2nd Year B. Tech. (Chemical Engineering)

Semester III

Course Code	Course title	Weekly Contact Hours (L-T-P)	Credits
ZZ xxx	Course – I, Minor program	X-X-X	3
MA 205	Complex analysis	3-1-0 (Half Semester)	2
MA 207	Differential equations	3-1-0 (Half Semester)	2
ChE 201	Chemical Engineering Thermodynamics	2-1-0	3
ChE 203	Transport Phenomena	2-1-0	3
ChE 205	Materials Science for Chemical Engineers	2-1-0	3
ChE 207	Chemical Process Calculations	2-1-0	3
ChE2xx	Department Elective -1	2-1-0	3
ChE 251	Heat and Mass Transfer Lab	0-0-2	1
ChE 255	Materials Characterization lab	0-0-2	1
Total		13-6-4 (23)	21/24

Semester IV

Course Code	Course title	Weekly Contact Hour (L-T-P)	Credits
ZZ xxx	Course – II, Minor program	X-X-X	3
MA 204N	Numerical Methods	2-0-2	3
ChE 202	Fluid Mechanics	2-1-0	3
ChE 204	Chemical Reaction Engineering	2-1-0	3
ChE 206	Separation processes	2-1-0	3
ChE 2xx	Department Elective – 2	2-1-0	3
ZZ 2xxx	Institute open elective – 1	2-1-0	3
ChE 258	Computational Chemical Engineering Lab -1	0-0-3	1.5
ChE 254	Reaction Engineering lab	0-0-2	1
ChE 252	Fluid Mechanics lab	0-0-2	1
Total		12-5-9 (26)	21.5/24.5

Suggested Course code	ChE 204
Title of the course	Chemical Reaction Engineering
Course Category	Core
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Course objective	The objective of this course is to study the kinetics of homogeneous and heterogeneous reactions and interpret the kinetic data to perform the design of chemical reactors.
Course Outcomes	• Ideal and non-ideal reactor systems • Design equations for isothermal and non-isothermal reactors. • Design methodology for multiple reactions.
Course Content	**Module 1: Kinetics of homogeneous reaction** Introduction to chemical reaction engineering, kinetics of homogeneous reactions, kinetic models, testing kinetic models, effect of temperature on reaction rates. Interpretation of batch reactor data, differential and integral methods of analysis of batch reactor data, half-life and fractional life methods. **Module 2: Ideal reactors and design for single and multiple reactions** Design of single homogeneous reactors: ideal reactors, design equations for ideal reactors, optimum reactor size problems, combination of ideal flow reactors, recycle reactor, autocatalytic reactions, series reactions, parallel reactions, series–parallel reactions **Module 3: Design of non-isothermal reactors** General graphical design procedure, steady state non–isothermal design of ideal reactors for single and multiple reactions, stability of reactor **Module 4: Non-Ideal Reactors and design of non-ideal reactor** Reasons for non–ideal flow, residence time distribution (RTD) functions, calculation of mean residence time and variance from the RTD data, limitation of RTD, Conversion in non–ideal reactors, tanks in series model, axial dispersion model. **Module 5: Heterogeneous reaction** Introduction to heterogeneous reactions**,** Classification of heterogeneous reaction, Introduction of non-catalytic fluid solid reaction, Shrinking core model, kinetics of solid catalyzed reactions, reaction and diffusion in porous catalysts, Thiele modulus and effectiveness factor.

Suggested Books	**Textbooks** (1) O. Levenspiel, Chemical Reaction Engineering, 3rd ed., John Wiley & Sons (2006), ISBN:9788126510009 (2) H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd ed., Prentice Hall (2006), ISBN: 9780131278394 **Reference books** (3) J. M. Smith, Chemical Engineering Kinetics, 2nd ed., McGraw–Hill (1981), ISBN: 9780070665743

Suggested Course code	ChE 202
Title of the course	Fluid Mechanics
Course Category	Core
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Course objective	The course aims to provide an introduction to the fundamental principles of fluid mechanics and their applications in the chemical engineering context.
Course Outcomes	• Basic understanding of fluid statics and dynamics • Analytical skills to solve various types of fluid flows
Course Content	**Module 1: Fundamental Concepts** Dimensions and Units, Fluid statics, vector and tensor analysis **Module 2: Fluid Flow Phenomena** Mass balance in a flowing fluid, differential momentum balance, equations of motion, laminar and turbulent flow, rheological properties of fluids, Poiseuille flow, boundary layers. **Module 3: Flow of Incompressible Fluids** Flow of incompressible fluids in pipes, Friction factor, Laminar flow of Newtonian and non-Newtonian fluids, Turbulent flow in pipes and closed channels, Effect of roughness, Friction factor chart, effect of fittings and valves, velocity heads, expansion and contraction losses. **Module 4: Introduction to Compressible Flow** Definitions and basic equations, Propagation of sound waves, isentropic, adiabatic and isothermal friction flow. **Module 5: Fluid Flow Measurement and Machinery** Transportation and metering of fluids. Fluid machineries: pumps, fans, blowers, compressors, measurement of flowing fluids. **Module 6: Flow past immersed objects** Drag and drag coefficients, Flow through packed beds, fluidization, sedimentation and rise of bubbles and drops
Suggested Books	**Textbooks** (1) R. W. Fox and A. T. McDonald, “Introduction to Fluid Mechanics”, 8th ed., John Wiley & Sons (20011), ISBN: 978-81-265-1583-7 (2) R. B. Bird, W. E. Stewart, and E. N. Lightfoot, “Transport Phenomena”, 3rd ed., John Wiley & Sons (2010), ISBN: 978-81-265-0808-2

	(3) W. L. McCabe, J. C. Smith, and P. Harriott, "Unit Operations of Chemical Engineering", 4th ed., McGraw-Hill (2005), ISBN: 007-124710-6 **Reference Textbooks** (4) D. W. Green and R. H. Perry, "Perry's Chemical Engineers' Handbook",9th ed., McGraw-Hill (2018), ISBN: 0-07-142294-3

Suggested Course code	ChE 206
Title of the course	Separation Processes
Course Category	Core
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Course objective	To introduce concepts, processes and equipments that are commonly utilized to separate different chemical and biological mixtures.
Course Outcomes	• Fundamental understanding of chemical engineering separation processes • Design of distillation equipments • Design of adsorption and stripping units • Introduction to separation processes employed in bioprocessing and biomanufacturing
Course Content	**Module 1: Fundamental concepts** Introduction to various chemical engineering separation equipments, Thermodynamics of Separation processes, Mass Transfer and Diffusion, Single Equilibrium Stages and Flash Calculations **Module 2: Absorption and stripping of mixtures** Equipment for Vapor-liquid separations, Design of packed tower, Counter-current multi-stage absorption, Absorption with chemical reactions, Adsorption processes, isotherms **Module 3: Distillation operations** Batch distillation, continuous fractionation, calculations with multiple feeds and withdrawals, MESH equations, McCabe-Thiele and Ponchon-Savarit Graphical Methods for trayed towers, Tray hydrodynamics and efficiencies, Multicomponent, multistage operations **Module 4: Liquid-Liquid extraction** Ternary phase diagrams, Examples of Solvent Extraction; Solvent Selection; Design Calculations. **Module 5: Bioseparations** Introduction to Bioseparations, Chromatography, Bioproduct Crystallization, Drying of Bioproducts, Electrophoresis, Membranes in Bioprocessing

Suggested Books	**Textbooks:** (1) J.D. Seader, E.J. Henley and D. Keith Roper, Separation Process Principles, 3rd ed, John Wiley & Sons (2013), ISBN 978-0470481837 (2) Treybal, R. E. Mass Transfer Operations. 3rd ed., McGraw-Hill (1980). ISBN: 9780070651760. (3) W. L. McCabe, J. C. Smith, and P. Harriott, "Unit Operations of Chemical Engineering", 4th ed., McGraw-Hill (2005), ISBN: 0071247106 **Reference books:** (4) Dutta, Binay K. Principles of mass transfer and separation processes. PHI Learning Pvt. Ltd., (2007), ISBN: 8120329902

Suggested Course code	ChE 208
Title of the course	Process Data Analytics & Monitoring
Course Category	Elective
Credit Structure	L - T - P - Credits 2 – 1 – 0 - 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the course	This course refers to techniques and tools for making inferences and decisions based on data from process systems. These technologies and techniques are increasingly used by the process industries to make better decisions about operations and supply chains for achieving operational excellence.
Learning Outcomes	• Understand the importance of data analytics in chemical engineering • Apply statistical and machine learning techniques for process data analysis • Develop the ability to build predictive and prescriptive models for process engineering applications and real-time monitoring.
Course Content	**Module 1** – Introduction to Chemical Process Data Analytics, Types of process data (continuous, batch, discrete) in chemical industry, data sources and data quality issues in chemical processes, Data visualization, normalization, scaling and time-series analysis. **Module 2 -**Multivariate Statistical Process Control techniques, Principal Component Analysis (PCA), Partial Least Squares (PLS). **Module 3 -** Types of learning problems: Supervised, Unsupervised, Classification and Clustering- (K-nearest neighbors, Logistic regression, Support vector machines, Decision trees, Random forests, Boosting), Regression – Simple Linear regression, Multiple Linear Regression), Neural Networks for soft sensing, cross-validation and performance evaluation metrics **Module 4** – Problem based learning through various Practical Applications and Chemical Engineering Case Studies, Fault detection and diagnosis.
Suggested Books	**Textbooks** (1) T. Agami Reddy, Gregor P. Henze, Applied Data Analysis and Modeling for Energy Engineers and Scientists, 1st ed., Springer (2011), ISBN: 9781441996138

	(2) M. Gopal, Applied Machine Learning,2nd ed., McGraw Hill (2022), ISBN:9789353160265 **Reference books**. (3) S. Sridhar, M. Vijayalakshmi, Machine Learning, 1st ed., Oxford University Press (2021), ISBN: 9780190127275

Suggested Course code	ChE 254
Title of the course	Reaction Engineering Lab
Course Category	Core
Credit Structure	L - T - P - Credits 0 – 0 – 2 – 1
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the Lab	Introduce the students to the basics of reactors design
Learning Outcomes	• Understand the nuances in the chemical reactors
Course Content	**List of representative experiments:** • Determine the rate using iso-thermal batch reactor. • Study the reaction rate using semi-batch reactor • Determine the reaction rate for liquid phase reaction in a Continuous Stirred Tank Reactor (CSTR). • Calculate the rate of reaction for homogeneous reaction in a straight tube reactor. • Determine the reaction rate for homogeneous reaction in a coil tube flow reactor • Experiments with CSTR connected in series. • CSTR and Plug flow in series and parallel. • Determine Residence Time Distribution (RTD) in a CSTR. • Determine RTD in a Plug Flow Reactor (PFR). • Determine RTD in a Packed bed reactor
Suggested Books	**Textbooks:** (1) O. Levenspiel, Chemical Reaction Engineering, 3rd ed., John Wiley & Sons (2006), ISBN:9788126510009

Suggested Course code	ChE 258
Title of the course	Computational Chemical Engineering Lab -1
Course Category	Core
Credit Structure	L - T - P - Credits 0 – 0 – 3 – 1.5
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the Lab	To understand the practical applications of computational methods in chemical engineering
Learning Outcomes	• To be able to write codes for solving mathematical problems in chemical engineering
Course Content	**List of representative computations exercises and example systems** • Introduction to an Engineering Programming Software such as Python, Matlab • Error analysis: truncation, roundoff, propagation - numerical integration of heat transfer equations, sensitivity analysis of reaction rate constants • Gaussian elimination and iterative methods for linear algebraic systems - Solving material and energy balance equations for a adsorption column, determining flow rates in a pipe network. • Newton-Raphson: root finding for single and simultaneous equations- Finding equilibrium compositions in a chemical reaction • Polynomial interpolation, cubic splines - Interpolating experimental data for viscosity, fitting vapor pressure data with a suitable equation. • Euler integration- unsteady-state heat transfer problems, concentration profile of a batch reactor • Multistep integration methods - solving reaction kinetics problems • Solving ODEs/PDEs using finite difference techniques - solving heat conduction problem for different geometries • Correlation and Regression - fitting experimental data to a Langmuir isotherm and various order reaction kinetics
Suggested Books	**Textbooks:** (1) S.K. Gupta, Numerical Methods for Engineers, New Age International, (2003) ISBN: 9788122433593 (2) S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, 5th Ed., McGraw Hill, (2006), ISBN: 9780073401065

Suggested Course code	ChE 252
Title of the course	Fluid Mechanics Lab
Course Category	Core
Credit Structure	L - T - P - Credits 0 – 0 – 2 – 1
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the Lab	To augment the principles learned in the theory component,and understand flow through various geometries as well as the functioning of flow measuring equipment.
Learning Outcomes	• Understand pressure loss occurring in various pipe fittings • Decide appropriate choice of pumping and flow measuring equipment for various applications • Basic understanding of flow visualization through the use of simulation packages.
Course Content	**List of representative experiments:** • Determination of viscosity using Stokes' law • Experiment to characterize the Reynolds-number-based transition from laminar to turbulent flow regime. • Experiment to understand pressure drop, by calculating equivalent length of pipe fittings. • Experiment for the calculation of friction in annulus of a circular pipe. • Use of a venturimeter and orifice meter for flow measurement in pipe flow. • Determining the performance characteristics of a centrifugal pump. • Determining the discharge coefficient for flow through a rectangular notch. • Flow visualization through Virtual Lab experiments.
Suggested Books	**Textbooks** (1) V. Gupta, S. K. Gupta, "Fluid Mechanics and Its Applications", New Age international Private Ltd (2015), ISBN: 9788122439977 (2) F. M. White, "Fluid Mechanics",7th Ed., McGraw Hill (2022), ISBN: 9789355322043