SHIVAJI UNIVERSITY, KOLHAPUR
416 004, MAHARASHTRA
PHONE : EPABX – 2609000, BOS Section – 0231-2609094, 2609487
Web : www.unishivaji.ac.in Email: bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर ४१६ ००४, महाराष्ट्र
दूरध्वनी - इपीबीएक्स - २०६०९०००, अभ्यासमंडळे विभाग : ०२३१- २६०९०९४, २६०९४८७
वेबसाईट : www.unishivaji.ac.in ईमेल : bos@unishivaji.ac.in

Estd. 1962
"A++" Accredited by NAAC (2021)
With CGPA 3.52

SU/BOS/Sci & Tech/ 316 **Date: 23/05/2025**

To,

The Director,
School of Engineering and Technology,
Shivaji University, Kolhapur.

Subject: Regarding revised syllabus of **B. Tech.** Part - III (Sem - V & VI) degree **Programme (Deparment of Technolgy)** under the Faculty of Science and Technology as per NEP 2020.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, Nature of Question paper and equivalence of B. Tech. Part - III (Sem - V & VI) under the Faculty of Science & Technology as per NEP 2020.

No.	Course Syllabus
1	Civil Engineering
2	Mechanical Engineering
3	Computer Science and Technology
4	Chemical Engineering
5	Electronics and Telecommunication Engineering
6	Food Technology

This Syllabus, shall be implemented from the academic year **2025-26** onwards. A soft copy containing the syllabus is attached herewith and it is available on university website **www.unishivaji.ac.in NEP-2020@suk (Online Syllabus).**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October/ November 2025 & March / April 2026. These chances are available for repeater students, if any

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dr. S. M. Kubal
Dy. Registrar

Copy to: for Information and necessary action

1	The I/c Dean, Faculty of Science & Technology	6	Appointment Section A & B
2	Director, Board of Examinations & Evaluation	7	Affiliation Section (T.1) (T.2)
3	The Chairpersan, Respective Board of Studies	8	P.G.Admission Section, /P.G Seminar Section
4	OE 4 Exam Section,	9	Computer Centrev/ IT Cell
5	Eligibility Section,	10	Internal Quality Assorance Cell (IQAC)

Shivaji University
Vidyanagar, Kolhapur-416004, Maharashtra.

Department of Technology

As per NEP2020 guidelines

Third Year B. Tech. (Chemical Engineering),Detailed Curriculum, 2025-26 onwards

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 and 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**	**Total**
	30	70	-	-	-	-	100
Pre-requisites(if any)	BSC 221, PCC 221, PCC 224						
Course Rationale	The course Thermal Engineering and Plant Utilities 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 aims to: 1. Explain thermal engineering principles for chemical process industries. 2. Illustrate the design, operation, and maintenance of industrial utilities. 3. Analyze energy efficiency techniques in thermal systems. 4. Describe the roles of steam, boilers, and utility systems. 5. Explore sustainable practices in utility management. 6. Demonstrate the integration of thermal systems in chemical industries.						
Course Outcomes	After completing the course, students will be able to: 1. Describe heat transfer processes in industrial utilities. 2. Analyze boiler operations and suggest efficiency improvements. 3. Evaluate refrigeration and air-conditioning system performance. 4. Compare types of pumps and compressors for specific applications. 5. Apply safety measures to inerting and utility systems. 6. Recommend sustainable practices for thermal utilities.						

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 Performance: Criteria for selecting compressors for different industrial needs, efficiency calculations, Compressed Air Systems: Design and operation of centralized compressed air systems, energy-efficient practices, ir 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	07

	gas 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.	

Year, Program, Semester	T.Y. B. Tech.(Chemical Engineering), Part III, Semester V						
Course Code	PCC311						
Course Category	Program Core Course						
Course title	Mass Transfer Operations-I(Theory)						
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)	BSC 221, PCC 221, PCC 224						
Course Rationale	This course is designed to provide a deep understanding of the principles, mechanisms, and applications of mass transfer operations. Students will explore the theoretical and practical aspects of mass transfer, enabling them to design and analyse various separation processes essential in industries such as petrochemicals, pharmaceuticals, and environmental engineering. By understanding these concepts, students will be prepared to evaluate real-world engineering challenges and contribute to advancements in sustainable process technologies.						
Course Objectives	The Course Teacher will ensure to 1. Introduce the fundamental principles of mass transfer 2. Provide a comprehensive understanding of interphase mass transfer mechanisms 3. Develop the ability to analyse and design distillation processes.						

	4. Introduce liquid-liquid extraction principles, including equilibrium data interpretation, equipment design. 5. Familiarize students with the principles and calculations involved in solid-liquid extraction. 6. Equip students with the knowledge to analyse gas absorption processes.
Course Outcomes	Upon completion of this course, student should be able to 1. Explain the concepts of flux, resistance, driving force, and equilibrium. 2. Derive and apply mass transfer coefficients, analyse diffusion in solids and gases. 3. Design distillation columns using McCabe-Thiele, Ponchon-Savarit, and other methods. 4. Construct ternary phase diagrams, choose appropriate solvents, and design stage-wise and continuous extractors for different solvent systems. 5. Perform material balance calculations for leaching processes, and design leaching equipment for specific applications. 6. Perform NTU, HTU, and HETP calculations, determine tray efficiency, and design packed towers for absorption operations effectively.

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

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 Ist and IInd 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,	**01**
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, 2-7, 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, 2-11, 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="8">T.Y. B.Tech(Chemical Engineering), Part III, Semester V</td></tr>
<tr><td>Course Code</td><td colspan="8">PCC311</td></tr>
<tr><td>Course Category</td><td colspan="8">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="8">Mass Transfer Operations-I(Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="3">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">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 colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td>-</td><td>50</td><td>50</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">BSC211, PCC 222, BSC212, BSC221, PCC221, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This laboratory provides hands-on experience and practical understanding of fundamental mass transfer principles. Through experimental studies, students gain insight into various mass transfer phenomena such as diffusion, distillation, liquid-liquid extraction, and leaching. These experiments connect theoretical knowledge with real-world applications, preparing students to design and optimize separation processes in the chemical industry.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The course Teacher will ensure to
1. Equip students with the ability to measure and analyze diffusion, equilibrium, and distribution coefficients for mass transfer systems.
2. Familiarize students with the practical aspects of distillation, liquid-liquid extraction, and leaching operations.
3. Develop skills in plotting phase equilibrium curves and evaluating stage-wise operations in mass transfer equipment.
4. Enable students to interpret experimental data and assess the performance of laboratory-scale mass transfer equipment. theoretical knowledge to design and conduct advanced</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Calculate and analyse diffusion coefficients, vapor-liquid equilibrium data, and distribution coefficients for different systems.
2. Design and evaluate the efficiency and stage performance of single and multistage separation processes such as distillation, extraction, and leaching.
3. Apply phase equilibrium principles to interpret and optimize separation operations.
4. Develop critical thinking and problem-solving skills by correlating experimental data with theoretical predictions in mass transfer operations.</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	2	2	2	1	1	1	2	2	1	3
CO 2	3	3	3	3	2	1	2	1	2	2	2	3
CO 3	3	3	3	2	2	1	2	1	2	2	1	3
CO 4	3	3	3	3	3	1	2	2	3	3	2	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.	Experiment Title/Objective	Hours
1.	To calculate the Diffusion Coefficient for a liquid –liquid system.	**02**
2.	To construct the vapor-liquid equilibrium curve.	**02**
3.	To verify 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.	To plot a binodal curve by using system distilled water (A), chloroform (B) &, acetone (C).	**02**
7.	To study liquid-liquid extraction by experimental method.	**02**
8.	To study single stage extraction.	**02**
9.	To study multistage extraction.	**02**
10.	To determine the efficiency of single stage leaching operation for leaching of NaOH aqueous solution & $CaCO_3$.	**02**
11.	To determine 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**
12.	To calculate the Diffusion Coefficient for a liquid –liquid system.	**02**
13.	To construct the vapor-liquid equilibrium curve.	**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., 2--1 & 2--5, 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., 2--4, 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,

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 (Theory)							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**				**Total Credits**
	03	01	-	04				04
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30	70		-	-	-	-	100
Pre-requisites(if any)	BSC111, BSC212, PCC211, PCC212, PCC224							
Course Rationale	The purpose of this course is to introduce and make aware the students about concepts and implementation of the reaction rate, reactor types, method of analysis, principles of chemical reactor analysis and design, design of batch and continuous reactors, selection of the most appropriate reactor for a given feed. This second level course on chemical reaction engineering extensively covers design of fluid-solid catalytic and non-catalytic reactors. Moreover, various aspects of residence time distribution, an important and often parameter used for various fault-diagnosis purposes is also covered with its applicability in designing reactors. The content of this course will build on the basic topics of the first level chemical reaction engineering course..							
Course Objectives	The Course Teacher will 1. Impart knowledge on types of chemical reactors. 2. Analyze rate data to derive rate laws and determine reaction parameters through experimental methods. 3. Design ideal and Non-ideal reactors and evaluate their performance using different mathematical models 4. Discuss rate-controlling model and rate equation, mass transfer and reaction for heterogeneous reactions 5. Comprehend catalytic processes and integrate mass transfer with reaction kinetics for heterogeneous systems. 6. Discuss various types of reactors and factors affecting the choice of reactor.							
Course Outcomes	Upon completion of this course, student should be able to 1. Explain the fundamental principles of reaction kinetics and reactor design, including the role of temperature, pressure, and catalysts							

	in reaction systems. 2. Determine rate laws and reaction parameters using differential and integral methods from experimental data 3. Design and optimize ideal and non-ideal reactors for single and multiple reactions, ensuring efficient and safe operations. 4. Develop rate-controlling model and rate equation for heterogeneous fluid -fluid and fluid -particle reactions 5. Evaluate catalytic reactor performance by integrating reaction kinetics with mass and heat transfer concepts. 6. Understand the different types of reactors and its affecting factors

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	1	-	-	-	-	-	-	-	-	-
CO 2	3	3	2	-	-	-	-	-	-	-	-	-
CO 3	3	2	3	3	2	-	-	-	-	-	-	2
CO 4	3	3	2	3	3	-	-	-	-	-	-	-
CO 5	3	2	2	2	3	-	2	-	-	-	-	-
CO 6	3	2	2	-	-	-	-	-	-	-	-	2

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.	**10**
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.	**05**
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	**08**

	dispersion models, Effects of non-ideal flow on reactor performance.	
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	**05**
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 deactivation, the rate and performance equations.	**06**
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. (2-2-). 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. (2-2-). Essentials of chemical reaction engineering (2nd ed.). Pearson Education.	
5.	Hill, C. G., & Root, T. W. (2-14). Introduction to chemical engineering kinetics and reactor design (2nd ed.). Wiley.	
Reference Books		
1.	Nauman, E. B. (2--8). 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. (2--1). 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	

<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">PCC312</td></tr>
<tr><td>Course Category</td><td colspan="8">Program Core Course</td></tr>
<tr><td>Course title</td><td colspan="8">Chemical Reaction Engineering (Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="3">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">BSC111, BSC212, PCC211, PCC212, PCC224</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This course is designed to acquaint the students with practical knowledge and hands-on experience in chemical reaction, for various topics pertaining to chemical reaction engineering. They will also acquire adequate knowledge on various types of ideal and non-ideal reactors, its experimental data analysis, Catalysis, technical report writing and work in team. They will develop critical thinking and problem-solving skills in the laboratory setting.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">1. Demonstrate and explain the principles of reaction kinetics through experiments.
2. Discuss about the performance of various types of reactors
3. Demonstrate concept of residence time distribution in reactor systems;
4. Discuss about the non-catalytic and catalytic reaction in different reactors
5. Enhance critical thinking and problem-solving abilities through experimental design and analysis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Determine the value of rate constant and activation energy of the reactions.
2. Demonstrate various experiment for reactors connected in series
3. Characterize laboratory reactors through residence time distributions
4. Determine properties for non-catalytic and catalytic reactions
5. Analyze experimental data, interpret results, and draw conclusions, fostering critical thinking and problem-solving skills.</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	2	3	2	-	-	-	-	-	-	2
CO3	3	2	3	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-
CO5	3	3	-	3	-	-	-	-	-	2	-	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.	Experiment Title/Objective	Hours
1.	To investigate the Arrhenius equation by studying the temperature dependency of a chemical reaction's rate constant.	**02**
2.	To determine the order and rate constant of a reaction using differential and integral methods.	**02**
3.	To study the reaction rate of saponification in a batch reactor.	**02**
4.	To investigate the kinetics of acid-catalysed esterification in a batch reactor.	**02**
5.	To measure the conversion of reactants in a single CSTR.	**02**
6.	To compare the performance of multiple CSTRs connected in series.	**02**
7.	To study the conversion of reactants in a plug flow reactor.	**02**
8.	To perform tracer studies to determine RTD in a single CSTR by pulse input.	**02**
9.	To perform tracer studies to determine RTD in a single CSTR by step input.	**02**
10.	To perform the tracer experiments to determine RTD in a plug flow reactor by pulse input.	**02**
11.	To perform the tracer experiments to determine RTD in a multiple CSTRs connected in series by pulse input.	**02**
12.	To study the kinetics for Second Order Saponification Reaction in Mixed Flow Reactor	**02**
13.	To study the effect of temperature on the Kinetics of the Reaction	**02**
14.	To determine the kinetics of reaction in batch reactor under adiabatic conditions	**02**
15.	To study the RTD in a Packed Bed Reactor	**02**

Suggested Text Books/ Reference Books/Manual	
1.	Fogler, H. S. (2-2-). 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. (2-2-). Essentials of chemical reaction engineering (2nd ed.). Pearson Education.

Year, Program, Semester	T.Y. B. Tech(Chemical Engineering), Part III, Semester V							
Course Code	PCC313							
Course Category	Program Core Course							
Course title	Organic Chemical Technologies (Theory)							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Credits**		
	03	-	**-**	03		03		
Evaluation Scheme	**ISE**		**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30		70	--	**-**	-	-	100
Pre-requisites(if any)	BSC221, BSC111, PCC212, PCC224							
Course Rationale	Chemical Industries are the prime factors to convert the raw materials into desired products that we use in daily life. This sector has brought a tremendous change in the way the things operate. There has been continuous up gradation in technologies for improving the overall economy of the process. The purpose of this course is to improve knowledge of the chemical processes along with emphasis on recent technological development. The course primarily covers studies of process technologies, availability of raw materials, production trends, preparation of flow sheets, engineering and environmental problems of various organic based chemical industries.							
Course Objectives	The Course Teacher will 1. Impart knowledge about sources and processes pertaining to Food Industry. 2. Explain various processes for manufacture of oils and surfactants. 3. Elaborate different methods used for paper manufacture. 4. Discuss various manufacturing processes for plastic and rubber industry. 5. Impart knowledge about sources and processes pertaining to petroleum.							

	6. State the processes and application for petrochemical products.
Course Outcomes	Upon completion of this course, student should be able to 1. Identify various components of food industry and its quality concern. 2. Classify different oils and surfactants and understand related manufacturing. 3. Remember different methods for paper and pulp production. 4. Understand correct processes for production of plastic and rubber. 5. Recognize various processes for refining of petroleum. 6. Visualize various methods and applications for petrochemical based compounds.

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-	**07**

	Ethenic and Poly-condensation process	
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, 2--1, 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, 2--7, 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 (Practical)</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 colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">--</td><td>--</td><td>50</td><td>-</td><td>50</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 course is designed to acquaint the students with practical knowledge of the terms like acid value, iodine value, and saponification value. It also covers various preparation methods for organic compounds in the industry/engineering and experimental skills for building technical competence as well as developing critical thinking and problem-solving skills in the laboratory setting.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">1. Develop proficiency in fundamental organic chemistry laboratory techniques and procedures.
2. Apply theoretical knowledge of organic chemistry concepts to practical laboratory experiments.
3. Acquire skills in the synthesis, purification, and characterization of organic compounds.
4. Enhance critical thinking and problem-solving abilities through experimental design and analysis.
5. Cultivate an appreciation for the role of experimentation in advancing scientific knowledge and solving real-world problems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate proficiency in performing laboratory experiments in organic compounds.
2. Apply knowledge of reaction mechanisms and principles to successfully execute organic synthesis experiments.
3. Formulate thought process for organic compounds analysis
4. Analyze experimental data, interpret results, and draw conclusions, fostering critical thinking and problem-solving skills.
5. Tackle on to safety protocols and ethical standards in a 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	3	-	-	2	3	-	-	-	3	1	-	-
CO2	3	3	-	3	2	-	-	2	-	-	-	-
CO3	3	3	3	3	-	-	-	-	1	2	-	3
CO4	3	3	3	3	3	-	-	2	-	3	-	3
CO5	-	-	-	-	-	3	2	3	-	-	-	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.	Experiment Title/Objective	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	Ethics, Environment and Safety						
Course Objectives	The Course Teacher will 1. Discuss various safety programs, engineering ethics and importance of safety. 2. Explain industrial laws, regulations and source models. 3. Show different ways of getting fire and explosion and explain how their control is. 4. Discuss classification of preventive methods, relief and sizing methods. 5. Impart knowledge of industrial hazards, its risk assessment. 6. Emphasis on taking responsibility to ensure safety in chemical industry, further will explain few case studies.						

Course Outcomes	Upon completion of this course, student should be able to 1. Understand and explain the use of safety programs and ethics. 2. List and explain the industrial laws, regulations and source models. 3. Demonstrate different ways of getting fire and explosions and its prevention. 4. Understand relief and its sizing methods. 5. Analyze methods of hazard identification, preventive measures. 6. Realize responsibility to ensure safety in chemical industry, further interpret case studies.

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	-	-	-	-	-	-
CO 2	2	3	-	-	-	2	-	-	-	-	-	-
CO 3	2	2	3	-	-	2	-	-	-	-	-	-
CO 4	2	2	2	3	-	-	-	-	-	-	-	-
CO 5	2	3		2	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	3	-	-	-	2	-	-

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	**09**

	Concepts for Preventing Fires and Explosions.	
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, 2-11.
Reference Books	
1.	R.K. Sinnott, Coulson & Richardson's, Chemical Engineering, Vol. 6, Elsevier India, 2—6
2.	Fawcett H.H. and W.S.Wood, Safety and accident prevention in Chemical operations 2nd editon John Wiley and Sons Inc. (1982).

Year, Program, Semester	T.Y. B.Tech(Chemical Engineering), Part III, Semester V							
Course Code	MDM 3.2							
Course Category	Multidisciplinary Minor Course II							
Course title	Piping Design Principles							
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)	Basics of unit processes and unit operations							
Course Rationale	This course focuses on the principles and methodologies involved in the design of piping systems for chemical engineering applications.							
Course Objectives	The Course Teacher will 1. Describe design principles to create piping layouts. 2. Explain different design methodologies for piping systems.							

	3. Elaborate factors influencing piping design decisions.
Course Outcomes	Upon completion of this course, student should be able to 1. Develop piping layouts for chemical engineering processes. 2. Compare and contrast various design methodologies for piping systems. 3. Justify design decisions based on factors such as safety, cost, and efficiency.

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	PO12
CO1	-	-	03	-	-	-	-	-	-	-	-	-
CO2	-	-	-	02	-	-	-	-	-	-	-	-
CO3	-	-	-	-	02	-	-	-	-	-	-	-

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

Unit No.	Course Content	Hours
I	**Piping Design Process** 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** 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** 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** 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). 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** 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** 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. 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. (2-18). Piping Systems Manual. McGraw-Hill Education	
2.	William Beale and Rodney Boyer. (2-18). Process Piping: The Complete Guide to ASME B31.3, Fourth Edition. Momentum Press.	

Year, Program, Semester	T.Y. B. Tech.(Chemical Engineering), Part III, Semester V							
Course Code	AEC311							
Course Category	Ability Enhancement Course							
Course title	Introduction to Foreign Language							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**			**Credits**	
	01	-	-	01			01	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**	
	-	-	-	50	-	-	50	
Pre-requisites(if any)	BSC 112, BSC 122, BSC 212, PCC 211 and PCC 212							
Course Rationale	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.							
Course Objectives	The Course Teacher will 1. Help students to understand basics and deepen their knowledge in a chosen foreign language							

	2. Guide them to communicate and translate in the chosen foreign languages 3. Help them describe, narrate, and ask/answer questions in the foreign language in the present time about a variety of topics related to family, daily activities, eating, and traveling 4. Comprehend the foreign language with sufficient ability to grasp the main idea and some supporting details in short conversations (spontaneous or recorded) that pertain to the topics mentioned above 5. Explain how to write sentences and short paragraphs on familiar topics relating to personal interests and practical needs 6. Narrate on how the foreign language functions with awareness and understanding of the language culture.
Course Outcomes	Upon completion of this course, student should be able to 1. Learn alphabets, acquire knowledge of basic grammar of the foreign language, common words and phrases therein; 2. Learn to read the simple texts in foreign language; 3. Speak a little using the greetings, well wishes etc. in Foreign Language; 4. Count numbers, answer to the questions like, what is your name, surname, tell age, and can initiate little communication in Foreign Language; 5. Translate both verbally and written, simple sentences in the foreign language; 6. Achieve institute's mission with respect to global education and foreign language education.

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

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)	-						
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 1. To enhance quantitative and analytical aptitude through structured problem-solving activities. 2. To develop logical reasoning and data interpretation skills critical for decision-making. 3. To strengthen verbal communication and comprehension abilities for professional contexts.						

Course Outcomes	Upon completion of this course, student should be able to 1. Solve complex quantitative problems using structured methodologies. 2. Apply logical reasoning and interpret data effectively to make informed decisions. 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	PO12
CO 1	3	-	-	2	-	-	-	-	-	2	-	-
CO 2	-	3	2	3	-	-	-	-	-	2	-	-
CO 3	-	-	3	-	2	-	-	-	3	-	2	-
CO4	-	-	-	3	-	-	2	2	-	3	-	-

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

Unit No.	Course Content	Hours
I	Advanced Quantitative Aptitude Topics: 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 Topics: Puzzles, Syllogisms, Seating Arrangements, Charts, and Graphs. Activities: Solving logical puzzles, analyzing data sets in small groups.	02
III	Verbal Ability and Reading Comprehension Topics: Synonyms, Antonyms, Sentence Completion, Passage Analysis. Activities: Group discussions on comprehension passages, vocabulary quizzes.	02
IV	Problem-Solving Techniques and Strategy Topics: Problem-solving frameworks, time management in aptitude tests. Activities: Mock problem-solving sessions with timed activities.	02
V	Industry-Oriented Aptitude Applications Topics: 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.		
2.		

Year, Program, Semester	T.Y. B.Tech(Chemical Engineering), Part III, Semester V						
Course Code	PBL311						
Course Category	Project Based Learning						
Course title	Mini Project III & Industrial Visit						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	--	-	02	02		-	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-	IE at course in charge end	-	-	-	-
Pre-requisites (if any)	-						
Course Rationale	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, aligning with Outcome-Based Education (OBE) and Bloom's Taxonomy principles.						
Course Objectives	The Course Teacher will 1. Facilitate advanced application of theoretical knowledge to solve real-world chemical engineering problems. 2. Provide experiential learning through advanced project work and industrial exposure to contemporary chemical engineering practices. 3. Develop critical thinking, innovation, and professional skills to prepare students for industry or research-oriented careers.						
Course Outcomes	Upon completion of this course, student should be able to 1. Synthesize and apply chemical engineering concepts to design and execute innovative projects independently. 2. Critically analyze and interpret data from projects and industrial visits to derive meaningful conclusions. 3. Collaborate in multidisciplinary teams to address complex engineering challenges.						

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	3	2	3	-	-	-	-	-	-	2
CO2	2	3	2	3	3	-	-	-	-	-	-	3
CO3	-	-	2	-	-	-	-	-	3	2	-	-

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

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: 1. “Chemical Engineering Mini Projects” 2. “Chemical Engineering Industrial Visits” 3. “Hands-on Projects for Chemical Engineers” 4. “Industrial Visits in Chemical Process Industries”	

<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">ESC321</td></tr>
<tr><td>Course Category</td><td colspan="8">Engineering Science Course</td></tr>
<tr><td>Course title</td><td colspan="8">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="3">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="3">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">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="8">-</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This introductory course covers basics of process control and the instrumentation used for it.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">1. Understand the fundamental principles of measurement, instrumentation, and control systems used in the chemical process industry.
2. Develop skills in the design and operation of process control systems, including feedback and feedforward control strategies.
3. Identify and apply various types of sensors and transducers to measure process variables like temperature, pressure, flow, and level.
4. Analyze dynamic behavior of process systems and evaluate the stability and performance of control loops.
5. Apply control system design methodologies including PID controllers, process dynamics, and controller tuning.
6. Implement automation and control strategies for optimizing process operations, ensuring safety, and improving system efficiency.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon successful completion of this course, students should be able to:
1. Describe the different types of process instrumentation and control systems used in the chemical industry.
2. Identify the characteristics of sensors, transmitters, and controllers used for process measurement and control.
3. Analyze process dynamics and identify suitable control strategies for different process variables (temperature, pressure, flow, and level).
4. Design simple feedback control systems and apply controller tuning techniques (PID control).
5. Develop process control loop diagrams and select appropriate instrumentation for various chemical processes.
6. Evaluate system stability and performance using control system analysis 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	2	1	2	1	1	1	1	2	2	1	2
CO2	3	3	2	2	1	1	1	1	2	2	2	3
CO3	3	3	2	2	3	1	2	1	2	2	2	3
CO4	3	3	3	2	3	1	2	1	3	2	3	3
CO5	3	2	3	2	2	1	1	1	3	2	2	3
CO6	3	3	3	2	3	2	2	1	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** a) Development of mathematical models. b) Modelling considerations for control purposes.	06
III	**Dynamic Behavior of Chemical Processes** a) Transfer functions and the inputoutput models. b) Dynamics and analysis of first, second and higher order systems. c) Computer simulation and the linearization of nonlinear systems.	07
IV	**Feedback Control Schemes** a) Concept of feedback control. b) Dynamics and analysis of feedback-controlled processes. c) Stability analysis. d) Controller design. e) Frequency response analysis and its applications.	08
V	**Advanced Control Schemes** a) Feedback control of systems with dead time or inverse response. b) Control systems with multiple loops.	05
VI	**Other control strategies:** 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 V						
Course Code	ESC321						
Course Category	Engineering Science Course						
Course title	Process Instrumentation & Control (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)	-						
Course Rationale	The purpose of this course is to apply the key concepts of automatic control and instrumentation to process plants.						
Course Objectives	1. Explain practical aspects of dynamic behavior of the systems 2. Discuss and evaluate effect of controller on the control system 3. Demonstrate and explain the basic components of feedback control system						
Course Outcomes	Upon completion of this course, student should be able to – 1. Understand the modern hardware and instrumentation needed to implement process control 2. Analyze practical issues in control engineering and the benefits of control engineering 3. Explain effect of P, PI and PID controllers in process control.						

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	3	-	-	-	3	1	-	-
CO 2	3	3	-	3	2	-	-	2	-	-	-	-
CO 3	3	3	3	3	-	-	-	-	1	2	-	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.	**Experiment Title/Objective**	**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	

Year, Program, Semester	T.Y. B.Tech(Chemical Engineering), Part III, Semester VI				
CourseCode	PCC321				
Course Category	Professional Core Course				
Course title	Mass Transfer Operations-II (Theory)				
Teaching SchemeandCredits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**
	03	-	-	03	03
Evaluation Scheme					
Pre-requisites(if any)	BSC211, BSC221, PCC 221, PCC 224				

Course Rationale	The course covers key separation techniques like drying, humidification, crystallization, and adsorption, evaporation, and membrane processes, emphasizing their design, optimization, and industrial applications. Through this course, students gain the theoretical and practical knowledge necessary to address real-world challenges in process industries, such as pharmaceuticals, food processing, water treatment, and petrochemicals.
Course Objectives	1. Explore the principles of drying, analyze drying curves, and select appropriate drying equipment for various materials. 2. Describe principles of humidification and dehumidification, utilize psychometric charts, and design cooling towers. 3. Discuss the principles of crystallization, including nucleation, supersaturation, and crystal growth, and perform yield calculations for crystallization. 4. Describe adsorption equilibria, isotherms, breakthrough curves, and ion exchange mechanisms. 5. Explore the principles and mechanisms of evaporation. 6. Introduce membrane separation processes, study various types of membrane operations
Course Outcomes	Upon completion of this course, student should be able to 1. Explain drying mechanisms; determine drying time using drying rate curves, and select suitable dryers for solids, pastes, and slurries. 2. Perform design calculations for cooling towers, use psychrometric and enthalpy-humidity charts for humidity measurements. 3. Analyze solubility and supersaturation, calculate material and energy balances for crystallizers. 4. Explain adsorption principles; analyze equilibrium data using various isotherms, design stage-wise and continuous adsorption systems. 5. Evaluate evaporation systems and, calculate heat and mass transfer rates. 6. Apply general membrane equations to solve real-world separation problems

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	2	2	1	2	-	1	-	-	1	-	2
CO 2	3	2	2	2	3	-	-	-	-	1	-	2

CO 3	3	3	2	3	2	-	1	-	-	1	-	2
CO 4	3	3	2	3	2	-	1	-	-	1	-	2
CO5	3	2	3	3	2	-	-	-	-	1	-	2
CO6	3	3	3	3	3	-	-	-	-	1	-	2

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 ofcooling 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 adsorption; 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, 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, 2--7, 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, 2-11, Separation Process Principles, 3rd Edition, Wiley.
Useful web links	
1.	https://archive.nptel.ac.in/courses/1-3/1-4/1-31-4-46/

Year, Program, Semester	T.Y. B. Tech. (Chemical Engineering), Part III, Semester VI				
Course Code	PCC321				
Course Category	Professional Core Course				
Course title	Mass Transfer Operations-II (Laboratory)				
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**
	-	-	02	02	01
Evaluation Scheme	IE at the course in charge end. There is a detailed mention under the course assessment method.				
Pre-requisites(if any)	BSC211, PCC222, BSC212, BSC221, PCC221, PCC224.				
Course Rationale	This Laboratory provides hands-on experience with advanced mass transfer processes like drying, evaporation, crystallization, adsorption, and membrane separation techniques. Through a series of experiments, students will develop a deeper understanding of key mass transfer operations critical for chemical engineering applications. This laboratory focuses on the practical implementation of theoretical concepts, enabling students to analyse process efficiencies, optimize operational parameters, and connect laboratory findings with industrial practices.				
Course Objectives	The course Teacher will ensure to 1. Understand and evaluate drying, crystallization, and adsorption mechanisms for industrial applications. 2. Develop the ability to perform experiments on advanced mass transfer equipment, such as evaporators and membrane systems. 3. Enhance problem-solving skills by comparing experimental results with theoretical predictions. 4. Gain proficiency in calculating efficiencies, material balances, and operational parameters in various mass transfer operations.				
Course Outcomes	Upon completion of this course, student should be able to 1. Analyze drying curves, determine drying rates, and calculate batch drying time using different drying techniques.				

	2. Calculate operational efficiencies and material balances for crystallization, evaporation, and membrane separation processes. 3. Evaluate adsorption performance and interpret equilibrium data to optimize adsorption systems. 4. Correlate experimental findings with theoretical principles for enhanced understanding of mass transfer operations.

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	2	0	2	0	0	1	0	2
CO2	3	3	2	3	2	0	2	0	0	1	0	2
CO3	3	2	3	3	2	0	2	0	0	0	0	3
CO4	3	3	2	3	2	0	2	0	0	1	0	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.	Experiment Title/Objective	Hours
1.	To Study the drying of wet material and to calculate rate of drying in Tray Dryer.	**02**
2.	To find out the batch time of drying of a given material using fluidized bed dryer & compare the same with the theoretical equation.	**02**
3.	To determine the humidity of air by dew point method	**02**
4.	To calculate the economy and overall heat transfer coefficient of Pan evaporator.	**02**
5.	To study the process of crystallization in an agitated batch crystallizer/ To find the yield of crystals in batch crystallizer	**02**
6.	To find the yield of crystals in batch crystallizer	**02**
7.	To Verify 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.	To study the Reverse Osmosis membrane performance.	**02**
9.	To study the Ultra filtration/Microfiltration membrane performance.	**02**
10.	To study 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 V						
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	50	-	-	-	150
Pre-requisites(if any)	PCC 224,PCC 221,PCC312,PCC321						
Course Rationale	The present 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 1. Discuss design parameter basics i.e. commonly used in process equipment's design 2. Describe design of pressure vessels subjected to internal and external pressures 3. Illustrate design of special vessels (e.g. tall vessels) and various parts of vessels 4. Impart knowledge of shell & tube heat exchanger design. 5. Demonstrate design of reactor and agitator system 6. Elaborate equipment testing methods related to process hazard & its safety						
Course Outcomes	Upon completion of this course, student should be able to 1. Identify various design preliminaries 2. Evaluate and design various parts of Pressure Vessel. 3. Design storage vessel and Tall Vessel 4. Develop a design for Heat Exchanger and Evaporator. 5. Formulate reactor systems and agitator system. 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.	10
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.	08
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.	10
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.	08
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.	08

	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, 1st Edition1999.
	Reference Books
1.	Coulson & Richardson's Chemical Engineering (Vol. VI) Chemical Engineering Design ", fourth edition, R. K. Sinnott, Elsevier Butterworth-Heinemann

Year, Program, Semester	T.Y. B. Tech.(Chemical Engineering), Part III, Semester V						
Course Code	PEC321						
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 1. Explain the composition of petroleum and the allied topics. 2. Discuss the crude oil properties and concepts of crude oil distillation. 3. Describe a various cracking process and catalytic reforming process. 4. Discuss the hydro treating and hydrocracking process. 5. Explain the isomerisation, alkylation and polymerisation process. 6. Summarise the environmental issues in petroleum refinery.						

Course Outcomes	Upon completion of this course, student should be able to 1. Recognize the composition of petroleum products. 2. Understand the properties of crude oil and basic concept of distillation. 3. Perceive the various cracking process and reforming process used in the refinery. Differentiate the hydro treating and hydrocracking process. 4. Express the knowledge of isomerisation, alkylation and polymerisation process. 5. Aware about the actual environmental issues faced by the refinery industries 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	07

	Catalytic Cracking Units, Objective and application of catalytic reforming process reforming catalysts, Reformer feed reforming reactor design continuous and semi regenerative process.	
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 07consideration in petroleum refinery, Waste water treatment, control of air pollution, New trends in refinery, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.	**07**
	Text Books	
1.	Bhaskara Rao, B. K.,(199-), Modern Petroleum Refining Processes, 2nd Edition, Oxford and IBH Publishing Company, New Delhi.	
2.	Prasad, R.,(2--8),Petroleum refining technology,1st Edition, Khanna Publishers.	
3.	Gary, J.H., Handwerk, G.E., Kaiser, M.J, (2--7), 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 V						
Course Code	PEC321						
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 1. Explain basic concepts of polymer and its features. 2. Discuss the molecular arrangements of polymer and its states. 3. Describe the copolymers and composite of polymers. 4. Discuss the viscoelasticity properties of polymers. 5. Elaborate the polymer processing and polymerization kinetics. 6. Summarise biodegradable polymer and rheological models.
Course Outcomes	Upon completion of this course, student should be able to 1. Understand basic concepts of polymer. 2. Understand the molecular arrangements of polymers. 3. Perceive the copolymers and composite. 4. Express the knowledge of visco elasticity properties of polymers. 5. Acquired the knowledge of polymer process and polymerization kinetics. 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	**07**

	environment, Liquid crystalline polymers, Copolymers, Blends.	
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, 3rd ed., Wiley & sons.
2.	Gowariker, V.R.,Vishwanathan, N. V.,Sreedhar, J., (1986), Polymer Science, New Age International Publishers.
3.	Odian, G.,(2--4), Principles of Polymerization, 4th ed., Wiley.
4.	Hiemenz. P.C., Lodge. T.P., (2--7),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.,(2-2-),Polymer chemistry, Krishna Prakashan Media
2.	Bhatnagar, M.S., (2-12),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.,(198-),Plastic materials,2nded.,Newnes-Butterwarths
	Useful web links
1.	https://archive.nptel.ac.in/courses/1-3/1-6/1-51-62-5/

Year, Program, Semester	T.Y. B. Tech.(Chemical Engineering), Part III, Semester V						
Course Code	PEC321						
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 focus 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 1. Explain basic concepts of fertilizer. 2. Discuss nitrogen fertilizer. 3. Describe phosphorus fertilizer. 4. Discuss potash fertilizer and its application. 5. Explain the compound fertilizer and its properties. 6. Elaborate environmental issues in fertilizer industry.						
Course Outcomes	Upon completion of this course, student should be able to 1. Explore the basic concepts of fertilizer to make a more efficient and sustainable. 2. Perceive the importance of nitrogen fertilizer. Because it's essential for plant growth. 3. Outline the production and characteristics of phosphorus fertilizer. 4. Differentiate the potash and phosphorus fertilizer. 5. Identify the importance of compound fertilizer and its production. 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., (2-21),A Textbook of Fertilizers, New India Publishing Agency- Nipa	
2.	Chaduvula, A. I. R., Kvd P.,(2-22),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 (5th 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/	

<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">PEC321</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Elective Course</td></tr>
<tr><td>Course title</td><td colspan="7">Technology for Clean and Renewable Energy Production(Elective I)</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>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>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">Fundamentals of Thermodynamics, Heat Transfer, Fluid Mechanics</td></tr>
<tr><td>Course Rationale</td><td colspan="7">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.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Explain the principles and applications of various clean and renewable energy technologies.
2. Compare the advantages and limitations of different energy production methods.
3. Conduct feasibility studies for implementing renewable energy projects.
4. Develop conceptual designs for renewable energy systems tailored to specific needs.
5. Describe current research and developments in the field of renewable energy.
6. Elaborate various simulation tools to model energy production scenarios.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand the fundamental principles and classifications of clean and renewable energy technologies.
2. Analyze the environmental and economic impacts of various energy production methods.
3. Evaluate the efficiency and feasibility of different renewable energy systems.
4. Design basic systems for energy production utilizing clean and renewable technologies.
5. Assess the challenges and advancements in integrating renewable energy into existing infrastructures.
6. Apply relevant software tools for modeling and simulation of renewable energy systems.</td></tr>
</table>

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	

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
Useful web links	
1.	https://onlinecourses.nptel.ac.in/noc19_ch26/preview

Year, Program, Semester	T.Y.B. Tech (Chemical Engineering), Part III, Semester VI						
Course Code	PEC321						
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 1. Classify various types of waste and their potential for energy conversion. 2. Illustrate the working principles of thermochemical, biochemical, and physicochemical waste-to-energy processes. 3. Describe different waste-to-energy technologies based on efficiency, cost, and environmental impact. 4. Explain simplified models for converting municipal, agricultural, and industrial waste into energy. 5. Recommend appropriate waste-to-energy solutions for specific waste streams in real-world scenarios. 6. Evaluate the sustainability of waste-to-energy practices with respect to environmental, economic, and social dimensions.						
Course Outcomes	Upon completion of this course, student should be able to 1. Understand the fundamental principles and technologies of waste-to-energy conversion. 2. Analyze the physical, chemical, and biological processes involved in energy recovery from waste. 3. Evaluate the techno-economic feasibility and environmental						

	implications of different waste-to-energy systems. 4. Design basic waste-to-energy systems using appropriate engineering tools and techniques. 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. (2-13). Waste to Energy Conversion Technology. Woodhead Publishing.	
2.	Young, G. C. (2-1-). Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons. John Wiley & Sons.	
	Reference Books	
1.	Karagiannidis, A. (Ed.). (2-12). Waste to Energy: Opportunities and Challenges for Developing and Transition Economies. Springer.	
2.	Williams, P. T. (2-13). Waste Treatment and Disposal (2nd ed.). John Wiley & Sons	

<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">OEC 321</td></tr>
<tr><td>Course Category</td><td colspan="7">Open Elective Course</td></tr>
<tr><td>Course title</td><td colspan="7">Industrial Economics and Management (Open Elective-I)</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>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>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, BSC 221,HSMEC 211,PCC 223</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course provides basic knowledge about the concepts of economics and management. The emphasis is deal with various concepts related to economic problems, national income, inflation, food processing industries, principles of management, production, finance, and marketing management and its relevance.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course aims to provide students with:
1. Fundamentals of Economics – Understanding the basic concepts of micro and macroeconomics relevant to industries.
2. Industrial Structure & Growth – Analyzing different industrial structures, market conditions, and factors influencing industrial growth.
3. Cost & Production Analysis – Understanding cost concepts, production functions, and pricing strategies for business decision-making.
4. Market Structures & Competition – Examining different types of market structures such as monopoly, oligopoly, and perfect competition.
5. Economic Policies & Industrial Development – Evaluating government policies, trade regulations, and their impact on industries.
6. Financial & Business Management – Gaining knowledge of financial statements, investment decisions, and capital management.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completing the course, students will be able to:
1. Explain fundamental economic concepts and their application in industrial decision-making.
2. Analyze industrial structures, growth factors, and government policies affecting industries.
3. Apply cost and production theories to optimize business operations and pricing strategies.
4. Differentiate various market structures and assess competition levels in industrial sectors.
5. Evaluate financial statements and investment decisions to enhance business profitability.</td></tr>
</table>

	6. Develop strategic business plans and apply management principles in industrial operations.

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

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, Monopolistic Competition. Inflation: Causes, measurement, effects, controlling of inflation. Index Numbers.	**08**
III.	**Industrialization** 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,	**07**

	Controlling: Control techniques.	
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.	

Year, Program, Semester	T.Y.B. Tech (Chemical Engineering), Part III, Semester VI						
Course Code	HSMEC 321						
Course Category	Humanities and Social Sciences , Management, Environmental Course						
Course title	Industrial Safety and Hazard Management						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	03	-	-	03		03	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-	50	-	-	-	50
Pre-requisites(if any)	-						
Course Rationale	The purpose of this course is to inculcate the Management principles and Techniques for good industrial practices towards Safety, Health and Environment. The course is intended to introduce the students to the knowledge of industrial safety and hazard management						

Course Objectives	The Course Teacher will 1. Discuss about Industrial safety programs and toxicology, Industrial laws, regulations and source models. 2. Demonstrate and explain fire and explosion, preventive methods, relief and its sizing methods. 3. Describe industrial hazards and its risk assessment. 4. Impart knowledge about occupational health, industrial hygiene, and accidental prevention techniques to the students. 5. Make students aware about safety auditing and management systems, pollution prevention techniques etc.
Course Outcomes	Upon completion of this course, student should be able to 1. Analyze the effect of release of toxic substances. 2. Understand the industrial laws, regulations and source models. 3. Apply the methods of prevention of fire and explosions. 4. Understand the relief and its sizing method. 5. Understand the methods of hazard identification and preventive 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	-	2	-	3	1	-	-	-	-	-
CO2	3	3	-	2	2	-	-	-	-	-	-	-
CO3	3	2	2	-	2	3	-	-	-	-	-	-
CO4	3	2	3	2	3	-	-	-	-	2	-	-
CO5	3	3	3	2	2	3	-	3	-	2	2	3

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

General Instructions: While tutorial hours, any 8 study experiments from the list to be learnt with any 2 experiments to be studied as demonstration conducted at the Environmental Science Department, Shivaji University, Kolhapur.

Experiment No.	Experiment Title/Objective	Hours

1.	Noise level measurement and analysis: Measurement of noise level for various sources – Impact, continuous and intermittent. Frequency and spectrum analysis of noise: Instrument – precision type of Noise level meter with frequency and spectrum analyzer.	**02**
2.	Vibration measurement and analysis: Measurement of whole body vibration for various acceleration: Instrument – vibration simulator and vibration analyzer.	**02**
3.	Friction sensitivity test: Measurement of friction sensitivity for unstable materials: Instrument – BAM friction tester.	**02**
4.	Impact sensitivity test: Measurement of impact sensitivity for unstable materials: Instrument – BAM fall hammer	**02**
5.	Thermal reactivity test: Measurement of thermal reactivity for unstable materials: Instrument – DSC/TGA.	**02**
6.	Exhaust gas measurement and analysis: Measurement of Exhaust gas measurement of IC engines: Instrument – Gas analyzer.	**02**
7.	Breathing zone concentration: Measurement of breathing zone concentration of dust and fumes: Instrument – personal air sampler	**02**
8.	Ambient air monitoring: Measurement of respirable and non-respirable dust in the ambient air: Instrument – High volume sampler.	**02**
9.	Consequence analysis: Soft computing skills on developing effects of fire & explosion and dispersion: Software – RISK PHAST V 6.6 (DNV) and ALOHA.	**02**
10.	Study of personal protective equipment: Safety helmet, belt, hand gloves, goggles, safety shoe, gum boots, ankle shoes, face shield, nose mask, ear plug, ear muff, apron and leg guard.	**02**
11.	Study of fire extinguishers: Selection and demonstration of first-aid fire extinguishers: soda acid, foam, carbon dioxide (CO_2), dries chemical powder, and halon.	**02**
Suggested Text Books/ Reference Books/Manual		
1.	D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2-11.	
2.	R.K. Sinnott, Coulson & Richardson's, Chemical Engineering, Vol. 6, Elsevier India, 2--6.	
3.	Fawcett H.H. and W.S.Wood, Safety and accident prevention in Chemical operations 2ndediton John Wiley and Sons Inc. (1982).	

Year, Program, Semester	T.Y.B. Tech (Chemical Engineering), Part III, Semester VI
Course Code	AEC321
Course Category	Ability Enhancement Course

<table>
<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 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>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 survey type of 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. The course aligns with NEP 2020's emphasis on experiential learning and Outcome Based Education (OBE) principles, ensuring graduates are equipped with the competencies needed to excel in the dynamic global workforce.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Enable students to independently execute and complete a chemical engineering mini project by integrating all aspects of the curriculum.
2. Prepare students for professional roles by emphasizing problem-solving, innovation, and teamwork.
3. Facilitate exposure to advanced experimental, computational, or design methodologies in chemical engineering."
4. Provide students with practical exposure to real-world industrial operations, processes, and technologies in the chemical engineering domain.
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, student should be able to
1. Demonstrate the ability to design and optimize chemical processes or systems based on engineering principles.
2. Showcase the ability to work collaboratively in teams and manage project timelines effectively.
3. Apply modern tools and technologies relevant to chemical engineering in project execution.
4. Gain insights into the functioning of chemical industries, including safety, environmental compliance, and process efficiency.
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
CO 1	3	-	3	-	-	2	3	-	-	-	-	-
CO 2	3	3	-	-	3	1	-	-	2	-	-	-
CO 3	-	3	-	-	3	3	-	-	3	-	3	-
CO 4	-	3	-	3	2	-	-	-	1	-	-	2
CO 5	-	-	-	-	-	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:

Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for mini projects and industrial visit reports.
- Peer evaluation for team-based projects.
- Written exams or quizzes to assess theoretical knowledge.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

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: 1. “Chemical Engineering Mini Projects" 2. "Chemical Engineering Industrial Visits" 3. "Hands-on Projects for Chemical Engineers" 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		01	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30	70	-	-	-	-	100
Pre-requisites(if any)	-						
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 1. To advance students' capabilities in synthesizing complex design challenges into feasible solutions. 2. To refine iterative problem-solving skills through industry-focused projects and case studies. 3. To cultivate a proactive, entrepreneurial mindset that addresses sustainability and societal needs.						
Course Outcomes	Upon completion of this course, student should be able to 1. Analyze complex problems to develop innovative, user-centric design solutions. 2. Apply advanced prototyping techniques to validate and optimize product concepts. 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. (2--9). Change by Design. HarperBusiness.	
2.	Lewrick, M., Link, P., &Leifer, L. (2-18). The Design Thinking Playbook. Wiley	
	Reference Books	
1.	Plattner, H., Meinel, C., &Leifer, L. (2-2-). Design Thinking Research. Springer.	
2.	Christensen, C. M. (2-13). The Innovator's Dilemma. Harvard Business Review Press	

Year, Program, Semester	T.Y.B. Tech (Chemical Engineering), Part III, Semester VI						
Course Code	MAC 321						
Course Category	Mandatory Audit Course						
Course title	Aptitude Enhancement Course III						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	01	-	01		-	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-	-	-	-	-	-
Pre-requisites(if any)	-						
Course Rationale	This course sharpens cognitive skills, decision-making, and industry-relevant problem-solving, preparing students for competitive exams and professional challenges.						

Course Objectives	1. Strengthen quantitative and logical reasoning for industry applications. 2. Develop decision-making skills through real-world case studies. 3. Enhance time-efficient problem-solving for competitive exams.
Course Outcomes	1. Apply advanced reasoning techniques to solve real-world problems. 2. Analyze data for informed decision-making in industry settings. 3. Demonstrate proficiency in aptitude tests and competitive exams.

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.
9	-	Elective I	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 &	Newly introduced.

		Innovation -III	
13	-	Aptitude Enhancement Course III	Newly introduced.
14	-	Multidisciplinary Minor Course III	As per NEP feature, MDM is introduced.