



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Renewable Energy

Course / Subject Code : 4356403

Course / Subject Name : Fuel cell and Hydrogen Energy

w. e. f. Academic Year:	2024-2025
Semester:	5 th Semester
Category of the Course:	Elective-II

Prerequisite:	Basic knowledge of electrochemistry, thermodynamics and electrolysis
Rationale:	<p>The field of fuel cells and hydrogen energy integrates principles from chemistry, physics, materials science, and engineering. Covering the fundamental principles of electrochemistry, thermodynamics, kinetics, and materials science underlying fuel cell operation and hydrogen production/storage is crucial.</p> <p>Hydrogen is considered a crucial element in transitioning towards a low-carbon energy system. Leveraging its potential across multiple sectors and addressing technological, economic, and policy challenges, hydrogen can play a pivotal role in shaping the future energy landscape.</p>

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand fundamental concept and working principle of various fuel cells, their relative advantages / disadvantages.	U
02	Discuss the fuel cell components, materials, properties and processes its components, and characterization techniques including thermodynamics and electrochemistry.	U
03	Identify status of supply and demand, methods of hydrogen production.	U
04	Discuss safety considerations and challenges associated with hydrogen storage and transportation.	A

*Revised Bloom's Taxonomy (RBT)

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR		Theory		Tutorial / Practical		
			ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)		
3	0	2	4	70	30	25	25	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction to Fuel cell Technology Principle, working, fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, Performance evaluation of fuel cell, comparison of battery Vs fuel cell Relation of the fuel consumption versus current output. Low and high temperature fuel cells. Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage Fuel cell operating conditions: pressure, temperature, flow rates, humidity.	10	24
2.	Fuel Cell Reactions, processes and Performance. Thermodynamics and kinetics of fuel cell process Fuel cell reaction kinetics - electrode kinetics, activation kinetics Overvoltage, Tafel equation, Nernst equation, charge transfer reaction, exchange currents Electrocatalysis – design Fuel cell characterization: In-situ and Ex-situ; System and components characterization Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte Different types of fuel cells and applications	10	24
3.	Introduction to hydrogen energy technology Properties of hydrogen as fuel Hydrogen Economy Various hydrogen production methods Types of electrolyzer- proton-exchange membrane, alkaline, solid oxide, alkaline, microbial, Open circuit voltage, efficiency, and losses	9	21
4.	Hydrogen energy storage transport safety and applications Hydrogen separation and purification, Thermochemical cycles for hydrogen production, Fundamentals for electrolysis of water Components of electrolytic cell, configuration of electrolyzer stack, Different electrolyzer technologies, Photoelectrochemical hydrogen production, technical and economic comparison of different production methods and global status, Cost analysis hydrogen from fossil fuels, electrolysis of water, thermo chemical cycles	13	31



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	Transmission and infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems. Competency Standards for Emerging Hydrogen Related Activities		
	Total		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	40	30			

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:

1. Supramaniyam Srinivasan: Fuel cell: Fundamental to application.
2. Visvanathan B and M Aulice Scibioh, Fuel Cell: Principles and applications
3. Gregorhoogers- Fuel cell Technology handbook- 1st edition CRC press
4. Fuel Cells and Hydrogen: From Fundamentals to Applied Researchbooks Viktor Hacker, Shigenori Mitsushima
5. Electrocatalysts for Fuel Cells and Hydrogen Evolution Abhijit Ray, Indrajit Mukhopadhyay, Ranjan Kumar Pati · 2018.
6. Gupta R. B. (2008); Hydrogen Fuel: Production, Transport and Storage, CRC Press

(b) Open source software and website:

1. <https://www.energy.gov/eere/fuelcells/fuel-cell-basics>
2. <https://shs.hal.science/halshs-02890289/document>
3. <https://www.scirp.org/journal/paperinformation?paperid=100248>
4. https://onlinecourses.nptel.ac.in/noc22_ch66/preview

Suggested Course Practical List:

1. To develop fuel cell model
2. Determination of Fuel cell Value
3. Identify the main components of a solid-oxide fuel cell



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4. Performance Characteristics of Polymer Electrolyte Fuel Cell
5. Properties of Proton Exchange Membranes Used in Fuel Cells
6. Performance Characteristics of a Dissolved Methanol Fuel Cell
7. Borohydride Fuel Cell Performance Characteristics
8. Understanding of Solar Electrolyzer Fueled Polymer Electrolyte Membrane Fuel Cell
9. Prepare a technical report on hydrogen storage and safety considerations
10. Draw a neat sketch of hydrogen based electrical energy generation
11. Discuss different hydrogen extraction methods
12. Discuss Hydrogen Storage Capacity of Hydrogen-Containing Compounds

List of Laboratory/Learning Resources Required:

Fuel Cell Testing Equipment
Electrolysis kit for hydrogen extraction
Fuel cell efficiency testing kit
Load banks

Suggested Project List:

Prepare Chart on different types of fuel cell
Prepare chart on electrolysis process
Prepare a prototype for fuel cell
Prepare a prototype for electrolysis process

Suggested Activities for Students: If any

Virtual visit to hydrogen extraction from various technologies
Visit to hybrid vehicle manufacturing company
Visit to hydrogen filling station



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CO- PO Mapping:

Semester ____	Course Name Fuel cell and Hydrogen Energy (Course Code: 4356403)						
	POs						
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 Understand fundamental concept and working principle of various fuel cells, their relative advantages / disadvantages.	3	1			2		
CO2 Discuss the fuel cell components, materials properties and processes its components, and characterization techniques including thermodynamics and electrochemistry	3	2	3	1	2		1
CO3 Identify status of supply and demand, methods of hydrogen production.	3	1	1		1		
CO4 Discuss safety considerations and challenges associated with hydrogen storage and transportation	2	3	3	2	2	2	1
Average							

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

Any Other:
