Semester :V		
FUEL CELL TECHNOLOGY		
Course Code: 16G5B02		**CIE Marks: 100**
Credits: L:T:P:S:: 4:0:0:0		**SEE Marks: 100**
Hours: 45		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Recall the concept of fuel cells
2	Distinguish various types of fuel cells and their functionalities
3	Know the applications of fuel cells in various domains
4	Learn about the characterization of fuel cells

UNIT-I	
Introduction: Fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, EMF of the cell, Fuel Cell Reactions, fuels for cells and their properties	**09Hrs**
UNIT-II	
Fuel Cell Types: Classification of fuel cells, alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, advantages and disadvantages of each	**09Hrs**
UNIT-III	
Fuel Cell Reaction Kinetics: activation kinetics, open circuit voltage, intrinsic maximum efficiency, voltage efficiency, Faradaic efficiency, overall efficiency, over-voltages and Tafel equation	**09Hrs**
UNIT-IV	
Fuel Cell Characterization: current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques.	**09Hrs**
UNIT-V	
Applications of Fuel Cells: applications of fuel cells in various sectors, hydrogen production, storage, handling and safety issues.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the fundamentals and characteristics of fuel cells
2	Apply chemical engineering principles to distinguish fuel cells from conventional energy systems
3	Analyze the performance of fuel cells using different characterization techniques
4	Evaluate the possibility of integrating fuel cell systems with conventional energy systems

Reference Books	
1.	Viswanathan and M Aulice Scibioh, Fuel Cells – Principles and Applications, First Edition, Universities Press, 2009, ISBN – 13: 978 1420 060287
2.	James Larminie and Andrew Dicks, Fuel Cell Systems Explained, Second Edition, John Wiley & Sons, 2003, ISBN – 978 0470 848579
3.	O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, First Edition, Wiley, NY, 2006, ISBN – 978 0470 258439
4.	Bard, A. J. , L. R., Faulkner, Electrochemical Methods, First Edition, Wiley, N.Y., 2004, ISBN – 978 0471 043720

5	Basu. S, Recent Trends in Fuel Cell Science and Technology, First Edition, Springer, N.Y., 2007, ISBN – 978 0387 688152

In case of a course having only theory, the following minimum guidelines may be followed.

Continuous Internal Evaluation (CIE) (Theory – 100 Marks)	
Evaluation method	Marks
Quiz -1	10
Test -1	50
Quiz-2	10
Test -2	50
Quiz-3	10
Test-3	50
Assignment	10
Final evaluation quiz 10+10+10=30 Test 50+50+50=150 Reduced to 60, Assignment 10	

Semester End Evaluation Theory (100)	
Part- –A Objective type questions	**20**
Part –B There should be five questions from five units. Each question should be for maximum of 16 Marks. The UNIT-1, UNIT-4 and UNIT-5 should not have any choice. The UNIT-2 and UNIT-3 should have an internal choice. Both the questions should be of the same complexity in terms of COs and Bloom's taxonomy level.	**80**
Total	**100**

Note: The faculty teaching the course may adapt additional methods for evaluation within the total maximum marks.

	What		**To whom**	**Frequency of conduction**	**Max Marks**	**Evidence**	**Contribution to Course Outcome**		
Direct Assessment Methods	CIE	Quiz	Students	Three	30	Answer Scripts	80%	100%	90%
		Test		Two	60				
		Assignment		2 phases	10	Reports			
	SEE	Semester End Examination		End of every semester Consisting of Part-A and Part-B	100	Answer Scripts	20%		

Indirect	Course End Survey	Students	End of course		Questionnaire Based on COs	10%

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		-	-	-	-	2	2	-	-	-	-	-
CO2	2	2	2	1	-	2	2	-	-	-	-	2
CO3	2	2	2	2	-	2	2	-	-	-	-	2
CO4	3	3	3	3	-	3	3	-	-	-	-	3