# Shivaji University

## Vidyanagar, Kolhapur-416004, Maharashtra

## Department of Technology

**As per NEP2020 guidelines**

**Third Year B. Tech. (Chemical Engineering), Detailed Curriculum, w.e.f 2025-26**

# Shivaji University, Kolhapur
## Department of Technology

### Third Year B. Tech (Chemical Engineering), Semester- V

**Teaching and Evaluation Scheme**

| Sr. No. | Category | Course Code | Course Title | Hours per week | | | Contact Hours | Credits | Evaluation Scheme | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Theory | Practical |
| | | | | L | T | P | | | ISE:ESE | IE:EE |
| 1. | Engineering Science Course | ESC311 | Thermal Engineering &Plant Utilities | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 2. | Professional Core Course | PCC311 | Mass Transfer Operations-I | 03 | - | 02 | 05 | 04 | 30:70 | 00:50 |
| 3. | Professional Core Course | PCC312 | Chemical Reaction Engineering | 03 | 01 | 02 | 06 | 05 | 30:70 | 50:50 |
| 4. | Professional Core Course | PCC313 | Organic Chemical Technologies | 03 | - | 02 | 05 | 04 | 30:70 | 50:50 |
| 5. | Humanities and Social Sciences, Management Environmental Course | HSMEC 311 | Safety in Chemical Industry | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 6. | MDM Course | MDM311 | Multidisciplinary Minor Course II | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 7. | Ability Enhancement Course | AEC311 | Introduction to Foreign Language | 01 | - | - | 01 | 01 | - | 50:00 |
| | | | | **-** | **-** | **-** | **-** | **23** | **600** | **300** |
| 8. | Mandatory Audit Course | MAC311 | Aptitude Enhancement Course II | - | 01 | - | 01 | IE at Course-in-charge end | | |
| 9. | Project Based Learning | PBL311 | Mini Project III & Industrial Visit | - | - | 02 | 02 | IE at Course-in-charge end | | |
| | | | **Total Hours** | **19** | **02** | **08** | **29** | **-** | **-** | **-** |

*Note: The MDM course will be from the chosen Multidisciplinary Minor Title

# Shivaji University, Kolhapur
## Department of Technology

### Third Year B. Tech (Chemical Engineering), Semester- VI

**Teaching and Evaluation Scheme**

| Sr. No. | Category | Code | Course Title | Hours per week | | | Contact Hours | Credits | Evaluation Scheme | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Theory | Practical |
| | | | | L | T | P | | | ISE:ESE | IE:EE |
| 1. | Engineering Science Course | ESC321 | Process Instrumentation & Control | 03 | - | 02 | 05 | 04 | 30:70 | 50:00 |
| 2. | Professional Core Course | PCC321 | Mass Transfer Operations-II | 03 | - | 02 | 05 | 04 | 30:70 | 50:50 |
| 3. | Professional Core Course | PCC322 | Chemical Equipment & Plant Design | 03 | - | 02 | 05 | 04 | 30:70 | 50:00 |
| 4. | Professional Elective Course | PEC321 | Elective I | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 5. | Open Elective Course | OEC321 | Open Elective–I | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 6. | MDM Course | MDM321 | Multidisciplinary Minor Course III* | 03 | - | - | 03 | 03 | 30:70 | 00:00 |
| 7. | Humanities and Social Sciences , Management, Environmental Course | HSMEC321 | Industrial Safety, Health & Hazard Management | - | 01 | - | 01 | 01 | - | 50:00 |
| 8. | Ability Enhancement Course | AEC321 | Mini Project IV& Industrial Visit | - | - | 02 | 02 | 01 | - | 50:00 |
| | | | | **-** | **-** | **-** | **-** | **23** | **600** | **300** |
| 9. | Vocational & Skill Enhancement Course | VSEC321 | Design Thinking & Innovation–III | 01 | - | - | 01 | IE at Course-in-charge end | | |
| 10. | Mandatory Audit Course | MAC321 | Aptitude Enhancement Course III | - | 01 | - | 01 | IE at Course-in-charge end | | |
| | | | **Total Hours** | **19** | **02** | **08** | **29** | **-** | **-** | **-** |

*Note: The MDM course will be from the chosen Multidisciplinary Minor Title.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech.(Chemical Engineering), Part III, Semester V | | | | | | |
| Course Code | ESC311 | | | | | | |
| Course Category | Engineering Science Course | | | | | | |
| Course title | **Thermal Engineering and Plant Utilities** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | | **Total Credits** | |
| | 03 | - | - | 03 | | 03 | |
| Evaluation Scheme | **ISE** | **ESE** | | **IOE** | **IPE** | **EOE** | **EPE** | 
| | 30 | 70 | | - | - | - | - |
| Pre-requisites (if any) | BSC 221, PCC 221, PCC 224 | | | | | | |
| Course Rationale | The course is integral to the understanding of the energy needs, utility management, and process engineering in chemical industries. This course bridges the gap between fundamental thermodynamic principles and their practical applications in plant operations. It enables students to optimize energy usage, enhance operational efficiency, and minimize environmental impacts while addressing industrial challenges. | | | | | | |
| Course Objectives | The course teacher will ensure to:<br>1. Explain thermal engineering principles for chemical process industries.<br>2. Illustrate the design, operation, and maintenance of industrial utilities.<br>3. Analyze energy efficiency techniques in thermal systems.<br>4. Describe the roles of steam, boilers, and utility systems.<br>5. Explore sustainable practices in utility management.<br>6. Demonstrate the integration of thermal systems in chemical industries. | | | | | | |
| Course Outcomes | After completing the course, students will be able to:<br>1. Describe heat transfer processes in industrial utilities.<br>2. Analyze boiler operations and suggest efficiency improvements.<br>3. Evaluate refrigeration and air-conditioning system performance.<br>4. Compare types of pumps and compressors for specific applications.<br>5. Apply safety measures to inerting and utility systems.<br>6. Recommend sustainable practices for thermal utilities. | | | | | | |

Evaluation Scheme detail:

| ISE | ESE | IOE | IPE | EOE | EPE | Total |
|---|---|---|---|---|---|---|
| 30 | 70 | - | - | - | - | 100 |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | - | - | - | - | - | - | - |
| CO2 | 3 | 3 | 2 | 2 | - | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 3 | 2 | 2 | - | - | - | - | - | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 2 | 2 | - | 3 | 2 | 2 | 3 | - | - | - | - | 2 |
| CO5 | 3 | - | - | 2 | - | 3 | | 3 | | | | |
| CO6 | 2 | - | - | - | - | 2 | 3 | - | - | - | - | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I | **Introduction to Thermal Utilities and Systems:** Thermal Systems in Process Plants: Overview of thermal systems and their roles in process industries, Utility Systems Overview: Introduction to plant utilities including steam, cooling water, compressed air, and refrigeration systems, Energy Transfer in Utilities: Fundamental energy transfer concepts specific to utility operations, Industrial Applications: Examples of thermal utilities in chemical and petrochemical plants, Energy Efficiency Basics: Importance of energy efficiency in utility systems and its impact on operational costs. | **06** |
| II | **Steam Generation and Utility Integration:** Industrial Boilers: Types and selection criteria based on plant requirements, Steam Quality and Distribution: Ensuring steam quality, steam traps, and piping systems for efficient distribution, Condensate Management: Recovery and reuse of condensate to improve efficiency, Utility Integration: Integrating steam systems with other utilities like refrigeration and compressed air, Industrial Standards: Adhering to standards and codes for safe and efficient steam system operation. | **08** |
| III | **Compressors and Air Conditioning Systems:** Compressor Selection and Perform--ance: Criteria for selecting compressors for different industrial needs, efficiency calculations, Compressed Air Systems: Design and operation of centralized compressed air systems, energy-efficient practices, Air Conditioning in Process Plants: Psychrometric analysis, humidity control, and its importance in sensitive industries, Industrial Applications: Examples of air compression and conditioning in pharmaceuticals, food, and chemical industries. | **07** |
| IV | **Cooling Towers and Heat Exchangers:** Cooling Towers in Utilities: Role and types of cooling towers, performance parameters, and design considerations, Heat Exchangers in Utilities: Types of heat exchangers used for utilities, their operational principles, and maintenance practices, Water Quality Management: Ensuring water quality for cooling and heat transfer, fouling prevention techniques, Energy Recovery Systems: Incorporating waste heat recovery in cooling and heating systems for enhanced sustainability. | **07** |
| V | **Process Utilities and Energy Management:** Utility Systems Overview: Focused study on water, vacuum, compressed air, and inert gas utilities, Industrial Inert Gases: Types, properties, and their applications in chemical processes and safety considerations, Energy Audit Techniques: Tools and methods for auditing utility systems, Optimization Practices: Strategies for optimizing utility consumption and reducing energy costs, Renewable Energy Integration: Use of solar and wind energy in utility systems, case studies. | **07** |
| VI | **Industrial Inert Gases and Advanced Utility Systems:** Industrial Inert Gases: Applications in inerting, blanketing, and purging; storage and handling requirements, Cryogenic Systems: Overview of cryogenic utility systems for gas | **07** |

| | | |
|---|---|---|
| | storage and transport, Advanced Heat Recovery Systems: Integration of advanced heat recovery technologies into utility operations, Utility Automation: Smart systems for real-time monitoring and control of utilities, Global Practices: Case studies on innovative industrial utility systems worldwide. | |
| **Text Books** | | |
| 1. | Smith, J. M., Van Ness, H. C., Abbott, M. M., & Swihart, M. T. (2018). Introduction to Chemical Engineering Thermodynamics (8th ed.). McGraw-Hill Education. | |
| 2. | Towler, G., & Sinnott, R. K. (2013). Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design (2nd ed.). Butterworth-Heinemann. | |
| **Reference Books** | | |
| 1. | Kemp, I. C. (2007). Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy (2nd ed.). Butterworth-Heinemann. | |
| 2. | Perry, R. H., & Green, D. W. (2007). Perry's Chemical Engineers' Handbook (8th ed.). McGraw-Hill Professional. | |
| 3. | Coulson, J. M., & Richardson, J. F. (2005). Chemical Engineering Volume 6 - Chemical Engineering Design (4th ed.). Butterworth-Heinemann. | |
| 4. | Linnhoff, B., Townsend, D. W., Boland, D., Hewitt, G. F., Thomas, B. E. A., Guy, A. R., & Marsland, R. H. (1982). A User Guide on Process Integration for the Efficient Use of Energy. IChemE. | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech. (Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC311</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mass Transfer Operations-I (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC 221, PCC 221, PCC 224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course introduces the core principles and mechanisms of mass transfer operations essential in separation processes. It prepares students to analyse and design mass transfer equipment across industries such as petrochemicals, pharmaceuticals, and environmental engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will ensure to:<br>1. Introduce core principles and laws governing mass transfer.<br>2. Explain interphase mass transfer and associated mechanisms.<br>3. Teach distillation analysis and column design methods.<br>4. Cover equilibrium, solvent selection, and extractor design for liquid-liquid extraction.<br>5. Explain solid-liquid extraction and leaching equipment.<br>6. Demonstrate principles and design methods in gas absorption.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion, students will be able to:<br>1. Define and relate flux, resistance, driving force, and equilibrium.<br>2. Apply mass transfer coefficients to diffusion in solids and gases.<br>3. Design distillation columns using McCabe-Thiele and Ponchon-Savarit methods.<br>4. Analyse ternary systems and design extractors for liquid-liquid extraction.<br>5. Perform material balances and design leaching equipment.<br>6. Apply NTU, HTU, HETP concepts and design packed towers for absorption.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | – | – | – | – | – | – | – | – | – | 2 |
| CO2 | 3 | 3 | – | 2 | – | – | – | – | – | – | – | 2 |
| CO3 | 3 | 3 | 3 | 2 | – | – | – | – | – | – | – | 2 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 3 | 3 | 2 | – | – | 1 | – | – | – | – | 2 |
| CO5 | 3 | 2 | 2 | 2 | – | – | 1 | – | – | – | – | 2 |
| CO6 | 3 | 3 | 3 | 2 | – | – | 2 | – | – | – | – | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I | **Introduction to Mass Transfer:** Definition, classification, and significance of mass transfer operations based on gas-liquid-solid contacts. Concepts of flux, resistance, driving force, equilibrium, direction of mass transfer, Dimensionless numbers in mass transfer. Diffusion, Fick's I$^{st}$ and II$^{nd}$ law, Dependence of diffusivity on physical properties, Schmidt's number calculation, Determination of diffusivity in liquid-liquid, gas-gas, gas-liquid diffusion | **07** |
| II | **Interphase mass transfer:** Various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Multi component mixture diffusion, Maxwell's law of diffusion. Diffusion in solids, Unsteady state diffusion, Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory, Applications and problems. Application of mass transfer processes | **07** |
| III | **Distillation Operation:** Introduction to distillation operation, Vapor- Liquid Equilibrium, Raoult's Law and Dalton's law, partial vaporisation and partial condensation, relative volatility, differential distillation & flash distillation, steam distillation, Lewis Sorel and McCabe–Thiele methods & numerical, Ponchon-Savarit method, Underwood and Fenske equations, total reflux, minimum and optimum reflux ratios, multiple feeds and side streams, Azeotropic and Extractive distillation. Transfer unit Concept in Packed Column Design, | **07** |
| IV | **Liquid–liquid extraction:** Liquid-Liquid equilibria; Ternary phase diagrams & choice of solvent, Extraction equipment; Stage-wise contact; cross and counter current operation and its calculation, Design of stage type extractors and differential (continuous contact) extractors for immiscible and miscible solvents, related numerical problems, continuous contact extractors. | **06** |
| V | **Leaching:** Leaching Principles, Various Types of Leaching Operations with application, Method of Calculations, leaching single and multistage operations based on solvent free coordinates, Leaching equipment. | **06** |
| VI | **Absorption:** Introduction to absorption operation, Choice of solvent, Material balance on cross current and counter current absorption or stripping, Absorption factor and stripping factor, Tray efficiency, design equation for packed tower, HETP, NTU, HTU calculation for packed tower. | **06** |
| **Text Books** | | |
| 1. | R. E. Treybal, 1981, Mass Transfer Operations, 3rd Ed., McGraw -Hill International Edition. | |
| 2. | B.K. Dutta, 2--7, Principles of Mass Transfer and Separation Processes, 1st Ed., Prentice Hall of India. | |
| 3. | McCabe W.L, Smith J.C., Harriott P., 2--1 & 2--5, Unit Operations in Chemical Engineering, | |

| | |
|---|---|
| | 6th&7th Eds., McGraw-Hill, New York. |
| 4. | Coulson J.M., Richardson J.F., Backhurst J. R., Harker J.H., 2--4, Coulson & Richardson's Chemical Engineering, Vol. 1, 6th Ed., Elsevier, New Delhi. |
| **Reference Books** | |
| 1. | R. H. Perry, D. W. Green, 2007, Perry's chemical Engineer's Handbook, McGraw Hill, New York. |
| 2. | C. J. Geankoplis, 1993, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, |
| 3. | Ernest J. Henley, J. D. Seader, D. Keith Roper, 2011, Separation Process Principles, 3rd Edition, Wiley. |
| **Useful web links** | |
| 1. | https://nptel.ac.in/courses/1-3/1-4/1-31-4-46/ |
| 2. | https://archive.nptel.ac.in/courses/1-3/1-3/1-31-3154/ |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech (Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC311</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mass Transfer Operations-I (Laboratory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="2">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>50</td><td>50</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC211, PCC 222, BSC212, BSC221, PCC221, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This laboratory course imparts hands-on experience with key mass transfer operations such as diffusion, distillation, extraction, and leaching. It bridges theoretical knowledge with industrial practice, preparing students to design, evaluate, and optimize separation processes.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will:<br>1. Guide students in measuring diffusion, equilibrium, and distribution coefficients.<br>2. Demonstrate practical distillation, extraction, and leaching techniques.<br>3. Develop skills in plotting equilibrium curves and evaluating mass transfer stages.<br>4. Train students to interpret data and assess lab-scale mass transfer equipment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to:<br>1. Analyze diffusion, equilibrium, and distribution coefficients from experimental data.<br>2. Evaluate the stage efficiency of separation processes like distillation and extraction.<br>3. Use equilibrium data to optimize separation operations.<br>4. Correlate experimental findings with theoretical concepts in mass transfer.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | 2 | - | - | - | - | - | 2 | - | - |
| CO2 | 2 | 2 | 3 | 2 | - | - | - | - | - | - | - | - |
| CO3 | 2 | 2 | 2 | 2 | - | - | - | - | - | 1 | - | - |
| CO4 | 3 | 3 | 2 | 2 | - | - | - | - | - | 2 | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No. | List of Experiments | Hours |
|---|---|---|
| **1.** | Calculation the Diffusion Coefficient for a liquid –liquid system. | **02** |
| **2.** | Construction of the vapor-liquid equilibrium curve. | **02** |
| **3.** | Verification of Rayleigh equation for simple distillation. | **02** |
| **4.** | Analysis of the performance of laboratory scale sieve plate to obtain a desired separation of alcohol waste stream feed product. | **02** |
| **5.** | Determine distribution coefficient for liquid-liquid extraction. | **02** |
| **6.** | Binodal curve for a system: distilled water (A), chloroform (B) &, acetone (C). | **02** |
| **7.** | Study of liquid-liquid extraction by experimental method. | **02** |
| **8.** | Study of single stage extraction. | **02** |
| **9.** | Study of multistage extraction. | **02** |
| **10.** | Determination of single stage leaching operation efficiency for leaching of NaOH aqueous solution & $CaCO_3$. | **02** |
| **11.** | Determination of the stage efficiency and the overall recovery of NaOH for multistage cross current leaching operation for leaching NaOH from mixture of NaOH and $CaCO_3$ using water as a solvent. | **02** |

**Suggested Text Books/ Reference Books/Manual**


| | |
|---|---|
| 1. | R. E. Treybal, 1981, Mass Transfer Operations, 3rd Ed., McGraw -Hill International Edition. |
| 2. | McCabe W.L, Smith J.C., Harriott P., 2001 & 2005, Unit Operations in Chemical Engineering, 6th&7th Eds., McGraw-Hill, New York. |
| 3. | Coulson J.M., Richardson J.F., Backhurst J. R., Harker J.H., 2004, Coulson & Richardson's Chemical Engineering, Vol. 1, 6th Ed., Elsevier, New Delhi. |
| 4. | C. J. Geankoplis, 1993, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, |

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<tr><td>Year, Program, Semester</td><td colspan="10">T.Y. B. Tech (Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="10">PCC312</td></tr>
<tr><td>Course Category</td><td colspan="10">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="10">Chemical Reaction Engineering (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="4">Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>03</td><td>01</td><td>-</td><td colspan="4">04</td><td colspan="3">04</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td colspan="2">ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td colspan="3">Total</td></tr>
<tr><td>30</td><td colspan="2">70</td><td>-</td><td>-</td><td>-</td><td>-</td><td colspan="3">100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="10">BSC111, BSC212, PCC211, PCC212, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="10">This course develops a comprehensive understanding of chemical reactor analysis and design. It covers ideal and non-ideal reactor performance, kinetics, heterogeneous reactions, and residence time distribution. The course equips students to select, analyze, and optimize reactors in chemical industries based on feed characteristics and reaction requirements.</td></tr>
<tr><td>Course Objectives</td><td colspan="10">The course teacher will:<br>1. Introduce reactor types and fundamental reaction kinetics.<br>2. Teach experimental analysis of rate data and determination of reaction parameters.<br>3. Guide the design of ideal and non-ideal reactors using kinetic models.<br>4. Explain rate-controlling steps and modeling of heterogeneous systems.<br>5. Integrate mass transfer with catalytic reaction kinetics.<br>6. Analyze factors influencing reactor selection and performance.</td></tr>
<tr><td>Course Outcomes</td><td colspan="10">Upon completion of this course, students will be able to:<br>1. Explain reaction kinetics and reactor fundamentals, including temperature and catalyst effects.<br>2. Analyze experimental data to determine rate laws and reaction parameters.<br>3. Design ideal and non-ideal reactors for various reaction systems.<br>4. Develop rate models for heterogeneous reactions involving mass transfer.<br>5. Evaluate catalytic reactors by coupling reaction kinetics with transport phenomena.<br>6. Assess reactor types and selection criteria for process design.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 3 | 3 | - | 2 | - | - | - | - | - | - | - | - |
| CO 3 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 1 |
| CO 4 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | - |
| CO 5 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | - |
| CO 6 | 2 | 2 | 2 | 1 | - | - | - | - | - | 1 | - | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I | **Introduction to Chemical Reaction Engineering:** Importance and scope of reaction engineering in chemical industries, Fundamental concepts: rate of reaction, rate law and reaction mechanism, Molecularity and reaction order, Types of reactions, Arrhenius equation, activation energy, and temperature dependency of reaction rates. | **07** |
| II | **Kinetics of Homogeneous Reactions:** Determination of reaction rate by Experimental methods and data analysis, Differential and integral methods for rate law determination, Interpretation of reaction rate data, Temperature and pressure effects on reaction rates and equilibrium constants, Equilibrium Conversion, Optimum temperature progression, Adiabatic and non-adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions. | **08** |
| III | **Ideal and Non-Ideal Reactor Design:** Ideal reactor, its Design equation, Derivation and application, Reactor combinations: Series and parallel configurations, Performance comparison of ideal reactors, Conversion, space time, and space velocity concepts, Residence Time Distribution (RTD) theory, E, F, and C curves and their significance, Reactor models: Tanks-in-series and dispersion models, Effects of non-ideal flow on reactor performance. | **08** |
| IV | **Fluid-Particle and Fluid-Fluid reactions:** Introduction to fluid particle reactions, Kinetics- selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling. Fluid particle reactor design for non-catalytic heterogeneous reactions. Introduction to fluid-fluid reaction systems, Rate equations, Reactor design with and without mass transfer considerations. | **06** |
| V | **Catalysis and Heterogeneous Reactions:** Spectrum of kinetic regimes. Rate equation for surface kinetics, Pore diffusion resistance combined with surface kinetics, Porous catalyst particles, Heat effects during reaction, Performance equations for reactors containing porous catalyst particles, Experimental methods for finding rates, Deactivating catalysts mechanisms of catalyst | **08** |

| | | |
|---|---|---|
| | deactivation, the rate and performance equations. | |
| **VI** | **Reactors, its stability and Scale up:** Fixed bed reactor- construction, operation and design, Isothermal operation, Adiabatic operation, Fluidized bed reactor, Slurry reactor, Trickle bed reactor. Choice of reactor, Factors affecting choice of reactor, Optimum yield and conversion, Selectivity and reactivity. | **05** |
| **Text Books** | | |
| 1. | Fogler, H. S. (2020). Elements of chemical reaction engineering (6th ed.). Pearson Education. | |
| 2. | Levenspiel, O. (1999). Chemical reaction engineering (3rd ed.). Wiley. | |
| 3. | Walas, S. M. (1959). Reaction Kinetics for Chemical Engineers', McGraw Hill, New York. | |
| 4. | Scott Fogler, H., & Gurmen, N. M. (2020). Essentials of chemical reaction engineering (2nd ed.). Pearson Education. | |
| 5. | Hill, C. G., & Root, T. W. (2014). Introduction to chemical engineering kinetics and reactor design (2nd ed.). Wiley. | |
| **Reference Books** | | |
| 1. | Nauman, E. B. (2008). Chemical reactor design, optimization, and scale-up (2nd ed.). Wiley. | |
| 2. | Doraiswamy, L. K., & Sharma, M. M. (1984). Heterogeneous reactions: Analysis, examples, and reactor design *(Vol. 1 & 2).* Wiley-Interscience. | |
| 3. | Carberry, J. J. (2001). Chemical and catalytic reaction engineering. Dover Publications. | |
| 4. | Smith, J. M. (1981). Chemical engineering kinetics (3rd ed.). McGraw-Hill. | |
| 5. | Bischoff, K. B., & Froment, G. F. (199). Chemical reactor analysis and design (2nd ed.). Wiley. | |
| **Useful web links** | | |
| 1. | https://onlinecourses.nptel.ac.in/noc22_ch51 | |
| 2. | https://onlinecourses.nptel.ac.in/noc25_ch17 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech.(Chemical Engineering), Part III, Semester V | | | | | | |
| Course Code | PCC312 | | | | | | |
| Course Category | Program Core Course | | | | | | |
| Course title | **Chemical Reaction Engineering (Laboratory)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | | **Credits** | |
| | - | - | **02** | **02** | | **01** | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | - | - | 50 | **-** | 50 | - | 100 |
| Pre-requisites (if any) | BSC111, BSC212, PCC211, PCC212, PCC224 | | | | | | |
| Course Rationale | This laboratory course offers hands-on exposure to reactor performance, reaction kinetics, catalysis, and RTD analysis. It strengthens theoretical concepts through experiments and promotes analytical skills, teamwork, and scientific reporting for solving real-world chemical engineering problems. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Demonstrate reaction kinetics and parameter estimation experimentally.<br>2. Examine the performance of various ideal and non-ideal reactors.<br>3. Introduce residence time distribution and its role in reactor analysis.<br>4. Explore catalytic and non-catalytic reaction mechanisms in reactors.<br>5. Foster problem-solving and data interpretation through laboratory work. | | | | | | |
| Course Outcomes | Upon completion of this course, students will be able to:<br>1. Estimate rate constants and activation energy from lab-scale reactions.<br>2. Conduct experiments on reactor systems in series and assess performance.<br>3. Analyze residence time distribution in flow reactors.<br>4. Evaluate catalytic and non-catalytic reactions using experimental methods.<br>5. Interpret data, draw conclusions, and apply critical thinking in lab settings. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | - | - | - | - | - | - | 1 | - | - |
| CO2 | 2 | 2 | 3 | - | - | - | - | - | - | - | - | 1 |
| CO3 | 2 | 3 | 3 | 2 | - | - | - | - | - | - | - | 1 |
| CO4 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | - |
| CO5 | 2 | 3 | 2 | 2 | - | - | - | - | 2 | 2 | - | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No. | List of Experiments | Hours |
|---|---|---|
| **1.** | Verification of the Arrhenius equation by studying the temperature dependency of a chemical reaction's rate constant. | **02** |
| **2.** | Determination of the order and rate constant of a reaction using differential and integral methods. | **02** |
| **3.** | Study of the reaction rate of saponification in a batch reactor. | **02** |
| **4.** | Investigation of the kinetics of acid-catalysed esterification in a batch reactor. | **02** |
| **5.** | Measurement of the conversion of reactants in a single CSTR. | **02** |
| **6.** | Comparison of the performance of multiple CSTRs connected in series. | **02** |
| **7.** | Study of the conversion of reactants in a plug flow reactor. | **02** |
| **8.** | Performing tracer studies to determine RTD in a single CSTR by pulse input. | **02** |
| **9.** | Performing tracer studies to determine RTD in a single CSTR by step input. | **02** |
| **10.** | Performing the tracer experiments to determine RTD in a plug flow reactor by pulse input. | **02** |
| **11.** | Performing the tracer experiments to determine RTD in a multiple CSTRs connected in series by pulse input. | **02** |
| **12.** | Study of the kinetics for Second Order Saponification Reaction in Mixed Flow Reactor. | **02** |
| **13.** | Study of the effect of temperature on the Kinetics of the Reaction. | **02** |
| **14.** | Determination of the kinetics of reaction in batch reactor under adiabatic conditions. | **02** |
| **15.** | Study of the RTD in a Packed Bed Reactor | **02** |

**Suggested Text Books/ Reference Books/Manual**


| | |
|---|---|
| 1. | Fogler, H. S. (2020). Elements of chemical reaction engineering (6th ed.). Pearson Education. |
| 2. | Levenspiel, O. (1999). Chemical reaction engineering (3rd ed.). Wiley. |
| 3. | Walas, S. M. (1959). Reaction Kinetics for Chemical Engineers’, McGraw Hill, New York. |
| 4. | Scott Fogler, H., & Gurmen, N. M. (2020). Essentials of Chemical Reaction Engineering (2nd ed.). Pearson Education. |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech.(Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC313</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Organic Chemical Technologies (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td colspan="2">ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE / Total</td></tr>
<tr><td>30</td><td colspan="2">70</td><td>-</td><td>-</td><td>-</td><td>- / 100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC221, BSC111, PCC212, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This laboratory course provides an in-depth understanding of key organic-based chemical industries, focusing on raw material availability, manufacturing processes, and recent technological advancements. It aims to bridge theoretical concepts with industrial practices by examining process flow diagrams, production trends, and environmental considerations across sectors such as food, petroleum, petrochemicals, plastics, and surfactants.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will:<br>1. Impart knowledge about sources and processes pertaining to Food Industry.<br>2. Explain various processes for manufacture of oils and surfactants.<br>3. Elaborate different methods used for paper manufacture.<br>4. Discuss various manufacturing processes for plastic and rubber industry.<br>5. Impart knowledge about sources and processes pertaining to petroleum.<br>6. State the processes and application for petrochemical products.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students should be able to:<br>1. Identify various components of food industry and its quality concern.<br>2. Classify different oils and surfactants and understand related manufacturing.<br>3. Remember different methods for paper and pulp production.<br>4. Understand correct processes for production of plastic and rubber.<br>5. Recognize various processes for refining of petroleum.<br>6. Visualize various methods and applications for petrochemical based compounds.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1- | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | - | - | 2 | 2 | - | - | - | - | - |
| CO2 | 3 | 3 | | - | 3 | - | - | - | - | - | - | - |
| CO3 | 3 | - | 2 | - | - | - | 2 | - | - | - | - | - |
| CO4 | 3 | 2 | 3 | - | 2 | - | - | - | - | - | - | - |
| CO5 | 3 | 3 | - | 3 | 2 | - | - | - | - | - | - | - |
| CO6 | - | - | 3 | 2 | 3 | - | - | - | - | - | 2 | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I | **Food and Fermentation Industries:** Types of food processing, preservation method, products. Sugar and Starch industries, Carbohydrates, Introduction to fermentation industries: Ethanol, Penicillin production, Applications. | 06 |
| II | **Oil, Fat, Waxes and Surfactants:** Edible and essential oils, Manufacturing and processing of Vegetable oils, Processing of Oils and Waxes, Surfactants: Types and properties, Soaps and detergents, Soaps and Glycerine manufacture. | 07 |
| III | **Pulp, Paper and Polymer industries:** Manufacturing of pulp, manufacturing of paper, Kraft process, Polymer classification, Polymer manufacturing processes-Ethenic and Poly-condensation process. | 07 |
| IV | **Plastic and Rubber Industries:** Raw materials, general polymerization processes, manufacturing processes, Definition, types of rubber, Production of SBR, Silicon based rubber production. | 07 |
| V | **Explosives and Petroleum Industries:** Types of explosives, Explosive characteristics, Industrial explosives, propellants, Petroleum production and refining, Refinery products and Characteristics, Petroleum refinery processes. | 06 |
| VI | **Petrochemical - C1, C2 and C3 Products:** Manufacturing of Methanol, Formaldehyde, Ethylene dichloride, Isopropanol, Acetone, Isopropyl Benzene, Butadiene, Phenol, Styrene. | 08 |
| **Text Books** | | |
| 1. | G. Rao and M. Sittig, 2000, Dryden’s Outlines of Chemical Technology, 3rd Edition, East–West Press Pvt Ltd., New Delhi | |
| 2. | G. T. Austin, 1985, Shreve's Chemical Process Industries, 5th edition. , McGraw Hill Book Company. | |
| 3. | P. H. Groggins, 1984, Unit Processes in Organic Synthesis, 5th Edition, McGraw Hill. | |

| | |
|---|---|
| 4. | S. D. Shukla and G. N. Pandey, 1977, Text book of Chemical Technology, Vikas Publishing House Private Ltd. |
| 5. | J. K. Moulijn, M. Makkee and D. A. V. Diepen, 2001, Chemical Process Technology, Wiley. |
| **Reference Books** | |
| 1. | D. Venkteshwaralu, 1977, Chemical Technology, I & III manuals of Chemical Technology, Chemical Engineering. Ed. Dev. III Madras. |
| 2. | R. H. Perry, D. W. Green, 2007, Perry's chemical Engineer's Handbook, McGraw Hill, New York |
| 3. | R. E. Kirk and D. F. Othmer, 1991, Encyclopedia of Chemical Technology, 4th Edition, Interscience, New York. |
| **Useful web links** | |
| 1. | https://nptel.ac.in/courses/1-41-6119 |
| 2. | https://onlinecourses.nptel.ac.in/noc23_ch46/preview |
| 3. | https://www.sciencedirect.com/book/978-1213811-3/advanced-organic-chemistry |
| 4. | https://www.acs.org/ |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech. (Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC313</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Organic Chemical Technologies (Laboratory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="2">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td colspan="2">ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE | Total</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>50</td><td>-</td><td>50</td><td>- | 100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC221, BSC111, PCC212, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This laboratory course provides hands-on training in key organic chemistry techniques and processes relevant to the chemical industry. Students gain exposure to the synthesis, analysis, and evaluation of organic compounds, developing technical competence, analytical skills, and awareness of laboratory safety and ethics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will:<br>1. Train students in basic organic chemistry lab skills, including synthesis, purification, and analysis.<br>2. Bridge theoretical concepts with practical application in organic chemical processes.<br>3. Enable students to evaluate key parameters such as acid value, iodine value, and saponification value.<br>4. Foster analytical thinking through the design, execution, and interpretation of experiments.<br>5. Inculcate safe laboratory practices and ethical conduct in scientific work.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students will be able to:<br>1. Perform standard laboratory techniques for synthesis and testing of organic compounds.<br>2. Apply reaction mechanisms and theoretical concepts to practical synthesis processes.<br>3. Evaluate parameters like acid, iodine, and saponification values for industrial relevance.<br>4. Analyze and interpret experimental results to solve practical organic chemistry problems.<br>5. Follow safety protocols and ethical guidelines in the laboratory environment.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 2 | - | - | - | - | - | - | 1 | - | - |
| CO2 | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 |
| CO3 | 2 | 3 | 2 | - | - | - | - | - | - | - | - | 1 |
| CO4 | 2 | 3 | 3 | 2 | - | - | - | - | - | 2 | - | 1 |
| CO5 | 1 | - | - | - | - | 3 | - | 2 | 2 | 2 | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No | List of Experiments | Hours |
|---|---|---|
| **1.** | Extraction of essential oils from plant material using steam distillation. | **02** |
| **2.** | Preparation of soap from vegetable oils or fats using the saponification process and testing its properties. | **02** |
| **3.** | Synthesis of esters like ethyl acetate and characterization by odour and boiling point. | **02** |
| **4.** | Preparation of biodiesel from vegetable oil using transesterification and analysis of the product. | **02** |
| **5.** | Oxidation of ethanol to acetic acid or acetone using suitable oxidizing agents. | **02** |
| **6.** | Determination of iodine value of given oils and fats. | **02** |
| **7.** | Determination of saponification value of given oils and fats. | **02** |
| **8.** | Determination of acid value of given oils and fats. | **02** |
| **9.** | Comparison of soaps and detergents for parameters like foaming ability, cleaning power, and pH. | **02** |
| **10.** | Preparation of detergents using sulfonation reactions and analysis of active ingredients. | **02** |
| **11.** | Conversion of starch to glucose using acid hydrolysis and determination of glucose concentration. | **02** |
| **12.** | Production of ethanol from sugar or molasses by fermentation using yeast and its purification. | **02** |
| **13.** | Synthesis of a polymer and characterization of the product. | **02** |
| **14.** | Determination of cellulose and lignin content in pulp and assessment of paper strength. | **02** |

| | | |
|---|---|---|
| **15.** | Synthesis of Benzanilide from Aniline. | **02** |
| **Suggested Text Books/ Reference Books/Manual** | | |
| 1. | G. Rao and M. Sittig, 2000, Dryden’s Outlines of Chemical Technology, 3rd Edition, East– West Press Pvt Ltd., New Delhi | |
| 2. | G. T. Austin, 1985, Shreve's Chemical Process Industries, 5th edition. , McGraw Hill Book Company. | |
| 3. | P. H. Groggins, 1984, Unit Processes in Organic Synthesis, 5th Edition, McGraw Hill. | |
| 4. | S. D. Shukla and G. N. Pandey, 1977, Text book of Chemical Technology, Vikas Publishing House Private Ltd. | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech.(Chemical Engineering), Part III, Semester V | | | | | | | |
| Course Code | HSMEC311 | | | | | | | |
| Course Category | Humanities and Social Sciences, Management Environmental Course | | | | | | | |
| Course title | **Safety in Chemical Industry** | | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | | **Total Credits** | | |
| | 03 | - | - | 03 | | 03 | | |
| Evaluation Scheme | ISE | ESE | | IOE | IPE | EOE | EPE | Total |
| | 30 | 70 | | - | - | - | - | 100 |
| Pre-requisites (if any) | PCC211, PCC212, PCC221 | | | | | | | |
| Course Rationale | This course emphasizes the ethical responsibility, legal framework, and technical principles essential for ensuring safety in the chemical industry. It introduces students to safety programs, industrial laws, hazard identification, risk assessment, and mitigation methods. The course develops a safety-oriented mind-set through analysis of real-life case studies and best industrial practices. | | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Explain the significance of safety culture, engineering ethics, and safety programs in the chemical industry.<br>2. Introduce legal regulations, industrial safety standards, and source modeling techniques.<br>3. Analyze fire and explosion mechanisms and describe preventive and mitigation strategies.<br>4. Explain safety relief systems, their classification, and sizing techniques.<br>5. Equip students with tools for hazard identification, risk assessment, and safety audits.<br>6. Promote accountability and professional responsibility through case studies and best practices. | | | | | | | |
| Course Outcomes | Upon completion of this course, students will be able to:<br>1. Explain the role of engineering ethics and safety programs in promoting a safe industrial environment.<br>2. Identify and interpret key industrial laws, safety regulations, and modeling of accident sources.<br>3. Describe the causes of industrial fires and explosions, and suggest preventive strategies.<br>4. Explain relief systems and sizing methodologies for emergency pressure relief.<br>5. Apply hazard identification and risk assessment techniques in safety planning.<br>6. Recognize the importance of individual responsibility in safety management through case study evaluations. | | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 2 | - | - | - | - | 3 | - | 3 | 1 | 2 | - | 1 |
| CO 2 | 2 | 2 | - | 2 | - | 2 | - | 2 | - | - | - | - |
| CO 3 | 2 | - | 2 | 2 | - | 2 | 2 | 2 | - | - | - | 1 |
| CO 4 | 2 | 2 | 2 | - | - | - | 1 | - | - | - | - | 2 |
| CO 5 | 3 | 2 | 2 | 2 | - | 2 | - | - | - | - | - | 3 |
| CO 6 | 1 | - | - | - | - | 3 | 3 | 3 | 2 | 3 | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Safety Concepts and Necessity:** Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety, Seven Significant Disasters. Toxicology: Effect of Toxicants on Biological Organisms, Toxicological Studies, Dose versus Response, Models for Dose and Response Curves, Relative Toxicity, Threshold Limit Values, National Fire Protection Association (NFPA) Diamond. | 06 |
| II. | **Industrial Hygiene:** Government Laws and Regulations, OSHA: Process Safety Management**,** EPA: Risk Management Plan, DHS: Chemical Facility Anti-Terrorism Standards (CFATS). Industrial Hygiene: Anticipation and Identification, Evaluation, Control. Source Models: Introduction to Source Models, Flow of Liquid through Holes, and Pipes, Flow of Gases or Vapors through Holes and Pipes, Flashing Liquids, Liquid Pool Evaporation or Boiling, Conservative Analysis. | 07 |
| III. | **Fires and Explosions:** The Fire Triangle, Distinction between Fires and Explosions, Definitions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy, Auto-ignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions. Concepts to Prevent Fires and Explosions: Inerting, Static Electricity and its Control, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Miscellaneous Concepts for Preventing Fires and Explosions. | 09 |
| IV. | **Introduction to Reliefs:** Relief Concepts, Definitions, Location of Reliefs, Relief Types and Characteristics, Relief Scenarios, Data for Sizing Reliefs, Relief Systems. Relief Sizing: Conventional Spring-Operated Reliefs in Liquid and in Vapor or Gas Services, Rupture Disc Reliefs in Liquid in Vapor or Gas Services, Two-Phase Flow during Runaway Reaction Relief, Pilot-Operated and Bucking-Pin Reliefs, Deflagration Venting for Dust and Vapor Explosions, Venting for Fires External to Process Vessels, Reliefs for Thermal Expansion of Process Fluids. | 08 |

| | | |
|---|---|---|
| **V.** | **Hazards Identification:** Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods, Risk Assessment: Review of Probability Theory, Event Trees, Fault Trees, QRA and LOPA. | **07** |
| **VI.** | **Case Studies:** At least two to three recent and major incidents to be discussed in the class. The Chemical Engineer's connectivity to the society and his role in reducing or eliminating the chances of accidents to be discussed. | **03** |

| | |
|---|---|
| **Text Books** | |
| 1. | D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011. |
| **Reference Books** | |
| 1. | R.K. Sinnott, Coulson & Richardson's, Chemical Engineering, Vol. 6, Elsevier India, 2006 |
| 2. | Fawcett H.H. and W.S. Wood, Safety and accident prevention in Chemical operations 2$^{nd}$editon John Wiley and Sons Inc. (1982). |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B.Tech(Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="7">MDM 3.2</td></tr>
<tr><td>Course Category</td><td colspan="7">Multidisciplinary Minor Course II</td></tr>
<tr><td>Course title</td><td colspan="7">Piping Design Principles</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">Basics of unit processes and unit operations</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course focuses on the principles and methodologies involved in the Design of piping systems for chemical engineering applications.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will:<br>1. Describe design principles to create piping layouts.<br>2. Explain different design methodologies for piping systems.<br>3. Elaborate factors influencing piping design decisions.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students should be able to:<br>1. Develop piping layouts for chemical engineering processes.<br>2. Compare and contrast various design methodologies for piping systems.<br>3. Justify design decisions based on factors such as safety, cost, and efficiency.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | 3 | - | - | - | - | - | - | - | - | - |
| CO2 | - | - | - | 2 | - | - | - | - | - | - | - | - |
| CO3 | - | - | - | - | 2 | - | - | - | - | - | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| **I.** | **Piping Design Process**<br>Steps involved in piping design: Overview of the design process, including Conceptualization, preliminary design, detailed design, and as-built documentation, Design considerations: Factors influencing piping design decisions, such as process, requirements, material selection, operating conditions, and regulatory compliance. | **06** |

| | | |
|---|---|---|
| II. | **Piping Codes and Standards**<br>Overview of relevant codes and standards: Detailed examination of key industry, standards and specifications governing piping design, fabrication, installation, and maintenance, Interpretation and application: Understanding how to interpret and apply code requirements to ensure compliance and best practices in piping design. | 07 |
| III. | **Design Methodologies**<br>Traditional vs. computer-aided design approaches: Comparison of manual drafting methods with modern computer-aided design (CAD) software tools for piping layout and modelling. Design optimization techniques: Strategies for optimizing piping layouts and configurations to minimize material usage, pressure drop, and construction costs while maximizing efficiency and operability. | 08 |
| IV. | **Safety in Piping Design**<br>Hazard analysis and risk assessment: Techniques for identifying and mitigating potential hazards associated with piping systems, including hazard and operability(HAZOP) studies, risk matrices, and safety instrumented systems (SIS).<br>Safety considerations in design decisions: Integration of safety factors and design features (e.g., relief devices, pressure relief valves) to prevent overpressure, leakage, and other hazardous conditions. | 06 |
| V. | **Cost Estimation**<br>Factors influencing piping design costs: Analysis of cost drivers in piping design, including material costs, labor expenses, equipment requirements, and project duration. Cost estimation methods: Techniques for estimating piping design costs at different stages of the project lifecycle, including conceptual, preliminary, and detailed design phases. | 06 |
| VI. | **Environmental Considerations**<br>Impact assessment of piping systems: Evaluation of the environmental impact of piping systems throughout their lifecycle, including energy consumption, greenhouse gas emissions, and waste generation.<br>Sustainable design practices: Strategies for incorporating sustainability principles into piping design, such as minimizing resource usage, optimizing energy efficiency, and reducing environmental footprint. | 06 |
| **Text Books** | | |
| 1. | Peter Smith and R.W. Zappe. (2018). Piping Systems Manual. McGraw-Hill Education. | |
| 2. | William Beale and Rodney Boyer. (2018). Process Piping: The Complete Guide to ASME B31.3, Fourth Edition. Momentum Press. | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">T.Y. B. Tech.(Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="8">AEC311</td></tr>
<tr><td>Course Category</td><td colspan="8">Ability Enhancement Course</td></tr>
<tr><td>Course title</td><td colspan="8">Introduction to Foreign Language</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="3">Credits</td></tr>
<tr><td>01</td><td>-</td><td>-</td><td colspan="2">01</td><td colspan="3">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td colspan="2">ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>50</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">The pre-requisites should reflect the foundational readiness of students to engage with a new language and openness to cultural diversity and intercultural communication. Since this is an introductory-level course, it is generally open to beginners, and no prior knowledge of the foreign language is expected.</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This course provides a competitive edge for engineering graduates in their career choices. They will be able to communicate in a second language. The course enhances listening, reading skills and memory. Our graduates may be able to participate more effectively and responsibly in a multi-cultural world if they know another foreign language in addition to the English.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will:<br>1. Introduce basics of the chosen foreign language.<br>2. Train students in simple communication and translation.<br>3. Enable everyday interactions (family, food, travel, routines).<br>4. Develop listening comprehension for short conversations.<br>5. Teach writing of simple sentences and short texts.<br>6. Promote cultural awareness and language function.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, Students will be able to:<br>1. Recognize alphabets and basic grammar.<br>2. Read simple texts in the foreign language.<br>3. Use basic greetings and expressions.<br>4. Respond to simple personal questions (name, age, etc.).<br>5. Translate basic sentences orally and in writing.<br>6. Appreciate the cultural and global value of the language.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | - | - | - | - | - | - | 2 | 3 | - | 2 |
| CO2 | 1 | - | - | - | - | - | - | - | 2 | 2 | - | 2 |
| CO3 | - | - | - | - | - | - | - | - | 3 | 3 | - | 2 |
| CO4 | - | - | - | - | - | - | - | - | 3 | 3 | - | 2 |
| CO5 | 1 | - | - | - | - | - | - | - | 3 | 3 | - | 2 |
| CO6 | - | - | - | - | - | - | 2 | 2 | 2 | 3 | - | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| **I.** | General Information on Basic Grammar of the foreign language, Introduction to alphabets. | **07** |
| **II.** | Gender of Noun, Number of Noun, Pronouns, Adjectives, Verbs and their usage in simple sentences, Numbers (up to 10), Simple Greetings in foreign language. | **07** |
| **III.** | General Questions in foreign language, like What is your name/surname? Who/What is this? etc. | **07** |
| **IV.** | Simple narration about self/family/friend/University in foreign language chosen for studies. Practicing the learnt topics in the class itself. | **05** |
| **V.** | Formation of simple sentences using Parts of Speech, Information on Cases, One or Two simple lessons from any book. | **07** |
| **VI.** | Basic information on Country & Culture of language under study. | **06** |

**Text Books**

| | |
|---|---|
| 1. | V.N. Wagner and V. G. Ovsienko, “Russian Language”, Russian, People’s Publishing House, New Delhi. |
| 2. | S. Khavronina and A. Shirochenskaya, “Russian in Exercises”, 1991. |
| 3. | “Genki – Japan Times”. |
| 4. | Osamu & Nobuko Mizutani, “Aural Comprehension in Japanese”. |
| 5. | Osamu & Nobuko Mizutani, “An Introduction to Modern Japanese”. |
| 6. | Y. Yoshida, “Japanese for Today”. |
| 7. | Ed Swick, “The Everything Learning German Book: Speak, Write and Understand Basic German in No Time”. |
| 8. | Ed Swick, “Living German”. |
| 9. | Eugene Jackson and Adolph Geiger, “German Made Simple: Learn to Speak and Understand German Quickly and Easily”. |
| 10. | Professor Martin Durrell, “Hammer’s German Grammar and Usage” (Fifth Edition). |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech. (Chemical Engineering), Part III, Semester V | | | | | | | |
| Course Code | MAC311 | | | | | | | |
| Course Category | Mandatory Audit Course | | | | | | | |
| Course title | **Aptitude Enhancement Course II** | | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Credits** | | | |
| | - | 01 | - | 01 | - | | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | | **IPE** | **EOE** | **EPE** | **Total** |
| | - | - | IE at Course in charge end | | - | - | - | - |
| Pre-requisites (if any) | Aptitude Enhancement Course I | | | | | | | |
| Course Rationale | Aptitude Enhancement Course II builds on the foundational skills developed in its predecessor. The course aims to further hone students' critical thinking, problem-solving, quantitative aptitude, and analytical abilities, equipping them for competitive environments and professional success. The course emphasizes practical application and fosters a holistic approach to aptitude development, aligning with industry expectations and global standards. | | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Enhance quantitative and analytical aptitude through structured problem-solving activities.<br>2. Help develop logical reasoning and data interpretation skills critical for decision-making.<br>3. Help strengthen verbal communication and comprehension abilities for professional contexts. | | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Solve complex quantitative problems using structured methodologies.<br>2. Apply logical reasoning and interpret data effectively to make informed decisions.<br>3. Demonstrate proficiency in verbal reasoning and comprehension through real-world applications. | | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | - | - | 2 | - | - | - | - | - | 2 | - | - |
| CO 2 | - | 3 | 2 | 3 | - | - | - | - | - | 2 | - | - |
| CO 3 | - | - | 3 | - | 2 | - | - | - | 3 | - | 2 | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Advanced Quantitative Aptitude:** Percentages, Profit and Loss, Time and Work, Time, Speed, and Distance Activities: Solving case-based problems, peer-to-peer discussion on strategies. | 02 |
| II. | **Logical Reasoning and Data Interpretation:** Puzzles, Syllogisms, Seating Arrangements, Charts, and Graphs. Activities: Solving logical puzzles, analyzing data sets in small groups. | 02 |
| III. | **Verbal Ability and Reading Comprehension:** Synonyms, Antonyms, Sentence Completion, Passage Analysis.<br>Activities: Group discussions on comprehension passages, vocabulary quizzes. | 02 |
| IV. | **Problem-Solving Techniques and Strategy:** Problem-solving frameworks, time management in aptitude tests. Activities: Mock problem-solving sessions with timed activities. | 02 |
| V. | **Industry-Oriented Aptitude Applications:** Case studies on industry challenges, real-world data sets, Activities: Case analysis, presentations on problem-solving approaches. | 03 |
| VI. | **Assessment and Feedback:** Activities: Practice aptitude tests, individual feedback sessions on performance | 02 |
| **Text Books** | | |
| 1. | R.S. Aggarwal, 2023, Quantitative Aptitude for Competitive Examinations, Revised Edition, S. Chand Publishing, New Delhi. | |
| 2. | R.S. Aggarwal, 2022, A Modern Approach to Verbal & Non-Verbal Reasoning, Revised Edition, S. Chand Publishing, New Delhi. | |
| 3. | Nishit K. Sinha, 2020, Verbal Ability and Reading Comprehension for the CAT, 4th Edition, Pearson Education, New Delhi. | |
| 4. | Dinesh Khattar, 2021, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, 3rd Edition, Pearson Education, New Delhi. | |
| **Reference books** | | |
| 1. | Arun Sharma, 2023, How to Prepare for Quantitative Aptitude for the CAT, 9th Edition, McGraw Hill Education, New Delhi. | |
| 2. | R.S. Aggarwal, 2021, A Modern Approach to Logical Reasoning, Revised Edition, S. Chand Publishing, New Delhi. | |
| 3. | Norman Lewis, 2014, Word Power Made Easy, Revised & Expanded Edition, Goyal Publishers & Distributors Pvt. Ltd., New Delhi. | |
| 4. | Arun Sharma, 2022, How to Prepare for Data Interpretation for the CAT, 6th Edition, McGraw Hill Education, New Delhi. | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">T.Y. B.Tech(Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="8">PBL311</td></tr>
<tr><td>Course Category</td><td colspan="8">Project Based Learning</td></tr>
<tr><td>Course title</td><td colspan="8">Mini Project III & Industrial Visit</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td colspan="4">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td>02</td><td colspan="4">-</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td colspan="2">IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td colspan="2">IE at course in charge end</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="8">Mini Project II & Industrial Visit</td></tr>
<tr><td>Course Rationale</td><td colspan="8">The course Mini Project III & Industrial Visit aims to consolidate students' learning by integrating theoretical knowledge and practical exposure. It emphasizes applying advanced chemical engineering principles to solve real-world problems through innovative project work and gaining industry insights during structured industrial visits. This course fosters professional readiness by emphasizing research, innovation, collaboration, and exposure to industrial practices.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will:<br>1. Facilitate advanced application of theoretical knowledge to solve real-world chemical engineering problems.<br>2. Provide experiential learning through advanced project work and industrial exposure to contemporary chemical engineering practices.<br>3. Develop critical thinking, innovation, and professional skills to prepare students for industry or research-oriented careers.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, students should be able to:<br>1. Synthesize and apply chemical engineering concepts to design and execute innovative projects independently.<br>2. Critically analyze and interpret data from projects and industrial visits to derive meaningful conclusions.<br>3. Collaborate in multidisciplinary teams to address complex engineering challenges.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 |
| CO 2 | 2 | 3 | 2 | 3 | 3 | - | - | - | - | - | - | 3 |
| CO 3 | - | - | 2 | - | - | - | - | - | 3 | 2 | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Project Ideation and Proposal Development:** Identifying real-world chemical engineering problems and formulating project proposals, Literature review and benchmarking existing solutions, Developing problem statements and objectives for innovative projects. | 02 |
| II. | **Advanced Project Planning and Execution:** Designing experiments and simulations aligned with project objectives, Resource allocation, risk assessment, and timeline management, Conducting hands-on experiments or simulations with faculty guidance. | 02 |
| III. | **Data Analysis and Solution Optimization:** Data collection, processing, and statistical analysis, Application of advanced chemical engineering tools/software (e.g., Aspen, MATLAB), Optimizing solutions for technical feasibility and cost-effectiveness. | 02 |
| IV. | **Industrial Visit Preparation and Execution:** Pre-visit briefing on industrial site operations and safety protocols, Guided industrial visit to a chemical engineering facility, Observation and documentation of processes, safety measures, and technologies. | 02 |
| V. | **Reflection and Knowledge Sharing:** Analysing and presenting industrial visit observations, comparing theoretical knowledge with industry practices, Sharing project progress through group discussions and presentations. | 02 |
| VI. | **Project Presentation and Evaluation:** Preparing detailed project reports and presentations, Oral presentations to faculty and peers with Q&A sessions, Peer and rubric-based evaluations of teamwork, innovation, and outcomes | 02 |
| | **Reference Books** | |
| 1. | Ray, M. S., (1998), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), CRC Press. | |
| 2. | Turton, R., Bailie, R.C., Whiting, W.B., Shaeiwitz, J.A., & Bhattacharyya, D., (2013), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), Prentice Hall. | |
| 3. | Goyal, M., & Choudhary, S.K., (2016), Industrial Visits and Study in Chemical Process Industries, IK International Publishing House Pvt. Ltd. | |
| | **Useful web links/U-Tube Links** | |
| 1. | **https://youtu.be/C9Q0HCGa_8I?si=rzIo0XB75vWGtdS1** | |
| 2. | The students can search on u-tube for the following key words:<br>1. “Chemical Engineering Mini Projects”<br>2. “Chemical Engineering Industrial Visits”<br>3. “Hands-on Projects for Chemical Engineers”<br>4. “Industrial Visits in Chemical Process Industries” | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech(Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="7">ESC321</td></tr>
<tr><td>Course Category</td><td colspan="7">Engineering Science Course</td></tr>
<tr><td>Course title</td><td colspan="7">Process Instrumentation & Control (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BCS 111/121, BCS 112,122, ESC 113,123, BCS 212,PCC 211,PCC 221,224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course introduces the principles of process instrumentation and control systems widely used in the chemical industry. It builds foundational knowledge of dynamic system behavior and equips students with skills to design, analyze, and optimize control strategies for safe and efficient process operation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will:<br>1. Introduce types and functions of instrumentation and control systems in chemical processes.<br>2. Develop understanding of design and operation of feedback and feedforward control loops.<br>3. Explain the working and application of sensors and transducers for process measurement.<br>4. Analyze dynamic behavior of systems and assess control loop performance.<br>5. Teach design methods for PID control and tuning of controllers.<br>6. Apply control strategies for improving safety, automation, and efficiency in processes.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, students should be able to:<br>1. Explain the basics of process measurement and control systems.<br>2. Identify and describe components like sensors, transmitters, and controllers.<br>3. Analyze dynamic response and suggest control strategies for key variables.<br>4. Design and tune PID-based feedback control systems.<br>5. Create control loop diagrams and select suitable instruments for chemical processes.<br>6. Evaluate control system stability and efficiency using analytical tools.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | - | - | - | - | - | - | 1 | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO2 | 3 | - | 2 | - | 1 | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | - |
| CO4 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | - |
| CO5 | 3 | - | 3 | 2 | 2 | - | - | - | 1 | 1 | - | - |
| CO6 | 3 | 2 | 3 | 3 | - | - | - | - | - | - | - | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction to Process Control:** Measuring devices for flow, temperature, pressure and level. Brief of Laplace transforms | 06 |
| II. | **Mathematical Modeling:**<br>a) Development of mathematical models.<br>b) Modelling considerations for control purposes. | 06 |
| III. | **Dynamic Behavior of Chemical Processes:**<br>a) Transfer functions and the input output models.<br>b) Dynamics and analysis of first, second and higher order systems.<br>c) Computer simulation and the linearization of nonlinear systems. | 07 |
| IV. | **Feedback Control Schemes:**<br>a) Concept of feedback control.<br>b) Dynamics and analysis of feedback-controlled processes.<br>c) Stability analysis.<br>d) Controller design.<br>e) Frequency response analysis and its applications. | 08 |
| V. | **Advanced Control Schemes :**<br>a) Feedback control of systems with dead time or inverse response.<br>b) Control systems with multiple loops. | 05 |
| VI. | **Other control strategies:**<br>Feed forward controller - design with steady state model, design with dynamic model, combination of feed forward-feedback structure, | 07 |
| | **Text Books** | |
| 1. | Coughanowr, D. R. and L. B. Koppel, Process systems Analysis and Control, Mc-Graw-Hill, 2nd. Ed. 1991. | |
| | **Reference Books** | |
| 1. | Stephanopoulos, G., Chemical Process Control: An Introduction to Theory and Practice, Prentice-Hall, New Jersey, 1984. | |
| 2. | Luyben, W. L., Process Modelling Simulation and Control for Chemical Engineers McGraw Hill, 1990. | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B.Tech(Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | ESC321 | | | | | | |
| Course Category | Engineering Science Course | | | | | | |
| Course title | **Process Instrumentation & Control (Laboratory)** | | | | | | |
| Teaching Scheme andCredits | **L** | **T** | **P** | **Total Contact Hours** | | **Total Credits** | |
| | - | - | 02 | 02 | | 01 | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | - | - | 50 | - | - | - | 50 |
| Pre-requisites(if any) | BCS 111/121, BCS 112,122, ESC 113,123, BCS 212,PCC 211,PCC 221,224 | | | | | | |
| Course Rationale | This practical course enables students to apply principles of process control and instrumentation in real-time scenarios. It focuses on understanding dynamic system behavior and evaluating control strategies to optimize process performance. | | | | | | |
| Course Objectives | The course teacher will:<br>1. Demonstrate the dynamic behavior of various process systems through experiments.<br>2. Evaluate how different types of controllers affect system performance.<br>3. Explain the functioning and interconnection of key elements in feedback control systems. | | | | | | |
| Course Outcomes | Upon successful completion of this course, students should be able to:<br>1. Operate and understand modern instrumentation used in process control.<br>2. Identify and solve practical challenges in control systems used in industry.<br>3. Analyze and compare the impact of P, PI, and PID controllers on process control performance. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | 2 | 2 | 3 | - | - | - | - | 2 | 2 | - |
| CO2 | 2 | 3 | 3 | 3 | 2 | - | - | - | 1 | 2 | 2 | - |
| CO3 | 2 | 2 | 3 | 2 | 3 | - | - | - | - | 2 | 2 | - |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No. | List of Experiments | Hours |
|---|---|---|
| **1.** | Dynamic behavior of first order system: Mercury Thermometer | **02** |
| **2.** | Dynamic behavior of first order system: Single tank system | **02** |
| **3.** | Dynamic behavior of first order system: C.S.T.R | **02** |
| **4.** | Dynamic behavior of first order system in series: Two tank non-interacting system | **02** |
| **5.** | Dynamic behavior of first order system in series: Two tank interacting system | **02** |
| **6.** | Dynamic behavior of second order system: Mercury Manometer | **02** |
| **7.** | Dynamic behavior of final control Element: Pneumatic control valve. Study of Pneumatic controllers | **02** |
| **8.** | Dynamic behavior of final control Element: Proportional Controller | **02** |
| **9.** | Dynamic behavior of final control Element: Proportional Derivative Controller | **02** |
| **10.** | Dynamic behavior of final control Element: Proportional Integral Controller and Proportional Integral Derivative | **02** |

**Suggested Text Books/ Reference Books/Manual**


| | |
|---|---|
| 1. | Coughanowr, D. R. and L. B. Koppel, Process systems Analysis and Control, Mc-Graw-Hill, 2nd. Ed. 1991 |
| 2. | Stephanopoulos, G., Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, New Jersey 1984 |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech(Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC321</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mass Transfer Operations-II (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC211, BSC221, PCC 221, PCC 224</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course equips students with essential knowledge of advanced mass transfer operations such as drying, humidification, crystallization, adsorption, evaporation, and membrane processes. It emphasizes their design and industrial applications in sectors like pharmaceuticals, food, petrochemicals, and water treatment.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will:<br>1. Explain drying principles, interpret drying curves, and select appropriate dryers.<br>2. Describe humidification and dehumidification processes and design cooling towers using psychrometric tools.<br>3. Illustrate crystallization mechanisms and perform yield-based calculations.<br>4. Discuss adsorption equilibria and design fixed-bed and ion exchange systems.<br>5. Explain evaporation mechanisms and analyze related heat and mass balances.<br>6. Introduce membrane separation methods and discuss their industrial applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students should be able to:<br>1. Interpret drying curves and select suitable drying equipment for different feed materials.<br>2. Design cooling towers and analyze humidification using psychrometric charts.<br>3. Perform solubility, supersaturation, and crystallization calculations.<br>4. Apply isotherms to adsorption data and design single-stage or continuous adsorption systems.<br>5. Analyze evaporation processes and calculate energy requirements.<br>6. Solve separation problems using membrane transport principles.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 1 | – | – | – | – | – | – | – |
| CO2 | 3 | 2 | 2 | 2 | 1 | – | – | – | – | – | – | – |
| CO3 | 3 | 3 | 2 | 2 | – | – | – | – | – | – | – | – |
| CO4 | 3 | 3 | 2 | 2 | 1 | – | – | – | – | – | – | – |
| CO5 | 3 | 2 | 3 | 2 | – | – | – | – | – | – | – | – |
| CO6 | 3 | 2 | 2 | 3 | 2 | – | – | – | – | – | – | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Sr. No. | Course Content | Hours |
|---|---|---|
| I. | **Drying:** Principles of drying, phase equilibrium, cross circulation drying, through circulation drying, drying of suspended particles, rate of drying curve, drying time calculation from drying rate curve dryers for solids and pastes, dryers for solutions and slurries i.e., various types of dryers, selection of drying equipment. | **07** |
| II. | **Humidification:** Basic concepts, Principles of Humidification –Definitions Wet Bulb Temperature & Adiabatic Saturation Temperatures Terms, definitions, wet bulb temp., dry bulb temp., measurement of humidity, adiabatic saturation temp., study of temp humidity chart, Psychrometric Charts: Utilization of Psychrometric Charts Enthalpy-humidity charts, determination of humidity, Dehumidification – Cooling Towers –Mechanical Draft Towers: forced draft towers and induced draft towers**.** Design calculations of cooling tower. | **08** |
| III. | **Crystallization:** Principles of crystallization, crystal growth, properties of crystals nucleation, Effect of impurities in crystallization, Solubility curve, Super saturation, Method of obtaining super saturation, Theory of solubility Crystallization. Effect of temperature on solubility, caking and yield of crystals, Material and energy balance for crystallizers calculation of yield, Fractional crystallization, various types of crystallizers and their applications. | **08** |
| IV. | **Adsorption and Ion Exchange:** Types of adsorptions; Nature of adsorption; Stage wise and continuous adsorption. Adsorption equilibria - Various isotherms, Breakthrough curves, Ion exchange equilibria, Design of absorbers and ion exchangers. | **07** |
| V. | **Evaporation:** Principles of evaporation, applications of evaporation, liquid characteristics and types of evaporators, single effect evaporator calculation, pattern of liquor flow in multiple effect evaporators. | **06** |
| VI. | **Membrane Separation Operations:** Fundamentals of membrane separation process, different types of membrane separation process, (Ultra filtration, Reverse Osmosis, Dialysis, Electro Dialysis, Pervaporation), General membrane equation, Liquid membranes | **06** |

| | | |
|---|---|---|
| **Sr. No.** | **Text Books** | |
| 1. | R. E. Treybal, 1981, Mass Transfer Operations, 3rd Ed., McGraw -Hill International Edition. | |
| 2. | B.K. Dutta, 2007, Principles of Mass Transfer and Separation Processes, 1st Ed., Prentice Hall of India. | |
| 3. | McCabe W.L, Smith J.C., Harriott P., 2001 &2005, Unit Operations in Chemical Engineering, 6th&7th Eds., McGraw-Hill, New York. | |
| 4. | Coulson J.M., Richardson J.F., Backhurst J. R., Harker J.H.,2004, Coulson& Richardson's Chemical Engineering, Vol. 1, 6th Ed., Elsevier, New Delhi. | |
| **Reference Books** | | |
| 1. | R. H. Perry, D. W. Green, 2007, Perry's chemical Engineer's Handbook, McGraw Hill, New York. | |
| 2. | C. J. Geankoplis, 1993, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, | |
| 3. | Ernest J. Henley, J. D. Seader, D. Keith Roper, 2011, Separation Process Principles, 3rd Edition, Wiley. | |
| **Useful web links** | | |
| 1. | https://archive.nptel.ac.in/courses/1-3/1-4/1-31-4-46/ | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y. B. Tech. (Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC321</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mass Transfer Operations-II (Laboratory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td>02</td><td colspan="3">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC211, PCC222, BSC212, BSC221, PCC221, PCC224.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course offers hands-on experience in advanced mass transfer operations such as drying, evaporation, crystallization, adsorption, and membrane separation. It helps students connect theoretical concepts with practical applications and industrial relevance.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course Teacher will ensure to:<br>1. Explain the mechanisms of drying, crystallization, and adsorption.<br>2. Conduct experiments using equipment like evaporators and membrane separation units.<br>3. Compare experimental results with theoretical models.<br>4. Guide about material balances and calculation of operational efficiencies.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to:<br>1. Analyze drying behavior, determine drying rates, and calculate drying time.<br>2. Perform material balance and evaluate efficiencies in crystallization, evaporation, and membrane processes.<br>3. Interpret adsorption data and optimize adsorption systems.<br>4. Correlate laboratory findings with theoretical mass transfer principles.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | – | – | – | – | – | – | – | 2 |
| CO2 | 3 | 2 | 3 | 2 | – | – | – | – | – | – | – | 2 |
| CO3 | 3 | 3 | 2 | 2 | – | – | – | – | – | – | – | 2 |
| CO4 | 3 | 3 | 2 | 3 | – | – | – | – | – | – | – | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No. | List of Experiments | Hours |
|---|---|---|
| **1.** | Study of drying of wet material and to calculate rate of drying in Tray Dryer. | **02** |
| **2.** | Determination of the batch time of drying of a given material using fluidized bed dryer & compare the same with the theoretical equation. | **02** |
| **3.** | Determination the humidity of air by dew point method | **02** |
| **4.** | Calculation of the economy and overall heat transfer coefficient of Pan evaporator. | **02** |
| **5.** | Study of the process of crystallization in an agitated batch crystallizer/ To find the yield of crystals in batch crystallizer | **02** |
| **6.** | Estimate the yield of crystals in batch crystallizer | **02** |
| **7.** | Verification of the Freundlich Equation by an adsorbing acetic acid on activated carbon from an acetic acid solution and estimation of the constants of the equation. | **02** |
| **8.** | Study of the Reverse Osmosis membrane performance. | **02** |
| **9.** | Study of the Ultra filtration/Microfiltration membrane performance. | **02** |
| **10.** | Study of the operation of rotary dryer. | **02** |

**Suggested Text Books/ Reference Books/Manual**


| | |
|---|---|
| 1. | R. E. Treybal, 1983 Mass Transfer Operations, 3rd Ed., McGraw Hill. |
| 2. | McCabe W L, Smith J C, Harriot P,2021, Unit Operations of Chemical Engineering,7th edition, McGraw Hill. |
| 3. | Green D. and Perry R., 2007, Perry’s Chemical Engineers' Handbook, 8th Edition, McGraw-Hill Professional Pub. |
| 4. | C.J. Geankoplis, 1993, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall India. |
| 5. | A. S. Foust, 1980, Principles of Unit Operations, 2nd Ed., Wiley. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech. (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | PCC322 | | | | | | |
| Course Category | Professional Core Course | | | | | | |
| Course title | **Chemical Equipment & Plant Design** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | PCC 224, PCC 221, PCC312, PCC321 | | | | | | |
| Course Rationale | This course enables one to learn about the complete process design of Pressure vessel, Storage vessel, Reactor, Heat Exchanger, Evaporator, Packed column and Distillation column. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Discuss design parameter basics i.e. Commonly used in process equipment's design.<br>2. Describe design of pressure vessels subjected to internal and external pressures.<br>3. Illustrate design of special vessels (e.g. tall vessels) and various parts of vessels.<br>4. Impart knowledge of shell & tube heat exchanger design.<br>5. Demonstrate design of reactor and agitator system.<br>6. Elaborate equipment testing methods related to process hazard & its safety. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Identify various design preliminaries.<br>2. Evaluate and design various parts of Pressure Vessel.<br>3. Design storage vessel and Tall Vessel.<br>4. Develop a design for Heat Exchanger and Evaporator.<br>5. Formulate reactor systems and agitator system.<br>6. Express different safety measures. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | - | - | - | - | - | - | - |
| CO2 | 3 | 3 | 2 | - | 2 | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - |
| CO5 | 3 | 3 | 3 | 2 | 2 | - | - | - | - | - | - | - |
| CO6 | - | - | - | - | - | 3 | 2 | 2 | | 2 | 2 | 3 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Design Preliminaries:** Design codes, Maximum working pressure, Design pressure, Design temperature, Various mechanical properties of the material, Different methods of fabrication, Different types of welding joints, Joint efficiency, Weld joint efficiency factor, Radiography, Design stress, & factor of safety, Corrosion allowance & their types, Design wall thickness. | **06** |
| II. | **Design of Pressure Vessel and storage vessels:** Classification of pressure vessels, Codes and Standards for pressure vessels, Design of pressure vessels under internal and external pressures, Design of thick-walled high-pressure vessels, Design of Gasket, Flanges, Nozzle, Design of spherical vessels, Numerical, Storage of fluids, Different types of storage vessels, Design of cylindrical storage vessels with roof. | **08** |
| III. | **Tall Vessels & Support for Process Vessels:** Define tall vessel & their types, Stress distribution in design of tall vessel, Support & their classifications, Design of Bracket Support, Lug Support, Skirt Support & Saddle support. | **06** |
| IV. | **Design of Heat Exchanger and Evaporator:** Types of heat exchangers, Special type of heat exchangers, Design of Shell & Tube Heat Exchanger, Types of evaporators, Entrainment Separators, Design of Standard Short Tube, Vertical Evaporator. | **08** |
| V. | **Design of Reaction Vessel and Agitator:** Classification of reaction vessel, Heating systems, Design consideration, Types of agitators, Baffling, Power requirements for agitation, Design of agitation system components. | **06** |
| VI. | **Equipment testing methods, Process Hazards & Safety:** Hydrostatic Pressure test, Pneumatic pressure test, Dye penetrant test, Magnetic test, Ultrasonic test, Freon test, Radiography test, Hazards in Process Industry, Analysis of Hazards, Safety Measures, Safety measures in Equipment Design, Pressure Relief Devices. | **06** |
| | **Text Books** | |
| 1. | B. C. Bhattacharya, “Introduction to chemical equipment design” (Mechanical accepts) 1985. | |
| 2. | M. V. Joshi, “Process equipment design” McMillan India Ltd. 1981. | |
| 3. | Dr. S.D. Dawande, “Process Design of Equipment”, Central Techno Publication, 1$^{st}$ Edition 1999. | |
| | **Reference Books** | |
| 1. | Coulson & Richardson’s Chemical Engineering (Vol. VI) Chemical Engineering Design ", fourth edition, R. K. Sinnott, Elsevier Butterworth-Heinemann,2005 | |

| Year, Program, Semester | T.Y. B.Tech(Chemical Engineering), Part III, Semester VI | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | ESC321 | | | | | | |
| Course Category | Engineering Science Course | | | | | | |
| Course title | **Chemical Equipment & Plant Design (Laboratory)** | | | | | | |
| Teaching SchemeandCredits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | - | - | 02 | 02 | 01 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | - | - | 50 | - | - | - | 50 |
| Pre-requisites(if any) | BCS 111/121, BCS 112,122, ESC 113,123, BCS 212,PCC 211,PCC 221,224 | | | | | | |
| Course Rationale | This laboratory course provides hands-on experience in the design, analysis, and evaluation of key chemical process equipment such as heat exchangers, reactors, distillation columns, and pressure vessels, as well as the layout and integration of these units into a functional plant. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Provide hands-on experience in the design and analysis of chemical process equipment.<br>2. Introduce simulation tools and CAD software relevant to plant and equipment design.<br>3. Enable students to interpret and prepare technical documentation such as PFDs and P&IDs. | | | | | | |
| Course Outcomes | Students will be able to:<br>1. Design and simulate chemical process equipment using engineering principles and software tools.<br>2. Analyze operational and mechanical aspects of typical process equipment such as heat exchangers, reactors, and distillation columns.<br>3. Develop and interpret Process Flow Diagrams (PFDs) and Piping & Instrumentation Diagrams (P&IDs). | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| CO3 | 2 | 2 | 3 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

**General Instructions:** Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

| Experiment No. | List of Experiments | Hours |
|---|---|---|
| **1.** | Standard equipment symbols, Standard instrumentation symbols | **02** |
| **2.** | Heads or closures and Flanges | **02** |
| **3.** | Design of Pressure Vessel | **02** |
| **4.** | Design of Storage Vessel | **02** |
| **5.** | Design of Supports-Bracket, Lug, skirt and Saddle support | **02** |
| **6.** | Design of Fractional distillation column | **02** |
| **7.** | Design of Heat exchangers- Shell and tube heat exchanger | **02** |
| **8.** | Design of Reaction vessel | **02** |
| **9.** | Design of Evaporator | **02** |
| **10.** | Design of Agitation system | **02** |
| **11.** | Design of Absorption tower | **02** |

**Suggested Text Books/ Reference Books/Manual**


| | |
|---|---|
| 1. | B. C. Bhattacharya, “Introduction to chemical equipment design”, Mechanical Aspects, 1985. |
| 2. | M. V. Joshi, “Process equipment design” McMillan India Ltd. 1981. |
| 3. | Dr. S.D. Dawande, “Process Design of Equipment”, Central Techno Publication, 1st Edition, 1999 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech.(Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | PEC321.1 | | | | | | |
| Course Category | Professional Elective Course | | | | | | |
| Course title | **Petroleum Refinery Engineering (Elective I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC111, PCC 211, BSC211, PCC311 | | | | | | |
| Course Rationale | This elective course provides an overview of the integrated petroleum refining industry, its feedstock, and the processes used to transform crude oil and intermediate streams into finished products. It covers hydrocarbon and non-hydrocarbon chemistry, crude oil properties, and petroleum product quality. Each refining process is displayed and includes a description and conditions of operation, feedstock and catalyst selection, product yield, process parameters, plant performance and property relationships. This course provides key insights into primary and secondary processes for petroleum products. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Explain the composition of petroleum and the allied topics.<br>2. Discuss the crude oil properties and concepts of crude oil distillation.<br>3. Describe a various cracking process and catalytic reforming process.<br>4. Discuss the hydro treating and hydrocracking process.<br>5. Explain the isomerisation, alkylation and polymerisation process.<br>6. Summarise the environmental issues in petroleum refinery. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Recognize the composition of petroleum products.<br>2. Understand the properties of crude oil and basic concept of distillation.<br>3. Perceive the various cracking process and reforming process used in the refinery. Differentiate the hydro treating and hydrocracking process.<br>4. Express the knowledge of isomerisation, alkylation and polymerisation process.<br>5. Aware about the actual environmental issues faced by the refinery industries.<br>6. Describe the environmental issues in petroleum refinery. | | | | | | |

### Course Outcome and Program Outcome Mapping

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | - | - | 1 | 1 | - | - | - | - | 1 |
| CO2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO4 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO5 | 3 | 2 | 1 | - | - | 1 | - | - | - | - | - | - |
| CO6 | 3 | - | - | - | - | 1 | 3 | - | - | - | - | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction to Composition of petroleum, laboratory tests, refinery feed stocks and products:** General Definitions, Introduction to petroleum refinery, Classification of Crude oil, Characterization of crude oil ,Composition of crude, Physical properties, Crude oil; analysis and distillation, Introduction to refinery "feedstock/s" and refinery products. | 05 |
| II. | **Evaluation of crude oil properties and Design of crude oil distillation column and Furnace Design:** Dehydration and desalting of crude, Crude Assay ASTM TBP distillations evaluation of crude oil properties, API gravity various average boiling points and mid percent corves, Evaluation of properties of crude oil and its fractions, Design concept of crude oil distillation column design, Types of furnaces used in process plant, Furnace heat transfer, Hot gases as heat source. | 07 |
| III. | **Thermal, Catalytic cracking and Catalytic reforming:** Coking and Thermal process, Delayed coking, Catalytic cracking, Cracking reactions, Zeolite catalysts, Cracking Feed stocks and reactors, Effect of process variables, FCC Cracking, Catalyst coking and regeneration, Design concepts, New Designs for Fluidized-Bed Catalytic Cracking Units, Objective and application of catalytic reforming process reforming catalysts, Reformer feed reforming reactor design continuous and semi regenerative process. | 07 |
| IV. | **Hydro treating and Hydrocracking:** Objectives & Hydrocracking Reactions, Hydrocracking feed stocks, Modes of Hydrocracking, Effects of process variables, Hydro treating process and catalysts Resid hydro processing, Effects of process variables, Reactor design concepts. | 06 |
| V. | **Isomerization, Alkylation and Polymerization:** Isomerization process, Reactions, Effects of process variables, Alkylation process, Feed stocks, reactions, products, catalysts and effect of process variables, Polymerization: Objectives, process, Reactions, catalysts and effect of process variables. | 07 |
| VI. | **Lube oil manufacturing, Environmental issues and New Trends in petroleum refinery operations:** Lube oil processing: propane deasphalting Solvent extraction, dewaxing, Additives production from refinery feedstocks, Ecological | 07 |

| | | |
|---|---|---|
| | 07consideration in petroleum refinery, Waste water treatment, control of air pollution, New trends in refinery, Alternative energy sources, Biodiesel, Hydrogen energy from biomass. | |
| | **Text Books** | |
| 1. | Bhaskara Rao, B. K., (1990), Modern Petroleum Refining Processes, 2nd Edition, Oxford and IBH Publishing Company, New Delhi. | |
| 2. | Prasad, R., (2008), Petroleum refining technology, 1st Edition, Khanna Publishers. | |
| 3. | Gary, J.H., Handwerk, G.E., Kaiser, M.J, (2007), Petroleum Refining: Technology and Economics, 5th Edition, CRC Press. | |
| **Reference Books** | | |
| 1. | Nelson, W. L., (1985), Petroleum Refinery Engineering, 4th Edition, McGraw Hill, New York. | |
| 2. | Meyers, R. A., (1986), Handbook of Petroleum Refining Processes, McGraw Hill. | |
| 3. | Hobson, G. D., Phol, W., (1975), Modern Petroleum Technology, 4th Edition, Applied science Publishers. | |
| **Useful web links** | | |
| 1. | **https://archive.nptel.ac.in/courses/1-3/1-2/1-31-2-22/** | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | PEC321.2 | | | | | | |
| Course Category | Professional Elective Course | | | | | | |
| Course title | **Polymers: Concepts, Properties, Uses and Sustainability (Elective I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC111, BSC211, PCC 212, BSC 221, PCC312, PCC313 | | | | | | |
| Course Rationale | This course introduces basic concepts related to polymeric materials, engineering estimations about their properties, various applications and their impact on sustainability. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Explain basic concepts of polymer and its features.<br>2. Discuss the molecular arrangements of polymer and its states.<br>3. Describe the copolymers and composite of polymers.<br>4. Discuss the viscoelasticity properties of polymers.<br>5. Elaborate the polymer processing and polymerization kinetics.<br>6. Summarise biodegradable polymer and rheological models. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Understand basic concepts of polymer.<br>2. Understand the molecular arrangements of polymers.<br>3. Perceive the copolymers and composite.<br>4. Express the knowledge of visco elasticity properties of polymers.<br>5. Acquired the knowledge of polymer process and polymerization kinetics.<br>6. Aware about biodegradable polymer and rheological models. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | - | - | 1 | 1 | - | - | - | - | 1 |
| CO2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO4 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO5 | 3 | 2 | 1 | - | - | 1 | - | - | - | - | - | 1 |
| CO6 | 3 | - | - | - | - | 1 | 3 | - | - | - | - | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction of polymer and its features:** Polymers: Molecular structure and synthesis; Polymers: basic terms; Biopolymers; Molecular weight and distribution; Polymerization; Renewable sources, Simple concepts related to single macromolecule, Renewable sources for polymers, Polymerization / depolymerization, States of interest, Application based terms, Reuse and repurpose, Molecular conformations, Size, mobility and flexibility, Polyelectrolytes. | **05** |
| II. | **Molecular arrangements and states of polymers:** Structures in biopolymers, Amorphous / crystalline states, Orientation, Interactions, Kinetics of crystallization, Glass transition, Polymeric systems of different kind, States in environment, Liquid crystalline polymers, Copolymers, Blends. | **07** |
| III. | **Blends, copolymers and composites:** Microstructure in polymers, Composites, Stress strain response, Additives for polymeric systems, Blends / composites in recycling, Physical / chemical crosslinking, Mechanical properties, Physico-chemical, mechanical and electrical properties of polymers, Physical and chemical aging, Solutions: properties, Conducting polymers, Dielectric response, Plasticity, Properties of composites. | **07** |
| IV. | **Viscoelasticity in polymers:** Viscoelasticity: introduction, Thermal response, Viscoelasticity: characterization, Viscoelasticity – simple models, Dynamic mechanical analysis, Damping Applications, Time Temperature, superposition, Impact and energy absorption, Viscoelasticity in polymers / Interaction of polymers with other materials, Testing for applications, Properties of blends, Biomimetic polymers, Advanced mechanics, Viscoelastic response: examples, Polymer packaging, Porous polymers / membranes, Polymer at interfaces, Diffusion in polymers. | **06** |
| V. | **Polymers processing:** Polymers with other materials, Compatibilizers, Biopolymer applications, Adhesives and Paints, Dissolution and recovery, Polymerization kinetics, Polymerization reactors, Polymer processing, Polymers processing and recycling techniques, Flow simulations, Processing for recycling, Recycle, updown cycling, Flow behaviour - rheology, Crosslinking, Conversion of polymers. | **07** |
| VI. | **Biodegradable polymers:** Recycling techniques, Rheology and entanglement, Rheological models, Rheology and processing, Absorption and leaching, Swelling of polymers, Viscosity for polymer processing, Polymeric materials in nature, Microplastics, aerosols, sediments, Biodegradation of polymers, Biodegradable polymers. | **07** |
| | **Text Books** | |
| 1. | Billmeyer, F.W., (1984), Text Book of Polymer science, 3$^{rd}$ ed., Wiley & sons. | |
| 2. | Gowariker, V.R., Vishwanathan, N. V., Sreedhar, J., (1986), Polymer Science, New Age International Publishers. | |

| | |
|---|---|
| 3. | Odian, G., (2004), Principles of Polymerization, 4th ed., Wiley. |
| 4. | Hiemenz. P.C., Lodge. T.P., (2007), Polymer Chemistry, 2nd ed., CRC Press. |
| 5. | Brydson, J.H., Gosselin, C.C., (1968), Introduction to plastics, London: Newnes. |

| **Reference Books** | |
|---|---|
| 1. | Sharma, B.K., (2020), Polymer chemistry, Krishna Prakashan Media |
| 2. | Bhatnagar, M.S., (2012), Text Book of polymer, S. Chand Publishing |
| 3. | Winding, C.C., Hiatt, G.D., (1961), Polymeric Materials, McGraw Hill Book Co. |
| 4. | Brydson, J.A., (1980), Plastic materials,2nded., Newnes-Butterwarths |
| **Useful web links** | |
| 1. | **https://archive.nptel.ac.in/courses/1-3/1-6/1-51-62-5/** |

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|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y. B. Tech. (Chemical Engineering), Part III, Semester V | | | | | | |
| Course Code | PEC321.3 | | | | | | |
| Course Category | Professional Elective Course | | | | | | |
| Course title | **Fertilizer Engineering (Elective I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC211, BSC 221, HSMEC 211, PCC 223 | | | | | | |
| Course Rationale | This course focuses on methods of production of fertilizer and covers the various types of fertilizer like including Nitrogenous fertilizers, Potash Fertilizer, Complex fertilizer and Bio fertilizers. It is therefore vital for chemical engineers to understand for each fertilizer product, its flow diagram for industry production. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Explain basic concepts of fertilizer.<br>2. Discuss nitrogen fertilizer.<br>3. Describe phosphorus fertilizer.<br>4. Discuss potash fertilizer and its application.<br>5. Explain the compound fertilizer and its properties.<br>6. Elaborate environmental issues in fertilizer industry. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Explore the basic concepts of fertilizer to make a more efficient and sustainable.<br>2. Perceive the importance of nitrogen fertilizer. Because it's essential for plant growth.<br>3. Outline the production and characteristics of phosphorus fertilizer.<br>4. Differentiate the potash and phosphorus fertilizer.<br>5. Identify the importance of compound fertilizer and its production.<br>6. Aware about the environmental issues in fertilizer industry. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | - | - | 1 | - | - | - | - | - | 1 |
| CO2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO3 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |
| CO4 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | 3 | 2 | 1 | - | - | 1 | - | - | - | - | - | - |
| CO6 | 3 | - | - | - | - | 1 | 3 | - | - | - | - | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction to fertilizers:** Chemical fertilizers and organic manures – types of chemical fertilizers, nitrogenous fertilizers – methods of production of ammonia and urea. | 05 |
| II. | **Nitrogen Fertilizer:** Nitrogen sources - nitric acid, ammonium sulphate, ammonium sulphate nitrate, ammonium nitrate, ammonium chloride – their methods of production, characteristics, and storage and handling specifications. | 07 |
| III. | **Phosphorus fertilizer:** Phosphatic fertilizers - raw materials, phosphate rock, sulphur pyrites, process for the production of sulphuric and phosphoric acids, ground phosphate rock, bone, single super phosphate, triple super phosphate – methods of production, characteristics and specifications. | 07 |
| IV. | **Potash fertilizer:** Potassic fertilizers, potassium chloride, potassium sulphate, potassium schoenite – methods of production, specification, characteristics, complex fertilizers. | 06 |
| V. | **Compound Fertilizer:** NPK fertilizers, mono-ammonium phosphate, di-ammonium phosphate, nitro phosphate – methods of production. | 07 |
| VI. | **Fertilizers and Environment:** Environmental issues related to the use of fertilizer, Impact of fertilizer on environment, Environment impact of the fertilizer industry, Environment impact of the solid fertilizer industry. | 07 |
| | **Text Books** | |
| 1. | Biswas, D.R., (2021), A Textbook of Fertilizers, New India Publishing Agency- Nipa | |
| 2. | Chaduvula, A. I. R., Kvd P., (2022), Fertilizer Technology for Chemical Engineers: The Best Fertilizer for Its Knowledge is the Image of Its Reader, Scholars' Press | |
| | **Reference Books** | |
| 1. | Collings, G.H., (1955), Commercial Fertilizers ($5^{th}$ ed.), McGraw Hill, New York. | |
| 2. | Editorial board-Handbook on fertilizer technology, The Fertilizer Association of India, New Delhi, 1977. | |
| 3. | Slacks, A.V.,(1966), Chemistry and Technology of Fertilizers, Interscience, New York. | |
| | **Useful web links** | |
| 1. | https://archive.nptel.ac.in/courses/1-3/1-7/1-31-7-86/ | |

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|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y.B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | PEC321.4 | | | | | | |
| Course Category | Professional Elective Course | | | | | | |
| Course title | **Technology for Clean and Renewable Energy Production (Elective I )** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites(if any) | Fundamentals of Thermodynamics, Heat Transfer, Fluid Mechanics | | | | | | |
| Course Rationale | This course aims to equip students with the knowledge and skills to contribute effectively to the development and implementation of sustainable energy solutions, addressing environmental challenges and fostering innovation in energy production. | | | | | | |
| Course Objectives | The course teacher will:<br>1. Explain the principles and applications of various clean and renewable energy technologies.<br>2. Compare the advantages and limitations of different energy production methods.<br>3. Conduct feasibility studies for implementing renewable energy projects.<br>4. Develop conceptual designs for renewable energy systems tailored to specific needs.<br>5. Describe current research and developments in the field of renewable energy.<br>6. Elaborate various simulation tools to model energy production scenarios. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Understand the fundamental principles and classifications of clean and renewable energy technologies.<br>2. Analyze the environmental and economic impacts of various energy production methods.<br>3. Evaluate the efficiency and feasibility of different renewable energy systems.<br>4. Design basic systems for energy production utilizing clean and renewable technologies.<br>5. Assess the challenges and advancements in integrating renewable energy into existing infrastructures.<br>6. Apply relevant software tools for modeling and simulation of renewable energy systems. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | - | - | - | - | 2 | - | - | - | - | - |
| CO2 | 2 | 3 | - | - | - | - | 2 | - | - | - | - | - |
| CO3 | 2 | 3 | 2 | - | - | - | 2 | - | - | - | - | - |
| CO4 | 2 | 2 | 3 | 2 | - | - | 2 | - | - | - | - | - |
| CO5 | 2 | 2 | - | 3 | 3 | - | 2 | - | - | - | 2 | - |
| CO6 | 2 | 2 | 2 | - | - | - | - | 2 | 3 | 2 | - | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction to Energy Systems and Sustainability:** Overview of global energy demand and supply, Definitions and importance of clean and renewable energy, Sustainability and environmental considerations, Case studies on successful implementation of renewable energy projects. | **05** |
| II. | **Solar Energy Technologies:** Principles of solar radiation and photovoltaic effect, Design and operation of solar thermal and photovoltaic systems, Applications and integration of solar energy in various sectors, Advancements in solar energy materials and efficiency improvements. | **07** |
| III. | **Wind and Hydropower Energy Systems:** Fundamentals of wind energy conversion and turbine technology, Site assessment and design considerations for wind farms, Principles and types of hydropower systems, Environmental and social impacts of wind and hydropower projects. | **07** |
| IV. | **Biomass and Bioenergy:** Types and sources of biomass feedstocks, Conversion technologies: combustion, gasification, and anaerobic digestion, Biofuels production and applications, Economic and sustainability aspects of bioenergy. | **06** |
| V. | **Emerging Renewable Energy Technologies:** Overview of geothermal and ocean energy systems, Hydrogen production, storage, and fuel cell technology, Integration of renewable energy sources into smart grids, Policy frameworks and incentives for emerging technologies. | **07** |
| VI. | **Energy Storage and Integration:** Importance of energy storage in renewable systems, Types of energy storage technologies: batteries, thermal storage, and pumped hydro, Challenges in integrating renewable energy into the grid, Case studies on energy storage solutions and grid management. | **07** |
| | **Text Books** | |
| 1. | Sabonnadière, J.-C. (2009). Renewable Energy Technologies. Wiley-ISTE. | |
| 2. | Peake, S. (2021). Renewable Energy: Ten Short Lessons. Johns Hopkins University Press. | |
| | **Reference Books** | |

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|---|---|
| 1. | Verma, T. N., Singh, R., Rajak, U., Nashine, P., Dwivedi, G., & Kumar, A. (2023). Clean Energy: Technology, Advances, and Applications. CRC Press. |
| 2. | Pehcevski, J. (2021). Clean and Renewable Energy. Arcler Press. |
| 3. | Lovins, A. B. (2011). Reinventing Fire: Bold Business Solutions for the New Energy Era |
| **Useful web links** | |
| 1. | **https://onlinecourses.nptel.ac.in/noc19_ch26/preview** |

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|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y.B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | PEC321.5 | | | | | | |
| Course Category | Professional Elective Course | | | | | | |
| Course title | **Waste to Energy Conversion (Elective I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC211, BSC 221, HSMEC 211, PCC 223 | | | | | | |
| Course Rationale | This course introduces students to the scientific, engineering, and socio-economic aspects of transforming waste into renewable energy. This course equips students with the knowledge and skills to tackle environmental challenges, improve resource efficiency, and contribute to a circular economy. | | | | | | |
| Course Objectives | The course teacher will:<br>1. Classify various types of waste and their potential for energy conversion.<br>2. Illustrate the working principles of thermochemical, biochemical, and physicochemical waste-to-energy processes.<br>3. Describe different waste-to-energy technologies based on efficiency, cost, and environmental impact.<br>4. Explain simplified models for converting municipal, agricultural, and industrial waste into energy.<br>5. Recommend appropriate waste-to-energy solutions for specific waste streams in real-world scenarios.<br>6. Evaluate the sustainability of waste-to-energy practices with respect to environmental, economic, and social dimensions. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Understand the fundamental principles and technologies of waste-to-energy conversion.<br>2. Analyze the physical, chemical, and biological processes involved in energy recovery from waste.<br>3. Evaluate the techno-economic feasibility and environmental implications of different waste-to-energy systems.<br>4. Design basic waste-to-energy systems using appropriate engineering tools and techniques.<br>5. Develop innovative solutions for integrating waste-to-energy technologies in sustainable development. | | | | | | |

| | |
|---|---|
| | 6. Assess global and regional case studies on waste-to-energy initiatives to derive best practices. |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | 2 | - | - | 1 | - | 1 | - | - | 1 |
| CO2 | 3 | 2 | - | 2 | 2 | - | - | - | 1 | - | - | 1 |
| CO3 | - | - | 2 | - | - | 3 | - | 2 | - | - | - | - |
| CO4 | 3 | - | 3 | 2 | 2 | - | - | - | - | - | - | - |
| CO5 | - | - | 3 | 2 | 2 | - | - | 2 | - | 2 | - | 2 |
| CO6 | - | - | 2 | - | 2 | 3 | - | 2 | 2 | 2 | 2 | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Introduction to Waste to Energy Conversion:** Overview of waste management and energy demand, Classification and characterization of waste: Municipal solid waste (MSW), industrial waste, agricultural waste, hazardous waste, etc, Potential of waste as a resource: Economic, environmental, and societal benefits, Global and regional status of waste-to-energy initiatives | **06** |
| II. | **Thermochemical Conversion Processes:** Incineration: Principles, types, and system design, Pyrolysis: Mechanisms, reactor types, and applications, Gasification: Working principles, syngas production, and usage, Advantages, limitations, and case studies of Thermochemical processes | **07** |
| III. | **Biochemical Conversion Processes: Anaerobic digestion:** Process biology, reactor configurations, and biogas production, Fermentation: Conversion of organic waste to bioethanol, Microbial fuel cells: Principles and emerging trends. Comparative analysis of biochemical processes and their industrial applications | **07** |
| IV. | **Physicochemical Conversion Processes: Waste**-to-liquid fuel technologies: Transesterification for biodiesel production, Waste-derived hydrogen and other alternative fuels, Integration of physicochemical processes in industrial systems. | **07** |
| V. | **Environmental and Socio-Economic Impacts:** Life cycle assessment (LCA) of waste-to-energy systems, Environmental concerns: Emissions, residues, and sustainability metrics, Economic evaluation: Cost-benefit analysis and project viability, social implications: Public acceptance and community participation in waste-to-energy projects. | **06** |
| VI. | **Future Trends and Innovations:** Emerging technologies: Plasma gasification, algae-based systems, and advanced thermal treatments, Policy frameworks and regulatory aspects for waste-to-energy projects, Global case studies of successful waste-to-energy implementations, Roadmap for integrating waste-to-energy in circular economy models. | **08** |

| | **Text Books** |
|---|---|
| 1. | Klinghoffer, N. B., & Castaldi, M. J. (2013). Waste to Energy Conversion Technology. Woodhead Publishing. |
| 2. | Young, G. C. (2010). Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons. John Wiley & Sons. |
| **Reference Books** | |
| 1. | Karagiannidis, A. (Ed.). (2012). Waste to Energy: Opportunities and Challenges for Developing and Transition Economies. Springer. |
| 2. | Williams, P. T. (2013). Waste Treatment and Disposal (2nd ed.). John Wiley & Sons |

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|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y.B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | OEC 321.1 | | | | | | |
| Course Category | Open Elective Course | | | | | | |
| Course title | **Economics and Management for Industry (Open Elective-I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 03 | - | - | 03 | 03 | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC211, BSC 221, HSMEC 211, PCC 223 | | | | | | |
| Course Rationale | This course introduces essential concepts in economics and management. It covers economic issues, national income, inflation, food processing industries, and the fundamentals of management, production, finance, and marketing, all with a focus on industrial relevance. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. Provide basics of micro and macroeconomics relevant to industries.<br>2. Analyze industrial structures, market conditions, and growth factors.<br>3. Teach cost concepts, production functions, and pricing strategies.<br>4. Explore market structures like monopoly, oligopoly, and perfect competition.<br>5. Evaluate government policies and their effects on industries.<br>6. Introduce financial management, investment decisions, and capital management. | | | | | | |
| Course Outcomes | After completing the course, students will be able to:<br>1. Explain economic concepts and their application in industry.<br>2. Analyze industrial structures and government policy impacts.<br>3. Apply cost and production theories for business optimization.<br>4. Differentiate market structures and assess competition.<br>5. Evaluate financial data and investment decisions for profitability.<br>6. Develop business plans and apply management principles. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 2 |
| CO2 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | - | - | - | 2 | - |
| CO3 | 2 | 3 | 3 | 2 | 2 | 3 | 1 | - | - | - | 2 | 3 |
| CO4 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | - | 3 | - | 2 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | - | - | 2 | 2 | - |
| CO6 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | - | 3 | 3 | 2 | 2 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Demand Analysis and Forecasting:** Economic problem, law of diminishing utility, consumer surplus. Demand: concepts, types of demand, demand function, law of demand and determinant of demand, Forecasting concept, types, steps and techniques of demand forecasting. | 06 |
| II. | **Market and Inflation:** Concepts of costs, cost curves and revenue curves of a firm Market, break-even point Market: Meaning, types of market – Perfect Competition, Monopoly, Oligopoly, and Monopolistic Competition. Inflation: Causes, measurement, effects, controlling of inflation. Index Numbers. | 08 |
| III. | **Industrialization:** Need, Importance and Problems, Classification of Industries: role, problems and remedies, Industrial Productivity: norms, measurement, importance and Factors affecting productivity. New Economic Reforms: Liberalization, Privatization and Globalization GATT, WTO agreement, foreign exchange. | 08 |
| IV. | **Principles of Management:** Definition, nature, levels of management, functions of management. Planning Nature, importance, types of plans, planning process, decision making. Organization: Principles of organization, organizational structure. Directing, Theories of Motivation, Communication: process and barriers, Leadership styles, Controlling: Control techniques. | 07 |
| V. | **Production Management:** Production Management: Definition, Objectives, Functions and Scope, Production Planning and Control; its significance, stages in production planning and control. Concepts of material management and inventory control: importance and various methods. | 05 |
| VI. | **Financial and Marketing Management:** Financial Management: Scope and importance, capital structure planning, working capital management, sources of funds. Marketing Management: Definition of marketing, marketing concept, objectives and functions of marketing. Marketing Research – Meaning; Definition; objectives; Importance; Limitations. Advertising – meaning, objectives, functions. | 06 |
| | **Text Books** | |
| 1. | Divedi, D.N, "Managerial Economics". Vikas, New Delhi,2003 | |
| 2. | Ahuja, H.L, "Advanced Economic Theory". S. Chand Publication, New Delhi,2017 | |
| 3. | Gupta, R.S., Sharma, B.D., Bhalla, N.S, "Principles and Practice of Management". Kalyani Publishers,2018 | |
| 4. | Pugel. T.A, "International Economics". McGraw-Hill Education, 16th edition,2016 | |
| | **Reference Books** | |
| 1. | Koutsoyiannis, "Modern Microeconomics". Macmillan Press Ltd.,2008 | |
| 2. | Jhingan, M.L,"Principles of Economics" (Hindi and English), Vikas, New Delhi,2019 | |
| 3. | Seth, M.L., "Principles of Economics" (Hindi and English), Laxmi Narayan, Agra, 2020 | |
| 4. | Ahuja, H.L., "Economic Environment of Business - Macroeconomic Analysis" S. Chand Publication, New Delhi, 2019. | |
| 5. | Ahuja, H.L., "Macro Economics Theory and Policy" S. Chand Publication, New Delhi, 2019. | |

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|---|---|---|---|---|---|---|---|
| Year, Program, Semester | T.Y.B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
| Course Code | OEC 321.2 | | | | | | |
| Course Category | Open Elective Course | | | | | | |
| Course title | **Environmental Pollution Control (Open Elective-I)** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | | **Total Credits** | |
| | 03 | - | - | 03 | | 03 | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | 30 | 70 | - | - | - | - | 100 |
| Pre-requisites (if any) | BSC211, PCC211, PCC221, PCC311, HSMEC311 | | | | | | |
| Course Rationale | This course introduces chemical, physical, and biological treatment processes for industrial pollution control. It focuses on pollution prevention, waste minimization, and understanding environmental regulations. Students will learn treatment processes, risk assessments, and strategies for controlling pollution across different industries. | | | | | | |
| Course Objectives | The course teacher ensures to:<br>1. Explain pollution types, effects, control methods, and related laws and standards.<br>2. Discuss sources, properties, measurement, control methods, and efficiency analysis of air pollution.<br>3. Brief about water pollution sources, properties, measurement, and control techniques.<br>4. Describe noise and odor pollution, and waste management practices in chemical industries.<br>5. Explain pollution prevention strategies for industrial processes.<br>6. Guide about selection of appropriate treatment processes for effluents from various industries. | | | | | | |
| Course Outcomes | After completing the course, students will be able to:<br>1. Identify sources, types of pollutants, and their environmental impact, along with related laws and standards.<br>2. Understand causes and preventive measures for air pollution.<br>3. Measure and design wastewater treatment methods, including natural purification processes.<br>4. Implement solid waste, noise, and odor control methods and techniques.<br>5. Select technologies for effluent removal in process industries.<br>6. Understand pollution control in different process industries. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | 3 | 3 | - | - | - | 2 | 1 |
| CO2 | 3 | 2 | - | - | - | 3 | 3 | - | - | - | 3 | 2 |
| CO3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | - | - | - | 3 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | - | - | - | 2 | 2 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 1 | - | - | 3 | 2 |
| CO6 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | - | - | 3 | 3 |

Level of Mapping Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Environmental Pollution:** Definition, causes, effects of pollution, types of pollution, prevention and control of environmental pollution, water and air pollution laws, regulations and standards. Clean development mechanism (CDM), Kyoto protocol. | **05** |
| II. | **Air pollution control in industries:** Air pollution sources, classification, effects of air pollutants on human health, plants, animals, materials. Economic pollution, sampling and measurement of air pollutants, Air pollution control methods and equipment- particulate pollution�separation of particulate matter from effluent gases, particulate collection systems gravity chamber, solid traps, cyclone separator fabric filters, liquids scrubbers and ESP., Numerical problems based on theory. Gaseous pollution control- absorption, adsorption, combustion, removal of SOx, NOx, air pollution control standards: WHO, BIS, MPCB, CPCB | **08** |
| III. | **Water pollution control in industries:** Sources, effects of water pollutants, wastewater characteristics- DO, BOD, COD, TOC, total suspended solids, color and odor, determination of BOD and BOD constants, Water quality standards: ICMR, WHO, MPCB and CPCB, wastewater treatment�activated sludge process, trickling filters, waste stabilization ponds etc. Advanced wastewater treatment UASB, photo catalytic reactors. Removal of heavy metals- methods of removal of mercury, chromium, Removal of nitrogen, phosphorous. Numerical problems based on the theory. | **07** |
| IV. | **Industrial odor and noise control and Solid Waste Management:** sources and solutions, odor control by adsorption and wet scrubbing. Industrial noise pollution: measurement & control, effect on man & environment. Solid Waste Management: Sludge treatment and disposal, industrial hazardous waste management, waste minimization concept. Concept of common effluent plant, | **05** |
| V. | **Pollution control in major process industries:** Introduction to pollution control, Pollution control aspects of fertilizer industry: Introduction to pollution control in the fertilizer industry. Removal of carbon in ammonia plant effluents by | **07** |

| | | |
|---|---|---|
| | scrubbing with liquids using vacuum filtration, Removal of oil in ammonia plant effluents, Removal of hydrogen sulphide in ammonia plant effluent | |
| **VI.** | **Pollution control in major process industries**: Pollution control in petroleum and petrochemical Units: Introduction, Refinery Liquid-based treatment methods: Oxidation Pond treatment, disposal of sludge Treatment of liquid effluents from petrochemical industries, Removal of hydrogen sulphide gas from sour gas by stripping, Removal of ammonia from gases. Alcohol industry: Treatment method by recovery of potash from distillery spent-wash | **07** |
| | **Text Books** | |
| 1. | Rao, C.S., "Environmental Pollution Control Engineering," New Age International (P) Ltd, New Delhi, 2018 | |
| 2. | Peavy, H.S., Rowe, D.R., Tchobanoglous, G., "Environmental Engineering," McGraw-Hill Book Company Limited, New York, 1985 | |
| 3. | Metcalf & Eddy, "Wastewater Engineering: Treatment and Reuse," Tata McGraw Hill Publishing Company Limited, New Delhi, 2003. | |
| 4. | Mahajan, S.P., "Pollution Control in Process Industries," Tata McGraw Hill Publishing Company Limited, New Delhi, 1985 | |
| 5. | Davis, M.L., Cornwell, D.A., "Introduction to Environmental Engineering," McGraw-Hill Series in Water Resources and Environmental Engineering, New York, 2012. | |
| | **Reference Books** | |
| 1. | Hilary Theisen and Samuel A, Vigil, George Tchobanoglous, “Integrated Solid Waste Management”, McGraw Hill, New York,2019 | |
| 2. | Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001 | |

**Important Note:** Besides these two options for Open Electives, the students are at liberty to choose any other course launched by the other faculty of studies across Shivaji University campus provided the credentials are the same. The students aspiring to choose the courses from other faculty need to apply to the concerned Department for seeking mentoring of the chosen course.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y.B. Tech (Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="7">HSMEC 321</td></tr>
<tr><td>Course Category</td><td colspan="7">Humanities and Social Sciences, Management, Environmental Course</td></tr>
<tr><td>Course title</td><td colspan="7">Industrial Safety and Hazard Management</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td></td><td>01</td><td>-</td><td colspan="2">01</td><td colspan="2">01</td></tr>
<tr><td>Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td></td><td>-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>50</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">HSMEC 311</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course equips chemical engineering students with essential knowledge and practical tools to identify, assess, and manage industrial hazards. It fosters a safety-oriented mind-set through exposure to real-world practices, legal standards, and ethical considerations critical to safe and sustainable plant operations.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will:<br>1. Provide foundational understanding of industrial safety principles and hazard types in chemical industries.<br>2. Introduce tools and techniques for hazard identification and risk assessment.<br>3. Familiarize students with emergency preparedness, accident investigation, and control strategies.<br>4. Create awareness of legal frameworks and safety standards governing industrial operations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students should be able to:<br>1. Identify and classify various types of industrial hazards relevant to chemical processes.<br>2. Apply techniques such as HAZOP, risk matrix, and root cause analysis for hazard management.<br>3. Analyze case studies and formulate preventive and emergency response measures.<br>4. Interpret relevant safety legislation, standards, and codes applicable to industrial operations.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | – | – | – | 2 | 1 | 2 | – | – | – | 1 |
| CO2 | 3 | 3 | – | 3 | 2 | 2 | – | 2 | 1 | – | – | 2 |
| CO3 | 2 | 3 | – | 2 | 2 | 3 | 1 | 3 | 1 | 1 | – | 2 |
| CO4 | 2 | 2 | – | – | – | 3 | 2 | 3 | – | – | – | 1 |

Level of Mapping as: Low 1, Moderate 2, High 3

| Week wise Course Content | | Hours |
|---|---|---|
| Week 1 | Introduction to Industrial Safety: Importance of safety in chemical industries<br>Case study: Bhopal Gas Tragedy (discussion). | **01** |
| Week 2 | Types of Industrial Hazards: Classification: Physical, Chemical, Biological, Ergonomic, Psychosocial, Real-life examples from process plants. | **01** |
| Week 3 | Hazard Identification Techniques: HAZID, HAZOP (introduction), Group activity: Identify hazards in a lab-scale reactor. | **01** |
| Week 4 | Risk Assessment and Management: Risk Matrix, Risk Prioritization, Exercise: Risk scoring for a hypothetical process unit. | **01** |
| Week 5 | Fire and Explosion Hazards: Fire triangle, Flash point, Explosion index, Tutorial: Classify and mitigate a listed fire scenario | **01** |
| Week 6 | Toxic Releases and Control: TLV, IDLH, routes of exposure, Worksheet: Calculate safe exposure durations for given chemicals. | **01** |
| Week 7 | Safety Audits and Checklists: Elements of a safety audit, Group activity: Develop a simple checklist for a chemical lab. | **01** |
| Week 8 | Accident Investigation Techniques: Root cause analysis, Fishbone diagram, Case study: Analyze a real or simulated incident. | **01** |
| Week 9 | Safety in Handling Hazardous Chemicals: MSDS interpretation, Labelling, Handling & Storage protocols, Interactive session: Read & interpret sample MSDS. | **01** |
| Week 10 | Personal Protective Equipment (PPE): Types of PPE, selection criteria, Hands-on: PPE selection exercise for specific chemicals/processes. | **01** |
| Week 11 | Emergency Response Planning: Evacuation, Spill management, First Aid Group simulation: Draft an emergency response plan for a chemical leak. | **01** |
| Week 12 | Safety Regulations and Standards: Factories Act, OSHA, BIS standards, GHS Quiz + Discussion: Legal implications of negligence. | **01** |
| Week 13 | Behaviour-Based Safety (BBS): Human factors in accidents, Safety culture Role play: Unsafe vs Safe behavior scenarios. | **01** |
| Week 14 | Recap + Mini Project Discussion: Review of all tutorials, Assign students a short group-based safety audit mini-project (e.g., lab, plant section, utility area). | **01** |

| Suggested Text Books/ Reference Books/Manual | |
|---|---|
| 1. | D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011. |
| 2. | R.K. Sinnott, Coulson & Richardson's, Chemical Engineering, Vol. 6, Elsevier India, 2006. |
| 3. | Fawcett H.H. and W.S. Wood, Safety and accident prevention in Chemical operations 2$^{nd}$ editon John Wiley and Sons Inc. (1982). |
| 4. | Jain, R. K., & Rao, S. S. (2006). *Industrial Safety, Health and Environment Management Systems*. Khanna Publishers. |
| 5. | Jalihal, D. (n.d.). *Process Safety and Hazard Management* [Online course]. NPTEL. Retrieved from https://nptel.ac.in/courses/103106164 |

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">T.Y.B. Tech (Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="7">AEC321</td></tr>
<tr><td>Course Category</td><td colspan="7">Ability Enhancement Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mini Project IV & Industrial Visit</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td>02</td><td colspan="3">01</td></tr>
<tr><td>Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td></td><td>-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>50</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">Thorough revision of all the courses studied till Semester VI with a vigor to undertake small project work.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">Mini Project IV and Industrial Visit provide students with an opportunity to further develop and apply the knowledge and skills acquired in their previous coursework. It allows them to engage in hands-on experiential learning through project activities and real-world exposure gained from industrial visits. This course aims to bridge the gap between theoretical learning and practical application, fostering a deeper understanding of chemical engineering principles and practices in industrial settings.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will:<br>1. Enable students to independently execute and complete a chemical engineering mini project by integrating all aspects of the curriculum.<br>2. Prepare students for professional roles by emphasizing problem-solving, innovation, and teamwork.<br>3. Facilitate exposure to advanced experimental, computational, or design methodologies in chemical engineering."<br>4. Provide students with practical exposure to real-world industrial operations, processes, and technologies in the chemical engineering domain.<br>5. Bridge the gap between theoretical concepts and industrial practices to enhance understanding of professional environments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, students should be able to:<br>1. Demonstrate the ability to design and optimize chemical processes or systems based on engineering principles.<br>2. Showcase the ability to work collaboratively in teams and manage project timelines effectively.<br>3. Apply modern tools and technologies relevant to chemical engineering in project execution.<br>4. Gain insights into the functioning of chemical industries, including safety, environmental compliance, and process efficiency.<br>5. Develop a better understanding of industrial workflows, teamwork, and professional expectations in a real-world setting</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | 3 | - | - | 2 | 3 | - | - | - | - | - |
| CO2 | 3 | 3 | - | - | 3 | 1 | - | - | 2 | - | - | - |
| CO3 | - | 3 | - | - | 3 | 3 | - | - | 3 | - | 3 | - |
| CO4 | - | 3 | - | 3 | 2 | - | - | - | 1 | - | - | 2 |
| CO5 | - | - | - | - | - | 2 | - | 3 | 2 | 2 | - | 2 |

Level of Mapping as: Low 1, Moderate 2, High

**Course Content**

Mini Project IV and Industrial Visit provide students with an opportunity to further develop and apply the knowledge and skills acquired in their previous coursework. It allows them to engage in hands-on experiential learning through project activities and real-world exposure gained from industrial visits. Throughout the semester, all students will engage themselves in a series of mini projects that challenge them to apply theoretical concepts learned in previous courses to solve practical problems. These projects, conducted in small groups, will cover a range of topics relevant to their field of study, allowing students to explore different facets of their discipline and develop versatile skill sets.

Complementing the mini projects, students will participate in an industrial visit to domain relevant organizations in nearby regions, providing first hand exposure to industry operations, practices, and challenges. These visits will offer valuable insights into the application of theoretical knowledge in real-world settings, helping students understand the relevance and implications of their academic studies.

The course structure is carefully crafted to align with NEP 2020 and Outcome Based Education principles, emphasizing experiential learning, competency development, and holistic skill enhancement. Through active participation in mini projects and industrial visits, students will not only deepen their understanding of academic concepts but also cultivate essential soft skills such as teamwork, problem-solving, and effective communication.

Each week, students will dedicate two hours to course activities, including project discussions, progress updates, and preparation for industrial visits. Faculty guidance and mentorship will be provided to support students throughout their project work and industrial experiences, ensuring they maximize their learning outcomes and derive meaningful insights from their engagements.

By the end of the semester, students will emerge with a comprehensive understanding of how theoretical knowledge translates into practical applications within the industry, equipping them with the competencies and confidence to thrive in their future careers.

| Course Assessment Method |
|---|
| The course evaluation will be at the course teacher end. The teachers will follow the instructions as below:<br>Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:<br>• Rubric-based assessment for mini projects and industrial visit reports.<br>• Peer evaluation for team-based projects.<br>• Written exams or quizzes to assess theoretical knowledge.<br>• Instructor-led discussions or presentations to evaluate communication skills and critical thinking.<br>• Overall course grading based on a weighted average of individual assessments and participation.<br>The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey. |

| Reference Books | |
|---|---|
| 1. | Ray, M. S., (1998), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), CRC Press. |
| 2. | Turton, R., Bailie, R.C., Whiting, W.B., Shaeiwitz, J.A., & Bhattacharyya, D., (2013), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), Prentice Hall. |
| 3. | Goyal, M., & Choudhary, S.K., (2016), Industrial Visits and Study in Chemical Process Industries, IK International Publishing House Pvt. Ltd. |

| Useful web links/U-Tube Links | |
|---|---|
| 1. | https://youtu.be/C9Q0HCGa_8I?si=rzIo0XB75vWGtdS1 |
| 2. | The students can search on u-tube for the following key words:<br>1. “Chemical Engineering Mini Projects"<br>2. "Chemical Engineering Industrial Visits"<br>3. "Hands-on Projects for Chemical Engineers"<br>4. "Industrial Visits in Chemical Process Industries" |

| Year, Program, Semester | T.Y.B. Tech (Chemical Engineering), Part III, Semester VI | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | VSEC321 | | | | | | |
| Course Category | Vocational and Skill Enhancement Course | | | | | | |
| Course title | **Design Thinking & Innovation – III** | | | | | | |
| Teaching Scheme and Credits | **L** | **T** | **P** | **Total Contact Hours** | **Total Credits** | | |
| | 01 | - | - | 01 | - | | |
| Evaluation Scheme | **ISE** | **ESE** | **IOE** | **IPE** | **EOE** | **EPE** | **Total** |
| | - | - | - | IE at Course in charge End | - | | |
| Pre-requisites (if any) | Design Thinking & Innovation – I & II, Mini Project I, II & III | | | | | | |
| Course Rationale | The Design Thinking & Innovation III course aims to bridge the gap between conceptual design and real-world application. By integrating advanced design thinking methodologies with industry-relevant challenges, the course prepares students to develop, validate, and execute innovative solutions. | | | | | | |
| Course Objectives | The Course Teacher will:<br>1. To advance students' capabilities in synthesizing complex design challenges into feasible solutions.<br>2. To refine iterative problem-solving skills through industry-focused projects and case studies.<br>3. To cultivate a proactive, entrepreneurial mindset that addresses sustainability and societal needs. | | | | | | |
| Course Outcomes | Upon completion of this course, students should be able to:<br>1. Analyze complex problems to develop innovative, user-centric design solutions.<br>2. Apply advanced prototyping techniques to validate and optimize product concepts.<br>3. Collaborate effectively across disciplines to deliver actionable and sustainable innovations. | | | | | | |

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | - | - | 2 | - | - | - | - | - | - |
| CO2 | 2 | - | 2 | 2 | 3 | - | - | - | - | - | - | - |
| CO3 | - | - | - | - | - | - | - | - | 3 | 3 | - | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I. | **Design Thinking Framework Revisited:** Advanced principles of empathy, ideation, and prototyping, Reflection on learning from Design Thinking & Innovation I and II, Introduction to systems thinking in the design context | 02 |
| II. | **Problem Scoping and Opportunity Identification:** Techniques for problem discovery and framing, identifying gaps and opportunities in existing systems, Leveraging tools like Journey Mapping and SWOT Analysis | 02 |
| III. | **Ideation Techniques and Advanced Prototyping:** Brainstorming: Mind Mapping and SCAMPER techniques, Prototyping with a focus on technology integration, Real-world prototyping examples from diverse industries. | 03 |
| IV. | **Validation and Iterative Development:** Usability testing methods and feedback incorporation, Iterative designs models: Agile and Lean principles, Creating Minimum Viable Products (MVPs). | 02 |
| V. | **Innovation Strategy and Entrepreneurship:** Bridging design with business models (Canvas Model), Strategies for market positioning and scaling innovations, Ethical considerations and sustainable innovation practices. | 03 |
| VI. | **Case Studies and Capstone Projects:** Real-world applications of design thinking in Chemical Engineering, Group projects focusing on an innovative solution for an industry-related problem, Presentation and feedback. | 02 |
| | **Text Books** | |
| 1. | Brown, T. (2009). Change by Design. Harper Business. | |
| 2. | Lewrick, M., Link, P., &Leifer, L. (2018). The Design Thinking Playbook. Wiley | |
| | **Reference Books** | |
| 1. | Plattner, H., Meinel, C., &Leifer, L. (2020). Design Thinking Research. Springer. | |
| 2. | Christensen, C. M. (2013). The Innovator's Dilemma. Harvard Business Review Press | |

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">T.Y.B. Tech (Chemical Engineering), Part III, Semester VI</td></tr>
<tr><td>Course Code</td><td colspan="8">MAC 321</td></tr>
<tr><td>Course Category</td><td colspan="8">Mandatory Audit Course</td></tr>
<tr><td>Course title</td><td colspan="8">Aptitude Enhancement Course III</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>01</td><td>-</td><td colspan="2">01</td><td colspan="3">-</td></tr>
<tr><td>Evaluation Scheme</td><td>ISE</td><td>ESE</td><td colspan="2">IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td></td><td>-</td><td>-</td><td colspan="2">IE at Course in charge End</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">Aptitude Enhancement Course I & II</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This course sharpens cognitive skills, decision-making, and industry-relevant problem-solving, preparing students for competitive exams and professional challenges.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The course teacher will:<br>1. Strengthen quantitative and logical reasoning for industry applications.<br>2. Develop decision-making skills through real-world case studies.<br>3. Enhance time-efficient problem-solving for competitive exams.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, students will be able to:<br>1. Apply advanced reasoning techniques to solve real-world problems.<br>2. Analyze data for informed decision-making in industry settings.<br>3. Demonstrate proficiency in aptitude tests and competitive exams.</td></tr>
</table>

**Course Outcome and Program Outcome Mapping**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | 2 | - | - | - | - | - | 2 | - | - |
| CO2 | - | 3 | 2 | 3 | - | - | - | - | 2 | - | - | - |
| CO3 | - | 2 | 3 | - | - | - | - | - | 3 | 3 | 2 | - |

Level of Mapping as: Low 1, Moderate 2, High 3

| Unit No. | Course Content | Hours |
|---|---|---|
| I | **Advanced Engineering Quantitative Aptitude:** Covers algebra, probability, statistics, and matrices, with problem-solving using engineering case studies and peer discussions. | **02** |
| II | **Complex Logical Reasoning & Critical Thinking:** Focuses on advanced puzzles, logical sequences, and network diagrams through group challenges and real-world applications. | **02** |
| III | **Industry-Oriented Decision Making:** Includes engineering-based decision-making, situational judgment tests, and ethical problem-solving via case studies and business strategy games. | **02** |
| IV | **Data Interpretation & Predictive Analytics:** Explores graphs, tables, trend analysis, and predictive analytics, with projects involving industrial datasets and forecasting trends. | **02** |
| V | **Time-Efficient Aptitude Strategies:** Covers speed tests, memory recall techniques, and shortcuts for problem-solving, reinforced through mock aptitude tests and interview-based exercises. | **02** |
| VI | **Summative Assessment & Performance Feedback:** Includes comprehensive mock tests, reflective learning, and individual feedback to refine aptitude skills. | **02** |
| **Text Books & Reference Books** | | |
| 1 | Aggarwal, R. S. (2018). Quantitative Aptitude for Competitive Examinations. S. Chand Publishing. | |
| 2 | Thorpe, E. (2017). The Pearson Guide to Logical Reasoning and Data Interpretation. Pearson Education. | |
| 3 | Kumar, S., & Lata, P. (2015). Communication Skills (2nd ed.). Oxford University Press. | |
| 4 | Kallet, M. (2014). Think Smarter: Critical Thinking to Improve Problem-Solving and Decision-Making Skills. Wiley. | |
| 5 | Bradberry, T., & Greaves, J. (2009). Emotional Intelligence 2.0. TalentSmar | |

The Equivalence for the Courses of Chemical Engineering at Third Year B. Tech. Semester V and Semester VI of pre-revised Program under the faculty of Science and Technology is as follows.

**SEM – V**

| **Sr. No.** | **T.Y.B. Tech Semester V Pre-revised syllabus** | **T.Y.B. Tech Semester V Revised syllabus** | **Remark** |
|---|---|---|---|
| 1 | Thermal Engineering and Plant Utilities | Thermal Engineering and Plant Utilities | Content revision. |
| 2 | Inorganic Chemical Technologies | - | Shifted to IV semester. |
| 3 | - | Organic Chemical Technologies (Theory & Lab) | Shift of semester with content revision. |
| 4 | Safety in Chemical Industry | Safety in Chemical Industry | Content revision. |
| 5 | Mass Transfer Operations-I (Theory & Lab) | Mass Transfer-I (Theory & Lab) | Content revision. |
| 6 | Case Studies and Seminar | - | Shifted to last semester. |
| 7 | Chemical Reaction Engineering-I (Theory & Lab) | Chemical Reaction Engineering (Theory & Lab) | Clubbed in a single course with content revision. |
| 8 | Industrial Safety and Hazard Management (Tutorial) | - | Shift of semester. |
| 9 | Internship I | - | Shifted to last semester. |
| 10 | - | Introduction to Foreign Language | Made it as a Credit course |
| 11 | - | Aptitude Enhancement Course II | Newly introduced. |
| 12 | - | Mini Project III & Industrial Visit (Lab) | Newly introduced. |
| 13 | - | Multidisciplinary Minor Course II | As per NEP feature, MDM is introduced. |

## SEM – VI

| Sr. No. | T.Y.B. Tech Semester VI Pre-revised syllabus | T.Y.B. Tech Semester VI Revised syllabus | Remark |
|---|---|---|---|
| 1 | Chemical Reaction Engineering-II (Theory & Lab) | - | Clubbed in a single course with content revision. |
| 2 | Organic Chemical Technologies (Theory & Lab) | - | Shifted to previous semester |
| 3 | Industrial Pollution Control | - | - |
| 4 | Mass Transfer Operations-II (Theory & Lab) | Mass Transfer-II (Theory & Lab) | Content revision. |
| 5 | Micro Project | Mini Project IV & Industrial Visit | Made it as a Credit course with title change |
| 6 | Process Instrumentation and Control (Theory & Lab) | Process Instrumentation and Control (Theory & Lab) | Content revision. |
| 7 | Industrial Visits | - | Clubbed with mini project. |
| 8 | - | Chemical Equipment & Plant Design (Theory & Lab) | Content revision with title change. Also a shift of semester from the VIII to VI. |
| 9 | - | Elective I (Pool provided) | Shift of semesters. |
| 10 | - | Open Elective I | Newly added. |
| 11 | - | Industrial Safety, Health & Hazard Management (Tutorial) | Shift of semester with content revision. |
| 12 | - | Design Thinking & Innovation -III | Newly introduced. |
| 13 | - | Aptitude Enhancement Course III | Newly introduced. |
| 14 | - | Multidisciplinary Minor Course III | As per NEP feature, MDM is introduced. |