EMERGING TRENDS IN CHEMICAL ENGINEERING **Course Code : 316301**

Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Sixth**
Course Title : **EMERGING TRENDS IN CHEMICAL ENGINEERING**
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I. RATIONALE

Sustainable development is now actively pursued from the local to the global level. The chemical industry is also on the threshold of a shift from the traditional chemical industry to a sustainable and digital chemical industry. India is the largest producer and even exporter of many chemical products. The current challenge for chemical industry is to manufacture the chemicals in ecofriendly, efficiently and safe manner. To achieve this, there is an urgent need to realign the policies, reduce the environmental impact, reduce waste generation, and switch from traditional to sustainable chemical industry. This requires use of advanced materials, separation techniques and incorporating principles of green chemistry, process intensification and circular economy. The recent trend and requirement is to transform the traditional chemical industry into a digital chemical industry by using artificial intelligence, IIoT-based sensors, and use of data analysis. The proposed course on emerging trends in chemical engineering is intended to provide overview about above aspects.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

After completing the course, learners will be able to create a waste reduction plan, identify process intensification opportunities, integrate green chemistry, compare materials and separation techniques, and explore industry 4.0 principles.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify ecofriendly/sustainable practices in the chemical industry.
- CO2 - Develop awareness about advanced and nanomaterials in the chemical industry.
- CO3 - Explore process intensification aspects in the chemical industry.
- CO4 - Prepare waste reduction or utilization plan for the given industry.
- CO5 - Develop awareness about digital technologies applicable to the chemical industry.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												Total Marks
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316301	EMERGING TRENDS IN CHEMICAL ENGINEERING	ETCE	DSC	4	-	-	-	4	2	1.5	30	70*#	100	40	-	-	-	-	-	-	100

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Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Identify the strategies for sustainable chemical manufacturing. TLO 1.2 List out the step in the process with more environmental impact. TLO 1.3 Analyze the atom economical process from the given reactions. TLO 1.4 State the objectives of National Green Hydrogen Mission.	**Unit - I Sustainable strategies for Chemical industry** 1.1 Necessity to shift from traditional Chemical Industry to Green Chemical industry. 1.2 Integration of ecofriendly practices in raw material processing, unit processes and unit operations and brief explanation with reference to following points: i. Waste reduction and minimization ii. Improving economy iii. Enhancing efficiency iv. Alternate pathways for ecofriendly manufacturing. 1.3 Green chemistry: Concept and 12 Principles of green chemistry, concept of atom economy and E-factor. 1.4 India's hydrogen mission and key consideration: i. National Green Hydrogen Mission(NGHM):Objectives and key targets by 2030 ii. Properties of hydrogen such as colour, odour, density, melting point, boilint point, specific heat and calorific value. iii. Types of hydrogen such as green, blue and grey hydrogen. iv. List of different hydrogen manufacturing methods. v. Key considerations related to the safety and storage of hydrogen.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 State the different types of advanced material. TLO 2.2 Classify the materials on the basis of given criteria. TLO 2.3 Explain the properties of nanomaterials. TLO 2.4 Select the suitable material for a given application.	**Unit - II Advanced Materials and Nanotechnology** 2.1 Brief overview and classification of different advanced materials such as : i. Carbon material ii. Composites iii. Nanomaterials iv. Semiconductor materials with examples. 2.2 Nanomaterials and related terminologies: Nanoscale, nanomaterial, nanofiber, nanotube, nanoparticle, nanotechnology. 2.3 Properties of nanomaterials: Physical, Chemical, Electrical and Optical. 2.4 Application of nanomaterials : i. In a catalysis ii. As an energy storage material iii. As a nanocomposite iv. In a wastewater treatment.	Lecture Using Chalk-Board Demonstration Presentations
3	TLO 3.1 Comprehend the process intensification strategies. TLO 3.2 Distinguish between characteristics of micro reactor and traditional chemical reactor. TLO 3.3 Differentiate between the traditional over advanced separation processes on the basis of novelty and effectiveness. TLO 3.4 Select relevant advanced separation process for a given application.	**Unit - III Process Intensification and Advanced Separation Processes** 3.1 Process Intensification : Concept and importance. Brief description of process intensification by microwave, cavitation (acoustic and hydrodynamic) and photocatalysis (two examples of each). 3.2 Microreactors : Concept , sketch, salient features and application. Difference between plug flow reactor and microreactor. 3.3 Advantages and applications of advanced Separation process over traditional distillation, extraction processes: i. Reactive distillation versus simple distillation e.g. Production of methyl acetate from methanol and acetic acid, Production of isopropyl acetate from isopropyl alcohol and acetic acid, and production of dimethyl ether from methanol. ii. Membrane distillation versus azeotropic distillation Air gap Membrane distillation for separation of azeotropic mixture of HCl - water) iii. Supercritical fluid extraction(SCF) versus leaching: Examples of Supercritical fluids. Applications of SCF: Decaffeination of coffee from coffee beans. Extraction of essential oils from geranium. Extraction of flavours from mint, Extraction of fat from coconut oil.	Lecture Using Chalk-Board Site/Industry Visit Case Study Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Explore the circular economy approach for a process under consideration. TLO 4.2 Prepare the waste reduction plan on the basis of 5R approach. TLO 4.3 Explain waste valorizations approach. TLO 4.4 Propose ZLD approach for given system.	**Unit - IV Circular Economy and Waste Valorization in Chemical Industry** 4.1 Concept of circular economy and industrial ecology. 4.2 Approach for integrating circular economy and waste minimization concept in chemical industries by designing process for reuse, recycle, reduce, refuse and repurpose of waste. 4.3 Valorization in chemical industry by converting waste into resource such as :BR> i. Pyrolysis of plastics and tyre. ii. Extraction of valuable chemicals from vegetable waste iii. Biomass residue for production of chemicals by valorization (e.g. 2G technology for ethanol manufacturing). 4.4 Zero liquid discharge(ZLD) System and application: Concept and basic steps in ZLD system (pretreatment - concentration-crystallization- filtration-drying). Names and function of component in ZLD system: Sedimentation tank, Membrane filter (UF/NF/RO), Evaporator (Multiple Effect Evaporator), Crystallizer, Filter, Dryer or combination of above equipment.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Cooperative Learning Site/Industry Visit
5	TLO 5.1 Analyze the transformation of chemical industry from Industry 1.0 to Industry 4.0. TLO 5.2 Explain the function of different components of chemical industry. TLO 5.3 Explain role of artificial intelligence and machine learning in chemical industry.	**Unit - V Industry 4.0 and Digital Chemical Industry** 5.1 Journey from Industry 1.0 to Industry 4.0 : Meaning of the terms and comparative difference. 5.2 Digital chemical industry: Concept and benefits to chemical industry. 5.3 Components of digital chemical industry and functions IIoT sensors Advanced control systems Cloud computing and data analysis. 5.4 Future trends in Chemical Engineering : Applications of Artificial intelligence and machine learning in the chemical industry.	Lecture Using Chalk-Board Video Demonstrations Case Study Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED : NOT APPLICABLE

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Sustainable strategies for Chemical industry	CO1	12	4	8	4	16
2	II	Advanced Materials and Nanotechnology	CO1,CO2	12	4	6	4	14
3	III	Process Intensification and Advanced Separation Processes	CO1,CO3	14	4	8	4	16
4	IV	Circular Economy and Waste Valorization in Chemical Industry	CO1,CO4	14	4	8	4	16
5	V	Industry 4.0 and Digital Chemical Industry	CO1,CO5	8	2	4	2	8

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
Grand Total				60	18	34	18	70

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two objective type class tests of 30 marks each.

Summative Assessment (Assessment of Learning)

- End semester objective type online exam.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	2	2	3		3			
CO2	2	1	1		2		3			
CO3	3	2	1		3		3			
CO4	3	3	2	2	3		3			
CO5	2	1		1	2		3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Anastas Paul	Green Chemistry: Theory and Practice	OUP UK, ISBN-13 : 978-0198506980
2	Rashmi Sanghi (Editor), Vandana Singh (Editor)	Green Chemistry for Environmental Remediation	Wiley-Scrivener; 1st edition, ISBN-13 : 978-0470943083
3	B.S.Murty , P. Shankar , Baldev Raj, B. B. Rath Murdev J	Textbook of Nanoscience and Nanotechnology	Springer-Verlag Berlin and Heidelberg GmbH & Co. K; Softcover reprint of the original 1st ed. 2013 edition (23 August 2016) ISBN : 978-3662509128
4	Gyorgy Szekely	Sustainable Process Engineering	Szekely, Gyorgy. Sustainable Process Engineering, Berlin, Boston: De Gruyter, 2024. https://doi.org/10.1515/9783111028163

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description

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Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/118102003	NPTEL course on "Nano structured materials-synthesis, properties, self assembly and applications", IIT Delhi Prof. A.K. Ganguli
2	https://archive.nptel.ac.in/courses/103/103/103103152/	NPTEL course on "Chemical Process Intensification" by Prof.S.K.Muzumdar
3	https://aiche.onlinelibrary.wiley.com/doi/epdf/10.1002/aic.16489	Venkatasubramanian, V. (2019), The promise of artificial intelligence in chemical engineering: Is it here, finally?. AIChE J., 65: 466-478. https://doi.org/10.1002/aic.16489
4	https://pubs.rsc.org/en/content/articlelanding/2021/ma/d0ma00807a	Baig N, Kammakakam I, Falath W, Kammakakam I (2021) Nanomaterials: A review of synthesis methods, properties, recent progress, and challenges. Mater Adv 2:1821–1871. https://doi.org/10.1039/d0ma00807a
5	https://www.sciencedirect.com/science/article/abs/pii/S2214785319325507	Kolahalam LA, Kasi Viswanath I V., Diwakar BS, et al (2019) Review on nanomaterials: Synthesis and applications. Mater Today Proc 18:2182–2190. https://doi.org/10.1016/j.matpr.2019.07.371
6	https://www.wjpps.com/Wjpps_controller/abstract_id/22237	Pardhi S, More S, et al (2025) ATOM ECONOMY?: PIONEERING SUSTAINABLE PRACTICES IN. 14:960–974. https://doi.org/10.20959/wjpps20251-28928
7	https://www.mdpi.com/2071-1050/17/1/335	Cansado IP da P, Mourão PAM, Castanheiro JE, et al (2025) A Review of the Biomass Valorization Hierarchy. Sustain 17:1–29. https://doi.org/10.3390/su17010335
8	https://bombaytechnologist.in/index.php/bombaytechnologist/article/download/173197/117166	Thakur S, Deo A, Dhawale M (2024) Novel Separation Processes and Their Applications. Bombay Technol. https://doi.org/10.36664/bt/2023/v70i1/173197
9	https://www.researchgate.net/publication/263327729_Review_of_Green_Chemical_Technologies_for_Sustainable_Developments_in_Chemical_Process_Industries	Kiran D. Patil (2014) Review of Green Chemical Technologies for Sustainable Developments in Chemical Process Industries . J Curr Trends Chem Eng 2
10	https://www.sciencedirect.com/science/article/pii/S2095809917304198	Chen JF (2017) Green Chemical Engineering. Engineering 3:283–284. https://doi.org/10.1016/J.ENG.2017.03.025

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students