KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE - 638 052
(Autonomous)

M.Tech. DEGREE IN CHEMICAL ENGINEERING (FULL TIME)
CURRICULUM
(For the candidates admitted from academic year 2014-15 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHT11	Momentum, Heat and Mass Transfer	3	1	0	4	40	60	100
14MHT12	Modeling in Chemical Engineering	3	1	0	4	40	60	100
14MHT13	Chemical Reactor Engineering	3	1	0	4	40	60	100
14MHT14	Project Engineering of Process Plants	3	0	0	3	40	60	100
14MHT15	Advanced Separation Technology	3	0	0	3	40	60	100
	Elective–I (Professional)	3	0	0	3	40	60	100
	PRACTICAL							
14MHL11	Process Engineering, Control and Simulation Laboratory	0	0	3	1	100	0	100
				Total	**22**			

CA - Continuous Assessment, ESE – End Semester Examination

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M.Tech. DEGREE IN CHEMICAL ENGINEERING (FULL TIME)
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SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHT21	Chemical Process Design	3	0	0	3	40	60	100
14MHC21	Chemical Equipment Design	3	0	3	4	40	60	100
14MHT22	Computational Fluid Dynamics for Chemical Engineers	3	1	0	4	40	60	100
14MHT23	Chemical Engineering Thermodynamics	3	1	0	4	40	60	100
	Elective–II (Professional)	3	0	0	3	40	60	100
	Elective–III (Professional)	3	0	0	3	40	60	100
	PRACTICAL							
14MHL21	Instrumental Analysis Laboratory	0	0	3	1	100	0	100
				Total	**22**			

CA – Continuous Assessment, ESE – End Semester Examination

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M.Tech. DEGREE IN CHEMICAL ENGINEERING (FULL TIME)
CURRICULUM
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SEMESTER – III

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
	Elective-IV (Professional)	3	0	0	3	40	60	100
	Elective-V (Professional)	3	0	0	3	40	60	100
	Elective-VI (Open)	3	0	0	3	40	60	100
	PRACTICAL							
14MHP31	Project Work – Phase I	0	0	12	6	50	50	100
				Total	**15**			

CA – Continuous Assessment, ESE – End Semester Examination

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	PRACTICAL							
14MHP41	Project Work – Phase II	0	0	24	12	100	100	200
				Total	**12**			

CA – Continuous Assessment, ESE – End Semester Examination

Total Credits: 71

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M.Tech. DEGREE IN CHEMICAL ENGINEERING (PART TIME)
CURRICULUM
(For the candidates admitted from academic year 2014-15 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHT11	Momentum, Heat and Mass Transfer	3	1	0	4	40	60	100
14MHT13	Chemical Reactor Engineering	3	1	0	4	40	60	100
14MHT15	Advanced Separation Technology	3	0	0	3	40	60	100
	PRACTICAL							
14MHL11	Process Engineering, Control and Simulation Laboratory	0	0	3	1	100	0	100
				Total	**12**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHT21	Chemical Process Design	3	0	0	3	40	60	100
14MHT22	Computational Fluid Dynamics for Chemical Engineers	3	1	0	4	40	60	100
	Elective-II (Professional)	3	0	0	3	40	60	100
	PRACTICAL							
14MHL21	Instrumental Analysis Laboratory	0	0	3	1	100	0	100
				Total	**11**			

CA – Continuous Assessment, ESE – End Semester Examination

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M.Tech. DEGREE IN CHEMICAL ENGINEERING (PART TIME)
CURRICULUM
(For the candidates admitted from academic year 2014-15 onwards)

SEMESTER – III

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHT12	Modelling in Chemical Engineering	3	1	0	4	40	60	100
14MHT14	Project Engineering of Process Plants	3	0	0	3	40	60	100
	Elective-I (Professional)	3	0	0	3	40	60	100
				Total	**10**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14MHC21	Chemical Equipment Design	3	0	3	4	40	60	100
14MHT23	Chemical Engineering Thermodynamics	3	1	0	4	40	60	100
	Elective-III (Professional)	3	0	0	3	40	60	100
				Total	**11**			

CA – Continuous Assessment, ESE – End Semester Examination

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(Autonomous)

M.Tech. DEGREE IN CHEMICAL ENGINEERING (PART TIME)
CURRICULUM
(For the candidates admitted from academic year 2014-15 onwards)

SEMESTER – V

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
	Elective-IV (Professional)	3	0	0	3	40	60	100
	Elective-V (Professional)	3	0	0	3	40	60	100
	Elective-VI (Open)	3	0	0	3	40	60	100
	PRACTICAL							
14MHP31	Project Work – Phase I	0	0	12	6	50	50	100
				Total	**15**			

CA – Continuous Assessment, ESE – End Semester Examination

SEMESTER – VI

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	PRACTICAL							
14MHP41	Project Work – Phase II	0	0	24	12	100	100	200
				Total	**12**			

CA – Continuous Assessment, ESE – End Semester Examination

Total Credits: 71

LIST OF ELECTIVES					
Course Code	**Course Title**	**Hours/Week**			**Credit**
		L	**T**	**P**	
14MHE01	Scale Up Methods for Chemical Engineers	3	0	0	3
14MHE02	Chemical Product Design	3	0	0	3
14MHE03	Chemical Engineering Applications in Micro Electronics Processing	3	0	0	3
14MHE04	Mixing Technology	3	0	0	3
14MHE05	Optimization Techniques for Chemical Processes	3	0	0	3
14MHE06	Multiphase Flow	3	0	0	3
14MHE07	Polymer Science and Engineering	3	0	0	3
14MHE08	Petroleum Refinery Engineering	3	0	0	3
14MHE09	Food Process Engineering and Technology	3	0	0	3
14MHE10	Environmental Impact Assessment	3	0	0	3
14MHE11	Advanced Biochemical Engineering	3	0	0	3
14MHE12	Energy Management in Chemical Industries	3	0	0	3
14MHE13	Computer Control of Processes *	3	0	0	3
14MHE14	Advances in Fluidization Engineering	3	0	0	3
14MHE15	Risk Analysis	3	0	0	3
14MHE16	Multicomponent Distillation	3	0	0	3
14MHE17	Piping Flow sheeting Process and Instrumentation diagrams	3	0	0	3
14MHE18	Industrial Waste Water Treatment *	3	0	0	3
14MHE19	Operations Research for Chemical Engineers	3	0	0	3
14MHE20	Process Instrumentation and Automation	3	0	0	3

*- Open Elective

14MHT11 MOMENTUM, HEAT AND MASS TRANSFER

3 1 0 4

UNIT – I **9**

Introduction: Phenomenological equations and transport properties, Rheological behavior of fluids, Balance Equations - Differential and Integral equations, shell balance approach to transfer problems; Momentum flux and velocity distribution for flow of Newtonian and Non-Newtonian fluids in pipes, planes, slits and annulus.

UNIT – II **9**

Energy and mass transfer in laminar flow: Heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous and chemical, forced and free convection, Mass flux and concentration profile for diffusion in stagnant gas, systems involving reactions.

UNIT – III **9**

Applications of equations of change and turbulent flow: Development of equations of change and solutions to momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change, Comparison of laminar and turbulent flows, Time-smoothed equations of change for incompressible fluids, The time smoothed velocity, temperature profile near a wall, Semi-Empirical Expressions for turbulent momentum, heat and mass flux.

UNIT – IV **9**

Interphase transport in isothermal and non isothermal systems: Friction factor, Average velocity of turbulent flow in pipe, Blasius equation for turbulent flow, Flow through packed bed, Friction factors for flow around spheres, Heat Transfer co-efficient for forced convection in tubes, around submerged object, packed bed, Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates

UNIT – V **9**

Macroscopic balance for steady state system: Macroscopic momentum and mass balance, Overall energy and mechanical balance, Friction losses in expansion, contraction and Pipe fittings.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Bird, R.B., Stewart, W.E. and Lightfoot, E.N. “Transport Phenomena”, (Revised Second Edition), John Wiley & Sons, 2007.
2. Welty, J.R., Wicks, C. E. and Wilson, R. E., “Fundamentals of Momentum, Heat Mass Transfer”, 5th Edition., John Wiley and Sons**,** 2007.

Course Outcomes:

On completion of the course the students will be able to

- understand the phenomena behind the transport of momentum, mass and energy from a first principles perspective
- apply the shell balance approach to solve momentum, mass and energy transport problems
- understand and apply the concept of interphase transport

14MHT12 MODELING IN CHEMICAL ENGINEERING

3 1 0 4

UNIT – I **9**

Introduction: Introduction, Physical modeling, Mathematical modeling, Chemical systems modeling - Principles of formulation - Fundamental laws used in modeling, Representation of model, Model building, Types of modeling equations. Classification based on – Independent and Dependent variables and parameters - Variation of independent variables - State of the process - Types of the process, Boundary condition, Black Box principles.

UNIT – II **9**

Modeling of reactors: Mathematical model aspects of tubular reactor, Continuous stirred tank reactor, Jacketed tubular reactor, Non isothermal CSTR, Continuous Stirred Tank Bioreactor.

UNIT – III **9**

Modeling of mass-transfer operations: The process and the model aspects of: Ideal Binary Distillation Column, Binary Continuous distillation column, Gas-Liquid Bubble Reactor, Solvent Extraction, Absorption Column.

UNIT – IV **9**

Modeling of other chemical systems: The process and the model aspects of: Multi component Flash Drum, Mixing Tank, Single-Component Vaporizer, Refinery Debutanizer Column, Interacting and Non-Interacting Tanks.

UNIT – V **9**

Process simulation: Introduction, Scope of process simulation, Formulation of problem, Simulation approach for steady state process – Modular approaches to process simulation, Equation Solving Approach, MAT LAB as a tool for simulation.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Amiya K. Jana, “Chemical Process Modeling and Computer Simulation’, Prentice Hall of India, New Delhi, 2011.
2. Gaikwad R.W and Dhirendra, “Process Modeling and Simulation”, Second Edition, Denett & Co., Nagpur, 2006.
3. Luyben W.L, “Process Modeling, Simulation and Control for Chemical Engineers”, Second Edition, McGraw Hill Book Co., New York, 1990.
4. Babu B.V, “Process Plant Simulation”, Oxford University Press, New Delhi, 2004.

Course Outcomes:

On completion of the course the students will be able to

- understand the basic concepts of various types of mathematical models
- develop mathematical models for reactors, distillation columns and tanks
- understand the scope and approaches in process simulation

14MHT13 CHEMICAL REACTOR ENGINEERING

3 1 0 4

UNIT – I **9**

Industrial catalysis: Classification of Catalysis - Homogeneous, Heterogeneous, Biocatalysts, Typical industrial catalytic processes. Preparation of catalysis - Laboratory Techniques, characterization of catalysts, Catalysts deactivation - Poisons, Sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration

UNIT – II **9**

Theories of catalysts: Adsorption isotherms - Langmuir model, Tempkin model, Freundich model, Elovich equation, Langmiur Hinshel - wood model, Rideal - Eely mechanism, Reversible - irreversible mono and bimolecular reactions with and without inerts. Determination of rate controlling steps, Inhibition

UNIT – III **9**

External diffusion effects in heterogeneous reactions: Fixed bed Reactors: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Effect of external transport processes on selectivity. Modelling diffusion with and without reaction

Fluidized Bed Reactors: Particle- fluid : Mass and Heat Transfer, Slurry bed Reactors: Mass Transfer coefficients – Gas to liquid, Effect of mass transfer on Observed rate Trickle bed Reactors Mass Transfer coefficients – Liquid – to particle, Calculation of Global rate

UNIT – IV **9**

Gas-solid non-catalytic reactors: Models for explaining the kinetics; volume and surface models; controlling resistances and rate controlling steps; time for complete conversion for single and mixed sizes.

UNIT – V **9**

Design of heterogeneous catalytic reactors: Fixed bed Reactors: Construction and operation, one dimensional and two dimensional models, variations of fixed bed reactors, importance of transport process. Fluidized bed Reactors: Two phase fluidized bed model and operating characteristics. Models of slurry reactors trickle bed reactor.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Smith J M, “Chemical Engineering Kinetics”, 3rd Edition, McGraw-Hill, New York, 1981.
2. Fogler H Scott, “Elements of Chemical Reaction Engineering”, 4rd Edition, Prentice Hall Inc. New Jersey, 2005.

Course Outcomes:

On completion of the course the students will be able to

- familiarize with different types of catalysts and its preparation techniques
- acquire knowledge in the models commonly used for heterogeneous reactors
- understand the different rate controlling mechanisms in reactor design
- acquire knowledge catalytic and multi-phase reaction and reactor design

14MHT14 PROJECT ENGINEERING OF PROCESS PLANTS

(Common to Chemical Engineering & Food Technology)

3 0 0 3

UNIT – I **9**

Project identification and process planning: Project definition, Project Profile and standards, Feedback information (MIS), Evaluation and Modification, Selection, Criteria. Planning the process, Strategic and Managerial Planning, Organizing the process planning.

UNIT – II **9**

Project engineering: Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Application of reliability theory.

UNIT – III **9**

Engineering management : Plant Engineering Management, Objectives, Programme, Control, Plant Location and Site Selection, Layout diagrams, Selection and procurement of equipment and machineries, Installation, Recommissioning, Commissioning and performance appraisal, Strategies choice and Influence, Product planning and development, Provision and maintenance of service facilities.

UNIT – IV **9**

Financial aspects: Cost and Costing, Cost Control systems, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Break even strategies. Defining project financing, typical project stages, setting up a basic project finance structure, risk management in context of project financing.

UNIT – V **9**

Legal aspects of business enterprises: Government regulations on procurement of raw materials and its allocation. Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Policies on depreciation and corporate tax, Labour laws, Social welfare legal measurements, Factory act, Regulations of Pollution Control Board.

TOTAL: 45

REFERENCE BOOKS:

1. Clements .T and Gido.L. “Effective Project Management”, Thomson Education press, NewDelhi, 2007.
2. Peters, M.S. and Timmerhaus, K.D., “Plant design and economics for chemical engineers, McGraw Hill (ISE)”, 2002.
3. Perry, J. H. “Chemical Engineer’s Hand Book”, 8th Edition, McGraw-Hill, New York, 2007.
4. Rase F.Howard and Barrows M.H., “Project engineering of process plants”, Wiley, 1957.
5. Pathi P.K. “Labour and Industrial laws”, Second Edition, Prentice Hall India, 2012.

Course Outcomes:

On completion of the course the students will be able to

- acquire the basic knowledge in project engineering and management
- understand process planning, costing, network planning, process feasibilities and break even strategies
- understand plant engineering management, plant location and layout
- apply the financial concepts and the legal aspects of business enterprises

14MHT15 ADVANCED SEPARATION TECHNOLOGY

3 0 0 3

UNIT – I **9**

Recent advancements in separation techniques: Recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. Process concept, theory and equipment used in cross flow filtration, cross flow electro filtration and dual functional filter. Surface based solid - liquid separations involving a second liquid, Sirofloc filter.

UNIT – II **9**

Membranes and modules: Types and choice of membranes. Membrane manufacturing techniques. Plate and frame, tubular, spiral wound and hollow fiber membrane reactors and their relative merits.

UNIT – III **9**

Membrane processes : Dialysis, Reverse Osmosis, Nanofiltration, Ultrafiltration, and Microfiltration and Donnan dialysis. Design of the Reverse Osmosis Plant - Cleaning of Membrane - Economics of membrane operations.

UNIT – IV **9**

Adsorption and ionic separations: Adsorption based Processes: Types and choice of adsorbents, Affinity chromatography and immuno chromatography. Ionic Separation Processes: Working principle, controlling factors, equipment employed for electrophoresis, Dielectrophoresis, Ion exchange chromatography and electro dialysis.

UNIT – V **9**

Other techniques: Separations involving Lyophilisation, Pervaporation and permeation techniques for solids, liquids and gases. Zone melting, Adductive crystallization, Foam separation, Supercritical fluid extraction. Industrial effluent treatment by modern techniques.

TOTAL: 45

REFERENCE BOOKS:

1. Perry Robert H., "Perry's Chemical Engineers' Hand book", 8th Edition, McGraw Hill, New York, 2007.
2. Scott, K. and Hughe, R., "Industrial Membrane Separation Technology", Blackie academic and Professional Publications, 1996.
3. Humphrey, Jimmy L. and Killer, George E. "Separation Process Technology", McGraw-Hill Publications, New York, 1996.

Course Outcomes:

On completion of the course the students will be able to

- understand the recent developments in separation techniques
- apply membrane processes for microfiltration, ultra filtration, reverse osmosis and nanofiltration
- use modern separation techniques for process and product specific applications

14MHL11 PROCESS ENGINEERING, CONTROL AND SIMULATION LABORATORY

0 0 3 1

LIST OF EXPERIMENTS :

1. Examine the heat transfer in Compact Heat Exchanger / Packed Bed Heat Transfer
2. Study the mass Transfer in Rotating Disc Contactor / Sieve Plate Distillation
3. Evaluate the application of controllers for flow and level processes
4. Determine the stability of temperature/ pressure control systems
5. Performance studies on control valves
6. Studies on Feed Forward Control loop
7. Performance evaluation of Ratio Control loop
8. Process Simulation using HYSYS Software
9. Process Simulation using ASPEN Software
10. Process modelling using gPROM
11. Measuring the viscosity index
12. Evaluate the Cascade control using DCS(Demonstration)
13. Evaluation of best controller for a two tank system using SIMULINK

TOTAL: 45

Course Outcomes:

On completion of the course the students will be able to

- examine the heat and mass transfer in heat exchangers, packed beds, contactors and distillation columns
- evaluate the performance of different control systems with classical controllers
- familiarize Process simulation in ASPEN, HYSYS and gPROM

14MHT21 CHEMICAL PROCESS DESIGN

3 0 0 3

UNIT – I **9**

Introduction to process design: Chemical products, process creation, simulation to assist the process creation, The hierarchy of chemical process design and integration – Approaches to process design. Design layout importance in Projects

UNIT – II **9**

Choice of reactors: Reactor performance: Reaction path, reaction systems, idealized reactor models. Reactor conditions: Equilibrium, temperature, pressure, phase and concentration. Reactor configuration: Temperature control, catalyst degradation, Gas –Liquid, Liquid- Liquid, Solid – catalyst reactions.

UNIT – III **9**

Choice of separators and synthesis of reactor – separation systems: Separation of heterogeneous mixtures, Homogenous fluid mixtures, Selection and choice of distillation, absorption, evaporators, dryers. The function of process recycles, recycles with purges, the process yield, Reaction, separation system for batch process.

UNIT – IV **9**

Distillation sequencing: Distillation sequencing using single columns, Practical constrains, Using column with more than two products, Distillation sequencing using Thermal Coupling, Retrofit of distillation sequences, and Optimization of a reducible structure. Introduction to distillation sequencing for azeotropic distillation: Pressure shift, use of an entrainer and membrane separation.

UNIT – V **9**

Heat exchanger network analysis: Energy targets: Heat recovery pinch, threshold problems, the problem table algorithm, utilities selection. Capital and total cost targets: Number of heat exchanger units, heat exchange area targets, number of shells targets, capital cost targets, total cost targets.

TOTAL: 45

REFERENCE BOOKS:

1. Robin Smith, "Chemical Process Design and Integration", Wiley India (P) Ltd , 2005.
2. Douglas J.M., "Conceptual Design of Chemical Process", McGraw-Hill, New York, 1988.
3. Seider, W.D., Seader, J.D. and Lewin, D.R. "Product and Process Design Principles - Synthesis, Analysis and Evaluation", 2nd ed , John Wiley and Sons Inc., 2004.

Course Outcomes:

On completion of the course the students will be able to

- understand the fundamentals chemical process design
- choose and synthesize reactors and other equipment for separating
- perform cost analysis for heat exchanger network based on energy targets and selection of utilities

14MHC21 CHEMICAL EQUIPMENT DESIGN

3 0 3 4

UNIT – I **9**

Design of Process Equipment : Design of multi component and plate hydraulic distillation column, design of absorber with chemical reaction, venturi scrubber

UNIT – II **9**

Design of Heat Transfer Equipment: Design of shell and tube heat exchanger, fired heaters (Hottel's Method), Design of spiral / plate heat exchanger, surface condensers, air cooled heat exchanger.

UNIT – III **9**

Design of Mass Transfer Equipment: Design of Evaporators-multiple effect, design of fluid bed , rotary, spray dryers

UNIT – IV **9**

Design of Pressure Vessels: Design of internal and external pressure vessels, failure of the pressure vessels.

UNIT – V **9**

Design of Miscellaneous Equipments: Design of Cooling towers , Crystallizers, Mixer-settlers, Flash drum / knock out drum

Lecture: 45, Practical: 45, TOTAL: 90

REFERENCE BOOKS:

1. Sinnot, R.K., "Chemical Equipment Design: Chemical Engineering Volume - 6, Elsevier Butterworth, 2005.
2. Thakore, S.B and Bhatt, B I., "Introduction to Process Engineering and Design", Second reprint, Tata McGraw-Hill Publishing Company Limited, 2009.
3. Towler C Gavin and Sinnott Ray., "Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design", Elsevier, 2012.
4. Joshi, M.V and Mahajan V.V., "Process Equipment Design" Third Edition, Macmillan India Limited, 1996.
5. Perry's "Chemical Engineers' Handbook", Eighth Edition, McGraw-Hill Publications, 2008.

Course Outcomes:

On completion of the course the students will be able to

- apply the skill on design of distillation, absorption column and heat exchangers
- design evaporators and dryers
- familiarize with design of pressure vessels and cooling towers

14MHT22 COMPUTATIONAL FLUID DYNAMICS FOR CHEMICAL ENGINEERS

3 1 0 4

UNIT – I **9**

Conservation laws of fluid motion and boundary conditions: Governing equations of fluid flow and heat transfer, equations of state, Navier-Stokes equations for Newtonian fluid, conservative form of governing equations of flow, differential and integral forms of general transport equations, classification of physical behaviour, the role of characteristics in hyperbolic equations.

UNIT – II **9**

Finite volume method for diffusion and convective- diffusion problems: Finite volume method for one-dimensional, two-dimensional and three-dimensional steady state diffusion, steady one-dimensional convection and diffusion, the central differencing scheme. Properties of discretisation schemes, assessment of the central differencing scheme for convection-diffusion problems, the upwind differencing scheme, the hybrid differencing scheme, the power-law scheme, higher order differencing schemes for convection-diffusion problems.

UNIT – III **9**

Solution algorithms for pressure-velocity coupling in steady flows: Staged grid, momentum equations, SIMPLE algorithm, assembly of a complete method, SIMPLER, SIMPLEC, and PISO algorithms; Solution of discretised equations: tri-diagonal matrix algorithm, application TDMA to two-dimensional and three-dimensional problems.

UNIT – IV **9**

Finite volume method for unsteady flows: One-dimensional unsteady heat conduction, implicit method for two-and three-dimensional problems, discretisation of transient convection-diffusion equation, transient convection-diffusion using QUICK differencing, solution procedures for unsteady flow calculations, steady state calculations using pseudo-transient approach.

UNIT – V **9**

Turbulence and its Modelling: Transition from laminar to turbulent flow, characteristics of simple turbulent flows, effect of turbulence on properties of the mean flow, turbulent flow calculations, Reynolds-averaged Navier-Stokes equations and classical turbulence models.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Versteeg H.K. and Malalasekara W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Second Edition, Pearson Education Limited, 2007.
2. Anderson John D., “Computational Fluid Dynamics- The Basics with Applications”, First Edition, Tata-Mcgraw Hill Publisher, 2012.

Course Outcomes:

On completion of the course the students will be able to

- apply the knowledge of C.F.D techniques in developing fluid flow models
- apply finite volume method for developing solution of steady state diffusion and convection diffusion problems
- demonstrate the application of SIMPLER, SIMPLEC and PISO algorithms for solution of industrial and R & D problems; solve unsteady flow heat conduction and convection diffusion processes

14MHT23 CHEMICAL ENGINEERING THERMODYNAMICS

3 1 0 4

UNIT – I **9**

Basic concepts and introduction to phase equilibrium: Review of basic concepts; laws of thermodynamics; Phase equilibrium of binary mixtures; Ideal solution; criteria for phase equilibrium in single and multi-component systems; introduction to vapour-liquid, solid-liquid and solid-vapour equilibrium.

UNIT – II **9**

Applications of phase equilibrium: Vapour liquid equilibrium at low and high pressures; models for excess Gibbs free energy; phase equilibrium in polymer solutions; thermodynamic consistency test of VLE data.

UNIT – III **9**

Chemical equilibrium: Criteria for chemical equilibrium, Equilibrium constant and standard free energy change; effect of temperature on equilibrium constant; introduction to thermodynamic analysis of single and simultaneous parallel reactions; gas-phase and liquid-phase homogeneous reactions.

UNIT – IV **9**

Introduction to statistical thermodynamics: The statistical foundation of classical thermodynamics; classification scheme for statistical thermodynamics; Fundamentals of Statistical Thermodynamics - probability: definitions and basic concepts, permutations and combinations, probability distributions; The Statistics of Independent Particles - essential concepts from quantum mechanics, the ensemble method of statistical thermodynamics, the two basic postulates of statistical thermodynamics, the most probable macrostate, Bose–Einstein and Fermi–Dirac statistics, entropy and the equilibrium particle distribution.

UNIT – V **9**

Introduction to molecular simulation: Outline of Molecular Simulation and Microsimulation Methods - molecular dynamics method, Monte Carlo method, Brownian dynamics method, dissipative particle dynamics method, Lattice Boltzmann method; Outline of Methodology of Simulations - initial positions, initial velocities, reduction methods of computation time, boundary conditions.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Smith, J M., Van Ness H C and Abbot, M M., “Introduction to Chemical Engineering Thermodynamics”, 7th Edition, McGraw-Hill, 2005.
2. Stanley I. Sandler, “Chemical and Engineering Thermodynamics’, Third Edition, John Wiley & Sons, New York, 1999.
3. Normand M. Laurendeau, “Statistical Thermodynamics - Fundamentals and Applications”, Cambridge University Press, Cambridge, UK, 2005.
4. Akira Satoh,“Introduction to Practice of Molecular Simulation”, Elsevier, Burlington, USA, 2011.

Course Outcomes:

On completion of the course the students will be able to

- understand thermodynamics of multi-component phase equilibrium and apply high pressure Vapour Liquid Equilibrium and Liquid-Liquid Equilibrium concepts
- perform thermodynamic analysis of homogeneous and heterogeneous, single and simultaneous parallel reactions
- understand the fundamentals and applications of statistical thermodynamics and molecular simulation

14MHL21 INSTRUMENTAL ANALYSIS LABORATORY

0 0 3 1

LIST OF EXPERIMENTS:

1. UV Spectro photometer: Analysis of iron, cobalt, etc, in the given sample.
2. Determination of BOD, COD for the given Industrial waste water.
3. Analysis of water: pH, Conductivity, Hardness, Chlorides and Sulphate.
4. Flame Photometer: Determination of Sodium and Potassium.
5. Nephelometer: Determination of Turbidity.
6. Conductometric Titrations.
7. Potentiometric Titrations
8. Oswald Viscometer: Viscosity Measurement for Polymer solutions.
9. Thermodynamic Parameters for first order Kinetics.
10. Determination of Melting and Boiling points of solids, Liquid samples.
11. Atomic absorption Spectroscopic Analysis of heavy metals in industrial Waste waters*
12. Infrared IR spectroscopic analysis of Organic compounds*

*Demonstration experiments

TOTAL: 45

Course Outcomes:

On completion of the course the students will be able to

- understand the principles of instrumental analysis of waste water
- familiar in determining physical parameters of waste water
- determine chemical and biological parameters of waste water
- learn to evaluate the data generated by these tests and thereby interpret and draw conclusions about water quality from the results of these tests
- be proficient in wastewater laboratory analytical methods and to be able to interpret the relevance of these in relation to environmental regulations

14MHE01 SCALE -UP METHODS FOR CHEMICAL ENGINEERS

3 0 0 3

UNIT – I **9**

Fundamentals of Scale up, Dimensional Analysis and Scale-up Criterion: Principals of Similarity, Pilot Plants and Models, Introduction to Scale-up Methods
Dimensional Analysis, Regime Concept, Similarity Criterion and Scale up Methods Used in Chemical Engineering.

UNIT – II **9**

Scale-Up of Heat Transfer Equipment: Typical Problems in Scale-up of Mixing Equipment and Heat Transfer Equipment

UNIT – III **9**

Scaling up of Reactors: Scale-up Techniques available for Tubular Reactor, CSTR and Catalytic reactors.

UNIT – IV **9**

Scale-Up of Mass Transfer Equipment: Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes and dryers

UNIT – V **9**

Scale up of Miscellaneous equipment and limitations: Scaling up of Ball Mill, Pressure jet Nozzle and Centrifugal disk Atomizers and Screw Extruders, Furnaces and Kilns, Analogue models, limitations of scale up techniques.

TOTAL: 45

REFERENCE BOOKS:

1. Johnstone, R.E. and Thring, M.W "Pilot Plants Models and Scale-up methods in Chemical Engineering.", McGraw Hill, New York, 1962.
2. Marko Zlokarnik, "Scale-up in Chemical Engineering.", Wiley-VCH, Germany, 2002.
3. Marko Zlokarnik, "Dimensional Analysis and Scale-up in Chemical Engineering.", Springer - Verlag, Berlin, Germany, 1986.
4. Donald G. Jordan, "Chemical Process Development", Part -1 and 2, Intersciences Publishers, 1988.

Course Outcomes:

On completion of the course the students will be able to

- familiarize with fundamentals of Scale up, dimensional analysis and Scale-up Criterion
- acquire knowledge in the Scale-Up of Heat Transfer Equipments, Reactors and Mass Transfer Equipments
- understand the Scale up of miscellaneous equipment and limitations of scale up techniques

14MHE02 CHEMICAL PRODUCT DESIGN

3 0 0 3

UNIT – I **9**

Needs and specifications: Customer needs, Consumer Products, Converting needs into specification, Revising product specifications.

UNIT – II **9**

Source and screening of ideas: Human sources of ideas, chemical sources of ideas, sorting the ideas, Screening the ideas.

UNIT – III **9**

Selection criteria: Selection based on thermodynamics, Selection based on Kinetics, Loss objective criteria, risk associated with product selection.

UNIT – IV **9**

Manufacturing strategy: Intellectual properties, Collection of missing information, final specifications, Development of Microstructure products, device manufacture and related approach Strategy

UNIT – V **9**

Speciality chemical manufacture and economic considerations: First steps towards production, separation Specialty Scale - up. Product versus process design, process Economic, Economic for products.

TOTAL: 45

REFERENCE BOOKS:

1. E.L. Cussler and G.D. Moggridge, "Chemical Product Design", Cambridge University Press, 2001
2. Douglas, J.M., "Conceptual Design of Chemical Process", McGraw-Hill, NewYork, 1988.
3. Turton, Richard, and Bailie, Richard C., "Analysis, Synthesis, and Design of Chemical Processes", Prentice Hall, New Jersey, 2003.
4. Chemical process Equipment Selection and Design, Stanley M.Wales Butter ward-Heinemann Publishers, 2001

Course Outcomes:

On completion of the course the students will be able to

- understand needs and ideas for product design
- apply thermodynamic and kinetic knowledge for the selection of products
- understand device manufacturing strategy and perform economic analysis

14MHE03 CHEMICAL ENGINEERING APPLICATIONS IN MICRO ELECTRONICS PROCESSING

3 0 0 3

UNIT – I **9**

Introduction: Semiconductor Process Technology, Basic fabrication steps.

UNIT – II **9**

Crystal growth and photolitholography: Silicon crystal growth from melt, Silicon flotzine process, GaAr crystal growth Technology, Material charcterisation, Silicon oxidation. Optical lithography, next generation lithographic methods, comparison of various Lithographic methods.

UNIT – III **9**

Etching and diffusion: Wet Cleaning Etching, Dry Etching Basic diffusion process, Extrinic diffusion, lateral diffusion.

UNIT – IV **9**

Ion implementation and film deposition: Range of implemented ions, implent damage and Annealing, Implementation - related processes, Explicit Growth techniques, dielectric deposition polysilicon deposition, metallization, Equilibrium constants for homogenous and heterogeneous reactions.

UNIT – V **9**

Process Integration and I.C. Manufacturing: Passive components, Bipolar Technology, MOSFET Technology, MESFET Technology, MEMS technology. Electrical Testing, Packaging, Statistical process control, Experimental design yield computer integrated manufacturing.

TOTAL: 45

REFERENCE BOOKS:

1. May, G.S., and Sze, S.M., "Fundamental of Semiconductor Fabrication", Wiley International Edition, Singapore, 2004.
2. Lee, H.H., “Fundamentals of Microelectronics Processing", McGraw Hill International Edition, New Delhi, 1990.
3. Cambell, S.A., "The Science and Engineering of Microelectronic Fabrication", Second Edition, Oxford University Press, Oxford, 2001

Course Outcomes:

On completion of the course the students will be able to

- understand and gain in depth knowledge in crystal growth and lithographic methods
- understand the concept of ion implementation and film deposition
- apply various process integration techniques

14MHE04 MIXING TECHNOLOGY

3 0 0 3

UNIT – I **9**

Introduction: Agitation and Mixing, Types of Impellers based on flow Pattern, Impeller Power Number, Power correlation for Newtonian and Non Newtonian Liquids. Fundamentals of Blending and Emulsion.

UNIT – II **9**

Flow Patterns, Fluid Velocities And Mixing In Agitated Vessel: Relationship between flow pattern, fluid velocities, flow rates and mixing, Impeller discharge rates, Batch mixing and continuous mixing in agitated vessel, Flow regime and Flow map in agitated vessel.

UNIT – III **9**

Mass transfer: The role of dispersion in mass transfer, Measurement of physical properties of fluid dispersion, The mechanics of dispersion of fluids, Theory of mass transfer in continuous phases, continuous phase heat and mass transfer properties of dispersion

UNIT – IV **9**

Suspension of solids: Variable which affects uniformity of solid suspension, impellers and circulation patterns- Effects of vessel and auxiliary equipment on suspension, operating techniques, extrapolation of small-scale tests.

UNIT – V **9**

Equipment selection and sizing: Principles of similarity, design correlations, Common rules of thumb, agitation intensity, Scaling based on tests Procedure for scale-up, Design and selection of agitator-case study.

TOTAL: 45

REFERENCE BOOKS:

1. Uhl, V.W., and Gray, J.B., "Mixing Theory and Practice", Volume I, II and III Academic Press Inc: 1966.
2. Tatterson, "Gas – Liquid Mixing", McGraw Hill, 1997.

Course Outcomes:

On completion of the course the students will be able to

- understand the flow patterns in various agitation and mixing operations
- understand the mass transfer and solid suspension characteristics in mixing vessels
- apply the scale up of agitation and mixing equipment

14MHE05 OPTIMIZATION TECHNIQUES FOR CHEMICAL PROCESSES

3 0 0 3

UNIT – I **9**

Introduction: Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problems.

UNIT – II **9**

Linear Programming: Simplex method, Barrier method, sensitivity analysis, Examples for chemical process industries.

UNIT – III **9**

Nonlinear Unconstrained Optimization: Convex and concave functions unconstrained NLP, Newton's method, Quasi-Newton's method, Examples of chemical process optimization.

UNIT – IV **9**

Constrained Optimization: Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT – V **9**

Multi Objective Optimization: Weighted Sum of Squares method, Epsilon constraint method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

TOTAL: 45

REFERENCE BOOKS:

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
2. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
3. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2011.

Course Outcomes:

On completion of the course the students will be able to

- understand the fundamental principles and types of optimization
- solve linear and non-linear optimization problems
- familiarize with constrained and multi objective optimization techniques

14MHE06 MULTIPHASE FLOW

3 0 0 3

UNIT – I **9**

Flow Classification: Fluid – solid systems, Flow through porous media, Fluid – fluid system- Flow pattern and flow regimes. Two – phase co – current flow of fluids-upward and downward flow in vertical pipes, Suspension rheology. Models for chemical reactor - Diffusion and bubbling bed model –Role of draft tube and wall baffles.

UNIT – II **9**

Flow – Power Correlation: Theories of intensity and scale of turbulence, Calculation of circulation velocities and power consumption in agitated vessels for Newtonian/ Non-Newtonian fluids. Blending and Mixing of phases. Power required for aeration to suspend to an immiscible liquid or solids in Slurry reactors, Segregation phenomena, Prediction of optimum speed of impeller rotor and Design criteria for scale up.

UNIT – III **9**

Flow- Two Phase system: Prediction of holdup and pressure drop of volume fraction, Bubble size in pipe flow, Lockhart – Martinelli parameters, bubble Column and its Design aspects, minimum carryover velocity. Holdup ratios, Pressure drop and transport velocities and their prediction.

UNIT – IV **9**

Flow - Three Phase Systems: Gas, Solid and Liquid composite slurries in horizontal and vertical pipes, Flow through Porous media of composite mixtures, Prediction of holdup, pressure drop and through put. Velocities in Three – phase system. Design of multiphase contactors involving fluidization, pervaporation, Lyophilisation and permeatation for solids, liquids and gases.

UNIT – V **9**

Design and Development of Software programmes: Design and Development of Software programmes in multiphase flow, simulation in packed and fluidized beds and Stirred tank process equipment. Selection of equipment for gaseous, particulate and liquid effluents of various industries such as scrubbers, Stacks and Chinneys, Absorbers, Combustion devices, Electrostatic precipitators and filtration / reverse osmosis devices.

TOTAL: 45

REFERENCE BOOKS:

1. Govier, G.W. and Aziz K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold Co., New York, 1972.
2. Wallis, G.B. “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969.
3. Gad Hestsroni, “Handbook of Multiphase systems”, McGraw Hill Book Company, London, 1982.

Course Outcomes:

On completion of the course the students will be able to

- understand the fundamental principles on transfer phenomena
- draw momentum and mass balance for a multiphase system
- acquire knowledge of the classification of flow and flow regimes
- design and Develop Software programmes used in multiphase flow

14MHE07 POLYMER SCIENCE AND ENGINEERING

3 0 0 3

UNIT – I **9**

Science of Large Molecules: Basic concepts - Macromolecular science – Molecular forces and chemical bonding in polymers Molecular weight & its distribution; Polymerization Types characteristics- Addition, Step, Radical, Ionic, Co-ordination and Co-polymerization with kinetic treatment.

UNIT – II **9**

Characterization, Analysis and Testing: Measurement of Molecular weight and size- End group; Colligative properties-Light scattering, Ultra centrifugation, Solution viscosity and molecular size. Spectroscopic methods-IR, NMR, Mass, X-ray diffraction analysis, Thermal analysis: DSC, DTA and TGA

UNIT – III **9**

Homochain polymers & Heterochain Polymers: Polyolefins polymers, Diene polymers, Vinyls polymers, Acrylics polymers, Fluorocarbon polymers, Acrylonitrile – Butadiene – Styrene group polymers.(manufacture method flow diagram with reaction conditions) Polyester polymers, Polyether polymers, Polysaccharide polymers, Polyamide polymers, Silicone polymers, Aldehyde condensation polymers. .(manufacture method flow diagram with reaction conditions)

UNIT – IV **9**

Structure and Properties: Morphology of crystalline polymer-crystallization and melting, strain induced morphology. Rheology – Viscous flow, rubber elasticity- viscoelasticity; Mechanical properties of crystalline polymers-glassy state and glass transition. Properties involving large and small deformations.SEM TEM analysis of polymers. **Polymer Processing:** Plastics technology-Molding, extruding, Calendaring, Casting, Forming; Additives and compounding: Fiber technology – Fabric properties, types of spinning, Fiber after treatments; Elastomeric technology-Vulcanization reinforcement, Elastomeric properties and compounding, Polymer composites.

UNIT – V **9**

Polymer composites: Introduction to polymer composites – material selection for composite design – composite types – factors determining polymer matrix. Replacement of metals with polymer composites – Mechanical & environmental testing for composites –Polymer matrix composites applications. Case study (polyester, vinyl ester, epoxy, Bismaleimide, polyimide, Glass fiber, carbon fiber, aramid fiber & boron fiber.

TOTAL: 45

REFERENCE BOOKS:

1. Billmeyer, F.W., “Textbook of Polymer Science”, Third Edition, John Wiley & Sons, Singapore, 2002.
2. George Odian, “Principles of Polymerization”, Third Edition, John Wiley & Sons, Singapore, 2004
3. Williams, D.J.; “Polymer Science and Engineering ", Prentice Hall, New York, 1971

Course Outcomes:

On completion of the course the students will be able to

- understand the fundamental principles on Macromolecular science
- acquire knowledge in Characterization, Analysis and Testing of polymer materials
- gain knowledge in Homochain and Heterochain Polymers
- acquire knowledge in Properties of polymers, Polymer Processing and Polymer composites

14MHE08 PETROLEUM REFINERY ENGINEERING

3 0 0 3

UNIT – I **9**

Formation and Composition of Petroleum &Petroleum Processing Data: Origin and Formation of Petroleum, Reserves and Deposits of World, Composition of Petroleum. Evaluation of Petroleum, Thermal Properties of Petroleum Fractions, Product Properties, Specifications of Petroleum Products and Test Methods.

UNIT – II **9**

Fractionation of Petroleum: Dehydration and Desalting of Crude, Heating of Crude-Pipe Still Heaters and their Design, Distillation of Petroleum and Blending of Gasoline.

UNIT – III **9**

Treatment Techniques: Fractions -Impurities, Treatment of Gasoline, Treatment of Kerosene, Treatment of Lubes, Wax and Purification.

UNIT – IV **9**

Thermal and Catalytic Process: Cracking, Catalytic Cracking, Catalytic Reforming, Naphtha Cracking, Coking, Hydrogen Processes, Alkylation Processes, IsomerisationProcesses and Polymer Gasolines.

UNIT – V **9**

Hydro cracking and Asphalt Technology: Source of Asphalt, Air Blowing of Bitumen, Up gradation of Heavy Crudes.

TOTAL: 45

REFERENCE BOOKS:

1. Bhaskara Rao B.K., "Modern Petroleum Refining Processes", Fifth Edition, Oxford & IBH Publishing, 2008.
2. Nelson WL, "Petroleum Refining Engineering", Fourth Edition, McGraw-Hill Company, 1987.

Course Outcomes:

On completion of the course the students will be able to

- understand the classification, composition and testing methods of petroleum crude/ product to develop innovative refining process and develop quality control and assurance techniques
- familiarize the students with different treatment processes in the manufacture of petroleum products
- understand the various cracking operations undergone in petroleum industries
- apply the knowledge in selection of right technique for the treatment of Asphalt and Bitumen

14MHE09 FOOD PROCESS ENGINEERING AND TECHNOLOGY

3 0 0 3

UNIT – I **9**

Constituents of Food: Carbohydrates – proteins, Lipids, Vitamins, Additives, Preservatives, Solvents, Flavors, Agents, Food Engineering Operations, Food Sorting, Cleaning, Grading – Harvesting –Drying storage –Prime processing.

UNIT – II **9**

Food Process Engineering Operations: Materials and Energy Balances – Fluid flow applications, Heat transfer applications, Drying, Evaporation, Equilibrium stage process, leaching and Extractions, Applications, Application of Mechanical separations and Mixing, in Diary, Meat Industry, Oil and Flat Industry, Cereal processing.

UNIT – III **9**

Preservation Operations & plant Hygiene: Preservation methods & strategies, Thermal Methods, Nabla Factor Sterilization, Pasteurization, Dehydro freezing, Irradiation, Dosimetry, Transport of food & Preservation Strategies.

Plant Hygiene: Plant Hygiene, Design of sterilization Process, Water Quality Upkeep, waste disposal, Material handling, Packaging, Packing of solid Liquid foods, Food storage, Special case Studies.

UNIT – IV **9**

Developments in Food Processing: Food Constituents and processing, Food emulsions, Food Rheology, Advances in thermal Operation, Extrusion, cooking Spray dryer design, Energy expenditure & Saving Food for developing countries, Food Detoxification, Production of Sweeteners, Starch, Microbial Polysaccharides, Amino acid, Rice bran Tocopherols.

UNIT – V **9**

Food safety & Quality control: Quality Control in Food Industry, Dose Response Relationship, Health Problem, Chemical and Micro biological aspects, Food analysis, Instruments & Enzymatic Analysis, Food Safety. Food laws and standards PFA, FPO, ISI/BIS and AGMARK. GMP's, SSOP's HACCP and ISO9000 programs.

TOTAL: 45

REFERENCE BOOKS:

1. Jowitt R., "Hygienic Design and operation of Food Plant", AVI Pvt., Co., Westort, 1980.
2. Head man D.R. and Singh, R.P. "Food Processing Technology", AVI Pvt., Co., West Port 1981.
3. Brennan. J., Butters G.J.R., Cowell, N.D. and AEV Lilly, "Food Engineering Operations", Third Edition, Applied Scientific Publishers, London, 1990.

Course Outcomes:

On completion of the course the students will be able to

- understand the constituents of food and food process engineering operations
- familiarize the students with preservation operations and plant hygiene in food processing industries
- acquire the knowledge in safety and quality control in food processing industries

14MHE10 ENVIRONMENTAL IMPACT ASSESSMENT

3 0 0 3

UNIT – I **9**

Basics of EIA: Introduction to EIA Audit of Environment & Industries, Input information, Plant operation, Environmental Management planning.

UNIT – II **9**

EIA and Society:EIA and industrial development and Economic growth, Social issues, Waste Streams impact on water bodies

UNIT – III **9**

Planning and Audit: Environmental Impact Assessment planning. Activities, Methodology for Environmental Impact Assessment, Role of Environmental Engineering firm, Role of Regulatory agencies and pollution control boards, Role of the Public.

UNIT – IV **9**

Environmental Audit: Introduction, Environmental information Purpose and advantage of studies, General approach of environmental Auditing, Audit programs in India, Auditing program in major polluting Industries, Reports of the Environmental audit studies.

UNIT – V **9**

Legislations Supporting Environment: Pollution prevention and control laws & acts: Constitution of India & environment, Constitution protection to Environment laws, Administrative & legislative arrangement for Environmental production, Indian Standards.

TOTAL: 45

REFERENCE BOOKS:

1. Canter, Larry. W., “Environment Impact Assessment”, Second Edition, McGraw-Hill Publishers, New York, 1996.
2. Bhatia S. C., “Environmental Pollution and Control in Chemical Process Industries,” Khanna Publishers, Delhi, 2014.

Course Outcomes:

On completion of the course the students will be able to

- understand the concept of EIA and management planning
- understand the role of EIA on economic growth and the impacts of wastes on water bodies
- understand the role of different agencies on EIA
- ability to apply the concept of audit program in polluting industries
- understand the importance of different laws on environment

14MHE11 ADVANCED BIOCHEMICAL ENGINEERING

3 0 0 3

UNIT – I **9**

Enzyme Kinetics: Classification of enzymes, Commercial application of Enzyme, Immobilization of Enzymes, Michaelis –Menten kinetics, Evaluation of parameters in the Michaelis –Menten equation, Inhibition Kinetics.

UNIT – II **9**

Sterilization and Fermentation: Sterilization: Sterilization of medium, batch and continuous sterilization, Sterilization of air. Fermentation**:** Medium requirements, Application of fermentation process, Types of fermentation process – aerobic and anaerobic, solid state and submerged fermentation, Sterilization of fermenter.

UNIT – III **9**

Mass Transfer and Biochemical Reaction in Porous Catalyst: Theories of diffusional and convective mass transfer, oxygen transfer methodology in fermenter, Factors affecting oxygen transfer rate, intra particle diffusion and reaction rate, effectiveness factor and Thiele Modulus.

UNIT – IV **9**

Product Recovery: Removal of solids, Filtration, Sedimentation, Centrifugation, Cell disruption, Extraction, Membrane separation, Chromatography, Electrophoresis, Crystallization and Drying.

UNIT – V **9**

Design and Analysis of Bioreactors: Stability and Analysis of bioreactors, Design and operation of continuous stirred tank bioreactor, fed batch bioreactor, air-lift bioreactor, Fluidized bed bioreactor, Scale up of bioreactors, criteria for selection of bioreactors

TOTAL: 45

REFERENCE BOOKS:

1. Rao, D. G., "Introduction to Biochemical Engineering", Second Edition, Tata McGraw-Hill, New Delhi, 2009.
2. Lee, J. M., "Biochemical Engineering", Prentice-Hall Inc., New Jersey, 1992.
3. Bailey, J. E. and Ollis, D. F., "Biochemical Engineering Fundamentals", Second Edition, Tata McGraw-Hill, New Delhi, 2010.
4. Shuler, M.L and Kargi, F., "Bioprocess Engineering: Basic concepts", Second Edition, Prentice Hall India, New Delhi, 2008.

Course Outcomes:

On completion of the course the students will be able to

- apply the knowledge of micro organisms and enzymes to study different biochemical reactions and rate equations
- design and analyze the performance of bioreactors with the understanding of transport mechanisms and sterilization concepts
- develop process suitable industrial bioreactors and downstream processing techniques

14MHE12 ENERGY MANAGEMENT IN CHEMICAL INDUSTRIES

3 0 0 3

UNIT – I **9**

General: Energy Resources: Coal, Petroleum, Natural gas; Reserves and Depletion, need for conservation.

UNIT – II **9**

Power generation: Fossil-fueled power plants: components, advanced cycles; Nuclear-fueled power plants: nuclear energy, radioactivity, nuclear reactors, nuclear fuel cycle, fusion; Co-Generation of power; Generation Process: Economical and technical efficiency, Socio economic factor.

UNIT – III **9**

Alternative energy: Renewable Sources: Hydropower, wind energy, geothermal energy, tidal power, ocean wave power, ocean thermal power, solar Energy, biomass energy; Issues and challenges in using the renewable energy sources.

UNIT – IV **9**

Energy consumption and audit: Various types of Energy audit, Advantages of each type; Bureau of Energy Efficiency; Energy Conservation act of 2001. Concept of monitoring and targeting, energy targets, reporting techniques, waste avoidance, prioritizing. Exergy Analysis.

UNIT – V **9**

Optimisation techniques in energy management: Recovery of waste heat using recuperative and regenerative heat exchangers; optimum shell and tube exchanger networks, evaporator systems, boiler turbo generator system.

TOTAL: 45

REFERENCE BOOKS:

1. Twidell John and Weir Tony, "Renewable Energy Sources", Second Edition, Taylor & Francis, New York, 2006.
2. Fay James A. and Golomb Dan S., "Energy and the Environment", Oxford University Press, Inc., New York, 2002.
3. Beggs Clive, "Energy: Management Supply and Conservation", Butterworth-Heinemann, Oxford, 2002.

Course Outcomes:

On completion of the course the students will be able to

- understand the power generation methods from conventional and non-conventional energy resources
- monitor the energy consumption patterns to ensure efficient utilization of energy through energy audit
- apply energy recovery techniques through waste heat avoidance

14MHE13 COMPUTER CONTROL OF PROCESSES

3 0 0 3

UNIT – I **9**

Advanced Control Strategies: Feed forward, cascade, dead time compensation, split range, selective and override control; adaptive and inferential control

UNIT – II **9**

Internal Model Control: Model based control – IMC structure – development and design; IMC based PID control, Model Predictive Control

UNIT – III **9**

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

UNIT – IV **9**

Discrete Systems: Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function.

UNIT – V **9**

Digital Feedback Controllers: Closed Loop System Stability, Design of digital feedback controllers and digital approximation of classical controllers, effect of Sampling.

TOTAL: 45

REFERENCE BOOKS:

1. Stephanopoulos, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.
2. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
3. Kannan M. Moudgalya, Digital Process Control, John Wiley & Sons Ltd, 2007
4. Chidambaram M., "Computer Control of Processes", Alpha science international Ltd, 2002.

Course Outcomes:

On completion of the course the students will be able to

- understand the advanced control techniques and its principles
- apply the principles and design of multivariable control
- familiarize with discrete systems and digital feedback controllers

14MHE14 ADVANCES IN FLUIDIZATION ENGINEERING

3 0 0 3

UNIT – I **9**

Applications of Fluidised Beds: Introduction, Industrial application of fluidised beds, physical operations and reactions.

UNIT – II **9**

Mapping of regimes and dense bed: Fixed beds pf particles, types of fluidization without carryover and with carryover of particles, mapping of fluidization regimes, distributor types, Davidson model for gas flow at bubbles.

UNIT – III **9**

Heat and Mass Transfer in Fluidised Bed Systems: Mass and heat transfer between fluid and solid. Gas conversion in bubbling beds. Heat transfer between fluidised bed and surfaces.

UNIT – IV **9**

Elutriation and Entrainment: RTD and also distribution of solid in a fluidised bed, Circulation systems- circuits for the circulation of solids, flow of gas- solid mixtures in downcomers, flow in pneumatic transport lines.

UNIT – V **9**

Design of Fluidised Bed Systems: Three phase fluidisation, design of fluidization columns for physical operations, catalytic and non- catalytic reactions.

TOTAL: 45

REFERENCE BOOKS:

1. Kunji Diazo and Levenspiel O., "Fluidization Engineering", Second Edition, Butterworth Heinemann, 1991.
2. Davidson, J.F and Harrison, “Fluidisation", Academic Press, London, 1990.

Course Outcomes:

On completion of the course the students will be able to

- understand the applications of fluidized beds in industries
- understand the types of fluidization and fluidizing regimes
- understand the concept of heat and mass transfer between fluid and solid
- understand the concept of circulation systems
- apply the skill in design of fluidization columns for physical operations and reactions

14MHE15 RISK ANALYSIS

3 0 0 3

UNIT – I **9**

Introduction: Need for safety engineering, Risk, Identifying a risk in the system. Methodology of Risk assessment. The use of standards in safety.

UNIT – II **9**

Risk Assessment: Probability theory, Interaction between process units, Revealed and Unrevealed failures, Probability of coincidence, Application to chemical process problems.

UNIT – III **9**

Process Safety Analysis: HAZOP, HAZAN, FAULT Tree Analysis. Safety system followed in Ammonia plants, refineries, power plants. Case studies of Flixborough accident, Bhopal accident, Seveso accident.

UNIT – IV **9**

Risk Evaluation: Risk analysis model, Developing accident scenario and initiating events, event trees, consequences determination, uncertainty, Risk evaluation, calculating safety costs.

UNIT – V **9**

Risk Management: Relief concepts, Location of relief, Relief types, Relief scenarios, Data for sizing reliefs, Relief systems.

TOTAL: 45

REFERENCE BOOKS:

1. Bahr Nicholas J., "System Safety Engineering and Risk Assessment: A Practical Approach", First Edition, Taylor and Francis, 1997.
2. Crown Daniel A. and Louvor Joseph F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall International, New Jersey, 2001.
3. Greenberg Harris R. and Cramer Joseph J., "Risk Assessment and Risk Management for the Chemical Process Industry", Stone & Webster Engineering Corporation, 1991.

Course Outcomes:

On completion of the course the students will be able to

- demonstrate the awareness on the importance of Risk assessment and understand the methodology of risk assessment
- exhibit the skill in analyzing process safety analysis
- analyze and evaluate the risk
- exhibit the skill in risk management

14MHE16 MULTICOMPONENT DISTILLATION

3 0 0 3

UNIT – I **9**

Introduction to Multicomponent Distillation: Separation of multicomponent mixture by use of one equilibrium stage, Multi stage separation of binary mixtures, Separation of multicomponent mixtures at total reflux.

UNIT – II **9**

Thermodynamic Relationships for Multicomponent Mixtures: Calculation of VLE and enthalpies of multicomponent mixtures, Equation of state and its usage in prediction of K values and Enthalpies, Use of multiple equation of state.

UNIT – III **9**

Conventional columns, Complex Columns and System of Columns: Formation, application and convergence characteristics of theta method of convergence, K_b Method, the constant – composition method. Applying Theta method of convergence to Complex distillation columns and systems of interconnected column. Formation of 2N Newton Raphson method for single and system of columns.

UNIT – IV **9**

Systems of Azeotropic and Extractive Distillation Column: Qualitative characteristics. Solving problems involving single column. Systems of columns in the service of separating mixtures of non ideal solutions.

UNIT – V **9**

Distillation Accompanied with Chemical Reaction and optimum design: Applying theta method, formation of N(r+2) Newton Rapson method applicable to columns where chemical reaction occur. Determination of minimum number of stages, Economical design and minimization of Reflux ration.

TOTAL: 45

REFERENCE BOOKS:

1. Holland, Charles Donald, “Fundamentals of Multicomponent Distillation”, McGraw-Hill, New York, 1997.
2. Ross Taylor R. Krishna, “Multicomponent Mass Transfer”, Wiley Series in Chemical Engineering, John Wiley & Sons, New York, 1993.

Course Outcomes:

On completion of the course the students will be able to

- understand the ways and means of separating components from multicomponent mixture
- understand multicomponent separation using single, complex and system of columns
- perform design calculations for distillation with chemical reaction and systems forming azeotropes

14MHE17 PIPING FLOW SHEETING PROCESS AND INSTRUMENTATION DIAGRAMS

3 0 0 3

UNIT – I **9**

Flow Sheets & Process Flow Diagram: Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols, Process Flow Diagram- Synthesis of Steady State Flow sheet. Flow sheeting software. P & I D objectives, guide rules, Symbols, Line numbering, Line Schedule.

UNIT – II **9**

Piping and Instrumentation Diagrams: P & I D development, typical Stages of P & I D, P & I D for rotating equipment and static pressure vessels, Process vessels, Absorber, Evaporator

UNIT – III **9**

Control System – Heat Transfer Equipments and Reactors: Control System for Heater, Heat exchangers, Reactors.

UNIT – IV **9**

Control System – Mass Transfer Equipments: Control System for Dryers, Distillation Column, Expander.

UNIT – V **9**

Applications of P & I D: Applications of P & I D in design stage - Construction stage - Commissioning stage - Operating stage - Revamping stage - Applications of P & I D in HAZOPS and Risk analysis.

TOTAL: 45

REFERENCE BOOKS:

1. Ernest E. Ludwig, “Applied Process Design for Chemical and Petrochemical Plants”, Vol.-I Gulf Publishing Company, Houston, 1989.
2. Max. S. Peters and Timmerhaus K.D., “Plant Design and Economics for Chemical Engineers”, McGraw Hill, Inc., New York, 2002.
3. Anil Kumar, “Chemical Process Synthesis and Engineering Design”, Tata McGraw-Hill, New Delhi, 1981.
4. Westerberg A.N., et al., “Process Flow sheeting”, Cambridge University Press, 1979.

Course Outcomes:

On completion of the course the students will be able to

- understand the flow sheeting principles
- apply the Piping and Instrumentation Diagrams in equipment design
- familiarize with Control System for Heat exchangers, Reactors and Mass Transfer Equipment

14MHE18 INDUSTRIAL WASTEWATER TREATMENT

3 0 0 3

UNIT – I **9**

Sources and types of Industrial Wastewater: Sources and types of industrial wastewater – Characterization: Physical, Inorganic non metallic constituents, metallic constituents, Organic constituents, Biological Characteristic, Toxicity tests.

UNIT – II **9**

Introduction to process selection: Physical unit operation: Screening, Coarse solid reduction, Mixing and flocculation, Equalization, Gravity separation, Grit removal, Sedimentation, Neutralization, Clarification, Flotation.

Role of Chemical unit operations in waste water treatment, Chemical unit Process: Chemical Coagulation, Chemical Precipitation- Heavy metal Removal, Phosphorus removal, Chemical oxidation, Chemical Neutralization and stabilization.

UNIT – III **9**

Biological Treatment: Composition and Classification, Bacterial growth, Microbial growth, Aerobic biological oxidation, biological Nitrification, Anaerobic fermentation and oxidation, Biological removal of heavy metals, Activated sludge process, Trickling Filters, Rotating Biological Contactors, Combined aerobic treatment processes, Anaerobic treatment process, Anaerobic sludge blanket process, Attached growth process.

UNIT – IV **9**

Advanced waste water treatment: Depth filtration, surface filtration Membrane filtration, Adsorption, Ion exchange, advanced oxidation process, Photo catalysis, Wet Air Oxidation, Evaporation.Disinfection Processes: Disinfection with chlorine, Disinfection with chlorine dioxide, Dechlorination, Disinfection with ozone, Ultraviolet radiation Disinfection. Other chemical Disinfection methods

UNIT – V **9**

Effluent Treatment Plants: Individual and Common Effluent Treatment Plants – Zero effluent discharge systems -Wastewater reuse – Disposal of effluent on land – Quantification, characteristics and disposal of Sludge

Industrial process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – petrochemical - Pharmaceuticals – Sugar and Distilleries – Food Processing –fertilizers – Thermal Power Plants and Industrial Estates, Indian regulations.

TOTAL: 45

REFERENCE BOOKS:

1. Eckenfelder, W.W., “Industrial Water Pollution Control”, McGraw-Hill, 1999.
2. George Tchobanoglous, Franklin L. Burton ,” Wastewater Engineering: Treatment and Reuse Metcalf Eddy”, McGraw Hill, 2011
3. Frank Woodard, “Industrial waste treatment Handbook”, Butterworth Heinemann, New Delhi, 2001.

Course Outcomes:

On completion of the course the students will be able to

- acquire the knowledge in Sources and types of Industrial Wastewater
- apply the principles of physical and chemical unit operations in waste water treatment
- understand the Biological and Advanced waste water treatment applied in industries
- acquire knowledge of various Effluent Treatment Plants and their operations

14MHE19 OPERATIONS RESEARCH FOR CHEMICAL ENGINEERS

3 0 0 3

UNIT – I **9**

Mathematical Programming: Linear programming- methods- Simplex method – Big M method – Two phase method –Special cases - Goal programming.

UNIT – II **9**

Duality And Sensitivity Analysis: Duality analysis-sensitivity analysis-changes in right- hand side constants of constraints changes in objective function co-efficient-adding a new constraints-adding a new variable.

UNIT – III **9**

Dynamic Programming: Dual simplex method- Cutting plane algorithm- Branch and Bound technique-Zero-one implicit enumeration algorithm - applications of dynamic programming – Cargo loading model – Work force size model – Equipment replacement model – Inventory model-application to chemical processes.

UNIT – IV **9**

Critical path methods: Shortest path model – Maximal flow problem - Crashing of project network – Resource leveling and Resource allocation techniques.

UNIT – V **9**

Unconstrained and constrained algorithms: Unconstrained nonlinear algorithms-Constrained algorithms- Separable programming - Quadratic programming-Geometric programming-Stochastic programming- application to chemical processes.

TOTAL: 45

REFERENCE BOOKS:

1. Handy M. Taha, Operations Research, An introduction, 6th Prentice Hall of India, New Delhi,2001
2. Don. T. Philips, A.Ravindram and J. Soleberg, Operations Research, Principles & Practice, John Wiley & sons, 1992.
3. Panneerselvam ,R, "Operations Research", Prentice – Hall of India, New Delhi,2002

Course Outcomes:

On completion of the course the students will be able to

- understand the fundamentals of mathematical programming and dynamic programming
- apply the program evaluation and critical path methods to chemical processes and projects
- understand the elements of Unconstrained and constrained algorithms, quadratic and geometric programming for solution of chemical process problems

14MHE20 PROCESS INSTRUMENTATION AND AUTOMATION

3 0 0 3

UNIT – I **9**

Intrumenttion: Principles of measurement and classification of process control instruments; temperature, pressure, fluid flow, liquid level, velocity, fluid density, viscosity. Instrument scaling; sensors; transmitters and control valves; instrumentation symbols and labels.

UNIT – II **9**

Controller tuning: Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio - Tuning:- Process reaction curve method, Continuous cycling method and Damped oscillation method – Determination of optimum settings for mathematically described processes using time response and frequency response approaches – Pole placement – Lambda tuning

UNIT – III **9**

Distributed Control System (DCS): Evolution - Different architectures - Local control unit - Operator Interface –Factors to be considered in selecting DCS.

UNIT – IV **9**

Programmable Logic Controllers (PLC): Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – Communication Networks for PLC.

UNIT – V **9**

SCADA: Remote terminal units, Master station, Data acquisition, Supervisory control, Communication architectures - Open SCADA protocols - Direct digital control

TOTAL: 45

REFERENCE BOOKS:

1. Nakara. B.C. and Choudary. K.K., “Instrumentation and Analysis”, Tata McGraw-Hill, New Delhi, 1993.
2. Stephanopoulos. G., “Chemical Process Control”, Tata McGraw-Hill, New Delhi, 1993.
3. Astrom. Karl J. and Willermans. Bjorn, “Computer Controlled Systems”, Prentice Hall of India Pvt. Ltd., New Delhi, 1994.
4. Chemical Engineering Refresher Series on “Process Automation”, McGraw-Hill Publications, New York, 1991.
5. Hughes T., “Programmable Logic Controllers”, ISA press, 2012

Course Outcomes:

On completion of the course the students will be able to

- understand the measurement systems, automation concepts, advanced control strategies
- apply the principles of distributed control, computer control and programmable logic control in process industries