ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 10

(Syllabi for Chemical Engineering Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Contents (Volume - 10)

Syllabi for Higher Semester (3 - 8) Chemical Engineering Courses

ACADEMIC CURRICULA

Engineering Science Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21CHS201T	Course Name	INTRODUCTION TO CHEMICAL ENGINEERING	Course Category	S	ENGINEERING SCIENCE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the basic concepts and laws of thermodynamics, as applied to various systems and processes; to illustrate the PVT behavior and various equations of state*
CLR-2:	*explain the modes of heat transfer, evaluation of rate of heat transfer for conduction mode and heat transfer coefficient*
CLR-3:	*understand the classifications and kinetics of chemical reactions*
CLR-4:	*explain the basic principles of mass transfer, Diffusion phenomena and theories of mass transfer*
CLR-5:	*introduce the different software used in chemical engineering computations and design*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the laws of thermodynamics for different processes, and calculate the volumetric properties using equations of state*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*evaluate the conductive rate of heat transfer for different geometry and evaluate heat transfer coefficient*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*calculate the kinetic parameters and derive the rate equations for various types of reactions*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*Solve diffusion problems for fluids, analyze the mass transfer coefficients and evaluate the mass transfer coefficients*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*comprehend the ability and limitations of various software tools as applied to Chemical Engineering field*	*3*	-	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Energy Interaction — 9 Hour

Energy and its transformations (Work, heat and Energy, Internal energy, Enthalpy), Thermodynamic concepts, properties and processes (Classification, characterization, Reversible Process, Constant volume and Constant pressure processes), First law of thermodynamics (Energy balance for closed systems, steady-state flow processes, Limitations), PVT behavior of pure substances (PT diagram, PV diagram), Thermodynamic Processes involving Ideal gas (Isothermal process, isobaric process, isochoric process, Adiabatic process, and polytropic), PVT interactions using Cubic equations of state (Vander Waals equation, Redlich/Kwong equation, Virial equations of state and applications), Compressibility factor and Theorem of corresponding states

Unit-2 - Reaction Kinetics — 9 Hour

Chemical reactions and reaction rate (variables affecting the rate equation, Concentration and temperature dependency of rate equation), Concept of fractional conversion in constant volume batch reactor, Method of Analysis of kinetic data (Analysis of concentration, total pressure data obtained in a constant-volume System), Integrated rate expressions for first order, second order and zero order reactions, Reversible Reactions (Rate expression for First-Order), Empirical Rate Equations of nth order reactions (calculation of time of complete conversion, half-life data for irreversible reactions), Varying volume batch reactor and expansion factor calculation (Integrated rate expressions for varying volume systems)

Unit-3 - Fundamentals of Heat Transfer — 9 Hour

Introduction to Heat Transfer (modes of Heat transfer, concept of rate of heat transfer), Principles of conduction, convection and radiation, Fourier's law of heat conduction and Thermal conductivity, Newton's law of cooling, natural and forced convection, Resistance to heat transfer (Thermal conductivity, film coefficient), Combined conductive and convective heat transfer, Heat transfer coefficient and Overall heat transfer coefficient, Basic concepts of radiation, examples and application, Various types of heat exchange equipments

Unit-4 - Fundamentals of Mass Transfer	***9 Hour***
Introduction to Mass Transfer (Diffusion, molar and mass flux), Steady state molecular diffusion, Theories of mass transfer (film theory, penetration theory, surface-renewal Theory), Interphase Mass Transfer (Concentration profile, Two film theory), Unified approach for Momentum, Heat and Mass Transport, Various mass transfer operations and their applications, Industrial Mass Transfer Equipments (Distillation columns, absorption columns, Extractors, Driers), Membrane separation processes	
Unit-5 - Introduction to Software in Chemical Engineering and Calculations	***9 Hour***
Software in Chemical Engineering (Capabilities and Limitations), Engineering Computations using Microsoft Excel, Computer Programming, Process Engineering Design Software, Statistical and Numerical Analysis Software, Control Software, Piping and Equipment Design Software, Computer-Aided Design & Drafting	

Learning Resources	*1. Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4th Edn., Pearson India Education Services Pvt. Ltd., 2015.* *2. Smith, J.M., Van Ness, H.C., Abbott, M.M., Introduction to Chemical Engineering Thermodynamics, 8th ed., McGraw Hill*	*3. Warren L. McCabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, Indian Edition, 7th ed., McGraw Hill Education, 2022* *4. Uche Nnaji, Introduction to Chemical Engineering, Scrivener Publishing LLC, Wiley, 2019*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	10%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	20%	-	30%	-
Level 5	*Evaluate*	-	-	20%	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Mr. V. Ganesh, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. E. Kavitha, SRMIST*

Course Code	21CHS303J	Course Name	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING	Course Category	S	ENGINEERING SCIENCE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*review the numerical methods and solve the nonlinear algebraic equation in chemical engineering problems*
CLR-2:	*familiarize with solving the linear simultaneous algebraic equation, involved in engineering problems*
CLR-3:	*summarize the numerical Integration methods and their application in Chemical Engineering*
CLR-4:	*acquire curve-fitting techniques and learn to estimate parameters in model equations*
CLR-5:	*provide training to solve ordinary differential and partial differential equations*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*utilize the root-finding methods for solving the nonlinear algebraic equations engineering problems*	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	*solve the linear simultaneous algebraic equations involved in engineering problems*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*select an appropriate numerical integration method for solving the integral equations*	3	-	1	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*apply the curve fitting methods to estimate the parameters in the experimental model equations*	3	-	-	-	2	-	-	-	-	-	-	-	-	1	-
CO-5:	*solve the ordinary differential and partial differential equations using numerical techniques*	3	-	-	-	2	-	-	-	-	-	-	-	-	2	-

Unit-1 - Nonlinear Algebraic Equations	***12 Hour***
Single nonlinear equation –Bisection Method, Regula-Falsi: Method of False Position, Newton-Raphson in Single Variable; Simultaneous nonlinear equations - Newton-Raphson: Extensions and Multivariate, Modified Secant Method, ***Case studies and examples:*** *Fluid flow problems - Pressure Drop in Pipe, Power required for a pump in pipeline networks, Size of the pipeline networks as per standards, Minimum Fluidization Velocity, Terminal Velocity; Equilibrium calculations - Vapor pressure using cubic Equation of State, Chemical Reaction Equilibrium – Two Simultaneous Reactions*	
Unit-2 - Two-phase Vapor-Liquid Equilibrium and Linear Algebraic Equations	***12 Hour***
Two-phase Vapor-Liquid Equilibrium - Bubble point and dew point calculations using Modified Raoult's Law, Flash Calculation using Modified Raoult's Law, P-x-y and T-x-y Diagram using Gamma-Phi Approach ***Simultaneous Linear Algebraic Equations*** *- Tridiagonal Matrix Algorithm (TDMA); Thomas Algorithm; Gauss Elimination Method; Gauss-Seidel Method; Case Studies and Examples - Heat transfer problems – Heat Conduction, Multiple Effect Evaporator, Thermal Desalination Plant, Process Flow Sheet*	
Unit-3 - Regression in Multiple Variables	***12 Hour***
Linear Least Squares Regression, Nonlinear Estimation – Functional Regression by Linearization; Regression in Multiple Variables - General Multilinear Regression, Polynomial Regression. ***Case Studies and Examples*** *- Chemical Engineering Thermodynamics - Antoine equation for vapor pressure, Linear Regression for Benzene, Nonlinear Regression for Ethylbenzene; Chemical Reaction Engineering – Monod Kinetics, Complex Langmuir-Hinshelwood Kinetic Model, Reaction Rate: Differential Approach*	
Unit-4 - Ordinary Differential Equations	***12 Hour***
Single Ordinary Differential Equation – Euler's Explicit method, Euler's Implicit method, Fourth-Order Runge-Kutta: Classical RK-4 method; Simultaneous Ordinary Differential Equations – Fourth-Order Runge-Kutta: Classical RK-4 method. ***Case studies and examples*** *- Heat Transfer – Double Pipe Heat Exchanger; Stirred Tank with Coil Heater; Series of Stirred Tanks with Coil Heater; Fluid Flow – Pneumatic Conveying; Mass Transfer – Flash Separation/Batch Distillation; Chemical Reaction Engineering – Simulation of PFR, single and multiple reactions, Multiple Steady States: Non-isothermal CSTR, Step change in inlet Temperature, Chemostat with time-varying inlet flow rate, Heterogeneous Catalytic Reactor: Single Complex reaction.*	

Unit-5 - Partial Differential Equations **12 Hour**

Finite Difference method: Discretization in one-dimensional space, Convective-Diffusion problems, First order and second order upwind scheme, Forward in Time Central in Space Differencing;, Crank-Nicolson: Second-Order Implicit Method, ***Case Studies and Examples*** *- Heat Transfer - Heat Transfer in Fluid Flowing through a tube, Effect of Velocity Profile, Calculation of Nusselt Number; Chemical Reaction Engineering - Tubular Reactor with Axial dispersion, packed Bed Reactor with Multiple Reactions, non-isothermal Plug Flow Reactor, Chemical reaction and diffusion in a spherical Catalyst Pellet.*

Practice

Practice 1: Non-linear Algebraic Equations – Pressure drop in a pipe flow, minimum fluidization velocity
Practice 2: Non-linear Algebraic Equations – Density of pure component from Van der Waals Equation, Bubble and dew points using Raoult's law
Practice 3: Non-linear Algebraic Equations – Bubble and dew points calculation using modified Raoult's law
Practice 4: Non-linear Algebraic Equations – P-x-y and T-x-y diagram using Gamma Phi Approach
Practice 5:Two simultaneous non-linear Equations – Chemical Reaction Equilibrium, Flash calculation using modified Raoult's law
Practice 6: Linear Simultaneous Equations – Velocity in pipe network, Three-stage counter-current extraction
Practice 7: Linear Simultaneous Equations – Multiple Effect Evaporators
Practice 8: Linear Simultaneous Equations – Heat conduction, Exit concentration of species in CSTR
Practice 9: Regression in multiple variables – Temperature dependent non-Newtonian fluid, Elementary reaction rate
Practice 10: Regression in multiple variables – Monod kinetics, heterogeneous catalytic reactor – complex reaction rate
Practice 11: Ordinary Differential Equation – Double pipe exchanger, series of stirred tanks with coil heater
Practice 12: Ordinary Differential Equation – Batch distillation
Practice 13: Ordinary Differential Equation – Determine the heights in two-tanks network
Practice 14: Ordinary Differential Equation – Non-isothermal CSTR
Practice 15: Ordinary Differential Equation – A step change in inlet temperature time-varying inlet flow

Learning Resources

1. *Niket S. Kaisare, Computational Techniques for Process Simulation and Analysis Using MATLAB®, CRC Press, 2018 by Taylor & Francis Group, LLC*
2. *Pradeep Ahuja, Introduction to Numerical Methods in Chemical Engineering, PHI Learning Private Limited, 2010.*
3. *H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics – The finite volume method, Longman Group Ltd 1995.*
4. *H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall International Series.*

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*10%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. K. Suresh, SRM IST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRM IST*

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

							L	T	P	C
Course Code	21CHC202T	**Course Name**	CHEMICAL PROCESS CALCULATIONS	**Course Category**	C	PROFESSIONAL CORE	3	1	0	4

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the various system of units, predict the PVT properties of Ideal gases and real gases, understand the composition of solid, liquid, gas mixtures and liquid solutions*
CLR-2:	*formulate and solve material balance for non-reactive chemical process systems*
CLR-3:	*formulate and solve material balance for reactive chemical process systems*
CLR-4:	*formulate and solve energy balance for reactive and non-reactive chemical process systems*
CLR-5:	*formulate and solve material balance for simple process flow sheets, recycle, bypass and purge streams in chemical process systems*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of various system of units, and solve problems related to unit conversion, analyze the composition of solid, liquid, gas mixtures and liquid solutions, and PVT properties*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply the law of conservation of mass to solve the material balance problems in non-reactive Chemical process systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*apply the law of conservation of mass to solve the material balance problems in the reactive chemical process systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply the law of conservation of energy to solve the energy balance problems in reactive and non-reactive chemical process systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply the concept of sequential system material balance to solve simple process flow sheets material balance problems including recycle, bypass and purge streams*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Unit Conversions, Composition Analysis	***12 Hour***
Units and dimensions in chemical engineering, various temperature scales, Types of pressure, density, specific gravity, Unit conversions. The concept of mass, mole, calculations of mass fraction, and mole fraction. Basis of calculations, composition analysis of solid, liquid, and gas mixtures, evaluating PVT properties of gases using ideal gas law, Van der Waals equation, Redlich-Kwong equation. Density of gas mixtures. Analysis of the degrees of freedom.	
Unit-2 - Material Balance for Non-Reactive Systems	***12 Hour***
Law of conservation of mass, steady-state and dynamic processes, single and multi-phase systems. Fundamentals of material balances and material balance calculations, general procedure for material balance calculation, formulation of overall and individual component balance equations. steady-state material balance for non-reactive chemical processes: mixing, drying, crystallization, distillation, extraction, membrane separation processes. Concept of humidity and saturation, types of humidity, properties of a vapour gas mixture. The material balance calculations involved in two-phase gas liquid systems as in humidification and dehumidification.	
Unit-3 - Material Balance for Reactive Systems	***12 Hour***
Chemical reactions and stoichiometric Equations, limiting reactant, excess reactant. Identifying limiting and excess reactant, and evaluating percentage conversion, degree of completion, selectivity, and yield of a chemical reaction. Material balance for processes with chemical reaction. Fuels, types of fuel, combustion reaction, theoretical air, excess air. Calculation of excess air and flue gas analysis.	

Unit-4 - Energy Balance for Reactive and Non-Reactive Systems	**12 Hour**
Conservation of energy with reference to general energy balance. Thermophysics: Heat capacity of gases, liquids, solids, and solutions, Kopp's rule, temperature dependency, calculations on change in enthalpy. Thermochemistry: standard heat of reaction, standard heat of formation, standard heat of combustion, Hess law, Heat of reaction calculation based on Hess's law. Calculation on the heat of reactions at different temperature. Theoretical flame temperature, calculation of theoretical flame temperature.	
Unit-5 - Recycle, Bypass, Purge, and Material Balance for Multiple Unit Systems	**12 Hour**
Basic concepts of recycle, bypass, and purge streams, material balances for non-reacting chemical systems with recycle, bypass, and purge streams. Introduction to material balance for sequential processes, steady-state material, and energy balance analysis for multiple sub-systems without chemical reaction. Unsteady state material balance for chemical processes. Case studies with simple process flow sheets. The aid of computer in solving material balance problems: spreadsheet / Aspen Plus	

Learning Resources	*1. Himmelblau. D.H and James B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8th Edition, Prentice Hall, 2012.* *2. Bhatt, B.I. and Thakore S.M., Stoichiometry, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2010.*	*3. R. M. Felder and R. W. Rousseau, Elementary Principles of Chemical processes, John Wiley, 2004* *4. Narayanan K.V. and Lakshmikutty B., Stoichiometry and process calculations, 2nd Edition, PHI Publishing, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	30%	-	15%	-
Level 2	Understand	25%	-	30%	-	25%	-
Level 3	Apply	30%	-	20%	-	30%	-
Level 4	Analyze	30%	-	20%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	1. Dr. Lima Rose Miranda, Anna University	1. Dr. E. Kavitha, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Mr. V. Ganesh, SRMIST

Course Code	21CHC203J	Course Name	MECHANICAL OPERATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the process of Solid Characterizing, Screening, storage and conveying*
CLR-2:	*explain the principles of size reduction and size enlargement of solid particles*
CLR-3:	*describe the methods of separations of particles through fluids*
CLR-4:	*explain the principles of filtration and working of various industrial filtration equipment*
CLR-5:	*explain the concepts of agitation and mixing in processes & design the agitation vessel*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the particle characterization, acquire the knowledge of storage and transportation of solids*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*apply the concept of size reduction machineries and calculate the crushing power requirement*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*implement the suitable fluid-solid separation techniques respect to the particle characteristics*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the filtration concepts and design of filtration processes*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*apply the concepts of agitation and design of agitated vessel*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Solid Characterization, Separation, Storage and Conveying **12 Hour**

Characterization of particulate material: Particle shape and size, Mixed Particle size. Measurement Techniques: Specific surface area of mixture, Average particle size. Screen analysis: Standard screen series, Ideal and actual screens, Capacity and Screen effectiveness. Screening equipment: Stationary screens and Grizzlies, Gyrating screens, Vibrating screens, Trommels. Introduction to Particulate Storage and conveying equipment's.

Unit-2 - Particle Size Reduction **12 Hour**

Size reduction: Purposes of size reduction, Principles of Comminution, crushing efficiency, Empirical relationships, Power and energy required for size reduction by power law`s. Classification of size reduction equipment's: Crushers, Grinders, Impactors, Tumbling mills, Ball mill and Critical speed of Ball mill, Ultrafine grinders, Fluid energy mills, wet milling process. Cutting machines: Knife cutters. Introduction to Size enlargement. Open and Closed-circuit operation. Process performance of milling operation by Simulation.

Unit-3 - Motion of Particle Through Fluids **12 Hour**

Classification of Classifier and Clarifier. Sorting Classifiers: Sink and Float method, Differential settling method and Equal settling, Batch Sedimentation. Equipment for Sedimentation: Thickeners, Kynch theory of sedimentation, Design of thickener, Flocculation and Froth floatation, Bag filters, Cyclone Separators, Electro static precipitator, Centrifugal decanters, Hydrocyclones.

Unit-4 - Filtration **12 Hour**

Principles of Filtration, Mechanism of filtration, Filter Medium and Filter aids, Cake and Filter medium Resistances, Principles of cake filtration, Pressure drop through filter cake, Compressible and incompressible filter cakes, Constant pressure Filtration, Constant rate filtration. Filtration equipment's: Pressure Filters, Plate and Frame Filter press, Vacuum Filters. Introduction to Micro, Ultra, Nano filtration techniques. Continuous filters: Rotary Drum Vacuum filter, Centrifugal filters, Types of centrifuges, Working mechanism of Suspended batch centrifuge.

Unit-5 - Agitation and Mixing	***12 Hour***
Introduction and purposes of mixing and agitation. Agitation equipment: Impellers, Turbines, Propellers and Paddles. Standard turbine design, Flow patterns inside the agitation vessel, Prevention of swirling and vortex formation, Draft tubes, Flow number, Calculation of power consumption in Newtonian & Non-Newtonian liquids, Dimensional analysis for Power number correlation. Blending and Mixing, power consumption in blending & mixing, Type of Mixers and its application. Dispersion Operations.	

Practice

Practice 1: Determination of Average Particle Size using Sieve Analysis method
Practice 2: Efficiency calculation of given cut diameter opening of Sieve using Screen Effectiveness method
Practice 3: Determination of Conveyance efficiency of Screw Conveyor
Practice 4: Determination of reduction ratio of the given Solid material Using Jaw crusher
Practice 5: Determination of size reduction ratio of the given substance using Ball Mill and to find the critical speed of Ball mill
Practice 6: Process simulation of milling operations using Aspen Plus
Practice 7:Analyze settling of particle under gravity using batch sedimentation set up and design of thickener
Practice 8: Determination of particle size and collection efficiency using Cyclone separator
Practice 9: Simulation study on efficiency of cyclone separator using Aspen Plus
Practice 10: Calculation of Cake and medium resistance using plate and frame filter press
Practice 11: Determination of Filtration & resistance offered by cake & filter media in leaf filtration
Practice 12: Aspen plus simulation of plate and frame filter press to determine cake and medium resistance
Practice 13: To study the mixing behavior and power consumption of a mixture in an agitated vessel
Practice 14: Determination of mixing index for the given solid-liquid
Practice 15: Study of mixing behavior of agitated vessel using Aspen plus

Learning Resources	*1. McCabe, W.L., Smith, J.C., Harriot, P., Unit Operations of Chemical Engineering, 7th ed., McGraw-Hill, 2014.* *2. Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., Anderson, L.B., Principles of Unit Operations, 2nd ed., John Wiley & Sons, 2008.*	*3. Badger W.L., Banchero J.T., Introduction to Chemical Engineering, Tata McGraw Hill, 1997.* *4. Coulson. J.M, Richardson. J.F, Backhurst.. J.R., Harker. Chemical Engineering, Vol. II, 5th ed., Butter worth Heinemann, Oxford, 2002.* *5. Swain. A, Patra H, Roy. G K, Mechanical Operations, Tata McGraw Hill, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*20%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. K. Sofiya, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. P. Muthamilselvi, SRMIST*

							L	T	P	C
Course Code	21CHC204J	**Course Name**	CHEMICAL ENGINEERING FLUID MECHANICS	**Course Category**	C	PROFESSIONAL CORE	2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the behavior of fluids, mechanics of fluids and fluid flow phenomena*
CLR-2:	*explain the concepts of Kinematics and dynamics of fluid flow*
CLR-3:	*understand the concept of flow past immersed bodies*
CLR-4:	*compare the different types metering of fluids*
CLR-5:	*compare the different pumps for transportation of fluids*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze fundamental knowledge in fluids properties, classification, flow in boundary layers, and pressure measurements*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply Bernoulli equation, Friction factor and pressure measurements*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*apply the Ergun equation, Navier–Stokes, settling velocity and fluidization*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	2	-	--
CO-4:	*implement the correct flow meters for the given conditions*	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*implement the correct pumps for the given conditions*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Fluid Properties, Static and Flow Phenomena ***12 Hour***

Fluids and its properties, Classification of fluids, Fluid Statics: Hydrostatic equilibrium, pressure distribution, Eddy viscosity, Reynolds number, laminar and turbulent nature, laminar and turbulent flow in boundary layers, boundary layer and wake formation, Unsteady flows, Dimensional analysis derivation for pressure drop, Boundary layer, Boundary layer formation in flat plate, Pressure measuring devices: Manometer.

Unit-2 - Fluid Flow Equations ***12 Hour***

Streamlines and stream tubes, Eulerian and Lagrangian descriptions, Continuity equation, Bernoulli equation, Pump work in Bernoulli equation, Friction factor, relationships between skin-friction parameters, Flow of incompressible fluids in conduits and thin layers, Moody diagram, Relationships between average velocity and maximum velocity, roughness parameter, Vorticity and Circulation, Equivalent diameter, form friction losses in Bernoulli equation, couette flow, Hagen-Poiseuille equation, Hydraulically smooth pipe, Von Karman equation.

Unit-3 - Flow Past Immersed Bodies ***12 Hour***

Drag, drag coefficients, Drag coefficients of typical shapes, Ergun equation, Navier–Stokes equation, Settling velocity-Free and hindered settlings, Terminal settling velocity, Stokes' law- Newton's law for settling, criterion for settling regime. Fluidization: Types of fluidizations, Conditions for fluidization-Minimum fluidization velocity.

Unit-4 - Metering of Fluids ***12 Hour***

Introduction to Metering of fluids, Types of metering of fluids, Constructional features of venturi meter, working principles of venturi meter, Derivation for flow measurement by using Bernoulli equation. Constructional features of orifice meter, working principles of orifice meter, Derivation for flow measurement by using Bernoulli equation. Constructional features and working principles of Pitot tube, Derivation for flow measurement by using Bernoulli equation. Constructional features and working principles of Rotameters, Derivation for flow measurement. Target meter, turbine meter, Vortex shedding meter, Magnetic Flow Meter.

Unit-5 - Transportation of Fluids ***12 Hour***

Transportation of fluids-pipes and design of pipes, Joints, fittings, Flanges, Stuffing boxes, Mechanical seals, Type of Valves. Classification, selection and design of pumps. Construction, working principles, efficiency, characterizations of Centrifugal, Reciprocating, and other pumps. Fan, blowers and compressors. Vacuum Pumps- Constructional features and working principle of jet ejectors.

Practice

Practice 1: Determination of Reynold`s number of the fluid flow through pipe
Practice 2: Measurement of properties fluids
Practice 3: Study on Pressure measurement using simple U-tube manometers
Practice 4: Calculate pressure loss coefficient of contraction, Expansion and fittings on pipe
Practice 5: Verify relationship between Reynolds number and friction factor using pipe friction test Rig.
Practice 6: Verification of Bernoulli equation.
Practice 7: Determination of drag coefficient of solid through different fluid medium
Practice 8 Calculate minimum fluidization velocity of flow through Fluidized bed using Aspen plus
Practice 9: Determination of pressure drop through packed column Using Aspen plus
Practice 10: Find the Orifice Coefficient using Orificemeter
Practice 11: Find the venturi Coefficient using venturimeter
Practice 12: Find the discharge coefficient using Rotameter
Practice 13: Verify performance Characteristics of centrifugal pumps
Practice 14: Verify performance Characteristics of reciprocating pumps
Practice 15: Verify performance Characteristics of Gear pumps

Learning Resources	1. *McCabe, W.L., Smith, J.C., Harriot, P., Unit Operations in Chemical Engineering, 7th ed., McGraw-Hill, 2002.* 2. *Noel de Nevers, Fluid Mechanics for chemical Engineers, 2nd ed., McGraw Hill International Editions, 1991*	3. *Badger W.L. and Banchero J.T., Introduction to Chemical Engineering, Tata McGraw Hill, 1997.* 4. *Coulson. J.M, Richardson. J.F, Backhurst.. J.R. Harker. J.M, Coulson & Richardson's Chemical Engineering, Vol. II, 5th ed., Butter worth Heinemann, Oxford, 2002*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	-	10%	20%	-
Level 2	*Understand*	20%	-	-	10%	20%	-
Level 3	*Apply*	30%	-	-	20%	30%	-
Level 4	*Analyze*	30%	-	-	30%	30%	-
Level 5	*Evaluate*	-	-	-	30%	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. K. Sofiya, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Anbalagan, SRMIST*

Course Code	21CHC205J	Course Name	HEAT TRANSFER	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of heat conduction, rate of heat transfer, heat flux and derive the rate equation for various geometry based on the Fourier's law of heat conduction for steady state heat transfer*
CLR-2:	*understand the concept and types of convection, apply dimensional analysis, and evaluate the rate of heat transfer, and heat transfer coefficient for convection without phase change*
CLR-3:	*understand the concept of film-wise and drop-wise condensation, elaborate on the concepts of radiation and energy exchange between surfaces*
CLR-4:	*understand the application of heat transfer principles in heat exchanges, evaporators, reboilers*
CLR-5:	*understand the concepts of heat transfer in extended surfaces, unsteady state heat transfer by conduction, principle, and applications of electronic cooling systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*evaluate the rate of heat transfer by steady state heat conduction for various geometry, and composite systems, evaluate the critical thickness of insulation*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*evaluate the heat transfer coefficient for natural, and forced convection as applied to various flows and geometry*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*formulate the heat transfer coefficient for condensation and boiling heat transfer, analyze the principles of radiation heat transfer and evaluate the emissive power*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*analyze the sizing of heat exchangers, evaporators, reboilers*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*formulate the rate of heat transfer in fins and unsteady state conduction, and apply the principles of heat transfer in electronic cooling systems*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Conduction	***15 Hour***
Concept of heat transfer by conduction and resistance to heat transfer. Fourier's law of heat conduction, the Effect of temperature on thermal conductivity, steady state conduction of heat through a plane wall and hollow cylinder. Steady state conduction of heat through a composite plane wall and coaxial cylinders. Steady state conduction in bodies with heat sources: plane wall and hollow cylinder. Combined conductive and convective heat transfer and the concept of heat transfer coefficient. Heat transfer between fluids separated by a composite plane wall and coaxial cylinders. Critical insulation thickness, and applications.	
Unit-2 - Convection without Phase Change	***15 Hour***
Concept of heat transfer by convection. Application of dimensional analysis for convection, physical significance of the dimensionless groups. Hydrodynamic and thermal boundary layers, heat transfer analogies. Mean temperature difference, empirical relations for forced convection for different geometry- flow over a flat surface, flow through a cylinder, flow across a cylinder. Empirical relations for natural Convection for different geometry- flow over a flat surface, and cylinder.	
Unit-3 - Convection with Phase Change & Radiation	***15 Hour***
Heat transfer to fluids with phase change- condensation phenomenon, and its types. Nusselt's theory of film-wise condensation, heat transfer coefficient for film-wise and drop-wise condensation for different geometry, and the effect of non-condensable gases. The boiling mechanism and curve: the regimes of boiling in saturated pool boiling, correlations for pool boiling heat transfer. Basic concepts of radiation, radiation intensity, laws of radiation, and radiation shape factor. The energy exchange between black bodies, and non-black surfaces: Energy exchange between two large parallel planes, two large parallel planes of different emissivity, a small object placed in a large enclosure. The concept of radiation shield, energy exchange between two large parallel planes and coaxial cylinders intercepted by radiation shield.	

Unit-4 - Heat Transfer Equipments	**15 Hour**
Types of heat exchangers, flow patterns, and temperature distribution in heat exchangers. Shell and tube heat exchanger - single pass and multipass, baffles, and tube arrangements. LMTD, LMTD correction factor, process design considerations, enthalpy balance. Compact Heat exchangers and plate type heat exchangers. Effectiveness of heat exchangers Introduction to evaporation and types of evaporators, working principle. Evaporator capacity, economy, Boiling point elevation, Duhring's rule. Enthalpy balance equation and calculations for single effect evaporator. Multiple effect evaporators: methods of feeding, effect of boiling point elevation in a multiple effect evaporator. Types of reboilers and selection of reboilers for industrial applications.	
Unit-5 - Unsteady State Heat Transfer and Special Topics of Heat Transfer	**15 Hour**
Unsteady state conduction; transient heat conduction, one-dimensional transient conduction in a flat surface, cylinder. Heat transfer from extended surfaces: The fins, fin efficiency for different geometry. Heat transfer in electronic cooling devices: concept and applications of conventional cooling methods, heat pipes, transient cooling, spray cooling, microchannel cooling, jet impingement cooling, advanced liquid metal cooling, nanofluid as coolants.	

Practices:

Practice 1: Thermal conductivity of a lagged pipe,
Practice 2: Heat transfer coefficient in natural convection
Practice 3: Heat transfer coefficient in forced convection
Practice 4: Heat transfer coefficient in dropwise condensation
Practice 5: Heat transfer coefficient in filmwise condensation
Practice 6: Stefan Boltzmann's law constant
Practice 7: Emissivity of a non-black surface
Practice 8: Heat exchanger effectiveness of double pipe heat exchanger
Practice 9: Heat exchanger effectiveness of shell and tube heat exchanger
Practice 10: Performance evaluation of plate type heat exchanger
Practice 11: Performance evaluation of a double pipe heat exchanger using: Aspen Plus
Practice 12: Performance evaluation of a single pass shell and tube Heat exchanger using: Aspen Plus
Practice 13: Performance evaluation of a multipass shell and tube Heat exchanger using: Aspen Plus
Practice 14: Performance evaluation of evaporator using: Aspen Plus
Practice 15: Fin efficiency for a cylinder

Learning Resources	1. *Holman J.P, Souvik Bhattacharyya, Heat Transfer, 10th edition. Special Indian Edition, McGraw Hill Education (India) Pvt. Ltd., 2017* 2. *Binay K Dutta, Heat Transfer: Principles and Applications, PHI Learning Private Limited, 2015* 3. *Warren L. McCabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, Indian Edition, 7th edition, McGraw Hill Education, 2022*	4. *Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer, 5th edition, McGraw Hill, 2017* 5. *Sadik Kakac, Hafit Yuncu, K. Hijikata, Cooling of electronic systems, Springer, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*20%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. E. Kavitha, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Mr. V. Ganesh, SRMIST*

Course Code	21CHC206T	Course Name	CHEMICAL PROCESS TECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide an overview of the essential features of chemical process industries*
CLR-2:	*explain the process flow diagrams of various fertilizer industries*
CLR-3:	*understand the concept of upstream and downstream processes associated in production of natural products*
CLR-4:	*familiarize the sequence of unit operations in production of petrochemicals*
CLR-5:	*explain the technological concept of process flow diagram for the various polymers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the knowledge on the process flow diagrams of various process industries*	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*interpret the process knowledge in conversion of raw material into useful products through process flow diagram for different fertilizers*	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*apply the knowledge of fundamentals to develop process flow diagrams for different natural products*	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*comprehend the fundamental knowledge of unit processes in petrochemical products*	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*demonstrate the production technology and processes of the polymer industry*	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Inorganic Chemical Industry	***9 Hour***
Overview of chemical industry – Global and Indian Scenario, process flow diagrams, unit operations and unit processes, inorganic chemicals - soda ash, chlorine and caustic soda, Sulfur, sulfuric acid, silicate industries ***–****ceramics -glass, cement industries*	
Unit-2 - Fertilizer Industry	***9 Hour***
*Overview of fertilizer manufacturing sectors in India****,*** *Major Components of Fertilizer industries****,*** *Nitrogenous fertilizers - commercial manufacturing methods and applications of ammonia, nitric acid, urea, Phosphatic fertilizers – manufacturing process and applications of ammonium phosphate, diammonium phosphate, Superphosphate, triple super phosphate, Potash fertilizers – production and uses of potassium sulphate, Mixed fertilizers*	
Unit-3 - Natural Products	***9 Hour***
Introduction to natural products industries, Edible and essential oils – extraction and purification, vanaspati production, soaps, detergents and glycerin, pulp and paper industries, sugar, Maize and its application	
Unit-4 - Petrochemical Technology	***9 Hour***
Overview of petroleum refining operations and petrochemical technology, refining - Pyrolysis, cracking, reforming, synthetic organic chemicals- methane, ethylene, acetylene and propylene, aromatic compounds- Benzene, toluene, and xylene, intermediate and end chemicals – methanol, formaldehyde, ethylene dichloride, vinyl chloride	
Unit-5 - Polymer Industries	***9 Hour***
Introduction to polymer industries, Thermosetting and Thermoplastics, polymerization -types, Manufacture of Polyethylene, Polypropylene, Phenol Formaldehyde, polyamides, polyesters, Nylon 66, viscose rayon, natural and synthetic rubber – styrene butadiene rubber	

Learning Resources	1. *GopalaRao. M. and Marshall Sittig, "Dryden's Outlines of Chemical Technology", 3rd Edn., East- West Press, New Delhi, 2008* 2. *George. T Austin, "Shreve's Chemical Process Industries", 5th Edn., 5th Reprint, McGraw-Hill International Editions, Singapore, 2015*	3. *Kirk-Othmer, Encyclopedia of Chemical Technology,27 Volume set, John Wiley, 2004.* 4. *Jacob A. Moulijn, MichielMakkee, Annelies E. van Diepen, "Chemical Process Technology", 2nd Edition, John Wiley, 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	10%	-	10%	-	10%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	10%	-	10	-	10%	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. S. Kiruthika, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Selvam, SRMIST*

Course Code	21CHC301T	**Course Name**	CHEMICAL ENGINEERING THERMODYNAMICS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the concept of entropy and entropy changes; demonstrate the thermodynamic properties, relations and thermodynamic diagrams*
CLR-2:	*elucidate the applications of thermodynamics laws and energy balance for flow processes, devices and refrigeration*
CLR-3:	*understand the thermodynamics of mixtures and partial molar properties; acquire knowledge on fugacity and fugacity coefficient*
CLR-4:	*analyze the phase equilibrium for ideal and non-ideal mixtures*
CLR-5:	*expose the students to the fundamentals of reaction equilibrium, equilibrium constants and conversions*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the concept of entropy and derive the thermodynamic properties with their relations*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*apply the thermodynamic principles to various mechanical processes and refrigeration*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*derive the partial molar properties in a mixture and estimate the fugacity and fugacity coefficient*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*comprehend the phase equilibrium and estimate the degrees of freedom and the intensive variables*	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-5:	*formulate the equilibrium rate constant and conversion in a single and multi-reactions*	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-

Unit-1 - Thermodynamic Relations	***12 Hour***
Second law of thermodynamics (Statements, Heat Engine, Heat pump), Carnot's theorem and Carnot's equation (Carnot's cycle, Ideal-gas temperature scale), Entropy and Entropy changes (Entropy changes of an ideal gas in a closed system, system and surrounding), Mathematical statement of the second law, Entropy balance for open systems, Third law of thermodynamics, Fundamental Property relations (for a homogeneous fluid of constant composition in a closed system), Maxwell's relations and property estimation (U, H and S as functions of T, P ,V, Cp, Cv), Two-phase systems: temperature dependence of the vapor pressure of liquids, Residual Properties and thermodynamic diagrams	
Unit-2 - Thermodynamics Applications	***12 Hour***
Joule Thomson expansion, applications, Flow of compressible fluids (Duct, Pipe flow), Nozzles, Throttling process, Pressure changing devices (Turbines, Compressors, Pumps), Power cycles (Rankine cycle, Otto engine, Diesel engine), Refrigeration systems (Heat Pump, Carnot refrigerator, Vapor-compression cycle, Absorption refrigeration), Liquefaction processes (Linde liquefaction process, Claude liquefaction process).	
Unit-3 - Solution Thermodynamics	***12 Hour***
Introduction to solution thermodynamics, Partial molar properties – analytical and graphical, Chemical potential and applications, Ideal-gas mixture model, Fugacity and Fugacity coefficient (pure species and for species in solution), Fugacity coefficient correlations, Ideal Solution Model (Lewis-Randall Rule), Excess properties, Excess Gibbs Energy and Activity coefficient.	
Unit-4 - Phase Equilibrium	***12 Hour***
Introduction to Phase Equilibrium (Duhem's Theorem, VLE – qualitative behavior), Simple models of Vapour Liquid Equilibrium, Vapour Liquid Equilibrium with modified Raoult's Law, VLE from K-values, Flash Calculations, Applications of Phase Equilibrium, Gamma/Phi formulation of VLE, VLE from cubic equations of state, Equilibrium and Stability.	

Unit-5 - Reaction Equilibrium	***12 Hour***
Reaction Equilibrium (Reaction Coordinate, Extent of reaction, composition), Criteria for Reaction Equilibrium (T, P, G, S), Standard Gibbs's Energy change and Equilibrium Constant, Effect of Temperature on Equilibrium Constant, Equilibrium Constants (Types and evaluation), Equilibrium Conversions for single reactions, Reacting systems – Phase rule and Duhem's Theorem, Multi reaction Equilibrium, Equilibrium Conversions for multiple reactions	

Learning Resources	1. *Smith, J.M., Van Ness, H.C., Abbott, M.M., Introduction to Chemical Engineering Thermodynamics, 8th ed., McGraw Hill* 2. *Sandler. S "Chemical, Biochemical and Engineering Thermodynamics", 4th Edition, Wiley India, 2006.*	3. *Kevin D. Dahm, Donald P. Visco, Fundamentals of Chemical Engineering Thermodynamics, Cengage Learning, 2014*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Mr. V. Ganesh, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S. Sam David, SRMIST*

Course Code	21CHC302J	Course Name	MASS TRANSFER APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the basic concepts of mass transfer, diffusion phenomena and illustrate various theories of mass transfer and mass transfer across fluid interfaces*
CLR-2:	*explain the principles of gas absorption to design a packed/tray absorption tower*
CLR-3:	*explain the basic principles of distillation, methods and types of distillation and gain knowledge on the design methods of distillation column*
CLR-4:	*compare the difference between liquid – liquid extraction and leaching*
CLR-5:	*describe the principles of drying, types of driers and drying time for different drying periods and to have an insight on the mechanism of adsorption*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the basic knowledge of mass transfer principles, to solve diffusion problems and demonstrate the types of mass transfer coefficients and identify the rate controlling mechanism*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*design the absorption column and analyze the performance of packed and plate columns*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*analyze the composition of product streams in batch and flash distillation operations and demonstrate the design of distillation column by implementing McCabe -Thiele method*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*apply extraction principles to determine the percentage recovery of solute and number of stages*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*apply the basic principles of drying for selection of driers and calculate drying time and analyze the different types of adsorbents for appropriate industrial application*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Diffusion, Mass Transfer Coefficients and Interphase Mass Transfer — *15 Hour*

Introduction to Mass Transfer operations, Diffusion: Introduction, Types, Fick's I law of Diffusion. Steady – state molecular diffusion in fluids at rest and in laminar flow: Molecular diffusion in gases: - Steady state diffusion of A through non diffusing B - Gas phase equimolal counter diffusion - Diffusion in multicomponent gas mixtures. Molecular diffusion in liquids: - Steady state diffusion of A through non diffusing B - Liquid phase equimolal counter diffusion, Pseudo – steady state diffusion. Effect of temperature and pressure on diffusivity. ***Mass Transfer Coefficients****: Introduction – Types - Relationship between mass transfer coefficients. Dimensionless groups in mass transfer - Simultaneous momentum, heat and mass transfer. Theories of mass transfer: Film theory - Penetration theory - Surface-renewal theory.*

Interphase Mass Transfer*: Introduction, Equilibrium between phases, Concentration profile in interphase mass transfer, two film theory, Mass transfer using film mass transfer coefficients and interphase concentrations, Overall mass transfer coefficients and driving forces, Relation between individual and overall mass transfer coefficient.*

Unit-2 - Gas Absorption — *15 Hour*

Introduction, Principle, Industrial gas absorption systems. Equilibrium solubility of gases in liquids. Selection of solvent for absorption. Packing characteristics, Types of tower packings. Contact between liquid and gas, Pressure drop and limiting flow rates – loading and flooding. Material balances, Minimum liquid gas ratio. Design of packed towers, alternate forms of transfer coefficients. Counter current multi stage operation - absorption in plate columns -plate types. Introduction to desorption or stripping, selection of stripping medium. Absorption with chemical reaction.

Unit-3 – Distillation — *15 Hour*

Introduction, Principle, Methods and Types: Flash Distillation, Simple Batch Distillation - Rayleigh's equation, Steam Distillation, Vacuum Distillation, Continuous Distillation. Design of Distillation Column: McCabe-Thiele method, Energy balance for a distillation column- Condenser and reboiler duty. Reflux ratios, Fenske's equation, Efficiencies.

Unit-4 – Extraction	**15 Hour**
Liquid – liquid Extraction: *Introduction, Principle, Choice of solvent for extraction, Types of solvent. Extraction equipment's: Mixer-settlers, Packed tower extractors, Agitated tower extractors, Pulsed column extractors. Percentage extraction calculation for single stage and multistage cross current operations when liquids are insoluble. Minimum solvent rate and number of theoretical stages for continuous countercurrent, multistage extraction operation when liquids are insoluble.* ***Solid - liquid extraction***: *Introduction, Principle, factors affecting leaching, overflow and underflow, constant and variable underflow conditions. Bollman extractor.*	
Unit-5 - Drying and Adsorption	**15 Hour**
Drying: *Introduction, Importance of drying in processes, Principles of drying, Basis, Moisture contents. Mechanism of drying, Rate of drying curve, Calculation of drying time under constant drying conditions: Constant rate period, Falling rate period, Total drying time. Classification of dryers, solids handling in dryers. Equipment's for batch and continuous drying processes, tray drier, rotary drier and spray drier.* ***Adsorption***: *Introduction, Characteristics of adsorbents, Physisorption and chemisorption. Commercial adsorbents - preparation, application & regeneration. Adsorption isotherms. Fixed bed adsorbers.*	

Practice		
Practice 1: Vapour in air diffusion *Practice 2: Absorption* *Practice 3: Batch Distillation* *Practice 4: Steam Distillation* *Practice 5: Sieve plate distillation column*	*Practice 6: Liquid – liquid extraction* *Practice 7: Single stage extraction* *Practice 8: Multi stage extraction* *Practice 9: Soxhlet Extractor* *Practice 10: Simple batch - Tray drier*	*Practice 11: Forced draft tray dryer* *Practice 12: Batch adsorption* *Practice 13: Fixed bed adsorption* *Practice 14: Distillation in Aspen* *Practice 15: LLE in Aspen*

Learning Resources	*1. Robert E. Treybal, "Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012.* *2. Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2022.* *3. Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4thEdn. Pearson India Education Services Pvt. Ltd., 2015.*	*4. Binay K. Dutta, "Principles of Mass transfer and Separation Processes", Prentice- Hall of India, New Delhi, 2016.* *5. N. Anantharaman and K.M.Meera Sheriffa Begum, "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd., New Delhi, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. E. Poonguzhali, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. E. Kavitha, SRMIST*

Course Code	21CHC304J	**Course Name**	CHEMICAL REACTION ENGINEERING	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*discuss the design aspects of ideal reactors, size comparison of single reactor and performance of multiple reactor system*
CLR-2:	*explain the favorable contacting patterns and conditions for multiple reactions and temperature - pressure effects on reaction*
CLR-3:	*examine the flow behavior in non - ideal reactors and kinetics of solid catalyzed reactions*
CLR-4:	*analyze the kinetics and reactor design for fluid - particle reactions*
CLR-5:	*outline the methods for catalyst properties determination and catalyst preparation techniques*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the performance equation for ideal reactors, reactor size comparison expression and performance equations for multiple reactor system*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*interpret the conditions favorable for multiple reactions and temperature - pressure affecting reaction mechanism*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*calculate conversion in non - ideal reactors and kinetic parameters in solid catalyzed reactions*	2	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*explain reaction kinetic models and heterogeneous reactor design for fluid - particle reactions*	2	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*summarize the catalyst characterization techniques and preparation methods*	2	*1*	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Ideal Reactor Design and Design for Single Reactions	***15 Hour***
Broad classification of reactor types and applications, characteristics of ideal reactors, material balance and energy balance for reactors, performance equation for ideal reactors, holding time and space time for flow reactors, design of ideal plug flow and CSTR reactor with and without recycle, size comparison of single reactors, multiple reactor systems, design of recycle reactor, problems based on ideal reactors, multiple reactors and recycle reactor	
Unit-2 - Multiple Reactions, Temperature and Pressure Effects	***15 Hour***
***D**esign for parallel reactions, qualitative and quantitative treatment, yield, selectivity, reactor design for multiple reactions, irreversible reaction in series, favorable contacting patterns, series reaction – qualitative and quantitative treatment, temperature and pressure effects on reaction kinetics and equilibrium conditions, optimum temperature progression, conversion in adiabatic and non – adiabatic operations, phenomenon of stability, un-stability, runaway reactions, Strategies for stable operations of reactors, problems in parallel reaction, series reaction and equilibrium conversion*	
Unit-3 - Non – Ideal Flow Reactor Analysis and Solid Catalyzed Reactions	***15 Hour***
Basics of non – ideal flow, residence time distribution (RTD) concepts, tracer study, E, F and C curves, experimental methods to find distribution curves, conversion in non – ideal flow reactors, models of non-ideal flow: dispersion model and tanks – in – series model, temperature distribution and pressure drop in packed bed reactors, Heterogeneous catalytic reactions - effectiveness factor, internal and external transport processes, rate equation for surface kinetics, single site and dual site mechanism, concentration profile of gas reactant inside cylindrical catalyst pore, design equation for plug flow and mixed flow catalytic reactors, experimental methods for finding rate of catalytic reactions, problems based on RTD function, non – ideal reactor models and catalytic reactors	

Unit-4 - Kinetics and Design of Fluid – Particle Reactions	***15 Hour***
kinetics of fluid – particle reactions, models for fluid – particle reactions, rate equation for various controlling resistances for spherical particles unchanging in size, rate of reaction for shrinking spherical particles for different controlling mechanism, rate limiting step determination, fluid – particle reactor design, conversion in plug flow and mixed flow of particles, finding the size of a fluidized bed, instantaneous reaction concepts, multiphase reactors – slurry reactor and trickle bed reactor, problems in fluid – particle kinetics and reactor design	
Unit-5 - Catalyst Preparation, Characterization and Deactivation Mechanism	***15 Hour***
Catalyst properties and characteristics, catalyst types, determination of surface area, pore volume distribution, void volume and solid density of catalyst, promoters, accelerators, inhibitors, and supports, classification of catalyst, preparation of catalysts, catalyst poison types, causes and kinetics of catalyst deactivation, factors considered for catalyst replacement, problems in catalyst properties determination	

Practice	
Practice 1: Kinetic study in a batch reactor	*Practice 9: Study of tubular flow reactor followed by mixed flow reactor*
Practice 2: Performance study of a semi batch reactor	*Practice 10: Study of cascade mixed flow reactor*
Practice 3: Performance study of a tubular flow reactor	*Practice 11: Performance study of a packed bed reactor*
Practice 4: Performance study of a mixed flow reactor	*Practice 12: Study of RTD in packed bed reactor*
Practice 5: Study of an adiabatic reactor	*Practice 13: Batch reactor simulation using ASPEN plus*
Practice 6: Study of RTD in tubular flow reactor	*Practice 14: Plug flow reactor simulation using software tools*
Practice 7: Study of RTD in mixed flow reactor	*Practice 15: Simulation study of packed bed reactor*
Practice 8: Study of mixed flow reactor followed by tubular flow reactor	

Learning Resources	*1. Octave Levenspiel, Chemical Reaction Engineering, 3rd edition, John Wiley & sons, 1999* *2. H. Scott Fogler, Elements of Chemical Reaction Engineering, 3rd edition, Prentice – Hall of India Private Limited, 2004*	*3. J .M. Smith, Chemical Engineering Kinetics, 3rdEdn., McGraw Hill, New York, 1981*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. M. Magesh Kumar, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Mr. V. Ganesh, SRMIST*

Course Code	21CHC305J	**Course Name**	PROCESS DYNAMICS, CONTROL AND INSTRUMENTATION	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the importance of process control in industrial process plants and use Laplace Technique to obtain Transfer Function*
CLR-2:	*explain the concept of closed loop control system, controllers and final control elements*
CLR-3:	*describe the stability Analysis Techniques for open and closed loop system*
CLR-4:	*explain the Advanced Control strategy, and devise simple but effective plant-wide control strategies using appropriate methods*
CLR-5:	*describe the construction and working principles of f instrumentation for the effective design of process control loops for process engineering plants*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the Laplace method to obtain transfer functions related to the first and higher-order system*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*develop linear closed loop control system, controllers, and final control elements and use them in problem-solving*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*analyze stability of open and closed loop control systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply possible control schemes and advanced controller in chemical Process plants*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply the instrumentation knowledge in the modern chemical operations*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Laplace Transforms and Process Transfer Function	***12 Hour***
Basic Concepts of process control, Block diagram, Linear open loop systems, Laplace transform of simple functions, Laplace transform of derivatives, Properties of Laplace transform, Physical examples of first-order systems, Transfer function approach, Linearization of nonlinear system, Response of first-order systems, Response of first- order systems in series, Higher order systems: Second-order, Transportation lag.	
Unit-2 - Closed Loop System, Controllers and Final Control Elements	***12 Hour***
Linear closed loop systems, Controllers and final control element, Principles of pneumatic and electronic controllers, Transfer function of controllers, Dynamic behavior of controllers, Closed loop response, Servo problem, Regulatory problem, Mechanism of control valves, Valve characteristics.	
Unit-3 - Stability Analysis	***12 Hour***
Concept of stability, Stability criterion, Stability for linear system: Routh-Hurwitz stability criterion, Root locus diagrams. Design of control system using frequency response: Bode diagram stability criterion, phase and gain margins, and Ziegler Nichols controller settings.	
Unit-4 - Advanced Control System and Control Schemes	***12 Hour***
Introduction to multivariable control, Cascade control scheme, Selective control systems, Override control, Auctioneering Control, Split-range control, Feed forward control scheme. Control of distillation column: control of composition, control of pressure. Introduction to digital control, Microprocessor-based controllers, Hardware Components, Tasks of a Microprocessor based controller, Special features of Microprocessor based controller. Introduction to PLC's and DCS. Introduction to Fuzzy Logic Control.	

Unit-5 - Measuring Instruments	***12 Hour***
Principles of measurements, Classification of process control instruments, Elements of instruments, Static and dynamic characteristics, Temperature measuring instruments, Liquid-level measuring instruments, Pressure measuring instruments, Composition measuring instruments, Measurements of viscosity, Measurements of pH, Measurements of thermal conductivity, Measurements of humidity of gases.	

Practice

Practice 1: Verifying Step Response of First Order system for a given tank problem.
Practice 2: Verifying Impulse response of Interacting system
Practice 3: Verifying Step response of non-interacting system
Practice 4: Study on Flapper nozzle arrangement, Current to Pressure and Pressure to Current converter
Practice 5: Study on Valve Characteristics
Practice 6: Study on different mode of controllers P, PI, PD, PID
Practice 7: Stability analysis by Bode plot using MATLAB
Practice 8 Tuning of controller parameters
Practice 9: Stability Analysis by Root Locus Concept using MATLAB
Practice 10: Cascade simulation of Chemical Reactor using Aspen Plus software
Practice 11: Feedforward simulation of Heat exchanger using Aspen plus Software
Practice 12: Split range control in valve applications using Aspen plus Software
Practice 13: Temperature Process Controller
Practice 14: Level Process Controller
Practice 15: Pressure Process Controller

Learning Resources

1. *Donald R. Coughanowr., Steven E. LeBlanc., "Process system Analysis & Control", 3rd edition.,McGraw Hill, New york, 2009.*
2. *George Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice",Prentice Hall, New Delhi, 1984.*
3. *Peter Harriott, "Process Control" Tata McGraw Hill, New Delhi, 1972.*
4. *William L. Luyben, "Process modeling, simulation, and control for Chemical Engineers ", 2nd edition,McGraw Hill, New York, 1996.*
5. *Donald P. Eckman, "Industrial Instrumentation", Wiley Eastern Limited, 2004.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*20%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr.K.Sofiya, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr.P.Muthamilselvi, SRMIST*

Course Code	21CHC306T	Course Name	TRANSPORT PHENOMENA	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehend the momentum, energy and mass transport process mechanism*
CLR-2:	*introduce the equations of change for momentum energy and mass transfer*
CLR-3:	*discern the boundary conditions in momentum, energy and mass transport process*
CLR-4:	*formulate the equation for change for steady state one dimensional momentum, energy and heat transport process*
CLR-5:	*obtain the velocity, temperature and concentration profile*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the momentum, energy and mass transport process mechanism in a given system*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*formulate the equations of change for momentum energy and mass transfer for a system*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify the boundary conditions in momentum, energy and mass transport process*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*formulate the equation for change for steady state one dimensional momentum, energy and heat transport process*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply the equation of change to obtain the velocity, temperature and concentration profile*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Viscosity and the Mechanisms of Momentum Transport	***9 Hour***
Momentum flux and Kinetic energy, Pressure & shear stress, kinetic energy - Coordinate systems, Vector and tensor analysis, Newton law of viscosity - Substantial derivative and Theory of Continuity - Shell momentum balance and Navier stokes equation - balance- Navier Stokes equation - Turbulence modelling	
Unit-2 - Velocity Distributions in One Dimensional Laminar Flow - Isothermal Systems	***9 Hour***
Equations of Change – flow over an inclined plane slab as thin film - Equations of Change – flow through pipe - Equations of Change – flow through annular pipe & flow through two immiscible liquids - Equations of Change – flow through narrow slit	
Unit-3 - Mechanisms of Energy Transport and Equations of Change for Non-Isothermal Systems	***9 Hour***
Shell Energy Balances and special forms of energy equation - Heat Conduction with an Electrical Heat Source, Chemical heat source and viscous heat source - Cooling of a Sphere in Contact with a Well-Stirred Fluid - Lumped heat capacitance	
Unit-4 - Mechanisms of Energy Transport and Temperature Distributions in Solids & Laminar Flow	***9 Hour***
Velocity and Temperature distributions in laminar Flow - Dimensional Analysis - Boundary layer theory & Flow approximations - Heat transfer through fins, variable surface area. Case study	
Unit-5 - Mechanisms of Mass Transport	***9 Hour***
Basics of mass transfer, mass balance equation–Equimolar counter diffusion, Diffusion through a stagnant film, Diffusion with chemical reaction, homogeneous, heterogeneous reaction, fast & slow reaction – Application of Momentum, Energy and Mass transfer analogies: Case study	

Learning Resources	1. *R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, Transport Phenomena. John Wiley & Sons, Inc. Revised 2ed, An Indian Adaptation (2021)* 2. *J.H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer; 4th ed. CBS Publishers & Distributors Pvt. Ltd (2020)*	3. *William M. Deen Analysis of Transport Phenomena USA; 2nd edition (2012)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. S. Sam David, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Suresh, SRMIST*

Course Code	21CHC307J	Course Name	PROCESS MODELING AND SIMULATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*organize the fundamental concept involved in conservation law equations*
CLR-2:	*review the molecular and convective flux and its mathematical formulation*
CLR-3:	*recap the generation and unsteady state terms in conservation laws with suitable examples*
CLR-4:	*provide the training to develop process model equations for homogeneous systems*
CLR-5:	*evaluate the conserved quantities by solving the governing equations using commercial software*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*propose the mathematical model equation for Molecular and Convective transport*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*provide conserved quantities for chemical engineering systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*develop the mathematical model equation for generation and unsteady state terms*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*create the mathematical model equation for homogeneous liquid systems*	*3*	*2*	-	-		-	-	-	-	-	-	-	*3*		-
CO-5:	*solve the model equations using commercial software tools*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction, Molecular, and Convective Transport	***12 Hour***
Basic Concepts; Definitions – Steady-State, Uniform, Equilibrium, Flux; Mathematical Formulation of the Basic Concepts; Simplification of the Rate Equation; Molecular Transport – Newton's Law of Viscosity, Fourier's Law of Heat Conduction, Fick's First Law of Diffusion; Dimensionless Numbers; Convective Transport; Total Flux.	
Unit-2 - Interphase Transport and Evaluation of Transfer Coefficient	***12 Hour***
Friction factor – Physical Interpretation of Friction Factor; Heat Transfer Coefficient – Convective and Radiation Heat Transfer Coefficient; Mass Transfer Coefficient – Physical Interpretation of Mass Transfer Coefficient and Concentration at the Phase Interface; Dimensionless Numbers; Transport Analogies – The Reynolds Analogy, The Chilton-Colburn Analogy; Reference Temperature and Concentration; Flow past a Flat Plate; Flow past a Single Sphere; Flow in Circular Pipes; Flow in Packed Beds	
Unit-3 - Rate of Generation in Momentum, Energy, and Mass Transfer	***12 Hour***
Rate of Generation in Momentum Transport – as a Result of Gravitational Force, as a result of Pressure Force, and Modified Pressure; Rate of Generation in Energy Transport; Rate of Generation in Mass Transport – Stoichiometry of a Chemical Reaction, The Law of Combining Proportions, and Rate of Reaction.	
Unit-4 - Steady-State Macroscopic Balances	***12 Hour***
Conservation of Chemical Species; Conservation of Mass; Conservation of Energy – Energy Equation without Chemical Reaction, Energy Equation with Chemical Reaction Case Studies and Examples: Series of CSTR, Steady supply of compressed air, Jacketed CSTR, Parallel reaction in an isothermal CSTR.	
Unit-5 - Unsteady-State Macroscopic Balances	***12 Hour***
Approximations used in Unsteady Process – Pseudo-Steady-State Approximation, No Variation of Dependent Variable within the Phase of Interest; Conservation of Chemical Species; Conservation of Total Mass; Conservation of Momentum; Conservation of Energy – Unsteady-State Energy Balance Around a Continuous Stirred Tank Reactor; Design of a Spray Tower – Determination of Tower Diameter, Determination of Tower Height	

Practice

Practice 1: Properties, VLE data and fraction of liquid
Practice 2: Heater and Mixer
Practice 3: Heat Exchanger – Design and simulation
Practice 4: Heat Exchanger – Sensitivity analysis for minimum heat transfer area
Practice 5: Pressure Changer – Power required and discharge pressure
Practice 6: Pressure Changer – Sensitivity analysis for power required for a process
Practice 7: Separation Units – Absorption and extraction
Practice 8: Distillation – mole fraction as a function of the number of stages
Practice 9: Reactors – Exit composition of the reactors (PFR, CSTR, Stoichiometric reactor and Gibbs reactor)
Practice 10: Flowsheet simulation
Practice 11: Optimization – minimum total volume of the two reactors
Practice 12: Non isothermal PFR
Practice 13: Open-loop control
Practice 14: Closed loop control – step change in reactor
Practice 15: Heat Exchanger – detail design

Learning Resources	1. *Ismail Tosun, Modeling in Transport Phenomena – A Conceptual Approach, 2ndEdn., Elsevier Publications 2007* 2. *Kamal LM. AL-Malah, Aspen Plus® Chemical Engineering Applications, 2017, John Wiley & Sons.*	3. *Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, 6thEdn., McGraw Hill International Editions, New York, 2010* 4. *William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, 2ndEdn., McGraw Hill International Editions, New York, 1990.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*10%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. K. Suresh, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S. Sam David, SRMIST*

Course Code	21CHC401J	Course Name	PROCESS EQUIPMENT DESIGN AND DRAWING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the basics of representation of equipment's through process flow sheeting, various types of selection of enclosures, flanges, nozzles and supports for process vessels*
CLR-2:	*recap the unit operations and unit process equipment's and the theoretical design and drawing of reaction/agitated vessels, filtration and cyclone separator*
CLR-3:	*outline the principles of heat transfer and theoretical design and drawing of heat transfer equipment's such as shell and tube heat exchanger, Evaporator*
CLR-4:	*overview of the principles of mass transfer process and theoretical design and drawing of distillation column and cooling tower*
CLR-5:	*consolidate the fundamental concepts and theoretical relationships useful in theoretical design and drawing of process equipment with simultaneous heat and mass transfer*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design the process vessel and to choose appropriate enclosures, flanges, nozzles and supports for process vessels*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*perform the theoretical design and drawing of reaction/agitated vessels, filtration and cyclone separator*	-	*3*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*analyze and theoretically design and draw the heat transfer equipment's such as shell and tube heat exchanger, evaporator*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*relate the principles of mass transfer and theoretically design and draw the distillation column and cooling towers*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*evaluate the design of simultaneous heat and transfer with the equipment's of dryer and crystallizer*	-	-	-	*3*	*2*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Pressure Vessels and its Components	***12 Hour***
Chemical Engineering Design – Classification, Convections, Representation, Labelling- Process flow sheeting- General design procedure-Materials of construction and Design considerations- Pressure vessels - Classification, Applications and Design considerations, Numerical problem with internal pressure-Classification of enclosures (heads or cover)-Introduction to various types of enclosures, flanges-Introduction to various types of nozzles and supports-Case studies.	
Unit-2 - Equipment's for Particular Matter	***12 Hour***
Overview of reaction/agitated vessels-Introduction, Classification and Design consideration of Reaction Vessel-Numerical Problems-Overview of filtration- Design equations- Flux, area and time calculation -Theory on design of cyclone separator-Case studies on cement industries.	
Unit-3 - Equipment's on Heat Transfer	***12 Hour***
Outline of Heat Exchangers-Principles of heat transfer-Types of heat exchangers - Design procedure for 1-2 shell and tube heat exchanger-Numerical Problems-Design of compact heat exchanger- Theory of Evaporators – Types and their applications- Numerical problems on single effect-multiple effect evaporator.	

Unit-4 - Equipment's on Mass Transfer	***12 Hour***
Distillation: Overview of distillation column-Theory and design aspects-Numerical problem on distillation- Plate design Humidification: Introduction to humidification, Humidity, dry bulb temperature, saturated gas, saturation humidity, Relative humidity, Percentage humidity, Humid volume, Humid heat, Total enthalpy, Dew point, Concept of adiabatic saturation, Adiabatic saturation temperature, Wet-bulb temperature, Theory of wet-bulb temperature, Psychrometric line and Lewis relation, Humidity chart, Use of humidity chart, Types of Cooling towers, Working principle of cooling towers- Numerical problems on design of cooling towers	
Unit-5 - Equipment's on Simultaneous Heat and Mass Transfer	***12 Hour***
Dryer: Theory and design aspects of rotary drier-Numerical problem- Case studies- Fluidized bed dryer- Crystallizer-Theory of crystallizers –Types and their applications- Numerical problem- Case study on the design of crystallizers.	
Practice	
Practice 1: Introduction to CAD software: Demo, Menu, Toolbars, Drawing Area, Dialog box, Command Line *Practice 2: Create, Select, Erase, Status Bar, Create, Edit, use layers, Extend lines* *Practice 3: Change of position method, create objects and all shapes- arcs, circles, polygon* *Practice 4: Change of reference line method, Different zoom methods* *Practice 5: Creating combination of solids isometric, perspective, shaded, wire-frame* *Practice 6: Drawing of Pressure vessel* *Practice 7: Drawing of Heads* *Practice 8: Drawing of Supports*	*Practice 9: Drawing of Cyclone* *Practice 10: Drawing of Agitated vessels* *Practice 11: Drawing of Evaporator* *Practice 12: Drawing of Heat exchanger* *Practice 13: Drawing of Distillation column* *Practice 14: Drawing of Crystallizer* *Practice 15: Drawing of Dryer*

Learning Resources		
Learning Resources	*1. Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 6, 4th Edn., Butterworth Heinemann, New Delhi, 1999.* *2. Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 2, 5th Edn., Butterworth Heinemann, New Delhi, 1999.* *3. Perry. R.H., et al., Perry's, "Chemical Engineers Handbook," 9th Edn., McGraw Hill, NewYork, 2019* *4. Bownell, L.E., and Young, E.M., "Process Equipment Design", Wiley Eastern, 1968.*	*5. Joshi. M.V, and Mahajani. V.V, "Process Equipment Design," 4th Edn., Macmillan India Limited, New Delhi, 2009* *6. Bhattacharya, B C., "Introduction to Chemical Equipment Design: Mechanical Aspects", 5th Edn. CBS Publisher, 2012* *7. Bethunc, J., Engineering Graphics with AutoCAD 2017, Pearson Education, 2016* *8. User Manual of Respective CAD Software's*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*30%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. G. Keerthiga, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Mr. V. Ganesh, SRMIST*

Course Code	21CHC402T	Course Name	PROCESS ECONOMICS AND PROJECT MANAGEMENT	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*present the fundamental concepts of interest and depreciation*
CLR-2:	*provide the essential features of cost accounting and financial statement*
CLR-3:	*impart knowledge on the basics of selection of alternatives and taxes in process plants using theoretical economic equations*
CLR-4:	*explain concepts of the economic analysis and project scheduling methods for chemical processes*
CLR-5:	*present the project management principles and strategies as applied in chemical process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of interest and depreciation to solve process economic problems*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-2:	*interpret and explain the cost accounting and financial statements for a typical chemical process industry*	-	-	-	*2*	-	-	-	-	-	-	*3*	-	*3*	-	-
CO-3:	*analyze the chemical engineering processes and illustrate the economic principles used in it towards the selection of alternatives and taxes*	-	*3*	-	-	-	*3*	-	-	-	-	-	-	*3*	-	-
CO-4:	*perform economic balance calculations for batch (or cyclic) processes and to understand project scheduling*	-	-	-	-	-	-	-	-	*2*	-	*3*	-	*3*	-	-
CO-5:	*demonstrate the knowledge and understanding of project planning, finance and project management*	-	-	-	-	-	-	-	*2*	-	-	*3*	-	*3*	-	-

Unit-1 - Interest and Depreciation	***9 Hour***
Simple and compound Interest -Nominal and effective interest rates-Continuous interest- time value of money- Equivalence- Equations for economic studies – Amortization- Depreciation-causes and methods of depreciation- Cost index.	
Unit-2 - Cost Accounting and Financial Statements	***9 Hour***
Cost accounting - Capital requirements- Earnings, Process and returns - Economic production – Break-even analysis-determination- break even chart- Pre construction cost-Numerical problems. Importance of Financial Statements-Compilation of Financial Statements including Balance Sheet- Income statement and Profit and loss statement	
Unit-3 - Alternatives and Taxes	***9 Hour***
Economics of selecting alternative- Four methods of economics of alternative selection- Annual cost method- Present worth method and NET Present value- Replacement: Rate-of-return- Pay-out time method-. Taxes: Relationship between Depreciation and Taxes, Types of Taxes, Equivalence after Taxes, Cost comparison after taxes and Numerical.	
Unit-4 - Economics Analysis and Assessment	***9 Hour***
Plant location- Site selection; Feasibility Report-Concept identification- Economic balance -Batch Process-Multiple equipment units-Illustrative example using Excel, Aspen, Case studies of problems in heat and mass transfer; Economic analysis- Appraisal value, earning value, Stock and bond Value- Numerical Problems-Detailed project report-Environmental impact assessment Life cycle assessment using OPENLCA and GaBI software.	
Unit-5 - Project Management and Project Scheduling	***9 Hour***
Project planning-Project management for chemical engineers-Principles and initiation -Resource Allocation strategies, Generation and screening of project ideas and plans, Market and demand analysis-Technical analysis-Investment criteria -Risk factors and analysis- Analysis of rate of return- Financing of projects-Raising capital methods and means, Venture capital. Project_Scheduling-Time Control Method- Introduction Critical Path Method- PERT (Program Evaluation and Review Technique) - GANTT charts-Numerical problems	

Learning Resources	1. Max. S,Peters and Klaus. D Timmerhaus, *"Plant Design and Economics for Chemical Engineers", 5th Edn., McGraw Hill International Editions, New York, 2004.* 2. *Schweyer. H.E, "Process Engineering Economics", McGraw Hill, 1969* 3. *F.C. Jelen and J.H. Black, "Cost and Optimization Engineering", McGraw Hill, 3rd Edn., 1992.*	4. *Peachey B., R. Evitts and Hill G.,"Project Management for Chemical Engineers", Trans IChemE, Part D, 2007* 5. *Gillian Lawson, Stephen Wearne, Peter Iles-Smith, "Project management for the Process Industries",IChemE, UK, 1999.* 6. *Donald E. Garrett, "Chemical Engineering Economics", Springer, Van Nostrand Reinhold, Newyork, 1989*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*		*20%*	-
Level 2	*Understand*	*20%*	-	*20%*		*20%*	-
Level 3	*Apply*	*30%*	-	*20%*		*30%*	-
Level 4	*Analyze*	*20%*	-	*30%*		*30%*	-
Level 5	*Evaluate*	*10%*	-	*20%*		-	-
Level 6	*Create*	-	-			-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr G Keerthiga, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr.N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K.Anbalagan, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21CHE351T	**Course Name**	RENEWABLE ENERGY ENGINEERING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the need for conservation and alternate energy sources*
CLR-2:	*explain the concepts of Solar energy utilization and applications*
CLR-3:	*discuss the concept of Wind energy production and its uses*
CLR-4:	*describe the technologies of Bioenergy production and its applications*
CLR-5:	*expose to other sources of renewable energy and Energy storage concepts*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*articulate the need for alternate energy sources and awareness on energy conservation*	2	-	-	-	-	-	3	-	-	-	-	-	-	-	1
CO-2:	*compare the Solar energy conversion equipment's and PV cell concepts, applications*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*elaborate the Wind energy conversion system concepts and its techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze the types of biomass resources and its energy conversion technologies*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*infer the other types of energy resources and energy storage concepts*	*3*	-	-	-	-	-	2	-	-	-	-	-	-	-	1

Unit-1 - Need for Alternate Energy Resources	***9 Hour***
India's energy demand and supply, management, Regional prospects and stresses, Global demand, Energy resources of India, economic development, Energy cropping, Energy conversion, Classification of Energy, Energy conservation, Various techniques of energy conservation.	
Unit-2 - Solar Energy	***9 Hour***
Introduction on solar energy, Solar angles, Solar collectors: flat and dish type, Solar Concentrators: Types, Configuration and working of collectors and concentrators, Fundamentals of PV cell, principle, types, design and its advancement. Application of Solar energy: Solar pumping, Solar refrigeration, Solar air cooling, Solar furnaces, Solar drying, stills and cooking	
Unit-3 - Wind Energy	***9 Hour***
Availability of wind, Types of wind, Types of wind mills: horizontal axis and vertical axis, Wind turbines: horizontal and vertical axis, The power from the wind, Betz theorem, Design parameters and design principles and wind turbines, Parameters affects performance, Wind power forms, Application of wind energy	
Unit-4 - Bioenergy	***9 Hour***
Biomass and its resources, Composition, properties; Biomass conversion technologies: Direction combustion, Pyrolysis, Gasification, Biogas technology - Anaerobic digestion, mechanism of biogas production, Bioethanol and Biodiesel Production, Community and institutional biogas plants, Family biogas plants, design consideration of digester, Factors affecting biogas production, Recent Developments, Energy farming.	
Unit-5 - Other Energy Resources and Energy Storage	***9 Hour***
Tidal energy, Wave energy, OTEC (Open and closed OTEC Cycles), Geothermal energy production and conversion, Small hydro energy conversion, Hydrogen energy production and storage, Batteries (types, Lead-acid battery), Mechanical Energy storage, Fuel cell (Fundamental and its types).	

Learning Resources	1. Rai. G.D. “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 6th edn.,2017. 2. Bansal..N.K Manfred Kleen Man and Michael Meliss, Renewable energy sources of conversion technology”: TMH Publication, 1990.	3. Kothari. P, K C, Singal and Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies”, PHI Pvt. Ltd.,New Delhi, 2008.

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai*	1. *Dr. Lima Rose Miranda, Anna University, Chennai*	1. *Dr. K.Selvam, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Deepa, SRMIST*

Course Code	21CHE352T	Course Name	INTRODUCTION TO BIOCHEMICAL PRINCIPLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*expose to the importance of biochemical process and products*
CLR-2:	*study the different fermentation media*
CLR-3:	*teach the principle of sterilization and sterilization kinetics*
CLR-4:	*study the growth kinetics methods and yield coefficient cell growth and product formation*
CLR-5:	*study process flow for manufacture of biochemical products*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the industrial importance microorganism and different fermentation process*	*1*	-	*2*	-	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-2:	*develop specific media for bio product production process*	*2*	-	*2*	-	-	-	*2*	-	-	-	-	-	*2*	-	-
CO-3:	*express Sterilization kinetics and sterilization methods*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*evaluate microbial growth kinetic in the fermentation and product yield coefficient in biochemical reaction*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*demonstrate the design and unit operation involved in the biochemical product development*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Basic of Fermentation Process	***9 Hour***
Overview of biochemical engineering, History of industrial microbiology, Comparison of chemical and biochemical Processes, Overview of fermentation process, Classification of Microorganisms, Isolation of micro-organisms-serial dilution method, Preservation of pure culture-storage at reduced temperature	
Unit-2 - Fermentation Media	***9 Hour***
Selection of good medium, medium requirements for fermentation processes, Components of fermentation media, Classification of carbon source and function, Nitrogen source and function, Minerals source and function, Growth factors and additives in media preparation, Designing of media for fermentation processes, Types of media, simple, complex and commercial media	
Unit-3 - Sterilization Methods	***9 Hour***
Sterilization and function, Types of Sterilization, Physical method: heat sterilization, pasteurization, Autoclave methods, radiation sterilization, Chemical method: liquid sterilization and gas sterilization, Mechanical method: filtrations sterilization, Factors affecting sterilization process, Batch sterilization, Thermal death kinetics of micro-organisms, Continuous sterilization: Indirect heating method	
Unit-4 - Bacterial Growth Kinetic	***9 Hour***
Monod growth kinetic model, Growth curve and doubling time calculation, Phases of cell growth in batch cultures, Solving problem (growth rate and Monod constant, Stoichiometry of microbial growth, degrees of reduction, Respirator co-efficient, Determination yield coefficient calculation.	
Unit-5 - Bio Products Production	***9 Hour***
Industrial fermentation process, selection of raw materials, media preparation, Production of primary metabolites like citric acid production, acetic acid, amino acid production, ethanol production and Production of secondary metabolites like antibiotic production and vitamin production.	

Learning Resources	1. Peter F.Stanbury, Allan Whitaker, Stephen J Hall “Principles of Fermentation Technology” 2nd Edition, Butterworth – Heinemann (an imprint of Elsevier), 1995. 2. Michael L.Shuler and Fikret Kargi, “Bioprocess Engineering Basic concepts”, Prentice Hall, 2002.	3. Casida Jr, L.E., “Industrial Microbiology”, New Age International (P) Ltd. 4. Bailey, J.E. and Ollis, D.F. “Biochemical Engineering Fundamentals” 2nd Edition, McGraw–Hill, 1988

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	20%	-
Level 2	Understand	20%	-	10%	-	20%	-
Level 3	Apply	30%	-	20%	-	30%	-
Level 4	Analyze	30%	-	20%	-	30%	-
Level 5	Evaluate	-	-	20%	-	-	-
Level 6	Create	-	-	20%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	1. Dr. Lima Rose Miranda, Anna University	1. Dr. M.P.Rajesh, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. K.Tamilarasan, SRMIST

Course Code	21CHE353T	Course Name	ENERGY ENGINEERING AND TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recite the various energy resources, challenges in energy production and familiarize the energy audit*
CLR-2:	*detail the thermal power plant working and energy production through MHD system*
CLR-3:	*acquire knowledge of nuclear energy, its potential in energy generation and its challenges*
CLR-4:	*elaborate the energy storage and energy distribution technologies*
CLR-5:	*expose themselves to energy conservation methods and awareness of developing technologies*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the importance of energy and its sources, energy auditing technology*	*2*	-	-	-	-	-	*3*	-	-	-	-	-	*1*	-	-
CO-2:	*explain the power production through thermal energy and MHD system*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*acquire the knowledge of nuclear energy production and various type of nuclear reactors*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*explain the various energy storage methods and its transportation*	*2*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	*3*
CO-5:	*figure out the energy conservation and optimization techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Introduction Energy and Energy Audit ***9 Hour***

A brief history of energy technology, Types of energy, Energy Chains, Energy demand and Supply, Conventional and Non – Conventional energy resources, Energy and environment, Climate change, Global warming, Effects of greenhouse gases, Carbon credit, Applications of carbon credit, Energy Audit (definition & methodology), Duties and responsibilities of Energy Manager; Energy financial management, Energy Audit Instruments.

Unit-2 - Thermal and Magneto Hydrodynamic Energy ***9 Hour***

Electrical and Non-electrical route of energy generation, Thermal power plant, Coal fire thermal power plant, Gas-turbine power plants, Components of Gas-turbine, Open and closed cycle Gas turbine power plant, Gasification types, Integrated Coal Gasification combined cycle power plant, Principles of MHD power, Open and closed Cycle MHD Technologies, Seeded inert gas system, Liquid metal system, Materials for MHD, Applications of MHD, Advantages & Disadvantages of MHD

Unit-3 - Nuclear Energy ***9 Hour***

Basics of nuclear fission and fusion, Concept of binding energy, Nuclear fission reactors, Components of nuclear reactor, Types of fission reactor, Pressurized water reactor, Benefits of nuclear energy, Nuclear fusion principle, D-T fusion reactor, Requirements for nuclear fusion, Ignition temperature, Driven systems and Energy break even condition, Plasma Confinement, Magnetic confinement, Thermo Nuclear Function reactors, Tokamak reactor, Methods of plasma heating, Inertial Confinement Fusion

Unit-4 - Energy Storage Systems ***9 Hour***

Energy storage systems, Mechanical energy storage, Pumped Hydroelectric Storage, Compressed Air storage, Energy storage via Flywheels, Electrical storage, The lead-acid battery, Basic theory of battery, Chemical energy storage: Energy storage via hydrogen, Electro Magnetic Energy storage, Thermal Energy storage: Sensible & Latent Heat storage, Phase change materials in energy storage, Distribution of energy: Gas pipelines, Electricity transmission

Unit-5 - Energy Conservation and Optimization	***9 Hour***
Principles of energy conservation, Co-generation and its types, Waste heat utilization: Heat recovery boiler, Classification of heat exchangers (Recuperator and Regenerator), The Thermal wheel, Heat pumps Operating principles and its applications, Heat pipe principle and its applications. Pinch Technology (Introduction, Basic concepts-ΔT_{min}, Data extraction, targeting) and its elements in energy optimization	

Learning Resources	*1. Rai. G.D. "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 6th edn.,2017.* *2. Rao, S.and Parulakar B.B., Energy Technology, Khanna Publishers, New Delhi, 1994.*	*3. John Andrews and Nick Jelley, Energy Science: Principles, Technologies, and Impacts, 2nd edition, Oxford University Press, 2013.* *4. Thumann, Albert, and D. Paul Mehta. Handbook of energy engineering. River Publishers, 2020.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K.Selvam, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT, Trichy*	*2. Dr. K. Deepa, SRMIST*

Course Code	21CHE354T	**Course Name**	POLYMER TECHNOLOGY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of polymers, polymerization techniques and behavior in polymers*
CLR-2:	*familiarize the various types of thermoplastics, thermosetting and elastomers*
CLR-3:	*acquire knowledge on the polymer processing techniques for polymers, rubbers and fibers*
CLR-4:	*conceive knowledge on various testing methods and characterization of polymers*
CLR-5:	*impart knowledge on specialty polymers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop the knowledge of basics of polymer science, polymerization and properties*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*organize the various types of thermoplastics, thermosetting and elastomers*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*demonstrate the processing methods and techniques of polymers, resins and rubbers*	*2*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the various testing methods and characterization of polymers*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*implement the importance of specialty polymers*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Chemistry, Properties and Polymerization	***9 Hour***
Degree of polymerization - Classification of Polymers - Chemistry of Polymerization –Addition Polymerization - Condensation polymerization- Coordination polymerization- Copolymerization - Molecular weight- Crystallinity in polymers- Solid state properties of polymers: Glassy state, high elastic rubbery state - Polymerization Techniques with reference to industrial manufacture: – Bulk polymerization- Solution polymerization- Suspension polymerization- Emulsion polymerization	
Unit-2 - Thermoplastics, Thermosets and Elastomers	***9 Hour***
Thermoplastic Polymers - Commodity plastics -Polyolefins – Polyethylene-HDPE, LDPE - Polypropylene and vinyl polymers – PVA, PVC - Acrylic polymers – PAN, PMMA– Polystyrene - Engineering plastics- Polyamides-Nylon, Fluoropolymers-PTFE, PVDF, Polyesters – PET, PC, ABS, Thermosetting resins - Phenolic resins - Epoxy resins - Polyurethane resins - Silicone resins- Elastomers - Natural rubber- Synthetic rubbers: Butyl rubber - Styrene Butadiene Rubber - Chloroprene rubber - Nitrile rubber – EPDM	
Unit-3 - Polymer Processing Technology	***9 Hour***
Processing of Thermoplastics and Thermosetting Plastics - Compounding and processing aids - Injection Moulding - Extrusion Moulding - Blow Moulding - Compression Moulding - Transfer Moulding - Rotational Moulding - Processing of Rubbers –Mastication – Calendaring - Reaction Injection Moulding - Solution Casting - Reinforcing: Hand lay-up technique – Filament winding - Spray up technique - Fibre Spinning and drawing – Elastomer Technology – Vulcanization - Rubber processing -Two-roll mill, internal mixer, Softwares in Polymer processing.	
Unit-4 - Characterization and Testing of Polymers	***9 Hour***
Polymer Characterization Tests - Melt Flow Index - Viscosity determination - Thermal Characterization - Thermal Gravimetric Analysis - Differential Scanning Calorimetry - Morphological properties - Scanning Emission Microscopy - Transmission Emission Microscopy - X-ray Diffraction - Physical testing - Mechanical Properties - Tensile Test - Impact Test – Hardness - Electrical properties – Di-Electric strength - Di-Electric Constant - Thermal Properties-Heat deflection temperature - Vicat Softening temperature	

Unit-5 - Specialty Polymers	***9 Hour***
Specialty polymers and its application- Poly-Electrolytes – Ionomers - Conducting Polymers - Luminescent Polymers - Electrically conductive Polymers - Thermoplastic Elastomers - High Temperature Polymers - Polymer Blends - Polymer Composites - Interpenetrating Polymer Networks (IPN) - Liquid Crystalline Polymers - Biomedical Polymers – Polymers for space applications.	

Learning Resources	1. *V R Gowariker, N V Viswanathan, Sreedhar, "Polymer Science", New Age International Publishers, 4th Edition* 2. *Joel R. Fried, "Polymer Science and Technology", Pearson Education, Inc, 3rd Edition* 3. *Fred. W. Billmeyer, "Text book of Polymer Science", 3rd Edition, A Wiley- Interscience publication.*	4. *D.H. Morton and Jones, Polymer Processing, Chapman and Hall, London, 1989.* 5. *Vishu Shah, "Handbook of Plastics Testing Technology", Wiley international publication, 2nd edition, 1998* 6. *Maurice Morton, Rubber Technology, Van Nostrand Reinhold, New York, third Edition, 2002.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*40%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. D. Nanditha, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Deepa, SRMIST*

Course Code	21CHE355T	**Course Name**	INDUSTRIAL POLLUTION PREVENTION AND CONTROL	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize the sustainability concepts and global issues*
CLR-2:	*learn about the environmental regulations an integrated approach*
CLR-3:	*understand the solid waste generation and disposal methods*
CLR-4:	*demonstrate the concepts of water treatment principles and methods*
CLR-5:	*analyze the air pollution and noise pollution control methods*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the major industries that creates pollutants, global issues and its impact on the environment*	-	-	-	-	-	-	*3*	*2*	-	-	-	*1*	-	-	-
CO-2:	*summarize the environmental regulations and policies*	-	-	-	-	-	-	*2*	-	-	-	-	*3*	-	-	*1*
CO-3:	*discuss the sources and processing methods of solid wastes*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*analyze the different water treatment methods and its implementation*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*examine the sources of air pollution and the way to control it*	-	*3*	-	-	-	-	*2*	-	-	-	-	*1*	-	-	-

Unit-1 - Sustainability and Global Issues — *9 Hour*

Industrial activity and environment, industrialization and sustainable development, indicators of sustainability, sustainability strategies, Barriers to sustainability, Pollution prevention in achieving sustainability. Global Effects-Greenhouse effect, Ozone depletion, Global warming, Acid rain.

Unit-2 - Regulations and Integrated Approach — *9 Hour*

Environment policies to control pollution, Environmental Impact assessment, Impact of industries on the environmental pollution, Environment friendly chemical processes, and Case studies on waste management: dairy, fertilizer industries. Integrated waste management policies, Challenges and opportunities associated with waste management in India, Indian waste management market size, Government initiatives towards environmental protection, and Circular economy strategies in waste management.

Unit-3 - Solid Waste Management — *9 Hour*

Sources, types and general disposal methods of solid waste, Waste disposal and management laws and guidelines, Value-extraction from the solid wastes, energy from solid waste. Processing methods: Municipal waste, Biomedical waste, E-waste, plastic waste and nuclear waste.

Unit-4 - Wastewater Treatment — *9 Hour*

Wastewater characteristics, Need of water treatment. Principle, removal mechanism, processing methods of Primary, secondary and tertiary treatments, Need of advanced water treatment, recovery of valuables from effluent. Case studies on water pollution control: pharmaceutical, pulp and paper industries.

Unit-5 - Air Pollution and Noise Pollution Control — *9 Hour*

Sources and types of air pollution, Classification of air pollutants. Air pollution control equipment:Gravity Settlers, Centrifugal Separators, Electrostatic Precipitators (ESP), Bag filters,wet Scrubbers. Dust management, Suspended Particulate matter, Odor Control Systems. Control methods of emissions: SO_x, NO_X, Hydrocarbons, VOC, CO. Noise pollution: Sources, causes, effects and control methods

Learning Resources	1. Bishop.P, "Pollution Prevention: Fundamentals and Practice", McGraw Hill International Edn., McGraw Hill Book Co., Singapore, 2000 2. Pandey.G.N and Carney.G.C, “Environmental Engineering”, Tata McGraw Hill, New Delhi, 2017. 3. Rajaram, V., Siddiqui, F.Z., Agrawal, S.,Khan, M.E., “Solid and Liquid Waste Management Waste to Wealth”, PHI Learning Pvt Ltd, 2016.	4. Rumana Riffat, “Fundamentals of Wastewater Treatment and Engineering”, CRC Press, 2012. 5. Noel de Nevers, “Air Pollution Control Engineering”, 3rd Edition, Kindle Edition, 2016.

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. Paromita Chakraborty, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S.Vishali, SRMIST*

Course Code	21CHE356T	**Course Name**	ENZYME ENGINEERING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the mechanism of enzyme action and learn about the different classes of enzymes*
CLR-2:	*explain the kinetics of enzyme action and compare the types of inhibition*
CLR-3:	*examine the ways of enzyme deactivation and analyze methods of enzyme immobilization*
CLR-4:	*analyze the methods of isolation, purification, and characterization of the enzymes*
CLR-5:	*analyze the various enzymatic reactor configuration and industrial applications of enzymes*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the basic concepts about enzymes, mechanism of enzyme action, and the classification of enzymes*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	*1*	-	-
CO-2:	*identify and estimate the kinetic parameters and type of inhibition using various kinetic plots*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*identify the circumstances of enzyme deactivation and choose the appropriate method of immobilization*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*describe the methods of isolation, purification, and characterization of the enzymes*	*3*	*2*	-	-	-	-	-	-	-	-	-	-		*2*	-
CO-5:	*analyze the characteristics of different enzymatic reactors and their industrial applications*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Action of Enzymes	***9 Hour***
Role and structure of enzymes, Classification of enzymes, Mechanisms of enzyme action, Active site, Holoenzyme, Apoenzyme, Prosthetic group, Models for enzyme-substrate interactions, Lock and key model, Induced fit model, Principles of catalysis, Activation energy, Collision state theory, Transition state theory, Enzyme activity, Turnover number.	
Unit-2 - Kinetics of Enzyme Action and Deactivation	***9 Hour***
Kinetics of single substrate reactions, Michaelis- Menten equation, Estimation of Michaelis-Menten parameters using Lineweaver-Burk plots, Mechanisms of multi-substrate reactions, Inhibitors, Types of inhibition mechanisms, Competitive inhibition, Uncompetitive inhibition, Non-competitive inhibition, Substrate and product inhibition, Allosteric regulation of enzymes, Concerted and sequential model.	
Unit-3 - Enzyme Deactivation Kinetics and Immobilization Techniques	***9 Hour***
Effect of pH, Effect of temperature, Deactivation models and kinetics, Mechanical forces acting on enzymes, Strategies for enzyme stabilization, Introduction to immobilization, Types of immobilization, Adsorption, Matrix entrapment, Encapsulation, Cross linking, Covalent binding, Advantages and disadvantages of different immobilization techniques, Immobilization enzyme kinetics, Effects of external mass-transfer resistance, Analysis of intraparticle diffusion and reaction, Simultaneous film and intraparticle mass-transfer resistances.	
Unit-4 - Isolation and Purification of Enzymes	***9 Hour***
Isolation and extraction of enzymes from various sources and locations in cell, Purification of Enzymes: chromatography and electrophoresis, Characterization of enzymes, Criteria of Purity, Units of enzyme activity, Enzyme assays, Fermentation of ethanol, Case study for isolation, purification, characterization and application of any one enzyme (Research paper).	
Unit-5 - Enzymatic Reactors and applications of Enzymes	***9 Hour***
Enzymatic reactors – Stirred tank reactors, Packed bed reactors, Fluidized bed reactors, Membrane reactors, Enzyme electrodes as enzyme biosensors, Applications of enzymes in industries - food, beverage, leather, detergents, pharmaceuticals, diagnostics, therapeutics	

Learning Resources	1. *Palmer, Trevor "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry", Woodhead Publishing, 2nd Edition, 2007.* 2. *Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals" 2nd Edition, McGraw–Hill, 1986.*	3. *Michael L.Shuler and Fikret Kargi, "Bioprocess Engineering Basic concepts", Prentice Hall, 2nd Edition, 2002.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Tamilarasan, SRMIST*

Course Code	21CHE357T	Course Name	FERTILIZER TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the importance of fertilizers and growth potential of fertilizer Industries*
CLR-2:	*learn the various nitrogen fertilizers production processes*
CLR-3:	*familiarize the different phosphate fertilizers and its manufacturing processes*
CLR-4:	*understand the Importance of compound fertilizers and production processes*
CLR-5:	*learn the process flow diagram of biofertilizers and Environmental issues from fertilizer industry*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the chronological development of fertilizer industry*	*1*	-	*2*	-	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-2:	*recognize the raw materials and processes for manufacture of nitrogenous fertilizers*	*2*	-	*2*	-	-	-	*2*	-	-	-	-	-	*2*	-	-
CO-3:	*understand the block diagram of phosphate fertilizers*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*review the flow diagrams of potassium and compound fertilizers*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*develop the process for bio fertilizers production*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Soil Nutrients ***9 Hour***

Overview of plant nutrients, Functions of nutrients, Classification of soil nutrients-macro and micro nutrient, Fundamentals of soil nitrogen, Fundamentals of soil Phosphorus, Fundamentals of soil potassium, Need of fertilizer, Classification of fertilizers, Growth of fertilizer Industry in India, Location of fertilizer Industry in India, Soil nutrient testing and analysis, Types of soil tests: Nutrients, Salinity, acidity Test.

Unit-2 - Nitrogen Fertilizer ***9 Hour***

Ammonia- -physical and chemical properties, Ammonia production and applications; Urea- physical and chemical properties, Manufacture of urea, Granulation Methods-Wet and dry Granulation; Nitric acid-chemical and physical properties, applications, Manufacture of nitric acid; Other nitrogen fertilizers Ammonium chloride, Ammonium sulphate and Ammonium nitrate- manufacturing process and calcium ammonium nitrate (CAN)

Unit-3 - Phosphate Fertilizers ***9 Hour***

Importance of phosphate fertilizers, Classification of phosphate fertilizers, Phosphoric acid: Raw materials selection- production methods- dihydrate process, hemihydrate and dihemi hydrate process; Mono ammonium phosphate: physical and chemical properties and production process; Diammonium phosphate: physical and chemical properties and production process; Production process for SSP, TSP and Nitro phosphates fertilizers.

Unit-4 - Potash Fertilizers ***9 Hour***

Overview of potash fertilizers, Types of potash fertilizers, Selection of raw materials for manufacture of potassium chloride, Potassium nitrate, and potassium sulphate, Manufacture of complex and mixed fertilizers; Water soluble fertilizers- Types of water-soluble fertilizers

Unit-5 - Environmental Issues and Biofertilizers ***9 Hour***

Importance of Bio fertilizers, Types of bio fertilizers: Bacterial Biofertilizers, Algal Biofertilizers and Fungal Biofertilizers, Production technology: Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid biofertiizers, Bio compost making- types, method of vermicomposting , Environmental issues related to the use of fertilizers, Soil, water and air Pollution from fertilizer industry

Learning Resources	1. *GopalaRao. M. and Marshall Sittig, “Dryden's Outlines of Chemical Technology”, 3rd Edn., East- West Press, New Delhi, 2008* 2. *George. T Austin, “Shreve's Chemical Process Industries”, 5th Edn., 5th Reprint, McGraw-Hill International Editions, Singapore, 2015.*	3. *Hand book of Fertilizer Association of India, New Delhi, 1998* 4. *Slack A.V., Chemistry & Technology of Fertilizers, Interscience, New York, 1967* 5. *A.M. Deshmukh R.M. Khobragade P.P. Dixit,Hand book of Biofertilizers and Biopesticides, Oxford Book Company,2007*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai*	1. *Dr. Lima Rose Miranda, Anna University, Chennai*	1. *Dr. K. Tamilarasan, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Selvam, SRMIST*

Course Code	21CHE358T	**Course Name**	PETROLEUM TECHNOLOGY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the formation and evaluation of crude oil, overview of petroleum refining processes, latest trends in petroleum engineering*
CLR-2:	*explain the evaluation and testing, properties, petroleum refining processes, distillation*
CLR-3:	*explain the thermal and catalytic cracking, treatment techniques*
CLR-4:	*describe the production of fuels, lubricating oil, storage and transportation, enhanced oil recovery techniques*
CLR-5:	*describe the production of olefin gases, intermediates compounds and important petrochemicals, health safety and environment in petroleum industry*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compile the overview of petroleum refining processes*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*define the thermal properties of petroleum fractions*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*incorporate the conversion of petroleum, hydrodesulphurization*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*express the fuel, storage, transportation and oil recovery*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*demonstrate the flow sheets of important petrochemicals, health, safety, environment and instrumentation and control in a refinery*	*2*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*

Unit-1 - Crude Classification ***9 Hour***

Origin of crude, formation theories, migration of crude, accumulation of petroleum, types of crude, crude classification, general processing of crude and coal bed methane, shale gas, oil shale, gas hydrate, and heavy oil.

Unit-2 - Thermal Properties ***9 Hour***

Octane number, cetane number, diesel index, their determination and importance, evaluation of crude oil, testing of petroleum products, physical properties, thermal properties, properties of petroleum fractions, petroleum refining processes, atmospheric distillation of crude, vacuum distillations.

Unit-3 - Cracking ***9 Hour***

Thermal cracking, catalytic cracking, reforming process, catalytical hydro cracking, hydro processing, removal of sulphur compounds, reforming and isomerization alkylation and polymerization, product blending.

Unit-4 - Refinery Products ***9 Hour***

Refinery products, properties, lubricating oil manufacture, petroleum waxes and asphalts, storage of petroleum products, transportation of petroleum products, road, rail, importance of pipeline transportation.

Unit-5 - Petrochemicals ***9 Hour***

Petro chemicals flow sheets, health hazards in petroleum industry safety system, environment concepts, impact on eco-system, air, water and soil, environmental transport of petroleum wastes, offshore environmental studies, offshore oil spill and oil spill control, waste treatment methods, instrumentation and control in a refinery.

Learning Resources		
Learning Resources	*1. W. L. Nelson, Petroleum Refinery Engineering, 4th Edition, McGraw Hill, New York, 1958.* *2. B. K. Bhaskara Rao, Modern Petroleum Refining processes, 5th Edition, Oxford and IBH Publishing Co. Pvt. Ltd., 2008.*	*3. J.H. Gary and G. E. Handwerk, Petroleum Refining: Technology and Economics, , 4th Edition, Marcel Dekkar, Inc., New York, 2001.* *4. John C. Reis, Environmental Control in Petroleum Engineering, Gulf Publishing Company, 1996.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*20%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*30%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. K. Anbalagan, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Kiruthika, SRMIST*

Course Code	21CHE359T	**Course Name**	PRINCIPLES OF MEMBRANE SEPARATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the details about membranes and its applications*
CLR-2:	*understand the concepts about pressure driven membrane processes*
CLR-3:	*understand the process features and design philosophy of Sea Water Reverse Osmosis desalination*
CLR-4:	*understand the membrane processes driven by electrical and concentration gradients*
CLR-5:	*impart knowledge on Environment Impact Assessment and setting up a desalination plant*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the different types of membranes, their preparation methods and characterization techniques*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*analyze the difference between various pressure driven membrane processes*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*familiarize the design methodology for desalination of seawater & brackish water*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*familiarize the applications and limitations of other membrane processes*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*familiarize with a knowledge to prepare detailed project report of desalination plant*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Introduction to Membrane Separation Process	***9 Hour***
Introduction to membrane and membrane processes – membrane types and classification – advantages & limitations of membrane processes over conventional processes. Membrane preparation and characterization. Configuration of membranes into different modules and their relative characteristics. Classification of membrane processes. Osmosis, osmotic pressure and osmotic equilibrium. Solution properties and their relevance to membrane processes. Basic thermodynamic concepts for estimating minimum energy for membrane separation - concept of exergy & its application.	
Unit-2 - Pressure Driven Membrane Separation Processes	***9 Hour***
Pressure driven membrane processes – classification based on pore-size – differentiating characteristics – Terminologies used in pressure driven membrane processes. Microfiltration (MF) and Ultrafiltration (UF): Separation mechanism and operating features. Performance parameters - flux equation. Nanofiltration (NF) and Reverse osmosis (RO). Nature of membranes used – distinguishing features - Transport mechanism - operating mechanisms. Concept of concentration polarization and its effect in NF and RO. Effect of operating variables on membrane performance for both NF & RO. Laboratory experiments using single element to collect design data. Applications of MF - UF – NF – RO in different industries	
Unit-3 - Sea Water Reverse Osmosis Desalination	***9 Hour***
Desalination - basics of desalination technology – natural desalination processes – Brackish and seawater desalination. Seawater intake location. Composition of feed water and its impact on fouling & scaling. Pretreatment- use of UF and its advantages-quality monitoring. Terminologies – Concept of stages and passing. Effect of series / parallel arrangement on performance. High-pressure pumps –Energy recovery devices. Cost elements and costing of RO water. SWRO desalination – front end (source – pretreatment-HPP- ERD- module design and arrangement) – back end (post treatment – reject disposal)	
Unit-4 - Electro membrane processes and other processes	***9 Hour***
Electrically driven membrane processes for desalination and water purification: Electrodialysis –Limitations – energy consumption. Electro -de-ionization (EDI), Capacitive de-ionization (CDI), Bipolar electrodialysis (BPED). Electro Electrodialysis (EED), Membrane processes under development for desalination: Forward Osmosis, Membrane Distillation –coupling RO and FO, Pressure retarded osmosis – Application of membranes for azeotrope separation – pervaporation. Biomedical application for membrane process - Dialysis.	

Unit-5 - Environmental Impact Assessment	***9 Hour***
Environmental Impact Assessment (EIA) of SWRO plants: Once through / Recycle mode of operation. Economic aspects of SWRO plants - cost of water – lifecycle cost as well as OPEX + CAPEX evaluations-reject disposal. Design of remote area and industrial RO Plants – sustainability, acceptability, and affordability - elements of DPR.	

Learning Resources	*1. H.T. El-Dessouky, H.M.Ettouney, Fundamentals of salt water Desalination, Elsevier 2002* *2. Peter Marcel Mulder: Basic Principles of Membrane Technology Springer (India)Private Ltd. NewDelhi (2007) ISBN978-81-8128-683-3*	*3. W.S. Winston HO and K.K. Sirkar (Ed):Membrane Hand Book VonNostrand Reinhold(1992)* *4. Kaushik Nath Membrane Separation Processes PHI learning Pvt. Ltd. (2016) ISBN10:8120352912*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. S. Prabhakar, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. E. Poonguzhali, SRMIST*

							L	T	P	C
Course Code	21CHE360T	**Course Name**	SAFETY AND HAZARD ANALYSIS IN PROCESS INDUSTRIES	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*achieve an understanding of principles of safety management*
CLR-2:	*teach the principles of safety applicable to the operation of chemical process plants*
CLR-3:	*understand the various aspects of industrial accidents and fire safety*
CLR-4:	*familiarize the student with various types of Hazard Identification techniques*
CLR-5:	*teach the significance of occupational health and industrial hygiene*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the importance and basic principles of safety management*	2	-	-	-	-	-	-	-	-	-	-	1	-	-	3
CO-2:	*describe the safety aspects of chemical process industries*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the methods of prevention of industrial accidents and learn the fire safety*	-	1	-	-	-	-	-	-	-	-	-	3	-	2	-
CO-4:	*familiarize the student with various types of Hazard Identification techniques*	1	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*identify the components needed to provide a safe and healthful work environment and to gain insight into the laws relating to industries*	-	-	2	-	-	-	-	-	-	-	-	1	-	-	3

Unit-1 - Industrial Safety Management	**9 Hour**
Introduction- Safety- Goals of safety engineering. Need for safety. Industrial accidents- case studies - Safety organization- objectives, types, functions, elements, Safety policy. Role of management, supervisors, workmen. Safety Officer responsibilities, authority. Safety committee- needs, types, advantages, Safety Education & Training-Importance, Various training methods, Communication- purpose, barrier to communication	
Unit-2 - Chemical Plant Safety	**9 Hour**
Chemical hazards-types- Routes of entry into human body - Toxic effects of chemicals , PEL, TLV, LC 50 and LD 50 & Toxicology; Dose Vs. Response Relationship - Siting and Layout of a Chemical plant, Designing process layout – CRAFT, ALDEP, Chemical process in hazardous operations – Chemical reactors- reaction hazards and control -case studies, Boiling Liquid expanding vapour explosion - operational deviations - case studies– Hazardous chemicals - Classification and Transportation – Storage – Ammonia, chlorine and LPG, Handling - Safe guarding of Machines – Ergonomics - Emergency Evacuation plan	
Unit-3 - Accident Prevention and Fire Safety	**9 Hour**
Accident, Injury, Unsafe act, Unsafe Condition, Theories of accident causation. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate, Safe T-Score. Cost of accidents - Computation of Costs- Utility of Cost data. Plant safety inspection, types, inspection procedure. Job safety analysis (JSA), Safety surveys, and Safety audits. Fire triangle- Classification of fires, Common causes of industrial fires, Fire protection systems- prevention-Case Studies	
Unit-4 - Hazard Identification Techniques	**9 Hour**
Hazard and risk, Types of hazards - fire, explosion and toxic gas release, Structure of hazard identification and risk assessment. Hazard Identification Techniques- HAZID, Hazard and Operability study (HAZOP), Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, The Mond Index, Plant layout and unit hazard rating, Preliminary hazard analysis, Failure mode and Effect Analysis (FMEA), Fault Tree Analysis, Cause and Effect Analysis in process industries.	

Unit-5 - Industrial Hygiene and Occupational Safety	***9 Hour***
Concepts - Industrial and Occupational health hazards, Housekeeping, Personal protective equipment – Head protection – Eye and face protection- Hand protection – Foot and leg protection -Body protection – Respirators – Safety unions, government and voluntary agencies -OSHA, ILO, NEPA in safety. Safety legislation in India, Factories act, Trade Union act, Worker's compensation act -Indian boilers act, Indian explosives act and rules, Mines act, Petroleum act and rules, Environmental protection act	

Learning Resources	*1. Sharma. A M., "Safety and Health in Industry" -A Hand book, BSPublications, 2019.* *2. Fulekar. M.H, "Industrial Hygiene and Chemical Safety", Dreamtech Press, 2020.* *3. Fawcett .H.H, and Wood W.S,,"Safety and Accident Prevention in Chemical Operations", John Wiley & sons, U.S.A.,1965.* *4. Willie Hammer, Dennis Price, "Occupational safety management and Engineering", Prentice Hall, 2001.*	*5. William Handley, "Industrial safety hand book", McGraw- Hill, 1969.* *6. Daniel. A, Crowl and Joseph. F.Louvar,"Chemical Process safety: fundamentals with applications", Prentice Hall international series, 2020.* *7. Geoff Wells, "Hazard Identification and Risk Assessment",1997.* *8. Francis, R.L. and White, J.A, "Facilities layout and Location", Prentice Hall of India, 2002.* *9. James A. Klein, Bruce K. Vaughen, "Process Safety Key Concepts and Practical approaches", CRC press, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. D. Nanditha, SRMIST*
2. Mr. S. Ravichandran, Assistant General Manager, SPIC	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Selvam, SRMIST*

Course Code	21CHE361T	**Course Name**	FUNDAMENTALS OF DESALINATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the importance of desalination technologies towards fulfilling societal needs*
CLR-2:	*provide the basic concepts and design requirements of different thermal desalination technologies*
CLR-3:	*understand the nature and behavior of various membrane process used for desalination*
CLR-4:	*understand the process features and design philosophy of Reverse Osmosis desalination*
CLR-5:	*impart knowledge for setting up a desalination plant*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recognize need for desalination technologies in global context and India*	-	*3*	-	-	-	*2*	-	-	-	-	-	-	*1*	-	-
CO-2:	*demonstrate the working principle of various thermal desalination devices*	-	*1*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*familiarize the working principle of various membrane desalination technologie*	-		*2*	-	-	-	*3*	-	-	-	-	-	*1*	-	-
CO-4:	*summarize the design concepts of RO membrane process for desalination of seawater*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*familiarize with a knowledge to prepare detailed project report of desalination plant*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Fundamentals of Desalination	***9 Hour***
Statistical information on the availability of resources and current demand in different sectors; Desalination process –Natural desalination processes; Types of desalination processes and classification, Specific characteristics in terms of resources, and product quality; Minimum thermodynamic energy; specific energy requirements for desalination; Concept of exergy and its application to desalination processes; Sources, quality, composition of seawater and feed sourcing; Colligative properties and their relevance to desalination processes.	
Unit-2 - Thermal Desalination Technologies for Seawater	***9 Hour***
Seawater desalination technologies – Classification – location of seawater intake - seawater chemistry with respect to scaling potential– behavior of calcium sulphate and carbonate scales– inverse solubility – Corrosion - Selection of material of construction; pretreatment requirement; limitation of maximum seawater temperature. Basic heat transfer properties of steam and water – unsaturated/saturated/super-heated steam; Flashing and boiling; Sensible and latent heat; Performance and energetics of thermal desalination plants - concept of stages and effects in thermal processes. Thermal desalination process: Multi Stage Flash, Multi effect desalination, Mechanical Vapour Compression, Thermo Vapour Compression. Jet ejectors and Vacuum pumps	
Unit-3 - Membrane Based Desalination Technologies for Seawater	***9 Hour***
Classification of membrane process – relative characteristics. Electro-dialysis - operational aspects - current efficiency – polarization – limitations. Membrane distillation - principle of operation – membrane requirements – membrane configuration –characteristics. Forward Osmosis -principle of operation– membrane requirements – draw solute characteristics	
Unit-4 - Seawater Reverse Osmosis Desalination Technology	***9 Hour***
Reverse osmosis – principle of operation – membrane requirements – membrane configuration –characteristics. Basic terminologies used in membrane processes -Effect of operational parameters on RO performance. Osmotic pressure; Selection of module configuration- Concept of staging and passing; Brackish and seawater desalination, Pretreatment of seawater, objectives and methods; Monitoring of feed water quality after pretreatment; High pressure pumps & Energy recovery devices; Design of RO system - equations – criteria for number of elements in series – estimation of product rate and concentration – use of commercial software; Post treatment; Criterion for designing RO for inland, remote area and industrial waste water. Cleaning of membrane elements.	

Unit-5 - Process Control and Cost Elements in Desalination	***9 Hour***
Control & Instrumentation in Desalination Plants: DCS, PLC, sensors for temperature, pressure (Sub and higher atmospheric) and flow. Cost elements of various desalination technologies; Relative comparison of desalination technologies: Resources requirement - type of energy required - scale of operation – pretreatment - operation & maintenance – economics - limitations and logistics. Detailed Project Report – Preparation - purpose and intent. Preceding events and post requirements.	

Learning Resources	*1. H.T. El-Dessouky, H.M. Ettouney, Fundamentals of salt water Desalination, Elsevier 2002*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. S. Prabhakar, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. E. Poonguzhali, SRMIST*

Course Code	21CHE362T	Course Name	AIR POLLUTION CONTROL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the effect of pollution on human health and the necessity to control the pollutants*
CLR-2:	*familiarize the methods to measure the concentration of the pollutants by models and experiments*
CLR-3:	*categorize the air pollution control devices based on the pollutants*
CLR-4:	*control the emission of Oxides of Sulphur, Nitrogen*
CLR-5:	*analyze the global issues, noise pollution and application of software*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the sources of air pollution and its impact on human health*	-	-	-	-	-	-	3	-	-	-	-	1	-	-	2
CO-2:	*discuss the measurement of pollutant concentration and prediction models*	2	1	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*select the air pollution control devices based on the requirement*	3		2	-	-	-	-	-	-	-	-	-	-	-	1
CO-4:	*analyze the methodologies to control the sulfur and nitrogen emissions*	3	2	-	-	-	-	1	-	-	-	-	-	-	-	-
CO-5:	*infer the impact of global issues on environment and application of software in pollution prevention*	-	-	-	-	2	-	-	-	-	-	-	1	-	-	3

Unit-1 - Air Pollutants and Regulations	***9 Hour***
History of Air pollution and episodes, Sources of air pollution and types, Air pollution: composition and structure of atmosphere, global implications of air pollution. Classification of air pollutants: suspended particulate matter, hydrocarbon, carbon monoxide, oxides of sulphur, oxides of nitrogen and photochemical oxidants. Indoor air pollution. Dust management, Effects of air pollutants on humans, animals, property and plants. Air pollution laws and regulations, Effect on property, visibility. Air pollution control Philosophies.	
Unit-2 - Air Pollutant Concentration	***9 Hour***
Ambient Air Quality and Emission standards. Air pollution measurements, Sample collection methods, Concentration determination, Averaging, Standard Analytical Methods of Particulate and Gaseous Pollutants. Meteorology for Air pollution Control Engineers: Horizontal Atmospheric motion, Vertical Atmospheric Motion, Wind velocity and direction, Temperature Inversions, Fumigations, Stagnations, Air pollutant Concentration Models: Fixed–Box Models, Diffusion Model, Long Term Average Uses of Gaussian Plume Models, Multiple Cell Models, Receptor-Oriented and Source-Oriented Air Pollution Models	
Unit-3 - Control Equipments	***9 Hour***
Air pollution control equipment: Wall Collection devices- Gravity Settlers, Centrifugal Separators, Electrostatic Precipitators (ESP),Dividing Collection Devices- Surface Filters, Depth Filters, Filter Media, wet Scrubbers. Design calculations. Odor Control Systems. General ideas in Air Pollution Control	
Unit-4 - Unit Operations and Emission Control	***9 Hour***
Role of unit operations on the control of gaseous contaminants: Absorption, Adsorption, Condensation. Control methods of emissions: SOx, NO_x, Hydrocarbons, VOC, CO.	
Unit-5 - Global Issues and Noise Pollution	***9 Hour***
Global Effects-Greenhouse effect, Ozone depletion, Global warming, Acid rain, Heat Island, dust storms, climate change. Automobile pollution sources and legislation for control, Photochemical smog, Future engines and fuels. Application of Artificial intelligence in air pollution control and monitoring. Noise pollution: Sources, causes, effects and control methods	

Learning Resources	1. *Noel de Nevers, "Air Pollution Control Engineering", 3rd Edition, Kindle Edition, 2016.* 2. *Rajni Khant, Keshav Khant, "Air pollution and control", Khanna Book Publishing Pvt. Ltd., 2018.*	3. *Bhatia, S.C., "Textbook Of Air Pollution and Its Control", Atlantic Publishers & Distributors (P) Ltd., 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	30%	-	30%	-	30%	-
Level 2	*Understand*	30%	-	30%	-	30%	-
Level 3	*Apply*	20%	-	20%	-	20%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd., Chennai*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. Paromita Chakraborty, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S.Vishali, SRMIST*

Course Code	21CHE363T	**Course Name**	WASTEWATER TREATMENT	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various water pollutants*
CLR-2:	*familiarize the primary treatment methods*
CLR-3:	*categorize the types of secondary treatment methods*
CLR-4:	*apply the unit operations and processes used in the advanced treatment of waste water*
CLR-5:	*demonstrate the water treatment methods for various industries*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the various water pollutants*	*1*	*2*		-	-	-	-	-	-	-	-	*3*	-	-	-
CO-2:	*recall the available primary treatment methods*	*1*	-	*2*	-	-	-	*3*	-	-	-	-	-	-	-	-
CO-3:	*differentiate the various secondary treatment methods*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*know the need of advanced water treatment process*	-	*2*	*1*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*develop the treatment unit for various industries*	-	*1*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Wastewater and Water Pollutants	***9 Hour***
Sources and types of wastewaters, need for water treatment, water management and recycling. Types of water pollutants, Wastewater analysis, Determination of organic content: BOD, COD, DO, Determination of in organic content, carbonate ions, alkalinity, TSS, TDS, physical characteristics and bacteriological measurements. Central Pollution Control Board guidelines. Environmental regulations.	
Unit-2 - Primary Treatment	***9 Hour***
Preliminary treatment process, principles and its need: Screening, Comminution, grit removal *Primary treatment: - screens filters process, gravity settling process, oil skimmer, flow equalization, flotation, coagulation, adsorption, settling. Physical and chemical methods involved in primary treatment.*	
Unit-3 - Secondary Treatment	***9 Hour***
Principle, mechanism and need of Secondary treatment. High-rate processes: Activated sludge processes, Trickling filters, Rotating biological contractors, Fluidized-bed-reactors, Attached growth aerobic processes. Low-rate processes: Waste Stabilization Ponds, wetland treatment, Macrophyte, Nutrient Film Technique. Handling and disposal of sludge.	
Unit-4 - Tertiary and Advanced Treatment	***9 Hour***
Need and types of the advanced wastewater Treatment, Ion exchange treatment process, Electrodialysis process, Removal of nitrogen, phosphorous, colour and odour from water. Membrane treatment: MF, RO, UF and NF. Disinfection: chlorination process, UV-treatment. Value recovery methods and need Wealth from waste, Regulations for treatment ALARA concept, Zero Liquid Discharge.	
Unit-5 - Industrial Approach	***9 Hour***
Water treatment in chemical processes industries-Pulp and paper, fertilizer, tannery, pharmaceutical, textile. Treatment of Raw water, cooling water and boiler feed water, Challenges involved in trace contaminant removal. Integrated water treatment system, Recycling concept, Circular economy.	

Learning Resources	1. *Metcalf and Eddy, "Wastewater Engineering", 4th ed., McGraw Hill Higher Edu., 2017.* 2. *W. Wesley Eckenfelder, Jr., "Industrial Water Pollution Control", 2nd Edn., McGraw Hill Inc., 1989.* 3. *C.S. Rao, "Environmental Pollution Control Engineering", 4th Ed., New Age International, 2021*	4. *Eldridge, E.F, "Industrial Waste Treatment Practice", Hassell Street Press, 2021.* 5. *Berne, F., Jean, C., "Industrial Water Treatment" Editions Technip, 1994*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	30%	-	30%	-	30%	-
Level 2	*Understand*	40%	-	40%	-	40%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. S. Prabhakar, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S.Vishali, SRMIST*

Course Code	21CHE364T	Course Name	CHEMICAL PROCESS OPTIMIZATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*summarize the necessities and concepts of optimization*
CLR-2:	*describe the methods for optimizing one variable functions*
CLR-3:	*explain the optimization techniques for multivariable functions*
CLR-4:	*determine optimum for linear programming and specialty optimization problems*
CLR-5:	*formulate optimization strategies for real time chemical processes*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss optimization problems and formulate objective function*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*interpret optimized condition for single variable function*	2	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	*apply methods for multivariable function optimization*	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*analyze optimized condition for linear programming problem*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*evaluate the optimum condition for industrial chemical processes*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Introduction to Optimization and Developing Models	***9 Hour***
Need for optimization, Scope and Hierarchy of Optimization, essential features of optimization problems, steps to solve optimization problems, obstacles to optimization, Classification of Optimization Problems, examples of applications of Optimization, Formulation of Optimization Problem - Optimization of liquid storage tank, optimal scheduling of production in process plants, classification of models, phases of model building and various mathematical forms of models, Fitting models by Least Squares, degrees of freedom and its analysis in model. Curve fitting problems and optimization problems solving.	
Unit-2 - Optimization of Unconstrained Functions: One-Dimensional Search	***9 Hour***
*Introduction to single variable function, **U**nimodal and multimodal functions, criteria for optimization of single variable function, stationary points and their classification, Numerical Methods for Optimizing a Function of One Variable -Scanning and Bracketing Procedure, Newton method, Quasi – Newton method and finite difference method, polynomial approximation methods: quadratic interpolation and cubic interpolation, region elimination method - Fibonacci method, Golden section method, problems for optimizing single variable function by various methods.*	
Unit-3 - Unconstrained Multivariable Optimization	***9 Hour***
multivariable function concepts and properties, Hessian matrix, Eigen values - definition and applications, interpretation of objective function in terms of its quadratic approximation, Multivariable functions – unimodal and multimodal concepts, saddle surface and saddle point characteristics, Necessary and sufficient conditions for an extremum of an unconstrained multivariable function, methods for unconstrained Multivariable Optimization: Random search, Grid search, univariate search, Simplex search method, Nelder – Mead method, Hooke – Jeeves procedure. Methods using first derivatives: steepest descent method (Cauchy method), conjugate gradient method (Fletcher and Reeves method), Newton's method and Quasi – Newton method. Problems solving for optimizing multivariable functions. Lagrange multiplier method for constrained functions.	
Unit-4 - Linear Programming Method and Non – Linear Programming Method with Constraints	***9 Hour***
Linear Programming (LP) method and applications, geometrical meaning of linear programs, Standard form for linear programs, basic linear programming definitions, equivalent systems and elementary operations, pivoting and use of pivot operations, Simplex algorithm for LP problems, graphical solution for LP problems, geometric programming method, dynamic programming method, quadratic programming method and integer programming method for optimization. Branch-and-Bound method, Problems for formulating and solving LP.	

Unit-5 - Optimization Applications in Chemical Process and Large – Scale Plant Design	***9 Hour***
Optimization of chemical engineering systems, heat transfer and energy conservation, optimizing recovery of waste heat, optimal design of distillation column, calculation of optimal pipe diameter and minimum work of compression, modeling, classification and objective function of reactors, optimization in large scale plants, Process Simulators and optimization codes, optimization using equation-based process simulators and using modular-based simulators. Introduction to multi objective optimization and genetic algorithm method.	

Learning Resources	1. *Edgar, Himmelblau, Lasdon, Optimization of Chemical Processes, 2nd edition, McGraw – Hill publishing company, 2001.* 2. *Suman Dutta, Optimization in Chemical Engineering, 1st edition, Cambridge University Press, 2016.*	3. *Singiresu S. Rao, Engineering Optimization: Theory and Practice, 4th edition, John Wiley & Sons, Inc., 2009.* 4. *A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization: Methods and Applications, 2nd edition, John Wiley & Sons, Inc., 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	20%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Professor, Anna University*	1. *Dr. M. Magesh Kumar, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S. Vishali, SRMIST*

Course Code	21CHE365T	Course Name	EQUILIBRIUM STAGE OPERATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain special methods of distillation*
CLR-2:	*describe multicomponent distillation*
CLR-3:	*describe the characteristics of various commercial extractors*
CLR-4:	*demonstrate leaching operations and their design*
CLR-5:	*explain the principles of adsorption*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design distillation column using Ponchon Savarit method*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*estimate bubble and dewpoint in multicomponent systems*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*analyze and select appropriate extractor for suitable applications*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*design cross current and counter current solid liquid extractors*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*design a fixed bed adsorber*	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Distillation ***9 Hour***

Review of Distillation - Ponchon - Savarit method, Comparison between McCabe Thiele method and Ponchon -Savarit method, Continuous contact distillation - packed tower distillation, low pressure distillation, Use of open steam in binary distillation, use of reflux below its bubble point, multiple feed or product withdrawal, Azeotropic distillation, Extractive distillation, Selection of Entrainer and solvent, Comparison between Azeotropic Distillation and Extractive Distillation, Reactive Distillation, Membrane Distillation.

Unit-2 - Multicomponent Distillation ***9 Hour***

Introduction to multicomponent distillation, Estimation of bubble point and dew point in multicomponent systems, multicomponent flash distillation, batch distillation of a multi component mixture. Multistage batch distillation with reflux - constant and variable reflux.

Unit-3 - Liquid - Liquid Extraction ***9 Hour***

Review of liquid – liquid extraction, Classification of commercial extractors and their characteristics, selection of extractors. Design of extractor, stage wise extraction with reflux. Hydrodynamics and mass transfer in a stirred liquid - liquid dispersion.

Unit-4 - Solid - Liquid Extraction ***9 Hour***

Review of Solid – liquid extraction. Design of extractors – batch contact, cross current contact, counter current contact. Analytical determination of the number of stages for constant underflow. Super critical fluid extraction.

Unit-5 - Adsorption ***9 Hour***

Review of Adsorption. Physisorption and chemisorption. Single stage operation, multistage cross current operation, optimization of two stage cross current operation, multistage counter current adsorption, optimization of two stage counter current operation. Batch adsorption in a stirred vessel, adsorption in a fixed bed, Mass transfer Zone (MTZ) and breakthrough, equilibrium time, stoichiometric front, length of unused bed (LUB), stoichiometric time, Design calculation using LUB, Adsorption equipment.

Learning Resources	1. *Binay K. Dutta, "Principles of Mass transfer and Separation Processes", Prentice- Hall of India, New Delhi, 2016.* 2. *Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4th Edn., Pearson India Education Services Pvt. Ltd., 2015.* 3. *J. D. Seader, Ernest J. Henley, D. Keith Roper, "Separation Process Principles: Chemical and Biochemical Operations", 3rd Edn., 2011*	4. *Robert E. Treybal, "Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012.* 5. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2022.* 6. *N. Anantharaman and K. M. Meera Sheriffa Begum, "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd., New Delhi, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-		-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	1. Dr. Lima Rose Miranda, Professor, Anna University	1. Dr. E. Poonguzhali, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. E. Kavitha, SRMIST

Course Code	21CHE366T	Course Name	COMPUTATIONAL FLUID DYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*introduce the basics and application of CFD*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*introduce various models to describe turbulence flow*															
CLR-3:	*demonstrate the discretization techniques for solving steady and unsteady flow conservation equations*															
CLR-4:	*demonstrate the discretization schemes and unsteady state flow conservation equation solving using finite volume method*															
CLR-5:	*introduce solution of discretized equations and solution algorithm for pressure-velocity coupling in steady flows and CFD modelling of combustion*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*acknowledge the capability and the application of CFD methods in solving conservation equations*	-	3	-	-	3	-	-	-	-	-	-	-	-	2	-
CO-2:	*distinguish various models to describe turbulence flow*	-	3	-	-	3	-	-	-	-	-	-	-	-	2	-
CO-3:	*apply finite volume method and various discretize techniques to solve the steady and unsteady flow conservation equation*	-	3	-	3	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*identify various discretization schemes and to obtain solutions of unsteady state flow conservation equation using finite volume method*	-	3	-	3	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*obtain solutions of discretized equation and to exercise solution algorithm for pressure-velocity coupling in steady flows*	-	3	-	3	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Introduction to CFD and Transport Equations	***9 Hour***
Introduction to CFD – Applications - CFD solution strategies - Types of models in CFD - CFD solution procedure – Implementation of Boundary conditions - Types of mesh - mesh quality parameters - Solver settings – Errors and Uncertainty in CFD modelling - Differential and integral forms of the general transport equations - Classification of fluid flow equations - Auxiliary conditions for viscous fluid flow equations	
Unit-2 - Turbulence Modelling	***9 Hour***
Turbulence flow: Reynolds-averaged Navier–Stokes equations and classical turbulence models - Mixing length model, the k–å model, Reynolds stress equation models.	
Unit-3 - Discretization Techniques: Steady and Unsteady Flows	***9 Hour***
Types of PDEs - Solution using various discretization scheme - Finite volume method for steady state, one-dimensional transport equation. Discretization Schemes for steady flows: central differencing scheme, upwind differencing scheme, hybrid differencing scheme, power-law scheme, Quadratic upwind differencing scheme: the QUICK scheme	
Unit-4 - Properties of Discretization Schemes and Finite Volume Method for Unsteady Flows	***9 Hour***
Properties of discretization schemes: Conservativeness, Boundedness, Transportiveness. Assessment of discretization schemes. Finite volume method for unsteady flows: Explicit scheme, Crank–Nicolson scheme, fully implicit scheme, Transient SIMPLE, The transient PISO algorithm.	
Unit-5 - Solution for Discretized Equations and Solution Algorithms for Pressure-Velocity Coupling in Steady Flows	***9 Hour***
Introduction - The TDMA and its applications - Point-iterative methods, Jacobi iteration method, Gauss–Seidel iteration method, Relaxation methods, multi-grid techniques and procedure, multi-grid cycles. Introduction to solution algorithms for pressure-velocity coupling in steady flows - staggered grid - momentum equations - SIMPLE algorithm - Assembly of a complete method. The SIMPLER algorithm, The SIMPLEC algorithm, The PISO algorithm. CFD calculation of turbulent non-premixed combustion - - Modelling of premixed combustion	

Learning Resources	1. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics – The finite volume method, Pearson; 2nd edition (2008). 2. J.H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer; 4th ed. CBS Publishers & Distributors Pvt. Ltd (2020);	3. Tu, Jiyuan, Guan-HengYeoh, and Chaoqun Liu. Computational fluid dynamics: a practical approach. Butterworth-Heinemann, 3rd edition (2018)

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	40%	-
Level 2	Understand	40%	-	30%	-	40%	-
Level 3	Apply	20%	-	40%	-	20%	-
Level 4	Analyze	-	-	-	-	-	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam,PESCO Beam Environmental Solutions Pvt. Ltd	1. Dr. Lima Rose Miranda, Anna University	1. Dr. S. Sam David, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. K. Suresh, SRMIST

Course Code	21CHE367T	Course Name	BIOCHEMICAL PROCESS DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze and compare various bioreactors and accessories types and their characteristics*
CLR-2:	*identify problems associated with bioprocess scale-up*
CLR-3:	*distinguish different bioprocess control requirements and associated instrumentation*
CLR-4:	*discern the different methods of product recovery and purification*
CLR-5:	*comprehend different types of biofuel technology processes and their sustainability concepts*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*evaluate bioreactors based on bioprocess requirements*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*demonstrate ability to scale-up of bioreactor in industrial bioprocesses*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*develop instrumentation schemes for bioprocesses*	-	*1*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*plan bioproduct recovery processes*	-	-	*1*	*2*	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*develop biorefinery processes incorporating sustainability and value-added products concepts*	-	-	-	*1*	-	-	*2*	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Bioreactors	***9 Hour***
Introduction to Bioreactors – Basic principle of bioreactor – Components of bioreactor – Classification and configuration of bioreactors – Analysis of batch bioreactors – Analysis of continuous flow bioreactors – Analysis of fed-batch bioreactors – Design of novel biochemical reactors – Operation of novel biochemical reactors – Air-lift loop reactors – Fluidized bed biochemical reactors – Immobilized enzyme reactors – Design of immobilized enzyme reactors – Packed bed reactors – Membrane reactors	
Unit-2 - Biochemical Reactor Scale-up	***9 Hour***
Biochemical reactor scale-up – Transport phenomena in Bioprocess systems – Gas-liquid mass transfer – Determination of oxygen transfer rates – Measurement of $k_{L}a$ – Key dimensionless groups – Correlations for mass transfer coefficients and interfacial area – Overall $k_{L}a$ estimates and power requirement for sparged and agitated vessels – Heat transfer correlations – Scaling of mass transfer equipment – Regime analysis of Biochemical reactor processes – Scale-up criteria for bioreactors based on oxygen transfer and power consumption	
Unit-3 - Instrumentation and Control of Bioreactors	***9 Hour***
Instrumentation and control of bioreactors – Measurement of physical and chemical parameters in bioreactors – Bioreactor sensors for temperature control – Principles of dissolved oxygen measurement and control – Principles of pH control – Principles of redox measurement and control – On-line sensors – Off-line analytical methods – Measurement of medium properties – Analysis of cell population composition – Prevention of foam – Determination of biomass – Application of biosensors – Design and operation strategies for batch operation – Continuous process control	
Unit-4 - Bioproduct Recovery Operations	***9 Hour***
Bioproduct recovery operations – Separation of biomolecules – Cell disruption for release of products – Mechanical methods of cell disruption – Enzymatic methods of cell disruption – Chemical methods of cell disruption – Cells and solid particle separation – Filtration – Centrifugation – Product isolation – Adsorption – Liquid-liquid extraction – Product purification – Chromatography	

Unit-5 - Biofuels and Biorefinery Technology	***9 Hour***
Biodiesel – First generation biodiesel from edible vegetable oils – Food versus fuel debate – Second generation biodiesel from non-conventional and non-edible plant oils – Third generation from algae feedstock – Transesterification for biodiesel production – Chemical and enzyme catalyzed transesterification – Biodiesel characteristics – Biorefinery concept – Yeast, lignocellulosic and algal biomass feedstock based biorefinery – Consolidated bioprocessing strategies – Biofuels and value added products – Biooil and biochar – Case studies – Sustainability issues	

Learning Resources	1. *Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals", 2nd edition, McGraw– Hill, 1988.* 2. *Shuler, M.L. and Kargi, F. "Bioprocess Engineering: Basic Concepts", 2nd edition, PHI, 2002.* 3. *Stanbury, P. F. and Whitaker, A., "Principles of Fermentation Technology", 2nd edition, Butterworth – Heinemann (an imprint of Elsevier), 1995.*	4. *Frohling, M. and Hiete, M., "Sustainability and Life Cycle Assessment in Industrial Biotechnology", 1st edition, Springer 2020.* 5. *Bastidas-Oyanedel, J and Schmidt, J.E., "Biorefinery - Integrated Sustainable Processes for Biomass Conversion to Biomaterials, Biofuels, and Fertilizers", 1st edition, Springer 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai*	1. *Dr. Lima Rose Miranda, Anna University, Chennai*	1. *Dr. M.P.Rajesh, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K.Tamilarasan, SRMIST*

Course Code	21CHE368T	Course Name	MICRO CHEMICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the theory, flow in microchannels and electrical double layers*
CLR-2:	*understand the microcapillary transport, contact angle and electro kinetics*
CLR-3:	*explain the different methods of fabrication of microfluidics and their limitations*
CLR-4:	*describe various components of microfluidics and their role in the function of microfluidic*
CLR-5:	*explain the principles of a Lab-on-a-chip technology and their potential in detecting food contaminants*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the flow in microchannels and electrical double layers*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*evaluate the significance of contact angle and electro kinetics in microcapillary transport*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*understand pros and cons of different microfluidic fabrication techniques*	*2*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*understand basic requirements for a design application related to microfabrication and its methodologies to develop sensing systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze, compare, and appreciate the performance and merit of different lab-on -a chip concepts, designs, and modes of work*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Theory and Flow in Microchannels	***9 Hour***
Introduction to Microfluidics—Continuum Assumption—Gas and Liquid Flows—Boundary Conditions—Parallel Flows—Low Reynolds Number Flow—Entrance Effect—Physics of near- Wall Microscale Liquid Flows—Intermolecular Forces—Electrical Double Layers—DLVO Theory.	
Unit-2 - Microcapillary Transport and Electrokinetics	***9 Hour***
Surface Tension—Interfacial Energy—Contact Angle and Young-Laplace Equations—Dynamics of Capillary Rise—Electroosmosis—Electrophoresis—Dielectrophoresis—Pressure Driven Microflows—Surface Tension Driven Microflows—Modulation of Surface Tension.	
Unit-3 - Fabrication Techniques for Microfluidics	***9 Hour***
Conventional Techniques: Photolithography, Additive, Subtractive and Pattern Transfer Techniques—Silicon based Micromachining Techniques: Silicon Bulk and Surface Machining Processes—Polymer based Micromachining Techniques: Thick Resist Lithography, Bulk and Surface machining, Microsterio Lithography and Micromoulding.	
Unit-4 - Components of Microfluidics	***9 Hour***
Materials—Clean Room—Micropumps—Microvalves—Microflow Sensors—Microneedles—Micromixers—Microdispenser—Microparticle Separators—Microreactors.	
Unit-5 - Lab-On-A-Chip Technology	***9 Hour***
Concept of Lab-On-a-Chip Technology—Field Flow Fractionation (FFF)—Microfluidic PCR—Microfluidic Cell Sorter—Drug Delivery—Point-of-Care Devices—Sensors—Environmental Monitoring—Biomedical Diagnostics. Demonstration of Fabrication of Macrochannels in Polymer Substrates and Its Applications in Colorimetric Detection of Common Contaminant and Other Molecules. Practical Demonstration of Lab-on-a-Chip Model in General Contaminant Detection of Multi-Molecules.	

Learning Resources	1. *Nguyen, N. T. and Werely, S. T., Fundamentals and Applications of Microfluidics, Artechhouse Inc., 2002.* 2. *Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.* 3. *Kirby, B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.*	4. *Tabeling, P., Introduction to Microfluidics, Oxford University Press Inc., 2005* 5. *Colin, S., Microfluidics, John Wiley & Sons, 2009.* 6. *Suman Chakraborty, Microfluidics and Microfabrication, Springer, 2014.* 7. *Francesco Piraino and Šeila Selimovic, Diagnostic Devices with Microfluidics, CRC Press 1 edition, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	20%	-	30%	-
Level 4	*Analyze*	30%	-	20%	-	30%	-
Level 5	*Evaluate*	-	-	20%	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Professor, Anna University*	1. *Dr. S. Anandhakumar, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. K. Suresh, SRMIST*

Course Code	21CHE369T	Course Name	ELECTROCHEMICAL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the concept of electrochemistry and electrochemical laws*
CLR-2:	*familiarize the concepts of corrosion, its types and prevention*
CLR-3:	*familiarize the concepts of electrochemical processes, batteries and fuel cells*
CLR-4:	*exposure of different electrodes and industrial electrochemical reactors*
CLR-5:	*exposure of different electroanalytical technique*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the concepts of electrochemistry using Faraday's law and electrochemical double layers*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*illustrate suitable industrial corrosion prevention techniques*	3	-	-	2	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*outline the merits and demerits of different electrochemical process for industrial applications. Summarizing the concepts of batteries and fuel cells*	2	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*summarize different types of electrodes and evaluate the design of electrochemical reactors for industrial processes*	2	-	1	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*understand various electroanalytical techniques and its basic working principles*	2	-	-	3	-	-	-	-	-	-	-	-	-	3	-

Unit-1 - Introduction to Electrochemistry and Electrical Double Layers	***9 Hour***
Basic Principles of Electrochemistry: Faraday's Law–Nernst Potential–Galvanic Cells–Potential and Thermodynamics of Electrochemical Cells–Spontaneous and Non-Spontaneous Reactions. The Electrical Double Layer and It's Role in Electrochemical Processes–Electro Capillary Curve–Helmoltz Layer–Guoy–Chapman's Models–Fields at the Interface.	
Unit-2 - Corrosion	***9 Hour***
Introduction to Corrosion, Corrosion Theories–Activities Controlled and Diffusion Controlled Corrosion Processes–Corrosion Rate, Current Density and Material Loss Estimation. Potential-pH Diagram, Various Forms of Corrosion: Definition, Factors and Control Measures–General Corrosion Protective Strategies: Protective Coatings, Vapor Phase Inhibitors, Cathodic Protection and Sacrificial Anodes–Industrial Boiler Water Corrosion Control	
Unit-3 - Electrochemical Processes, Batteries and Fuel Cells	***9 Hour***
Electro Deposition–Electro Refining–Electroforming–Electro Polishing– Anodizing – Primary and Secondary Batteries–Types of Batteries–Fuel cells.	
Unit-4 - Electrodes and Electrochemical Reactors	***9 Hour***
Electrodes Used in Different Electrochemical Processes: Metals–Graphite–Lead Dioxide–Titanium Electrodes–Iron Oxide–Semi conducting Type etc. Types of Electrochemical Reactors: Batch Cell, Fluidized Bed, Filter Press Cell, Swiss Roll Cell, Plug Flow Cell, Design Equation and Figures of Merits of Electrochemical Reactors.	
Unit-5 - Electroanalytical Methods	***9 Hour***
Basic Principles of Electroanalytical Methods: Potentiometry, Ion Selective Electrodes (ISE), Two and Three Electrode Set-Up, Electrogravimetric Analysis, Polarography, Cyclic Voltammetry, Conductometry and Dielectrometry, Impedence Methods and Modern Electrochemical Methods including Quartz Crystal Microbalance, Atomic Force Microscopy and Spectroelectrochemistry. Practical Demonstration of Use of COMSOL Package in Explaining Electrochemistry and Fluid Flow Module-Practical Demonstration of Cyclic Voltammetry, Corrosion Process and Galvanic Cells.	

Learning Resources	1. Geoffrey Prentice, "Electrochemical Engineering Principles", Prentice Hall. 1990. 2. Newman, J. S., Thomas-Alyea, K. E., "Electrochemical systems", Third Edition, Wiley-Interscience, 2004. 3. Barak, M., "Electrochemical Power Sources: Primary and Secondary Batteries" Institution of Engineering and Technology, 1980.	4. Mantell, C., "Electrochemical Engineering", McGraw Hill, 1972. 5. BRETT, Christopher M. A., Ana Maria Oliviera BRETT.,"Electroanalysis" Oxford: Oxford University Press, 1998, ISBN 0198548168. 6. Bard, Allen J., Larry R. Faulkner.,"Electrochemical Methods : Fundamentals and Applications. 2nd ed. New York: John Wiley & Sons, 2000, ISBN: 978-0-471-04372-0.

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. S. Anandhakumar, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. G. Keerthiga, SRMIST*

							L	T	P	C
Course Code	21CHE370T	**Course Name**	PETROCHEMICAL TECHNOLOGY	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the importance petrochemical products and feedstock*
CLR-2:	*explain the different resource for basic petrochemical synthesis process*
CLR-3:	*explain the various second, third generation petrochemical synthesis process*
CLR-4:	*describe the process flow diagram for polymers production and application*
CLR-5:	*describe the process flow for Agrochemicals and Pharmaceuticals products*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analysis the importance of petrochemicals and growth potential of petrochemical industry*	2	-	1	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*develop processes for manufacture of basic petrochemicals from hydrocarbon feedstock*	2	-	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	*familiarize to draw flow diagrams of intermediate petrochemicals production processes*	2	-	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-4:	*ability to draw flow diagram for plastic, rubber, fibres and resin production process*	2	-	2	-	-	-	-	-	-	-	-	-	-	3	-
CO-5:	*design and analysis the production process for agrochemicals, DDT and pharmaceuticals products*	2	-	2	-	-	-	-	-	-	-	-	-	1	-	-

Unit-1 - Overview of Petrochemicals ***9 Hour***

History of petrochemical industry, growth potential of petrochemical in India, overview of petrochemical products, importance of petrochemical, petrochemical building block, petrochemicals from petroleum fractions feedstock, classification of petrochemicals, various uses of petrochemical products.

Unit-2 - Petroleum Feed Stock ***9 Hour***

Process flow for manufacture of acetylene, process flow for manufacture of ethylene, application of C1 and C2 petrochemical, process flow for manufacture of propylene, butadiene synthesis, application of C3 and C4 petrochemical, preparation of raw materials and process for aromatic compound synthesis, BTX, application of methanol and ethanol.

Unit-3 - Petro Chemical Derivatives ***9 Hour***

Process flow for manufacture of acrylonitrile, selection of raw material and process for ethylene derivative synthesis, industrial application of acrylonitrile, process flow for manufacture of propylene oxide, ethylene chloride, manufacture of vinyl acetate, vinyl chloride, process flow for manufacture of phenol and process flow for manufacture of styrene.

Unit-4 - Applications of Petrochemicals ***9 Hour***

Classification of industrial important polymers, plastics and its classification, selection of raw material and process for polyethylene synthesis, process block diagram for PVC production, Process flow for manufacture of synthetic rubber, Raw material and process condition for nylon synthesis, Feed stock for polyesters synthesis and Synthetic resins- process for phenol formaldehyde synthesis.

Unit-5 - Agrochemicals ***9 Hour***

Classification of agrochemicals, selection of raw material and process for DDT synthesis, feed stock and selection process for parathion synthesis, importance of detergents, raw material and process for ionic and non-ionic detergents synthesis and various methods of carbon black production and its application.

Learning Resources	1. *Bhaskara Rao. B.K, "Petrochemicals", Khanna Publishers, New Delhi.* 2. *Gopala Rao. M. and Marshall Sittig, "Dryden's Outlines of Chemical Technology", 3rd Edn., East-West Press, New Delhi, 2008.*	3. *Steiner H. "Introduction to Petroleum Chemicals", Pergammon Press, 1992.* 4. *Petroleum Refinery Engineering, W. L. Nelson, 4th Edition, McGraw Hill, New York, 1958.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*20%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*30%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr.K.Anbalagan, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. S. Kiruthika, SRMIST*

Course Code	21CHE371T	Course Name	FOOD TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize general aspects of food industry, role of chemical engineers in food industry and constituents of food*
CLR-2:	*study the unit operations used in food processing*
CLR-3:	*know about the food deterioration, preservation and packing method*
CLR-4:	*learn the different food products development process*
CLR-5:	*apply the knowledge gained able dispose the food waste in proper way to provide value added product*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*know about the general aspects of food industry, role of chemical engineers in food industry and constituents of food*	*1*	-	*2*	-	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-2:	*acquire a knowledge about the different types unit operations used in food processing industry*	*2*	-	*2*	-	-	-	*2*	-	-	-	-	-	*2*	-	-
CO-3:	*control the food deterioration by the way of preservation and packing method*	*2*		-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*understand the technology involved in different food products production*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*able to convert product from food industry waste*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Constituents of Food	***9 Hour***
Characteristics of food industry and role of Engineers, Constituents of food- Carbohydrates, Proteins, Fats and Oils and additional food constituents, Nutritive aspects of food constituents, Food additives, Estimation of carbohydrate, proteins and fats and oils from food; Food Safety and Standard Authority of India regulations (FSSAI) – Act; International food safety regulations - International food standards - FAO / WHO, EU committee for standardization	
Unit-2 - Food Conversion Operation	***9 Hour***
Preparative operation: cleaning, sorting, grading methods, food conversion operation: size reduction, mixing, emulsification methods, Application of extraction in food industry (Extraction of edible oil), Application of filtration in food industry, Application of crystallization in food industry (Sugar crystal from syrup), phase diagram of sucrose-water system.	
Unit-3 - Food Preservation Operation	***9 Hour***
High temperature operation (drying, bleaching, pasteurization and sterilization), factors affecting heat resistance of microorganisms, Thermal death time of bacterial cells, Low temperature operation (Refrigeration, freezing operation) Freezing characteristics of foods, factors affecting the quality of frozen foods, Irradiation application in food industry	
Unit-4 - Food Product Development	***9 Hour***
Milk and dairy products: Manufacture of Cheese, Casein, whey, Beverage's products (coffee, Wine and Beer), confectionary (Chocolate), Sweeteners (HFCS), Meat processing cooking and Carving process, meat preservation methods: drying, smoking, dehydration, Poultry processing flow diagram and fish products	
Unit-5 - Food Waste Management	***9 Hour***
Case studies: Food process industry waste management: Processes for utilization Beverage's industry waste, Products development for utilization of Dairy industry waste, Co-product recovery in Fruit and Vegetable waste, Sugar industry waste management (bagasse and molasses).	

Learning Resources	*1. Potter. JH, Hotchkiss NN, “Food Science”, 5th edn., The CBS Publishing Co, Delhi, 2007.* *2. Toldeo. RT, “The Fundamentals of Food Engineering”, The CBS Publishing Co, Delhi, 2000.*	*3. Sivasankar., B, “Food Processing and Preservation”, Prentice-Hall of India, New Delhi, 2002.* *4. Desrosier, NW., “The Technology of Food Preservation,” The CBS Publishers & Distributors, 1998.*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

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1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University*	*1. Dr. K.Tamilarasan, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. M.P.Rajesh, SRMIST*

Course Code	21CHE372T	**Course Name**	INTRODUCTION TO PROCESS PLANT SIMULATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the process synthesis and analysis techniques*
CLR-2:	*evaluate the individual equipment sizing and control philosophy*
CLR-3:	*perform the dynamic simulation for the process plant*
CLR-4:	*propose the line sizing, standard, and codes for the process plant*
CLR-5:	*prepare the plant layout using the virtual reality tool*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*prepare the process flow diagram from lab scale to process*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*create the process instrumentation diagram*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*analyse quantitative risk analysis for the process plant*	-	*3*	-	-	2	-	-	-	-	-	-	-	2	-	-
CO-4:	*estimate the line sizing and pump capacity calculations*	*3*	-	-	-	2	-	-	-	-	-	-	-	-	2	-
CO-5:	*walk through the model to identify deviations*	*3*	-	-	-	3	-	-	-	-	-	-	-	-	2	-

Unit-1 - Process Flow Diagram	***9 Hour***
A detailed description of the process, feasibility study, and technical study report, steady-state simulation of the manufacturing process	
Unit-2 - Process Instrumentation Diagram	***9 Hour***
Equipment sizing and equipment specification sheet, all instruments including control valve specification, pressure safety valve	
Unit-3 - Dynamic Simulation and Control	***9 Hour***
Dynamic simulation of normal operation, the control structure of the process, selection of deviation scenarios, quantitative risk analysis methodology	
Unit-4 - Line sizing, Standards, and Codes	***9 Hour***
Line sizing and hydraulic check, pressure drop calculation, material of construction, all applicable codes, regulations, and client requirement	
Unit-5 - Plant Layout	***9 Hour***
Equipment and pipeline layout, Utility balances and utility header design, utility layout, virtual reality for clash checking	

Learning Resources	1. *Luyben, W.L., 2006. Distillation Design and Control Using Aspen simulation, John Wiley and Son Inc.* 2. *Kamal LM. AL-Malah, 2017. Aspen Plus® Chemical Engineering Applications, John Wiley & Sons, Inc.*	3. *Luyben, W.L., 1999. Process Modeling, Simulation and Control for Chemical Engineers, Second Edition, McGraw-Hill Publishing Company, New York.* 4. *API 520-I, 2008, API Standard. API 520 Sizing, Selection, and Installation of pressure relieving devices in Refineries Part 1 – Sizing and Selection Vol. 520*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
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Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

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