4: Hydrogen Storage, Transport and Safety</p> <ul style="list-style-type: none"> ● Hydrogen Storage Technologies: <ul style="list-style-type: none"> ○ Compressed gas storage (cylinders, tanks). ○ Liquid hydrogen storage (cryogenic tanks, challenges). ○ Solid-state storage: metal hydrides, chemical hydrides, carbon nanomaterials. ● Hydrogen Transport Methods: <ul style="list-style-type: none"> ○ Pipelines, tube trailers, cryogenic tankers. ○ On-site generation vs centralized production. ○ Role of blending hydrogen with natural gas (H2NG). ● Hydrogen Infrastructure: <ul style="list-style-type: none"> ○ Hydrogen fueling stations – layout and working. ○ Storage tanks, compressors, dispensers. ○ Integration with renewable power sources. ● Safety Considerations: <ul style="list-style-type: none"> ○ Hydrogen leak detection methods. ○ Properties related to safety: flammability, diffusivity, ignition energy. ○ Ventilation and safe handling practices. ○ Standards and regulations (ISO, BIS, DOE guidelines – overview only). 	11	25%
	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
30 %	50 %	20 %	00	00	00

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



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

References/Suggested Learning Resources:

(a) Reference Books:

- 1 B. Viswanathan & M. AuliceScibioh – *Fuel Cell: Principles and Applications*, CRC Press.
- 2 Supramaniam Srinivasan – *Fuel Cells: From Fundamentals to Applications*, Springer.
- 3 Gregor Hoogers (Ed.) – *Fuel Cell Technology Handbook*, CRC Press.
- 4 Ryan O’Hayre, Suk-Won Cha, Whitney Colella & Fritz B. Prinz – *Fuel Cell Fundamentals*, Wiley.
- 5 Viktor Hacker & Shigenori Mitsushima – *Fuel Cells and Hydrogen: From Fundamentals to Applied Research*, Elsevier.
- 6 R. B. Gupta – *Hydrogen Fuel: Production, Transport and Storage*, CRC Press.
- 7 Abhijit Ray, Indrajit Mukhopadhyay & Ranjan Kumar Pati – *Electrocatalysts for Fuel Cells and Hydrogen Evolution*, Springer.

(b) Open-Source Software and Website:

Unit 1: Introduction to Fuel Cell Technology

- <https://www.energy.gov/eere/fuelcells/fuel-cell-basics>
- <https://www.fuelcellstore.com/blog-section>
- <https://chem.libretexts.org>

Unit 2: Fuel Cell Reactions and Performance

- <https://phet.colorado.edu/en/simulations/category/chemistry/electrochemistry>
- https://onlinecourses.nptel.ac.in/noc22_ch66/preview
- <https://www.openfcst.org>

Unit 3: Hydrogen in Fuel Cell Technology

- <https://h2tools.org/basics>
- <https://www.irena.org/publications>
- <https://www.nrel.gov/hydrogen/>

Unit 4: Hydrogen Storage, Transport and Safety

- <https://h2tools.org>
- <https://www.iea.org/reports/global-hydrogen-review-2023>
- <https://www.fch.europa.eu/page/hydrogen-safety>



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

Suggested Course Practical List: Each week includes one tutorial session (1 hour) and two lab sessions (2 hours each), designed such that they complement each other, means Each tutorial directly supports the upcoming four-hour (one or two) practical.

Sr. No.	Practical Outcome/Title of experiment	Unit/CO	Approx. Hours required
1	Demonstration of a simple PEM fuel cell kit – observe generation of electricity from hydrogen.	1,5	2
2	Identification of fuel cell components (membrane, electrodes, bipolar plates, gas diffusion layer).	1,3	2
3	Comparison experiment of battery vs fuel cell performance (voltage/current characteristics).	2	2
4	Measurement of fuel cell efficiency using a test kit under different loads.	3,5	2
5	Study of polarization curve (voltage vs current) of a PEM fuel cell.	3,5	2
6	Electrolysis of water to produce hydrogen and oxygen gases (small lab setup).	4,5	2
7	Study of hydrogen purity requirements for different fuel cells (using literature/case study).	3,5	2
8	Performance test of a Direct Methanol Fuel Cell (DMFC) module.	1,5	2
9	Study of Solid Oxide Fuel Cell (SOFC) components (demonstration/video-based if no kit available).	1,3	2
10	Investigation of effect of operating parameters (temperature, humidity, pressure) on fuel cell performance (simulation or experimental if kit supports).	3,5	2
11	Demonstration of hydrogen storage methods (compressed gas cylinder, metal hydride samples, or video-based).	4	2
12	Hydrogen safety drill – precautions, detection methods, and handling procedures.	4	2
13	Case study presentation: Applications of fuel cells in transportation (cars, buses, trains).	2,4	2
14	Mini-project: Solar-powered electrolysis connected to a PEM	4	2



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Renewable Energy

Subject Code: DI04064031

Subject Name: Fuel Cell Technology

	fuel cell to run a small fan/LED.		
15	Technical report preparation on hydrogen economy and future scope of fuel cells in India.	4	2
			30 Hrs
