K. K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous wef AY 2022-23)

Structure and Syllabus of T.Y. B. Tech (Chemical Engineering)

Pattern: 2023
(wef AY 2022-23)

K. K. Wagh Institute of Engineering Education and Research, Nashik

(Autonomous from Academic Year 2022-23)

T.Y. B. Tech Chemical Engineering																	
(wef AY 2025-26)																	
SEM-V																	
Course Code	Course Type	Title of Course	Teaching Scheme			Evaluation Scheme and Marks								Credits			
			TH	TU	PR	INSEM	ENDSEM	CCE	TU	TW	PR	OR	TOTAL	TH	TU	PR	TOTAL
2307301	PCC	Mass Transfer I	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307302	PCC	Chemical Reaction Engineering I	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307303	PCC	Process Equipment Design	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307304	PCC	Lab Work in Mass Transfer I	-	-	2	-	-	-	-	25	25	-	**50**	-	-	1	**1**
2307305	PCC	Lab Work in Chemical Reaction Engineering I	-	-	2				-	25	25	-	**50**	-	-	1	**1**
2307306	PEC	Elective I	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307307	PEC	Lab Work in Elective I	-	-	2	-	-	-	-	25	-	25	**50**	-	-	1	**1**
2307308	OE	IPR and Patents	2	-	-	-	-	50	-	-	-	-	**50**	2	-	-	**2**
2307309	MDM	Piping Design and Engineering	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307310	CEP	Seminar	-	1	2	-	-	-	25	25	-	-	**50**	-	1	1	**2**
Total hours/marks/credits			**17**	**01**	**08**	**100**	**300**	**150**	**25**	**100**	**50**	**25**	**750**	**17**	**1**	**4**	**22**

Elective I		**Lab Work in Elective I**	
2307306A	Renewable Energy	2307307A	Renewable Energy
2307306B	Artificial Intelligence	2307307B	Artificial Intelligence
2307306C	Transport Phenomena	2307307C	Transport Phenomena

PCC	Programme Core Course
PEC	Programme Elective Course
OE	Open Elective
MDM	Multidisciplinary Minor
CEP	Community Engagement Project
VSEC	Vocational Skill Enhancement Course
RM	Research Methodology

T.Y. B.Tech Chemical Engineering
(wef AY 2025-26)
SEM-VI

Course Code	Course Type	Title of Course	Teaching Scheme			Evaluation Scheme and Marks							Credits			
			TH	TU	PR	INSEM	ENDSEM	CCE	TU	TW	PR	OR	TOTAL	TH	TU	PR	TOTAL
2307311	PCC	Mass Transfer II	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307312	PCC	Chemical Reaction Engineering II	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307313	PCC	Lab Work in Mass Transfer II	-	-	2	-	-	-	-	25	25	-	**50**	-	-	1	**1**
2307314	PEC	Elective II	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307315	PEC	Elective III	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307316	PEC	Lab Work in Elective II	-	-	2	-	-	-	-	25	-	25	**50**	-	-	1	**1**
2307317	MDM	Process Instrumentation	3	-	-	20	60	20	-	-	-	-	**100**	3	-	-	**3**
2307318	OE	Optimization Techniques	2	-	-	-	-	50	-	-	-	-	**50**	2	-	-	**2**
2307319	VSEC	Computer Aided Chemical Engineering	-	1	2	-	-	-	25	-	-	25	**50**	-	1	1	**2**
2307320	RM	Project Phase I	-	-	2	-	-	-	-	50	-	-	**50**	-	-	1	**1**
Total hours/marks/credits			**17**	**01**	**08**	**100**	**300**	**150**	**25**	**100**	**25**	**50**	**750**	**17**	**1**	**4**	**22**

Elective II		**Lab Work in Elective II**		**Elective III**	
2307314A	Chemical Process Industries	2307316A	Chemical Process Industries	2307315A	Heat Transfer Operations
2307314B	Chemical Process Synthesis	2307316B	Chemical Process Synthesis	2307315B	Food Technology

Semester V (TY - B. Tech.) Chemical Engineering
2307301: Mass Transfer I

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisite: Fundamental Knowledge of Process Calculations, Thermodynamics and Unit Operations in Chemical Engineering

Course Objectives:

1. To acquire basic understanding of the general principles and theories of Mass Transfer operations used in Chemical industries.
2. To apply the knowledge in the design of Mass transfer operations for the separation.
3. To be able to operate the various mass transfer operations such as Gas absorption, Humidification, Dehumidification and Drying in Chemical process industries.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Express the fundamental principles of Mass Transfer and theories of mass transfer operations in chemical process industries.	2-Understand
CO2	Apply mass transfer principles to analyze absorption processes and design gas-liquid equipment like packed, plate columns and cooling towers etc.	3-Apply
CO3	Analyze psychrometric relationships and cooling tower operations, and **solve** on applications and cooling tower using process design principles.	4-Analyze
CO4	Evaluate and design gas-liquid contactors and drying systems for various industrial applications, considering performance, efficiency, and operating conditions.	5- Evaluate

Course Contents:

Unit 1	Introduction (L07)	COs Mapped: CO1

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation methods, Steady State Molecular Diffusion in Fluids, Diffusivities of gases and liquids, Fick's and Maxwell law of diffusion, Diffusion in solids, Unsteady-state mass transfer. Types of solid diffusion.

Mass transfer coefficients in laminar flow and turbulent flow, Theories of mass transfer, Analogies between Momentum, Heat and Mass transfer, Inter-phase mass transfer, Overall Mass Transfer Coefficients, Methods of contacting in Mass Transfer; continuous co-current, countercurrent and crosscurrent processes, cascades, Theory of mass transfer accompanied by chemical reaction

Unit 2	Gas Absorption (L08)	COs Mapped: CO1, CO2, CO4

Mechanism of gas absorption, equilibrium in gas absorption, Choice of solvent for absorption, Minimum Liquid-Gas Ratio for absorber, Absorption Factor, Plate column Design, Murphree Tray efficiency, Overall column efficiency, Packed tower Design.

Unit 3	Humidification and Dehumidification (L07)	COs Mapped: CO1, CO2, CO3, CO4

Principles, Vapour-liquid equilibria, Enthalpy of pure substances, System of Air-Water, Basic Terminologies in humidification, Psychrometric chart, Wet bulb temperature relation,

Adiabatic Saturation Temperature, Lewis relation, methods of humidification and dehumidification, Water Cooling in cooling towers, Process design of Cooling Tower.		
Unit 4	**Equipment for Gas Liquid Operation (L07)**	**COs Mapped: CO1, CO2**
Types of gas-liquid contactors: 1. Packed column 2. Tray column 3. Bubble column 4. Agitated vessels, detailed process design of individual gas-liquid contactors,		
Unit 5	**Drying (L07)**	**COs Mapped: CO1, CO4**
Principles, equilibrium in drying, type of moisture content, Rate of drying, Theory of drying, Rate of drying. Time of drying, Mechanism of Batch Drying, Types of dryers: batch/continuous; Vacuum Drying, Freeze Drying, dryers for thermally sensitive materials. Process design of dryers.		

REFERENCE BOOKS:

1. Mass Transfer Operations, Treybal R.E., McGraw Hill, 3rd Edition.
2. Chemical Engineering, Vol I & II , Coulson J.M. and |Richardson J.F., McGraw Hill, 6th Edition.
3. Principles of Unit Operations, Wiley Student Edition, 2nd Edition.
4. Separation Processes, C. Judson King, 2nd Edition.
5. Design of Equilibrium Stage Processes, Buford D.Smith, McGraw Hill, 1st Edition.
6. Unit Operations of Chemical Engineering, W. L. McCabe, J. C. Smith and Peter Harriott, McGraw Hill, 7th Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three Assignments on Unit-1, Unit-2, Unit-3 & 4	10
2	Group Presentation on Unit-5	05
3	LMS Test on Each Unit	05
	Total	**20**

Semester V (TY - B. Tech.) Chemical Engineering
2307302: Chemical Reaction Engineering I

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisite: Concept of order of reaction, molecularity, rate of reaction, conversion and yield as covered in the subject of process calculations and chemistry

Course Objectives:

1. To understand concepts of rate equation and types of reactions.
2. To determine kinetics and design reactor.
3. To analyze temperature effects and deviations from ideality.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Describe the behavior of chemical reactions under various conditions and differentiate between reactor types and idealizations.	2-Understand
CO2	Apply kinetic models and reactor design equations to determine conversion, reaction rate, and reactor performance.	3-Apply
CO3	Analyze reaction data and multiple reaction systems to determine product distribution, selectivity, and yield.	4-Analyze
CO4	Evaluate deviations from ideal reactor behavior using non-ideal flow models and suggest suitable reactor configurations.	5- Evaluate

Course Contents:

Unit 1	Introduction to Chemical Kinetics (L07)	COs Mapped: CO1

Defining a rate equation and its representation, single and multiple reactions, elementary and non-elementary reactions, molecularity and order of reactions, rate controlling step, relation between concentration and conversion, concept of fractional change in volume, temperature dependency of rate constant.

Unit 2	Chemical Kinetics Modelling of Batch Reactor (L08)	COs Mapped: CO1, CO2

Batch reactor details, analysis of total pressure data, integral and differential methods for analysis of kinetic data, Half-life method for analysis of kinetic data, zero order, first order, second order reactions for constant and variable volume systems, reversible reactions, autocatalytic reactions.

Unit 3	Reactor Design (L07)	COs Mapped: CO1, CO2, CO4

Concept of space time and space velocity, performance equation of batch reactor, continuous stirred tank reactor and plug flow reactor, reactors in series and parallel, concept of Damkohler number in reactor design.

Unit 4	Multiple Reactions (L07)	COs Mapped: CO1, CO3

Types of multiple reactions, qualitative and quantitative discussion for multiple reactions in terms of product distribution for different reactors, instantaneous and overall fractional yield.

Unit 5	Temperature Effects And Deviations from Ideal Reactor (L07)	COs Mapped: CO1, CO3, CO4

Temperature dependency from various theories, Residence Time Distribution (RTD), F,C,E, curves and relation between them. Models for non-ideal reactions, dispersion model, tanks in series model, segregated flow model.

REFERENCE BOOKS:

1. Chemical Reaction Engineering, Octave Levenspiel, Wiley, 3rd Edition.
2. Chemical Engineering Kinetics, J. M. Smith, McGraw-Hill Education, 3rd Edition.
3. Elements of Chemical Reaction Engineering, H. Scott, Fogler. Prentice Hall India Learning Private Limited, 4th Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three Assignments on Unit-1, Unit-2, Unit-3 & 4	10
2	Group Presentation on Unit-5	05
3	LMS Test on Each Unit	05
	Total	**20**

2307303: Process Equipment Design

Teaching Scheme:	**Credit Scheme: 3**	**Examination Scheme:**
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: Basic Concepts of Design and Unit Operations in Chemical Engineering.

Course Objectives:

1. To acquire basic understanding of design parameters in process and mechanical design of equipment in chemical engineering.
2. To design mechanical aspects of various process vessels and their supports used in chemical engineering.
3. To select and design various heat exchanging equipment's.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Explain the basic concepts, classifications, standards, and terminology related to process equipment design.	2-Understand
CO2	Perform design calculations for distillation columns, pressure vessels, storage tanks, heat exchangers, and agitators.	3-Apply
CO3	Compare design alternatives and analyze key parameters to determine optimum design.	4-Analyze
CO4	Justify design choices, materials, methods, and optimize equipment design for performance and safety.	5- Evaluate

Course Contents:

Unit 1	**Design of Distillation Column (L07)**	**COs Mapped: CO1, CO2, CO3, CO4**

Design variables in distillation, Choices of plates or packing, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, and plate hydraulic design. Packed column design procedure, packed bed height (distillation and absorption), HTU, Cornell's method, Onda's method, column diameter, column internals, wetting rates, column auxiliaries.

Unit 2	**Design of Pressure Vessels (L08)**	**COs Mapped: CO1, CO2, CO3, CO4**

Introduction, types of pressure vessels, proportioning of pressure vessels, selection of L/D ratio, optimum proportions, codes and standards for pressure vessels (IS: 2825), design stress, design criteria, design of shell (spherical and cylindrical), design of different types of heads and closures, design of flanges and nozzles, compensation for openings and branches. Design of pressure vessels subjected to external pressure.

Design of High Pressure Vessel; Materials of construction, stresses in thick cylinder, pre stressing of thick walled vessels, analysis and design of high-pressure vessels including shell and head with stress distribution.

Unit 3	**Designs of Storage Vessels and Tall Vertical Vessels (L08)**	**COs Mapped: CO1, CO2, CO3, CO4**

Study of various types of storage vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Horton sphere, Losses in storage vessels, Various types of roofs for storage vessels, Design of cylindrical storage vessels as per API-650 and IS: 803 codes and specification; design of base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs.

Design of Tall Vessels: Stresses in the shell, shell design, vessel supports- introduction and classification of supports, design of skirt supports design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates Design of saddle supports, ring stiffeners.

Unit 4	**Design of Heat Exchangers (L07)**	**COs Mapped: CO1, CO2**

Introduction, Classification of Heat Exchangers, Shell and tube heat exchanger- General design considerations; Thermal design and Mechanical design of shell and tube heat exchangers, Codes and standards for design; BS, IS: 4503 and TEMA, Design of double pipe heat exchanger. Plate heat exchanger: design procedures.

Unit 5	**Design of Agitation System (L06)**	**COs Mapped: CO1, CO2, CO3, CO4**

Agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems, Power Curve.

REFERENCE BOOKS:

1. Process Equipment Design, V. V. Mahajani and S. B. Umarji, Laxmi Publications, 5th Edition.
2. Process Equipment Design, Brownell Young, Wiley, 1st Edition.
3. Coulson and Richardson's Chemical Engineering Series: Chemical Engineering Design, R.K. Sinnott, Vol. VI, Elsevier Butterworth-Heinemann, 4th Edition.
4. Introduction to Chemical Equipment Design: Mechanical Aspects, B.C. Bhattacharya, C.B.S. Publications, 1st Edition.
5. Code for unfired pressure vessels, Bureau of Indian standards, IS – 2825 (1969).
6. Chemical Process Equipment-Selection and Design, James R. Couper, W. Roy Penney, James R. Fair, Butterworth-Heinemann, 3rd Edition.
7. Ludwig's Applied Process Design for Chemical and Petrochemical Plants: 1, A. Kayode, Coker, Gulf Professional Publishing, 4th Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on Unit-1, Unit-2, Unit-3 & 4	10
2	Group presentation on Unit-5	05
3	LMS Test on each Unit	05
	Total	**20**

Semester V (TY - B. Tech.) Chemical Engineering
2307304: Lab work in Mass Transfer I

Teaching Scheme: Practical: 2 hrs./Week	**Credit Scheme: 1**	**Examination Scheme:** TW: 25 marks Practical: 25 marks Total: 50 Marks

Prerequisite: Fundamental Knowledge of Process Calculations, Thermodynamics and Unit operations in Chemical Engineering

Course Objectives:
1. To acquire basic understanding of the general principles and theories of Mass Transfer operations used in Chemical industries.
2. To apply the knowledge in the design of Mass transfer operations for the separation.
3. To be able to operate the various mass transfer operations such as Gas absorption, Humidification, Dehumidification and Drying in Chemical process industries.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Express the fundamental principles of Mass Transfer and theories of mass transfer operations in chemical process industries.	2-Understand
CO2	Apply mass transfer principles to analyze absorption processes and design gas-liquid equipment like packed, plate columns and cooling towers etc.	3-Apply
CO3	Analyze psychrometric relationships and cooling tower operations, and **solve** on applications and cooling tower using process design principles.	4-Analyze
CO4	Evaluate and design gas-liquid contactors and drying systems for various industrial applications, considering performance, efficiency, and operating conditions.	5- Evaluate

Suggested List of Laboratory Assignments:

Any eight practical's to be performed out of the following:

Sr. No	Laboratory Experiments	COs Mapped
1.	Tray Dryer – To calculate the rate of Batch Drying	**CO1, CO4**
2.	Rotary Dryer – To study the Characteristics of Rotary Dryer	**CO1, CO4**
3.	Spray Dryer – To study the design and Operating Principles of Spray Dryer	**CO1, CO4**
4.	Fluidized Bed Dryer –To study the characteristics of Fluidized bed Dryer	**CO1, CO4**
5.	Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system	**CO1**
6.	Winkelmann's method – To find the diffusion Coefficient of vapour in air by experimental method	**CO1**
7.	Enhancement Factor – To find the enhancement factor for absorption with chemical reaction	**CO1, CO2, CO4**
8.	Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower	**CO1, CO2, CO4**
9.	Cooling Tower– To study the characteristics	**CO1, CO2, CO4**
10.	Humidifier and Dehumidifier – To study the Characteristics	**CO1, CO2, CO3 CO4**
11.	Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient	**CO1, CO2, CO3 CO4**
12.	Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column	**CO1, CO2, CO3 CO4**

Guidelines for Laboratory Conduction
• Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment. • Apparatus and equipments required for the allotted experiment will be provided by the lab assistants using SOP. • Students will perform the allotted experiment in a group under the supervision of faculty and lab assistant. • After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher. • Students will then complete the experimental write up.
Guidelines for Student's Lab Journal
Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.
Guidelines for Termwork Assessment
1. Each experiment from lab journal is assessed for 30 marks based on three rubrics. 2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester V (TY - B. Tech.) Chemical Engineering 2307305: Lab work in Chemical Reaction Engineering I		
Teaching Scheme:	**Credit Scheme: 1**	**Examination Scheme:**

Practical: 2hrs/week		TW: 25 marks Practical: 25 marks Total: 50 Marks

Prerequisite: Concept of order of reaction, molecularity, rate of reaction, conversion and yield as covered in the subject of process calculations and chemistry.

Course Objectives:

1. To understand concepts of rate equation and types of reactions.
2. To determine kinetics and design reactors.
3. To determine parameter dependency and deviations occurring in reactors.

Course Outcomes: On completion of the course, learner will be able to–

Sr. No.	Course Outcomes	Bloom's Level
CO1	Describe the behavior of chemical reactions under various conditions and differentiate between reactor types and idealizations.	2-Understand
CO2	Apply kinetic models and reactor design equations to determine conversion, reaction rate, and reactor performance.	3-Apply
CO3	Analyze reaction data and multiple reaction systems to determine product distribution, selectivity, and yield.	4-Analyze
CO4	Evaluate deviations from ideal reactor behavior using non-ideal flow models and suggest suitable reactor configurations.	5- Evaluate

Suggested List of Laboratory Assignments:

Any **eight** practical's to be performed out of the following:

Sr. No.	Laboratory Experiments	COs Mapped
1.	Study of saponification of ethyl acetate reaction in batch reactor	**CO2, CO3**
2.	Determination of Arrhenius parameters	**CO1, CO2**
3.	Study of pseudo first order reaction: Acid catalyzed hydrolysis of methyl acetate	**CO2, CO3**
4.	Study of saponification of ethyl acetate reaction in mixed flow reactor (CSTR)	**CO2, CO3**
5.	Study of saponification of ethyl acetate reaction in plug flow reactor (PFR)	**CO2, CO3**
6.	CSTRs in series	**CO3, CO4**
7.	CSTR followed by PFR	**CO3, CO4**
8.	RTD studies in PFR	**CO1, CO4**
9.	RTD studies in MFR	**CO1, CO4**
10.	RTD studies in Helical coil reactor	**CO4**

Guidelines for Laboratory Conduction

- Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment.
- Apparatus and equipments required for the allotted experiment will be provided by the lab assistants using SOP.
- Students will perform the allotted experiment in a group under the supervision of faculty and lab assistant.
- After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher.
- Students will then complete the experimental write up.

Guidelines for Student's Lab Journal

Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.

Guidelines for Termwork Assessment

1. Each experiment from lab journal is assessed for 30 marks based on three rubrics.
2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester: V (TY - B. Tech.) Chemical Engineering 2307306A: Renewable Energy		
Teaching Scheme:	**Credit Scheme: 3**	**Examination Scheme:**

Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: Basic knowledge of Physics and Chemistry, Thermodynamics, Basic Electrical Engineering, Environmental Science.

Course Objectives:
1. To understand energy sources, including renewables, and energy conversion processes.
2. To explore biomass, solar, and waste-to-energy technologies, and applications.
3. To study hydrogen production, storage, and its use in fuel cells and transportation.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Classify various energy sources based on their availability and explain different methods of energy conversion.	2-Understand
CO2	Demonstrate solar energy systems and biomass-based renewable technologies.	3-Apply
CO3	Analyze waste-to-energy conversion methods and hydrogen energy systems with their manufacturing procedures.	4- Analyze

Course Contents:

Unit	Title	COs Mapped
Unit 1	**Sources of energy (L07)**	**COs Mapped: CO1**
Energy sources and their availability, renewable energy sources, Difference between renewable and non-renewable energy sources, Basics of energy: Different forms of energy, energy conversion process, indirect and direct energy conversion. Conventional energy systems: engines, power plants, various methods of power generation		
Unit 2	**Energy from Biomass (L08)**	**COs Mapped: CO1, CO2**
Biomass as a Renewable Energy Source, Biomass Conversion Technologies, Biogas Generation and Classification of Biogas Plants, Biomass Gasification, Production Processes and Properties of Bio-alcohol and Bio-diesel, Engine Applications of Biofuels		
Unit 3	**Solar Energy (L07)**	**COs Mapped: CO1, CO2**
Sun and solar energy, solar radiation and its measurement, solar energy collectors, solar energy storage methods, Photovoltaic systems, Application of solar energy. Solar PV modules, Applications of solar PV systems: water pumping application, home & street lighting applications etc.		
Unit 4	**Waste to energy (L07)**	**COs Mapped: CO1, CO3**
Introduction to Energy from waste: classification of waste as fuel: Agro-based waste, forest residue, industrial waste. MSW conversion devices: incinerators, gasifiers, digesters. Environmental monitoring system for land fill gases, Mitigating Environmental Impacts of Waste Incineration.		
Unit 5	**Hydrogen energy (L07)**	**COs Mapped: CO1, CO3**
Hydrogen Production Processes: Thermal, Electrochemical and Biological. Methods of Hydrogen Storage and Transportation, Applications of Hydrogen Fuel Cells, Hydrogen-Based Fuel for Vehicles.		

REFERENCE BOOKS:

1. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers, 6th Edition.
2. Non-Conventional Energy Sources, T.P. Ojha Rajesh K. Prasad, Jain Brothers, 4th Edition.
3. Solar energy – Thermal Collection and storage, P. S. Sukhatme, McGraw Hill Education, 3rd Edition.
4. Power plant Technology, M. M. El-Wakil, McGraw Hill Education, 1st Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

Semester V (TY B. Tech.) Chemical Engineering 2307306B: Artificial Intelligence		
Teaching Scheme: Theory: 3 hrs/week	**Credit Scheme: 3**	**Examination Scheme:** In Semester Exam: 20 marks

		End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisite: - Basic Programming Knowledge**,** Engineering Mathematics, Fundamentals of Chemical Engineering.

Course Objectives:

1. Introduce the fundamental concepts and applications of Artificial Intelligence (AI) in the context of Chemical Engineering.
2. Equip students with the necessary knowledge and skills to utilize AI techniques for problem-solving, analysis, and design in the chemical engineering domain.
3. Develop critical thinking and problem-solving skills through hands-on experience with AI tools and techniques.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Express core AI concepts and methods for chemical engineering applications.	2 - Understand
CO2	Employ Python and ML concepts to build basic AI models for chemical engineering problems.	3 - Apply
CO3	Analyze advanced AI solutions for complex chemical engineering problems considering performance and ethical aspects.	4 - Analyze

Course Contents:

Unit 1	**Introduction to AI (L07)**	**COs Mapped: CO1**

Introduction to AI and its historical perspective; Implications of AI for solving engineering problems, specifically in chemical engineering analysis and design; Case studies showcasing the use of AI in the chemical engineering industry.

Unit 2	**Symbolic AI (L07)**	**COs Mapped: CO1**

Knowledge representation: Propositional and predicate calculus, Production rules, Frames, objects, and ontologies; Search: Game trees and search algorithms (depth-first, breadth-first, best-first), Forward and backward chaining techniques.

Unit 3	**Python Programming Fundamentals (L07)**	**COs Mapped: CO1, CO2, CO3**

Introduction to Python programming language; Learning basic programming syntax, data structures, and control flow statements

Unit 4	**Knowledge-Based Systems and Machine (L07)**	**COs Mapped: CO1, CO2, CO3**

Knowledge-Based Expert Systems: Introduction and its applications in chemical engineering, Case studies focusing on: Process fault diagnosis and control, Operating procedures synthesis and process safety, Process design, Product design; Machine Learning Techniques: Data visualization and clustering techniques (k-means, k-medoids, density-based clustering, hierarchical clustering), Classification techniques (PCA/PLS, decision trees, kNN, LDA, SVM, kernel methods, RBN, neural networks, autoencoders), Regression techniques (linear regression, regularization, nonlinear regression).

Unit 5	**Advanced AI Techniques (L08)**	**COs Mapped: CO1, CO3**

Genetic algorithms and directed evolution for materials design; Ensemble learning methods: boosting and random forests; Modeling with deep neural networks (DNNs) and recurrent neural networks (RNNs); Reinforcement learning and graphical models; Introduction to hybrid AI models - combining symbolic and numeric AI techniques; Domain-specific ontologies, languages, and compilers.

REFERENCE BOOKS:

1. Artificial Intelligence in Chemical Engineering**,** Thomas E. Quantrille, Academic Press, 1st Edition.
2. Artificial Intelligence: A New Synthesis, Nilsson Nils J., Morgan Kaufmann Publishers Inc., 1st Edition.
3. Artificial Intelligence, Patrick Henry Winston, Addison-Wesley Publishing Company, 3rd Edition.
4. Computational Intelligence: An Introduction, Andries P. Engelbrecht, Wiley India, 2nd Edition.
5. Artificial Intelligence: A Modern Approach, Russell S., Norvig P., Pearson Education, 4th Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on Each unit	05
	Total	**20**

Semester V (TY - B. Tech.) Chemical Engineering
2307306C: Transport Phenomena

Teaching Scheme:	**Credit Scheme: 03**	**Examination Scheme:**
Theory: 03 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks

		Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisite: Courses of Fluid Mechanics, Heat Transfer Processes, Mass Transfer

Course Objectives:

1. To apply the momentum balance equation to analyze shear stress and velocity distributions in different fluids and systems.
2. To use the energy balance equation to determine heat flux and temperature distributions across various systems.
3. To apply mass balance equations to analyze molar flux and concentration distributions in different systems and evaluate energy losses in macroscopic systems.

Course Outcomes: On completion of the course, students will be able to–

Sr. No.	Course Outcomes	Bloom's Level
CO1	Elaborate boundary conditions and transport mechanisms in momentum, heat and mass transfer and their analogies.	2 – Understand
CO2	Apply balance equations to determine velocity, temperature, and concentration distributions in different geometries.	3 – Apply
CO3	Analyze unsteady-state transport using equations of change, curvilinear coordinates, and tensor notation.	4 – Analyze
CO4	Evaluate interphase transport using flow data, friction factors, and macroscopic balances.	5 – Evaluate

Course Contents:

Unit 1	**Momentum Transport (L07)**	**COs Mapped: CO1, CO2**

Importance of transport phenomena, analogous nature of transfer process, Newton's law of viscosity, Momentum balance equation, procedure to solve viscous flow problems and boundary conditions, Shear stress and velocity distribution in laminar flow for falling film, narrow slit, adjacent flow of two immiscible fluids, circular pipe and annular region.

Unit 2	**Energy Transport (L07)**	**COs Mapped: CO1, CO2**

Fourier's law of heat conduction, Thermal energy balance equation, procedure to solve heat flow problems and boundary conditions, Heat flux and Temperature distribution for electrical heat source, nuclear heat source, viscous heat source, Heat conduction with variable thermal conductivity.

Unit 3	**Mass Transport (L07)**	**COs Mapped: CO1, CO2**

Fick's law of diffusion, Mass balance equation, procedure to solve mass transfer problems and boundary conditions, Molar flux and Concentration distribution for stagnant diffusion, heterogeneous chemical reaction, homogeneous chemical reaction, pyrex tube diffusion, leaching.

Unit 4	**Unsteady Momentum Transport (L07)**	**COs Mapped: CO3**

Equations of change for isothermal system -
a) The equation of continuity b) The equation of motion c) Equation of change in curvilinear coordinate systems d) Use of equation of change to set up steady flow problem e) Equation of mechanical energy f) Dimensional analysis of equation of change.

Introduction to Tensors-

a) Scalars, vectors, and second-order tensors b) Tensor notation for stress and fluxes
c) Transformation of tensors d) Application of tensor notation in transport equations

Unit 5	**Interphase Transport in Isothermal System and**	**COs Mapped: CO4**

	Analogies (L07)	

Friction factors: a) Flow in tubes b) Around spheres c) In packed columns
Macroscopic balances for isothermal systems: a) Mass, momentum, and energy balances b) Sudden enlargement c) Liquid-liquid ejector
Semi-empirical expressions for Reynolds stresses
Analogies among momentum, heat, and mass transfer (Reynolds, Prandtl, Chilton-Colburn)

REFERENCE BOOKS

1. Transport Phenomena**,** Bird R. B., Stewart W. E., and Lightfoot E. N., John Wiley & Sons, 2nd Edition.
2. Analysis of Heat and Mass Transfer, Eckert E. R. G. and Drake R. M., McGraw-Hill, 3rd Edition.
3. Fundamentals of Momentum, Heat, and Mass Transfer, James Welty, Charles Wicks, Robert E. Wilson, and Gregory L. Rorrer, John Wiley & Sons, 6th Edition.
4. Energy, Mass and Momentum Transport Phenomena in Continua, Slattery J. C., Cambridge University Press, 1st Edition.

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three Assignments on Unit-1, Unit-2, Unit-3 & 4	10
2	Group Presentation on Unit-5	05
3	LMS Test on Each Unit	05
	Total	**20**

Semester: V (TY - B. Tech.) Chemical Engineering
2307307A: Lab work in Renewable Energy

Teaching Scheme:	**Credit Scheme: 1**	**Examination scheme:**
Practical: 2hrs./Week		TW: 25 marks Oral: 25 marks Total: 50 Marks

Prerequisites: Basic knowledge of Physics and Chemistry, Thermodynamics, Basic Electrical Engineering, Environmental Science.

Course Objectives:
1. To understand energy sources, including renewables, and energy conversion processes.
2. To explore biomass, solar, and waste-to-energy technologies, and applications.
3. To study hydrogen production, storage, and its use in fuel cells and transportation.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Classify various energy sources based on their availability and explain different methods of energy conversion.	2-Understand
CO2	Demonstrate solar energy systems and biomass-based renewable technologies.	3-Apply
CO3	Analyze waste-to-energy conversion methods and hydrogen energy systems with their manufacturing procedures.	4- Analyze

List of Suggested Experiments / Assignments

Sr. No.	Experiments / Assignments	CO Mapped
1	Comparative Analysis of Renewable and Non-Renewable Energy Sources	**CO1**
2	Case Study of Renewable Energy Sources and Their Conversion Processes	**CO1, CO2**
3	Comparative Analysis of Power Generation Methods	**CO1**
4	Efficiency Study of Conventional Energy Systems	**CO1**
5	Case Study of Waste-to-Energy Facilities and Environmental Management	**CO3**
6	Case Study of Hydrogen Fuel Cell Applications in Transportation	**CO3**
7	Case Study of Challenges and Opportunities in Renewable Energy Development	**CO1, CO2**
8	Case Study on Future Trends, and Innovations in Renewable Energy Technologies	**CO1, CO2, CO3**

Guidelines for Termwork Assessment

Term work assessment is to be based on overall performance of students, which includes the following parameters: timely completion of tasks, performance quality, punctuality, participation, and contribution in the experiments. Students will be evaluated based on the experiment, report and presentation.

Semester V (TY B. Tech.) Chemical Engineering
2307307B: Lab work in Artificial Intelligence

Teaching Scheme:	Credit Scheme: 1	Examination Scheme:
Practical: 2Hrs. /Week		TW: 25 marks Oral: 25 marks Total: 50 Marks

Prerequisite: - Basic Programming Knowledge**,** Engineering Mathematics, Fundamentals of Chemical Engineering.

Course Objectives:

1. Introduce the fundamental concepts and applications of Artificial Intelligence (AI) in the context of Chemical Engineering.
2. Equip students with the necessary knowledge and skills to utilize AI techniques for problem-solving, analysis, and design in the chemical engineering domain.
3. Develop critical thinking and problem-solving skills through hands-on experience with AI tools and techniques.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Express core AI concepts and methods for chemical engineering applications.	2 - Understand
CO2	Employ Python and ML concepts to build basic AI models for chemical engineering problems.	3 - Apply
CO3	Analyze advanced AI solutions for complex chemical engineering problems considering performance and ethical aspects.	4 - Analyze

Suggested List of Laboratory Assignments:

Any eight practical's to be performed out of the following:

Sr. No	List of Laboratory Assignments	CO Mapped
1.	Explore and present applications of Artificial Intelligence (AI) in Chemical Engineering, highlighting its benefits and challenges.	**CO2**
2.	Build a collaborative timeline or history of AI using online tools.	**CO2**
3.	Solve chemical engineering problems using logical reasoning.	**CO1**
4.	Construct molecular structures by applying production rules.	**CO1**
5.	Write basic code for performing chemical engineering calculations.	**CO1**
6.	Use Python to identify patterns in chemical data.	**CO1**
7.	Apply AI to analyze data and predict chemical reactions.	**CO2**
8.	Use AI-based simulations to optimize chemical processes.	**CO3**
9.	Investigate how AI enhances safety in chemical processes.	**CO2**
10.	Solve a chemical engineering problem by integrating multiple AI techniques.	**CO3**

Guidelines for Laboratory Conduction

1. Teacher will brief the given problem statement to students, its objectives and outcome.
2. Students will solve the allotted problem either using standard literature survey or python software if required.
3. After solving problem, students will check their results from the teacher.
4. Students will then complete the write up.

Guidelines for Student's Lab Journal

Write-up should include title, software used, concept utilized, course usage and problem statement, conclusion, programming steps and programming results if any.

Guidelines for Termwork Assessment

1. Each experiment from lab journal is assessed for 30 marks based on three rubrics.
2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester V (TY - B. Tech.) Chemical Engineering
2307307C: Lab work in Transport Phenomena

Teaching Scheme:	**Credit Scheme: 1**	**Examination Scheme:**
Practical: 2 hrs. /Week		TW: 25 marks

		Oral: 25 marks Total: 50 Marks

Prerequisite: Basic knowledge of fluid properties, flow types, and momentum balance, Understanding of conduction, convection, radiation, and energy balance, Basics of diffusion, Fick's law, and mass transfer in different phases.

Course Objectives:

1. To apply the momentum balance equation to analyze shear stress and velocity distributions in different fluids and systems.
2. To use the energy balance equation to determine heat flux and temperature distributions across various systems.
3. To apply mass balance equations to analyze molar flux and concentration distributions in different systems and evaluate energy losses in macroscopic systems.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Elaborate boundary conditions and transport mechanisms in momentum, heat and mass transfer and their analogies.	2 – Understand
CO2	Apply balance equations to determine velocity, temperature, and concentration distributions in different geometries.	3 – Apply
CO3	Analyze unsteady-state transport using equations of change, curvilinear coordinates, and tensor notation.	4 – Analyze
CO4	Evaluate interphase transport using flow data, friction factors, and macroscopic balances.	5 – Evaluate

Suggested List of Laboratory Assignments:

Any six practical but not limited following:

Sr. No	Laboratory Experiments	COs Mapped
1.	Determination of Viscosity of a Fluid Using a Capillary Tube Viscometer	**CO1, CO3**
2.	Experimental Study of Velocity Profile in Laminar Flow through a Circular Pipe	**CO1, CO2, CO4**
3.	Heat Conduction through Composite Walls and Determination of Thermal Conductivity	**CO1, CO2**
4.	Analysis of Heat Transfer in a Rod Heated at One End (Longitudinal Conduction)	**CO1, CO2, CO3**
5.	Determination of Diffusion Coefficient in Liquid System (e.g., $KMnO_4$ in Water)	**CO1, CO2, CO4**
6.	Measurement of Mass Transfer Coefficient in a Wetted-Wall Column	**CO1, CO2, CO4**
7.	Dimensional Analysis Using Buckingham π-Theorem for Pipe Flow System	**CO1, CO4**
8.	Determination of Friction Factor for Laminar and Turbulent Flow through Pipes	**CO1, CO4**
9.	Study of Flow Past Spheres and Estimation of Drag Coefficient	**CO1, CO4**
10.	Use of Analogy (Reynolds or Chilton-Colburn) to Estimate Heat or Mass Transfer Coefficients	**CO1, CO2, CO4**
11.	Study of Unsteady-State Heat Conduction in a Slab Using Electrical Heating	**CO1, CO3**
12.	Determination of Momentum Diffusivity Using Stokes' Law for Falling Sphere	**CO1, CO2, CO4**
13.	Observation of Fluidization Behavior in a Packed and Fluidized	**CO1, CO2, CO4**

	Bed	
14.	Simulation of Heat and Mass Transfer Profiles Using Software (e.g., ANSYS Fluent or COMSOL Multiphysics)	**CO1, CO2, CO3, CO4**

Guidelines for Laboratory Conduction

- Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment.
- Apparatus and equipments required for the allotted experiment will be provided by the lab assistants using SOP.
- Students will perform the allotted experiment in a group under the supervision of faculty and lab assistant.
- After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher.
- Students will then complete the experimental write up.

Guidelines for Student's Lab Journal

Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.

Guidelines for Termwork Assessment

3. Each experiment from lab journal is assessed for 30 marks based on three rubrics.
4. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester V (TY - B. Tech.) Chemical Engineering
2307308: IPR and Patents

Teaching Scheme:	**Credit Scheme: 2**	**Examination Scheme:**
Theory: 2 hrs/week		Continuous Comprehensive Evaluation: 50 marks

		Total: 50 Marks

Prerequisite Courses: Basic communication and technical writing skills, Awareness of innovation in chemical engineering, Analytical thinking and problem-solving ability.

Course Objectives:

1. Provide basics of various forms of intellectual property.
2. Provide insight into the registration procedure for various forms of intellectual property.
3. Enable students to draft patent specifications on their own.

Course Outcomes: After successful completion of the course student should be able to:-

	Course Outcomes	Bloom's Level
CO1	Describe the fundamental concepts of IPR including patents, copyrights, trademarks, industrial designs, and trade secrets.	2 – Understand
CO2	Apply procedures related to patent filing, copyright, trademark registration, and IP management.	3 – Apply
CO3	Analyze patent specifications and claims to interpret invention-based solutions.	4 – Analyze

Course Content

Unit 1	Introduction to IP, Patent Basic, and Patent filing procedure **(L05)**	**COs Mapped: CO1, CO2**
Unit 2	Copyright basic, Industrial Design, Emerging issue **(L05)**	**COs Mapped: CO1, CO2**
Unit 3	Trademark basic, GI basic, IC Layout Design **(L05)**	**COs Mapped: CO1, CO2**
Unit 4	Trade secret, Comparative analysis, IP management **(L05)**	**COs Mapped: CO1, CO2**
Unit 5	Invention as a solution to an unsolved problem, Drafting a Claim, Types and Arrangement of Claims, Structure of the Patent Specification **(L05)**	**COs Mapped: CO3**

REFERENCE BOOKS:

1. Introduction to Intellectual Property, David Kline and David Kappos, OpenStax, 1st Edition.
2. Hughes on Copyright and Industrial Design, Roger T. Hughes, Neal Armstrong, and Susan J. Peacock, LexisNexis, 2nd Edition.
3. IC Layout Basics: A Practical Guide, Christopher Saint and Judy Saint, McGraw Hill, 1st Edition.
4. Learning Trade Secret Law: A Modular Approach to Intellectual Property, Shubha Ghosh, West Academic Publishing, 1st Edition.
5. Essentials of Patent Claim Drafting, Morgan D. Rosenberg, LexisNexis, 1st Edition.

NPTEL Course

1	https://onlinecourses.nptel.ac.in/noc24_mg125/preview NPTEL Course on INTELLECTUAL PROPERTY RIGHTS AND COMPETITION LAW.
2	https://archive.nptel.ac.in/courses/109/106/109106128/ NPTEL Course on PATENT DRAFTING FOR BEGINNERS.

3	https://archive.nptel.ac.in/courses/109/105/109105112/ NPTEL Course on INTRODUCTION ON INTELLECTUAL PROPERTY TO ENGINEERS AND TECHNOLOGISTS.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	30
2	Group presentation on unit-5	10
3	LMS Test on each unit	10
	Total	50

Semester V (TY - B. Tech.) Chemical Engineering
2307309: Piping Design and Engineering

<table>
<tr><td>Teaching Scheme:
Theory: 3 hrs/week</td><td colspan="2">Credit Scheme: 3</td><td>Examination Scheme:
In Semester Exam: 20 marks
End Semesters Exam: 60 marks
Continuous Comprehensive Evaluation: 20 marks
Total: 100 Marks</td></tr>
<tr><td colspan="4">Prerequisites: Fundamental of Fluid Mechanics, Chemical Engineering Materials</td></tr>
<tr><td colspan="4">Course Objectives:
1. To introduce the concepts of piping design, abbreviations used in piping engineering.
2. To identify the various piping components required in industry.
3. To apply the various concepts of piping supports, stress analysis.</td></tr>
<tr><td colspan="4">Course Outcomes: On completion of the course, learner will be able to:-</td></tr>
<tr><td>Sr. No</td><td colspan="2">Course Outcomes</td><td>Bloom’s Level</td></tr>
<tr><td>CO1</td><td colspan="2">Describe the evolution of piping design, pipe fittings, flanges, material specifications, and applicable codes and standards used in piping systems.</td><td>2 – Understand</td></tr>
<tr><td>CO2</td><td colspan="2">Apply engineering drawings and symbols to develop piping layouts and isometric drawings and interpret process flow and instrumentation diagrams.</td><td>3 – Apply</td></tr>
<tr><td>CO3</td><td colspan="2">Analyze the selection of piping materials, insulation types, and equipment for designing pipe supports and reducing system stresses.</td><td>4 – Analyze</td></tr>
<tr><td>CO4</td><td colspan="2">Evaluate piping system design with respect to layout, pipe rack design, support selection, and stress analysis for efficient and safe operation of process plants.</td><td>5-Evaluate</td></tr>
<tr><td colspan="4">Course Contents:</td></tr>
<tr><td>Unit 1</td><td colspan="2">Introduction to Piping Design & Engineering (L08)</td><td>COs Mapped: CO1, CO4</td></tr>
<tr><td colspan="4">Evolution of piping, Manufacturing methods, Piping materials and selection, Pipe dimensioning Schedule numbers, Common piping abbreviations, Major organizations for standards, ASME/ANSI Codes & Specification, Specification classes. Type of Fittings - elbows, weld tee, stub in, mitre bends, reinforcement pad calculation for branch connections, couplings, reducers, weld cap, screwed and socket welded fittings, blanks, reducers, expansion joints, pipe nipples, flanged fittings and use of fittings, Type Flange -Types, P-T ratings and facings, Gaskets, bolts and nuts.</td></tr>
<tr><td>Unit 2</td><td colspan="2">Materials for Piping (L07)</td><td>COs Mapped: CO1, CO3</td></tr>
<tr><td colspan="4">Selection of material for piping, desirable properties of piping materials, materials for various Temperature and pressure conditions, materials for corrosion resistance. Common ASTM and IS specifications for: Seamless / ERW pipes, materials for valves, Gaskets. Insulation for Hot and cold materials and their important properties, insulation material selection criteria, Typical insulation specification – hot and cold materials.</td></tr>
<tr><td>Unit 3</td><td colspan="2">Piping Engineering Drawings and its Concept (L07)</td><td>COs Mapped: CO2</td></tr>
<tr><td colspan="4">Uses of flow diagrams, process flow diagrams, mechanical flow diagrams, utility flow diagrams, piping symbols, line symbols, valve symbols, piping isometrics, general arrangement drawings- sections/elevations/ detail drawings, plot plan procedures, Purpose of P&ID’S, study of P&ID’S, symbols usage according to industrial practices, Purpose of P&ID in process industrial/plants. Introduction to equipment layout, piping layout, piping</td></tr>
</table>

isometrics and bill of material.		
Unit 4	**Design of Pipe Racks and Storage Terminals (L07)**	**COs Mapped: CO2, CO4**
Design of Pipe Rack, Pipe Rack Spacing, Placing Lines, Width & Height Calculations, development of Pipe Rack Layouts and Isometric Preparation, Design of Storage terminal, need of Tank Farm, development of Equipment and Piping Layouts, Nozzle Orientation.		
Unit 5	**Piping Supports and Introduction to Stress Analysis (L07)**	**COs Mapped: CO3, CO4**
Pipe Supports, pipe insulation shoes, pipe guides, field supports, dummy supports, hanger rods, spring hangers, pick-up, control valve manifolds, utility stations, sewer and underground piping system, Introduction to Pipe Stress Analysis, various methods of releasing stress in piping system, support selection to minimize stresses in piping system using support span calculations and loop calculations.		

REFERENCE BOOKS:

1. Piping Design Handbook, John J. Mcketta, CRC Press, 1st Edition.
2. Process plant layout and piping design by Ed Bausbacher& Roger Pearson Prentice Hall, 1st Edition.
3. Piping Handbook, Edited, Mohinder Nayyar, McGraw-Hill Professional, 7th Edition.
4. Pipe Drafting and Design by Roy A Parisher, Elsevier, 3rd Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

2307310: Seminar

Teaching Scheme:	**Credit Scheme: 2**	**Examination Scheme:**
Tutorial : 1 hr/Week Practical: 2 Hrs. /Week		TU: 25 Marks TW: 25 Marks Total: 50 Marks

Prerequisites: Basic knowledge of chemical engineering principles and processes, familiarity with academic research methods and resources.

Course Objectives:

1. To develop the skills necessary for identifying and selecting a relevant topic in the field of Chemical Engineering for seminar presentation.
2. To provide students with the ability to conduct comprehensive literature surveys to gather information from various sources such as reference books, journals, and the internet.
3. To enhance students' technical writing skills by preparing a seminar report using standard formatting guidelines.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Apply methodologies for selecting a research topic and conducting literature surveys, and employ principles of technical report writing for seminar documentation.	3- Apply
CO2	Analyze research findings by evaluating literature, organizing collected data, and structuring a comprehensive seminar report adhering to academic standards.	4- Analyze
CO3	Evaluate the effectiveness of research communication by critically assessing presentation delivery, visual aids, and ability to engage in constructive discussion on complex findings.	5- Evaluate

Course Contents:

Module 1	**Introduction and Topic Selection (L04)**	**COs Mapped: CO1**
Seminar Course Introduction, Guidance of Seminar topic selection, Discussion on Literature Survey Methods.		
Module 2	**Literature Survey (L05)**	**COs Mapped: CO2, CO3**
Understanding the importance of literature surveys in research, Techniques for conducting effective literature searches.		
Module 3	**Technical Writing (L05)**	**COs Mapped: CO1, CO2, CO3**
Develop Technical Writing Skills for Seminar Reports, Understand Report Organization: Introduction, Literature Survey, Results, Discussion, Conclusions, References, Prepare Seminar Presentations: Design PowerPoint slides, Structure Presentation.		

Guidelines for Tutorial Evaluation

Sr. No.	Components for Tutorial Evaluation	Marks Allotted
1	Two Assignments on Module 1 and Module 2	10
2	Group Presentation on Module 3	10
3.	LMS Test on Each Module	05
	Total	**25**

Guidelines for Term work Assessment

Term work assessment of seminar is to be based on overall performance of students, which includes the following parameters: timely completion of tasks, performance quality, punctuality, participation, and contribution in various seminar activities such as literature study, presentations, and teamwork. Students will prepare a seminar report and deliver a PowerPoint presentation on the seminar topic.

Format of the Seminar report and TW assessment:

1. The Seminar report should be based on a detailed study of any relevant topic to Chemical Engineering. The typing shall be with normal spacing and on one side of the paper.
2. The report should be submitted in spiral bound format.
3. Front cover: This shall have the following details.
   - Title of the seminar report.
   - The name of the candidate with roll number / examination seat number at the middle.
   - Name of the guide below the candidate's details.
   - The name of the institute and year of submission on separate lines at the bottom.
4. The format of the text of the seminar reports:
   - The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey.
   - The result-discussion and conclusions shall form the last part of the text. Nomenclature and symbols should be added. References should be written in the standard format after the conclusion.
   - The total number of typed pages, excluding cover shall be about 25 to 30. All the pages should be numbered. This includes figures and diagrams.
5. Two copies of the seminar report shall be submitted to the Institute. The candidate shall present the seminar through power point presentation. The total duration of presentation and discussion should be about 30 minutes max. [25 min + 5 min].

Teaching Scheme: Theory: 3 hrs/week	**Credit Scheme: 3**	**Examination Scheme:** In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: Fundamental knowledge of mass transfer principles, process calculations, thermodynamics, and unit operations in chemical engineering.

Course Objectives:

1. To acquire basic understanding of Mass Transfer operations, their principles used in Chemical industries.
2. To apply the knowledge for the process design of mass transfer operations for the separation of mixtures.
3. To be able to operate the mass transfer operations in Chemical process industries.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Describe the principles and equilibrium concepts of various mass transfer processes.	2 – Understand
CO2	Apply stage-wise and equilibrium methods to solve design problems in distillation, extraction, and leaching.	3 – Apply
CO3	Analyze the performance and efficiency of different separation systems based on mass transfer principles.	4 – Analyze
CO4	Evaluate mass transfer equipment and emerging separation techniques for industrial applications.	5 – Evaluate

Course Contents:

Unit 1	**Distillation (L08)**	**COs Mapped: CO1, CO2, CO3**

Basic Distillation, concept of relative volatility, Types of Distillation, binary and multi-component systems, Reflux ratio, McCabe-Thiele, Lewis-Sorel methods of estimation of number of plates, minimum and optimum reflux ratio, Fenske's equation, Fenske-Underwood equation, Partial and total Condensers, Tray efficiencies.

Unit 2	**Solvent Extraction (L08)**	**COs Mapped: CO1, CO2, CO3**

Principles, industrial applications, factors affecting solvent extraction, ternary liquid equilibria, three-liquid systems, and temperature effects; Stagewise operations: single-stage and multistage (crosscurrent, countercurrent); continuous extraction; Types of extractors.

Unit 3	**Leaching (L07)**	**COs Mapped: CO1, CO2, CO3**

Principles, industrial applications, factors affecting leaching, equilibrium, and methods of operation; Single-stage, multistage, and continuous counter-current leaching; stage efficiency and related calculations; Types of leaching equipment.

Unit 4	**Adsorption and Ion Exchange (L07)**	**COs Mapped: CO1, CO3, CO4**

Principles of physical and chemical adsorption, adsorbents, equilibrium, and isotherms (Langmuir, Freundlich); Single-stage and multistage adsorption operations, liquid-solid agitated vessels, column studies, breakthrough curves, pressure-swing adsorption.
Ion exchange principles, equilibrium, kinetics, and applications.

Unit 5	**Crystallization and Novel Separation Techniques (L07)**	**COs Mapped: CO1, CO3**

Role and mechanism of crystallization, solubility curves, Mier's supersaturation theory, and crystallization yield; Types of crystallizers.
Introduction to membrane separation: ultrafiltration, nano filtration, reverse osmosis; membrane types, modules, flux, and driving forces.

REFERENCE BOOKS:

1. Mass Transfer Operations, R. E. Treybal, McGraw Hill, 3rd Edition.
2. Chemical Engineering, Vol I & II, J. M. Coulson and J. F. Richardson, McGraw Hill, 6th Edition.
3. Principles of Unit Operations, F. A. Hougen, K. M. Watson, and R. M. Ragatz, Wiley Student Edition, 2nd Edition.
4. Separation Processes, C. Judson King, McGraw Hill, 2nd Edition.
5. Design of Equilibrium Stage Processes, Buford D.Smith, McGraw Hill 1st Edition.
6. Unit Operations of Chemical Engineering, W. L. McCabe, J. C. Smith and Peter Harriott, McGraw Hill, 7th Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

2307312: Chemical Reaction Engineering II

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: Concept of rate controlling step, reaction kinetics.

Course Objectives:

1. To understand kinetics of heterogeneous reactions
2. To analyze fluid-fluid, fluid-particle reactions
3. To analyze catalytic reactions for design

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Describe fundamental principles and theories of heterogeneous, fluid-fluid, and catalytic reactions, including adsorption and diffusion mechanisms.	2 – Understand
CO2	Apply kinetic models, adsorption isotherms, and reaction engineering principles to calculate rates, conversions, and design parameters for multiphase reaction systems.	3 – Apply
CO3	Analyze heterogeneous reaction systems to determine controlling mechanisms, selectivity, and catalyst performance under various operating conditions.	4 – Analyze
CO4	Evaluate catalyst suitability and reactor performance for complex industrial applications involving poisoned catalysts and non-ideal systems.	5 – Evaluate

Course Contents:

Unit 1	Heterogeneous reactions (L07)	COs Mapped:CO1, CO2, CO3

Types of heterogeneous reactions, rates, contacting patterns, fluid-particle reactions: selection of model unreacted core model, progressive conversion model, Rate of reaction for shrinking spherical particles, Determination of rate controlling step, application to design, application to fluidized bed with entrainment.

Unit 2	Fluid – Fluid Reaction (L07)	COs Mapped: CO1, CO2

Two film theory, Rate equation for reaction, kinetic regimes, film conversion parameter, slurry reaction kinetics, Hatta Number, concept of enhancement factor, application to design absorption column (fast and slow reactions).

Unit 3	Catalysis and Adsorption (L08)	COs Mapped: CO1, CO2, CO3

Surface chemistry and adsorption, adsorption isotherms and rates of adsorption. Catalysis: determination of surface area by BET method, void volume and solid density, pore-volume distribution, catalyst selection, preparation of catalyst and its deactivation, poisoning and regeneration, nature and mechanism of catalytic reactions.

Unit 4	Diffusion in porous catalytic reactions (L07)	COs Mapped: CO1, CO2, CO3, CO4

Gaseous diffusion in single cylindrical pore, diffusion in liquids, in porous catalyst, surface diffusion, mass transfer with reaction: effectiveness factor, experimental and calculated effectiveness factor, selectivity's for porous catalysts, rates for poisoned porous catalysts.

Unit 5	**Design of heterogeneous catalytic reactors (L07)**	**COs Mapped: CO3, CO4**
Multiphase reactors, Fluidized bed reactor, isothermal and adiabatic fixed bed reactor, fluidized bed reactor, slurry reactor, enzyme fermentation: Michaelis–Menten (M-M) kinetics, inhibition by foreign substance.		
REFERENCE BOOKS:		
1. Chemical Reaction Engineering, Octave Levenspiel, Wiley, 3rd Edition. 2. Chemical Engineering Kinetics, J. M.Smith, McGraw-Hill Education, 3rd Edition. 3. Elements of Chemical Reaction Engineering, H. Scott, Fogler, Prentice Hall India Learning Private Limited, 4th Edition. 4. Heterogeneous Reactions: Analysis Examples and reactor Design. Vol. I & II, L. K. Doraiswamy and M. M Sharma, John Wiley & Sons, 1st Edition. 5. An Introduction to Chemical Reaction Kinetics & Reactor Design, C. G. Hill, John Wiley & Sons, 2nd Edition.		

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group Presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

2307313: Lab work in Mass Transfer II

Teaching Scheme:	Credit Scheme: 1	Examination Scheme:
Practical: 2hrs./Week		TW: 25 marks Practical: 25 marks Total: 50 Marks

Prerequisites: Fundamental knowledge of mass transfer principles, process calculations, thermodynamics, and unit operations in chemical engineering.

Course Objectives:

1. To acquire basic understanding of Mass Transfer operations, their principles used in Chemical industries.
2. To apply the knowledge for the process design of mass transfer operations for the separation of mixtures.
3. To be able to operate the mass transfer operations in Chemical process industries.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Describe the principles and equilibrium concepts of various mass transfer processes.	2 – Understand
CO2	Apply stage-wise and equilibrium methods to solve design problems in distillation, extraction, and leaching.	3 – Apply
CO3	Analyze the performance and efficiency of different separation systems based on mass transfer principles.	4 – Analyze
CO4	Evaluate mass transfer equipment and emerging separation techniques for industrial applications.	5 – Evaluate

Suggested List of Laboratory Assignments:

Any eight practical's to be performed out of the following:

Sr. No.	Laboratory Experiments	COs Mapped
1.	To verify Rayleigh's equation and to study simple distillation.	**CO1, CO2**
2.	To study characteristics of steam distillation.	**CO1, CO2, CO3**
3.	To evaluate HETP and HTU in packed column distillation.	**CO2, CO3**
4.	Vacuum Distillation.	**CO3, CO4**
5.	To operate a sieve plate distillation column and determine tray efficiency.	**CO2, CO3, CO4**
6.	To study equilibrium diagram for a ternary liquid-liquid system.	**CO1**
7.	To determine HOR, HOE, KOR, KOE in liquid-liquid extraction.	**CO2, CO3**
8.	To determine mass transfer coefficient in a spray extraction column.	**CO3, CO4**
9.	To study operation and performance of York-Scheibel column.	**CO3, CO4**
10.	To study solid-liquid extraction and determine yield of oil.	**CO2, CO3**
11.	To determine crystallizer yield and verify material balance in batch crystallization.	**CO1, CO3**
12.	To study the principles and operation of an ion exchange process and determine ion exchange capacity.	**CO1, CO3, CO4**
13.	To determine the adsorption isotherm and/or breakthrough curve using batch or column adsorption method.	**CO1, CO2, CO3, CO4**

Guidelines for Laboratory Conduction

• Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment. • Apparatus and equipment's required for the allotted experiment will be provided by the lab assistants using SOP. • Students will perform the allotted experiment in a group under the supervision of faculty and lab assistant. • After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher. • Students will then complete the experimental write up.
Guidelines for Student's Lab Journal
Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.
Guidelines for Termwork Assessment
1. Each experiment from lab journal is assessed for 30 marks based on three rubrics. 2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

2307314A: Chemical Process Industries

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: Basic knowledge of Chemical compounds**,** Introduction of unit processes and unit operations.

Course Objectives:

1. To study introduction of chemical engineering and study of chlor-alkali and metallurgical industries
2. To study nitro-phosphorus, sulfur industry
3. To study natural chemical industry.
4. To study petroleum and polymer industry.
5. To study petrochemical industry.

Course Outcomes: On completion of the course, students will be able to–

CO	Course Outcomes	Bloom's Level
CO1	Understand raw materials, reactions, production methods, and applications of industrial chemicals.	2-Understand
CO2	Apply knowledge of process variables to evaluate product yield and waste/by-product formation in chemical industries.	3- Apply
CO3	Analyze process flow diagrams to identify key operational steps and engineering challenges in manufacturing processes.	4- Analyze

Course Contents:

Unit 1	Basic Concepts (L07)	COs Mapped: CO1, CO2, CO3

Introduction: Chemical industries-facts and figures, MSDS, Unit operation and unit process concepts, Chemical processing and role of chemical engineers, process flow diagrams, the anatomy of a chemical manufacturing process, major engineering problems.
Chlor-Alkali Industry: Production of Soda ash, Production of Chlorine and caustic soda.
Metallurgical Industries: Iron and steel, aluminum, copper, Zinc etc.

Unit 2	Nitrogen, Phosphorus and sulfur Industry (L07)	COs Mapped: CO1, CO2, CO3

i. Nitrogen Industry: Production of Ammonia, Nitric acid, Urea, Ammonium Nitrate.
ii. Phosphorous Industry: Production of Phosphoric acid, single and triple Super Phosphate, Ammonium Phosphate.
iii. Sulphur Industry: Production of Sulphur, Sulphuric acid, Ammonium sulphate.

Unit 3	Natural Chemical Industry (L07)	COs Mapped: CO1, CO2, CO3

i. Sugar and starch industry
ii. Oil, Fat and waxes
iii. Pulp and Paper industry
iv. Coal Chemicals

Unit 4	Petroleum and Polymer Industry (L07)	COs Mapped: CO1, CO2, CO3

i. Petroleum Industry: History of production of crude petroleum, characteristics of refineries-refinery operations.

ii. Introduction to Polymer, Classification of Polymerization, Production:polyolefins: polyethylene, poly propylene and polystyrene, styrene copolymers, polyvinyl chloride, polycarbonate, nylon 6, nylon 66, urea formaldehyde, styrene butadiene rubber (SBR) etc.

Unit 5	**Petrochemical Industry (L08)**	**COs Mapped: CO1, CO2, CO3**

i. C1 Compounds: Production of Methanol, Formaldehyde, and Halogenated Hydrocarbons etc.
ii. C2 Compounds: Production of Ethylene and Acetylene- Steam Cracking of Hydrocarbons, Ethylene Dichloride, Vinyl Chloride etc.
iii. C3 Compounds: Production of Propylene by Indirect Hydration, Acetone, Cumene etc.
iv. Aromatic Compounds: Production of Phenol, Phthalic Anhydride and Styrene etc.

REFERENCE BOOKS:

1. Dryden's Outlines of Chemical Technology, M Gopal Rao, Marshal Sittig, East-west press 3rd Edition.
2. Shreve's Chemical Process Industries, George T Austin, Tata McGRAW-Hill, 5th Edition.
3. Unit Processes in Organic Synthesis, P. H. Groggins., Tata McGRAW-Hill, 5th Edition.
4. Chemical Process Technology Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepe, Wiley, 2nd Edition.
5. Industrial Chemicals, Feith, Keys and Clerk, Wiley-Interscience, 4th Edition.
6. Chemical Technology- Venkateshwaralu, Vol. I, II, III, IV Chemical Engg. IIT Madras.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

Semester VI (TY B. Tech.) Chemical Engineering 2307314B: Chemical Process Synthesis		
Teaching Scheme: Theory: 3 hrs/week	**Credit Scheme: 3**	**Examination Scheme:** In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisite: Basic concepts of heat transfer, mass transfer, design.

Course Objectives:

1. To understand the fundamentals and hierarchy of chemical process design and synthesis.
2. To learn methods like pinch technology and distillation sequencing for process integration and optimization.
3. To design and optimize Heat Exchanger Networks considering energy, cost, and performance trade-offs.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Define the hierarchy of the process design, interpret the overall process design, and distinguish between different kinds of response systems.	2-Understand
CO2	Apply the pinch technology to optimize the energy usage in industries and design distillation sequencing.	3- Apply
CO3	Analyze energy integration using pinch analysis by assessing the effects of ΔTmin, utility usage, targeting methods, and network design on efficiency and cost.	4- Analyze

Course Contents:

Unit 1	**Introduction to Chemical Process Design (L07)**	**COs Mapped: CO1**
Introduction, approach to process development, development of new process, different considerations, development of particular process, overall process design, hierarchy of process design, onion model, approach to process design.		
Unit 2	**Choice of Reactor and Separator (L07)**	**COs Mapped: CO1, CO2, CO3**
Reaction path, types of reaction systems, reactor performance, idealized reactor models, reactor concentration, temperature, pressure, phase, catalyst. Separation of heterogeneous mixtures, separations of homogeneous mixtures, distillation, azeotropic distillation, absorption, evaporation, drying etc.		
Unit 3	**Pinch Technology-an overview (L07)**	**COs Mapped: CO1, CO2**
Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of Pinch Technology: Concept of ΔTmin, Data Extraction, Targeting, Designing, Optimization, Super-targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.		
Unit 4	**Distillation Sequencing (L07)**	**COs Mapped: CO1, CO2**
Distillation sequencing using simple columns, heat integration of sequences of simple distillation columns, distillation sequencing using thermal coupling, optimization of reducible structure, Retrofit of distillation systems.		
Unit 5	**Heat Exchanger Network (L08)**	**COs Mapped: CO1, CO3**

Targeting of Heat Exchanger Network: Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting. Pinch Design Methods, Heuristic 10rules, stream splitting, design of maximum energy recovery(MER). Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy. Network evolution and evaluation, identification of loops and paths, loop breaking and path relaxation. Design tools to achieve targets, Driving force plot, remaining problem analysis, diverse pinch concepts. Targeting and designing of HENs with different ΔTmin values, Variation of cost of utility, fixed cost, TAC, number of shells and total area with ΔTmin Capital-Energy tradeoffs.

REFERENCE BOOKS:

1. Chemical Process: Design and Integration, Robin Smith, Wiley–Blackwell, 2nd Edition.
2. Conceptual Design of Chemical Processes, James Douglas, McGraw-Hill Education, 1st Edition.
3. Unit Processes in Organic Synthesis, P.H. Groggins, McGraw-Hill Education, 5th Edition.
4. Dryden's Outlines of Chemical Technology, M Gopal Rao, Marshal Sittig, East-West Press Pvt. Ltd., 3rd Edition
5. Heat Exchanger Network Synthesis, U. V Shenoy, Gulf Publishing Company, 1st Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

Semester: VI (TY - B. Tech.) Chemical Engineering
2307315A: Heat Transfer Operations

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites: -Applied Mathematics, Basics of Heat Transfer, Thermodynamics

Course Objectives:
1. To use heat transfer principles to understand the behavior of thermal systems.
2. To recognize the various applications of heat transfer equipment's.
3. To provide basic knowledge in thermal system design and to enlighten heat transfer applications.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Explain the advanced principles of conduction and convection heat transfer and demonstrate concepts of advanced conduction & convection and interpret correlations for heat transfer in external flows and heat exchangers.	2-Understand
CO2	Apply heat transfer correlations and the knowledge of the Process design aspects of boiling and condensation processes in industrial equipment such as reboilers, condensers, Agitated Jacketed Vessels Systems, and evaporators.	3-Apply
CO3	Classify various types of boilers and their mountings and accessories and illustrate the steam calculations.	4-Analyze
CO4	Analyze theoretical prediction of process design and practical aspects of condensation, Boiling and evaporation.	5- Evaluate

Course Contents:

Unit 1	Advanced Conduction & Convection (L08)	COs Mapped: CO1

Extended surface heat transfer. Theories of heat transfer and analogy between momentum and heat transfer, Differential energy balance in boundary layers: thermal boundary-layer development, Local vs. average Nusselt correlations for laminar and turbulent external flows (flat plate, cylinder, sphere), Heat transfer outside various geometries in forced convection, Heat Transfer in packed and fluidized beds, Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects.

Unit 2	Condensation and Condenser Design (L07)	COs Mapped: CO1, CO2, CO4

Condensation of vapours: theoretical prediction of heat transfer coefficients, practical aspects, horizontal versus vertical condensation outside tubes, condensation inside tubes, Process Design aspects of total condensers, condensers with de-superheating and subcooling, condensers of multicomponent mixture, condensation of vapours in presence of non-condensables, Condenser design: shell-and-tube condensers for steam, air-cooled condensers, and refrigeration condensers.

Unit 3	Heat Transfer in Boiling and Evaporation Processes (L07)	COs Mapped: CO1, CO2, CO4

Heat transfer to boiling liquids: Rohsenow's correlation for nucleate boiling: application and data interpretation, Critical heat flux (CHF), Burnout point: Zuber's correlation, safety implications. Flow Boiling (Forced Convection Boiling); Flow-boiling heat transfer correlations (e.g., Chen's correlation, Kandlikar for micro-channels), Two-phase pressure drop considerations in boiling flows, Natural and forced circulation reboilers, Types of reboilers and Design of Reboilers. Process design of evaporators, Multiple-Effect Evaporators (MEE), Vapour Recompression Evaporators, Comparison of energy consumption in MEE vs. MVR vs. TVR systems.		
Unit 4	**Heat Transfer in Agitated Vessels and Jacketed Systems (L07)**	**COs Mapped: CO1, CO2**
Heat transfer in agitated vessels: coils, Types of jackets, limpet coils, calculation of heat transfer coefficients, Overall heat Transfer coefficient, heating and cooling times, applications to batch reactors and batch processes. Process Design of Jacketed agitated vessel.		
Unit 5	**Boilers and Fired Heater Design (L07)**	**COs Mapped: CO1, CO3**
Steam properties and Calculations, Boilers, classification, construction features, Boiler Accessories and Mountings, Economiser, super-heater, pre-heater., Types of Fired Heaters, furnace design equations, fire heater design features and applications.		

REFERENCE BOOKS:

1. Fundamentals of Engineering Heat and Mass Transfer (SI Units), R.C. Sachdeva, New Age International Publishers, 5th Edition.
2. Heat and Mass Transfer, P K Nag, McGraw-Hill publications, 3rd Edition.
3. Process Heat Transfer, D. Q. Kern., Tata McGraw Hill Publication, New Delhi, 11th Edition.
4. Heat Transfer, J P Holman, Tata McGraw Hill Publications, New Delhi, 9th Edition.
5. A Textbook on Heat Transfer, S. P. Sukhatme, Universities Press (India) , 4th Edition.
6. Transport phenomena, Bird R.B., Stewart W.E., Lightfoot E.N, Wiley Publications, 2nd Edition.
7. Heat and Mass Transfer, Yunus A. Cengel., Tata McGraw Hill Publications, New Delhi, 3rd Edition.
8. Process Equipment Design, V. V. Mahajani and S. B. Umarji, Trinity Laxmi Publications, 5th Edition.
9. Process Equipment Design, Brownell Young, Wiley, 1st Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each Unit	05
	Total	**20**

<table>
<tr><td colspan="4">Semester VI (TY B. Tech.) Chemical Engineering
2307315B: Food Technology</td></tr>
<tr><td>Teaching Scheme:
Theory:3hrs/week</td><td>Credit Scheme: 3</td><td colspan="2">Examination Scheme:
In Semester Exam: 20 marks
End Semesters Exam: 60marks
Continuous Comprehensive Evaluation: 20marks
Total:100Marks</td></tr>
<tr><td colspan="4">Prerequisite: Basics of food technology, Unit operations and nutritional awareness</td></tr>
<tr><td colspan="4">Course Objectives:
1. To provide knowledge and skills for better preservation techniques, processing and value addition to agricultural products.
2. To promote research and development for food products and process and guarantee sanitation and safety of processed food items.
3. To develop awareness among the students about environmental issues and work towards sustainable developments.</td></tr>
<tr><td colspan="4">Course Outcomes:
On completion of the course, learner will be able to:-</td></tr>
<tr><td>Sr. No.</td><td colspan="2">Course Outcomes</td><td>Bloom's Level</td></tr>
<tr><td>CO1</td><td colspan="2">Describe the fundamental concepts of food processing, preservation, equipment, packaging, and quality control.</td><td>2-Understand</td></tr>
<tr><td>CO2</td><td colspan="2">Apply techniques in processing and handling of food products, including packaging and storage.</td><td>3-Apply</td></tr>
<tr><td>CO3</td><td colspan="2">Analyze food engineering processes, packaging functionality, and quality assurance systems.</td><td>4-Analyze</td></tr>
<tr><td colspan="4">Course Contents:</td></tr>
<tr><td>Unit 1</td><td colspan="2">Principles of Food Processing (L07)</td><td>COs Mapped: CO1</td></tr>
<tr><td colspan="4">Scope and importance of food processing. Principles and methods of food preservation freezing, heating, dehydration, canning, additives, fermentation, irradiation, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, storage of food, modified atmosphere packaging. Refrigeration, freezing and drying of food, minimal processing, radiation processing.</td></tr>
<tr><td>Unit 2</td><td colspan="2">Technology of food Products (Milk, Fruits and Vegetables) (L08)</td><td>COs Mapped: CO1, CO2</td></tr>
<tr><td colspan="4">Sources and composition of milk, processing of market milk, standardization, toning of milk, homogenization, pasteurization, sterilization, storage, transportation and distribution of milk. Milk product processing-cream. Principles and methods of fruit and vegetable preservation. Composition and related quality factors for processing. Principles of storage of fruits and vegetables. Types of storage: natural, ventilated low temperature storage. preservation of fruits and vegetables by heat, chemicals, sugar, salt, fermentation, drying etc. canning of fruits and vegetables, tin cans, glass containers seaming technology, aseptic canning technology. other value-added products from milk and fruit and vegetables.</td></tr>
<tr><td>Unit 3</td><td colspan="2">Principles of Food Engineering (L07)</td><td>COs Mapped: CO1, CO2, CO3</td></tr>
<tr><td colspan="4">Unit operation in food engineering processing of food grains, theory of size reduction equipment's and effect of size reduction on foods, evaporation extrusion, hot air dehydration, baking, roasting and hot oil frying theory, equipment's, applications and effect on food materials for freezing / freeze drying and freeze concentration.</td></tr>
<tr><td>Unit 4</td><td colspan="2">Food Packaging (L07)</td><td>COs Mapped: CO1,</td></tr>
</table>

		CO2, CO3
Introduction to packaging. Packaging operation, package-functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods for prevention, shelf life of packaged foodstuff, methods to extend shelf-life. Food containers-rigid containers, corrosion of containers (tin plate). Flexible packaging materials and their properties. food packaging materials and their properties. Food packages-bags, pouches, wrappers, carton and other traditional package, containers-wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks.		
Unit 5	**Food Quality Assurance (L07)**	**COs Mapped: CO1, CO3**
Objectives, importance and functions of quality control. Methods of quality, concepts of rheology, assessment of food materials-fruits, vegetables, cereals, dairy products, meat, poultry, egg and processed food products. Food regulations, grades and standards, concept of Codex Almentarious/HACCP/USFDA/ISO 9000 series etc. Food adulteration and food safety, basis, trends and composition of India's foreign trade.		

REFERENCE BOOKS:

1. Physical Properties of Food and Food Processing Systems, M. J. Lewis, Woodhead Publishing, 1^{st} Edition.
2. Fundamentals of Food Engineering, S. E. Charm, AVI Publishing Co. Inc, 2^{nd} Revised Edition.
3. Encyclopedia of Food Engineering, C. W. Hall, A. W. Farral, A. L. Rippen, Avi Publishing Co.Inc.
4. Food Science and Processing Technology Vol I & II, Mridula Mirajkar & Sreelata Menon, Kanishka Publishing House, 1^{st} Edition.
5. Food Processing Technology Principles and Practice, P. J. Fellows, Woodhead Publishing, 4^{th} Edition
6. Handbook of Food Engineering, Dennis R. Heldman, Daryl B. Lund, Cristina Sabliov, CRC Press, 3^{rd} Edition.
7. Handbook of Analysis and Quality Control for Fruits and Vegetable Products, S. Ranganna, McGraw-Hill Education, 3^{rd} Edition.
8. A Handbook of Food Packaging, Frank A. Paine, Heather Y. Paine, Springer-Verlag New York Inc., 2^{nd} Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

Semester VI (TY B. Tech.) Chemical Engineering
2307316A: Lab work in Chemical Process Industries

Teaching Scheme:	**Credit Scheme: 1**	**Examination Scheme:**
Practical: 2Hrs. /Week		TW: 25 marks Oral: 25 marks Total: 50 Marks

Prerequisites: Basic knowledge of Chemical compound, Introduction of unit processes and unit operations.

Course Objectives:
1. To Study introduction of chemical engineering and study of glass, coal and chlor-alkali industries.
2. To study Natural chemical industry.
3. To study nitro-phosphorus, sulfur industry.
4. To study Petroleum and Polymer Industry.
5. To study Petrochemical Industry.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Understand the basic principles of mass and energy balances, recycle operations, and lab-scale product synthesis in chemical processes.	2- Understand
CO2	Apply process calculation methods and CAD tools to develop process flow diagrams and solve balance problems for selected chemical processes.	3- Apply
CO3	Evaluate chemical processes by simulating and analyzing mass and energy balances using process simulation software.	4- Evaluate

Suggested List of Laboratory Assignments:

Any eight practical's to be performed out of the following:

Sr. No.	Laboratory Experiments	CO Mapped
1.	Lab scale product synthesis.	**CO1**
2.	Mass balance calculations of any two processes using process calculation approach.	**CO1**
3.	Heat balance calculations of any two processes using process calculation approach.	**CO1**
4.	Calculations based on recycle operations.	**CO1**
5.	Process flow sheets drawing of any two processes using CAD.	**CO2, CO3**
6.	Process flow sheets drawing of any two processes using Simulation Software	**CO1, CO2, CO3**
7.	Mass Balance using Simulation approach	**CO1, CO2, CO3**
8.	Energy Balance using simulation approach	**CO1, CO2, CO3**

Guidelines for Laboratory Conduction

- Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment.
- Apparatus and equipment's required for the allotted experiment will be provided by the lab assistants using SOP.
- Students will perform the allotted experiment in a group under the supervision of faculty and

lab assistant. • After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher. • Students will then complete the experimental write up.
Guidelines for Student's Lab Journal
Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.
Guidelines for Termwork Assessment
1. Each experiment from lab journal is assessed for 30 marks based on three rubrics. 2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester: VI (TY - B. Tech.) Chemical Engineering
2307316B: Lab work in Chemical Process Synthesis

Teaching Scheme:	Credit Scheme: 1	Examination Scheme:
Practical: 2hrs./Week		TW: 25 marks Oral: 25 marks Total: 50 Marks

Prerequisite: Basic Concepts of heat transfer, mass transfer, design.

Course Objectives:

1. To understand the fundamentals and hierarchy of chemical process design and synthesis.
2. To learn methods like pinch technology and distillation sequencing for process integration and optimization.
3. To design and optimize Heat Exchanger Networks considering energy, cost, and performance trade-offs.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Define the hierarchy of the process design, interpret the overall process design, and distinguish between different kinds of response systems.	2-Understand
CO2	Apply the pinch technology to optimize the energy usage in industries and design distillation sequencing.	3- Apply
CO3	Analyze energy integration using pinch analysis by assessing the effects of ΔTmin, utility usage, targeting methods, and network design on efficiency and cost.	4- Analyze

Suggested List of Laboratory Assignments:

Term work and oral will be based on technical report prepared by individual or small groups (2-3) of students, focusing on Case study on Choice of reactor based on performance of reactor, Choice of reactor based on reactor model, Choice of Separators used in chemical process industries and Distillation sequencing using simple columns and their application in petroleum industries. Students are expected to deliver seminar presentation using audio-visual techniques on the topic. Students will be evaluated based on the experiment, report and presentation.

Guidelines for Laboratory Conduction

- Teacher will brief the given experiment to students with its procedure, observations, calculation, and outcome of the experiment.
- Apparatus and equipments required for the allotted experiment will be provided by the lab assistants using SOP.
- Students will perform the allotted experiment in a group under the supervision of faculty and lab assistant.
- After performing the experiment, students will perform calculations based on the obtained readings and get it verified from the teacher.
- Students will then complete the experimental write up.

Guidelines for Student's Lab Journal

Write-up should include title, aim, diagram, working principle, procedure, observations, graphs, calculations, results, conclusions, etc.

Guidelines for Termwork Assessment

1. Each experiment from lab journal is assessed for 30 marks based on three rubrics.
2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal.

Each rubric carries 10 marks.

Semester VI (TY - B. Tech.) Chemical Engineering
2307317: Process Instrumentation

Teaching Scheme:	Credit Scheme: 3	Examination Scheme:
Theory: 3 hrs/week		In Semester Exam: 20 marks End Semesters Exam: 60 marks Continuous Comprehensive Evaluation: 20 marks Total: 100 Marks

Prerequisites:- Basic knowledge of Fluid Mechanics, Physics, Basic Electrical Engineering, Material and Energy balance

Course Objectives:

1. To give a detailed knowledge on transducer characteristics and uncertainties in measurement, application of different sensors /transducers their signal conditioning and final control elements for instrumentation and control systems.
2. To impart knowledge about the various techniques used for the measurement of primary industrial parameters like flow, level, temperature, pressure etc.
3. To study different chemical analysis methods for chemical characterization.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Describe the classification and working of process instruments for temperature, pressure, level, and analytical measurements.	2-Understand
CO2	Select and apply suitable temperature, pressure, level, and analytical instruments based on process requirements.	3- Apply
CO3	Differentiate pressure and flow measurement systems and evaluate suitable analytical techniques for industrial processes.	4- Analyze

Course Contents:

Unit 1	**Process Instrumentation: Introduction (L07)**	**COs Mapped: CO1, CO2**

Importance of instruments in chemical process industries, Need and scope of process instrumentation, classification of process variables, measurement problem analysis, basic measurement terms, General classification of industrial instruments, Functional elements of instruments, static and Dynamic characteristics of measuring instruments (zeroth, first, and second-order instruments/ systems), measurement system configuration, transducer elements (types and Classification), Indicating and recording type instruments.

Unit 2	**Temperature Measuring Instruments (L07)**	**COs Mapped: CO1, CO2**

Temperature Measuring Instruments Introduction, classification, temperature scales, Mechanical Temperature Sensors- filled system thermometers, Expansion Thermometers, Electrical Temperature Sensors-RTD, thermistors, thermocouples, Radiation sensors- optical and radiation, Solid-State Sensors, Quartz Sensors.

Unit 3	**Pressure Measuring Instruments (L07)**	**COs Mapped: CO1, CO2, CO3**

Introduction, classification, pressure Scales, Mechanical pressure elements, liquid column element, elastic element, design of Bourdon Spring elements. Vacuum measurements, electronic pressure sensors. High pressure sensors like dead weight, strain gauge and capacitance.

Unit 4	**Level and Flow Measuring Instruments (L07)**	**COs Mapped: CO1, CO2, CO3**

Level measuring instruments: Introduction, classification, Ball-float mechanisms: displacer
Level measuring instruments: Introduction, classification, Ball-float mechanisms: displacer

type, hydrostatic type, Hydrostatic differential and dry type differential pressure manometers, Force balance diaphragm systems: electromagnetic type, electrical capacitance type, impedance type. Bulk Solids Level Systems: Pressure sensitive, weighing capacitance bridge, ultrasonic. Flow measurement: Head flow meters: Orifice meter, Venturimeter, pitot tube. Variable area flow meters: Rotameter, orifice & tapered plug meters, piston-type, Vortex Shedding Thermal Mass Flow sensors.

Unit 5	**Instrumental Methods of Chemical Analysis (L08)**	**COs Mapped: CO1, CO2, CO3**

Introduction, classification, basic components of analytical instruments, Absorption and Emission Spectrometric Methods: UV, visible and infrared (IR), AAS, MS, Refractometry, Chromatographic Methods: GC, LC, HPLC, Fundamentals of Imaging Techniques: SEM TEM, Electrochemical methods: measurement of pH, colorimetric, conducto-metric, potentiometric, Process instruments and automatic on-line analysis, Thermal Methods: TGA, DTA, DSC.

REFERENCE BOOKS:

1. Instrument Engineers' Handbook, Volume 1: Process Measurement and Analysis, Bella G. Liptak, CRC Press, 5th Edition.
2. Instrumentation: Devices and Systems, C. S. Rangan, G. R. Sarma, V. S. V. Mani, Tata McGraw-Hill Education, 2nd Edition.
3. Instrumental Methods of Analysis, Hobart H. Willard, Lynne L. Merritt Jr., John A. Dean, Frank A. Settle Jr., CBS Publishers and Distributors, 7th Edition.
4. Instrumental Approach to Chemical Analysis, A. K. Srivastava & P. C. Jain, S. Chand & Co. Ltd., 4th Revised Edition.
5. Handbook of Analytical Instruments, R. S. Khandpur, McGraw-Hill Education, 3rd Edition.
6. Industrial Instrumentation, Donald P. Eckman, Wiley, 1st Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three assignments on unit-1, unit-2, unit-3 & 4	10
2	Group presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

Semester: VI (TY - B. Tech.) Chemical Engineering
2307318: Optimization Techniques

Teaching Scheme:	Credit Scheme: 2	Examination Scheme:
Theory: 2 hrs/week		Continuous Comprehensive Evaluation: 50 marks Total: 50 Marks

Prerequisites: Mathematical skills, Programming Skills, Algorithms and Techniques, Domain-Specific Knowledge

Course Objectives:
1. To gain a comprehensive understanding of optimization principles.
2. To apply optimization algorithms and methodologies to solve chemical engineering optimization problems.
3. To analyze and Evaluate Optimization Solutions

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No	Course Outcomes	Bloom's Level
CO1	Discuss the basic concepts, terminology, and types of optimization problems used in engineering and industrial applications.	2-Understand
CO2	Apply mathematical tools and optimization techniques to formulate and solve linear and nonlinear optimization problems.	3- Apply
CO3	Analyze optimization models for engineering systems and interpret the results for decision-making using case studies and software tools.	4- Analyze

Course Contents:

Unit 1	Introduction to Optimization (L04)	COs Mapped: CO1

Overview of optimization in engineering, Types of optimization problems: linear, nonlinear, integer, dynamic, Optimization terminology and concepts, Formulating optimization problems in industrial engineering.

Unit 2	Mathematical Tools for Optimization (L05)	COs Mapped: CO2

Unconstrained optimization: gradient-based methods, Newton's method, Constrained optimization: Lagrange multipliers, KKT conditions, Convex optimization basics.

Unit 3	Linear Programming (L05)	COs Mapped: CO2, CO3

Formulating LP problems, Simplex method and its variants, Duality in linear programming, Sensitivity analysis and interpretation of results.

Unit 4	Nonlinear Programming (L05)	COs Mapped: CO2, CO3

Basics of nonlinear optimization, Gradient-based methods: steepest descent, Newton's method, Derivative-free optimization techniques, Convergence and global optimization.

Unit 5	Applications of Optimization in Industrial Engineering (L05)	COs Mapped:CO1, CO3

Optimization of reaction systems, Process synthesis and design optimization in process control, Case studies and real-world applications, Integration of optimization software in engineering practice.

REFERENCE BOOKS:

1. Optimization of Chemical Process, Thomas Edgar , David. Himmelblau, McGraw-Hill Education, 2nd Edition.

2. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons, 4th Edition.
3. Optimization for Engineering Design: Algorithms and Examples, Deb K, Prentice Hall India Learning Private Limited, 2nd Edition.
4. Applied Mathematical Methods for Chemical Engineer, Norman W. Loney, CRS Press, 3rd Edition.
5. Optimization: Theory and Practice, M.C. Joshi and Kannan M. Moudgalya, Alpha Science International Ltd, 1st Edition.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Three assignments on unit-1, unit-2, unit-3 & 4	30
2	Group presentation on unit-5	10
3	LMS Test on each unit	10
	Total	**50**

Semester VI (TY - B. Tech.) Chemical Engineering
2307319: Computer Aided Chemical Engineering

Teaching Scheme:	Credit Scheme: 2	Examination Scheme:
Tutorial: 1hr./Week Practical: 2hrs/Week	Tutorial: 1 Practical: 1	TU: 25 marks Oral: 25 marks Total: 50 Marks

Prerequisite: Fundamental Knowledge of Mathematics, Process Calculations, Thermodynamics and Unit Operations and Unit Processes, Reaction Engineering.

Course Objectives:
1. To acquire basic understanding of the programming to solve chemical engineering problems.
2. To apply the knowledge chemical process simulation for solving chemical engineering problems.
3. To apply numerical Techniques in chemical engineering.

Course Outcomes: On completion of the course, learner will be able to:-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Describe computer-aided tools, fundamentals of optimization, and select suitable simulation software for process analysis.	2-Understand
CO2	Apply basic programming knowledge, optimization tools for chemical engineering calculations.	3-Apply
CO3	Analyze and solve engineering problems using Excel/MATLAB, including error correction and data modeling.	4-Analyze

Course Contents:

Unit 1	**Introduction to Computer Aided Chemical Engineering (L05)**	**COs Mapped: CO1, CO2, CO3**

Introduction and basic concepts of Computer aided design in chemical engineering, Role and need for computer-aided tools in chemical engineering, Overview of key software: Excel, MATLAB, Python, DWSIM/Aspen, Basics of programming: variables, operators.

Unit 2	**Introduction to Optimization and Process Analysis (L05)**	**COs Mapped: CO1, CO2**

Concept of optimization in chemical engineering, Introduction to Excel Solver or MATLAB's fmincon / Python SciPy optimize, Simple optimization problems: cost minimization, reactor sizing, blending, Spreadsheet modeling for economic evaluation or energy analysis.

Unit 3	**Applications of Various Computer programs for solving problems (L05)**	**COs Mapped: CO3**

Simulation Packages, their selection, removing errors in excel, matlab and applications of excel for problem solving in chemical engineering.

Course Contents:

Suggested List of Laboratory Assignments:

Minimum 10 Practical Assignments must be completed using computational as well as simulation softwares. Aspen plus, Hysys, ChemCAD, EnviroPro, ANSYS, Mathcad, Matlab, Unisim, DWSim etc. can be used for solving practical assignments

Sr. No.	Laboratory Experiments	COs Mapped
1.	Computer program for solving basic linear algebra involving matrix operations	CO2
2.	Computer program for solving non-linear algebraic equation/s	CO2

3.	Computer program for solving steady state staged operation (distillation, gas absorption, Liquid-Liquid extraction, etc.)	**CO2**
4.	Computer program for solving un-steady state staged operation (distillation, gas absorption, Liquid-Liquid extraction, etc.)	**CO2**
5.	Computer program for plotting P-x-y and T-x-y diagram	**CO3**
6.	Computer program for design of reactor/ heat exchangers. distillation column/or any chemical equipment	**CO3**
7.	Computer program for solving ODE or PDE using finite difference method	**CO2**
8.	Simulation of mass transfer equipment using simple and rigorous methods	**CO1, CO3**
	Simulation of product synthesis using different reactors	**CO1, CO3**
10.	Simulation of steady state flow sheet synthesis	**CO1**
11.	Simulation of dynamic flow sheet synthesis	**CO1**
12.	Simulation of fluid flow problems with or without heat/mass transport	**CO1, CO3**

Guidelines for Laboratory Conduction

1. Teacher will brief the given problem statement to students, its objectives and outcome.
2. Students will solve the allotted problem analytically if else and then using simulator.
3. After solving problem, students will check their simulated results from the teacher.
4. Students will then complete the write up.

Guidelines for Student's Lab Journal

Write-up should include title, software used, concept utilized, course useage and problem statement, conclusion, simulation steps, simulated results if any.

Guidelines for Termwork Assessment

1. Each experiment from lab journal is assessed for 30 marks based on three rubrics.
2. Rubric R-1 is for timely completion, R-2 for understanding and R-3 for presentation/journal. Each rubric carries 10 marks.

Semester VI (TY - B. Tech.) Chemical Engineering
2307320: Project Phase I

Teaching Scheme:	Credit Scheme: 1	Examination scheme:
Practical: 02 hrs/week		Term work: 50 Marks Total: 50 Marks

Prerequisite: Courses of Chemical Engineering

Course Objectives:
1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve real life problems with teamwork and Multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.

Course Outcomes: on completion of course, learner will be able to-

Sr. No.	Course Outcomes	Bloom's Level
CO1	Apply foundational concepts of project planning and execution to define a relevant research problem through literature review.	3- Apply
CO2	Analyze research literature to identify knowledge gaps, formulate project objectives, and justify the scope and significance of the proposed work.	4-Analyze
CO3	Evaluate alternative approaches and methodologies for the proposed project using a multidisciplinary perspective and critical thinking.	5- Evaluate
CO4	Create a structured project proposal incorporating technical objectives, methodology, timeline, and ethical considerations, and present it effectively.	6-Create

Expected Working Areas:

Project phase-I is an integral part of the project work. The project work shall be based on the knowledge acquired by the student during graduation and preferably it should meet and contribute towards the needs of society. The project aims to provide an opportunity of designing and building complete systems or subsystems in the field of Chemical Engineering where the student likes to acquire specialized skills. The student shall prepare the duly certified report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

Guidelines for Term Work Assessment:

- Group Size: The student shall carry the project work individually or by a group of students. The maximum group size shall be 4 students. Projects selected should meet and contribute towards the needs of industry and society.
- Selection and approval of topic: Topic should be related to real life application in the field of Chemical engineering.
- The topic may be based on: Investigation of the latest development in a specific field of Chemical engineering, The investigation of practical problem in manufacture and / working model of Chemical engineering equipment/ Software based projects related to Modelling, Simulation, Material Processing, solving real time engineering problems faced by industries etc. with the justification for techniques used / any topic in the field of Chemical engineering may be allowed.
- Interdisciplinary projects should be encouraged. The examination of Interdisciplinary

projects shall be conducted independently in respective departments.

- The term work assessment of Project Phase I shall be based on Innovative Idea of selected project, literature survey, depth understanding, applications, individual contributions, progress review, presentation, project report, timely completion of work.
- Progress reviews should be conducted periodically by forming an evaluation committee at department level.
- The project report must undergo by plagiarism check and the similarity index must be less than 20 %. The plagiarism report should be included in the project report.
- A certified copy of the report is required to be presented to the evaluation committee at the time of examination.