Indian Institute of Technology, Kanpur
Proposal for a New Course

1. Course No: SEE-XXX

2. Course Title: Catalysis for Clean Energy

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 ~~/ Modular~~

4. Proposing Department/IDP : Sustainable Energy Engineering

Other Departments/IDPs which may be interested in the proposed course: CHM, CHE, MSE, MSP, CE, and ME

Other faculty members interested in teaching the proposed course:

5. Proposing Instructor(s): Sayan Kar

6. Course Description:

A) Objectives:

The objective of this course is to provide students with a conceptual overview of the role of catalysis in the clean energy transition. Students will be taught basic catalytic principles, their role in current energy systems, the importance of catalytic transformations in the green energy framework, and case studies on recent global developments in this area.

B) Contents (preferably in the form of 5 to 10 broad titles):

S. No	Broad Title	Topics	No. of Lectures
1	Introduction	Catalysis in the current energy framework, catalysis for energy transition, key catalytic processes, catalyst materials	2
2	Fundamentals of catalysis	Types of catalysis – homogeneous, heterogeneous, enzymatic, Surface science: adsorption desorption, Catalysis preparation and characterisation methods, Catalysis mechanism and kinetics, Catalyst deactivation and regeneration, Catalysis classifications by energy input: Thermocatalysis, Electrocatalysis, Photocatalysis, Biocatalysis, Plasma catalysis. Working principles	10

3	Catalysis for H_2 production	Steam methane reforming, water gas shift reaction, Electrochemical green H_2 production, Photochemical water splitting, Thermochemical processes for green H_2, Plasma catalysis	5
4	CO_2 utilisation and reduction catalysis	Carbon cycle, CCUS and CO_2 recycling, CO_2 reduction pathways – thermochemical hydrogenation (to syngas, methanol, ethylene), reverse water gas shift reaction, CO_2 electrolysis, Solar powered CO_2 reduction, artificial photosynthesis, Process integration and transition, Industrial scale CO_2 utilisation	6
5	Catalysis in fuel cells and batteries	Basics of fuel cells, catalysts in fuel cells, solid oxide fuel cells, hydrogen evolution, oxygen reduction and oxygen evolution reactions, direct methanol fuel cells, electrocatalysis in energy storage	5
6	Catalytic waste to energy	Waste to wealth technologies, biomass to biofuel, pyrolysis, gasification, hydrothermal methods, biocatalytic processes to biogas, bioethanol production, biodiesel, plastic to fuel, waste to green hydrogen, biomass to carbon feedstocks	6
7	Emerging topics and case studies	Metal organic frameworks, single atom catalysis, Plasma-assisted catalysis, Artificial intelligence and machine learning in catalysis, Industrial case studies (green H_2 plant, CO_2 reduction plant, biomass to energy plants)	5
Total			39

C) Pre-requisites, if any: Approval for instructor faculty

D) Short summary for including in the Courses of Study Booklet

This course will cover the importance of catalytic processes in the global energy transition from fossil-based infrastructures to a renewable framework. Catalysis plays an integral role in several clean energy generation and storage applications, including green hydrogen production, carbon dioxide recycling, waste-to-fuel conversion, batteries, and fuel cells – all of which will be covered in the course. The recent industrial shift towards decarbonization based on catalytic processes will also be covered.

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7. Recommended books:

- Introduction to catalysis and industrial catalytic processes, Robert J. Farrauto, Lucas Dorazio, C.H. Bartholomew, Wiley (2016)
- Catalysis for Renewables: From Feedstock to Energy Production, Editor(s): Prof. Gabriele Centi, Prof. Dr. Rutger A. van Santen, Wiley (2007)
- Chemical Technologies in the Energy Transition, Edited by Robin J. White; Marta Costa Figueiredo, Energy And Environment Series, RSC (2024)
- Challenges and Opportunities in Green Hydrogen Production, Editors: Paramvir Singh, Avinash Kumar Agarwal, Anupma Thakur, R. K. Sinha, Springer (2024)
- Photo- and Electro-Catalytic Processes: Water Splitting, N2 Fixing, CO_2 Reduction, Editor(s): Jianmin Ma, Wiley (2022)
- Fuel Cell Catalysis: A Surface Science Approach, Marc Koper (Editor), Andrzej Wieckowski, ISBN: 978-0-470-46374-1, Wiley (2009)
- Wealth from Waste: trends and technologies (Third Edition), Author(s): Banwari Lal and Priyangshu M Sarma, TERI Press (2015)
- Nyong, B. E. Catalysis in Renewable Energy: Theoretical Insights and Industrial Applications. Renewable and Sustainable Energy Technology 2025.

8. Any other remarks: None

Sayan Kar

Dated: 28/10/2025 Proposer: Sayan Kar

Dated:_____ DUGC/DPGC Convener:_____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:_____