ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M. TECH. CHEMICAL ENGINEERING

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Apply core chemical engineering principles to design, analyze, and optimize chemical processes and systems.
PSO2	Demonstrate practical skills in process control, separation, and intensification, with industry exposure through projects and training.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON.AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M. Tech. Chemical Engineering **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics)
ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))
SD – Skill Development
SL – Self Learning
OE – Open Elective
L –Laboratory Course
T – Theory
LIT –Laboratory Integrated Theory
PW – Project Work
TCP –Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	CX25101	Numerical Methods for Chemical Engineers	T	3	1	0	4	4	ES (PC)
2.	CX25102	Advanced Transport Phenomena	T	3	0	0	3	3	ES (PC)
3.	CX25103	Advanced Reaction Engineering	T	3	0	0	3	3	ES (PC)
4.	CX25104	Advanced Process Control	LIT	3	0	2	5	4	ES (PC)
5.	CX25105	Separation Processes	LIT	3	0	2	5	4	ES (PC)
6.	CX25106	Technical Seminar	---	0	0	2	2	1	SD
						Total Credits	**22**	**19**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Process Intensification	T	3	0	0	3	3	ES (PC)
2.		Modelling of Chemical Processes	LIT	3	0	2	5	4	ES (PC)
3.		Advanced Thermodynamics for Chemical Engineers	T	3	0	0	3	3	ES (PC)
4.		Chemical Process Optimization	T	3	0	0	3	3	ES (PC)
5.		Programme Elective I	T	3	0	0	3	3	ES (PE)
6.		Industry Oriented Course I	---	1	0	0	1	1	SD
7.		Virtual Laboratory	L	1	0	2	3	1	SD
8.		Industrial Training#	---	---	---	---	---	---	SD
9.		Self Learning Course	---	-	-	-	-	1	-
						Total Credits	**21**	**19**	

Evaluation will be done in third semester for the summer internship.

Semester – III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective -II	T	3	0	0	3	3	ES (PE)
2.		Programme Elective-III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective-IV	T	3	0	0	3	3	ES (PE)
4.		Open Elective	T	3	0	0	3	3	ES (OE)
5.		Industry Oriented Course II	---	1	0	0	1	1	SD
6.		Project Work I	---	0	0	12	12	6	SD
7.		Industrial Training#	---	---	---	---	---	2	SD
				Total Credits			**25**	**21**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Project Work II	---	0	0	24	24	12	SD
				Total Credits			**24**	**12**	

Programme Elective Courses (PE)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1		Biochemical Engineering	3	0	0	3	3
2		Waste to Energy	3	0	0	3	3
3		Fluidization Engineering	3	0	0	3	3
4		Nanocomposites	3	0	0	3	3
5		Thermal processing of food Products	3	0	0	3	3
6		Bioprocess Technology	3	0	0	3	3
7		Computational Fluid Dynamics	3	0	0	3	3
8		Design of Experiments	2	0	2	4	3
9		Sustainable Management	3	0	0	3	3
10		Polymer Processing Technology	3	0	0	3	3
11		Business Analytics	3	0	0	3	3

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
12		Chemical Processes and Pollution Control	3	0	0	3	3
13		Risk Analysis and Management	3	0	0	3	3
14		Project Engineering of Process Plants	3	0	0	3	3
15		Operations Research	3	0	0	3	3
16		Safety and Environment in Chemical Industries	3	0	0	3	3
17		Biomass Conversion Techniques	3	0	0	3	3
18		Industrial Instrumentation	3	0	0	3	3
19		Water and Wastewater Technologies	3	0	0	3	3
20		AI and ML in Chemical Engineering	3	0	0	3	3
21		Data Science in process industries.	3	0	0	3	3

Semester I

CX25101	Numerical Methods for Chemical Engineers	L	T	P	C
		3	1	0	4

Course Objective:
Apply the numerical techniques to solve the simultaneous equation, Ordinary Differential and Partial differential equations.

Finding the Roots: Mathematical models for solving engineering problems, programming and software; Finding roots of a single equation, Direct methods (bisection, Regula falsi), Indirect methods (Newton-Raphson, Secant method)

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Solution for Simultaneous Equations: Types of matrices and matrix operation rules, Solution for linear system of simultaneous equations, Direct methods (Gauss Elimination, Gauss Jordan), Iterative methods (Gauss-Jacobi and Gauss- Seidel); Overview of non-linear system of equations.

Activity: solving the numerical problems using MATLAB /Micro soft office Excel

Interpolation and Regression Analysis: Newton‟s divided, difference interpolating polynomial, Linear, polynomial, quadratic rules, Lagrange interpolating polynomial, Linear, polynomial Regression.

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Optimization: One-Dimensional Unconstrained Optimization, Golden section search and Newton‟s Method; Overview on multidimensional unconstrained optimization, gradient and non-gradient methods; Constrained optimization, Simplex method;

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Integration and Differentiation: Newton cotes Integration, Trapezoid method, Simpson‟s 1/3rd rule,Simpson‟s 3/8th rule; Numerical differentiation, Forward, Backward, Central difference methods.

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Ordinary Differential Equations: Initial Value Problems, Euler, Predictor, corrector, Runge-Kutta methods; Boundary Value Problems, Shooting method, Central difference method.

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Partial Differential Equations: Finite difference solutions of elliptic equations,Liebmann‟s method, finite difference solutions of parabolic equations, Crank-Nicolson and implicit methods, Overview of hyperbolic equations; Case study on solving PDEs.

Activity: solving the numerical problems using MATLAB /Micro soft office Excel.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Ahuja, P. (2010). *Introduction to numerical methods in chemical engineering*. PHI Learning Pvt.
2. Chapra, S. C., & Canale, R. P. (2016). *Numerical methods for engineers*. McGraw Hill.
3. Dorfman, K. D., &Daoutidis, P. (2017). *Numerical methods with chemical engineering applications*. Cambridge University Press.
4. Jana, A. K. (2011). *Chemical process modelling and computer simulation*. Prentice Hall of India.

	Description of CO	PO	PSO1	PSO2
CO1	Explain the numerical methods required for solving chemical engineering problems	PO1(3), PO2(2)	3	2
CO2	Solve the differential equations of chemical engineering processes	PO1 (3), PO2(2), PO4(2)	2	3
CO3	Apply Interpolation & optimization methods to solve equations arising from chemical engineering processes	PO1 (3), PO2(2), PO4(2)	2	1
CO4	Apply integration & differentiation numerical methods to solve chemical processes.	PO1 (3), PO2(2), PO4(2)	2	2

CX25102	Advanced Transport Phenomena	L	T	P	C
		3	0	0	3

Course Objective:

To impart knowledge on the concepts of transport phenomena and flow behavior in different systems

Basic Concepts: Phenomenological Equations and Transport properties, Rheological behavior of fluids, Models for Rheological Behavior; Balance Equations, Differential and Integral equations.

Activity: Identification of rheological behaviors of different fluids.

Applications of Differential Equations of Change: Applications in laminar and turbulent transport in compressible and incompressible fluids, Boundary layer theory, Momentum, Thermal and Concentration Boundary layer, Similarity Transformation, Blasius Solution.

Activity: Writing various differential form of equation in chemical engineering.

Applications of Integral Equations of Change: Reynolds Transport Theorem, application of RTT to solutions for Macroscopic balance for isothermal and non-isothermal systems and their applications in Momentum, Heat and Mass transport problems.

Activity: List out chemical engineering application of integral equations.

Interphase and Multiphase Momentum Transfer: Friction factor, Fluid Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid fluid systems, Forces acting on stagnant and moving solids, Flow through porous medium, capillary tube model and its applications.

Activity: Demonstration of flow through porous medium.

Interphase Transport in Non-Isothermal Systems: Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection, film type and dropwise condensation and equations for heat transfer, Heat transfer in boiling liquids, Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

Activity: Seminar presentation of various non isothermal systems with industrial applications.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Bird, R. B., Lightfoot, E. N., & Stewart, E. W. (2007). Transport phenomena. Wiley.

2. Welty, J. R., Wicks, C. E., & Wilson, R. E. (2007). Fundamentals of momentum, heat, and mass transfer. John Wiley & Sons.
3. Deen, W. M. (1998). Analysis of transport phenomena. Topics in Chemical Engineering, Vol. 1. Oxford University Press.
4. Leal, L. G. (2007). Advanced transport phenomena: Fluid mechanics and convective transport processes (Vol. 7). Cambridge University Press.
5. Brodkey, R. S., & Hershey, H. C. (2003). Transport phenomena: A unified approach. Brodkey Publishing.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Understand and explain phenomenological equations and rheological behavior of fluids in transport processes.	PO1(3), PO2(2)	3	2
CO2:	Apply differential equations of change to solve momentum, heat, and mass transfer problems.	PO3(1), PO2(2)	2	3
CO3:	Utilize integral equations of change for analyzing momentum, heat, and mass transport phenomena.	PO1(1), PO3(2)	2	1
CO4:	Analyze and evaluate interphase and multiphase momentum and mass transfer in both isothermal and non-isothermal systems.	PO3(3)	2	2

CX25103	Advanced Reaction Engineering	L	T	P	C
		3	0	0	3

Course Objective:
To teach advanced reaction engineering and apply the knowledge for the modelling & design of the chemical reactors.

Gas Solid Non-Catalytic Reactions and Reactors: Reaction kinetics, Different models used for gas solid non-catalytic reactions, shrinking core model, volume reaction model, zone models, grain models, rate controlling steps; time for Complete Conversion for Single and Mixed Sizes, design of gas solid reactors.

Activity: virtual demonstration of various models used in Gas-solid non catalytic reaction

Gas Solid Catalytic Reaction: Steps in catalytic reaction, Single site, dual site mechanisms, Langmuir Hinshelwood, Eley Rideal, Rate controlling steps. Experimental methods for determining rate. Intra particle diffusion mechanism of catalytic reactions- under isothermal and non-isothermal condition.

Activity: virtual demonstration of various Gas-solid catalytic reaction and the reactors.

Fluid-Fluid Reaction: Kinetics and design of Fluid-Fluid Reactions. Rate equation, Kinetic regimes for absorption combined with chemical reaction. Various cases of mass transfer with chemical reaction, Factors to select the contactor, gas-liquid reactor design, liquid-liquid reactors and Design.

Activity: Virtual demonstration of various kinetic regimes of fluid-fluid reactions.

Advanced Reactor Systems: Conventional reactors, advanced reactors,Static mixer reactor, Monolith Reactors, Spinning disc reactor, Multifunctional Reactors, Reactive distillation, Reactive extraction, Membrane reactor; Solar reactors, Micro channel reactors.

Activity: Virtual demonstration of various types of advanced reactor system.

Modelling Of Chemical Reactor Systems: Steady state and unsteady state modelling concepts, Modelling batch reactors and tubular reactors systems, Reactor optimization.

Activity: seminar presentation of steady state and unsteady state reactor systems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Doraiswamy, L. K., &Uner, D. (2014). *Chemical reaction engineering: Beyond the fundamentals* (1st ed.). CRC Press.
2. Froment, G. F., & Bischoff, K. B. (2011). *Chemical reactor design and analysis*. John Wiley & Sons.
3. Suresh, S., & Sundaramoorthy, S. (2014). *Green chemical engineering: An introduction to catalysis, kinetics, and chemical processes*. CRC Press.
4. Levenspiel, O. (1999). *Chemical reaction engineering*. John Wiley & Sons.
5. Fogler, H. S. (1999). *Elements of chemical reaction engineering*. Prentice Hall of India.

	Description of CO	PO	PSO1	PSO2
CO1:	Analyze various models and kinetics involved in non-catalytic reactions.	PO1(3), PO3(1)	3	2
CO2:	Evaluate mechanisms underlying catalytic reactions.	PO2(2), PO3(2)	2	3
CO3:	Apply principles to design fluid-fluid reactor towers.	PO1(1), PO3(2)	1	3
CO4:	Differentiate between advanced reactor systems and develop models for chemical reactors.	PO3(3)	2	2

CX25104	Advanced Process Control	L	T	P	C
		3	0	2	4

Course Objective:
To impart the advanced process control knowledge and apply various control systems for the industrial applications.

Advanced Control Strategies: Linear, nonlinear regression fitting for first order, second order models without and with time delay; development of discrete time model and parameter identification; Advanced control, Feed forward, cascade, dead time compensation, split range, inferential, selective and override control; smith predictor; automatic tuning and gain scheduling

Activity: MATLAB simulink model for first order and second order system.

Model Based Control Design: Model based control, IMC structure, development and design; Direct synthesis method; IMC based PID control, Overview of MPC, prediction for SISO and MIMO models, MPC calculation, set point calculation, selecting the tuning parameters in MPC, Design examples for typical case studies; Introduction to Non-linear MPC

Activity: MATLAB simulink model for PID controller and MPC.

Multivariable control: Control loop interaction, general pairing problem, relative gain array and application, sensitivity; Multivariable control, zeros and performance limitations, directional sensitivity and operability, decoupling

Activity: Virtual demonstration of multivariable control system

Discrete systems & non-linear systems: Z – Transform and inverse Z – transform properties; Discrete, Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability; Models for Time-varying and Nonlinear systems; Hammerstein and Wiener Systems; Fuzzy logic controls; Neural network control.

Activity: Seminar presentation on Fuzzy logic controls; Neural network control

Digital feedback controllers: Design of digital feedback controllers - Essential components, Digital control implementation, Programmable Logic Controller, Distributed Control System, SCADA, Hardware for computer - based control, Interfacing computer system with process.

Activity: Demonstration of Interfacing computer system with process.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%), Practical (30%), Internal Examinations (40%)

List of Experiments:

1. Level control process with data acquisition
2. Temperature control process with data acquisition
3. Flow control process with data acquisition
4. Pressure process trainer with data acquisition
5. Implementation of Model Predictive Control in process control station
6. Implementation of Fuzzy logic, control in process control station

7. PLC and web based real time process control system
8. Integration of process control equipment in COMOS software
9. Create P & ID diagram
10. Simulation of process plant using COMOS software

References:

1. Bequette, B. W. (2003). Process control: Modeling, design, and simulation. Prentice Hall.
2. Stephanopoulos, G. (2015). Chemical process control. Pearson Education India.
3. Moudgalya, K. M. (2007). Digital process control. John Wiley & Sons Ltd.
4. Luyben, W. L. (2013). Process modeling, simulation & control for chemical engineers. McGraw-Hill Education.
5. Seborg, D. E., Edgar, T. F., & Mellichamp, D. A. (2013). Process dynamics and control. Wiley India.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Identify and apply advanced control configurations to practical engineering problems.	PO1(3), PO2(2)	3	2
CO2:	Compare and evaluate the capabilities of various model-based control systems.	PO3(1), PO2(2)	2	2
CO3:	Analyze multivariable control systems, including interaction effects and sensitivity.	PO1(1), PO3(2)	2	1
CO4:	Apply Z-transform techniques for the analysis and design of discrete-time control systems.	PO3(3)	2	3

CX25105	Separation Processes	L	T	P	C
		3	0	2	4

Course Objective:

- To impart knowledge on recently developed unit operations like membrane separation, adsorption, Chromatography, supercritical fluid extraction and advanced distillation techniques.
- To acquaint the students with various types of contacting systems viz. liquid-liquid, solid-liquid, gas-solid with their technical insights.
- To impart knowledge on theoretical and practical insight of advanced separation techniques.
- To make the students understand the utilization of soft wares for the design of membrane and distillation units.
- To enable the students to select appropriate separation methodology for an intended application.

Membrane Separation Processes: Membrane types, materials, synthesis and characterization; Different membrane modules; Working principle, operating parameters, membranes used, transport processes/mechanisms and industrial applications for individual membrane processes such as Reverse osmosis, nanofiltration, ultrafiltration, microfiltration; MBR; Reverse Osmosis process design using software.

Activity: Demonstration of Reverse Osmosis process design using software.

Adsorption and ION Exchange: Fundamentals and types of adsorption, Types and properties of adsorbents, Adsorption Equilibrium and isotherms, stage contact operations, Fixed bed adsorption; Ion Exchange - Fundamentals of Ion Exchange Types of Ion Exchange Resins Theory of Ion Exchange, Applications - Removal and recovery of heavy metals, Removal of nitrogen, Removal of phosphorus, Organic chemical removal.

Activity: Industrial visit/ visit of ion exchange process units and measure the properties**.**

Chromatographic Separation: Principle and operation, Types of chromatography - Ion exchange chromatography, Gel filtration and affinity chromatography, Thin layer and paper chromatography, Liquid chromatography, Simulated Moving bed chromatography, Multicomponent Differential Chromatography; Advantages and disadvantages of chromatographic separations.

Activity: seminar presentation of various chromatographic separation techniques.

Supercritical Extraction: Working Principal, unique properties and solubility behavior of supercritical fluids, Advantages of supercritical extraction, Decaffeination, ROSE process for purification of crude oil, hydrothermal oxidation, and Commercial applications of supercritical extraction.

Activity: Virtual demonstration of super critical extraction process

Advanced Distillation Techniques: Reactive and catalytic distillation Concept, advantage & disadvantages, Structured packing and its comparison with conventional techniques, Concept & working of short path Distillation Unit (SPDU).

Activity: Virtual demonstration of distillation process
Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%
Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%), Practical (30%), Internal Examinations (40%)

List of Experiments:

1. Determination of the water permeability of a given polymeric membrane.
2. Determination of permeation flux of a membrane in flat-sheet module (Dye-water solution may be used as feed) (RO/NF/UF membranes can be used)
3. Numerical/design of reverse osmosis process using software.
4. Waste Water Treatment using MBR.
5. Adsorption Equilibrium and fixed bed adsorption studies for generation of breakthrough curves
6. Determination of ion exchange capacity of a given cation or anion exchanger
7. To separate a mixture of dyes using chromatography
8. Experimental design in supercritical fluid extraction
9. Study of extraction efficiency for the extraction of essential oils
10. Numerical/design assignment based on reactive and catalytic distillation.

References:

1. Seader, J. D., & Henley, E. J. (1998). Separation process principles. John Wiley & Sons.
2. Dutta, B. K. (2006). Principles of mass transfer and separation processes. Prentice Hall India Learning Private Limited.
3. Baker, R. W. (2012). Membrane technology and applications. John Wiley & Sons.
4. Geankoplis, C. J. (2004). Transport processes and separation process principles. Prentice Hall India Learning Private Limited.
5. Wankat, P. C. (2006). Separation process engineering. Pearson Education.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Design and develop membrane systems to determine flux and separation efficiency.	PO1(3), PO2(2)	2	3
CO2:	Analyze fixed bed column operations such as adsorption and ion exchange for fluid component separation.	PO3(1), PO2(2)	3	1
CO3:	Apply chromatographic techniques for effective separation and analysis of mixtures.	PO1(1), PO3(2)	3	2
CO4:	Interpret phase diagrams and optimize supercritical fluid and advanced distillation processes.	PO3(3)	2	2