AE-408: Fuel Cells										
L	**T**	**P**	Credit	Area		**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
3	0/1	2/0	4	DEC		15/25	25/-	20/25	40/50	-

Objectives: To familiarize the students with the concepts and analysis of fuel cells.Tofamiliarize the student about conventional and latest trends in this area.

AE-408: Fuel Cells		Contact Hours
Unit-1	Introduction and Thermodynamics : Introduction: Basic Operating Principles – Historical Highlights – Classification. Thermodynamics: Electrochemical Energy Conversion – Theoretical Efficiency – Electrochemical Energy Conversion – Factors Affecting Electrochemical Energy Conversion	**8**
Unit-2	Electrode Kinetics : Electrode Double Layer – Electrolyte Double Layer – Double Layer Models (Helmoltz Model, Gouy-Chapman Model, Stern Model, Grahame Model – Bockris, Devenathan and Muller Model, and Chemical Models)– Solid Metallic Electrode – Semiconductor Electrode – Specific Adsorption – Zero Potential	**6**
Unit-3	Alkaline Fuel Cells & Phosphoric Acid Fuel Cells: Alkaline Fuel Cells: Working Principle – Components – Modules and Stacks – Performance Characteristics (Power Density, Space Applications, Atmospheric Pressure Cells) – Limitations and R&D Challenges – System Issues – Ammonia As Fuel. Phosphoric Acid Fuel Cells: Cell Reactions – Electrodes (Stability of Catalysts, Electrode Fabrication – Fuel Cell Performance) – Stacks and Systems	**6**
Unit-4	Solid Oxide Fuel Cells & Molten Carbonate Fuel Cells: Solid Oxide Fuel Cell: Principle of Operation – Benefit sand Limitations – Cell Components (Electrolytes, Zirconia Systems, Ceria Based Electrolytes, Perovskite-Based Systems)– Cathode Materials – Anode Materials Interconnects –Fuel Reactions –Configurations and Performance (Tubular, Monolithic, Planar) – Environmental Impact –Applications. Molten Carbonate Fuel Cell: General Principle – Components(Electrolyte and Matrix, Cathode and Anode Materials) –Electrode Reactions – Life Time	**8**
Unit-5	Direct Methanol Fuel Cells & Proton Exchange Direct Methanol Fuel Cells: Operating Principle– Noble Metal Issue – Electro-Oxidation of Methanol (Catalysts, Oxygen Electro-Reduction, Electrolyte, Non-Catalytic Aspects) - Methanol Crossover – Catalyst Optimization – Vapour Feed Versus Liquid Feed Cells. Proton Exchange	**7**
Unit-6	Membrane Fuel Cells: Operating Principle(Membranes, Electrodes and Electrolysis, Optimization of Membrane and Electrode Assembly Impurities) – Technology Development (Single Cell and Stacks, Composite Plates) – Fuel Processing – Modeling Studies (Membrane, Electrode, Membrane-Electrode Assembly, Fuel Cell, Stack and System) – Technology Development and Applications	**7**
	Total	**42**

Reference Books:	
1	Viswanathan, B. and AuliceScibioh, M., Fuel Cells Principles and Applications, Universities Press (India) Pvt. Ltd., Hyderabad, 2006, ISBN:9781420060287 1420060287
2	Hoogers, G., Edr., Fuel Cell Technology Handbook, Crc Press, Washington D. C., 2003, ISBN:9780849308772

Course Outcomes

CO1	To study historical background and basics of fuel cells.
CO2	To explain electrode kinetics and models
CO3	To discuss alkaline fuel cells & phosphoric acid fuel.
CO4	To describe direct methanol fuel cells & proton exchange direct methanol fuel cells.
CO5	To implement Solid Oxide Fuel Cells & Molten Carbonate Fuel Cells
CO6	To apply membrane fuel cells: operating principle technology development and applications.

CO-PO/PSOMatrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	0	0	0	0	0	0	2	2	1	1
CO2	3	3	2	3	1	0	0	0	0	0	0	1	2	1	1
CO3	3	3	3	3	1	0	0	0	0	0	0	2	3	3	2
CO4	3	3	3	3	1	0	0	0	0	0	0	1	3	3	2
CO5	2	2	2	2	2	0	0	0	0	0	0	1	2	2	2