Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NCHD511	Electrochemical Energy Science and Engineering	3	0	0	3

Course Objective
• To provide a comprehensive knowledge of the physical basis of electrochemical phenomena and their applications to design electrochemical systems such as photovoltaic cells or batteries, the importance of engineering aspects of electrochemistry is growing to achieve optimized performance.
Learning Outcomes
Students will develop: • A comprehensive understanding of the electrochemical processes. • Ability to design/improve electrochemical energy generation/storage systems.

Unit No.	Description of Lectures	Contact Hours	Learning Outcomes
1.	**Introduction**: Electrochemistry in nature, the role of electrochemistry in the modern world, introduction to basic electrochemical terminology (current, voltage, resistance, conductivity, EMF, electrochemical series)	2	Familiarity with the importance of electrochemistry in the modern world, familiarity of basic definitions used in the electrochemistry
2.	**Interface at contacts:** Basics of interfacial electrochemistry, electrification of interfaces, electric double layer, ions in a solvent, solid-solid and solid-liquid interfaces, energy band diagram, energy band bending	5	Familiarity with the origin of electrochemical processes, basic knowledge about the interface between different materials and its physical implications.
3.	**Thermodynamics and electrodics**: Equilibrium cell potential, Nernst equilibrium equation, exchange current density, Faradic reactions, Butler-Volmer kinetics, activation overpotential, charge transfer coefficient	5	Understanding of concepts of electrochemical equilibrium and electrode kinetics. Understanding the similarity between chemical and electrochemical processes.
4.	**Ionics:** Transport of ionic species in solution, transference number, dilute solution theory, Nernst-Plank equation, concentrated solution theory, electro-neutrality, concentration overpotential, solution conductivity	5	Understanding transport processes in electrochemical systems, understanding the analogy between electric and ionic current.

5	**Current distribution:** Primary current distribution, secondary current distribution, ternary current distribution, supporting electrolyte, porous electrode theory	6	Understanding of the role of electric field, concentration field, and velocity field in electrochemical systems, identification of controlling mechanisms in the system.
6	**Applications (Energy generation systems):** P-N junction photovoltaic cells, Dye-sensitized solar cell, Fuel Cells, Bio-fuel cell, Electrolysis **Applications (Energy storage systems):** Primary and Secondary Batteries, Li-ion Battery, Lead Acid Battery, Redox Flow Batteries, Super-capacitors	12	Applying electrochemical science to energy generation systems, familiarity with modern electrochemical energy generation techniques Applying electrochemical science to energy storage systems, familiarity with modern electrochemical energy storage techniques
8	**Design aspects of electrochemical systems:** Scaling parameters, mathematical modeling and simulation, introduction to COMSOL multi-physics software	4	Applying electrochemical principles to the design of a system, familiarity with COMSOL multi-physics and its usage for the design and improvements
9	**Basics of characterization of electrochemical systems**: Cyclic voltammetry, impedance spectroscopy, chrono-techniques, galvanostatic/potentiostatic methods	3	Understanding fundamentals of characterization of electrochemical systems
	Total	42	

Textbooks:

1. John Newman and Nitash P. Balsara, Electrochemical Systems, 4th edition, Wiley, 2021
2. Allen J. Bard, Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd edition, Joh Wiley & Sons, INC

Reference Books:

1. John O'M. Bockris and Amulya K. N. Reddy, Modern Electrochemistry 1, Ionics, Kluwer Academic Publishers, 2002.
2. John O'M. Bockris, Amulya K. N. Reddy, and Maria Gamboa-Aldeco, Modern Electrochemistry 2A – Fundamentals of Electrodics, second edition, Kluwer Academic Publishers, 2000.
3. John O'M. Bockris and Amulya K. N. Reddy, Modern Electrochemistry 2B, Electrodics in Chemistry, Engineering, Biology, and Environmental Science, Kluwer Academic Publishers, 2000.