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: 2022
(wef AY 2022-23)

T.Y. B. Tech Chemical Engineering
(wef AY 2024-25)
SEM-V

Course Code	Course Type	Title of Course	Teaching Scheme			Evaluation Scheme and Marks						Credits			
			TH	TU	PR	INSEM	END SEM	CCE	TUT /TW	PR /OR	TOTAL	TH	TU	PR	TOTAL
CHE223001	DCC	Mass Transfer I	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223002	DCC	Chemical Reaction Engineering I	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223003	DCC	Process Equipment Design	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223004	DCC	Lab Work in Mass Transfer I	-	-	2	-	-	-	25	25	**50**	-	-	1	**1**
CHE223005	DCC	Lab Work in Chemical Reaction Engineering I	-	-	2				25	25	**50**	-	-	1	**1**
CHE223006	DEC	Elective I	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223007	DEC	Lab Work in Elective I	-	-	2	-	-	-	25	25	**50**	-	-	1	**1**
CHE223008	OEC	IPR and Patents	2	-	-	-	-	50	-	-	**50**	2	-	-	**2**
CHE223009	ESC	Piping Design and Engineering	3	-	-	20	60	20	-	-	**100**	3	-	-	**3**
CHE223010	PSI	Seminar	-	1	2	-	-	-	TUT-25 TW-25	-	**050**	-	1	1	**2**
Total hours/marks/credits			**17**	**01**	**08**	**100**	**300**	**150**	**125**	**75**	**750**	**17**	**1**	**4**	**22**

Elective I		**Lab Work in Elective I**	
CHE223006A	Chemical Process Industries	CHE223007A	Chemical Process Industries
CHE223006B	Artificial Intelligence	CHE223007B	Artificial Intelligence

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

(Autonomous from Academic Year 2022-23)

T.Y. B.Tech Chemical Engineering

(wef AY 2024-25)

SEM-VI

Course Code	Course Type	Title of Course	Teaching Scheme			Evaluation Scheme and Marks						Credits			
			TH	TU	PR	INSEM	ENDSEM	CCE	TUT /TW	PR /OR	TOTAL	TH	TU	PR	TOTAL
CHE223011	DCC	Mass Transfer II	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223012	DCC	Chemical Reaction Engineering II	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223013	DCC	Lab Work in Mass Transfer II	-	-	2	-	-	-	25	25	**50**	-	-	1	**1**
CHE223014	DEC	Elective II	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223015	DEC	Elective III	3	-	-	20	60	20	-	-	**100**	3	-	-	**3**
CHE223016	DEC	Lab Work in Elective II	-	-	2	-	-	-	25	25	**50**	-	-	1	**1**
CHE223017	ESC	Process Instrumentation	3	-	-	20	60	20			**100**	3	-	-	**3**
CHE223018	OEC	Optimization Techniques	2	-	-	-	-	50	-	-	**50**	2	-	-	**2**
CHE223019	ASM	Computer Aided Chemical Engineering	-	1	2				25	25	**50**	-	1	1	**2**
CHE223020	PSI	Project Phase I	-	-	2	-	-	-	50	-	**50**	-	-	1	**1**
Total hours/marks/credits			**17**	**01**	**08**	**100**	**300**	**150**	**125**	**75**	**750**	**17**	**1**	**4**	**22**

Elective II		**Lab Work in Elective II**		**Elective III**	
CHE223014A	Renewable Energy	CHE223016A	Renewable Energy	CHE223015A	Heat Transfer Operations
CHE223014B	Chemical Process Synthesis	CHE223016B	Chemical Process Synthesis	CHE223015B	Food Technology

Semester V (TY - B. Tech.) Chemical Engineering
CHE223001: 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	To apply the general principles of Mass Transfer and theories of mass transfer operations in chemical process industries.	3-Apply
CO2	Select and design of the gas-liquid contact Mass Transfer equipments and acquire the understanding of their principles.	6-Create
CO3	Separate the gas mixtures based on solubility of gas solute in selective solvent using gas absorption.	3-Apply
CO4	Apply the principles of humidification – dehumidification operations and design of cooling towers	3-Apply
CO5	Illustrate the principles and mechanism of drying and design the various dryers based on the applications.	6-Create

Course Contents:

Unit 1	Introduction (L07)	COs Mapped: CO1

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation method, methods of conducting mass transfer operations, design principles. Diffusion Mass Transfer, Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, diffusion in solids, unsteady state mass transfer. Mass transfer coefficients in laminar flow and turbulent flow, theories of mass transfer, mass, heat and momentum transfer analogies. Inter-phase mass transfer, equilibrium in mass transfer, the two resistance theory, continuous co-current, countercurrent and crosscurrent processes, cascades.

Unit 2	Gas Absorption (L08)	COs Mapped: CO2

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculations of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

Unit 3	**Humidification and Dehumidification (L07)**	**COs Mapped: CO3**

Principles, Vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

Unit 4	**Equipment for gas liquid operation (L07)**	**COs Mapped: CO4**

Types of columns, Types of trays, types of packing, Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers. Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns

Unit 5	**Drying (L07)**	**COs Mapped: CO5**

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

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.
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
CHE223002: 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.

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	Understand rate equation and its representation for given reaction.	2- Understand
CO2	Analyze kinetic data based on methods of analysis.	4-Analyze
CO3	Apply performance equations to determined kinetics for given reaction.	3-Apply
CO4	Understand different multiple reactions and determine product distribution	2- Understand
CO5	Analyze deviations from ideality and plot different curves	4-Analyze

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: 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: CO3**
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: CO4**
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: CO5**
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**

Semester V (TY - B. Tech.) Chemical Engineering CHE223003: Process Equipment Design		
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: 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's 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 equipments.

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

Sr. No.	Course Outcomes	Bloom's Level
CO1	Acquire basic understanding of design parameters in process and Mechanical Design of distillation column.	2-understand
CO2	Classify and design of various process vessels and its components.	4-Analyze
CO3	Design of storage and tall vertical vessels and their supports	4-Analyze
CO4	Select and design the agitator for specific mixing application and reaction vessels with heat exchange provision.	6-Create
CO5	Apply knowledge to design different types of heat exchangers in chemical industry.	3-Apply

Course Contents:

Unit 1	Design of distillation column (L07)	COs Mapped: CO1

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: CO2**

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 (L07)**	**COs Mapped: CO3**

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 Agitators and Reaction vessels (L07)**	**COs Mapped: 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, Reaction vessels: Heat Transfer aspects in the design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil, study and design of internal coil reaction vessels, heat transfer coefficients in coils.

Unit 5	**Design of Heat Exchange Equipments (L07)**	**COs Mapped: CO5**

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 procedure, **Evaporators:** classification, criteria for selection, design of Calendria type evaporator, Concept of Falling Film Evaporator, **Condensers:** heat transfer fundamentals, condensation outside horizontal tubes, condensation inside and outside vertical tubes, condensation inside horizontal tubes, and condensation of mixtures. Reboilers**:** types, selection, boiling heat transfer fundamentals, estimation of boiling heat transfer coefficients.

REFERENCE BOOKS:

1. Process Equipment Design, V. V. Mahajani and S. B. Umarji, Laxmi Publications, 5th Edition.
2. Process Equipment Design, Brownell Young, Wiley.
3. Chemical Engineering Vol.6, J.M. Coulson, J.F. Richardson and R.K. Sinott, Butterworth-Heinemann Ltd, 2nd Edition.
4. Introduction to Chemical Equipment Design: Mechanical Aspects, B.C. Bhattacharya, C.B.S. Publications..

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
CHE223004: Lab work in Mass Transfer I

Teaching Scheme:	Credit Scheme:1	Examination scheme:
Practical: 2 Hrs. /Week		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	To apply the general principles of Mass Transfer and theories of mass transfer operations in chemical process industries.	3-Apply
CO2	Select and design of the gas-liquid contact Mass Transfer equipments and acquire the understanding of their principles.	6-Create
CO3	Separate the gas mixtures based on solubility of gas solute in selective solvent using gas absorption.	3-Apply

CO4	Apply the principles of humidification – dehumidification operations and design of cooling towers	3- Apply
CO5	Illustrate the principles and mechanism of drying and design the various dryers based on the applications.	6-Create

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, CO5**
2.	Rotary Dryer – To study the Characteristics of Rotary Dryer	**CO1, CO5**
3.	Spray Dryer – To study the design and Operating Principles of Spray Dryer	**CO1, CO5**
4.	Fluidized Bed Dryer –To study the characteristics of Fluidized bed Dryer	**CO1, CO5**
5.	Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system	**CO1, CO5**
6.	Winkelmann's method – To find the diffusion Coefficient of vapour in air by experimental method	**CO1, CO2**
7.	Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction	**CO1, CO2, CO3**
8.	Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower	**CO1, CO2, CO3**
9.	Cooling Tower– To study the characteristics	**CO1, CO2, CO4**
10.	Humidifier and Dehumidifier – To study the Characteristics	**CO1, CO2, CO4**
11.	Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient	**CO1, CO2**
12.	Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column	**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 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
CHE223005: 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 reactor
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	Understand rate equation and its representation for given reaction.	2- Understand
CO2	Analyze kinetic data based on methods of analysis.	4-Analyze
CO3	Apply performance equations to evaluate kinetic parameters for given reaction.	5-Evaluate
CO4	Analyze deviations from ideality and plot different curves	4-Analyse

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.	CO1, CO2, CO3
2.	Determination of Arrhenius parameters.	CO2, CO3
3.	Study of pseudo first order reaction: Acid catalyzed hydrolysis of methyl acetate	CO1, CO2, CO3
4.	Study of saponification of ethyl acetate reaction in mixed flow reactor.	CO2, CO3
5.	Study of saponification of ethyl acetate reaction in plug flow reactor	CO2, CO3
6.	CSTRs in series.	CO2, CO3
7.	CSTR followed by PFR.	CO2, CO3
8.	RTD studies in PFR.	CO4
9.	RTD studies in MFR.	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.

<table>
<tr><td colspan="3">Semester V (TY - B. Tech.) Chemical Engineering
CHE223006A: Chemical Process Industries</td></tr>
<tr><td>Teaching Scheme:
Theory: 3 hrs/week</td><td>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="3">Prerequisites: Basic Knowledge of Chemical compound, Introduction of unit processes and unit operations</td></tr>
<tr><td colspan="3">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.</td></tr>
</table>

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

CO	Course Outcomes	Bloom's Level
CO1	Understand the basic concept and explain about glass, coal and chlor-alkali industry.	2-Understand
CO2	Understand and describe about natural chemical industry.	2- Understand
CO3	Understand and explain about nitro-phosphorus, sulfur industry	2- Understand
CO4	Understand and describe about petroleum and polymer industry.	2- Understand
CO5	Understand and describe about petrochemical industry	2- Understand

Course Contents:

Unit 1 | Basic Concepts (L07) | COs Mapped :CO1

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

Glass Industries: Method of manufacture, manufacture of special glasses

Coal Chemicals: Destructive distillation of coal, Types of carbonization, Coke oven–construction, working and applications

Chlor-Alkali Industry: Production of Soda ash, Production of Chlorine and caustic soda.

Unit 2 | Natural Chemical Industry (L07) | COs Mapped :CO2

i. Sugar and starch industry
ii. Oil, Fat and waxes
iii. Pulp and Paper industry
iv. Food and food- by product processing

Unit 3 | Nitrogen, Phosphorus and sulfur Industry (L07) | COs Mapped :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 4 | Petroleum and Polymer Industry (L07) | COs Mapped :CO4

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 :CO5

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
5. Industrial Chemicals, Feith – Keys and Clerk
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 V (TY B. Tech.) Chemical Engineering
CHE223006B: Artificial Intelligence

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: - 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	Define key AI concepts like knowledge representation, search algorithms, and machine learning techniques.	2-Understand
CO2	Explain the strengths and limitations of different AI approaches in various chemical engineering applications.	2-Understand
CO3	Implement basic AI models using Python programming to solve problems related to chemical engineering analysis and design.	3-Apply
CO4	Evaluate the effectiveness of applied AI solutions for specific chemical engineering tasks, considering factors like accuracy, efficiency, and interpretability.	5-Evaluate
CO5	Design and implement a simple AI solution using appropriate techniques to address a specific challenge in the chemical engineering domain.	5-Evaluate

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: CO2**

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: CO2**

Introduction to Python programming language; Learning basic programming syntax, data structures, and control flow statements; Utilizing online resources like Coursera for further learning.

Unit 4 | **Knowledge-Based Systems and Machine (L07)** | **COs Mapped: CO4**

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: CO5**

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. 3. Artificial Intelligence, Patrick Henry Winston, Addison-Wesley Publishing Company. 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
CHE223007A: 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
CO 1	Apply process calculation approaches to synthesize lab-scale products	3-Apply
CO 2	Gain proficiency in drawing process flow sheets using CAD software and simulating processes using simulation software.	2-Understand
CO 3	Demonstrate competency in applying mass and energy balance principles	3-Demonstrate

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.	CO3
3.	Heat balance calculations of any two processes using process calculation approach.	CO3
4.	Calculations based on recycle operations.	CO3
5.	Process flow sheets drawing of any two processes using CAD.	CO2
6.	Simple mass & energy balance using process simulators	CO2
7.	Process flow sheets drawing of any two processes using Simulation Software	CO2
8.	Mass Balance using Simulation approach	CO3
9.	Energy Balance using simulation approach	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 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
CHE223007B: 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: - 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
CO 1	Define key AI concepts like knowledge representation, search algorithms, and machine learning techniques.	2-Understand
CO 2	Explain the strengths and limitations of different AI approaches in various chemical engineering applications.	2-Understand
CO 3	Implement basic AI models using Python programming to solve problems related to chemical engineering analysis and design.	3-Apply
CO 4	Evaluate the effectiveness of applied AI solutions for specific chemical engineering tasks, considering factors like accuracy, efficiency, and interpretability.	5-Evaluate
CO 5	Design and implement a simple AI solution using appropriate techniques to address a specific challenge in the chemical engineering domain.	5-Evaluate

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 & present ChE applications of AI, with benefits & challenges.	**CO1**
2.	Build a collaborative history of AI with online tools.	**CO2**
3.	Solve a chemical engineering problems with logic.	**CO3**
4.	Build molecules by following production rules.	**CO3**
5.	Basic codes for chemical engineering calculations.	**CO3**
6.	Use of Python to find patterns in chemical data.	**CO3**

7.	Use AI to analyze data and predict chemical reactions.	**CO3**
8.	Use AI simulation to optimize chemical processes.	**CO4**
9.	Explore how AI safeguards chemical processes.	**CO4**
10.	Solve a chemical engineering problem using a combo of AI techniques.	**CO5**

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.

<table>
<tr><td colspan="4" align="center">Semester V (TY - B. Tech.) Chemical Engineering
CHE223008: IPR and Patents</td></tr>
<tr><td colspan="2">Teaching Scheme:
Theory: 2 hrs/week</td><td align="center">Credit Scheme:
2</td><td>Examination Scheme:
Continuous Comprehensive Evaluation: 50 Marks</td></tr>
<tr><td colspan="4">Prerequisite Courses: NA</td></tr>
<tr><td colspan="4">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</td></tr>
<tr><td colspan="4">Course Outcomes: After successful completion of the course student should be able to:-</td></tr>
<tr><td></td><td colspan="2" align="center">Course Outcomes</td><td align="center">Bloom's Level</td></tr>
<tr><td>CO1</td><td colspan="2">Define various forms of intellectual property and patent</td><td align="center">1-Remember</td></tr>
<tr><td>CO2</td><td colspan="2">Explain the registration procedure for various forms of intellectual property</td><td align="center">2-Understand</td></tr>
<tr><td>CO3</td><td colspan="2">Draft patent application</td><td align="center">3-Apply</td></tr>
<tr><td colspan="4" align="center">Course Content</td></tr>
<tr><td>Unit I</td><td colspan="2">Introduction to IP, Patent Basic, and Patent filing procedure (L05)</td><td>CO1, CO2</td></tr>
<tr><td>Unit II</td><td colspan="2">Copyright basic, Industrial Design, Emerging issue, (L05)</td><td>CO1, CO2</td></tr>
<tr><td>Unit III</td><td colspan="2">Trademark basic, GI basic, IC Layout Design, (L05)</td><td>CO1, CO2</td></tr>
<tr><td>Unit IV</td><td colspan="2">Trade secret, Comparative analysis, IP management(L05)</td><td>CO1, CO2</td></tr>
<tr><td>Unit V</td><td colspan="2">Invention as a solution to an unsolved problem, Drafting a Claim, Types and Arrangement of Claims, Structure of the Patent Specification(L05)</td><td>CO1, CO3</td></tr>
<tr><td colspan="4" align="center">NPTEL Course</td></tr>
</table>

1	https://archive.nptel.ac.in/courses/109/106/109106128/ NPTEL Course on "Patent Drafting For Beginners"
2	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 and LMS Tests on Unit-1, Unit -2, Unit -3.	30
2	Group Presentations on Unit-4 and Unit-5.	20
	Total	50

Semester V (TY - B. Tech.) Chemical Engineering
CHE223009: Piping Design and Engineering

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: Courses of Fluid Mechanics, Chemical Engineering Materials

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.

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

Sr. No	**Course Outcomes**	**Bloom's Level**
CO1	Utilise the piping design basic concept for designing of plant.	2-Understand
CO2	Implementing the appropriate pipe components as per the requirement in industries.	3-Apply
CO3	Distinguish between different piping flow diagrams such as piping isometric, P&IDs.	2-Understand
CO4	Prepare the piping layout as well as piping isometric.	3-Apply
CO5	Predicting the stress in a pipe line and distinguish between different piping supports as per the applications.	4-Analyse

Course Contents:

Unit 1	**Introduction to piping designing & engineering (L08)**	**COs Mapped: CO1**

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.		
Unit 2	**Materials for Piping (L07)**	**COs Mapped: CO2**
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.		
Unit 3	**Piping Engineering drawings and its concept (L07)**	**COs Mapped: CO3**
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 isometrics and bill of material.		
Unit 4	**Design of Pipe racks and storage terminals (L07)**	**COs Mapped: 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: CO5**
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**

Semester: V (TY - B. Tech.) Chemical Engineering CHE223010:Seminar		
Teaching Scheme: Tutorial : 1 hr/Week Practical: 2 Hrs. /Week	**Credit Scheme:2**	**Examination scheme:** Tut: 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	Develop the ability to critically assess and evaluate research data	5- Evaluate

	relevant to Chemical Engineering.	
CO2	Acquire the skills to compile this data into a well-organized seminar report, adhering to academic standards.	3-Apply
CO3	Exhibit effective communication skills by delivering a informative seminar presentation supported by visual aids such as PowerPoint slides.	3-Apply

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 (L04)**	**COs Mapped: CO2**
Understanding the importance of literature surveys in research, Techniques for conducting effective literature searches.		
Module 3	**Technical Writing (L04)**	**COs Mapped: 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 Unit	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].

Semester: VI (TY - B. Tech.) Chemical Engineering CHE223011: Mass Transfer II		
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 principles of mass transfer, 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
CO 1	Apply the principles of Distillation operation for its process design and operations.	3-Apply
CO 2	Separate the liquid mixtures based on solubility of solute in selective solvent using solvent Extraction.	4-Evaluate
CO 3	Apply the principles of leaching operation and produce the preferential solution of solute from solids using solvent in Leaching operation	3-Apply
CO 4	Illustrate the adsorption and ion Exchange techniques for the separation by concentrating the specific substances using the surface phenomenon.	2-Understand
CO 5	Select and design of the crystallizer for deriving the crystalline products and acquire the understanding of novel separation techniques.	6-Create

Course Contents:

Unit 1	Distillation (L08)	COs Mapped: CO1

Basic Distillation, concept of relative volatility, Differential distillation, Flash or equilibrium distillation, Fractionating column and multistage column, Batch, azeotropic and extractive distillation, binary and multi-component systems, Reflux ratio, need for reflux, McCabe-Thiele, Lewis-Sorel methods of estimation of number of plates, Operating and feed lines, minimum and optimum reflux ratio, Tray and column efficiency, Packed column distillation, Fenske's equation, Fenske-Underwood equation, use of open steam, Partial and total Condensers, reboilers, tray efficiencies

Unit 2	Solvent Extraction (L07)	COs Mapped: CO2

Principles of solvent Extraction, Applications in industry, Ternary liquid equilibria, systems of three liquids, Effect of temperature, Choice of solvent, distribution coefficient, Selectivity, Stage wise Contact: single stage extraction, multistage crosscurrent, countercurrent and co-current extraction, calculations based on triangular diagrams, x – y coordinates and solvent free basis, Continuous counter current extraction, stage efficiency, Differential (continuous contact extraction); packed towers, HTU and NTU concept, Numericals, types of extractors, Stage wise Extractors, Mixer- settler, Sieve Tray Extraction, Rotating Disk Contactor, Scheibel Extractor, Pulsed Column, Centrifugal Extractor

Unit 3	Leaching (L07)	COs Mapped: CO3

Principles of Leaching, Applications in industry, Factors affecting the rate of leaching, preparation of solids, temperature, Graphical representation of equilibrium, Methods of operation and equipment; unsteady state operation and steady state operations - continuous counter current leaching, ideal stage equilibrium, operating time, retention of liquid, percolation tank, filter press leaching, agitated vessels, constant and variable underflow, number of ideal stages, stage efficiencies, calculation of single stage and multistage leaching processes, Continuous countercurrent decantation, Rotocel, Bollman Extractor, Kennedy Extractor, Pachuka tank, Supercritical extraction

Unit 4	**Adsorption and Ion Exchange (L07)**	**COs Mapped: CO4**
Adsorption: Principles of Adsorption: Physical and chemical adsorption, Nature of adsorbents, adsorption equilibrium and isotherms, Adsorption Hysteresis, effect of temperature, Single-stage, multi-stage cross-current and multi-stage counter current operations, Fixed bed equilibrium and operating lines, adsorption Isotherms-Langmuir and Freundlich, Liquid-solid agitated vessel adsorbed, packed continuous adsorption, breakthrough curves, Adsorption model, pressure-swing adsorption, Ion Exchange-Principles of Ion Exchange Equilibrium and rate of ion exchange, Applications		
Unit 5	**Crystallization and Novel Separation Techniques (L07)**	**COs Mapped: CO5**
Principle of crystallization, rate of crystal growth, size distribution, Mechanism of crystallization, Solubility curves, Methods of super saturation, Mier's super saturation theory, material balance, enthalpybalances, calculation of yield, Numericals, Classification of Crystallizers; Agitated Tank Crystallizer, Swenson-Walker Crystallizer, Vacuum Crystallizer, Oslo Crystallizer. Introduction to membrane separation techniques: ultra-filtration, Nano-filtration, reverse osmosis, types of membranes and membrane modules, fluxes and driving forces in membrane separation processes.		

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.
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 VI (TY - B. Tech.) Chemical Engineering
CHE223012: 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

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

(Autonomous from Academic Year 2022-23)

		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	Determine rate controlling step for fluid-particle reactions and applications.	3-Apply
CO2	Apply the knowledge of fluid-fluid heterogeneous reactions for design of reactors.	3-Apply
CO3	Demonstrate the nature and mechanism of catalysis and adsorption	3-Apply
CO4	Apply the knowledge to predict diffusion in porous catalytic reactions.	3-Apply
CO5	Design heterogeneous reactors for catalytic reactions	6- Create

Course Contents:

Unit 1	Heterogeneous reactions (L07)	COs Mapped:CO1

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: 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: 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: 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: CO5

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.1 & 2, L. K. Doraiswamy and M. M Sharma
5. An Introduction to Chemical Reaction Kinetics & Reactor Design, C. G. Hill, John Wiley & Sons.

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
CHE223013: 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 principles of mass transfer, 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	Understand Basic principle of Distillation operation and its application in separation of components.	2- Understand
CO2	Evaluate the number of theoretical stages for packed bed distillation Column.	5- Evaluate
CO3	Separate the liquid mixtures based on solubility of solute in selective solvent using solvent Extraction and apply the principles of solid-liquid Extraction (leaching) for Solid-liquid separation.	3-Apply
CO4	Select and design of the crystallizer for deriving the crystalline products and acquire the understanding of novel separation techniques.	6-Create
CO5	Illustrate the adsorption and ion Exchange techniques for the separation by concentrating the specific substances using the surface phenomenon.	2- Understand

Suggested List of Laboratory Assignments:

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

Sr. No.	Laboratory Experiments	COs Mapped
1.	Simple Batch Distillation	**CO1, CO2**
2.	Steam Distillation	**CO1, CO2**
3.	Distillation with Total Reflux	**CO1, CO2**
4.	Vacuum Distillation	**CO1, CO2**
5.	Distillation using Sieve Plate, Column	**CO1, CO2**
6.	Liquid-liquid equilibrium for ternary system	**CO3**
7.	Liquid – Liquid Extraction (single stage and multistage)	**CO3**
8.	Characterization of Spray Extraction Column	**CO3**
9.	York Scheibel Column	**CO3**
10.	Batch/ Continuous Leaching	**CO3**

11.	Batch Crystallization	**CO4**
12.	Ion Exchange	**CO5**
13.	Adsorption (batch or column study)	**CO5**

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 CHE223014A: Renewable Energy		
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: Basic knowledge of Chemistry, Physics, Thermodynamics, Fluid Mechanics, Heat Transfer, Process 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, evaluate their availability, and compare different methods of energy conversion.	2- Understand
CO2	Illustrate the renewable energy related to biomass technologies.	4- Analyze
CO3	Illustrate conversion technologies for solar and its applications.	4- Analyze
CO4	Understand waste-to-energy conversion processes and their environmental impacts, proposing mitigation measures.	2- Understand
CO5	Understand the fundamentals of hydrogen energy systems and the production processes of hydrogen energy.	2- Understand

Course Contents:

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: 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: CO3**
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: CO4**

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: CO5**

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.
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. Powerplant 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 VI (TY B. Tech.) Chemical Engineering
CHE223014B: Chemical Process Synthesis

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

Course Objectives:
1. To understand how to invent chemical process flow sheets.
2. To understand how to develop process alternatives; how to generate them and how to quickly screen the alternatives.

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

Sr. No	Course Outcomes	Bloom's Level
CO1	Interprete to process development, different considerations, overall process design, hierarchy of process design	2-Understand
CO2	Differentiate types of reactions, kinetics, reaction paths, reactors and Separation techniques.	2-Understand
CO3	Apply the pinch technology in order to optimize the energy usage in industries	3-Apply
CO4	Design distillation sequencing, heat integration of sequences of simple distillation columns.	3-Apply
CO5	Evaluate efficient Heat Exchanger Networks: Pinch Technology, problem table algorithm, Threshold problems etc.	5-Evaluate

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: CO2

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: CO3, CO5**
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: CO4**
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: CO5**
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.
2. Conceptual design of chemical process-James Douglas, McGraw-Hill Education.
3. Unit process in organic synthesis – P.H. Groggins, McGraw Hill Education.
4. Dryden's Outlines Of Chemical Technology, M Gopal Rao, Marshal Sittig, East-west press 3rd Edition
5. Heat Exchanger Network Synthesis, U. V Shenoy, Gulf Publishing Company.

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 CHE223015A: Heat Transfer Operations		
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: -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 equipments
3. To provide the 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	Demonstrate concepts of conduction and evaluate the conduction problem Illustrate the renewable energy related to biomass technologies.	5- Evaluate
CO2	Analyze theoretical prediction of heat transfer coefficients and practical aspects of condensation.	4-Analyze
CO3	Apply the knowledge of the Process design aspects of boiling and evaporators	3- Apply
CO4	Select and design of jackets and coils for agitated vessels for heat transfer aspects	6-Create

CO5	Classify various types of boilers and their mountings and accessories along with the design of Fired Heaters and furnace	3- Apply

Course Contents:

Unit 1	**Fundamentals of Heat Conduction (L08)**	**COs Mapped: CO1**

General heat Conduction equation-initial and boundary conditions. Conduction with heat source. Transient heat conduction- Lumped system analysis-Heisler charts-semi-infinite solid-use of shape factors in conduction-2D transient heat conduction. Extended surface heat transfer. Theories of heat transfer and analogy between momentum and heat transfer, Heat transfer outside various geometries in forced convection, such as single sphere, bank of tubes or cylinders, packed and fluidized beds.

Unit 2	**Condensation and Condenser Design (L07)**	**COs Mapped: CO2**

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 and reboiler design.

Unit 3	**Heat Transfer in Boiling and Evaporation Processes (L07)**	**COs Mapped: CO3**

Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers, Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects

Unit 4	**Heat Transfer in Agitated Vessels and Jacketed Systems (L07)**	**COs Mapped: CO4**

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: CO5**

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

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

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
CHE223015B: Food Technology

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: Basics of Process Calculations, Unit Operations and Unit Processes

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 product 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.

Course Outcomes:

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

Sr. No	Course Outcomes	Bloom's Level
CO 1	To impart knowledge in various aspects of Food Technology through Theory and Practical knowledge.	3-Apply
CO 2	To make the students familiar with the technologies of food processing and preservation of plant foods fruits vegetables,	1-Knowledge

	spices, milk and dairy products.	
CO 3	To understand the principle of Unit operations and fundamentals of food engineering and its process	2-Understand
CO 4	To acquaint concepts of food engineering and packaging in food industry.	2-Understand
CO 5	To gain concepts of food safety and quality managements, national and international food laws and regulations as well as importance of food engineering and packaging in food industry.	1-Knowledge

Course Contents:

Unit 1	**Principles of Food Processing (L07)**	**COs Mapped: CO1**

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.

Unit 2	**Technology of food Products (Milk, Fruits and Vegetables) (L08)**	**COs Mapped: CO2**

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.

Unit 3	**Principles of Food Engineering (L07)**	**COs Mapped: CO3**

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.

Unit 4	**Food Packaging (L07)**	**COs Mapped: CO4**

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: CO5**

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, 1st Edition.

2. Fundamentals of food Engineering, S. E Charm. Avi Publishing Co Inc, 2nd 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, Menon Sreelata, S Mridula Menon Mirajkar, Kanishka Publishing House.
5. Food Processing Technology Principles and Practice, P J Fellows, Woodhead Publishing, 4th Edition
6. Handbook of Food Engineering, Dennis R. Heldman, Daryl B. Lund, Cristina Sabliov, CRC Press, 3rd Edition.
7. Handbook of Analysis and Quality Control for Fruits and Vegetable Products, S. Ranganna, McGraw Hill Education, 3rd Edition.
8. A Handbook of Food Packaging, Frank A. Paine, Heather Y. Paine, Springer-Verlag New York Inc. , 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**

Semester: VI (TY - B. Tech.) Chemical Engineering
CHE223016A: 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 Chemistry, Physics, Thermodynamics, Fluid Mechanics, Heat Transfer, Process 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
CO 1	Classify various energy sources, evaluate their availability, and compare different methods of energy conversion.	1-Knowledge
CO 2	Illustrate the renewable energy related to biomass technologies.	1-Knowledge
CO 3	Illustrate conversion technologies for solar and its applications.	1-Knowledge
CO 4	Understand waste-to-energy conversion processes and their environmental impacts, proposing mitigation measures.	2-Understand
CO 5	Understand the fundamentals of hydrogen energy systems and the production processes of hydrogen energy.	2-Understand

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**
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.	**CO4**
6	Case study of Hydrogen Fuel Cell Applications in Transportation.	**CO5**
7	Case study of challenges and opportunities in renewable energy development.	**CO4**
8	Case study in future trends, and innovations in renewable energy technologies.	**CO4**

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: VI (TY - B. Tech.) Chemical Engineering
CHE223016B: 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 how to invent chemical process flowsheets
2. To understand how to develop process alternatives; how to generate them and how to quickly screen the alternatives.

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

Sr. No.	Course Outcomes	Bloom's Level
CO 1	Interprete to process development, different considerations, overall process design, hierarchy of process design	2-Understand
CO 2	Differentiate types of reactions, kinetics, reaction paths, reactors and Separation techniques.	2-Understand
CO 3	Apply the pinch technology in order to optimize the energy usage in industries	3-Apply
CO 4	Design distillation sequencing, heat integration of sequences of simple distillation columns.	6- Create
CO 5	Evaluate efficient Heat Exchanger Networks: Pinch Technology, problem table algorithm, Threshold problems etc.	5-Evaluate

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.

Semester VI (TY - B. Tech.) Chemical Engineering
CHE223017: 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	Select the instrument for various chemical processes.	2-Undestand
CO2	Use temperature measuring instruments in chemical industry.	3-Apply
CO3	Use pressure measuring instruments in chemical industry.	3-Apply
CO4	Measure the flow and level using various measuring instruments in chemical industry.	3-Apply
CO5	Distinguish between various analytical methods possible for chemical analysis.	2-Undestand

Course Contents:

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

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: 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: 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: CO4**

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: CO5**

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 (Process Measurement)- Bella G. Liptak, CRC PRESS
2. Instrumentation devices and systems- Rangan, Sharma, Mani, Tata McGraw Hill Publishing Co. Ltd.
3. Instrumental methods of analysis – Willard, Merritt, Dean, Settle, CBS Publishers and Distributors
4. Instrumental approach to Chemical Analysis- Shrivastava, Jain, S. Chand and Co.
5. Handbook of Analytical Instruments- Khandpur, Tata McGraw Hill Publishing Co. Ltd..
6. Industrial Instrumentation, Donald P. Eckman CBS Publishers and Distributors Pvt. Ltd.

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
CHE223018: 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
CO 1	Understand optimization terminology and principles and apply them to formulate optimization problems	2- Understand
CO 2	Apply mathematical techniques such as gradient-based methods and Lagrange multipliers to solve optimization problems.	3- Apply
CO 3	Demonstrate the ability to formulate and solve linear programming problems using simplex method and interpret optimization results in engineering applications	3- Apply
CO 4	Apply nonlinear optimization methods to solve complex engineering optimization problems	3- Apply
CO 5	Implement optimization software in engineering, process synthesis, and control in real-world scenarios.	3- Apply

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 (LP) (L05)	COs Mapped:CO3

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

Unit 4	Nonlinear Programming (NLP) (L05)	COs Mapped:CO4

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:CO5**
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
CHE223019: Computer Aided Chemical Engineering

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

Prerequisite: Fundamental Knowledge of Mathematics, Process Calculations, Thermodynamics and unit operations and unit processes, Reaction Engineering etc.

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	Understand fundamentals of modelling and simulation	2- Understand
CO2	Analyze theory and apply programming knowledge to solve chemical engineering problems	4- Analyze
CO3	Simulate chemical processes using chemical process simulation software.	5-Evaluate

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	CO1, CO2
2.	Computer program for solving non-linear algebraic equation/s	CO1, CO2
3.	Computer program for solving steady state staged operation (distillation, gas absorption, L-L extraction, etc.)	CO1, CO2

4.	Computer program for solving un-steady state staged operation (distillation, gas absorption, L-L extraction, etc.)	CO1, CO2
5.	Computer program for plotting P-x-y and T-x-y diagram	CO1, CO2
6.	Computer program for design of reactor/ heat exchangers. distillation column/or any chemical equipment	CO1, CO2
7.	Computer program for solving ODE or PDE using finite difference method	CO1, CO2
8.	Simulation of mass transfer equipment using simple and rigorous methods	CO3
9.	Simulation of product synthesis using different reactors	CO3
10.	Simulation of steady state flow sheet synthesis	CO3
11.	Simulation of dynamic flow sheet synthesis	CO3
12.	Simulation of fluid flow problems with or without heat/mass transport	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 CHE223020: Project Phase I		
Teaching Scheme: Practical : 02 hrs/week	**Credit Scheme: 1**	**Examination scheme:** Term work: 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 the knowledge gained from courses in Chemical Engineering curriculum to work on practical problems.	3-Apply
CO2	Apply practical experience gained through the in-depth study of a challenging problem in Chemical Engineering field.	3- Apply
CO3	Design solutions for innovative problems using engineering skills.	6- Create
CO4	Acquire presentation skills, communication skills through report writing.	4- Analyze
CO5	Acquaint the team working skills for a successful professional career.	4- Analyze

Expected Working areas:

Project phase 1 is an integral part of the project work. The project work shall be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system 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. Maximum group size shall be 4 students. Projects selected should meet and contribute towards the needs of the 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 of understanding, applications, individual contributions, progress review, presentation, project report, timely completion of work.
- The department should prepare project planner and should follow accordingly.
- Progress reviews should be conducted periodically by forming evaluation committee at department level.
- The project report must undergo by plagiarism check and the similarity index must be less than 15%. The plagiarism report should be included in the project report.
- A certified copy of report is required to be presented to evaluation committee at the time of examination.