

**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****Course Code : 316301****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   | Min         | Max   | Min |             | Max | Min | Max |
| 316301      | EMERGING TRENDS IN CHEMICAL ENGINEERING | ETCE | DSC               | 4                         | -   | - | - | 4   | 2 | 1.5     | 30                | 70*#   | 100 | 40 | -     | -                | -     | - | -     | -           | 100   |     |             |     |     |     |

**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.

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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.<br>TLO 1.2 List out the step in the process with more environmental impact.<br>TLO 1.3 Analyze the atom economical process from the given reactions.<br>TLO 1.4 State the objectives of National Green Hydrogen Mission. | <b>Unit - I Sustainable strategies for Chemical industry</b><br>1.1 Necessity to shift from traditional Chemical Industry to Green Chemical industry.<br>1.2 Integration of ecofriendly practices in raw material processing, unit processes and unit operations and brief explanation with reference to following points:<br>i. Waste reduction and minimization<br>ii. Improving economy<br>iii. Enhancing efficiency<br>iv. Alternate pathways for ecofriendly manufacturing.<br>1.3 Green chemistry: Concept and 12 Principles of green chemistry, concept of atom economy and E-factor.<br>1.4 India's hydrogen mission and key consideration:<br>i. National Green Hydrogen Mission(NGHM):Objectives and key targets by 2030<br>ii. Properties of hydrogen such as colour, odour, density, melting point, boilint point, specific heat and calorific value.<br>iii. Types of hydrogen such as green, blue and grey hydrogen.<br>iv. List of different hydrogen manufacturing methods.<br>v. Key considerations related to the safety and storage of hydrogen. | Lecture Using Chalk-Board<br>Presentations<br>Video<br>Demonstrations<br>Site/Industry Visit |
| 2     | TLO 2.1 State the different types of advanced material.<br>TLO 2.2 Classify the materials on the basis of given criteria.<br>TLO 2.3 Explain the properties of nanomaterials.<br>TLO 2.4 Select the suitable material for a given application.                                                   | <b>Unit - II Advanced Materials and Nanotechnology</b><br>2.1 Brief overview and classification of different advanced materials such as :<br>i. Carbon material<br>ii. Composites<br>iii. Nanomaterials<br>iv. Semiconductor materials with examples.<br>2.2 Nanomaterials and related terminologies: Nanoscale, nanomaterial, nanofiber, nanotube, nanoparticle, nanotechnology.<br>2.3 Properties of nanomaterials: Physical, Chemical, Electrical and Optical.<br>2.4 Application of nanomaterials :<br>i. In a catalysis<br>ii. As an energy storage material<br>iii. As a nanocomposite<br>iv. In a wastewater treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                      | Lecture Using Chalk-Board<br>Demonstration<br>Presentations                                  |
| 3     | TLO 3.1 Comprehend the process intensification strategies.<br>TLO 3.2 Distinguish between characteristics of micro reactor and traditional chemical reactor.                                                                                                                                     | <b>Unit - III Process Intensification and Advanced Separation Processes</b><br>3.1 Process Intensification : Concept and importance. Brief description of process intensification by microwave, cavitation (acoustic and hydrodynamic) and photocatalysis (two examples of each).<br>3.2 Microreactors : Concept , sketch, salient features and application.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Lecture Using Chalk-Board<br>Site/Industry Visit<br>Case Study<br>Presentations              |

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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.                                                                                           |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
|       | TLO 3.3 Differentiate between the traditional over advanced separation processes on the basis of novelty and effectiveness.<br>TLO 3.4 Select relevant advanced separation process for a given application.                                                            | Difference between plug flow reactor and microreactor.<br>3.3 Advantages and applications of advanced Separation process over traditional distillation, extraction processes:<br>i. Reactive distillation versus simple distillation<br>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.<br>ii. Membrane distillation versus azeotropic distillation<br>Air gap Membrane distillation for separation of azeotropic mixture of HCl - water)<br>iii. Supercritical fluid extraction(SCF) versus leaching:<br>Examples of Supercritical fluids.<br>Applications of SCF:<br>Decaffeination of coffee from coffee beans.<br>Extraction of essential oils from geranium.<br>Extraction of flavours from mint, Extraction of fat from coconut oil.                                                                                                                                      |                                                                                                                          |
| 4     | TLO 4.1 Explore the circular economy approach for a process under consideration.<br>TLO 4.2 Prepare the waste reduction plan on the basis of 5R approach.<br>TLO 4.3 Explain waste valorizations approach.<br>TLO 4.4 Propose ZLD approach for given system.           | <b>Unit - IV Circular Economy and Waste Valorization in Chemical Industry</b><br>4.1 Concept of circular economy and industrial ecology.<br>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.<br>4.3 Valorization in chemical industry by converting waste into resource such as :BR> i. Pyrolysis of plastics and tyre.<br>ii. Extraction of valuable chemicals from vegetable waste<br>iii. Biomass residue for production of chemicals by valorization (e.g. 2G technology for ethanol manufacturing).<br>4.4 Zero liquid discharge(ZLD) System and application:<br>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<br>Video<br>Demonstrations<br>Flipped Classroom<br>Cooperative Learning<br>Site/Industry Visit |
| 5     | TLO 5.1 Analyze the transformation of chemical industry from Industry 1.0 to Industry 4.0.<br>TLO 5.2 Explain the function of different components of chemical industry.<br>TLO 5.3 Explain role of artificial intelligence and machine learning in chemical industry. | <b>Unit - V Industry 4.0 and Digital Chemical Industry</b><br>5.1 Journey from Industry 1.0 to Industry 4.0 : Meaning of the terms and comparative difference.<br>5.2 Digital chemical industry: Concept and benefits to chemical industry.<br>5.3 Components of digital chemical industry and functions<br>IIoT sensors Advanced control systems Cloud computing and data analysis.<br>5.4 Future trends in Chemical Engineering : Applications of Artificial intelligence and machine learning in the chemical industry.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Lecture Using Chalk-Board<br>Video<br>Demonstrations<br>Case Study<br>Presentations                                      |

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

**VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING /**

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| 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           |
| <b>Grand Total</b> |      |                                                              |             | <b>60</b>      | <b>18</b> | <b>34</b> | <b>18</b> | <b>70</b>   |

**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 |



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| Sr.No | Author                                                   | Title                                         | Publisher with ISBN Number                                                                                                                        |
|-------|----------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 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                                                                                                                                                                                              |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | <a href="https://nptel.ac.in/courses/118102003">https://nptel.ac.in/courses/118102003</a>                                                                                                                                                                                                                               | NPTEL course on "Nano structured materials-synthesis, properties, self assembly and applications", IIT Delhi Prof. A.K. Ganguli                                                                          |
| 2     | <a href="https://archive.nptel.ac.in/courses/103/103/103103152/">https://archive.nptel.ac.in/courses/103/103/103103152/</a>                                                                                                                                                                                             | NPTEL course on "Chemical Process Intensification" by Prof.S.K.Muzumdar                                                                                                                                  |
| 3     | <a href="https://aiche.onlinelibrary.wiley.com/doi/epdf/10.1002/aic.16489">https://aiche.onlinelibrary.wiley.com/doi/epdf/10.1002/aic.16489</a>                                                                                                                                                                         | 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     | <a href="https://pubs.rsc.org/en/content/articlelanding/2021/ma/d0ma00807a">https://pubs.rsc.org/en/content/articlelanding/2021/ma/d0ma00807a</a>                                                                                                                                                                       | 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     | <a href="https://www.sciencedirect.com/science/article/abs/pii/S2214785319325507">https://www.sciencedirect.com/science/article/abs/pii/S2214785319325507</a>                                                                                                                                                           | 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     | <a href="https://www.wjpps.com/Wjpps_controller/abstract_id/22237">https://www.wjpps.com/Wjpps_controller/abstract_id/22237</a>                                                                                                                                                                                         | Pardhi S, More S, et al (2025) ATOM ECONOMY?: PIONEERING SUSTAINABLE PRACTICES IN. 14:960–974. https://doi.org/10.20959/wjpps20251-28928                                                                 |
| 7     | <a href="https://www.mdpi.com/2071-1050/17/1/335">https://www.mdpi.com/2071-1050/17/1/335</a>                                                                                                                                                                                                                           | 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     | <a href="https://bombaytechnologist.in/index.php/bombaytechnologist/article/download/173197/117166">https://bombaytechnologist.in/index.php/bombaytechnologist/article/download/173197/117166</a>                                                                                                                       | 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     | <a href="https://www.researchgate.net/publication/263327729_Review_of_Green_Chemical_Technologies_for_Sustainable_Developments_in_Chemical_Process_Industries">https://www.researchgate.net/publication/263327729_Review_of_Green_Chemical_Technologies_for_Sustainable_Developments_in_Chemical_Process_Industries</a> | Kiran D. Patil (2014) Review of Green Chemical Technologies for Sustainable Developments in                                                                                                              |

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| <b>Sr.No</b>                                                                                                                                                                                                                     | <b>Link / Portal</b>                                                                                                                                  | <b>Description</b>                                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                  |                                                                                                                                                       | Chemical Process Industries . J Curr Trends Chem Eng 2                                                                                                              |
| 10                                                                                                                                                                                                                               | <a href="https://www.sciencedirect.com/science/article/pii/S2095809917304198">https://www.sciencedirect.com/science/article/pii/S2095809917304198</a> | Chen JF (2017) Green Chemical Engineering. Engineering 3:283–284. <a href="https://doi.org/10.1016/J.ENG.2017.03.025">https://doi.org/10.1016/J.ENG.2017.03.025</a> |
| <b>Note :</b> <ul style="list-style-type: none"><li>Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students</li></ul> |                                                                                                                                                       |                                                                                                                                                                     |

**MSBTE Approval Dt. 04/09/2025****Semester - 6, K Scheme**