SRI VENKATESWARA UNIVERSITY: TIRUPATI

SRI VENKATESWARA UNIVERSITY COLLEGE OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

Course

M.Tech CHEMICAL ENGINEERING

Choice Based Credit System (CBCS)

Academic Year 2017-2018

THE VISION

To be a world class department of chemical engineering in effective teaching and knowledge creation which is seamlessly integrated with bordering sciences and is committed to ignite and propel young minds with passion for originality, innovation and excellence.

THE MISSION

To train technically competent and socially aware chemical engineers through innovative and rigorous educational programs to meet technological needs of the society

To encourage self learning, problem solving, inquisitiveness and team work among students.

To enable students to develop capabilities needed to perform in multidisciplinary environment.

To promote industry- institute interaction to nurture collaborative and applied research programs

To help students develop a well rounded personality with qualities of innovative thinking, leadership, entrepreneurship and ethical mind.

To create amiable ambience of academics for intellectual pursuit and innovative research

THE GOALS

To promote self-learning among students

To help the students to develop a strong personality, so that in turn they help the Institute to realize its objectives

To strive for academic excellence

To sensitize students towards the needs and aspirations of the society

To identify the core strengths of the Department and develop expertise through advanced research

To promote Industry-Institute Interaction for mutual benefit

PROGRAMEDUCATIONALOBJECTIVES

The Department of Chemical Engineering offers B.Tech (Chemical Engineering) program with the following objectives of enabling its graduates.

1. To seek career as Chemical engineers in traditional Chemical industries and also in areas of manufacture of newer materials, pharmaceuticals and biological, environmental remediation and development of renewable energy sources.

2. To pursue higher qualification in Chemical Engineering or a related discipline, with a view to become a researcher or an academician.

3. To be able to synthesize a chemical process from simple and even complex chemistry and to translate any chemical process from conceptual to commercial stage.

4. To possess good breadth in scientific and engineering knowledge so as to understand, analyze and to offer novel solutions to problems arising in today's rapidly changing increasingly technological global society.

5. To be socially conscious chemical engineers through their sensitivity towards impact on environment, energy, security and sustainability.

PROGRAMOUTCOMES

A graduate of this Department

after successful completion of B.Tech, will be able

a. To integrate and apply concepts of mathematics, physics, chemistry and biology to real life situations.

b. To apply principles of conservation, thermodynamics, transport processes, reaction engineering and process control to analyze and design process equipment.

c. To develop mathematical models of chemical engineering systems.

d. To demonstrate computational abilities and use of software tools in design & simulation of process and equipment.

e. To apply techniques of optimization to improve the performance of chemical processes.

f. To analyze equipment and processes for retrofitting and debottlenccking.

g. To conduct energy audit and suggest strategies for its conservation.

h. To incorporate effective measures for environmental protection and sustainability into chemical process design.

i. To participate in laboratory scale process development and scale up or scale down of processes.

j. To communicate effectively in both verbal and written forms.

k. To adapt to changing scenario and circumstances, with self confidence.

l. To succeed in competitive examinations like GATE, UPSC

I Semester

	Cours e	Instructio n		Credit s	Test I	Test II	Continuou s	End Sem. Exam		Tot al
MACHT 01	Probability & Statistics for	4	- -	4	2 0	2 0	- -	3 hr	6 0	100
CHCHT 01	Advanced Transport	4	- -	4	2 0	2 0	- -	3 hr	6 0	100
CHCHT	Process Plant	4	-	4	2	2	-	3	6	100
CHCHT	Separation	4	-	4	2	2	-	3	6	100
	Elective I	4	-	4	2	2	-	3	6	100
	Elective II	4	-	4	2	2	-	3	6	100
CHCHP 01	Computatio nal	- -	3/0	2	- -	- -	4 0	3 hr	6 0	100
CHCHS	Seminar – I	-	0/2	1	-	-	1	-	-	100
		2	5	2	-	-	-	-	-	800

SRI VENKATESWARA UNIVERSITY COLLEGE OF ENGINEERING (Autonomous) : TIRUPATI M.Tech (Chemical Engineering) - Scheme of Instruction under Choice Based Credit System (with effect from 2017 – 2018)

II Semester

Course No	Course Name	Instructio n L/T	P/S	Credit s	Test I	Test II	Continuou s Assessme	End Sem. Exam		Total Marks
CHCHT 04	Optimizat ion	4	- -	4	2 0	2 0	- -	3 hr	6 0	1 0
CHCHT	Chemical	4	-	4	2	2	-	3	6	1
CHCHT 06	Advanced Control	4	- -	4	2 0	2 0	- -	3 hr	6 0	1 0
CHCHT 07	Proces s	4	- -	4	2 0	2 0	- -	3 hr	6 0	1 0
	Elective –III	4	-	4	2	2	-	3	6	1
	Elective – IV / Open	4	- -	4	2 0	2 0	- -	3 hr	6 0	1 0
CHCHP	Advanced	-	3/0	2	-	-	4	3	6	1
CHCHS	Seminar – II	-	0/2	1	-	-	1	-	-	1
CHCHV 01	Comprehensi ve Viva	- -	- -	2	- -	- -	- -	- -	100	1 0
		2	5	2	-	-	-	-	-	9

CHCHJ : III & IV Semesters – Dissertation - 24 credits

LIST OF ELECTIVES – I, II , III & IV from

CHCHE11	Pollution Control Systems
CHCHE12	Fluidization Engineering
CHCHE13	Polymer Science
CHCHE14	Polymer Engineering
CHCHE15	Fuel Cell Systems
CHCHE16	Computational Fluid Dynamics
CHCHE17	Reactive Separations
CHCHE18	Advanced Heat Transfer
CHCHE19	Enzyme Science & Engineering
CHCHE20	Bioprocess Engineering
CHCHE21	Membrane Separations
CHCHE 22	Energy Conservation and Audit in Process Industries

A student will have the option to choose elective IV from the Department list or any core or elective subject offered by other Departments.

Permission of the Heads of the Departments and the Course Coordinator is necessary.

MACHT01 PROBABILITY & STATISTICS FOR CHEMICAL ENGINEERING

Instruction : 4 hr/week **Credits : 4** **Evaluation : 40 + 60**

Course Objectives:

1. To To familiarize the students with the concept of probability distributions and statistics as indispensable tools for data analysis and decision making in engineering fields.
2. To introduce basic concepts of statistics, various distribution functions.
3. To explain the concept of estimation and t-test, F-test and Chi-square test.
4. To explain the objective of Correlation and Regression analysis.
5. To acquaint the students with different types Quality Control charts.

UNIT I :

Introduction to Probability – Sample space – axioms of probability.
Random variables – Discrete and continuous expectations – Moment Generating functions.
Conditional probability – Baye's theorem – independent events.

UNIT II :
Discrete distributions – Binomial, Hyper geometric, Gamma, Students t, chi-square, Weibell distributions.
Bivariate random variables and their distributions (with specific reference to bivariate normal distributions only). Conditional distributions – covariance, correlation coefficient – regression of the mean.

UNIT III :
Functions of random variables – Probability distribution of functions of random variables – their joint probability distributions.
Sampling – sampling distribution – law of large numbers – central limit theorem.
Estimation – point estimation, interval estimation and confidence intervals. (Maximum likelihood estimation). Bayesians estimation.

UNIT IV :
Testing of Hypothesis – Simple hypothesis and the Neyman – Pearson lemma – Composite hypothesis – goodness of fit tests
Non-parametric statistics – Ranking Tests, Spearman rank correlations – Willcoxon sign test.

UNIT V :
Analysis of variance – One way classification – Randomized, complete block designs.
Factorial design of experiments. Sequential Analysis.

Reference Books :

1. Fundamental of Applied Statistics by S.C.Gupta and V.K. Kapoor, Sultan Chand & Sons.
2. Mathematical Statistics by John E.Freund and Ronald E.Walpole, Prentice Hall of India.
3. Applied Statistics for Engineering by William Volk, McGraw Hill.
4. Statistics for Scientists and Engineers by R.L.Wine, Prentice Hall

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

1. To make use of the concepts of probability and their applications. Discrete and continuous expectations, Baye's theorem.

2.To discuss Distributions and Properties and applications.

3. To have Probability distribution of functions of random variables, sampling distribution, Bayesians estimation.

4. Design the components of a classical hypothesis test. Infer the statistical inferential methods based on small and large sampling tests. Interpret the association of characteristics and through correlation and regression tools.

5.To acquire knowledge of Analysis of variance.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**											
CO2		**2**			**2**							
CO3			**3**	**1**								
CO4			**1**									
CO5					**3**	**2**						

CHCHT 01 ADVANCED TRANSPORT PHENOMENA

Instruction : 4 hr/week Credits : 4 Evaluation : 40 + 60

Course Educational Objectives

1. Study the fluid dynamics, heat transfer and mass transfer together at the introductory level.
2. Carry out macroscopic mass, momentum and energy balance to solve engineering problems related to fluid and heat flow laminar flow.
3. Give an idea about simple flow problems involving Non-Newtonian models and turbulent flows.
4. Perform dimensional analysis of equation of motion and energy, time smoothed operations.
5. Analyze flow past solid surface, through packed bed and in fluidized beds and they can able to Focus on diffusivity and mechanism of mass transport, diffusion through a stagnant gas film and falling film

UNIT – I:

Introduction to Transport phenomena: The conservation laws- mechanism of transport of momentum, energy and mass. Shell momentum balances and boundary conditions, Shell energy balances and boundary conditions, Shell mass balances and boundary conditions.

Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, viz.., flow through a circular pipe, falling film with variable viscosity, operation of coquette viscometer, flow near slowly rotating sphere. Dimensional Analysis of the Equations of Change, pressure drop for creeping flow in a packed tube.

UNIT- II: Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids with examples like flow near a wall suddenly set in motion, unsteady laminar flow between two parallel plates and unsteady laminar flow near an oscillating plate. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Empirical Expressions for the Turbulent Momentum Flux.

Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the viscous loss, Use of the Macroscopic Balances for Steady-State Problems viz., pressure rise and friction loss in a sudden enlargement, liquid-liquid ejector, thrust on a pipe bend, the impinging jet. Derivation of the macroscopic mechanical energy balance.

UNIT – III : Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussinesq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems viz., tangential flow in an annulus with viscous heat source, steady flow in a non isothermal film, Transpiration cooling, free convection heat transfer from a vertical plate and adiabatic frictionless processes in an ideal gas. Dimensional analysis of the equations of change for non-isothermal systems.

Temperature Distribution with more than One Independent Variable - Unsteady Heat Conduction in Solids viz., heating of semi infinite and finite slabs, unsteady heat conduction near a wall with sinusoidal heat flux, cooling of sphere in contact with a well stirred fluid.

Temperature Distributions in Turbulent Flow - Time-Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the turbulent heat flux eg., an approximate relation for the wall heat flux for turbulent flow in a tube.

UNIT – IV: Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles viz., the cooling of an ideal gas, mixing of two ideal gas streams, the d-forms of macroscopic balances eg., parallel and counter flow heat exchangers.

Equation of change for multi component systems: The equation of continuity for a multi component mixture, Fick's second law of diffusion, Use of equation of change for mixtures with examples like simultaneous heat and mass transfer, concentration profile in a tubular reactor and catalytic oxidation of carbon monoxide.

UNIT – V: Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux.

Inter phase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions.

Text Books:

1. Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.
2. Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt. Ltd., New Delhi. 2004.
3. Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.

Course Out comes :

1. Have the knowledge on Shell momentum,energy ,mass balances and boundary conditions. Equations of Change for Isothermal Systems.
2. Able to Solve continuity, Velocity Distributions with more than one Independent Variable. Macroscopic Balances for Isothermal Systems.
3. Educate about Equations of Change for Non-Isothermal .Systems, Temperature Distributions in Turbulent Flow
4. Macroscopic Balances For Non-Isothermal Systems, Equation of change for multi component systems.
5. Inter phase Transport in Multi-Component Systems, Concentration Distributions in Turbulent Flow.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	2								1

CO2	1	2			2							1
CO3		1	2			1						1
CO4		1		2								1
CO5			2	1	1							1

CHCHT 02 PROCESS PLANT SIMULATION

Instruction : 4 hr/week Credits : 4 Evaluation : 40 + 60

Course Educational Objectives:

1. To develop a general methodology on modelling aspects .
2. To optimize variety of systems where modeling or engineering of reactions is needed.
3. To understand the suitability and performance characteristics of different models .
4. To teach various Error Propagation & Data Regression.
5. To understand the mechanism of Decomposition of Networks and Convergence Promotion.

UNIT I

Modeling Aspects: Deterministic vs. Stochastic Processes, Physical modeling, Mathematical modeling, Chemical Systems Modeling, Cybernetics, Controlled System, Principles of Similarity

Classification of Mathematical Modeling: Independent and Dependent variables, Classification based on variation of independent variables, Classification based on state of the process, Classification based on type of the process, Boundary Conditions, The black Box Principle, Artificial Neural Networks

UNIT II - Process Modeling - I

Models from mass transfer: steady state single stage solvent extraction, steady state two stage solvent extraction, steady state two stage cross current solvent extraction, , steady state N- stage solvent counter current extraction, unsteady state single stage solvent extraction, unsteady state mass balance in a stirred tank and in a mixing tank.

Models from Heat Transfer : steady state heat conduction through a hollow cylindrical pipe, unsteady state steam heating of a liquid, unsteady state heat loss through a measuring tank, heat transfer through extended surfaces, unsteady state heat transfer in a tubular gas pre heater

UNIT III – Process Modeling -II

Models from fluid flow: flow through a packed bed column, flow of a film on the outside of a circular tube, annular flow with inner cylinder moving axially, flow between coaxial cylinders and concentric spheres

Models from Reaction Engineering : chemical reaction with diffusion in a tubular reactor, chemical reactor with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction

UNIT IV

Error Propagation & Data Regression : Propagation of errors through addition, subtraction, multiplication and division, Errors of measurement, Precision errors, errors method

Data Regression : Theoretical properties, data regression methods, Problems in data regression

Process Simulation : Modular Approach, The equation solving approach

UNIT V

Decomposition of Networks : Tearing Algorithms, Algorithms based on signal flow graph and reduced digraph

Convergence Promotion: Newton's method, direct substitution method, Wegstein's method, dominant Eigen value method, quasi Newton method, Criterion for acceleration, Physical and Thermodynamic Properties

TEXTBOOKS:

1. Process Plant Simulation, B.V.Babu, Oxford University press, 2004
2. Process Modeling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990

REFERENCE:

1. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI learning Pvt. Ltd., New Delhi, 2010
2. Process Modeling and Simulation, Amiya K. Jana, 2012.

Course Outcomes:

1. Knowledge on Modeling Aspects and Classification of Mathematical Modeling.
2. Knowledge on models of mass and heat transfer for steady and unsteady state conditions.
3. Models from fluid flow and Models from Reaction Engineering .
4. Knowledge on Error Propagation & Data Regression.
5. Knowledge Tearing Algorithms, Algorithms based on signal flow graph and reduced digraph, Newton's , direct substitution , Wegstein's method, dominant Eigen value methods.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1		1	1	1			
CO2	1				2							
CO3			2			1						
CO4		1										
CO5				1	1				2			

CHCHT 03 SEPARATION PROCESSES

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

Course Educational Objectives:

1) Understand the classification of separation processes
2) To learn the fundamental concepts of rate governed processes
3) To impart the basic concepts of multistage separation processes
4) Understand the design of distillation column using different methods
5) Understand the energy requirements of different separation processes

UNIT I

Use and Characteristics of Separation Processes – Importance and variety of Separations – Characteristics of separation Processes- Inherent separation factors for equilibrium and rate Governed Processes

Simple equilibrium processes: Equilibrium calculations- Checking phase conditions for a mixture- Analysis of simple equilibrium separation-processes for binary and multi component systems - Computational and Graphical Approaches.

Unit II

Additional Factors Influencing Product Purities – Incomplete Mechanical Separation of Product Phases – Flow Configuration and Mixing Effects – Batch Operations – Methods of Regeneration – Mass and Heat Transfer Limitations – Stage Efficiencies

Multistage Separation Processes: Increasing product purity - Reducing consumption of separating agent - co-current, crosscurrent and countercurrent flow - Other separation processes - Fixed bed processes.

Unit-III:

Binary Multistage Separations - Distillation: Binary Systems - Equilibrium stages and McCabe-Thiele Diagram - design and other problems – Multistage batch distillation - Straight operating lines and curved operating lines.

UNIT IV

Patterns of Change: Binary and Multi component multistage separations

Group Methods - Linear stage-exit relationships and constant flow rates- non linear stage –Exit Relationships and varying flow rates.

Capacity of contacting devices: factors limiting capacity and factors influencing efficiency.

UNIT V

Energy Requirements of separations processes:

Thermodynamic efficiency - single stage and multistage separation processes - reduction of energy consumption**.**

Selection of Separation processes: Factors influencing the choice of separation Process - solvent extraction and Illustrative examples

TEXT BOOKS:

1. Separation Processes - C.Judson King,, McGraw – Hill, 1982

REFERENCE BOOKS

1. Separation Process Principles - J.D.Seader and E.J.Henley, , John Wiley, 1998.
2. Mass Transfer Operation - R.E. Treybal, , 3^{rd} edition - McGraw – Hill 1980
3. Transport Processes and Unit Operations – Geankoplis C.J. 4^{th} ed – PHI Pvt. Ltd

Course Outcomes:

1) Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations
2) Suggest and design equipment for various mass transfer operations
3) Study of the stage wise mass transfer operations, principles of various stage wise contact processes like distillation
4) Student will be able to select a separation process for a particular system.

5) Able to understand the energy requirements of separation processes

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1		1	1	1			
CO2	1				2							
CO3			2			1						
CO4		1										
CO5				1	1				2			

CHCHE 11 POLLUTION CONTROL SYSTEMS

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

OBJECTIVES

1. To learn aspects of industrial pollution Emissions and Indian Standards.
2. To educate about Activated Sludge Process and Anaerobic Treatment
3. To know the conceptual concepts on methods for Removal of Nitrogen and effluents.
4. To understand the Removal of Sulphur Dioxide.
5. To give knowledge about Pollution Control Aspects.

UNIT-I :

Pollution and Its Measurement- Introduction-Types of pollution—pollution Control aspects

Industrial pollution Emissions and Indian Standards-Industrial Emissions-Liquids and Gases—Environmental Legislation—Water quality Management in India—Air Act 1981

Analysis of pollutants-Industrial Waste Water Analysis-Industrial Gaseous Effluent Analysis

UNIT-II :

Removal of BOD—Biological oxidation—Activated Sludge Process—Trickling Filters—Fluidized bed contactors—Anaerobic Treatment

Removal of Chromium—Reduction Precipitation-Ion Exchange-Reverse Osmosis-Lime Coagulation and Adsorption

Removal of Mercury—From Gaseous Streams and Liquid Streams

UNIT-III :

Removal of Ammonia/Urea—Sources –Methods for Removal of Nitrogen —Physico –Chemical Processes—Biological Methods—Algal Bacterial Flocculating Systems—Miscellaneous Methods

Treatment of Phenolic Effluents—Sources—Treatment Methods

Removal of Particulate Matter— Introduction—Separation of Particulate Matter From Effluent Gases

UNIT-IV :

Removal of Sulphur Dioxide—introduction—Methods of Sulphur Dioxide Control — Process Changes—Reduction of Sulphur Dioxide Concentration—Wet And Dry Processes

Removal of Oxides of Nitrogen—Introduction—Control Measures

Removal of Organic Vapour from Effluent Gases—Absorption- Condensation- Adsorption of Vapour—Incineration of Vapour

UNIT–V :

Pollution control in Chemical Industries—Pollution Control Aspects of Fertilizer Industries—Pollution Control in Petroleum Refineries and Petrochemical Units- Pollution Control in Pulp and Paper Industries

Pollution Control in Miscellaneous Process Industries

Text Book:

1. Pollution Control In Process Industries SP Mahajan

Course Out comes

1. Acquired knowledge on creative aspects of types of pollution and its control .
2. Have the knowledge on removal of BOD and Chromium.
3. Have the knowledge on removal of urea,treatments of phenolic effluents.
4. Methods of Sulphur Dioxide Control -– Process Changes , Removal of Oxides of Nitrogen
5. Pollution control in Chemical Industries and Miscellaneous Process Industries.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHE 12 FLUIDIZATION ENGINEERING

Instruction: 4 hr/week Credits: 4 Assessment: 40 + 60

Course Educational Objectives:

1. This course focuses on different types of fluidization, their advantages and disadvantages.
2. Analyze the various types of distributors used for fluidized beds and its design.
3. Study the classification of particles, carry over particles in fluidization and pneumatic transport of solids.

4. Give the knowledge of Transport Disengaging Height (TDH) and its significance in entrainment.
5. This course will help to understand elutriation from fluidized beds and Elutriation constants.
6. This subject focus on solid circulation systems for fast fluidized operations and flow patterns of gas-solid mixtures flowing in horizontal and vertical pipes.
7. Educate the industrial applications of fluidized beds and spouted beds with examples.

UNIT- I :

Introduction: The Phenomenon of fluidization, Liquid like Behavior of a fluidized Bed, Comparison with other Contacting Methods, Advantages and Disadvantages of Fluidized beds for Industrial Operations, Fluidization Quality, Selection of a Contacting Mode for a given Application, Overall Plan.

Industrial Applications Of Fluidized Beds: Historical Highlights – Physical Operations – Synthesis Reactions – Cracking of Hydrocarbons –; Combustion and Incineration – Carbonization and gasification – Cacination - Reactions Involving Solids – Biofluidization

UNIT-II :

Fluidization And Mapping Of Regimes.: Fixed beds of particles: Fluidization without Carryover of particles, Types of Gas Fluidization without carryover – The Geldart classification of particles - Fluidization With Carryover Of Particles – The Mapping of Fluidization Regimes.

The Dense Bed Distributors, Gas Jets and Pumping Power: Distributor Types – Gas Entry Region of a Bed; Gas Jets in Fluidized Beds; Pressure Drop Requirements across distributors; Design of Gas Distributors, Power Consumption.

UNIT – III

Bubbles in Dense Beds: Single rising bubbles, Rise rate - Davidson model - Other Models - Comparison of Models with experiment - Evaluation of models - wake region and the movement of solids at bubbles -solids with in bubbles - coalescence and splitting of bubbles- Bubble formation above a distributor - slug flow.

Bubbling Fluidized bed: Experimental findings, Estimation of bed properties, physical models, Scale up and scale down, Flow models for bubbling beds.

UNIT – IV

Entrainment And Elutriation From Fluidized Beds: Freeboard Behavior –; Location of the Gas Outlet of a Vessel – Entrainment from Tall Vessels - Entrainment from Short Vessels

High – Velocity Fluidization: Turbulent Fluidized Beds – Experimental Findings; Fast Fluidization - Experimental Findings; The Freeboard – Entrainment Model Applied to Fast Fluidization – Design Considerations; Pressure Drop in Turbulent and Fast Fluidization

Circulation Systems - Classification – Pressure Balance in a circulation loop

UNIT – V

Solid Movement Mixing- segregation and staging - Vertical Movement of Solids – Horizontal movement of particles – Segregation of Particles – Large solids in beds of smaller particles – staging of fluidized beds – leakage of solids

Particle-to-Gas Mass & Heat Transfer – Mass Transfer – Interpretation of mass transfer coefficient - Heat Transfer – Interpretation of Heat transfer coefficient

Text Book :

1. Fluidization Engineering by Diazo Kunii & O.Levenspiel, John Wiley

References :

1. Fluidization by Davidson JF & Harrison B, Academic Press.
2. Fluidization and Fluid Particle systems Zenz PA & Othmer D F, Reinhold Pub. Co

Course Out comes

1. Know the advantages, disadvantages, and different types of fluidization. Understand the comparison and selection of contacting methods.Determine the minimum fluidization velocity and terminal velocity
2. Able to design gas distributors and calculate power consumption for fluidized beds.
3. Davidson model - Other Models - Comparison of Models with experiment - Evaluation of models.
4. Understand the fast fluidization, application of entrainment models to fast fluidization and solid circulation systems for fluidized beds.
5. Have the knowledge of Solid Movement Mixing- segregation and staging, Interpretation of mass and heat transfer coefficient .

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1					1	1			
CO2	1			1								
CO3	1		2	1					1			
CO4			1	2				1				
CO5			1					1	1			

SEMESTER - II

CHCHT 04 OPTIMIZATION THEORY AND PRACTICE

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

Course Educational Objectives :

1) To learn problem formulation and basic concepts of optimization.
2) To study the numerical methods to solve single variable un-constrained problems
3) To understand and apply numerical methods to solve un-constrained multi-variable problems
4) To learn linear& non-linear programming methods
5) To know the applications of optimization through different examples

Unit-I: Introduction

Basic concepts of optimization, applications of optimization, general procedure for solving optimization problem, formulation of the objective function, fitting models to data, classification of functions.

Unit-II: Single Variable unconstrained optimization methods

Direct search methods-Interval halving method, Fibonacci method, Golden section method;

Direct root methods-Newton method and Quasi Newton method;

Polynomial approximation methods - Quadratic interpolation and cubic interpolation.

Unit-III: Optimization of unconstrained multivariable functions
Direct search methods-random search, grid search, uni-variate search and pattern search methods. ; Indirect search methods - steepest descent, conjugate gradient methods, Newton's method and secant method.

Unit-IV: Linear and non-linear programming
Linear programming: Basic concepts in linear programming, Standard LP from, Graphical solution and Simplex method.
Non-linear programming: Lagrange multiplier method, Quadratic programming, Penalty function and augmented Lagrangian methods.

Unit –V: Applications of optimization
Optimizing recovery of waste heat, optimal design and operation of a conventional staged-distillation column, optimal pipe diameter, optimal residence time for maximum yield in chemostat and optimization of a thermal cracker using linear programming.

Text Book:

1.Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York.

Reference Books :

1. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer.
2. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
3. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers.

Course Outcomes: Student will be able to
1) formulate and analyse the optimization of the given physical situation.
2) Apply different methods of optimization and to suggest a technique for specific problem
3) Understand the difference between constrained and unconstrained optimization
4) Understand the importance of linear programming problems
5) Realize the importance of optimization by understanding different examples

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	1				1	1			
CO2		2		1					1			
CO3		1		1		2	1	1				
CO4	1		1	1								
CO5				1				1	1			

CHCHT 05 **Chemical Reactor Theory**

INSTRUCTION : 4 Hr/week **Credits : 4** **Assessment : 40 + 60**

Course Educational Objectives:

1. To develop a general methodology of combining reaction chemistry and chemical engineering concepts,
2. To optimize variety of systems where modeling or engineering of reactions is needed.
3. To understand the suitability and performance characteristics of different types of reactors like packed bed reactors, mixed reactors
4. To teach various types of flows like Ideal flow, Non-Ideal flow and mixing of fluids
5. To understand the mechanism of solid Catalyzed reactions and fluid –fluid reactions.

UNIT I

Isothermal Reactor design: Design structure for isothermal reactors - Scale-up of liquid phase batch reactor data to the design of a CSTR - Tubular reactors - Pressure drop in Reactors - Reversible reactions - unsteady state operation of reactors -Simultaneous reaction and Separation.

UNIT-II

Analysis of Non ideal Reactors - RTD - Measurement and characteristics of RTD- RTD in ideal reactors - Reactor modeling with the RTD - Zero and One parameter models - Two- Parameter model - Modeling real reactors with combinations of ideal reactors - Testing a model and determining it's parameters - Other models of non ideal reactors using CSTRs and PFRs

UNIT-III

External diffusion Effect on Heterogeneous Reactions - Binary diffusion - External resistance to mass transfer - the shrinking core model.

Diffusion and reaction in Porous Catalyst – Diffusion and reaction in spherical pellets -Internal Effectiveness factor - Falsified Kinetics - Overall effectiveness factor - Estimation of diffusion and reaction limited regimes - Mass transfer and reaction in a packed bed

UNIT-IV

Internal Transport Processes-Reaction and Diffusion in porous catalysts:
Intra pellet mass transfer and intra pellet heat transfer, Mass transfer with reaction, Mass and Heat transfer with reaction, effect of internal transport on selectivity and poisoning.

UNIT-V

Design of heterogeneous Catalytic Reactors: Fixed bed reactors and isothermal and adiabatic fixed-bed reactors, non isothermal, non adiabatic fixed bed reactors, Two phase model, Fluidized-Bed reactors, Operating characteristics of FBRs. Mass Transfer in Fluidized Beds: Gas-Solid Mass Transfer, Mass Transfer between the Fluidized-Bed Phases, Reaction in Fluidized Bed. *Trickle bed reactor Models, Slurry reactor models.*

Text Books

1. J.M.Smith "Chemical Engineering Kinetics" 3rd ED., Mc Graw Hill, New York

1980
2. Fogler H. S., Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall, 1999
3. Levenspiel, O., "Chemical Reaction Eng." John Wiley & Sons 1972.

Course Outcomes:
1) learn the importance of RTD and Non-ideal flow in reacting vessels.
2) Calculate the conversions based on segregated flow model, dispersion model and tanks-in-series models.
3) Understand the diffusion and reaction in a porous catalyst.
4) Learn the factors influencing catalyst decay, the role of pore diffusion on catalyst activity rate.
5) Understand the design of heterogeneous catalytic reactors.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1		1	1	1			
CO2	1				2							
CO3			2			1						
CO4		1										
CO5				1	1				2			

CHCHT 06 ADVANCED CONTROL SYSTEMS

Instruction : 4 hr/week Credits : 4 Evaluation : 40 + 60

OBJECTIVES
1) To learn aspects of advanced Control Strategies.
2) To educate about the Process interactions and control loop interactions,
3) To know the Sampling and signal reconstruction,
4) To understand the the z-Transform, inversion
5) To give knowledge about Data Control Systems.

Unit I :

Feed Forward and Ratio Control – Introduction, Feed forward controller design based on steady state and dynamic models, tuning and configuration of feed forward control

Advanced Control Strategies – Cascade control, time delay compensation and inferential control, selective and override systems, adaptive control, statistical process control

Unit II :

Control of Multi Input, Multi-Output Systems – Process interactions and control loop interactions, pairing of controlled and manipulated variables, strategy for reducing interactions, decoupling, multivariable control techniques

Supervisory Control – Basic requirements, applications, formulation and solution of optimization problems, unconstrained and constrained optimization

Unit III :

Digital Computer Control – Digital control systems in process control, distributed instrumentation and control systems, general purpose digital data acquisition, digital control hardware and software, table driven PID controller, Programmable logic controllers and batch process control

Sampling and Filtering of Continuous Measurements – Sampling and signal reconstruction, selection of sampling period, signal processing and data filtering, comparison of analog and digital filters, effect of filter selection on control system performance

Unit IV :

Development of Discrete Time Models – Finite difference models, exact discretization for linear systems, higher order systems, fitting discrete time equations to process data

Dynamic Response of Discrete –Time Systems – The z-Transform, inversion, pulse transfer function, relating pulse transfer functions to difference equations, effect of pole and zero locations, conversion between laplace and z- transforms

Unit V :

Analysis of Sampled – Data Control Systems – Open loop block diagram analysis, development of closed loop transfer functions, stability of sampled data control systems

Design of Digital Controllers – Digital PID controller, selection of controller parameters, direct synthesis methods, digital feed forward control, combined load estimation and time delay compensation

Text Books:

1. Process Dynamics and Control – D.E.Seborg, T.F.Edgar and D.A.Mellichamp, John Wiley & Sons
2. Chemical Process control – An Introduction to Theory and Practice - George Stephanopoulos, Prentice hall 1990.

Course Out comes

1. Acquired knowledge on creative aspects of Feed forward controller design based on steady state and dynamic models, tuning and configuration.
2. Have the knowledge in developing a conceptual Control of Multi Input, Multi-Output Systems.
3. Knowledge on Digital control systems in process control, Sampling and signal reconstruction
4. Able to have knowledge on Development of Discrete Time Models, Dynamic Response of Discrete –Time Systems.
5. Analysis of Sampled – Data Control Systems.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1	2			2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHT 07 PROCESS SYNTHESIS AND ANALYSIS

INSTRUCTION : 4 Hr/week **Credits : 4** **Assessment : 40 + 60**

OBJECTIVES

1. To learn aspects of process design.
2. To educate about the cost analysis,process profitability and economic analysis.
3. To know the conceptual design and finding the flow sheet.
4. To understand the separation system and heat exchanger networks.
5. To give knowledge about computer aided design programmes.

UNIT-I :

Nature of Process Synthesis & Analysis : Creative aspects – A hierarchial approach

Enginering Economics : Cost Information – Estimation of Capital and Operating Costs – Total Capital Investment- Total Product Cost - Time Value of Money – Measures of Process Profitability – Simplifying the Economic Analysis for Conceptual Design

UNIT II :

Economic Decision Making : Solvent Recovery System – Problem Definition & General Considerations – Design of a Gas Absorber – Equipment Design Consideration – Rules of Thumb

Input Information & Batch- Continuous: Input Information – Level 1 Decision – Batch Vs. Continuous

UNIT III :

Input-Output Structure of the Flow Sheet : Decisions for the I/O structure – Design Variables – Over all Material Balances – Stream Costs – Process Alternatives

Recycle Structure of the Flow Sheet : Decisions determining the recycle Structure – Recycle Material balances – reactor Heat Effects – Equilibrium Limitations – Compress Design & Costs – Reactor Design – recycle Economic Evaluation

Unit IV :
Heat Exchanger Networks – Minimum Heating & Cooling Requirements – Minimum Number of Exchangers – Area Estimates – Design of Minimum Energy Heat Exchanger Networks – Loops and Paths – Reducing the Number of Exchanger – Stream Splitting – Heat and Power Integration – Heat Distillation – HAD Process

UNIT V :
Separation System : General Structure – Vapor Recovery System – Liquid Separation System – Azeotropic Systems – Rigorous Material Balances
Cost Diagrams and Quick Screening of Process Alternatives - Cost Diagrams for simple and complex process – Quick Screening of Process Alternatives – HAD Process

Text Book :
1. Conceptual Design of Chemical Processes, Douglas, J.M., McGraw Hill,

Reference Books :
1. Chemical Process Design, Robin Smith, McGraw Hill,
2. Chemical Process Design, Dimian A.C, & Bidea,C.S., Wiley – VCH,2008
3. Chemical Process Synthesis & Engineering Design, Kumar,A, Tata McGraw Hill,1982
4. Systematic Methods of Chemical Process Design, Bieglar, L.T., Grossman, E.I and Westerberg, A.W. Prentice Hall Inc.
5. Product and Process Design Principles, Seider, W.D., Seider,J.D & Lewin, D.R. Wiley,2005

Course Out comes

1. Acquired knowledge on creative aspects of process design and a hierarchical approach to conceptual design.Able to estimate capital,operatingcost,total capital investiment and total product cost.
2. Have the knowledge in developing a conceptual design of batch and continuous processes.
3. Cost diagrams and the quick screening of process alternatives.
4. Able to design minimum energy requirement for cooling and heating in heat exchanger networks.
5. Cost Diagrams and Quick Screening of Process Alternatives

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1	2			2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHE 20 BIOPROCESS ENGINEERING

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

OBJECTIVES
1. To learn aspects of Engineering Approach to Biosynthesis.

2. To learn Methods of Sterilization.
3. To know the conceptual cell growth mechanism.
4. To understand the iimmobilization of Cells
5. To give knowledge about Recovery and Purification of Products.

UNIT I :

Introduction - Biotechnology & Bioprocess Engineering - Role of a Bioprocess Engineer – Engineering Approach to Biosynthesis - Bioprocesses: Regulatory Constraints - Steps in Bioprocess development - Major products of biological processing – A case study of Penicillin
Biology Basics - Microbial diversity – Cell Construction – Cell Nutrients

UNIT II :
Sterilization - Methods of Sterilization – Radiation & Chemical Sterilization - Batch Thermal Sterilization – Continuous Thermal Sterilization – Thermal death Kinetics – Calculation of Sterilization Time - Sterilization of Air and Filter Design - Indices to assess effectiveness of sterilization

UNIT III :
Cell Growth – Complexity of Growth Process – Batch Growth – Quantifying Growth Kinetics – Cell Growth in Continuous Cultures
Stoichiometry of Microbial Growth and Product Formation – Introduction – Stoichiometric Calculations- Theoretical Predictions of Yield Coefficients

UNIT IV :
Operating Considerations for Bioreactors - Choosing the cultivation method – Modifying batch and Continuous Reactors -
Immobilization of Cells - Active immobilization - Passive Immobilization – Diffusional Limitations – Bioreactor Considerations in Immobilized Cell Systems
Solid State Fermentation
Scale up of Bioreactors - Reactor Types – Aeration – Agitation – Heat Transfer – Scale up- Scale Down
Bioreactor Instrumentation and Control
-

UNIT V :

Recovery and Purification of Products - Strategy - Separation ofInsoluble Products – Cell Disruption – Separation of Soluble Products – Fininshing Steps – Integration of Reaction and Separation
Traditional Industrial Bioprocess - Anaerobic Bioprocesses (ethanol, Lactic Acid, Acetone-Butanol) – Aerobic Processes (Citric Acid ,Yeast , High Fructose Corn Syrup)

Text Books

1. Bioprocess Engineering Basic Concepts – Michael L Schler & Fikret Kargi – Prentice – Hall second Edition, 2002
2. Biochemical Engineering Fundamentals – Bailey, J.E. & Ollis,D.F., McGraw Hill

Course Objectives : Students will be able to

1) Know the mechanisms of Engineering Approach to Biosynthesis.
2) Understand Radiation & Chemical Sterilization - Batch Thermal Sterilization – Continuous Thermal Sterilization.
3) Stoichiometry of Microbial Growth and Product Formation
4) Operating Considerations for Bioreactors , Bioreactor Considerations in Immobilized Cell Systems .
5) Recovery and Purification of Products, Traditional Industrial Bioprocess

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHE 19 ENZYME SCIENCE & ENGINEERING

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Understand the Development of Enzymatic Assays
2) Solve Kinetics of Single Substrate Reactions
3) Do the Analysis on Immobilized Enzyme Systems
4) Learn the types of Immobilized Reactors
5) Design the Enzyme Electrodes

UNIT I :

Enzymes : Classification – Protein Structure –Extraction, Purification and characterization from natural sources – Development of enzymatic assays, Comparison of chemical and enzyme catalysis

UNIT II :

Mechanisms and Kinetics of Enzyme Action : Mechanisms of enzyme action – concept of active site and energetics of enzyme-substrate complex formation – Specificity of enzyme action – Kinetics of single substrate reactions (irreversible & reversible), estimation of Michaelis-Menten Parameters – Multi substrate mechanisms and kinetics

Types of inhibition – kinetic Models – substrate and product inhibition –

temperature and pH effects on enzyme activity – deactivation kinetics

UNIT-III:

Enzyme Immobilization – Physical and Chemical methods – Comparison of different methods –

Immobilized Enzyme Kinetics - Analysis of Film and Pore Diffusion effects on immobilized enzyme systems – Formulation of dimensionless groups and calculation of effectiveness factors

UNIT-IV :

Enzyme Reactors - Immobilized Enzyme Reactors – Packed bed, Fluidized bed, membrane reactors – Bioconversion calculations in free enzyme CSTRs and immobilized enzyme reactors

UNIT V :

Applications : Applications of free and immobilized enzymes

Biosensors : Applications of enzymes in analysis; Design of enzyme electrodes and their applications as biosensors in industry, health care and environment

Text Books

1. Enzymes-Palmer;T,(Affiliated East West Press Pvt.Ltd.), 2004
2. Biochemical Engineering Fundamentals – Bailey, J.E. & Ollis,D.F., McGraw Hill

References

1. Biochemistry- Stryer,Berg, 6thEdition, (W.H.Freeman and Co.), 2007.
2. Enzyme Biotechnology- Tripathi;G, (ABD Publishers), 2003.
3. Enzyme Technology, M.F. Chaplin and C. Bucke. Cambridge University Press
4. Industrial Enzymes & their applications, H. Uhlig, (John Wiley and Sons Inc.)

Course Objectives : Students will be able to

6) Know the mechanisms of Chemical and Enzyme Catalysts
7) Develop, understand and apply Kinetic Models
8) Formulate and Analyze Immobilized Enzyme Kinetics
9) Design and analyze Enzyme Reactors
10) Gain knowledge on Applications of Enzyme and on Biosensors

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHJ : III & IV Semesters – Dissertation - 24 credits

CHCHE 14 POLYMER ENGINEERING

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

UNIT-I

Biopolymers, natural Polymers and Fibers – Biopolymers and other Naturally Occurring Polymers – Fibers -

UNIT-II

Thermoplastics, Elastomers and Thermosets – Commodity Thermoplastics – Elastomers - Thermosets

UNIT-III

Engineering and Speciality Polymers – Engineering Thermoplastics – Speciality Polymers

Unit –IV

Polymer Processing and Rheology – Basic Processing Operations – Introduction to Polymer Rheology – Analysis of Simple Flows – Rheometry – Modeling of Polymer Processing Operations

UNIT-V

Polymers for Advanced Technologies – Membrane Science and Technology – Biomedical Engineering and Drug Delivery – Applications Electronics – Photonic Polymers

Text Book :

1. Polymer Science & Technology - John R.Fried – 2 nd edition – PHI Learning Pvt Ltd- 2010

Reference Books :

1. Polymer Science : A Text Book – V K Ahluwalia & Anuradha Mishra - Ane Books India 2008
2. Plastics Engineering – R J Crawford – Elsevier (Butterworth-Heinemann) – 3 rd edition - 2011

CHCHE 15 FUEL CELL SYSTEMS

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

UNIT-I

Introduction – Fuel Cells- Relevance and Importance – Historical Highlights - Difference from Batteries – Fuel Choice – Classification

Electrochemistry – Thermodynamic Aspects of Electrochemical(EC) Energy Conversion – Theoretical Efficiency of Heat of a Reaction to Mechanical Energy – Efficiency of EC Energy Conversion – Factors Affecting Efficiency of EC Energy Conversion Electrode Kinetics of EC Energy Conversion

UNIT-II

Alkaline Fuel Cells – Description – Working Principle – Components - Modules – Fuel Cell Stacks – General Performance Characteristics – Advancements – System Issues – Ammonia as AFC Fuel
Molten Carbonate Fuel Cells – General Principle – Cell Components – Mechanisms of Electrode Reactions- Status

UNIT-III

Phosphorus Acid Fuel Cells- Technology- Electrode Materials and Manufacturing – Stacks and Systems
Solid Oxide Fuel Cells – History – Advantages and Limitations- Cell Components – Electrode Materials – Interconnects – Fuel – Configuration and Performance – Environmental Impact – Applications

UNIT-IV

Direct Methanol Fuel Cells – Technology Evolution – The Noble Metal Issue- The Catalyst – Electro-oxidation of Methanol – The Electrolyte – Non Catalytic Aspects – Methanol Cross over to DMFC – catalyst Optimization and Scale up – Engineering Aspects

UNIT-V

Proton Exchange Membrane Fuel Cells – Basic Scientific aspects- Challenges – Technology Development – Fuel Processing – Modeling Studies of PEMFC Performance – Applications – Challenges to High Temperature Operations – Technological and Economic Challenges

Text Book :

1. Fuel Cell : Principles and Applications – B.Viswanathan and M. Aulice Scibioh – Universities Press - 2006

CHCHE 16 COMPUTATIONAL FLUID DYNAMICS

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

Unit I :

Philosophy of CFD – CFD - CFD as a research tool – CFD as a design tool – Examples
Governing Equations of Fluid Dynamics – Introduction – Models of Flow – The sustainable derivative- Divergence of Velocity – Continuity Equation – Momentum Equation – Energy Equation – Physical boundary conditions – Forms of Governing equations suited to CFD

Unit II :
Mathematical Behaviour of Partial Differential Equations (PDEs) – Classification of quasi linear PDEs – General Method of determining the classification of PDEs – General Behavior of different classes of PDEs

Unit III :
Discretization – Basic aspects – Finite Differences – Difference equations – Explicit and Implicit approaches – Errors and analysis of stability

Unit IV :

Grids with appropriate transformations – General transformation of equations – Metrics and Jacobians – Form of governing equations suited to CFD – Stretched grids – boundary fitted coordinate systems – adaptive grids – modern developments in grid generation, finite volume mesh

Unit V :

Simple CFD Techniques - The Lax – Wendroff Technique – MacCormack's technique - Viscous Flows, Conservation form and space marching – Relaxation Technique – Aspects of numerical dissipation and dispersion – Alternating – Direction- Implicit technique – Pressure correction technique

Text Book :

1. CFD : The Basics with Applications – John D. Anderson Jr. TMH Publication

Reference

1) Introduction to CFD – Pradip Niyogi, S K Chakrabarthy, M K Laha , Pearson Edu.:

CHCHE 17 REACTIVE SEPARATIONS

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

UNIT – I :

Reactive Distillation: Definition, introduction to reactive distillation process - Thermodynamic and kinetic effects on the feasible products of RD - Azeotropes, arheotropes, kinetics arheotropes in reactive membrane separation.

Equilibrium theory and nonlinear waves for reaction separation processes: Introduction, Theoretical background, Analysis of reaction separation processes.

UNIT – II :

Reactive stripping in structured catalytic reactors: introduction, hydrodynamics, Reactive experiments, comparison of different internals.

Reactive Absorption: introduction, reactive absorption equipment, modeling concept, model parameters, case studies.

UNIT – III :

Reactive Extraction: introductions, phase equilibria, reactive mass transfer, hydrodynamics.

Development of reactive crystallization process: introduction, work flow in process development, process synthesis, reactive phase diagrams, kinetic effects, asymmetric transformation of enantiomers.

UNIT – IV :

Reactive extrusion for solvent free processing: introduction, advantages & disadvantages, main reactions in extruders, extruder types, kinetic considerations, heat transfer and thermal instabilities.

Reactive comminution: introduction, mechanical comminution of solids, equipment and processes, applications.

UNIT – V :

Reactive filtration: introduction, separation of particulates and catalytic reaction of volatiles, separation of particles and reaction of solids.

Reactive assisted granulation in fluidized beds: introduction, modeling, experiments.

Text Books:

1. Sundmacher K., Kienle A., Siedel A., Integrated Chemical Processes, Wiley VCH, 2005.
2. Kulprathipanja, Reactive Separation Processes, Taylor and Francis, 2002.
3. LuybenW. L. and Cheng-Ching Yu, Reactive Distillation Design and Control, John Wiley and Sons, 2008.

CHCHE 18 ADVANCED HEAT TRANSFER

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

UNIT I :

Process heat transfer: Introduction, Steady state conduction in multiple dimensions, Principles of convection, Radiation Heat Transfer-Physical mechanism, radiation properties, radiation shape factor and relations between shape factors.

Unit II :

Heat-Transfer Equipment: Introduction, Basic design procedure and theory, Overall heat-transfer coefficient, Fouling factors, Shell and tube exchangers: construction details, Mean temperature difference (temperature driving force).

Unit III:

Shell and Tube Exchangers: general design considerations, Tube-side heat-transfer coefficient and pressure drop (single phase),Shell-side heat-transfer and pressure drop (single phase), Flow pattern, Design methods, Kern's method, Bell's method, Shell and bundle geometry, Effect of fouling on pressure drop, Pressure-drop limitations.

Unit IV:

Design of Condensers, Reboilers and Vaporizers.

Unit V:

Design of Plate heat exchangers: Gasketed plate heat exchangers, Welded plate, Plate-fin, Spiral heat exchangers, Direct-contact heat Exchangers, finned tubes, Double-pipe heat exchangers, Air-cooled exchangers, Fired heaters (furnaces and boilers), Heat transfer to vessels.

References:

1. Chemical Engineering Design by Coulson & Richardson's,Volume 6 Fourth Edition.
2. Heat Transfer" by J.P.Holman, Ninth Edition.
3.Process Heat Transfer by Donald Q. Kern.

CHCHE 13 POLYMER SCIENCE

INSTRUCTION : 4 Hr/week Credits : 4 Assessment : 40 + 60

OBJECTIVES

1. To learn aspects of Classification of Polymers.
2. To educate about Special Topics in Polymer Synthesis
3. To know the conceptual concepts on methods Polymer Confirmation and Chain Dimensions
4. To understand the Viscoelasticity and Rubber Plasticity.
5. To give knowledge on solid state properties.

UNIT-I

Introduction – Classification of Polymers – Polymer Structure – Molecular Weight – Chemical Structure and Thermal Transitions

Polymer Degradation and the Environment – Polymer Degradation and the Environment -

Management of Plastics in the Environment

UNIT-II

Polymer Synthesis – Step Growth Polymerization – Chain Growth Polymerization – Polymerization Techniques – Reactions of Synthetic Polymers – Special Topics in Polymer Synthesis – Chemical Structure Determination

UNIT-III

Conformational Solutions and Molecular Weight – Polymer Confirmation and Chain Dimensions – Thermodynamics of Polymer Solutions – Measurement of Molecular Weight

Unit –IV

Viscoelasticity and Rubber Plasticity – Introduction to Viscoelasticity – Introduction to Rubber Plasticity

UNIT-V

Solid State Properties – The Amorphous State – The Crystalline State – Thermal Transitions and Properties – Mechanical Properties

Additives, Blends and Composites – Additives – Polymer Blends and Interpenetrating Networks – Introduction to Polymer Composites

Text Book :

1. Polymer Science & Technology - John R.Fried – 2 nd edition – PHI Learning Pvt Ltd- 2010

Reference Books :

1. Polymer Science : A Text Book – V K Ahluwalia & Anuradha Mishra - Ane Books India 2008
2. Plastics Engineering – R J Crawford – Elsevier (Butterworth-Heinemann) – 3 rd edition - 2011

Course Out comes

1. Acquired knowledge on Classification of Polymers and its Structure,its degradation.

2. Have the knowledge on Polymer Synthesis.
3. Have the knowledge on Polymer Confirmation and Chain Dimensions – Thermodynamics of Polymer Solutions

4. Knowledge on Viscoelasticity and Rubber Plasticity
5. Solid State Properties, Polymer Blends and Interpenetrating Networks.

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHCHE 21 **Membrane Separations**

Instruction : 4 hr/week **Credits : 4** **Assessment : 40 + 60**

UNIT I :

OverView of Membrane Separations

Membrane Types, Materials, Preparation and Characterization - Types of Synthetic Membranes – Membrane Modules – Typical Flow patterns – Membrane materials – Pore Characteristics – Membrane Manufacture – Measurement of Pore size and Solute rejection Properties – surface Properties measurement and interpretation

UNIT II :

Nano Filtration – principles – nano-filtration membranes – Mass Transfer – Process Limitations – Industrial application

Ultrafiltration - Basic Principles – Membranes – Configuration – Types of Devices – Factors affecting performance – Flux – Models for Solvent Flux – Fouling and Flux decline – Methods to reduce Concentration Polarization – Energy Considerations – Micellar enhanced UF – Affinity UF – Applications

Microfiltration – Basic Principles – Membranes – Transport Mechanism – retention characteristics – Flow Characteristics – Membrane Plugging and Throughput – Fouling – energy Considerations – Applications

UNIT III :

Reverse Osmosis - Concepts – Phenomenon of RO – Models for RO transport – Design and Operating parameters – Concentration Polarization – Membrane plugging – Equivalent work requirement – Design of an RO module – RO of non-aqueous systems – Osmotic pinch effect – Forward osmosis – Applications

Dialysis – Principles – Dialysis systems – Membranes – Mass transfer – Applications – Diffusion dialysis

UNIT IV :

Gas Separation - Basic Principles – Membranes – Membrane Modules – Fundamental Mechanisms of Gas Transport - Factors affecting Gas Permeation – Complete Mixing Model – Cross and Countercurrent models – Applications

Pervaporation - Basic Principles – Advantages – Membrane characteristics – Thermodynamic Considerations – Mass transfer – Thermodynamic Considerations – Design of a Module – Concentration Polarization – factors affecting pervaporation – Temperature drop at the interface – Applications

UNIT V :

Ion Exchange Membrane Process - Basic Principles – Ion exchange Membranes – Energy requirement, Efficiency- Concentration Polarization and limiting current density – Other operating parameters – applications

Liquid Membranes - Types of liquid membranes – Mechanism of Mass transfer – Applications

Other Membrane Processes – Membrane contactor and applications – Membrane distillation – Membrane reactors – PEM Hydrogen Fuel Cell

Text Book

1. Membrane Separation Processes – Kaushik nath – Prentice Hall, 2008

References

1. Reverse Osmosis and Synthetic Membranes Theory, Technology and Engineering, Sourirajan,S National Research Council, Canada.
2. Reverse Osmosis/ Ultrafiltration Process Principles, Sourirajan,S. and Matsuura, T., National Research Council, Canada. Separation Processes, Elsevier Scientific Publication.
3. Industrial Membrane Separation Technology, Scott,K., and Hughes, R. (Eds.), Blackie Academic & Professional London.
4. Separation Processes, King, C.J, Tata McGraw Hill, New Delhi.
5. ,Membrane Processes, Rautenbatch, R., and Albrecht, R John Wiley & Sons, New York.
6. Membrane Separation Processes, Baum,B., Halley, W. and White, R.A, Elsevier Scientific Publication

CHCHE 22 Energy Conservation and Audit in Process Industries

Instruction : 4 hr/week Credits : 4 Assessment : 40 + 60

UNIT I :

Energy out-look - The second law of thermodynamics - Thermodynamics and economics part-I

UNIT II :

Characterising energy use (energy-audit) - Optimum performance of existing facilities - Facilities improvement

UNIT III

Methodology of thermodynamic analysis - Detailed thermodynamic analysis of common unit operations

UNIT IV

Use of Thermodynamic analysis to improve energy efficiency - Thermodynamic and economics

UNIT V :

Systematic design methods - Guidelines and recommendations for improving process operation

TEXT BOOK:

1. Energy Conservation in Process Industries - W.F.Kenney, Academic Press, Inc., (London) Ltd., 1984.

References :

1. Practical Techniques for Saving Energy in Chemical, Petroleum and Metal industries, Noys Data Corp. 197
2. Hand Book of Industrial Energy Analysis, Boustead, I and Hancock, G.F. Ellis Horwood Ltd., Chichester, U.K. (1979).
3. Hand Book of Energy Audit, Albert Thuman., P.E. The Fairmount Press Inc., (1979)

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