Department of Chemical Engineering

COURSE STRUCTURE (AR-13)

(Applicable for the batches admitted from 2013-14)

Non-FSI Model

B.Tech. 5th semester

Code	Subject	L	T	P	C
CHEM 3412	Chemical Reactor Theory	3	1	-	4
CHEM 3413	Chemical Technology	3	1	-	4
CHEM 3414	Principles of Mass Transfer	3	1	-	4
CHEM 3415	Process Dynamics & Control	3	1	-	4
Elective-I					
CHEM 3416	Fertilizer Technology	3	1	-	4
CHEM 3417	Industrial Pollution Control Engineering				
CHEM 3418	Polymer Technology				
	Available & Selected MOOCs Courses#				
CHEM 3219	CACE Lab	-		3	2
CHEM 3220	Process Dynamics & Control Lab	-		3	2
GMR 30206/ GMR 30204	Term paper/ Mini Project				2
Total		**20**		**6**	**26**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

B.Tech. 6th semester

Code	Name of the Subject	L	T	P	C
CHEM 3421	Applications of Mass Transfer	3	1	-	4
CHEM 3422	Chemical & Catalytic Reaction Engineering	3	1	-	4
CHEM 3423	Chemical Process Economics & Equipment Design	3	1	-	4
Elective-2					
CHEM 3424	Material Science for Chemical Engineers	3	1	-	4
CHEM 3425	Petroleum refining and petrochemicals				
CHEM 3426	Pharmaceuticals and Fine chemicals				
	Available & Selected MOOCs Courses#				
Elective-3 (Open elective)					
IT 3418	Cloud Computing	3	1	-	4
CE 3429	Disaster Management				
ECE 3424	Fundamentals of GPS				
CHEM 3427	Industrial Safety and Hazard Management				
ME 3432	Principles of Entrepreneurship (Mech)				
EEE 3427	Renewable Energy Resources				
PE 3409	Smart Grid technologies				
CSE 3417	Soft Computing				
CHEM 3228	Chemical Reaction Engineering Lab	-		3	2
CHEM 3229	Mass Transfer Operations Lab	-		3	2
GMR 30206/ GMR 30204	Term paper /Mini Project	-		-	2
GMR 30001	Audit Course	-		-	-
		20		**6**	**26**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

B.Tech. 7th semester

Code	Subject	L	T	P	C
HS3405	Engineering Economics and Project Management	3	1	-	4
Elective-4					
ME 4450	Computational Fluid Dynamics	3	1	-	4
CHEM 4430	Numerical Methods in Chemical Engineering				
CHEM 4431	Scale-up methods in Chemical Engineering				
CHEM 4432	Thermodynamic Properties of Crudes and Refinery Design				
	Available & Selected MOOCs Courses#				
Elective-5					
CHEM 4433	Biochemical Engineering	3	1	-	4
CHEM 4434	Clean Process Technology				
CHEM 4435	Corrosion Engineering				
CHEM 4436	Fluidization Engineering				
CHEM 4237	Process Equipment Design and Drawing Lab	-		3	2
CHEM 4238	Process Simulation Lab	-		3	2
Total		**12**		**6**	**16**

B.Tech. 8th Semester

Code	Subject	Lecture	Tutorial	Practical	Credits
CHEM 4439	Process Modeling &Simulation	3	**1**	-	4
CHEM 4440	Transport Phenomena	3	**1**	**-**	4
Elective-6					
CHEM 4441	Design and Analysis of Experiments	3	**1**	**-**	4
CHEM 4442	Novel Separation Techniques				
CHEM 4443	Process Intensification				
CHEM 4444	Process Optimization				
	Available & Selected MOOCs Courses#				
GMR 41205	Project work				12
Total		**9**	**3**	**-**	**24**

CHEM 4445- Power plant pollution and control-offered to Power Engg.

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

DEPARTMENT OF CHEMICAL ENGINEERING
COURSE STRUCTURE (AR-13)
(Applicable for the batches admitted from 2013-14)
FSI Model – For students going to FSI in 7th Semester

B.Tech. 5th Semester

Code	Subject	L	T	P	C
CHEM 3412	Chemical Reactor Theory	3	1	-	4
CHEM 3413	Chemical Technology	3	1	-	4
CHEM 3414	Principles of Mass Transfer	3	1	-	4
CHEM 3415	Process Dynamics & Control	3	1	-	4
Elective-I					
CHEM 3416	Fertilizer Technology	3	1	-	4
CHEM 3417	Industrial Pollution Control Engineering				
CHEM 3418	Polymer Technology				
	Available & Selected MOOCs Courses#				
CHEM 3219	Computer Application in Chemical Engineering Lab	-		3	2
CHEM 3220	Process Dynamics & Control Lab	-		3	2
GMR 30206 GMR 30204	Term paper/ Mini Project				2
Total		**20**		**6**	**26**

6th semester

Code	Name of the Subject	L	T	P	C
CHEM 3421	Applications of Mass Transfer	3	1	-	4
CHEM 3422	Chemical & Catalytic Reaction Engineering	3	1	-	4
CHEM 3423	Chemical Process Economics & Equipment Design	3	1	-	4
Elective-2					
CHEM 3424	Material Science for Chemical Engineers	3	1	-	4
CHEM 3425	Petroleum refining and Petrochemicals				
CHEM 3426	Pharmaceuticals and Fine chemicals				
	#Available & Selected MOOCs				
Elective-3 (Open elective)					
IT 3418	Cloud Computing	3	1	-	4
CE 3429	Disaster Management				
ECE 3424	Fundamentals of GPS				
CHEM 3427	Industrial Safety and Hazard				
ME 3432	Principles of Entrepreneurship				
EEE 3427	Renewable Energy Resources				
PE 3409	Smart Grid technologies				
CSE 3417	Soft Computing				
CHEM3228	Chemical Reaction Engineering Lab	-		3	2
CHEM 3229	Mass Transfer Operations Lab	-		3	2
GMR 30206/ GMR 30204	Term paper /Mini Project	-		-	2
GMR 30001	Audit Course	-		-	-
		20		**6**	**26**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

B.Tech. 7th th semester

Code	Subject	L	T	P	C
GMR 42007	Full Semester Internship	-	-	-	20

B.Tech. 8th th semester

Code	Subject	L	T	P	C
CHEM 4439	Process Modeling &Simulation	3	1	-	4
CHEM 4440	Transport Phenomena	3	1	-	4
Elective – 4& Elective –5 (Students shall opt two courses from the below list)					
CHEM 4441	Design and Analysis of Experiments	3+3	1+1	-	4+4
CHEM 4442	Novel Separation Techniques				
CHEM 4443	Process Intensification				
CHEM 4444	Process Optimization				
	# Available & Selected MOOCs				
CHEM 4237	Process Equipment Design and Drawing Lab	-		3	2
CHEM 4238	Process Simulation Lab	-		3	2
Total		**12**	**4**	**6**	**20**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

DEPARTMENT OF CHEMICAL ENGINEERING
COURSE STRUCTURE (AR-13)
(Applicable for the batches admitted from 2013-14)
FSI Model – For students going to FSI in 8th Semester

B.Tech. 5th Semester

Code	Subject	L	T	P	C
CHEM 3412	Chemical Reactor Theory	3	1	-	4
CHEM 3413	Chemical Technology	3	1	-	4
CHEM 3414	Principles of Mass Transfer	3	1	-	4
CHEM 3415	Process Dynamics & Control	3	1	-	4
Elective-I					
CHEM 3416	Fertilizer Technology	3	1	-	4
CHEM 3417	Industrial Pollution Control Engineering				
CHEM 3418	Polymer Technology				
	# Available & Selected MOOCs				
CHEM 3219	Computer Application in Chemical Engineering Lab	-		3	2
CHEM 3220	Process Dynamics & Control Lab	-		3	2
GMR 30206/ GMR 30204	Term paper/ Mini Project				2
Total		**20**		**6**	**26**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

6th semester

Code	Name of the Subject	Lecture	Tutorial	Practical	Credits
CHEM 3421	Applications of Mass Transfer	3	1	-	4
CHEM 3422	Chemical & Catalytic Reaction Engineering	3	1	-	4
CHEM 3423	Chemical Process Economics & Equipment Design	3	1	-	4
Elective-2					
CHEM 3424	Material Science for Chemical Engineers	3	1	-	4
CHEM 3425	Petroleum refining and Petrochemicals				
CHEM 3426	Pharmaceuticals and Fine chemicals				
	# Available & Selected MOOCs				
Elective-3 (Open elective)					
IT 3418	Cloud Computing	3	1	-	4
CE 3429	Disaster Management				
ECE 3424	Fundamentals of GPS				
CHEM 3427	Industrial Safety and Hazard				
ME 3432	Principles of Entrepreneurship				
EEE 3427	Renewable Energy Resources				
PE 3409	Smart Grid technologies				
CSE 3417	Soft Computing				
CHEM 3228	Chemical Reaction Engineering Lab	-		3	2
CHEM 3229	Mass Transfer Operations Lab	-		3	2
GMR 30206/ GMR 30204	Term paper /Mini Project	-		-	2
GMR 30001	Audit Course	-		-	-
		20		**6**	**26**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

B.Tech7th semester

Code	Subject	Lecture	Tutorial	Practical	Credits
HS3405	Engineering Economics and Project Management	3	1	-	4
CHEM 4433	Biochemical Engineering	3	1	-	4
	Elective-4				
ME4450	Computational Fluid Dynamics	3	1	-	4
CHEM 4430	Numerical Methods in Chemical Engineering				
CHEM 4431	Scale-up methods in Chemical Engineering				
CHEM 4432	Thermodynamic Properties of Crudes and Refinery Design				
	# Available & Selected MOOCs				
	Elective-5				
CHEM 4434	Clean Process Technology				
CHEM 4435	Corrosion Engineering				
CHEM 4436	Fluidization Engineering				
	# Available & Selected MOOCs				
CHEM 4237	Process Equipment Design and Drawing Lab	-		3	2
CHEM 4238	Process Simulation Lab	-		3	2
Total		**12**		**6**	**20**

List of the available & selected MOOCs courses will be intimated before the commencement of semester.

B.Tech. 8th semester

Code	Subject	Lecture	Tutorial	Practical	Credits
GMR 42007	Full Semester Internship	**-**	**-**	**-**	**20**

Department of Chemical Engineering
B.Tech- 5th Semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Chemical Reactor Theory **Subject code: CHEM 3412**

L	T	P	C
3	1	0	4

Course Objectives:
1. The emphasis of this course is on the fundamentals of chemical reaction kinetics and chemical reactor operation.
2. Heat transfer, mass transfer, thermodynamics and chemical kinetics all play an important role in chemical reactor analysis and design and will be discussed in detail.
3. The overall goal of this course is to develop a critical approach toward understanding complex reaction systems and elucidating chemical reactor design.
4. Integrate concepts from science & engineering to constitute a basis for the design of chemical reactor, a key element in the design of chemical process.

Course outcomes:
At the end of the course, the student will be able to:
1. Analyze and interpret experimental data from batch reactors and determine the order of simple chemical reactions.
2. Compare ideal reactor types (batch, CSTR and PFR) and apply quantitative methods to design and size reactors for simple chemical reaction schemes.
3. Determine optimal ideal reactor design for multiple reactions for yield or selectivity.
4. Predict reactor performance for reactors when the temperature is not uniform within the reactor.

Syllabus

UNIT- I: KINETICS OF HOMOGENEOUS REACTIONS **9+3Hrs**
Classification of reactions, Rate equations of elementary and non-elementary reactions, variables affecting the rate of reaction, reaction rate constant, reaction order and molecularity, reversible reactions, nonelementary reactions; Concentration dependent term of rate equation, Temperature dependent term of rate equation, predictability of reaction rate from theory.

UNIT-II: INTERPRETATION OF BATCH REACTOR DATA **13+5Hrs**
Constant and variable volume reaction systems, integral and differential methods of kinetic analysis, half-lives, fractional life method – general procedure, irreversible unimolecular type first order, bimolecular type second order, and trimolecular type third order reactions, empirical reactions of nth order, zero-order reactions, overall order of irreversible reactions, irreversible reactions in series and parallel, Analysis of total pressure data obtained in a constant-volume system, First and second order reversible reactions, reactions of shifting order, Biochemical Reaction systems (Enzymatic reactions); Non-elementary Homogeneous Reactions - reaction mechanisms, pseudo-steady state hypothesis, and search for a rate equation.

UNIT- III: ISOTHERMAL REACTOR DESIGN **9+3Hrs**

Ideal reactors for a single reaction - Ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug flow reactors; Design for single reactions - Size comparison of single reactors, Multiple reactor systems, Recycle reactor, Autocatalytic reactions.

UNIT IV: DESIGN FOR MULTIPLE REACTIONS AND TEMPERATURE & PRESSURE EFFECTS 14+4Hrs

Introduction to multiple reactions, qualitative discussion and quantitative treatment of product distribution and of reactor size, Irreversible first order reactions in series, quantitative discussion about product distribution, quantitative treatment - plug flow or batch reactor, mixed flow reactor, first-order followed by zero order reaction, zero order followed by first order reaction.

Non-isothermal operation of reactors: Optimum temperature progression; Adiabatic and non-adiabatic batch, mixed flow and plug flow reactors; Exothermic reactions in mixed flow reactors; Multiple reactions: Yield and selectivity.

Text Books:

1. O. Levenspiel, Chemical Reaction Engineering, 3rd ed. John Wiley & Sons, 2007.

Reference Books:

1. H. S. Fogler, Elements of Chemical Reaction Engineering, 4th ed., PHI, 2005.
2. K A Gavhane, Chemical Reaction Engineering – I, NiraliPrakashan, 2004.
3. K.G. Denbigh, J.C.R Turner, Chemical Reactor Theory: An introduction, Cambridge University Press, 3rd ed., 1984.

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Chemical Technology **Course code:** CHEM 3413

L	T	P	C
3	1	0	4

Course Objectives:

The course enables to:

• Understand the schematic representation of important unit operation/ unit processes involved in plant operations.

• Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as chloro-alkali industries, Pulp, Paper, and Fermentation Industries.

• Impart clear description of one latest process along with its Chemistry, Process parameters, Engineering Problems and Optimum Conditions.

• Demonstrate the importance of updating the latest technological developments in producing products economically and environment friendly.

• Appreciate the usage of other engineering principles such as Thermodynamics, Heat, mass and momentum transfer in operation and maintain the productivity.

Course outcomes:

Upon successful completion of the course the students will be able to:

1. Make a neat and easy to understand the plant process flow sheet.

2. Keeps up the productivity while maintaining all safety norms stipulated, during their job.

3. Solve Engineering problems that are likely to come across during the operation of plants.

4. Suggest alternative manufacturing process in terms of Economic viability of the product.

UNIT-I 18 Hrs

Schematic representation of Unit operations and Unit processes, Soda ash, Caustic soda, Chlorine,

Industrial gases: Hydrogen , Oxygen, Nitrogen industries: Synthetic ammonia, Urea and Nitric acid.

UNIT –II 14 Hrs

Sulfur and sulfuric acid, manufacture of glass, manufacture of Cements, Special cements, UNIT –III 14 Hrs

Manufacture of Phenol, formaldehyde, phenol-formaldehyde resin, SBR

Oils: expression and extraction of vegetable oils, hydrogenation of oils, Ethanol by fermentation

UNIT –IV 14 Hrs

Soaps: continuous process for productions of fatty acids, glycerin, and soap, Pulp & Paper industry: production of pulp by sulfate, sulfite process, black liquor recovery and production of paper by wet process,

TEXT BOOKS:

1. George T Austin, Shreve's Chemical Process Industries - International Student Ed., 5th ed., McGraw Hill Inc., 1998.

2. Sittig M. and Gopala Rao M., Dryden’s Outlines of Chemical Technology for the 21st Century, 3rd ed., WEP East West Press, 2010.

REFERENCE BOOK

1. Sharma, B.K., Industrial Chemistry, Goel Publishing House, Meerut, 1997.

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Principles of Mass Transfer **Course code:** CHEM 3414

L	T	P	C
3	1	0	4

Course Objectives: The course content enables the students

1. to discuss the fundamental concepts of mass transfer principles and to apply those concepts to real engineering problems.
2. Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations, absorption

Course outcome(s):

At the end of the course students are able to:

1. Recognize the various modes of mass transfer, Determine mass transfer rates using Fick's Law
2. Estimate diffusion coefficients, Solve unsteady state diffusion problems
3. Determine convective mass transfer rates, Determine convective mass transfer coefficients
4. Determine the number of transfer units and height requirements for a packed column
5. Differentiate various membrane process and their applications

UNIT- I: (Introduction to Mass Transfer Operations & Molecular Diffusion) 11+4Hrs
Introduction to Mass Transfer Operations: Classification of the Mass-Transfer Operations
Molecular Diffusion In Fluids: Molecular Diffusion, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids, Molecular Diffusion In solids: Diffusion in Solids, Fick's Diffusion, Unsteady State Diffusion, Types of Solid Diffusion, diffusion through polymers, diffusion through crystalline solids, Diffusion through porous solids & hydrodynamic flow of gases

UNIT-II: (Mass Transfer Coefficients & Inter Phase Mass Transfer) 12+4Hrs
Mass Transfer Coefficients Mass Transfer Coefficients in Laminar Flow (Explanation of equations only and no derivation), Mass Transfer Coefficients in Turbulent Flow, eddy diffusion, Film Theory, Penetration theory, Surface-renewal Theory, Combination Film-Surface-renewal theory, Surface-Stretch Theory, Mass, Heat and Momentum Transfer Analogies, Turbulent Flow in Circular Pipes. Mass transfer data for simple situations.

Inter Phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, Material Balances in steady state co-current and counter current stage processes, Stages, Cascades, Kremser – Brown equation.

UNIT- III: (Equipment for Gas-Liquid Operations) 12+4Hrs

Gas dispersed - sparged vessels (bubble columns), mechanical agitated equipments, tray towers - general characteristics, sieve tray design for absorption and distillation, different types of tray efficiencies.
Liquid dispersed - venturi scrubbers, wetted-wall towers, packed towers - counter current flow of liquid & gas, mass transfer coefficients, end effects and axial mixing, design of packed column- HTU concept, tray towers vs packed towers.

UNIT- IV: (Equipment for Gas-Liquid Operations) 10+3Hrs

Membrane Separation Processes (qualitative treatment only): Basic principles of membrane separation, classification of membrane processes – pressure driven, concentration gradient driven, electric potential driven processes – brief introduction on reverse osmosis, nanofiltration, ultrafiltration, microfiltration, pervaporation, dialysis, membrane extraction, electrodialysis. Types of synthetic membranes – microporous, asymmetric, thin-film composite, electrically charged and inorganic membranes. Membrane modules - industrial applications

TEXT BOOKS:

1. Mass transfer operations by R.E. Treybal, 3rd ed., McGraw Hill, 1980.
2. Membrane Separation Processes, Kaushik Nath, PHI, 2008

REFERENCE BOOKS:

1. 1. Unit Operations of Chemical Engineering, W.L. McCabe, J.C. Smith & Peter Harriott, McGraw-Hill, 6th Edition, 2001
2. 2. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Pvt. Ltd., 2009.
3. 3. Equilibrium Staged Separations, Phillip C.Wankat, Prentice-Hall PTR, 1988.

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Process Dynamics & Control **Course code:** CHEM 3415

L	T	P	C
3	1	0	4

Course objectives:

1. Ability to develop mathematical and transfer function models for dynamic processes.
2. Ability to analyze process stability and dynamic responses.
3. Ability to empirically determine process dynamics for step response data.
4. Familiarity with different types of PID feedback controllers.
5. Ability to read block diagrams and process and instrumentation diagrams.
6. Ability to understand feed forward control, cascade control and Smith predictors and their applications.
7. Knowledge of real time applications of process control implementation.

Course outcomes:

After taking this course, students should be able to:

1. Comprehend the basic concepts of process control and outline the importance in process operation and the role of process control engineers.
2. Develop mathematical models of various systems by writing unsteady-state mass and energy balances.
3. Analyze linear dynamical systems using Laplace transforms.
4. Design and tune feedback controllers on real systems as well as simulated systems.
5. Apply different methods to verify the stability and performance of feedback loops using Laplace and frequency domain techniques.
6. Understand the need of advanced control strategies and decide under which conditions they are required in process industries.

UNIT-1 **12+4Hrs**

Introductory Concepts of Process Control-the chemical process, An Industrial Perspective of a Typical Process Control Problem, Variables of a Process,The Concept of a Process Control System, Overview of Control System Design

Introduction to Control System Implementation- evolution of control system implementation, Elements of a digital computerControlSystem,Transducers for Data Acquisition and Control, finale control elements-Control valves, **Modes of Computer Control**-direct digital control,elements of a distributed control system network

UNIT-2 **11+3Hrs**

Tools of Dynamic Analysis -Formulating Process Models, The Concept of a Transfer Function, Linearization

Dynamic Behavior of Linear Low Order-Systems First Order Systems Response of First-Order Systems to step and impulse inputs, Pure Gain Systems Pure Capacity Systems
Dynamic Behavior of Linear Higher Order Systems Two First-Order Systems in Series Second-Order Systems, Response of Second-Order Systems to step and impulse inputs, ,*N*First-Order Systems in Series

UNIT-3 **11+4Hrs**
Control systems analysis Properties of Closed-loop transfer functions. Properties of Block diagram, Choice of controller type P, PI, PD, PID. Specifications and performance criteria
Controller tuning Tune PID controllers using the classical, Ziegler-Nichols, and Cohen-Coon methods

UNIT-4 **11+4Hrs**
Stability of a dynamic process Analysis Definitions of Stability, Routh-Hurwitz's stability criterion, Routh test, root locus
Frequency Response Analysis The frequency response for a stable system, Graphical frequency-response representation, bode stability criterion, bode plots, Stability margins
Process Applications Cascade Control, Feed-Forward Control, Ratio Control, Selective and Override Control, Split-Range Control, control of distillation towers and heat exchangers

Textbooks
1. Process System Analysis and Control., 2^{Edn}. Donald R.Coughnowr, McGraw-Hill Inc., 1991.

Reference Books:
1. Process Dynamics, Modeling, and Control Babatunde A. Ogunnaike, W. Harmon Ray- -Oxford University Press
2. Process Dynamics and Control Duncan A. Mellichamp, Dale Seborg, Thomas F. Edgar, Francis Doyle, John Wiley & Sons Inc, 2010, Third Edition
3. Chemical Process Control: An Introduction to Theory & Practice, George Stephanopoulos, Prentice - Hall of India Private Limited, New Delhi, 1993.
4. Principles and Practice of Automatic Process Control, Carlos A. Smith and Armando B. Corripio, John Wiley & Sons, New York, 1985

Department of Chemical Engineering
B.Tech - 5th Semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Fertilizer Technology **Course code:** CHEM 3416

L	T	P	C
3	1	0	4

Course Objectives: The course enables to:
1. Identify the sources available for Nitrogen and Hydrogen.
2. Know gas purification techniques.
3. Know different methods available for Production of ammonia and ammonia recovery.
4. Explain production of urea and nitric acid.
5. Understand the process available for production of various types of fertilizers.

Course outcomes:
Upon successful completion of the course, the students will be able to:
1. Define the characteristics of a good fertilizer
2. Explain types of fertilizer and raw materials available.
3. Discuss the production methods for various fertilizers.
4. Draw the production flow sheet and explain the equipments used in production process.
5. Explain about Controlled Released fertilizers.

UNIT –I **12+4Hrs**
Source of Nitrogen and Hydrogen, Steam Reformation of hydrocarbons, Coal Gasification process, Partial oxidation of fuel oils, Gas purification, high and low temperature shift conversion, CO removal processes, Methanation.

UNIT –II **11+3Hrs**
Manufacture of Ammonia, Ammonia synthesis by various processes, by product ammonia recovery by direct and indirect methods, Manufacture of nitric acid and production of urea, urea once through, total and partial recycle processes, Prilling**.**

UNIT –III **11+4Hrs**
Manufacture of other nitrogenous fertilizer such as ammonium sulfate, calcium ammonium nitrate, ammonium chloride etc., granulation techniques. Phosphatic fertilizers, single and triple super phosphate, manufacture and production of ammonium phosphate and nitro phosphates, manufacture of phosphoric acid.

UNIT –IV **11+4Hrs**
Potassium fertilizers, mixed and compound fertilizers, liquid fertilizers, Indian fertilizer industry, production economics and future plans, fertilizer application techniques for different soils, controlled release fertilizers.

TEXT BOOKS:
1. Chemistry and technology of fertilizers by V. Seucheli, Reinhold 1960/
2. Ammonia by Slack A.V. Marcel Dekker, 1973.

REFERENCE BOOKS:
1. Outlines of Chemical Technology by CE. Dryden
2. Manual of fertilizer processing by F.T.Nielsson, Dekker 1987

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Industrial Pollution Control Engineering **Course code:** CHEM 3417

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Emphasize on this course is on the fundamentals of pollution control aspects and characterization of effluent streams.
2. Know the primary, secondary and advanced wastewater treatment process.
3. Learn about different air pollutants sampling and analysis methods and air pollution control equipments.
4. Understand the solid, hazardous waste and their treatment and disposal methods and Learn pollution control aspects for selected process industries.

Course outcomes:
At the end of the course, the students will be able to:

1. Understanding of different types of pollution and apply knowledge for the protection and improvement of the environment
2. Select and use suitable wastewater treatment technique
3. Identify suitable sampling, analysis and equipment for air pollutants.
4. Apply their knowledge in controlling the pollution in process industries

UNIT- I: **11hr +3hr**
Types of emissions from chemical industries and effects on environment, Type of pollution and their sources, Effluent guide lines and standards.

Characterization of effluent streams, Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve mathematical, Controlling of BOD curve, Self purification of running streams.

UNIT-II: **12Hrs+4Hrs**
Wastewater treatment Process- Methods of primary treatment; Screening, sedimentation, flotation, neutralization, secondarytreatment: Biological treatment of wastewater and bacterial growth curve, suspended growth processes (activated sludge, aerated lagoon and stabilization pond), attached growth processes (trickling filter and rotating biological contactor); tertiary treatment methods (carbon adsorption, membrane separation, chlorination, and ozonation)

UNIT- III: **12Hr+4Hrs**

Criteria and toxic air pollutants, Air pollution sampling and measurement:Ambient air sampling: collection of gaseous air pollutants, Collection of particulate air pollutants, Stack sampling: Sampling system, particulate and gaseous sampling.

Air pollution control methods and equipments:Source correction methods: raw material changes, process changes and equipment modification, Particulate emission control: collection efficiency, Control equipments like gravity settling chambers, Cyclone separators, Fabric filters, Electrostatic precipitator, Scrubbers (spray towers andventuri scrubbers), Gaseous emission control (SO_x, NO_x and organic vapor): absorption by liquids and adsorption by solids

UNIT IV: **10Hrs+4 Hrs**

Solid waste management: Sources and classification, Methods of collection (HCS and SCS), Disposal methods (Landfill and incineration)

Hazardous waste management; Nuclear wastes; Health and environment effects, sources and disposal methods, Chemical wastes; Health and environment effects, Treatment and disposal.

Pollution control in selected process industries: Fertilizer industries, Petroleum refineries and Thermal power plants.

Text Book:

1. Environmental Pollution and Control Engineering by Rao C.S– Wiley Eastern Limited, India, 1993.
2. Pollution Control in Processes Industries by S.P. Mahajan, TMH., 1985.

References:

1. Waste water treatment by M.NarayanaRao and A.K.Datta, 3rd Edition, Oxford and IHB, 2008.
2. Air Polution by MN Rao and H V N Rao, Tata McGraw Hill Education Private Limited, India,2010.
3. Environmental Engineering by H.S.Peavy, P.R. Rowe, G. Tchobanoglous, McGraw Hill, 1985.
4. Wastewater engineering treatment and reuse by Metcalf and Eddy, 4th edition, Tata McGraw Hill Edition 2003.

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Polymer Technology **Course code:** CHEM 3418

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:
The course content enables the students to:
1. Understand and be able to compute molecular weight averages from the molecular weight distribution.
2. Understand the major classes of step growth and chain growth polymerization and be able to specify reaction conditions to control molecular weight and, to the extent possible, its distribution.
3. Understand how polymers from the same monomer can have different chain architecture and how to control it during polymerization.
4. Understand the typical microstructure of glassy and semi-crystalline polymers, how this microstructure develops and how it may be characterized.
5. Articulate the physical basis of the elasticity of polymer networks, both cross-linked and entangled, and be able to specify what factors control their shear modulus.

COURSE OUTCOME(S):
At the end of the course students will be able to:
1. Identify chemical formulas for common polymers and distinguish whether a polymer was likely synthesized via a condensation (step growth) or addition (chain) polymerization reaction.
2. Calculate the extent of reaction required to reach a particular degree of polymerization reaction and the time required to reach that extent of reaction given appropriate rate constants.
3. Determine the solubility of a polymer in a solvent given the Flory-Huggins interaction parameter.
4. Identify and analyze data from experimental methods of measuring the radius of gyration, different molecular weight averages, and second virial coefficient for polymer solutions.
5. Determine the volume fraction of crystallinity for a polymer sample and measure the glass transition temperature.

UNIT-I **15 Hrs**
Introduction; definitions: polymer& macro molecule, monomer, functionality, average functionality, copolymer,
polymer blend., plastic and resin.
Classification of polymers: based on source, structure, applications, thermal behavior, mode of polymerization.
Methods of polymerization: mass or Bulk polymerization process, solution polymerization process, suspension polymerization process and emulsion polymerization method comparison of merits and demerits of three methods.
Mechanism and kinetics of Addition or chain polymerization
a) Free radical addition polymerization
b) Ionic addition polymerizations
c) Coordination polymerization.
d) Coordination or step growth or condensation polymerization.
UNIT –II **15 Hrs**
Measurement of molecular weight and size:

End group analysis, Colligative property measurement, light scattering, ultra centrifugation, solution viscosity and molecular size and gel permeation chromatography, poly-electrolytes.
Polymer structure and physical properties: The crystalline melting point, the glass transition temperature, properties involving large deformations, properties involving small deformations, Property requirements and polymer utilization.

UNIT –III **15 Hrs**

Thermodynamics of polymer mixtures: Introduction, criteria for polymer solubility, the Flory Huggins theory, free volume theories, Free volume theory of diffusion in rubbery polymers, gas diffusion in glassy polymers, polymer-polymer diffusion.
Degradation of polymers, Role of the following additives in the polymers:
Fillers and reinforcing fillers ii) Plasticizers iii) Lubricants iv) Antioxidants and UV stabilizers v) Blowing agents vi)Coupling agents vii)Flame retardents viii) Inhibitors

UNIT –IV **15 Hrs**

Brief description of manufacture, properties and uses of:
i) Polyethylene (HDPE&LDPE), ii) Poly propylene iii) Polyvinylchloride iv) Polystyrene v) Polytetrafloroethylene vi) Polymethylmehacrylate vii) Polyvinylacetate&Polyvinylalcohol.
Polymer Processing: Molding, Extrusion, other processing methods (calandering, casting, coating, foaming, forming, laminating), multi-polymer systems and composites, additives and compounding.

TEXT BOOK:

1. Polymer Science and Technology, Joel R. Fried, Prentice Hall India.
2. Textbook of Polymer Science, Bill meyer, F.W.Jr. (3rd ed.) John Wiley & sons 1984.

REFERENCE BOOKS:

1. Introduction to Plastics, J.H. Brison and C.C. Gosselin, Newnes, London, 1968.
2. Polymeric Materials, C.C.Winding and G.D.HiattMcGraw Hill Book Co., 1961

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Computer Application in Chemical Engineering Lab **Course code:** CHEM 3219

L	T	P	C
0	0	3	2

Course Objectives:

1. To familiarize students with basic programming skills required for solving chemical engineering problems.
2. To analyze the data obtained from simulation with theoritcal concepts.
3. To compare different thermodynamic property estimation methods and analysing the results.
4. To familiarize students with fundamental applications of chemical engineering in ASPEN PLUS.

CourseOutcomes:

At the end of the laboratory course, the students will be able to:

1. Understand the process flow sheets and how it gives the result.
2. Select proper operating tool to meet process needs and run the program based on the data & method.
3. Understand the application of artificial intelligence based modeling methods using Excel, C Language /MAT Lab/Aspen Plus.
4. Understand the industrial usage of process modeling and simulation.
5. Understand the simulation of steady state lumped, modeling of chemical process equipments like mixers, reactors, distillation, absorption, extraction columns, evaporators, and heat exchangers etc.

Following problems are to be solved in EXCEL/C/MATLAB

1. Solving Equation of State
2. Property Estimation for a Given Compound
3. Mass Balances Without Recycle Streams
4. Mass Balances With Recycle Streams
5. Bubble Point Calculations
6. Dew Point Calculations

Following problems are to be solved in ASPEN PLUS

7. Simulation of a Mixer
8. Simulation of a flow splitter
9. Simulation of a Gravity Flow tank
10. T-x-y diagram of a binary mixture using ASPEN PLUS
11. P-x-y diagram of a binary mixture using ASPEN PLUS
12. Solving material balances using ASPEN PLUS

Department of Chemical Engineering
B.Tech - 5th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Process Dynamics & Control Lab **Course code: CHEM 3220**

L	T	P	C
0	0	3	2

Course Objectives:

1. To understand the dynamic behavior of the systems
2. To evaluate response of fist and higher order characteristics.
3. Study the installed characteristics of the valve.
4. Study if there is a hysteresis in the control valve and sensor.
5. Evaluate the tuning of a PID control via manual and automatic tuning.
6. Evaluate the effect controller on the control system

Course Outcomes:

At the end of the course, the students will be able to:

1. Estimate the dynamic behavior of the control systems
2. Understand the controllability, speed of response the control systems.
3. Select proper control valve to meet process needs.
4. Understand direct digital control systems handling and operation.
5. Tuning of a PID control via manual and automatic tuning.
6. Choose PID modes that effect controllability, speed of response the control systems

Experiments: (Students would perform any 12 experiments out of the following 16 experiments)

1. Study of step response of Mercury-in-Glass thermometer
2. Study of control valve flow coefficient
3. Study of installed characteristics of control valve
4. Study of hysteresis of control valve
5. Study of step response of manometer
6. Step response of first order systems arranged in non- interacting mode
7. Step response of first order systems arranged in interacting mode
8. To study impulse response of first order systems arranged in non-interacting mode
9. To study impulse response of first order systems arranged in interacting mode
10. Step response of single capacity system
11. Study of open loop response control system
12. Study of response of Temperature controller with proportional integral derivative controller mode
13. Study of response of Level controller with proportional integral controller mode
14. Study of response of pressure controller with proportional integral derivative controller
15. Study of response of Flow controller with proportional controller mode
16. Closed loop method Tuning of cascade controllers

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Applications of Mass Transfer **Course code:** CHEM 3421

L	T	P	C
3	1	0	4

COURSE OBJECTIVES: This course deals with:
1. Various chemical engineering separation processes
2. Design of equilibrium-based multistage separations such as absorption, extraction and leaching.
3. Design of distillation column using McCabe-Thiele and Ponchon-Savarit methods.
4. Principles and applications of Fluid –solid separation processes (drying and adsorption).

COURSE OUTCOME(S):
At the end of the course students will be able to:
1. Describe and differentiate various separation processes
2. Design multistage separation systems for specific operations involving absorption, extraction, leaching, drying and adsorption.
3. Construct McCabe-Thiele, Ponchon-Savarit diagrams for distillation
4. Construct triangular diagrams for multiple contact or counter current liquid-liquid extraction
5. Analyze and design constant rate drying systems

UNIT- I: **12+4 Hrs**
Humidification Operations: Vapor pressure curve, definitions, psychometric charts, enthalpy of gasvapor mixtures, humidification and dehumidification, operating lines and design of packed humidifiers, dehumidifiers and cooling towers, spray chambers. Absorption and Stripping: Absorption equilibrium, ideal and non ideal solutions selection of a solvent for absorption, one component transferred: material balances. Determination of number of plates (graphical), absorption Factor, estimation of number of plates by Kremser Brown equation**.**

UNIT- II **11+4Hrs**
Distillation: Fields of applications, VLE for miscible liquids, immiscible liquids, steam distillation, Positive and negative deviations from ideality, enthalpy-concentration diagrams, Flash vaporization and differential distillation for binary mixtures.
Continuous rectification-binary systems, multistage tray towers–method of McCabe and Thiele and Ponchon and Savarit method, enriching section, exhausting section, feed introduction, total reflux, minimum and optimum reflux ratios, use of steam, condensers, partial condensers, cold reflux, tray efficiencies, Azeotropic distillation, extractive distillation, comparison of azeotropic and extractive distillation**.**

UNIT- III: **11+4Hrs**
Extraction: fields of usefulness, liquid-liquid equilibrium, equilateral triangular co-ordinates, choice of solvent, stage wise contact, multistage cross-current extraction, Multi stage counter current without refluxmulti stage counter current with reflux.
Extraction Equipment: Differential (continuous contact) extractors, spray towers, packed towers, mechanically agitated counter-current extractors, centrifugal extractors

Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, equipment for leaching operation.

UNIT-IV: **11+3Hrs**

Drying: Equilibrium, definitions, drying conditions- rate of batch drying under constant drying conditions, mechanisms of batch drying, drying time through circulation drying.

Batch and continuous drying equipment, material and energy balances of continuous driers, rate of drying for continuous direct heat driers

Adsorption: adsorption equilibrium- single gases and vapors, vapor and gas mixtures- one component adsorbed, Liquids- adsorption of solute from dilute solution, the Freundlich equation, adsorption operations- stage wise operation, application of Freundlich equation to single and multistage adsorption (cross current & counter current). Adsorption of vapor from a gas - fluidized bed, continuous contact, unsteady state–fixed bed adsorbers (break through curve)

TEXT BOOKS:

1. Mass Transfer Operations by R.E. Treybal, 3rd ed., McGraw Hill, 1980.

REFERENCE BOOKS:

1. Unit Operations of Chemical Engineering, W.L. McCabe, J.C. Smith & Peter Harriott, McGraw-Hill, 6th ed., 2001.
2. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Pvt. Ltd., 2009.
3. Equilibrium Staged Separations, Phillip C.Wankat, Prentice-Hall PTR, 1988

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Chemical & Catalytic Reaction Engineering **Course code:** CHEM 3422

L	T	P	C
3	1	0	4

Course Objectives:

1. To impart the knowledge of deviations in chemical reactors and to understand the parameters thatinfluences the models of non-ideal reactors.

2. To develop the rate equation for heterogeneous reactions and study about the properties and preparation

of solid catalysts

3. To discuss the effects of diffusion, mass and heat transfer in catalyst pellet in reaction rates and thesignificance of Thiele modulus.

4. To develop the rate-controlling model for heterogeneous reactions, in which diffusion, and reactionscontrolling the reaction rate influence the rate of reaction and to arrive at the relationship for completeconversion for the different types of reactors.

Course Outcomes:

At the end of the course, the students will be able to:

1. Predict reactor performance under non-ideal flow situations using RTD data.

2. Develop rate equation for heterogeneous reactions.

3. Estimate the effects of diffusion, mass and heat transfer in catalyst pellet on reaction rates.

4. Develop the rate-controlling model for heterogeneous catalytic reactions.

UNIT- I: BASICS OF NON-IDEAL FLOW **12+4Hrs**

Non-ideal flow, Residence time distribution (Importance and interpretation of RTD curve, E, F and C curves and relationship between them in reactor, Statistical Interpretation, RTD measurement, Conversion in non-ideal flow reactors, Diagonizing reactor ills, Dispersion model), Tanks-in-series model, Mixing of fluids; Degree of segregation; Laminar flow reactor; Conversion in segregated flow; Early and late mixing.

UNIT-II: HETEROGENEOUS REACTIONS AND SOLID CATALYSIS **11+4Hrs**

Heterogeneous processes, Rate equations for heterogeneous reactions, adsorption isotherm and rates of adsorption, desorption and surface reaction, concept of rate controlling steps and analysis of rate equation.Classification and preparation of catalysts, Promoters and inhibitors, Catalyst characterization: Surface area and pore size distribution, Poisoning of catalysts.

UNIT- III: SOLID CATALYZED REACTIONS 11+3Hrs

Characteristics of catalyzed reaction, Mechanism, Pore diffusion resistance combined with surfacekinetics, Single cylindrical pore + first order reaction, Effectiveness factor, Porous catalyst particles, Heat effects during reaction, Performance equation for reactors containing porous catalyst particles, Experimental methods for finding rates, Deactivation of catalysts and mechanism - the rate and performance equations.

UNIT IV: FLUID--PARTICLE REACTIONS 11+4Hrs

Introduction to fluid particle reactions, The rate Equations, Selection of kinetic model, Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, Chemical reaction controls; Rate of reaction for shrinking spherical particles: Chemicalreaction controls, Diffusion through gas film controls, SCM for cylindrical particles of unchanging size, determination of rate controlling step.

Text Books:

1. O.Levenspiel, Chemical Reaction Engineering, 3rd ed. John Wiley & Sons,1999.

2. H.S.Fogler, Elements of Chemical Reaction Engineering, 2nd ed., PHI, 1992.

3. J.M.Smith, Chemical Engineering Kinetics, 3rd ed., McGraw Hill, 1981.

Reference Book:

1. K.A. Gavhane, Chemical Reaction Engineering – II, NiraliPrakashan, 2008.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Chemical Process Economics & Equipment Design **Course code:** CHEM 3423

L	T	P	C
3	1	0	4

Course Objectives:

The course will enable the students to:

1. Understand general design considerations involving process design development.
2. Learn basic concepts of economic analysis for process, involving equipment cost, and profitability.
3. Acquire basic understanding of design parameters, knowledge of design procedures for pressure vessels.
4. Acquire knowledge of shell & tube heat exchanger Design.
5. Demonstrate procedures in designing of tray distillation columns including minimum reflux ratio, number of stages, feed stage, and column diameter.

Course Outcomes:

At the end of the course, the students will be able to:

1. State the basic concepts of process design development and general design considerations.
2. Perform economic analysis for process to calculate equipment cost, and profitability for process.
3. Design internal pressure vessels and external pressure vessels
4. Design of shell & tube heat exchanger
5. Design of sieve tray distillation column.

Syllabus

UNIT-I **12hr+4hr**

The Anatomy of a Chemical Manufacturing Process, General design considerations- Feasibility Survey, plant location, plant layout, factors to be considered in a comparisonof different processes.
Introduction to Interest and types of Interest, Present worth and discount annuities,Cash flow and cash-flow diagrams

UNIT-II **11hr+4hr**

Costing and Project Evaluation: Fixed and working capital,Rapid capital cost estimation methods-Estimating Equipment Costs by Scaling, cost indexes method,the factorial method of cost estimation,Depreciation - Types of Depreciation, methods for determining the depreciation-straight line method, declining balance method, double declining balance method, sinking fund method, profitability-payout period, capitalized cost.

UNIT-III **11hr+3 hr**

Process Equipment Design:

Shell and tube exchanger design: Construction details- Heat-exchanger standards and codes,Fluidallocation,Basic design procedure, Kern's method of rating, Kern's method of Sizing.
Separation equipment design: Plate Contactors, Selection of Trays, Designing Steps of Distillation Column(Using F-U-G Correlations): Calculation of Minimum number of stages, Minimum Reflux Ratio,

Actual Reflux Ratio, theoretical number of stages, actual number of stages, diameter of the column, weeping point, entrainment, pressure drop and the height of the column.

UNIT-IV **11hr+4hr**

Mechanical Design of Process Equipments: Fundamental principles and equations-Principal stresses, Theories of failure, Elastic stability, Membrane stresses in shells of revolution, Flat plates, Dilation of vessels,Design pressure, Design temperature, Materials, Design stress (nominal design strength), Welded joint efficiency, Corrosion allowance, Design loads, Minimum practical wall thickness,The design of thin-walled vessels under internal pressure, Design of vessels subject to external pressure, Design of vessels subject to combined loading.

Text Books:

1. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003)
2. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Ed., Butterworth-Heinemann.

References:

1. D.Q.Kern, Process Heat Transfer, McGraw Hill, 1950.
2. Applied process Design for Chemical and Petrochemical Plants, Volume 3, 3rd Edition, Ernest E. Ludwig.
3. Bhattacharya B. C; "Introduction of Chemical Equipment Design", CBS Publisher, 2003.
4. Seader J. D. and Henley E. J., "Separation Process Principles", 2nd Ed., Wiley-India.
5. I.S.; 4503 - 1967, Indian Standard Specification for Shell and Tube Type Heat Exchangers.
6. Hewitt G.F., Shires G. L. and Bott T. R., "Process Heat Transfer", Begell House.
7. Serth R.W., "Process Heat Transfer: Principles and Applications", Academic Press.
8. Brownell L. E. and Young H. E., "Process Equipment Design", John Wiley.
9. I.S.:2825-1969, "Code for Unfired Pressure Vessels".
10. Process Equipment Design byM.V.Joshi , V. V. Mahajani, 3rd Edition, Macmillan Publishers, 2009.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Material Science for Chemical Engineers **Course code:** CHEM 3424

L	T	P	C
3	1	0	4

Course Objectives:

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between atomic, molecular, crystalline, and microscopic structures, characterization, properties and processing and design of materials.
3. Possess knowledge of the significance of research, the value of continued learning and environmental/social issues surrounding materials.

Course Outcomes:

1. Students would have knowledge about the existence of new materials and their properties.
2. The students will be able to choose appropriate material for process equipment.
3. Understand the failure analysis and select appropriate materials or relevant corrosion protection schemes for corrosion resistance; and
4. Understand the basic aspects of advanced materials and their applications.

UNIT I **12 +4 Hours**

Introduction: Introduction to material science, classification of engineering materials, Level of structure, Structure property relationships in materials.

Crystal Geometry and Structure Determination: Geometry of crystals- Concept of unit cell space lattice, the Bravais lattices, Crystal directions and planes-the miller indices, Atomic packing factor and density Structure determination-X-Ray diffraction- Bragg law, The powder method.

Crystal Imperfections: Point imperfections, Line imperfections-edge and screw dislocations, Surface imperfections.

Covalent solids, Metals and alloys, Ionic solids, Structure of silica and silicates.

UNIT II **09 +3Hours**

Elastic deformation: Modulus as a parameter in design, Anelastic behavior-Relaxation processes Viscoelastic behavior: Spring-dashpot models.

Plastic deformation: The tensile stress-strain curve, Plastic deformation by slip, the shear strength of perfect and real crystals, work hardening and dynamic recovery.

Creep: Mechanisms of Creep, creep resistant materials.

Fracture: Brief theoretical consideration of Fracture and Fatigue.

Unit – III **12 +4 Hours**

Heat Treatment: Various types of heat treatment such as Annealing, Normalizing, Quenching, Tempering and Case hardening. Time Temperature Transformation (TTT) diagrams. Brief outlines of heat treatment of plane steel.

Cast iron as material of construction with reference to its application in chemical engineering, selection of material, general criterion of selection of material of construction in process industries-mild steel, high carbon steel, stainless steel, high silicon steel, molybdenum and tungsten steel.

Unit – IV **12 +4 Hours**

Metals:

Engineering materials - elementary study of nonferrous metals and alloys copper, aluminum, lead, chromium, tin, brass, bronze and monel with reference to the application in chemical industries.

Non-metals – Glass, Enamels, graphite, wood, plastics, rubber, ebonite lining materials, composite materials: fiber reinforced plastic composite material, concrete, asphalt and asphalt mixture, ceramic mixture-structure and properties, polymeric material with reference to the application in chemical industries.

TEXT BOOKS:

1. Material Science and Engineering; V. Raghavan; 4th Edition, Prentice Hall of India Pvt. Ltd.,
2. Elements of Material Science and Engineering, Lawrence H. Van Vlack, 6th Edition, Addison-Wesley Publishing Company
3. S. K. HajraChoudhury, "Material Science and processes", 1stEdn. , 1977. Indian Book Distribution Co., Calcutta.
4. Russel E. Gackenbach, Materials selection for process plants.
5. Frank Ramford, Chemical Engineering materials.
3. Lee Z.Z., Materials of construction for Chemical Process Industries.

REFERENCE BOOKS:

1. Science of Engineering Materials Vol. 1 &2; Manaschand; Mcmillan Company of India Ltd.
2. Principles of Materials science and engineering; William F.Smith, MGH Publishing Company.
3. Materials science for engineering; William.DCallistersJr; 3rded, 1994 Wiley & Sons.
4. Khanna O.P., A Text Book of Material Science & Metallurgy.
6. Chilton &Perry, Chemical Engineers Handbook.
7. Agrawal B.K., Introduction to Engineering Materials.
8. Khurmi R.S., Materials Science.
9. Gupta K.M., Material Science & Engineering.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Petroleum refining and petrochemicals **Course code:** CHEM 3425

L	T	P	C
3	1	0	4

COURSE OBJECTIVE(S):
The course content enables students to:

1. Learn the formation, refining of crude oil and products of refinery.

2. Understand the means of processing data including thermal properties, important products characteristics.

3. Develop skills in drawing neat flow diagrams of different petroleum refining processes (cracking/reforming/alkylation/isomerization / hydrocracking etc.,) that are aimed at producing high value/demand products.

4. Understand final product treating/finishing operations.

5. Identify important testing methods for important petroleum products.

6. Have idea on Indian standards for major petroleum products

COURSE OUTCOME(S):

At the end of the course students are able to:

1. Describe the formation of crude oil, its refining techniques.

2. Describe the chemical composition and physical properties of crude oil

3. Understand various processes employed in petroleum refinery such that we can meet customer demand in terms of quality & quantity.

4. Demonstrate the different methods available for removal of impurities from crude and products manufacture

5. Understand, draw and describe the process flow diagrams of various refinery processes like distillation, cracking and reforming etc.,

UNIT-I **12+4Hrs**

Origin, formation and composition of petroleum: Origin and formation of petroleum, theories explaining crude formation. Fractionation of petroleum: Dehydration and desalting of crudes, heating of crude-pipe still heaters,distillation of petroleum.

UNIT –II **11+4Hrs**

Petroleum processing data: Evaluation of petroleum, thermal properties (viscosity index, flash, fire points, of petroleum fractions), important products, properties and test methods.
Treatment techniques: fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.

UNIT –III **11+4Hrs**

Thermal and catalytic processes: Cracking, catalytic cracking, catalytic reforming, Naphtha cracking, coking, Hydrogenation processes, Alkylations processes, Isomerization process.
Petrochemical Industry – Feedstocks-gases, liquids, solids; purification of gases, aromatics separation from Reformates-Udex process

UNIT –IV **11+3Hrs**

Chemicals from methane: Introduction, production of Methanol, Formaldehyde, Ethylene glycol, and Methylamines, Chemicals from Ethane-Ethylene-Acetylene: Oxidation of ethane, production of Ethylene, Manufacture of Vinyl Chloride monomer, vinyl Acetate manufacture, Ethanol from Ethylene, Acetaldehyde from Acetylene.

TEXT BOOKS:

1. Modern Petroleum Refining Processes, B.K. BaskaraRao, Oxford & IBH Publishing, 4th ed., 2002.

REFERENCE BOOKS:

1. A text book on Petrochemicals, 4th ed., B.K. BhaskaraRao, Khanna publishers, 2002.

2. Fuels Furnaces and Refractories by O P Gupta, Kanna Publishers, 1967.

3. George T Austin, Shreve's Chemical Process Industries - International Student Ed., 5th ed.,

McGraw Hill Inc., 1998.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Pharmaceuticals and Fine chemicals **Course code:** CHEM 3426

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Study the origin, preparation, properties, effects, dosage and dispensation of medicines.
2. Achieve the overall goal in the transformation of raw materials into valuable products by chemical, biochemical or physical processes in pharmaceuticals and fine chemicals.
3. Identify and understand separation processes, that are used in production of fine and speciality chemicals including pharmaceuticals.
4. Identify the safety measures and environmental issues related to pharmaceuticals and fine chemicals.

Course outcomes:
At the end of the course, the students will be able to:

1. Learn the principles of limit test for pharmaceuticals and sources of impurities in chemicals.
2. Preparation outlines for the manufacture of pharmaceuticals and fine chemicals.
3. Design various unit operations pertinent to fine chemicals and pharmaceuticals sectors
4. Investigate environmental impacts in the field of pharmaceuticals and fine chemicals

SYLLABUS

UNIT- I: **10 hr+3hrs**
A brief outline of grades of chemicals, sources of impurities in chemicals, limit test, principles of limit test for arsenic, lead, iron, chloride and sulfate in Pharmaceuticals.

Unit II: **11hr +4Hrs**
Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals -sulfacetamide, paracetamol.
Manufacture with flowsheets, properties, uses and testing of the following Pharmaceuticals – aspirin, penicillin.

UNIT- III: **12hrs +4Hrs**

Outlines of Preparation, properties, uses and testing of the following fine chemicals - Methyl orangeandparamino salicylic acid.
Manufacture with flowsheets, properties, uses and testing of ferric ammonium citrateandpthallic anhydride.

UNIT IV: **12hrs +4Hrs**

Overview of unit operations important to the production of pharmaceuticals and fine chemicals such as filtration, centrifugation, extraction, adsorption, membrane separation, distillation, drying. Unit operations associated with tablet making, such as granulation, blending, compression, agglomeration, encapsulation. Safety, toxicity, and environmental issues in fine chemicals and pharmaceuticalproduction.

TEXT BOOKS:

1. Remington's Pharmaceutical Science, Mac publishing company, 16th Edition, 1980.
2. Blently's TEXT BOOK of Pharmaceutics by H A Rawlins, B Tindell and Box, 8th ed. OU Press, London, 1977.

REFERENCES:

1. Text Book of Pharmaceutical Chemistry by Blently and driver. Oxford University press, London, 8th ed. 1960.
2. Industrial Chemicals by Faith, Kayes and Clark, John Wiley & Sons, 3rd.Ed. 1965.
3. Organic Chemistry - T.R. Morisson and R. Boyd, 6th edition, Prentice Hall of India Pvt. Ltd., New Delhi – 1992.
4. William Lawrence Faith, Donald B. Keyes and Ronald L. Clark, Industrial Chemicals, 4th Edition, John Wiley & Sons, 1975.
5. Separation Process Principles by J. D. Seader, E. J. Henley, 2006.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))
Elective-3 (Open elective)

Course Title: Industrial Safety and Hazard Management **Course code:** CHEM 3427

L	T	P	C
3	1	0	4

Course Objectives:
The course content enables students to:
1. Work and develop safety and hazard management system.
2. Learn how to design inherently safer chemical plant.
3. Get knowledge of different hazardous chemicals and what are the hazards and how to work withthem, inspection for safety, designing of flares, hazard analysis and risk assessment.
4. Know how to assist engineers and process safety personnel who are involved with chemicalprocesses and operations where flammable gases, vapors, or mists are present.
5. Learn the techniques available for both preventing dust explosions and protecting people andfacilities from their effects.

COURSE OUTCOME(S): At the end of the course students will be able to:
1. Understand the safety and ethical issues that may arise from industrial processes.
2. Understand and be able to communicate the importance of Safety in chemical engineeringpractice—both in ethical and economic terms.
3. Evaluate hazards both qualitatively, using techniques like "what if" and "HAZOP" analyses, andquantitatively, using techniques like fault tree and event tree analyses.
4. Understand and be able to communicate the difference between Hazard and Risk. Be able toexpress Safety in terms of Risk and to recognize unacceptable/inappropriate levels of Risk.
5. Understand hazards arising from runaway reactions, explosions and fires, and how to deal withthem.
6. Understand the behavior of accidental releases of hazardous materials from industrial chemicalprocesses, including consequences related to health and property.

UNIT-I **12+4Hrs**
Introduction: Safety Programs- Engineering Ethics- Accident and Loss Statistics- Acceptable Risk-Public Perceptions- The nature of the Accident Process-Inherent Safety.
Toxicology: how toxicants enter biological organisms – how toxicants are eliminated from biologicalorganisms- effects of toxicants on biological organisms – toxicological studies .

UNIT-II **11+3Hrs**
Industrial Hygiene: Government of India regulations and OSHA – Industrial HygieneIdentification – Evaluation - Control.
Fires and Explosions: The fire triangle, Distinction between fire and explosions; Definitions, Flammability characteristics of liquids and vapors, MOC and inerting, ignition energy, Auto ignition, Autooxidation, Adiabatic compression, Explosions.

UNIT- III **11+4Hrs**

Designs to prevent fires and explosions: Inerting – static electricity – controlling static electricity – explosion – proof equipment and instruments – ventilation – sprinkler systems – miscellaneous designs for preventing fires and explosions.

Introduction to Reliefs: relief concepts – definitions – location of reliefs – relief types – relief scenarios – data for sizing reliefs – relief systems.

UNIT- IV **11+4Hrs**

Relief sizing: conventional spring – operated reliefs in liquid service – conventional spring –operated reliefs in vapor or gas service – rupture disc reliefs in liquid service- rupture disc reliefs in vapor or gasservice – deflagration venting for dust and vapor explosions- venting for fires external to process vessels reliefs for thermal expansion of process fluids.

Hazards identification: process hazards checklists – hazards surveys – hazards and operability studies – safety reviews – other methods.

Risk assessment: review of probability theory – event trees – fault trees – QRA and LOPA.

TEXT BOOKS:

1. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, 3rd Ed., Prentice Hall, 2011.

REFERENCE BOOKS:

1. H.H.Fawcett and W.S.Wood, Safety and Accident Prevention in Chemical Operations, John Wiley and sons, 2nd edition, New York, 1982.
2. Coulson and Richardson's – Chemical engineering – R. K. Sinnot, Vol.6, Butterworth - Heinmann Ltd. 1996.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Chemical Reaction Engineering Lab **Course code:** CHEM 3228

L	T	P	C
0	0	3	2

CourseObjectives:

1. To familiarize students with main type of chemical reactors.
2. To analyze the experimental data to obtain the reaction rate expression (reaction order and specific reaction rate constant).
3. To compare the conversion of reactants for a specific reaction in various types of reactor.
4. To understand the concept of residence time distribution in reactor systems.
5. To determine mass transfer coefficient of systems with chemical reaction.

Course Outcomes:

At the end of the laboratory course, the students will be able to:

1. Estimation of rate constant by applying Arrhenius theorem.

2. Understand the estimation of rate law parameters for a given reaction in a batch reactor by using two different methods.

3. Determine the rate law parameters in a Mixed Flow Reactor for a given reaction.

4. Estimation of residence time distribution in a Plug Flow Reactor for a given reaction.

5. Find the residence time distribution by applying Non-ideal dispersion model in CSTRs in series.

6. Estimation of mass transfer coefficients in mass transfer with and with-out chemical reactions.

Experiments:

1. Experiments using Batch reactor

o Determination of reaction order using a batch reactor and data analysis by (a) Differential method (b) Integral method.

o Determination of the activation energy of a reaction.

o Determination of rate constant of a reaction of known order.

2. Experiments using Tubular reactor

o Determination of the order of reaction and rate constant

o Determination of RTD and dispersion number using a tracer

3. Experiments using CSTR

o Determination of rate constant and the effect of residence time on conversion.

4. Experiments using CSTR in series

o Comparison of experimental and theoretical values of space times of reactors

5. Experiments using Packed bed reactor

o Determination of RTD and dispersion number for a packed-bed using a tracer.

6. Mass transfer with chemical reaction (Solid-Liquid System)

o Determination of mass transfer coefficient.

7. Mass transfer with & without chemical reaction (Liquid-Liquid System)

o Determination of mass transfer coefficient.

Department of Chemical Engineering
B.Tech - 6th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Mass Transfer Operations Lab **Course code:** CHEM 3229

L	T	P	C
0	0	3	2

COURSE OBJECTIVES:

This laboratory course will enable the students to:

1. Apply hand-on experiments relevant to the principles learned in the Mass Transfer Operations.
2. Estimate diffusivity coefficients and mass transfer coefficients.
3. Find out the equilibrium data for various systems.
4. Perform various experiments to understand the concept behind separation techniques.

COURSE OUTCOME(S):

At the end of the course students are able to:

1. Perform experiments in relation to the Mass Transfer fundamentals.
2. Find out diffusivity and mass transfer coefficients.
3. Compare the equilibrium data developed with the theoretical data.
4. Evaluate the effectiveness of different separation techniques.

Experiments:

1. Estimation of diffusivity coefficients (any Two)
(a) Vapors (b) solids (c) Liquids
2. Evaluation of Mass transfer coefficients
(a) Surface Evaporation (b) Wetted wall column
3. Estimation of Equilibria (any Two)
(a) Solid – Liquid (b) Liquid – Liquid (c) Vapor – Liquid
4. Distillation Experiments (any Two)
(a) Steam distillation (b) Differential distillation
(c) Packed bed distillation
5. Extraction Experiments
(a) Ternary Liquid Equilibria (binodal curve)
(b) Multi stage crosscurrent extraction
6. Batch Drying Experiment
7. Leaching Experiment

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Engineering Economics and Project Management **Course code: HS 3405**

L	T	P	C
3	1	0	4

CourseObjectives:
The course content enables students to:
1. To acquaint the basic concepts of Engineering Economics and its application
2. To know various methods available for evaluating the investment proposals
3. To gain the relevant knowledge in the field of management theory and practice
4. To understand the project management lifecycle and be knowledgeable on the various phases from project initiation through closure

Course Outcomes:
At the end of the course students are able to:
1. Understand basic principles of engineering economics.
2. Evaluate investment proposals through various capital budgeting methods.
3. Analyze key issues of organization, management and administration.
4. Evaluate project for accurate cost estimates and plan future activities.

UNIT-I:
Introduction to Engineering Economics: 10 + 3*
Concept of Engineering Economics – Types of efficiency – Theory of Demand - Elasticity of demand-Supply and law of Supply – Indifference Curves.
Demand Forecasting & Cost Estimation:
Meaning – Factors governing Demand Forecasting – Methods – Cost Concepts – Elements of Cost –Break Even Analysis.

UNIT-II
Investment Decisions & Market Structures: 11 +6*
Time Value of Money – Capital Budgeting Techniques - Types of Markets – Features – Price Out-putdetermination under Perfect Competition, Monopoly, Monopolistic and Oligopoly
Financial Statements & Ratio Analysis:
Introduction to Financial Accounting - Double-entry system – Journal – Ledger - Trail Balance – FinalAccounts (with simple adjustments) – Ratio Analysis (Simple problems).

UNIT-III
Introduction to Management: 12 + 2*
Concepts of Management – Nature, Importance – Functions of Management, Levels - Evolution ofManagement Thought – Decision Making Process - Methods of Production (Job, Batch and MassProduction) - Inventory Control, Objectives, Functions – Analysis of Inventory – EOQ.

UNIT-IV
Project Management: 12 +4*

Introduction – Project Life Cycle – Role Project Manager - Project Selection – Technical Feasibility – Project Financing – Project Control and Scheduling through Networks - Probabilistic Models – Time-Cost Relationship (Crashing) – Human Aspects in Project Management.

Text Books:

1. Fundamentals of Engineering Economics by Pravin Kumar, Wiley India Pvt. Ltd. New Delhi, 2012.
2. Project Management by Rajeev M Gupta, PHI Learning Pvt. Ltd. New Delhi, 2011.

Reference Books:

1. Engineering economics by PanneerSelvam, R, Prentice Hall of India, New Delhi, 2013.
2. Engineering Economics and Financial Accounting (ASCENT Series) by A. Aryasri&Ramana Murthy, McGraw Hill, 2004.
3. Project Management by R.B.Khanna, PHI Learning Pvt. Ltd. New Delhi, 2011.
4. Project Management by R. PanneerSelvam&P.Senthil Kumar, PH

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Computational Fluid Dynamics **Course code: ME 4450**

L	T	P	C
3	1	0	4

Course Objectives:

The course enables the students to:

1. Introduce them to widely used techniques in the numerical solution of fluid flow equations
2. Emphasize on 'learning by doing', as they will work on class room projects and assignments.
3. Provide them with basic mathematical and numerical concepts of fluid flow and heat transfer problems.
4. Get exposed to modern trends in CFD.
5. Enhance their skills related to computer design and evaluation in fluid flow, critical thinking and lifelong learning.

Course Outcomes:

At the end of the course, the students will be able to:

1. Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
2. Develop governing equations for a given fluid flow system.
3. Adapt finite difference techniques for fluid flow models.
4. Apply finite difference method for heat transfer problems.
5. Solve computational fluid flow problems using finite volume techniques.
6. Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems.

Syllabus

UNIT- I: Governing equations for basic fluid flow **18Hrs (13L + 5T)**

Introduction to CFD, Basic Philosophy of CFD, Governing equations of fluid dynamics (Mass Equation), Governing equations of fluid dynamics (Newton's Equation), Governing equations of fluid dynamics (Energy Equation), Incompressible Inviscid flows sources, Vortex flow model.

UNIT-II: Implementation of finite difference techniques in fluid flow 15Hrs (12L + 3T)

Transformations and grids, MacCormack's method, finite differences, discritization, consistency, stability, fundamentals of fluid flow modeling, elementary finite difference quotients, implementation aspects of finite difference equations.

UNIT- III: Application of finite difference technique in heat transfer15Hrs (11L + 4T)

Finite difference applications in heat conduction and convection- Heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer.

UNIT IV: Finite Volume Methods & Overview on Commercial Packages 12 Hrs(9L + 3T)

Introduction of finite volume methods in computational fluid dynamics, Approximation of surface integrals, volume integrals, interpolation and differeantiation practices, Cell Centered formulation, LAX-Wendroff time stepping

Aspects of CFD computations with commercial packages Like ZN Tutor and Fluent.

Text Books:

1. Computational Fluid Dynamics: An Introduction, John F. Wendt, John David Anderson, Springer, 2009.
2. Computational fluid flow and heat transfer, Niyogi, Pearson Publications.

References:

1. Numerical Heat Transfer and Fluid flow, S.V. Patankar, Taylor & Francis, 1980.
2. Computational Fluid Dynamics – The Basics with Applications (1-5 Chapters), John D.Anderson, Jr. McGraw – Hill, Inc., New York, 1995.
3. Muralidhar, K .Sundarajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Numerical Methods in Chemical Engineering **Course code:** CHEM 4430

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:
1. Perform an error analysis for various numerical methods
2. Derive appropriate numerical methods to solve non-linear algebraic and transcendental equations and linear system of equations
3. Develop appropriate numerical methods to approximate a function
4. Provide appropriate numerical methods to calculate a definite integral and to evaluate a derivative at a value
5. Develop appropriate numerical methods to solve an ordinary differential equation
6. Understand the various techniques to solve Partial differential equations

Course outcomes:
At the end of the course, the students will be able to:

1. Perform an error analysis for a given numerical method
2. Solve a linear system of equations and non-linear algebraic or transcendental equation using an appropriate numerical method
3. Approximate a function using an appropriate numerical method
4. Calculate a definite integral and evaluate a derivative at a value using an appropriate numerical method
5. Solve an Ordinary differential equation using an appropriate numerical method
6. Solve partial differential equations using an appropriate numerical method

Syllabus

Unit- I **12 hr+4 hr**
Computation and Error Analysis
Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation.
Linear Systems and Equations
Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method,
Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations
Non-linear Algebraic Equations (single and multi variable)
Secant, Multivariate Newton's method
Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc.

Unit – II **12 hr +4 hr**

Regression and Interpolation

Polynomial regression, Newton's Difference Formulae, Cubic Splines

Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc.

Numerical Differentiation

Numerical differentiation; higher order formulae.

Integration and Integral Equations

Two and Three point Gaussian quadrature formula

Chemical Engineering Examples: Rayleigh's equation, Rate equation

Unit – III **11 hr +4hr**

ODEs: Initial Value Problems

Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique

Stiffness of ODE's

ODEs: Boundary Value Problems: Orthogonal Collocation**,** shooting techniques.

Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc.

Unit - IV **10 hr +3 hr**

Solution of partial differential equations: Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method,

Chemical Engineering Examples: unsteady-state one dimensional heat conduction.

Text Books:

1. Numerical Methods for Engineers, Gupta S.K.; New Age International, 1995
2. Numerical Methods for Engineers, Chapra S.C. and Canale R.P.; 5th Ed; McGraw Hill 2006
3. Numerical Methods, M. K. Jain, S. R. K. Iyengar, and R. K. Jain, 6th New Age International Publishers, New Delhi, 2012.

References:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, 4th Ed, PHI Learning Pvt. Ltd., 2005
2. Introduction to Numerical Methods in Chemical Engineering, PradeepAhuja, PHI Learning Pvt. Ltd., 2010

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Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Scale-up methods in Chemical Engineering **Course code:** CHEM 4431

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Acquire knowledge of proto types, models, principle of similarity
2. Study the physical, static, dynamic, thermal and chemical similarity
3. Understand the principle of dimensional analysis and develop differential equation based on physical and chemical laws
4. Understand the regime concept and criteria for static dynamic process and extrapolate the process taking into account boundary effect
5. Learn to develop scale up techniques for chemical engineering unit operations and process for both batch and continuous process

Course Outcomes:

At the end of the course, the students will be able to:

1. Understand any given chemical process and develop flow chart
2. Develop scale up equations based on physical and chemical laves to design appropriate equipment
3. Test the scale up design and suggest the design of equipment
4. Address the problems related to environmental challenges
5. Evaluate the material and energy requirements

Syllabus

UNIT- I: Introduction&Dimensional analysis **12hr + 4hr**
Concept of prototypes, models, scale ratios, element. Principles ofsimilarity: Geometric similarity. Distorted similarity. Static, dynamic, kinematics,thermal and chemical similarity with examples
(Review of Rayleigh's, Buckingham Π methods),Differential equation for static systems, flow systems, thermal systems, masstransfer processes, chemical processes-homogeneous and heterogeneous

UNIT- II: Regime concept **10hr+ 3hr**
Static regime.Dynamicregime.Mixed regime concepts.Criteriato decide the regimes.Equations for scale criteria of static, dynamic processes,Extrapolation. Boundary effects

UNIT- III: Scale up of Unit Processes **11hr + 4hr**
Chemical reactor systems-Homogeneous reaction systems.Reactor for fluid phase processes catalysedbysolids.Fluid-fluid reactors.

UNIT IV: Scale up of Unit Operations **12hr + 4hr**
Mixing process, agitated vessel, Stagewise mass transfer processes. Continuous mass transfer processes. Scale upof momentum and heat transfer systems. Environmental challenges of scale up

Text Book:

1. Scale up of Chemical Processes: Conversion from Laboratory Scale Tests to Successful Commercial Size Design, Bisio, A., Kabel, R.L., , John Wiley & Sons,1985
2. Dimensional Analysis and Scale-up in Chemical Engg, Marko Zlokarnik,. Springer Verlag, Berlin, Germany, 1986

References:

1. Pilot Plants and Scale up Studies, Ibrahim and Kuloor, IISc

Chemical Process Development (Part 1 and 2), Donald G. Jordan, Interscience Publishers, 1988

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Thermodynamic Properties of Crudes and Refinery Design **Course code:** CHEM 4432

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Relate upon his/her skills in chemicalprocess design with the elements of refinery process design.
2. Get acquainted with the various refinery processes and the products.
3. Be aware of the challenges involved in refining from the viewpoint of economic considerations and environmental regulations.
4. Understand the safety and environmental issues in designing relevant equipments.

Course outcomes:
At the end of the course, the students will be able to:

1. Get conversant the basic separation and conversion processes used in refining crude oil
2. Apply chemical engineering principles to the analysis of safe and efficient refinery operations
3. Use the Fenske Underwood and Gilliand method in designing oil-water separators, Design of light end units.
4. Design ADU/VDU and absorbers

UNIT- I: **12hr + 4 hrs**
Crude oil introduction, refinery products, brief out lines of: crude distillation process atmospheric distillation unit (ADU) vacuum distillation unit (VDU).Thermal and catalytic cracking, Catalytic reforming, Hydrotreating, and Hydrocracking.Introduction to refinery Process Design :Analogies between refinery and Chemical Process Design

Unit II: **10hr + 3 hrs**
Graphical and analytical correlations for refinery stream property estimation; refinery mass balancesQulitative Treatment

UNIT- III: **11hr + 4 Hrs**
Design of oil-water separators, Design of light end units – Fenske Underwood and Gilliand method. Qulitative Treatment

UNIT IV: **12hr + 4 Hrs**
Design of refinery absorbers and strippers.Design of crude and vacuum distillation units, design of FCC units.

Text Books :

1. Handbook of Petroleum Proessing, D.S.J. Jones and P.R. Pujado , Springer, 2006
2. Practical Advances in Petroleum Processing, C.S.Hsu and P.R. Robinson, Springer, 2006.
3. Chemical Process Design and Integration, R. Smith, John Wiley, 2005.

4. Refinery process modeling, G.L. Kaes, Elliott & Fitzpatrick Publishers, 2000.

References :

1. NPTEL Courses on Refining available at http://nptel.ac.in/courses/103103029/pdf/mod2.pdf
2. Petroleum Refining Process, J.G. Speight and NB. Ozum, Marcel Dekker, 2002.
3. Petroleum Refinery Process Economics, R.E. Maples, 2nd Ed., Pennwell Books, 2000.
4. Elements of Petroleum Processing, D. S. D. Jones, John Wiley & Sons Inc., 1999
5. Refinery process modeling, G.L. KaesElliott& Fitzpatrick Publishers, 2000.
6. Modern Petroleum Refining Processes, Bhaskararao, B.K, Fifth Edition, Oxford and IBH Publishing Co. Pvt. Ltd, 2007.

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Biochemical Engineering **Course code:** CHEM 4433

L	T	P	C
3	1	0	4

Course Objectives:

The course will enable the students to:

1. To understand the fundamentals of biological processes and their applications
2. To learn about the basic structure and function of cells, including enzyme structure and functions
3. To learn about the processes in terms of microbial growth and influence of environmental parameters, metabolism
4. To learn the relationship of cellular function to the formation of products and the performance of processes useful to man, and the kinetics of cellular processes
5. To know the principles and practice of cell culture including sterilisation techniques, bioreactor design, and some of the common unit processes of the downstream processing of biological products.

Course Outcomes:

At the end of the course, the students will be able to:

1. Understand the different cells and their use in biochemical processes
2. Understand the role of enzymes in kinetic analysis of biochemical reaction
3. Apply the basic concepts of thermodynamics, mass and energy balances, reaction kinetics and reactor design for biochemical processes
4. Analyze bioreactors, upstream and downstream processes in production of bio-products
5. Demonstrate the fermentation process and its products for the latest industrial revolution

Syllabus

UNIT-I **11hr+ 4 hrs**

Introduction to microbiology and biochemistry: Classification and characteristics of microorganism, Essential chemicals of life - Lipids, sugars and polysaccharides, RNA and DNA, amino acids and proteins.

Introduction to metabolic pathways – EMP Pathway and TCA Cycle, biosynthesis, end products of metabolism, stoichiometry of cell growth and product formation.

UNIT- II **12hr + 4 hrs**

Kinetics of enzyme catalyzed reaction: Enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, modulation and regulation of enzyme activity, effects of other parameters on enzyme activity.

Immobilized enzyme technology: Applications of Enzyme immobilization in industrial processes, Immobilized enzyme kinetics: effect of external mass transfer resistance, analysis of intra-particle diffusion and reaction.

UNIT-III **11hr + 3 hrs**

Kinetics of cellular growth and analysis of bioreactors – Growth phases, yield coefficient, Monod growth kinetics, ideal bioreactors – batch – fed-batch - mixed flow - CSTR reactors with recycle and cell growth, plug flow reactors and their analyses.

Transport phenomena in bioprocess systems: Transport across cell membranes (Active, passive and facilitated diffusion), Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, overall $k_L a'$ estimates.

UNIT- IV **11hr+ 4 hrs**

Fermentation technology: Medium formulation, design and operation of a typical aseptic, aerobic fermentation process, sterilization of reactors, medium and gases.

Downstream processing: Strategies to recover and purify products; cell disruption-mechanical and non-mechanical methods; membrane separation (dialysis, ultra filtration and reverse osmosis), chromatographic techniques, important industrial bio-products – ethanol, penicillin, citric acid, and acetic acid.

Text Books

1. Biochemical Engineering Fundamentals, J.E.Bailey and D.F.Ollis, 2nd Edition, McGraw Hill, 1986.
2. Bioprocess Engineering by Michael L. Shuler and FikretKargi, 2nd Edition, Prentice Hall, 2002.

References

1. Bioprocess engineering principles, Pauline M. Doran, Academic Press, 2012.
2. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997.

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Clean Process Technology **Course code:** CHEM 4434

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:
The overall aim of the course is to provide
1. Knowledge and understanding of strategies and technologies for a cleaner industrial production.
2. Pollution prevention and waste minimization management strategies to industrial processes.
3. The understanding of advantages and disadvantages of applying cleaner production activities.
4. Knowledge on the implementation of cleaner technologies on selected industrial sectors.
5. Understanding of the concept and benefits of industrial ecology and eco-industrial parks.

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Understand the concept of environmental sustainability, and the difference between pollution prevention vs. pollution control.
2. Describe cleaner production activities and its benefit.
3. Describe the function of process internal solutions to minimize air pollution emissions (flue gas pollutants and VOC) and emissions through waste water discharges.
4. Explain the function of different process external methods to minimize pollutions to air or water.
5. Explain the concept of industrial ecology and its benefit.

UNIT I **11+3Hrs**
Industrial and commercial sector development and related energy and environmental issues, Global environmental issues including global energy issues, global warming, and ozone depletion, air and water quality issues, Overview of environmental sustainability, Introduction to life-cycle assessment.

UNIT II **12+4Hrs**
Pollution prevention vs. pollution control, Principles of pollution prevention and cleaner production, approaches and means of pollution prevention, Introduction to methods and tools for cleaner production, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications, Pollution prevention in material selection for unit operations, Pollution prevention for chemical reactors, Pollution prevention for separation devices, Pollution prevention in storage tanks, pollution prevention assessment integrated with HAZOP analysis,

UNIT III **11+4Hrs**
Air pollution control and gas cleaning technology, Process internal solutions (process changes, raw material changes) and external solutions (gas treatment) in order to minimize air pollution (both gaseous compounds and particles)
Waste water treatment, Process internal solutions (process changes, raw material changes) and external solutions (different methods to treat waste water) in order to minimize water pollution.

UNIT IV **11+4Hrs**
Basic concept of industrial ecology and eco-industrial parks, Case studies on industrial applications of cleaner technologies in various industries including chemical, metallurgical, pulp and paper, textile, dairy,

cement and other.

Text Books:

1. Paul. L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2000.
2. D.T. Allen and D.R. Shonnard, Green Engineering: Environmentally Conscious Design of Chemical Processes, Prentice-Hall, Inc., 2002.
3. N.L Nemerow, Zero Pollution for Industry: Waste Minimization through Industrial Complexes, John Wiley &Sons, 1995.

Reference Books:

1. Graedel, T.E., Allenby, B.R. Industrial Ecology and Sustainable Engineering, PHI Publishers, 2

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Corrosion Engineering **Course code:** CHEM 4435

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Be introduced to the principles of electrochemistry as well as the essential elements of electrochemical corrosion.
2. Lay a foundation for understanding the forms of corrosion, the mechanisms of corrosion, electrochemical methods.
3. Develop the thermodynamic and kinetic aspects of electrochemistry, including potential-pH (Pourbaix) diagrams,mixed potential theory, and the theory and application of polarization.
4. Design methods for combating corrosion, the principles and methods leading to mitigation of corrosion problems that might occur in engineering practice.

Course Outcomes:
At the end of the course, the students will be able to:

1. Understand the electrochemical and metallurgical behavior of corroding systems.
2. Apply the electrochemical and metallurgical aspects of combating eight forms of corrosion.
3. Select or choose the testing procedures for corroding systems.
4. Evaluate the polarization behavior of corroding systems.
5. Design of suitable materials, methods to combat corrosion.
6. Predict the function of corrosion inhibitors.

Syllabus

UNIT- I:Introduction **12hr + 4hr**
Definitions of Corrosion - Overall classification of types of corrosion-Basic electrochemistry – Galvanic and electrolytic cells – Potential measurements - EMF and Galvanic series – Galvanic corrosion and bimetallic contacts – Eh – pH diagrams, Cost of Corrosion, Metallurgical properties influencing corrosion.

UNIT-II: Forms of Corrosion **12hr + 4hr**
Uniform attack, galvanic, crevice, pitting, Inter granular, selective leaching, erosion and stress corrosion – Mechanisms,testing procedures and their protection.

UNIT- III:Electrode kinetics and polarization phenomena **11hr +4 hr**
Electrode – solution interface – Electrode kinetics and polarization phenomena – Exchange current density – Polarization techniques to measure corrosion rates – Mixed potential theory – Activation and diffusion controlled mixed electrodes.

UNIT IV:Methods of corrosion prevention and control **10hr + 3hr**
Design, coatings and inhibition – Cathodic protection – Stray current corrosion – Passivity phenomena and development of corrosion resistant alloys – Anodic control.

Text Book:
1. M. G. Fontana, Corrosion Engineering (Third Edition) McGraw-Hill Book Company.
2. Denny A Jones, Principles and Prevention of Corrosion (second edition), Prentice-Hall, N. J. (1996).

Reference:
1. H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley (NY) (1985).

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Elective-5

Course Title: Fluidization Engineering **Course code:** CHEM 4436

L	T	P	C
3	1	0	4

Course Objectives: The course will enable the students to;

1. Understand the fundamental of fluidization.
2. Acquainted with the fundamentals of fluidization engineering, different regimes,classification of particles.
3. Realize themovement of bubbles mixing in bed.
4. Know the mathematical models of Fluidized Bed

Course Outcomes: At the end of the course, the students will be able to:

1. Understand the fluidization behavior.
2. Estimate pressure drop, bubble size, voidage, heat and mass transfer rates forthe fluidized beds.
3. Write model equations for fluidized beds.
4. Design gas-solid fluidized bed reactors.

SYLLABUS

UNIT –I **12hr+ 4hrs**

Introduction: The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with othercontacting methods; Advantages and disadvantages of fluidized beds.

Industrial applications of fluidized beds: Coal gasification; gasoline from other petroleum fractions;Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics; Drying of solids; FCCU; Fluidized combustion ofcoal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization.

UNIT- II **12hr+ 4 hrs**

Fluidization and mapping of regimes: Minimum fluidization velocity; Pressure drop vs. velocity diagram;effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity ofparticles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems;Voidage diagram; Mapping of regimes of fluidization.

Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of modelsfor gas flow at bubbles.

UNIT- III **11hr+ 4hrs**

Bubbling Fluidized beds: Experimental findings; Estimation of bed porosities; Physical models: simple twophase model; K-L model.

High velocity Fluidization: Turbulent fluidized bed; Fast fluidization pressure drop in turbulent and fastfluidization.Solids Movement, Mixing, Segregation and staging:;Vertical movement of solids; Horizontal movement ofsolids; Staging of fluidized beds.

UNIT-IV **10hr+ 3 hrs**

Spouted bed: Definition, pressure drop-flow diagram, minimum spouting correlation and effect of various parameters on spouting,

Heat and mass transfer in fluidized beds: Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes, models proposed by i) Wicke-Fetting, ii)Mickley and Fair Banks and iii) Levenspiel and Walton, heat transfer in fixed and fluidized beds, definition and evaluation of mass transfer coefficient.

Text Books:

1. Fluidization engineering. By Kaizo Kunii and Octave Levenspiel, Butterworth-Heinemann Publisher, 2nd. Ed., 1991

Reference Books:

1. D. Geldart Ed., “Gas Fluidization Technology”, John Wiley Sons, 1986.

2. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering,,Butterworths, 1989

3. MosoonKwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992

Department of Chemical Engineering
B.Tech - 7th / 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Process Equipment Design and Drawing Lab **Course code:** CHEM 4437

L	T	P	C
0	0	3	2

Course Objectives:
The course will enable the students to:
1. Familiarize standard symbols of process flow diagrams.
2. Learn basic symbols used instrumentation diagrams
3. Impart the knowledge mechanical aspects of pressure vessel design
4. Translatemechanical design specifications in to fabrication drawings for plant erection.
5. Draw detailed dimensional drawingsshall include sectional front view, Full Top/side view depending on equipment.

Course Outcomes:
At the end of the course, the students will be able to:
1. Identify equipment and process involved in process flow diagrams.
2. Demonstrate process from process flow diagrams.
3. Explain the different control strategies employed in the process from the instrumentation diagrams
4. State the IS Codes used in the mechanical design.
5. Design and draw fabrication diagrams by scaling.

Total 10 / any 7 from drawing minimum 3 from design
Drawing:
1. Flow sheet symbols.
2. Instrumentation symbols.
3. Process flow diagrams.
4. Instrumentation diagrams
5. Pressure vessel.
6. Double pipe heat exchanger
7. Shell and tube heat exchanger
8. Batch reactor.
9. Evaporator

Equipment Design:
10. Mechanical aspects of Pressure vessel design
11. Process design of Double pipe heat exchanger
12. Process design of Batch reactor
13. Process design of evaporator
14. Process design of Absorption Column

Text Book:
1. Process Equipment Design by M.V. Joshi, V.V.Mahajani, 3rd Edition, Macmillan Publishers, 2009

Reference Books:

1. Brownell, L.E. and Young, E.H. , Process Equipment Design - Vessel Design,John Wiley and Sons, Inc.1959.
2. Ludwig, E.E. , Applied Process Design for Chemical and Petrochemical Plants,Vol. 1 and 2, 3rd Ed., Gulf Publishing Co. 1997.
3. Indian Standards Institution, Code for unfired pressure vessels, IS – 2825.
4. Bhattacharya, B.C, Introduction to chemical equipment design, CBSPublications,1985.
5. Perry’s Chemical Engineers Handbook.

Department of Chemical Engineering
B.Tech - 7th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Process Simulation Lab **Course code:** CHEM 4238

L	T	P	C
0	0	3	2

Course Objectives:

The course will enable the students to:

1. Familiarize MATLAB as simulation tool
2. Use MATLAB to solve chemical engineering problems
3. Solve the developed process models of chemical engineering
4. Learn the commercial simulation tools like ASPEN PLUS
5. Develop a solution for chemical engineering design problems using ASPEN PLUS

Course Outcomes:

At the end of the course, the students will be able to:

1. Identify MATLAB as a simulating tool to solve chemical engineering problems
2. Solve steady state chemical engineering problems using MATLAB
3. Use the commercial simulation tools like ASPEN PLUS
4. Develop solutions for different ideal reactor systems
5. Simulate basic Heat transfer and Mass transfer equipment

The following experiments are to be solved in MATLAB (Any 8)

1. Gravity Flow tank.
2. Three CSTRs in series – open loop
3. Three CSTRs in series – closed loop
4. Non isothermal CSTR
5. Binary Distillation column
6. Heat Exchanger
7. Isothermal Batch reactor.
8. Interacting & Non interacting system-two tank liquid level
9. Optimization of Minimum Reflux Ratio of distillation columns
10. Boundary value problems in heat and mass transfer
11. Stability analysis of process control systems using simulink

Any 4 of the following experiments are to be solved in commercial software like ASPEN PLUS etc.

12. T-xy,P-xy diagrams of a Binary mixture
13. Flash drum
14. Ideal reactor – CSTR
15. Ideal reactor - Batch
16. Ideal reactor - Plug flow
17. Distillation column
18. Heat exchanger

Text Book: Process Modeling, Simulation and Control for Chemical Engineers by W. L. Luyben, McGraw Hill, 2nd Ed.,

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Process Modeling &Simulation **Course code:** CHEM 4439

L	T	P	C
3	1	0	4

The course will enable the students to:

1. Formulate a chemical engineering problem as a mathematical model, and select an appropriate solution method.
2. Understand the computational requirements of various solution options and use this understanding in the selection of the solution method
3. Select the MATLAB to perform the numerical solution to achemical engineering problem.
4. Formulate and solve process design problems, based on fundamental analysis and using mathematical models of chemical processes

Course Outcomes:
At the end of the course, the students will be able to:
1. Understand the stages involved in the development of a process model.
2. Formulate a chemical engineering problem as a mathematical model from basic engineering principles.
3. Identify the appropriate numerical solutions used in solving the models
4. Apply various simulation tools for solving the chemical engineering models developed.
5. Understand the solution techniques for solving ODEs.

Unit-I: **11hr + 4hr**
Mathematical models for chemical engineering systems, introduction to fundamental laws.
Examples of mathematical models of chemical engineering systems: constant volume CSTRs, two heated tanks, gas phase pressurized CSTR, non-isothermal CSTR, single component vaporizer, batch reactor, mass transfer with chemical reaction

Unit-II: **12hr + 3hr**
Examples of mathematical models of chemical engineering systems: ideal binary distillation column, batch distillation with holdup.
Solution of linear algebraic equations: Gauss elimination method, LU decomposition, Gauss-Jordan
Solution of non-linear algebraic equations (single variable):
Iterative methods - bisection, false position, Newton –Raphson, successive substitution methods, comparison of iterative methods.

Unit-III: **11hr + 4hr**
Numerical integration: Trapezoidal and Simpson's rules
Function Approximation: Least square curve fit

Interpolation & regression: Lagrange interpolation, forward difference, backward difference and central difference interpolation methods, linear regression, polynomial regression.

Ordinary Differential equations (Initial value problems): Euler method, Runge-Kutta methods, predictor corrector methods (Milne, Adams- Moulton).

Unit-IV: **11hr + 4hr**

Introduction to MATLAB, MATLAB Scripts, MATLAB Arrays, Linear models, Graphing data in MATLAB, MATLAB Array Math, Advanced graphing in MATLAB

Simulation Examples of : Heat exchanger, Distillation column, Plug flow reactor, CSTR.

Text Books:

1. Process Modeling, Simulation and Control for Chemical Engineers, W. L. Luyben, McGraw Hill, 2nd Ed.,
2. Numerical Methods for Engineers, S.K. Gupta, New Age International, 1995
3. Getting Started With MATLAB: A Quick Introduction For Scientists And Engineers, RudraPratap, Oxford University Press, 2010

References:

1. Modeling and Simulation in Chemical Engineering, Roger G.E. Franks, Wiley-Interscience, 1972.
2. Chemical Engineering: Modeling, Simulation and Similitude, T.G. Dobre, J. G. Sanchez Marcano, Wiley-VCH., 2007.
3. Applied Mathematics and Modeling for Chemical Engineers, R. G. Rice, D. D. Do, John Wiley & Sons, 1995.
4. Chemical Process Modeling and Computer Simulation, Jana Amiya K. 2nd edition, Phi learning, 2011.
5. Numerical Simulation of Fluid Flow and Heat, Mass Transfer process, N. C. Markatos, D. G. Tatchell, M. Cross; Springer, 1986.
6. Computational Methods for Process Simulation, W.F.Ramirez, Butterworth- Heinmann,2nd Edition, 1998.

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model)

Course Title: Transport Phenomena **Course code: CHEM 4440**

L	T	P	C
3	1	0	4

Course Objectives: The course will enable the students to:

1. Understand the fundamental connections between the conservation laws in heat, mass, and momentum.
2. Formulate conservation statements in heat, mass, and momentum at multi-scales from microscopic to macroscopic in both steady and unsteady modes.
3. Solve analytic linear partial differential equations including separation of variables, similarity solutions, Laplace transforms, and coordinate transformations.
4. Find classic transport solutions including rotating disks, flow around spheres and in channels with heat and/or mass transfer occurring.
5. Formulate multi-component diffusion and simultaneous heat and mass transfer problems.

Course Outcomes: At the end of the course, the students will be able to:

1. Use the general equations of change for specific applications.
2. Analyze advanced transport problems in heat, mass, and momentum, both macroscopic and microscopic.
3. Formulate simultaneous energy and mass balances in chemical processes.
4. Solve simple linear partial differential equations arising in transport problems.
5. Recognize initial-value versus boundary-value problems and how to solve them either analytically or numerically.

SYLLABUS

UNIT –I (Momentum Transport)

Mechanisms of momentum transfer: **9 +3 hrs**

Newton's law of viscosity (molecular momentum transport), generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity, molecular theory of the viscosity of gases at low density, molecular theory of the viscosity of liquids.

Shell momentum balances in laminar flow:

Shell momentum balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

UNIT- II (Energy Transport)

Mechanisms of energy transport: **12+4 hrs**

Fourier's law of heat conduction (molecular energy transport), temperature and pressure dependence of thermal conductivity, theory of thermal conductivity of gases at low density.

Shell energy balances in solids and laminar flow:

Shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a nuclear heat source, heat conduction with a viscous heat source, heat conduction with a chemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection, free convection.

UNIT- III (Mass Transport)

Mechanisms of mass transport: **12+4 hrs**

Fick's law of binary diffusion (molecular mass transport), temperature and pressure dependence of diffusivities, theory of diffusion in gases at low density.

Shell mass balances in solids and laminar flow:

Shell mass balances; boundary conditions, diffusion through a stagnant gas film, diffusion with a heterogeneous chemical reaction, diffusion with a homogeneous chemical reaction, diffusion into a falling liquid film (gas absorption), diffusion into a falling liquid film (solid dissolution), diffusion and chemical reaction inside a porous catalyst.

UNIT-IV

The equations of change: **12+4 hrs**

The equations of energy, Special forms of energy equations, the equations of change in curvilinear coordinates, use of the equations of change to setup steady-state heat transfer problems. The equations of continuity for a binary mixtures, the equation of continuity of 'A' in curvilinear coordinates, use of the equations of change to setup diffusion problems.Unsteady state one dimensional transport of Momentum, heat and component.

The equations of change for turbulent transport:

Time smoothed equations of change for an incompressible fluids, the time smoothed velocity profile near a wall. Temperature fluctuations and time smoothed temperature, time smoothing the energy equation, Concentration fluctuations and time smoothed Concentration, time smoothing of the equation of continuity of A.

Text Books:

1. R.B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, Revised 2nd edition, John Wiley and Sons, 2007.

References:

1. Transport processes and unit operations by Christie J. Geankopolis, PHI.1993.
2. J.R.Wilty, R.W.Wilson, and C.W.Wicks, " Fundamentals of Momentum Heat and Mass Transfer 2nd Edn., John Wiley, New York, 1973.
3. W.J.Thomson, "Introduction to Transport Phenomena", Pearson Education Asia, New Delhi, 2001.

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: **Design and Analysis of Experiments** Course Code: **CHEM 4441**

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Which factors affect a given experiment?
2. Find the most significant factor for an experiment.
3. Calculate the factor levels that optimize the outcome of an experiment.
4. Factorial Design of experiments.
5. Response surface methodology for design of experiments.

Course outcomes:
At the end of the course, the students will be able to:

1. Predict how many numbers of experiments are to be carried out, given the number of important factor
2. Design an experiment and calculate the factor levels that optimize a given objective.
3. Use response surface methodology to optimize the process, by considering curvature effects.
4. Understand strategy in planning and conducting experiments
5. Choose an appropriate experiment to evaluate a new product design or process improvement

UNIT- I **10 hr+3 hr**

Strategy of Experimentation, Some Typical Applications of Experimental Design, Basic Principles, Guidelines for Designing Experiments, A Brief History of Statistical Design.

UNIT- II **12 hr+4 hr**

The Analysis of Variance, Analysis of the Fixed Effects Model, Statistical Analysis of the Randamized Complete Block Design (RCBD)

UNIT- III **11 hr+3 hr**

Introduction to Factorial Designs, Basic Definitions and Principles, The Advantage of Factorials, The Two-Factor Factorial Design, The General Factorial Design

UNIT-IV **12 hr+4 hr**

Introduction to Response Surface Methodology, the Method of Steepest Ascent, Experimental Designs for Fitting Response Surfaces- Designs for Fitting the First-Order Model, Designs for Fitting the Second-Order Model, Evolutionary Operation

TEXT BOOK:

1. "Design and analysis of experiments" by D.C. Montgomery, 2nd edition John Wiley and sons, NewYork (1984).

REFERENCE:

1. Statistics for experimenters by G.E.P. Box, William G. Hunter and J.S. Hunter, John Wiley & Sons.

2. Statistics for Experimenters: Design, Innovation, and Discovery ,George. E. P. Box, J. Stuart Hunter, William G. Hunter, 2nd Edition, Wiley, 2005.

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Novel Separation Techniques **Course code: CHEM 4442**

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. Learn the fundamentals of adsorptive separations and modeling
2. Study the Pressure swing & thermal swing adsorption, Counter currentseparations.
3. Study the basic concepts and design procedures of chromatographic columns.
4. Learn different membrane separation technological processes and their design
5. Study the surfactant based separations
6. Learn super critical fluid extraction process with examples

Course Outcomes:

At the end of the course, the students will be able to:

1. Explain different types of adsorptive separations and derive the equations forthe same.
2. Design the chromatographic columns
3. Develop design equations for membrane separation processes such as RO&UF.
4. Explain concepts of surfactant based separations
5. Explain physico chemical aspects and applications of Super critical fluidextraction
6. Explain the applicability of electric, magnetic and centrifugal separationprocesses for practical situations

Syllabus

UNIT- I:Adsorption&Chromatography **12+ 4hr**
Adsorptive separations: Review of fundamentals. Mathematical modeling ofcolumnfactors.Pressure swing & thermal swing adsorption. Counter currentseparations
Chromatography: Chromatography fundamentals. Different types. Gradient&affinity chromatography. Design Calculations for chromatographic columns.

UNIT- II: Membrane separation processes **12 + 3hr**
Membrane separation processes: Thermodynamic considerations. Mass transferconsiderations. Design of RO &UF. Ion selective membranes. Micro filtration, Electro dialysis. Pervaporation. Gaseous separations.

UNIT- III: Surfactant based & Super critical Separations **11 + 4hr**
Surfactant based separations: Fundamentals. Surfactants at inter phases and inbulk. Liquid membrane permeation. Foam separations. Micellar separations. Super critical fluid extraction: Thermodynamics and physicochemical principles. Process description. Application. Case Study.

UNIT IV: External field induced separations: 10 + 4hr

External field induced separations: Electric & magnetic field separations. Centrifugal separations and calculations.Other Separations: Separation by thermaldiffusion, electrophoresis and crystallization

Text Book:

3. Handbook of Separation Process Technology,Rousseu, R.W., John Wiley &Sons,2001
4. Separation Process Principles,Seader.J.D., John Wiley & Sons,3rd edition,2010

Reference Book:

2. Encyclopedia of Chemical Technology, Kirk-Othmer, 5th Edition,2007.
3. Rate Controlled Separations,Wankat, P.C., Springer, 2005.
4. Large Scale Adsorption Chromatography,Wankat, P. C., CRC Press, 1986.
5. Reverse Osmosis and Ultra Filtration ProcessPrinciple,Sourirajan, S. &Matsura, T., , NRC Publication, Ottawa, 1985.
6. Supercritical Fluid Extraction, McHugh, M. A. &Krukonis, V. J., Butterworth,1985

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Course Title: Process Intensification **Course Code: CHEM 4443**

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:
1. Understand the concept of Process Intensification.
2. Know the limitations of intensification of the chemical processes.
3. Applythe techniques of intensification to a range of chemical processes.
4. Develop various process equipment used for intensifying the processes.
5. Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

Course Outcomes:
At the end of this course, students are able to:
1. Assess the values and limitations of process intensification, cleaner technologies and waste minimization options
2. Measure and monitor the usage of raw materials and wastesgeneratingfromproduction and frame the strategies for reduction, reuse and recycle.
3. Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.
4. Analyze data, observe trends and relate this to other variables.
5. Plan for research in new energy systems, materials and process intensification.

Syllabus

Unit- I: Basics of Process Intensification **12 + 3hr**
Definition of Process Intensification (PI). Benefits of PI, Techniques for PI application: active and passive techniques.
Spinning disc reactor (SDR): Operating principle and development of models for thin film flow on rotating disc.Examples of application of SDR to a range of processes.

Unit-II: Rotatory &Oscillatory Systems **13 + 5hr**
Rotary packed bed (RPBs): Operating principle of rotating Contactors. Development of models for counter-current multiphase flow in rotating systems, Examples of the application of multiphase Contactors.
Oscillatory flow reactor (OFR): Description & operating principles, Explanation of niche applications. Design, Case studies.

Unit- III: Heat Exchangers **11 + 4hr**
Compact heat exchangers (CHE): Definition of CHEs', Construction and main properties, Applications, Basic design procedures, the printed circuit heat exchanger (PCHE), Plate heat exchangers (PHEs).

Unit - IV: Micro Reactors **9 + 3hr**
Micro-reactors: Description and operating principles, oscillatory baffled reactor, mixing-limited reactor involving mass transfer and membrane reactors.

Text Book:

1. Re-Engineering the Chemical Processing Plant- Process Intensification,Stankiewicz, A., and Moulijn, Marcel Dekker Inc., New York, 2003.

Reference Book:

1. Engineering for Efficiency, Sustainability and Flexibility- Process Intensification, David Reay, Colin Ramshaw and Adam Harvey, Butterworth Heinemann, Elsevier Ltd., 2008.

Department of Chemical Engineering
B.Tech - 8th semester
SYLLABUS
(Applicable for the batches admitted from 2013-14, Non-FSI & FSI Model))

Elective-6

Course Title: Process Optimization **Course Code: CHEM 4444**

L	T	P	C
3	1	0	4

Course Objectives:
The course will enable the students to:

1. To learn problem formulation of optimization.
2. To realize the numerical methods of un-constrained optimization.
3. To learn linear programming and its applications
4. To understand the use of genetic algorithms in optimization
5. To know the applications of numerical optimization.

Course Outcomes:
At the end of the course, the students will be able to:

1. Apply the knowledge of optimization to formulate the problems
2. Analyze the optimization criterion for solving problems
3. Apply different methods of optimization and to suggest a technique for specific problem
4. Apply simplex method for linear optimization problems
5. Understand advanced optimization techniques like Genetic algorithms
6. Understand how optimization can be used to solve the industrial problems of relevance tothe chemical industry

Syllabus

UNIT-I: **11+4hr**

Nature and organization of optimization problems: Examples of applications of optimization, the essential features of optimization problems, formulation of objective functions, general procedure for solving optimization problems, obstacles to optimization. Classification of models, how to build a model
Basic concepts of optimization: Continuity of functions, unimodal versus Multimodel functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremum of an unconstrained function, interpretation of the objective function in terms of its quadratic approximation

UNIT-II: **11+4hr**
Optimization of unconstrained functions: one-dimensional search: Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of unidimensional search, polynomial approximation methods, region elimination methods.

Unconstrained multivariable optimization: random search, grid search, uni-variate search, simplex method, conjugate search directions, gradient method - Steepest Descent, conjugate gradient method, second order gradient, Newton method, and Quasi-Newton method.

UNIT-III: **11+4hr**

Linear programming and applications: Basic concepts in linear programming, Degenerate LP's – graphical solution, natural occurrence of linear constraints, standard LP form, the simplex method of solving linear programming problems, obtaining a first feasible solution.

Genetic Algorithms: (Qualitative treatment) Working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods,

UNIT-IV: **12+3hr**

Optimization of Unit operations (Problem Formulation): Recovery of waste heat, shell & tube heat exchangers, evaporator design, liquid-liquid extraction process, optimal design of staged distillation column, optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat

TEXT BOOKS:

1. Optimization of chemical processes by T. F. Edgar, Himmelblau D, Leon S. Lasdon.-2nd ed., Mc-Graw Hill, 2001.
2. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI-2009.

REFERENCE BOOKS:

1. Engineering Optimization: Theory and Practice, Singaresu S. Rao, 4th Edition, John Wiley & Sons, 2009.
2. Optimization Concepts and Applications in Engineering, Ashok Belegundu, Tirupathi R. Chandrupatla, Cambridge University Press, 2011.
3. Practical Optimization: Algorithms and Engineering Applications, Andreas Antoniou, Wu- shing Lu, Springer, 2007.