ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 22
Syllabi for School of Bioengineering Programme

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Chemical Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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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	21CHC501J	Course Name	COMPUTATIONAL TRANSPORT PHENOMENA	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:	*introduce fundamental concepts of transport phenomena and CFD, laying the foundation for advanced study*
CLR-2:	*explore velocity distributions in laminar flow systems under isothermal conditions.*
CLR-3:	*investigate turbulent flow phenomena and introduce turbulence modelling techniques.*
CLR-4:	*examine energy transport mechanisms and equations governing non-isothermal systems, focusing on heat transfer principles.*
CLR-5:	*explore mass transport phenomena and principles, including diffusion and mass transfer analogies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic principles of transport phenomena and CFD, including coordinate systems, substantial derivative, and momentum balance.*	*1*	*3*	*2*
CO-2:	*gain proficiency in analyzing and solving laminar flow problems, applying equations of change to various geometries.*	*1*	*3*	*2*
CO-3:	*develop an understanding of turbulent flow characteristics*	*1*	*3*	*2*
CO-4:	*acquire skills in analyzing and solving non-isothermal energy transport problems, including heat conduction and cooling processes.*	*1*	*3*	*2*
CO-5:	*develop proficiency in analyzing and solving mass transport problems, understanding diffusion mechanisms, and applying mass transfer analogies.*	*1*	*3*	*2*

Module-1 - Introduction to Transport Phenomena	**9 Hour**
Viscosity and the Mechanisms of Momentum Transport - Momentum flux and Kinetic energy, Pressure and 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 - Introduction to CFD and its applications - CFD solution strategies - Types of models in CFD - CFD solution procedure	
Module-2 - Velocity Distributions in Laminar Flow - Isothermal Systems	**9 Hour**
Equations of Change – flow over an inclined plane slab as thin film, flow through pipe, flow through annular pipe and flow through two immiscible liquids, flow through narrow slit	
Module-3 - Velocity Distribution in Turbulent Flow - Isothermal Systems	**9 Hour**
Comparisons of laminar and turbulent flows - Time-smoothed equations of change for incompressible fluids - The time-smoothed velocity profile near a wall - Empirical expressions for the turbulent momentum flux - Introduction to Turbulence Modelling in CFD - Turbulence models - Flow over an object: friction factors, Friction factors for flow in tubes	
Module-4 - 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	
Module-5 - Mechanisms of Mass Transport	**9 Hour**
Theory of Diffusion, diffusivity and mass transfer coefficient - Shell mass balance equation - Diffusion through a Stagnant Gas Film - Diffusion with a Homogeneous Chemical Reaction - Diffusion into a Falling Liquid Film - Lumped mass transfer - Analogy Momentum, energy and Mass transfer: Reynolds Analogy, Chilton Colburn analogy, Prandtl analogy	

Practice	**15 Hour**
1.Introduction to CFD Software Environment	7.Forced Convection over a Flat Plate
2.Flow in a Pipe	8.Cooling of a Heated Block
3.Flow around a Cylinder	9.Diffusion in a Binary System
4.Turbulence Modelling	10.Boundary Conditions Practice
5.Conduction in a Rectangular Plate	11.Meshing Techniques
6.Natural Convection in a Square Enclosure	12.Grid Independence Study

Learning Resources	1.Byron R. Bird., Warren E. Stewart and Edwin N. Lightfoot, “Transport Phenomena”, John Wiley & Sons, New York, 2nd edition 2007. 2.Christie John Geankoplis “Transport Processes and Separation Process Principles”, “Pearson Education”, Prentice Hall, 4thEdition 2003. 3.James R. Welty., Charles E. Wicks., Robert E. Wilson. and Gregory L. Rorrer “Fundamentals of Momentum, Heat, and Mass Transfer”, “John Wiley &Sons”, New York, 5th edition, 2007	4.H. K. Versteeg and W. Malalasekera, “An introduction to computational fluid dynamics – The finite volume method”, Longman Group Ltd 1995. 5.J.H. Ferziger and M. Peric, “Computational Methods for Fluid Dynamics”, “Springer”, 2002. 6.Tu, Jiyuan, Guan-Heng Yeoh, and Chaoqun Liu, “Computational fluid dynamics: a practical approach”. “Butterworth-Heinemann”, 2018.

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- Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	-	10%	15%	-
Level 2	Understand	25%	-	-	30%	25%	-
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, Chennai	1.Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. K. Suresh, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	**2.** Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. S. Sam David, SRMIST

Course Code	21CHC502J	Course Name	COMPUTER-AIDED PROCESS PLANT SIMULATION	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:	*recap the inventory rate equation for mass and energy*
CLR-2:	*apply the inventory rate equation to unit operation/processes with recycling and bypassing*
CLR-3:	*estimate the rate constant and order of heterogeneous chemical reactions*
CLR-4:	*prepare block diagram, process flow diagram, piping, and instrumentation diagram*
CLR-5:	*formulate the process flow diagram with control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*propose the process modeling for any chemical engineering system*	*2*		*1*
CO-2:	*simulate the process flow sheet with recycling and bypassing*	*1*		*2*
CO-3:	*estimate the rate of reaction using experimental data of heterogeneous system*	*2*		*2*
CO-4:	*synthesis of process flow sheet, P&ID diagram, and line sizing*	*1*		*2*
CO-5:	*perform Aspen dynamic simulation with control system*	*2*		*1*

Module-1 - Material and Energy Balance	**9 Hour**
Material balances involve with and without Chemical Reactions, Electrochemical Reactions, Recycling, Parallel, and Bypassing Unit Operation and Process. Energy balances, heat capacity of gaseous and liquid mixtures, and enthalpy changes accompanying chemical reactions.	
Module-2 - Stoichiometry, Unit Operations and Processes	**9 Hour**
Stoichiometry and Unit Operations Distillation, Absorption and Stripping, Extraction and Leaching, Crystallization, Psychrometry, Drying, Evaporation and Less Conventional Operations, Air requirement and Flue Gases and Combustion Calculations.	
Module-3 - Utilization of CO_2 into Methanol	**9 Hour**
Kinetic parameters for elementary reactions – single and multiple reactants, Methanol Reaction Kinetic model, Refitting of kinetic parameters, Choice of reactor and operation conditions, Preliminary Flowsheet layout study, One-stage synthesis flowsheet, Two-stage synthesis.	
Module-4 - Flow sheets and P & I Diagrams	**9 Hour**
Executing a Process Plant – Feasibility study, Basic Engineering, Execution of the project, Pre-commissioning and Commissioning, and Plant Acceptance and Handover. Flow sheets, Equipment lists, and line lists – Block flow diagram, process flow diagram, Piping and Instrumentation Diagram, Utility P & ID, material selection diagram, line list, and equipment list.	
Module-5 - Process Dynamic Modeling	**9 Hour**
Material balances of Unsteady-state operations and processes with Examples, Control of CSTR systems – Nonlinear Dynamic model, Nonlinear Dynamic Simulation, Effect of Jacket Volume, Demonstration of Aspen Dynamics simulation of CSTRs.	

Practice	**15 Hour**
1.Perform the unit operations simulation *2.Analyze the unit process simulation and optimization* *3.Simulate the flowsheet using the process data and identify the optimum condition* *4.Utilization of CO_2 into methanol - Kinetic model for reaction, LHHW kinetic model, Methanol Reaction Kinetic model, Refitting of kinetic parameters, and One-Stage synthesis flowsheet*	*5.Power required for a pump in the process flow sheet* *6.Demonstration of Nylon 6,6 resin reactor simulation, Simulation of azeotropic distillation of water-ethanol mixture* *7.Prepare piping and instrumentation diagram* *8.Demonstration of Aspen Dynamics simulation of CSTR*

Learning Resources	*1. BI Bhatt and SB Thakore, "Stoichiometry", Mc Graw Hill Education, Fifth Edition, 2015.* *2.J.F. Portha, "Kinetics of Methanol Synthesis from Carbon Dioxide Hydrogenation over Copper-Zinc Oxide Catalysts", Ind Eng Chem Res, Vol 56, pp. 13133 - 13145* *3.Achyuta K, "Techno-Economic Analysis of Utilization of CO_2 into Methanol",2023*	*4.Siddhartha Mukherjee, "Process Engineering and Plant Design: The Complete Industrial Picture", "Taylor & Francis Group", LLC., CRC Press First edition Publication 2022.* *5.William L. Luyben, "Chemical Reactor Design and Control", "A John Wiley and Sons, Inc., Publication", 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (45%)		Continuous Learning Assessment (CLA) Life Long Learning CLA-2- Practice (15%)		Summative Final Examination (40% weightage)	
		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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Suresh, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. P. Muthamilselvi, SRMIST*

Course Code	21CHC503J	Course Name	ADVANCED 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:	*understand the catalytic reaction mechanism and kinetics*
CLR-2:	*familiarize the design aspects of reactors with solid catalysts*
CLR-3:	*develop the rate equation for gas – liquid reactions on solid catalysts*
CLR-4:	*understand the development of fluid – fluid reaction rate equations*
CLR-5:	*familiarize the fluid – fluid reactors design calculations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*predict the rate limiting mechanism in catalytic reactions*	*3*	*1*	
CO-2:	*design various types of fluidized bed reactors*	*2*		*1*
CO-3:	*analyze the performance of multiphase reactors*	*2*		*1*
CO-4:	*develop rate equation for non-catalytic fluid – fluid reactions*	*2*		*1*
CO-5:	*interpret the design aspects of fluid – fluid reactors*	*2*		*1*

Module-1 - *Catalysis and Catalytic Reactors* **9 Hour**

Properties and types of catalyst, Reasons for catalyst deactivation, Sequence of steps in a catalytic reaction, Information required for catalytic reactor design, Molecular adsorption model and dissociative adsorption model for adsorption isotherm, Surface reaction kinetics and types of models, Desorption rate law, Electrical analog to heterogeneous reactions, Developing rate law equation for adsorption as rate limiting step, Developing rate law equation for surface reaction as rate limiting step, Developing rate law equation for desorption as rate limiting step, Types and mechanism of catalyst deactivation

Module-2 - *Reactors with Suspended Solid Catalyst* **9 Hour**

G/S contacting regimes, from low to very high gas velocity in suspended solid reactors, Geldart classification of solids in Bubbling Fluidized Bed (BFB), Concept of Minimum Fluidizing Velocity and Terminal Velocity, Conditions for Bubbling Fluidized Bed, Models for Bubbling Fluidized Bed, K – L model for Bubbling Fluidized Bed, Material Balance for Gas and for Solids in K – L model for Bubbling Fluidized Bed, Applications of K – L model, Circulating fluidized bed (CFB), Turbulent bed (TB) and solid distribution, Behavior and model of Fast Fluidized Bed (FF), Model for Pneumatic Conveying (PC) reactor and Downflow CFB

Module-3 - *G/L Reactions on Solid Catalysts* **9 Hour**

General rate equation, Various ways of running G/L reactions catalyzed by solids, resistances involved in the G/L reaction on a catalyst surface, Performance equations for an excess of liquid reactant (B), Performance equations for an excess of gas reactant (A), Selection criteria for G/L contactor and applications, Slurry reactor – uses, reaction steps and rate equation, Rate limiting steps in slurry reactor, Trickle bed reactor – rate and transport equations, Optimization in chemical reactors

Module-4 - *Fluid – Fluid Reaction Kinetics* **9 Hour**

Factors affecting the kinetics, General rate equation form, General stoichiometry and nomenclature for fluid – fluid reactions, Rate Equation for Straight Mass Transfer (Absorption) of gas reactant, Rate

Equation for Mass Transfer and Reaction, Rate equation for various cases of infinitely fast to very slow reaction, Role of the Hatta Number, Importance of two film theory, Clues to the Kinetic Regime from Solubility Data	
Module-5 - *Fluid – Fluid Reactors: Design*	**9 Hour**
Factors to consider in selecting a contactor, Typical characteristics of G/L contactors, Contacting patterns for G/L contactors, Rate equation for straight mass transfer in countercurrent tower, Mass Transfer with reaction in a countercurrent tower, Mass Transfer with reaction in a co-current tower, Mass transfer with reaction in an agitated tank contactor, Mass transfer with reaction in bubble tank contactors, Absorption with reaction in a batch agitated tank contactor, Procedure to find the time needed for a given operation	
Practice	**15 Hour**
1. Performance in a fixed bed reactor *2. Performance in a fluidized bed reactor* *3. Performance in a fluidized bed reactor - Effect of fluid velocity* *4. Performance in a slurry reactor - Effect of bubble size*	*5. Performance in a slurry reactor - Effect of particle size of the catalyst* *6. Performance in a trickle bed reactor* *7. Study of reaction kinetics for a photochemical reaction* *8. Performance in a photocatalytic reactor*

Learning Resources	*1. Octave Levenspiel, "Chemical Reaction Engineering", "John Wiley & Sons", 3rd edition 1999.* *2. H. Scott Fogler, "Elements of Chemical Reaction Engineering" "PHI India Pvt., Ltd"., 3rd edition 2004.* *3. J. M. Smith, "Chemical Engineering Kinetics", "McGraw- Hill", 3rd edition 1981.*	*4. S. Suresh, Sundaramoorthy, "Green Chemical Engineering An Introduction to Catalysis, Kinetics, and Chemical Processes", "Routledge Taylor & Francis group", "CRC Press", 2015* *5. Missen, Ronald William, Charles W. Mims, and Bradley A. Saville. "Introduction to chemical reaction engineering and kinetics.", "John Wiley & Sons",1999*

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- Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	-	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	30%	30%	-
Level 4	Analyze	30%	-	-	20%	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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. M. Magesh Kumar, SRMIST*

Course Code	21CHC504J	Course Name	PROCESS AUTOMATION AND CONTROL	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 process control's main terms and parameters*
CLR-2:	*find whether the system bound to steady state and unsteady state condition*
CLR-3:	*differentiate between discrete, multistep, and continuous controllers*
CLR-4:	*get an exposure on the important parameters to be monitored and analyzed in industry*
CLR-5:	*learn the essentials of process control and instrumentation for a successful career in process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*introduce the dynamics of various processes and modelling of physical processes*	*2*		*1*
CO-2:	*educate the effect of various control actions*	*2*		*3*
CO-3:	*learn the methods of tuning the controller*	*3*		*2*
CO-4:	*get adequate knowledge about basic and advanced control schemes and related issues*	*2*		*1*
CO-5:	*introduce the concept of Multi input Multi output process and its control schemes*	*3*		*1*

Module-1 - Time Domain Dynamics and Control	**9 Hour**
Motivation for Studying Process Control - Uses of Mathematical Models - Examples of Mathematical Models of Chemical Engineering Systems - Two Heated Tanks - Ideal Binary Distillation Column – First order system – Second order system - Linearization - First-Order Linear Ordinary Differential Equation - Second-Order Linear ODES with Constant Coefficients - Nth-Order Linear ODES With Constant Coefficients – Steady state Techniques.	
Module-2 - Frequency-Domain Dynamics and Control	**9 Hour**
Frequency-Domain Solution Techniques - Bode Plots - Nyquist Plots - Nyquist Stability Criterion – Closed loop Specifications in the Frequency Domain - Phase Margin - Gain Margin - Maximum Closed loop Log Modulus - Frequency Response of Feedback Controllers - Proportional Controller- Proportional-Integral Controller - Proportional-Integral-Derivative Controller.	
Module-3 - Conventional Control Systems and Hardware	**9 Hour**
Control Instrumentation – Sensors – Transmitters - Control Valves - Analog and Digital Controllers - Computing and Logic Devices - Performance of Feedback Controllers - Specifications for Closed loop Response - Load Performance - Controller Tuning - Rules of Thumb - On-Line Trial and Error - Ziegler-Nichols Method – Control of multivariable Processes.	
Module-4 - Control Scheme	**9 Hour**
Cascade, Feed-forward, Feed-forward plus Feedback, Ratio control, Inferential control, Dead time and Inverse response compensation, Nonlinear and Adaptive Control, Model reference adaptive control, Computed Variable Control, Dynamic Matrix Control - DMC Algorithm. Digital Control- Sampling and reconstruction, Discrete systems analysis, Stability and controller design using Z transform and difference equations, Smoothing filter realization using difference equations	

Module-5 - Automated Process	**9 Hour**
Building Blocks of Automation System - Distributed Control System - Evolution and advantages of computer control, Configuration of Supervisory, Direct digital control (DDC) and DCS. Artificial Intelligence in Process Control: Expert systems, Neural networks, Fuzzy logic, Neuro Fuzzy, Genetic algorithm, Virtual instrumentation. Programmable Logic Controllers: Comparison with hard wired relay and semiconductor logic, Hardware, Ladder diagram programming, Case studies. Modeling and Simulation for Plant Automation	
Practice	**15 Hour**
1. To study interacting and non-interacting system for the first order system in series	*6. To study the advanced control schemes with examples*
2. To study the control valve characteristic	*7. To study the Programmable Logic Controllers*
3. To study the Valve Positioner	*8. To study the Distributed Control System*
4. To study the tuning parameter by using various controllers	*9. To study the automated distillation Process*
5. To study the performance of controllers such PI, PID	*10. Introduction to Piping software*

Learning Resources	*1 .William L. Luyben "Process Modelling, Simulation and Control for Chemical Engineers" "McGraw-Hill Education", 1990* *2. Carlos A. Smith, Armando B. Corripio, "Principles and Practice of Automatic Process Control" "John Wiley & Sons", 2nd edition, 1997*	*3. Ronald P. Hunter, "Automated Process Control Systems: Concepts and Hardware" "Prentice-Hall", 1987.* *4. Uttam Ray Chaudhuri, Utpal Ray Chaudhuri, "Fundamentals of Automatic Process Control", "CRC Press" ,2019.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (45%)		Continuous Learning Assessment (CLA) Life Long Learning CLA-2- Practice (15%)		Summative Final Examination (40% weightage)	
		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,Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. P. Muthamilselvi, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Sofiya, SRMIST*

Course Code	21CHC505T	Course Name	PROCESS INTEGRATION AND INTENSIFICATION	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:	*outline the meaning, concept and advantages of process integration and process intensification in chemical process industries*
CLR-2:	*expose the learners to process intensification in heat transfer and know about various compact heat exchangers*
CLR-3:	*import the knowledge of hybrid separation techniques*
CLR-4:	*understand the various membrane processes used for process intensification*
CLR-5:	*provide an overview of miniaturization and microfabrication*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the concept of process integration and process intensification, and the benefits of process intensification in chemical process industries*	*2*	*3*	*3*
CO-2:	*design compact heat exchangers*	*3*	*2*	*3*
CO-3:	*apply intensified reactors and/or separators in process industries*	*2*	*3*	*3*
CO-4:	*solve process challenges using intensified technologies*	*3*	*2*	*3*
CO-5:	*analyze scale up/down issues in the process industries and its advantages*	*2*	*3*	*3*

Module-1 - Introduction	**9 Hour**
Chemical process design and integration: Definition, hierarchy, approaches. Process Integration: Industrial applications, current status, classification, techniques and energy management through process integration. Process Intensification: Meaning and concept, history, benefits, toolbox, equipment, methods, techniques, application. Process integration vs process intensification.	
Module-2 - Heat Exchanger Intensification	**9 Hour**
Compact Multifunctional Heat Exchangers: A Pathway to Process Intensification: Compact heat exchangers: Classifications, plate heat exchangers, spiral heat exchangers, flat tube-and fin heat exchangers, micro channel heat exchangers, matrix heat exchangers. Selection of heat exchanger technology. Single phase flow, flow pattern, heat transfer and pressure drop, fouling, phase-change heat transfer, heat and mass transfer. Applications: Feed and effluent heat exchangers, integrated heat exchangers in separation processes, reactor heat exchangers. Pinch technology.	
Module-3 - Reactive and Hybrid Separations and Their Applications	**9 Hour**
Overview of reactive separations, need for integration of reactions and separations, reactive absorption/stripping, reactive distillation, reactive extraction, reactive adsorption, reactive crystallization/precipitation. Case study: Absorption of NOx, Synthesis of methyl tertiary butyl ether. Hybrid separations: Extractive distillation, adsorptive distillation and other hybrid separations.	
Module-4 - Membrane Engineering in Process Intensification	**9 Hour**
Application areas of membrane engineering for the realization of process intensification strategy, Desalination: RO pre-treatment, RO post-treatment. Membrane-based reactive separations: membrane bioreactor. Membrane-based hybrid separations: Membrane distillation, integrated distillation-pervaporation/vapor permeation systems, membrane absorption/stripping, membrane chromatography (adsorptive membranes), membrane extraction, membrane crystallization	
Module-5 - Miniaturization and Microfabrication	**9 Hour**

Process intensification through micro-reaction technology: Effect of miniaturization on unit operations and reactions, implementation of micro-reaction technology; microfabrication of reaction and unit operation devices - wet and dry etching Processes.

Learning Resources	*1. Stankiewicz, A. and Moulijn, "Reengineering the Chemical Process Plants, Process Intensification", "Marcel Dekker", 2003.* *2. Reay D., Ramshaw C., Harvey A., "Process Intensification", "Butterworth Heinemann", 2008* *3. Kamelia Boodhoo. Adam Harvey, "Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing", "Wiley", 2013* *4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián, "Process Intensification in Chemical Engineering Design Optimization and Control", "Springer", 2016*	*5. Reay, Ramshaw, Harvey, "Process Intensification, Engineering for Efficiency, Sustainability and Flexibility", "Butterworth-Heinemann", 2013* *6. Enrico Drioli, Andrzej I. Stankiewicz, Francesca Macedonio, "Membrane engineering in process intensification—An overview", Journal of Membrane Science. 380 (2011) 1– 8.* *7. Robin Smith, "Chemical Process Design and Integration","John Wiley & Sons,Ltd", 2005* *8. https://youtu.be/-uY66EVQksk?si=LIKMjwXQ1ZqVDE9k.*

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%	-	10%	-	15%	-
Level 2	Understand	25%	-	30%	-	25%	-
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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. E. Poonguzhali, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Prabhakar, SRMIST*

ACADEMIC CURRICULA

Chemical Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

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	21CHE551T	Course Name	GREEN 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 chemical, physical, and biochemical methods for waste minimization and recycling, with a focus on sustainability and safety.*
CLR-2:	*learn and integrate the principles of green engineering and green chemistry into chemical processes to enhance sustainability and environmental protection.*
CLR-3:	*explore advanced green process technologies such as sono chemistry, microwave-assisted processes, and carbon capture, emphasizing their role in sustainable engineering.*
CLR-4:	*apply the green engineering principles of process intensification through miniaturization in chemical engineering operations.*
CLR-5:	*learn the environmental impact assessment principles and methodologies of sustainable product design to minimize environmental impacts.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*Implement effective waste minimization techniques and recycling technologies to manage chemical, physical, and biochemical wastes in an environmentally friendly and safe manner.*	*2*	*3*	*3*
CO-2:	*Apply green engineering and green chemistry principles to design and optimize chemical processes that minimize environmental impact and promote sustainability.*	*3*	*2*	*3*
CO-3:	*Utilize advanced green process technologies such as sono chemistry and carbon capture to develop sustainable chemical engineering solutions.*	*2*	*3*	*3*
CO-4:	*Design and operate miniaturized unit operations and apply reactive separation techniques to enhance process efficiency and sustainability.*	*3*	*2*	*3*
CO-5:	*Conduct Environmental Impact Assessments and integrate sustainable product design principles to develop eco-friendly and sustainable products.*	*2*	*3*	*3*

Module-1 - Waste - Resource, Recovery and Management	**8 Hour**
Sources and types of waste - chemical, physical and biochemical methods of waste minimization and recycling - Recycling technologies for plastics, metals, and e-waste. Hazard identification, assessment and safety aspects at process development and design stage. Need for environmental mitigation and energy efficient processes	
Module-2 - Introduction to Green Technology	**9 Hour**
Definition and scope of green technology, Importance of sustainability and environmental protection, Principles of green engineering, Life cycle analysis (LCA), Material selection and eco-design, Regulatory framework and standards for green technology, Principles of green chemistry - an overview of green synthesis and catalysis.	
Module-3 - Green Process Engineering	**10 Hour**
Sono chemistry, Microwave assisted processes, photochemistry, Carbon capture and sequestration technologies, carbon trading, Industrial symbiosis and eco-industrial parks, Solvent selection: Supercritical fluids, ionic liquids, water as a green solvent	
Module-4 - Process Intensification and Miniaturization	**9 Hour**
Principles of intensification by miniaturization, Miniaturization for unit operation – Micromixers, Fluid contactor, heat exchanger reactor, challenges in miniaturization. Reactive separation concept- Heat exchanger reactor design, reactive distillation and its application	
Module-5 - Environmental Impact Assessment and Case Studies	**9 Hour**
Environmental impact assessment (EIA) methodologies, Tools and techniques for impact mitigation, The role of legislation, Barries and drivers, Case studies – Green manufacturing of acetic acid, vitamin	

C, leather tanning, dyes, pesticides, polymers

Learning Resources	*1. M. Lancaster, “Green Chemistry – An introduction text” “RCS” 2002* *2. Martine Poux, Patrick Cognet, Christophe Gourdon, “Green Process Engineering: From Concepts to Industrial Applications”, “CRC Press”, 2015* *3.John Pitchel, “Waste Management Practices Municipal, Hazardous, and Industrial” Second Edition, “Taylor and Francis group”, 2014*	*4.David T. Allen, David R. Shonnard, “Green Engineering: Environmentally Conscious Design of Chemical Processes”, “Pearson Education”, 2001* *5. David Reay, Colin Ramshaw, Adam Harvey, “Process Intensification: Engineering for Efficiency, Sustainability and Flexibility”, Butterworth-Heinemann, second edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	10%	-	15%	-
Level 2	Understand	25%	-	30%	-	25%	-
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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. S. Kiruthika, 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	21CHE552T	Course Name	DATA SCIENCE IN CHEMICAL 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 basic statistics for data science*
CLR-2:	*know the different advanced data structures for data processing*
CLR-3:	*working with various data formats*
CLR-4:	*describe ensemble techniques – supervised and unsupervised machine learning*
CLR-5:	*utilize data analytics options available in python for real-time application development*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*learn measure of central tendency and dispersion*	*2*		*1*
CO-2:	*create and explore different operations on advanced data structures,*	*1*		*2*
CO-3:	*handle different data formats from different sources of data*	*1*		*2*
CO-4:	*apply the basic level supervised learning Techniques with working knowledge*	*2*		*1*
CO-5:	*identify opportunities for the application of data visualization in various domains*		*2*	*1*

Module-1 - Understanding Statistics for Data Science **9 Hour**

Role of statistics in Data science - Different types of data - Measure of Central Tendency - Measure of Dispersion - Distribution of Data - Analysis of Variance - Statistical analysis of Linear and non-linear Regression models - Error analysis -MSE, RMSE, MAE, MAPE. Introduction to Probability - Sampling Techniques – Simple random, Stratified, Systematic and Cluster sampling -Hypothesis Testing – Categorical vs Continuous –- More than 2 samples-examples - Determine the order and rate constant for elementary and non-elementary reactions. Propose the heat and mass transfer coefficient correlations

Module-2 - Introduction to Python **9 Hour**

Introduction to Python programming language - Overview of python Techniques- advantages/ disadvantages - Python IDE installation-windows/Linux And Python IDE overview - Programming basics Variables declaration, operators and indentation - Working with Lists – indexing , slicing, manipulations, operations - Working with Tuples - indexing , slicing, manipulations, operations - Working with Sets - Working with Dictionaries - indexing , slicing, manipulations, operations - Conditional statements-If, If-else, nested if else statements – Loops for and while – when and how to use - User defined functions: Creating functions and calling them - Custom functions: lambda and recursive functions - Introduction to strings - String manipulations - String slicing - Datetime class in python - Manipulation of date time functions - Different class/methods associated with datetime

Module-3 - Dataframe and Series in Python **9 Hour**

Introduction to Pandas - Data structure in pandas – Dataframe and Series - Accessing and slicing of series and dataframes - Arithmetic and logical operations on dataframe - Sorting and filtering of series and dataframes - Joining and merging of Dataframes - Groupby operations on Dataframe - Pivot tables to understand the relationship between variables in the data with different - Crosstab to understand the relationship between variables in the data aggregation - File handling: Reading a file, file functions - Data structure in pandas – Dataframe and Series - Accessing and slicing of series and dataframes - Arithmetic and logical operations on dataframe - Sorting and filtering of series and dataframes - Joining and merging of Dataframes - Groupby operations on Dataframe - Pivot tables to understand the

relationship between variables in the data with different aggregation - Crosstab to understand the relationship between variables in the data.	
Module-4 - Machine Learning	**9 Hour**
Machine learning what and why? supervised and unsupervised learning. supervised Learning - Maximum likelihood estimation – least squares, robust linear expression, ridge regression. supervise Learning Classification models – Applications and examples -Logistic Regression - Construction of Decision Tree - Classification model performance metric - Confusion matrix – TP, TN, FP and FN - Accuracy, Recall, Precision, F1 score. Unsupervised Learning – Concept and applications in Date measures - Clustering Models: K Means Clustering Mathematics behind KMeans - Cluster Visualization. Antoine equation for vapor pressure, Data collection through online acquisition.	
Module-5 - Data Exploration and Visualization	**9 Hour**
Introduction to Explorative Data analysis – Structure vs unstructure, dependent and independent, Numerical vs Categorical. Univariate Analysis of Data - Visualization of univariate analysis - Bivariate Analysis: Types of Bivariate analysis -Choice of different plots - Data Preprocessing Techniques: Need of Data preprocessing - Missing Value Imputation: Reason for Missing values – MCAR, MAR, MNAR. Data Transformations: Need of transforming data - Types of transformation techniques -Data Scaling with example -Identifying the Outlier: Through IQR and Z Score method.	

Learning Resources	*1. Dr. Ossama Embarak Apress, "Data Analysis and Visualization Using Python: Analyze Data to Create Visualizations for BI Systems" "A press"1st ed. Edition, 2018* *2. Suresh Kumar Mukhiya, Usman Ahmed, "Hands-On Exploratory Data Analysis with Python"," Packt Publishing",2020* *3. Glenn J. Myatt, "Making Sense of Data", "Wiley" 2007*	*4.Grus, J. "Data Science from Scratch", "O'Reilly Media, Inc", 2nd Edition 2019* *5. McKinney, W. "Python for data analysis: Data wrangling with pandas, NumPy, and IPython". "O'Reilly Media, Inc.,", 2018.* *6.Vanderplas, J. T. "Python data science handbook: Essential tools for working with data". "O'Reilly Media, Inc.," 2017*

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%	-	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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1.Dr.P. Muthamilselvi, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Suresh, SRMIST*

Course Code	21CHE553T	Course Name	ADVANCED THERMODYNAMICS	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:	*introduce the concepts of statistical thermodynamics to the learners*
CLR-2:	*relate the concepts of classical thermodynamics to statistical thermodynamics*
CLR-3:	*correlate the principles and laws of classical thermodynamics to statistical thermodynamics*
CLR-4:	*delineate chemical equilibrium as per statistical thermodynamics*
CLR-5:	*depict the rates of chemical reactions as per statistical thermodynamics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify statistical-mechanical ensembles and postulates*	*1*	*3*	*2*
CO-2:	*relate classical thermodynamics variables and laws to ensembles*	*1*	*3*	*2*
CO-3:	*apply statistical thermodynamics principles to monoatomic and diatomic gases*	*1*	*3*	*2*
CO-4:	*express statistical thermodynamics for chemical equilibrium of ideal mixtures*	*1*	*3*	*2*
CO-5:	*demonstrate statistical thermodynamics based rates of chemical reaction in ideal mixtures*	*1*	*3*	*2*

Module-1 - Statistical-Mechanical Ensembles and Thermodynamics	**9 Hour**
Ensembles and Postulates, Canonical Ensemble and Thermodynamics, Grand Canonical Ensemble, Microcanonical Ensemble, Entropy, Other ensembles, characteristic equations, Fluctuations	
Module-2 - General Relations for Independent Molecules	**9 Hour**
Thermodynamic equivalence of ensembles, Second law, Criteria for spontaneous change, Systems of distinguishable and indistinguishable particles, Boltzmann Statistics, Translational Partition Function	
Module-3 - Ideal Monoatomic and Diatomic Gas	**9 Hour**
Ideal Monatomic Gas, Density of States, Thermodynamic Functions, Internal Degrees of Freedom, Homonuclear Diatomics, Molecular Partition Functions, Ideal Diatomic Gas, Vibrational, Rotational, Gas of Homonuclear Diatomics at Low Temperature, Quantum Statistics, Polyatomic Molecules	
Module-4 - Chemical Equilibrium in Ideal Mixtures	**9 Hour**
Chemical Equilibrium, General Relations, Statistical Derivation in a Special Case, Fluctuations in a Simple Chemical Equilibrium, Examples of Chemical Equilibria	
Module-5 - Rates of Chemical Reactions in Ideal Mixtures	**9 Hour**
Potential Surfaces, Absolute Rate Theory, A Non-Chemical Application of the Eyering Theory	

Learning Resources	*1. Terrel L. Hill, "An Introduction to Statistical Thermodynamics," "Dover Publications", 2012*	*2. Donald A. McQuarirre , "Statistical Mechanics", "University Science Books Publishers", 2nd Edition, 2000*

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	50%	-	25%	-	25%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	25%	-	50%	-	50%	-
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, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. M. P. Rajesh, SRM IST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. K. Tamilarasan, SRM IST

Course Code	21CHE554T	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:	*understand the concepts and importance of optimization*
CLR-2:	*expose the learners to various methods of optimization*
CLR-3:	*enable the learners to optimize different functions*
CLR-4:	*understand the solution strategy for linear programming problems*
CLR-5:	*familiarize the applications of optimization methods in chemical processes and industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*model the process and optimize the process conditions*	*3*	*2*	*2*
CO-2:	*formulate the objective function, constraints and identify the variables type*	*3*	*2*	*2*
CO-3:	*optimize single variable and multi variable function*	*3*	*2*	*2*
CO-4:	*find the extreme values of functions with different types of constraints*	*3*	*2*	*2*
CO-5:	*understand the applications of optimization principles in process industries*	*3*	*2*	*3*

Module-1 - Nature and Organization of Optimization Problems **9 Hour**

Introduction to optimization concepts, need for optimization in chemical industries, scope and hierarchy of optimization, examples of applications of optimization, essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization, developing models for optimization, classification of models, major activities and phases in model building prior to application, Selecting functions to fit empirical data, procedure to determine the form of a model, typical mathematical forms of models, fitting models and solving problems by least square method, degrees of freedom analysis in model solving, examples of equality and inequality constraints in models, problems based on formulation of equality and inequality constraints in industrial operations.

Module-2 - Objective Function Formulation and Condition for Optimum **9 Hour**

Formulation of the objective function, economic objective functions, time value of money in objective functions, problems based on operating profits and capital costs as objective function, optimum thickness of insulation, optimization involving an integer – valued variable, nonlinear program (NLP) problem statement, NLP geometry, convexity and its applications, convex and concave function, determination of convexity and concavity of functions, positive definiteness and negative definiteness of a function, Hessian matrix and Eigen values concept. Interpretation of the objective function in terms of its quadratic approximation, Necessary and sufficient conditions for an extremum of an unconstrained single variable and multivariable function, mathematical conditions of unimodal and multimodal functions, Problems based on finding extreme values of multi variable functions using partial derivatives

Module-3 - Optimization of Unconstrained Functions: One Dimensional Search and Multivariable Optimization **9 Hour**

Numerical methods for optimizing a function of one variable, Scanning and bracketing procedures, Newton and Quasi-Newton methods of uni-dimensional search, Finite difference approximations to derivatives, polynomial approximation methods – Quadratic interpolation and Cubic interpolation methods, Region elimination methods – Golden section and Fibonacci methods, problems based on optimizing a function of one variable, unconstrained multivariable optimization, Methods using function values – random search, grid search, univariate search, Simplex search method and conjugate search directions, Methods that use first derivatives – steepest descent method and conjugate gradient method, problems on unconstrained multivariable optimization, Newton's method and Quasi – Newton

method for multivariable function optimization, forcing the Hessian matrix to be positive-definite, problems based on Newton and Quasi – Newton method	
Module-4 - Linear Programming and Applications	**9 Hour**
Geometry of linear programs (LP), standard form for linear programs, transformation of linear program into standard form, basic linear programming definitions, concept of equivalent systems and pivoting operations, Simplex algorithm, canonical form and test for optimality, degeneracy and unboundedness in LP, iterative solution of an LP problem, graphical representation and solution of LP problems, problems based on Simplex algorithm for LP problems, non – linear programming (NLP) with constraints, direct substitution method, graphic interpretation of constrained optimization problem, Lagrange multipliers concepts and problems, first order necessary conditions for an extremum, problems containing only equality constraints, sensitivity interpretation of Lagrange multipliers, Kuhn-Tucker conditions for inequality constraints - geometrical interpretation, and algebraic statement, problems containing both equality and inequality constraints, second-order necessary and sufficiency conditions for optimality	
Module-5 - Applications of Optimization	**9 Hour**
Examples for optimizing heat transfer rate and energy conservation in chemical plants, case studies and examples, Optimal Shell-and-Tube heat exchanger design, Optimization of a multi-effect evaporator, optimization of flow rates in a liquid-liquid extraction column, fitting vapor-liquid equilibrium data via nonlinear regression, optimal pipe diameter, minimum work of compression, economic operation of a fixed bed filter, modeling and optimization of chemical reactors, optimization of a thermal cracker via linear programming, optimal design of an ammonia reactor, optimization in large scale plant design and operations, process simulators and optimization codes, optimization using equation-based process simulators, optimization using modular – based simulators, plant optimization hierarchy	

Learning Resources	*1.Thomas F. Edgar, David Mautner Himmelblau, Leon S. Lasdon, "Optimization of chemical processes","McGraw-Hill", 2nd edition, 2001.* *2. Rao S.S., "Optimization: Theory and Applications", "Wiley Eastern", New Delhi, 2nd Edition. 1984.*	*3. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., "Engineering Optimization", "John Wiley", New York, 2006, ISBN-13 9780471558149* *4.Suman Dutta, "Optimization in Chemical Engineering", "Cambridge University Press", 1st 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	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., Chennai	*1. Dr. Lima Rose Miranda, Former Professor, Anna University, Chennai*	*1. Dr. M. Magesh Kumar, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Vishali, SRMIST*

Course Code	21CHE555T	Course Name	ARTIFICIAL INTELLIGENCE IN PROCESS 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:	*analyze the various characteristics of Intelligent agents*
CLR-2:	*organize different search strategies in AI*
CLR-3:	*incorporate knowledge in solving AI problems*
CLR-4:	*construct in different ways of designing software agents*
CLR-5:	*plan various applications of AI*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*use appropriate search algorithms for any AI problem*	*2*		*1*
CO-2:	*represent a problem using first order and predicate logic*	*1*		*2*
CO-3:	*provide the apt agent strategy to solve a given problem*	*2*		*1*
CO-4:	*design software agents to solve a problem*	*2*		*1*
CO-5:	*develop application that uses Artificial Intelligence*	*1*		*2*

Module-1 - Introduction **9 Hour**

What is Artificial Intelligence? Types of problems AI addresses like Computer Vision, Natural Language Processing, Robotics, Expert Systems, Object detection and Image segmentation. Applications of AI in chemical engineering areas like fault diagnosis, Process control, Process design, Planning and operations, Modeling and simulation and Product design, development and selection like Separation Design, Heat-Exchanger Network Synthesis, Thermodynamic Model Selection and Physical Property Estimation, Oil reservoir image segmentation, Corrosion and crack predictions based on image detection. Early applications of AI techniques in chemical engineering. The FALCON, CATDEX, BIOEXPERT and the ExSep algorithms

Module-2 - Deep Artificial Neural Networks **9 Hour**

Deep Artificial neural networks (DNN). The working of the Rosenblatt perceptron, multilayer perceptrons. Activation functions and their importance in incorporating nonlinearities into the predictive models. The feedforward process in ANN layers with dense fully connected layers. The error (loss) functions as a measure of the ANN performance. Backpropagation algorithm for neuron learning. Various optimization algorithms for neuron learning like Adams, Stochastic Gradient Descent and their variations. The role of learning rate in backpropagation and learning rate scheduling algorithms

Module-3 - Convolution Neural Networks (CNN) **9 Hour**

The drawbacks of Deep ANN. How CNN take into account the spatial patterns. The working of the CNN in pattern recognition. The role of kernels, pooling, padding and stride in CNN learning. How the kernels help in reducing the learning parameters (weight sharing). One, two and three dimensional convolutions. The problems of vanishing and exploding gradients in deep networks. The concept of dropouts and batch renormalization in overcoming some problems in CNN learning.

Module-4 - Sequence Modeling using the Recurrent Neural Networks (RNN) **9 Hour**

The application of this architecture in predictions based on sequential data. Various RNN architectures proposed like many to one, One to many and Many to many. The variants of RNN like Gated Recurrent Units (GRU) and the Long Short Term Memory (LSTM) architectures. Object Detection with the R-CNN, Fast and Faster R-CNN algorithms. The working of the YOLO algorithm.

Module-5 - Case Study	**9 Hour**
Some outstanding deep networks proposed like AlexNet, VGGNet, Inception, GoogleNet and ResNets. The problems they faced and how they resolved the problems. The concept of Transfer Learning and how one can use these proposed networks to solve other relevant problems. Autoencoders for dimensionality reduction.	

Learning Resources	*1. Raff, Edward, "Inside Deep Learning: Math, Algorithms and Models", " Manning Publications", 2022.* *2. Quantrile, Thomas, Liu, Y. A, "Artificial Intelligence in Chemical Engineering", "Academic Press", 1991.*	*3. Ian Goodfellow, Yoshua Bengio, Aaron Courville. "Deep Learning. (Adaptive Computation and Machine Learning series)". 2015.* *4. Deepak Khemani, "A First Course in Artificial Intelligence", "McGraw Hill Education", 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*	*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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Suresh, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. P. Muthamilselvi, SRMIST*

Course Code	21CHE556T	Course Name	STRATEGIES FOR CO_2 UTILIZATION	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 sources of CO_2 emission along with its physical and chemical properties*
CLR-2:	*exploit on the methods of CO_2 capture, storage and conversion*
CLR-3:	*comprehend on various biological carbonization methods*
CLR-4:	*understand various techniques of thermo and electrocatalytic conversion of CO_2*
CLR-5:	*analyze the carbon capture by renewable energy-based process*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the sources and treatment strategies for CO_2 reduction*	*3*		*2*
CO-2:	*analyze the methods of CO_2 capture and sequestration methods*	*3*	*2*	
CO-3:	*develop the biological methods to carbonize CO_2*	*3*	*2*	
CO-4:	*illustrate the method of thermocatalytic and electrocatalytic conversion of CO_2*	*3*		*3*
CO-5:	*illustration of carbon capture by solar, photocatalytic and plasma activated process*	*2*		*3*

Module-1 - Introduction to CO_2 Related Pollution Sources	**9 Hour**
Sources of Carbon Dioxide Emission-Physical and Chemical Properties of CO_2-Challenges for Treatment of Carbon Dioxide Emission-Treatment Strategies for CO_2	
Module-2 - Conventional Techniques of Carbon Capture	**9 Hour**
Methods for Carbon Dioxide Capture, Physical and Chemical Separations and Concentrate Technologies- Transportation of Captured CO_2-CO_2 Sequestration Methods-Direct Utilization of CO_2, Storage of CO_2	
Module-3 – Non- Conventional Techniques of Carbon Capture	**9 Hour**
Carbon Capture by Mineral Carbonation and Production of Construction Materials-Methods of Carbonation-Challenges and Perspectives for Carbonation Processing- Biological Conversion of Carbon Dioxide-Photosynthetic CO_2 Reduction by Algae-Green Algae-Microalgae-Biorefinery Concept of Microalgal Biomass	
Module-4 - CO_2 Conversion by Conventional Techniques	**9 Hour**
CO_2 Conversion to Fuels and Chemicals by Thermal and Electro-Catalysis – Principle, Developments and future scope on thermo and electro catalysis	
Module-5 - CO_2 Conversion by Novel Techniques	**9 Hour**
Carbon Dioxide Conversion Using Solar, Thermal and Photo Catalytic Processes. Plasma-Activated Catalysis for CO_2 Conversion	

Learning Resources	1. Yatish T. Shah, "Sustainable Energy Strategies book on CO_2 Capture, Utilization, and Sequestration Strategies", "Taylor and Francis", CRC PRESS, First edition, 2022 2. Dr. Sonil Nanda, Dai-Viet N. Vo, Van-Huy Nguyen, "Carbon Dioxide Capture and Conversion: Advanced Materials and Processes", "Elsevier" 2022,	3. Zhicheng Zhang, Wiley-VCH Verlag, "CO_2 Conversion and Utilization - Photocatalytical and Electrochemical Methods and Applications", "Wiley", First edition, 2023

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%	-	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, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1.Dr. G.Keerthiga, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2.Dr. S. Anandhakumar, SRM IST

Course Code	21CHE557T	Course Name	MODERN SEPARATION PROCESSES	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:	*outline the modern processes applied in the separation of various components from different phases based on size, physical, chemical characteristic, ionic, thermal principles.*
CLR-2:	*provide an overview of the concepts of membrane separation techniques*
CLR-3:	*expose the learners to know the separation by sorption techniques*
CLR-4:	*import the knowledge of various chromatographic techniques*
CLR-5:	*understand the various other techniques involved in separation process*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*appreciate the importance of the concepts involved in separation methods and understand the need for modern separation process*	*2*	*3*	*3*
CO-2:	*understand the working mechanism of various membrane separation processes and their application*	*3*	*2*	*3*
CO-3:	*recognize the mechanism of adsorption and design the fixed bed adsorber*	*3*	*2*	*3*
CO-4:	*recognize the various chromatographic techniques used for analysis and separation*	*2*	*3*	*3*
CO-5:	*understand the advanced extraction techniques and other methods used for separation*	*2*	*3*	*3*

Module-1 – Separation Processes **9 Hour**

Batch, continuous and semi continuous process, key operation and auxiliary operation, block flow diagram, process flow diagram, mechanism of separation, general separation process, characteristics of separation processes, separating agent, energy-separating-agent vs. mass-separating-agent processes, categorizations of separation processes, mechanical vs. diffusional processes, equilibration processes vs. rate-governed processes. Basic separation techniques: Separations by phase addition, phase creation, barriers, solid agents, external field or gradient. Component recoveries and product purities, split fractions and split ratios, purity and composition designations, separation sequences, separation factor, selection of feasible separation process. Conventional separation processes-limitations – need for modern separation processes.

Module-2 - Membrane Separations **9 Hour**

Membrane: classification. Membrane separation processes: classification, advantages and limitations. Membrane modules, concepts and mechanism of separations. Mechanism and applications of microfiltration, ultrafiltration, nanofiltration, Reverse Osmosis. SWRO, pretreatment and post treatment, design of RO plant. Mechanism and applications of dialysis & electrodialysis. Design of ED Unit

Module-3 - Adsorption and Ion Exchange **9 Hour**

Adsorption: types, mechanism, industrial Applications; Adsorbents: characteristics, properties, selection, types, preparation and activation methods. Adsorption isotherms (Freundlich, Langmuir, BET); Principle and applications of: Pressure swing adsorption and thermal swing adsorption. Regeneration methods. Fixed bed adsorption: Design, Mass Transfer Zone (MTZ), breakthrough curve, length of unused bed (LUB). Ion Exchange, ion exchange equilibria, ion exchange resins, separation factors in ion exchange, ion exchange in a column, mixed bed exchanger, regeneration of resins.

Module-4 - Chromatography **9 Hour**

Chromatography basic principle - static/mobile phase, Classification of chromatographic systems, general description of a column chromatography, partition coefficient, retention time, retention volume, capacity factor, retention ratio, relative retention, column efficiency, resolution, peak asymmetry, column processes and band broadening, extra column broadening, LC, HPLC, GC, planar

chromatographic techniques- paper chromatography, thin layer chromatography, high performance thin layer chromatography, preparative chromatography, ion exchange chromatography, applications of chromatographic techniques	
Module-5 - Other Separation Techniques	**9 Hour**
Advanced methods of extraction- ultrasound-assisted extraction, microwave-assisted extraction, super critical fluid extraction, emulsion liquid membrane, supported liquid membrane. Pervaporation, permeation, membrane distillation, forward osmosis, lyophilization	

Learning Resources	*1.J.D. Seader, Ernest J Henley and D. Keith Roper, "Separation Process Principles – Chemical and Biochemical Operations", "John Wiley & Sons", United States of America, 3rd edition, 2011.* *2.Kaushik Nath, "Membrane Separation Processes", "PHI Learning Private Limited", New Delhi, Second Edition 2017.* *3. K V Narayanan and B Lakshmikutty, "Mass Transfer Theory and Applications," CBS Publishers and Distributers Private Limited", First Edition New Delhi, 2018.* *4.Binay K. Dutta, "Principles of Mass transfer and Separation Processes", "Prentice- Hall of India", New Delhi, 2011*	*5.C. J. King, "Separation Processes", "Mc Graw Hill", Second Edition, USA, 1980.* *6. Ronald W. Roussel, "Handbook of Separation Process Technology" "John Wiley", New York, 1987.* *7. Richard W. Baker, "Membrane Technology and Applications", "John Wiley", England, Second Edition 2004.* *8.B. Sivasankar, Bioseparations, "Principles and Techniques", "Prentice Hall of India Pvt. Ltd", New Delhi, 2010* *9.M. Mulder, "Basic Principles of Membrane Technology", "Kluwer Academic Publishers", Netherlands, 1996.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	10%	-	15%	-
Level 2	Understand	25%	-	30%	-	25%	-
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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. E. Poonguzhali, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Prabhakar, SRMIST*

Course Code	21CHE558T	Course Name	FLUIDIZATION 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:	*establish the foundational understanding of fluidization and its role in chemical engineering processes*
CLR-2:	*explore the practical applications of fluidized bed technology across various industrial sectors*
CLR-3:	*investigate the characteristics of fluidization regimes and their mapping*
CLR-4:	*analyze the operational aspects and characteristics of fluidized beds*
CLR-5:	*introduce mathematical models for simulating fluidized bed behavior*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the principles underlying different fluidized bed models and their assumptions.*	*2*		*3*
CO-2:	*apply CSTR models and two-region models to simulate fluidized bed behavior under various operating conditions.*	*1*		*2*
CO-3:	*evaluate the accuracy and limitations of fluidized bed models in predicting bed performance.*	*3*		*1*
CO-4:	*utilize the Kunii-Levenspiel model to optimize fluidized bed reactor design and operation.*	*2*		*3*
CO-5:	*demonstrate proficiency in using mathematical modeling software to simulate and analyze fluidized bed systems.*	*2*		*3*

Module-1 - Introduction to Fluidization Phenomenon	**9 Hour**
Introduction: Fluidization phenomenon, Liquid-like behavior of a fluidized bed	
Module-2 - Industrial Applications of Fluidized Beds	***9 Hour***
Industrial Applications: Physical operations, Synthesis reaction, cracking of hydrocarbons, Combustion, Incineration, and gasification	
Module-3 - Fluidization and Mapping of Regimes	**9 Hour**
Fluidization and Mapping of Regimes: Distributors, Gas jets in fluidized beds, Pressure drop in fixed beds, Geldart classification of particles, Gas fluidization with and without entrainment, Mapping of fluidization regimes.	
Module-4 - Fluidized Beds and Their Characteristics	**9 Hour**
Fluidized Beds: Dense beds, Bubbling fluidized beds, Entrainment from fluidized beds, High velocity fluidization, Solids mixing, segregation, and staging, Gas dispersion and Interchange in bubbling beds, Heat and mass transfer, Industrial applications.	
Module-5 - Fluidized Bed Models	**9 Hour**
Fluidized Bed Models: CSTR model, two region model, Kunii-Levenspiel model	

Learning Resources	*1.Kunii, D., Levenspiel, O. and Robert, E., "Fluidization Engineering", "Butterworth-Heinemann", 1991.* *2.Coulson, J.M., and Richardson, J.F., "Chemical Engineering", "Asian Books Private Limited", Vol. 2, , 2002.*	*3.Yates, J.G., "Fundamentals of Fluidized Bed Chemical Processes", "Butterworth-Heinemann" Butterworth's Monographs in Chemical Engineering, 1983.* *4.Yang, W. and Amin, N.D., "Fluidization engineering: fundamentals and applications", "American Institute of Chemical Engineers",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%	-	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, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. S. Sam David, SRM IST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr.K.Suresh, SRM IST

Course Code	21CHE559T	Course Name	BIOMASS CONVERSION AND BIO-REFINERY	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:	*examine the significance of bioenergy and the availability of biomass resources utilization in bio refinery process*
CLR-2:	*elucidates effective methods for the fractionation and conversion of the biomass feedstock.*
CLR-3:	*decipher an understanding on the biofuels production from biomass by biochemical process*
CLR-4:	*comprehend the importance and production of various platform chemicals with commercial significance*
CLR-5:	*apprehend the photocatalytic process for the production of fuels and chemicals with industrial importance*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand basic concepts about biomass derived energy*	*1*	*3*	*1*
CO-2:	*understand and evaluate various biomass pre-treatment and thermochemical conversion techniques*	*3*	*2*	*3*
CO-3:	*able to understand the various biochemical techniques in biomasses conversion*	*2*	*3*	*2*
CO-4:	*ability to design a sustainable bio refinery for biofuels and biochemical production by combining various processes*	*2*	*3*	*2*
CO-5:	*accomplish knowledge on the various engineering basics of photocatalytic techniques in bio refinery process*	*3*	*2*	*2*

Module -1 – Biomass Resources	**7 Hour**
Importance of Bioenergy and bio-fuels, Global and Indian scenario, Availability of biomass, composition and energy potential, waste biomass (municipal, industrial, agricultural and forestry) availability. First, second and third generation biofuels and biomass as energy resources. Oil crops and microalgae as feedstock for biofuels and biochemical productions. Advantages and Challenges of Using Agro-industrial Wastes as the Feedstock for Bio refinery, Agro-industrial Waste Biorefinery: Engineering Breakthroughs, Enhancing biomass properties for biofuels productions, and challenges	
Module-2 - Thermo-Chemical Conversion	**10 Hour**
Biomass pre-processing: size reduction and densification, Fundamentals of thermal conversion process: pyrolysis, gasification, combustion, hydrothermal liquefaction. Biofuel productions from oils, microalgae and seaweeds production. Barriers in lignocellulose biomass conversion, different pre-treatment technologies in the bio refinery concept.	
Module-3 - Biochemical Conversion	**10 Hour**
Lignocellulosic biofuels, direct fermentation for ethanol and butanol production. Biogas plants/systems; classification and models of biogas plant; Types of bio-digesters; floating and fixed dome reactors; Design concept and construction of biogas plant. Bio hydrogen generation from biomass feedstock's, Integration process for bio hydrogen with fuel cell system. Enzymes in Biorefinery, Pretreatment Process in Biorefinery, Enzyme Technology in Bio refineries.	
Module-4 - Bio Refinery-Based Platform Chemicals	**10 Hour**
Platform Chemical for Biofuel and High-Value Biochemicals, Potential C3 and C4 Platform Chemicals production, Process Development Strategies for Enhanced chemicals Production, Application Aspects of C3 and C4 chemicals. Potential of C5 Platform Chemicals and Process Development Strategies, Potential Applications and Market Potential of C5 Platform Chemicals.	
Module-5 - Photo Bio-Refinery Concept	**8 Hour**

Types of photo catalyst, Photocatalytic reactor development, Photo thermal system, Photocatalytic Reforming of Biomass; Photo biorefinery Routes for platform Chemicals and hydrogen Production

Learning Resources	1. Alain A. Vertès, Nasib Qureshi, Hans P. Blaschek, Hideaki Yukawa, "Biomass to Biofuels: Strategies for Global Industries", "John Wiley & Sons, Ltd", 2010 2. Satinder Kaur Brar, Saurabh Jyoti Sarma, Kannan Pakshirajan, "Platform Chemical Biorefinery, Future Green Chemistry", "Hardback", 1st Edition, ISBN: 9780128029800	3. Hongzhang Chen., "Lignocellulose Biorefinery Engineering - Principles and Applications", "Elsevier Inc Publishers", 2015.

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%	-	30%	-	20%	-
Level 2	Understand	20%	-	40%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	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, 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.S.Kiruthika, SRM IST

Course Code	21CHE560T	Course Name	ADVANCED BIOCHEMICAL 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:	*analyze and compare various bioreactors and accessory 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 process design of biotechnology processes and techno-economic analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*evaluate and select bioreactors based on bioprocess requirements*	*1*	*3*	*1*
CO-2:	*demonstrate ability to scale-up of bioreactor in industrial bioprocesses*	*3*	*2*	*3*
CO-3:	*understand and apply control systems for maintaining optimal bioreactor conditions to enhance bioprocess efficiency*	*2*	*3*	*2*
CO-4:	*integrate knowledge of cell disruption, separation, isolation, and purification techniques for efficient bioprocessing*	*2*	*3*	*2*
CO-5:	*develop bioprocesses incorporating sustainability and techno-economic analysis concept*	*3*	*2*	*2*

Module-1 - Overview of Biochemical Process	**7 Hour**
General requirements of biochemical process, Upstream process unit operation, Downstream unit operation, Components - of bioreactor - Classification and configuration of bioreactors - Analysis of batch bioreactors - Analysis of batch bioreactors - Analysis of continuous flow bioreactors	
Module-2 - ***Mass and Heat Transfer in Bioprocess Scale-Up***	**10 Hour**
Biochemical reactor scale-up - Transport phenomena in Bioprocess - systems - Gas-liquid mass transfer - Determination of oxygen transfer rates - Measurement of kLa - Measurement of kLa - Key dimensionless groups - Correlations for mass transfer co-efficients and interfacial area - Overall kLa estimates and power requirement for sparged and agitated vessels - Overall kLa estimates and power requirement for sparged and agitated vessels - Heat transfer - Heat transfer correlations - Scaling of mass transfer equipment - Scaling of mass transfer equipment - Regime analysis of Biochemical reactor processes - Regime analysis of Biochemical reactor processes - Scale-up criteria for bioreactors based on oxygen transfer and power consumption - Scale-up criteria for bioreactors based on oxygen transfer and power consumption	
Module-3 - Bioreactor Monitoring and Control	**10 Hour**
Instrumentation control of bioreactors - Measurement of physical and chemical parameters in bioreactors - Bioreactor sensor s 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 - Application of biosensors	
Module-4 - Biomolecule Recovery and Purification	**10 Hour**
Product recovery operation - Separation of biomolecules - Cell disruption for release of products - 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; Filtration - Centrifugation - Centrifugation - Product isolation - Product isolation, Adsorption - Liquid-	

liquid extraction - Product purification- Chromatography - Product purification- Chromatography	
Module-5 - Economic Analysis of Bioproducts	**8 Hour**
Techno-economic analysis: Techno-economic assessment of biofuels and value added products in industrial process, Process design, Equipment sizing, Capital cost estimation, Operating cost estimation, Cash flow analysis	

Learning Resources	*1.Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals", "McGraw– Hill", 2nd edition, 1988.* *2.Shuler, M.L. and Kargi, F. "Bioprocess Engineering: Basic Concepts", "PHI", 2002.*	*3. Magnus Frohling, Michael Hiete,"Sustainability and Life Cycle Assessment in Industrial Biotechnology", "Springer", 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%	-	30%	-	20%	-
Level 2	Understand	20%	-	40%	-	20%	-
Level 3	Apply	30%		30%	-	30%	-
Level 4	Analyze	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, 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. M.P. Rajesh, SRM IST*

Course Code	21CHE561T	Course Name	CLEANER TECHNOLOGIES AND SUSTAINABILITY	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:	*elaborate the concepts of clean technology to achieve sustainability*
CLR-2:	*provide acquaintance with modern, cleaner production processes and emerging energy technologies*
CLR-3:	*facilitate the understanding of the need for clean technologies in power generation*
CLR-4:	*familiarize the concepts of energy audit*
CLR-5:	*comprehend the applications of cleaner production in chemical process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the environmental pollutants, comprehend the concepts of clean technology and cleaner production*	*2*		
CO-2:	*apply the cleaner production assessment and waste management techniques*	*2*	*3*	
CO-3:	*develop and implement clean technologies for power generation*	*2*		*2*
CO-4:	*conduct the energy audit and prepare the energy audit report*	*2*	*3*	
CO-5:	*apply cleaner production in chemical process industries*	*3*	*3*	*2*

Module-1 - Sustainability	**9 Hour**
Sustainability and biodiversity, the problem of environmental pollutants, clean technology and clean-up technology, environmental life cycle assessment, materials reuse: the new industrial ecology, cleaner production definition, evaluation of cleaner production, cleaner production network, and the area covered by cleaner production. Role of cleaner production in achieving sustainability, role of industry, institutions, and Government. Outline about greenhouse gas emission.	
Module-2 - Cleaner Production	**9 Hour**
Overview of cleaner production assessment steps and skills, preparing for the site visit, information gathering, and process flow diagram, material balance, waste reduction at source. Practical techniques for waste minimization: good housekeeping; input material changes; product changes; technical changes, recycling: on-site and off-site recovery.	
Module-3 - Clean Technologies for Power Generation	**10 Hour**
Environmental Issues, emission control in power plants: pre-combustion controls; combustion control techniques; post-combustion technologies, clean power plant configurations: Integrated Gasification Combined Cycle (IGCC) Power Plant. Production of hydrogen: steam reforming, partial oxidation, water electrolysis: reverse fuel cell operation, direct thermal or catalytic splitting of water. Fuel cell: electrochemistry and thermodynamics of fuel cells; proton exchange membrane fuel cell. Use of clean fuels.	
Module-4 - Energy Audit	**7 Hour**
Types of energy audit, energy audit process: pre-site work; site visit; and post-site work, energy audit report preparation, energy conservation via cleaner technology	
Module-5 - Case Studies and Cleaner Production Applications	**10 Hour**
Application of cleaner production in chemical process industries: Ammoniacal nitrogen recovery from wastewater, carbon capture, reuse of water from the sewage treatment plant, practical ways for energy saving in industries, sustainable aviation fuel. Case Studies of cleaner production in chemical process industries	

Learning Resources	1.R.C. Kirkwood and A.J. Longley, "Clean Technology and the Environment", "Chapman & Hall", 2012. 2.P. M. Randall, "Engineers Guide to Cleaner Production Technologies", "CRC Press" 1st edition 1996. 3.W. Hoyle and M. Lancaster, "Clean Technology for the manufacture of Specialty Chemicals", Royal Society of Chemistry, 2004.	4. Bent Sorensen, "Hydrogen and Fuel Cells: Emerging technologies and applications", "Elsevier Academic Press", 3rd edition, 2018. 5. Albert Thumann P.E., William J. Younger, "Handbook of energy audits", "Fairmont Press", 9th 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	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, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. E.Kavitha, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr.K.Anbalagan, SRM IST

Course Code	21CHE562T	Course Name	NANOSCIENCE AND NANOTECHNOLOGY	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 types of nanomaterials based on their composition*
CLR-2:	*understand the approaches for synthesizing nanomaterials*
CLR-3:	*explain the concepts of different characterization tools and techniques*
CLR-4:	*familiarize the role of nanosensors*
CLR-5:	*gain insight into the diverse applications of nanotechnology*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the properties of different nanomaterials*	*3*		
CO-2:	*elaborate the principles of different synthesis strategies*	*2*		*1*
CO-3:	*choose the appropriate method of characterization*	*2*		*1*
CO-4:	*illustrate the working mechanism of nanosensors*	*2*		*1*
CO-5:	*comprehend the applications of nanotechnology in various fields*	*2*		*1*

Module-1 - Types of Nanomaterials	**9 Hour**
Metal nanoparticles, Semiconductor nanoparticles, Magnetic nanoparticles, Organic nanoparticles, Carbon- based nanomaterials - Carbon dots, carbon nanotubes, graphene, Polymeric nanoparticles, Hydrogels, Dendrimers, Nanocomposites	
Module-2 - Approaches for the Synthesis of Nanomaterials	**9 Hour**
Physical approaches - Photolithography, Optical lithography, Chemical approaches - Precipitation, Co-precipitation, Sol-gel synthesis, Microemulsions, Solvothermal synthesis, Thermolysis, Microwave assisted synthesis, Sonochemical synthesis, Photochemical synthesis, Synthesis in supercritical fluids, biological approaches	
Module-3 - Characterization of Nanomaterials	**9 Hour**
X-ray diffraction, Transmission electron microscopy, scanning electron microscopy, Scanning probe microscope (AFM and STM), Small Angle X-ray scattering, Vibrating Sample Magnetometry, Electron Spin Resonance, UV-Visible Spectrophotometer; FT-IR Spectrophotometer; Micro-Raman Spectrometer, Dynamic light scattering	
Module-4 - Nanosensors	**9 Hour**
Sensing principles, Types of sensors - Mechanical, acoustic, magnetic, thermal, chemical, radiation, Design, fabrication and characterization of nanosensors, Chemical nanosensors, Optical nanosensors, Nanobiosensors	
Module-5 - Applications of Nanotechnology	**9 Hour**
Everyday materials and processes, Electronics and Information Technology, Medicine and Healthcare, Energy, Environment, Future transportation	

Learning Resources	*1. Geoffrey A. Ozin, Andre C. Arsenault, "Nanochemistry: A Chemical Approach to Nanomaterials", Royal Society of Chemistry, Cambridge, UK, 2005.* *2. C. N. R. Rao, Achim Muller, A. K Cheetham, "Chemistry of nanomaterials : Synthesis, properties and applications" , "Wiely-VCH", 2004* *3. Daniel L. Fedlheim, Colby A. Foss, Marcel Dekker, "Metal Nanoparticles: Synthesis Characterization & Applications", 2002* *4. Cao Guozhong, ying Wang, "Nanostructures and Nanomaterials - Synthesis, Properties and Applications", "World Scientific", 2011.*	*5. N. John DiNardo, "Nanoscale Characterization of Surfaces and Interfaces", "Wiley", 2008.* *6. B. D Cullity, S.R. Stock, "Elements of X Ray Diffraction", "Prentice Hall", 2001.* *7.Yang Leng,"Materials Characterization: Introduction to Microscopic and Spectroscopic Methods", "John Wiley & Sons", 2013.* *8. Vinod Kumar Khanna, "Nanosensors: Physical, Chemical, and Biological", "CRC", 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	20%	-	20%	-	10%	-
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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE563T	Course Name	COLLOIDS AND SURFACES	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 concepts of surface, inter particle and inter molecular forces*
CLR-2:	*familiarize the concepts of surface wetting, flotation and electrokinetic properties of colloids*
CLR-3:	*understand the concepts of adsorption, monolayer and multilayer film formation on surfaces*
CLR-4:	*formation of gels, foams, aerosols and emulsions, and their characterization*
CLR-5:	*understanding various applications of colloids in different chemical industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the concepts of colloid chemistry using surface forces and electrochemical double layers*	*3*		*1*
CO-2:	*understand the concepts of wetting and their role in flotation and aggregation*	*2*		*1*
CO-3:	*understand the concepts of self-assembly process and formation of various colloidal structures*	*2*		*1*
CO-4:	*characterization of different colloidal structures*	*1*		*2*
CO-5:	*application of colloids in petrochemical, paint, food, pharma, and cosmetic industries*	*2*		*1*

Module-1 - Theory and Colloidal Stability	**9 Hour**
Introduction to Colloids—Surface Free Energy, Surface Tension, Contact Angle and Young-Laplace Equations and Surface Potential—Surface Forces: Double Layer Forces, Van der Waal's Forces, Steric Forces, and Hydration Forces—Colloidal Stability—Gecko Effect.	
Module-2 - Wetting and Electrokinetics	**9 Hour**
Wetting of Surfaces by Liquids—Lotus Effect—Flotation—Aggregation and Flocculation—Detergency—Friction and Lubrication—Electroosmosis—Electrophoresis—Dielectrophoresis	
Module-3 - Adsorption and Self Assembly	**9 Hour**
Adsorption from Liquids and Gases (including Polymers, Polyelectrolytes and Formation of Polyelectrolyte Complexes)—Surface Films on Liquid and Solid Substrates—Monomolecular Films, Langmuir-Blodgett Films, and Layer-by-Layer Assembled Films—Solution behavior of Micelles, Vesicles, Polyelectrolytes and Free Standing Films.	
Module-4 - Dual Systems and Characterization of Colloids	**9 Hour**
Formation of Gels, Emulsions, Foams and Aerosols—Characterization of Colloids: Zeta Potential and Size, Optical Microscopy, UV-Visible Spectroscopy, Scanning Electron Microscopy and Transmission Electron Microscopy.	
Module-5 - Industrial Applications	**9 Hour**
Exploring the Potential Applications of Colloids and Surface Chemistry in Petrochemical, Paint, Food, Pharma, and Cosmetic Industries.	

Learning Resources	*1.Drew Myers, "Surfaces, Interfaces, and Colloids: Principles and Applications". "Wiley-VCH", 2nd Ed., 2002.* *2.D. J. Shaw, "Colloid & Surface Chemistry", "Butterworth-Hienemann", 4th Edition,1992.* *3.Jacob N. Israelachvili, "Intermolecular and Surface Forces", "Academic Press" Third Edition, 2011.*	*4. Rodney Priestley and Robert Prud'homme, "Polymer Colloids: Formation, Characterization and Applications", Royal Society of Chemistry, 2019.* *5. Tharwat F. Tadros, "Handbook of Colloid and Interface Science, Volume 4: Industrial Applications: Agrochemicals, Paints, Coatings and Food Systems", "De Gruyter", 2018.* *6. Tharwat F. Tadros, "Handbook of Colloid and Interface Science, Volume 3: Industrial Applications: Pharmaceuticals, Cosmetics, and Personal Care", "De Gruyter", 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	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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE564T	Course Name	INTERFACIAL SCIENCE AND 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 concepts of surface forces, adhesion, cohesion, wetting and adsorption isotherms*
CLR-2:	*familiarize the concepts of colloidal stability, rheology and optical properties of colloids*
CLR-3:	*understand the concepts of self assembly, their kinetics, and formation of colloidal structures*
CLR-4:	*investigation on interactions and confinements at engineered interfaces and surfaces*
CLR-5:	*understanding the concepts of interfacial phenomenon in chemical and biological separations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding the surface forces and adsorption isotherms of colloids*	*3*		*1*
CO-2:	*understand the concepts of colloidal stability, optical and rheological properties of colloids*	*2*		*1*
CO-3:	*understand the concepts of self assembly process and formation of various colloidal structures*	*2*		*1*
CO-4:	*investigation of ion and molecular confinements at engineered surfaces, and their adsorption and desorption kinetics*	*1*		*2*
CO-5:	*the role of interfacial phenomenon in chemical and biological separations*	*2*		*1*

Module-1 - Surface Forces and Adsorption Isotherms of Colloids	**9 Hour**
Introduction to Intermolecular Forces and Interparticle Forces, and Hamaker Constant—Contact Angle and Marangoni Flow—Adhesion, Cohesion, Wetting and Spreading—Adsorption at Interfaces—Physisorption and Chemisorption—Gibbs free energy—Gibbs, Langmuir and BET Isotherms, and Surface Area Calculations.	
Module-2 - Stability, Optical and Rheological Properties of Colloids	**9 Hour**
Colloidal Stability—DLVO Theory—Types of Aggregation, Sedimentation and Kinetics—Smoluchowski Equation—Optical Properties: Theories, Scattering by large and Small Particles and Turbidity—Rheological Properties: Viscosity, Newtonian/Non-Newtonian Fluids and Electroviscous Effects.	
Module-3 - Formation and Kinetics of Colloidal Structures	**9 Hour**
Introduction to Surfactants, Micelles and Self-Assembly—Nucleation, Flocculation and Oswald Ripening—Kelvin Equation—Foams, Gels and Aerosols: Their Preparation and Stability, Mechanisms of Breakup Under Shear and Rheological Properties—Polymers at Interfaces, Blends, Composites and Polymeric Surfactants.	
Module-4 - Interactions and Confinements at Engineered Interfaces and Surfaces	**9 Hour**
Introduction to Chemical Process Systems—Complex Interactions of Ions and Molecules at Engineered Surfaces —Adsorption, Desorption Kinetics Within Common Chemical Engineering Processes—Nanoconfinement at Interfaces—Theory and Approaches of Investigation of Transport and Thermodynamic Properties Within Nanopores at Engineered - Porous Surfaces in Common Chemical Engineering Processes.	
Module-5 - Interfacial Phenomenon in Chemical and Biological Separations	**9 Hour**

Estimation of Mass Separating Agents at Industrial Scales (E.g., Sorbents and Membranes)—Field Induced Separation Processes with Lower Energy and Material Requirements—Colloidal and Interfacial Phenomenon in Bioprocesses to Improve Yield and Purity (E.g., Processes for Bio-derived Chemicals and Proteins)—Engineering Interfaces for Molecular Recognition to Improve the Specificity.

Learning Resources	*1.Drew Myers, "Surfaces, Interfaces, and Colloids: Principles and Applications". "Wiley-VCH", 2nd Ed., 2002.* *2.D. J. Shaw, "Colloid & Surface Chemistry", "Butterworth-Hienemann", 4th Edition, 1992.* *3.Jacob N. Israelachvili, "Intermolecular and Surface Forces", "Academic Press", Third Edition, 2011.*	*4.Richard I. Masel, "Principles of Adsorption and Reaction on Solid Surfaces", "Wiley Series in Chemical Engineering", 1996.* *5.Simone Napolitano, "Non-equilibrium Phenomena in Confined Soft Matter", "Springer", 2015.*

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%	-	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, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE565T	Course Name	BIOMATERIALS AND DRUG DELIVERY 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 fundamental principles in biomaterials, material science and chemistry, and how they contribute to biomaterial development and performance.*
CLR-2:	*learn more about implant materials and their design along with different regulations.*
CLR-3:	*understand the fundamentals of various characterization techniques involved in evaluating biomaterials.*
CLR-4:	*earn more about drug delivery systems, and different approaches of drug delivery.*
CLR-5:	*learn more about the emerging drug delivery systems and technologies that can provide better health care and patient compliance.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*learn more about biomaterials and their properties and requirements.*	*2*		*1*
CO-2:	*understand more details about the design and other requirements of biomaterials.*	*1*		*2*
CO-3:	*learn more about various characterization techniques of biomaterials.*	*3*		*1*
CO-4:	*understand the fundamentals of drug delivery systems*	*1*		*2*
CO-5:	*understand different materials and technologies that are being used in drug delivery*	*2*		*1*

Module-1 - Introduction to Biomaterials	***9 Hour***
Biomaterials—Classification—Metals, Ceramics, Polymers and Composites—Surface and Bulk Properties—Surface modification and types—Cell surface Interactions—Protein Absorption—Biocompatibility—Immune responses—In-vitro and In-vivo Analysis of Biocompatibility	
Module-2 - Implants and Their Requirements	***9 Hour***
Introduction to Implant Materials—Permanent and Absorbable Devices—Criteria for Materials Selection—Survey of Biomaterials and Case Studies—Biocompatibility: Contraction, Scar Formation, Tissue Bonding, Modulus Matching, Corrosion, Wear and Tear—Ethical Clearance and Medical Device Regulations.	
Module-3 - Characterization of Biomaterials	***9 Hour***
Contact Angle—Universal Testing Machine—Optical Microscopy—X-ray Diffraction—Atomic Force Spectroscopy—Scanning Electron Microscopy—Transmission Electron Microscopy—X-ray Photoelectron Spectroscopy—Secondary Ion Mass Spectrometry (SIMS) —Auger Electron Spectroscopy.	
Module-4 - Drug Delivery	***9 Hour***
Introduction to Drug Delivery Systems—Therapeutic Window—Route Specific Drug Delivery: Oral, Subcutaneous, Intramuscular, Transdermal, Inhalation and Intravenous—Sustained and Controlled Drug Delivery—Targeted Drug Delivery—Prodrugs—Diffusion Controlled Systems: Principle, Fick's Law, Non-Erodible Matrix Systems—Bio-erodible Systems—Drug Conjugates—PEGylation.	
Module-5 - Novel Drug Delivery Systems	***9 Hour***
Introduction to Different Drug Delivery Systems—Emulsions: Types and Applications—Hydrogels: Physical and Chemical Systems, Cross-linking and Pore Size Calculations—Dendrimers—Liposomes—Niosomes—Micelles—Different Novel Systems: Metal, Ceramic, Polymeric and Hybrid Micro and Nano Particles—Cell and Gene Delivery—Applications of Drug Delivery Systems.	

Learning Resources	1.J. S. Temenoff and A. G. Mikos, "Biomaterials", "Pearson Prentice Hall", 2008. 2.W. D. Callister, "Materials Science and Engineering: An Introduction", "John Wiley and Sons", New York, 2001.	3.I. V. Yannas, "Tissue and Organ Regeneration in Adults", "Springer", ISBN: 9780387952147,2001 4. N. K. Jain, "Controlled and Novel Drug Delivery", "CBS Publisher and Distributors Pvt. Ltd.", 2nd Edition 2023.

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%	-	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, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1.Dr. K. Deepa, SRM IST
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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