Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for Revision of a Course

1. Course Number: SEE606
2. Course title: Fundamentals of Electrochemical Energy Systems
3. Per Week Lectures: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours[0-2]: 0 (A), Credits (3*L+2*T+P+A): 9. Duration of Course: Full Semester
4. Proposing Department/IDP: SEE

   Other Departments/IDPs which may be interested in the proposed course: CHE, MSE, ME CHEM

   Other faculty members interested in teaching the proposed course: Sudarshan Narayanan, Soumyabrata Roy, Raju Gupta
5. Proposing Instructor(s): Lalit Pant
6. Course Description:

   A) Objectives: The objective of this course is to familiarize students with the basic physical processes occurring in electrochemical energy systems (e.g., fuel cells, batteries, electrolyzers), their origins, mathematical frameworks, and characterization. The course will help the students understand how different multi-physical processes interact within these systems and give rise to their characteristic performance.

   B) Contents:

	Topic	**Detailed Contents**	**No. of Lectures**
1	Introduction/ Overview	• Course overview. • Role and brief history of electrochemical energy systems	2
2	Basic Electrochemistry	• Electrochemistry & electrochemical systems. • Basics of electrochemical cell and redox reactions	2
3	Thermodynamics	• Gibbs free energy. Chemical potential, electrochemical potential, cell voltage. • Nernst equation, chemical and electrochemical equilibrium, Pourbaix diagram. Junction potential	4
4	Reaction Kinetics	• Types of reactions: Combination, formation, displacement, insertion, etc. • Homogeneous reactions, Activation energy, Arrhenius equation • Single electron reaction, activation energy shift due to potential, Butler-Volmer, Tafel • Multi-step reactions • Charge transfer at the catalyst interface, double layer • Heterogeneous reactions	8
5	Mass Transport	• Diffusion, convection, reaction-diffusion • Multi-component diffusion in concentrated solutions • Transport in porous media, effective properties • Multiphase transport • Concentration polarization	4

6	Charge transport	• Convection, diffusion, migration • Charge transfer in electrolytes • Charge transfer mechanisms in solid conductors, solutions, polymers, and ceramics • Charge distribution and double-layer properties	6
7	Electrochemical Characterization	• Two electrodes and three electrode systems. RDE, RRDE • Voltage-current characteristics, charge-discharge characteristics • Cyclic voltammetry, current interrupt/pulsing • Impedance analysis (HFR, LFR, Warburg impedance, circuit models) • Data analysis, interpretation, and presentation	8
8	Applied topics	• Understanding the performance of a sample system (e.g., fuel cell) from physics. Losses and characterization. Modeling • Corrosion in electrochemical systems	5

C) Pre-requisites, if any: None

D) Short summary for inclusion in the Courses of Study Booklet:

This course introduces the physical principles governing electrochemical energy systems such as batteries, fuel cells, and electrolyzers. Topics include electrochemical thermodynamics, reaction kinetics, mass and charge transport, electrochemical characterization techniques, and performance analysis. Students will develop the ability to quantitatively analyze electrochemical systems and understand the coupling between different phenomena that govern the overall device performance.

7. Recommended books:

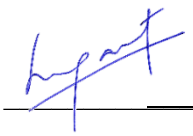
i. J. Bard and L. R. Faulkner, *Electrochemical methods: fundamentals and applications*, 2nd ed. New York: Wiley, 2001.

ii. J. Newman and K. E. Thomas-Alyea, *Electrochemical Systems*, 3rd ed. New York, USA: Wiley, 2004.

iii. R. B. Bird, W. E. Stewart, and E. N. Lightfoot, *Transport phenomena*, 2nd ed. New York, USA: Wiley, 2002.

iv. M. E. Orazem and B. Tribollet, *Electrochemical impedance spectroscopy*. In the Electrochemical Society series. Hoboken, N.J: Wiley, 2008.

v. R. O'Hayre, S. W. Cha, W. Colella, and F. B. Prinz, *Fuel Cell Fundamentals*, 3rd ed. New York, USA: Wiley, 2016.

Dated: 02/07/2026 Proposer: 

Dated:_____ DUGC/DPGC Convener:_____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:_____