KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE - 638 052
(Autonomous Institution affiliated to Anna University of Technology, Coimbatore)

M.Tech. DEGREE IN CHEMICAL ENGINEERING (FULL TIME)

CURRICULUM

(For the candidates admitted from academic year 2011-12 onwards)

SEMESTER - I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
11ED101	Applied Mathematics for Engineering and Technology	3	1	0	4	50	50	100
11MH101	Advanced Transport Phenomena	3	1	0	4	50	50	100
11MH102	Advanced Chemical Reaction Engineering	3	1	0	4	50	50	100
11MH103	Advanced Separation Technology	3	0	0	3	50	50	100
11MH104	Project Engineering of Process Plants	3	0	0	3	50	50	100
	Elective - I	3	0	0	3	50	50	100
	PRACTICAL							
11MH105	Chemical Engineering Laboratory	0	0	3	1	100	0	100
				Total	**22**			

CA - Continuous Assessment, ESE – End Semester Examination

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SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
11MH201	Advanced Biochemical Engineering	3	0	0	3	50	50	100
11MH202	Computer Control of Processes	3	1	0	4	50	50	100
11MH203	Chemical Process Design	3	1	0	4	50	50	100
11MH204	Industrial Waste Water Management	3	0	0	3	50	50	100
	Elective - II	3	0	0	3	50	50	100
	Elective - III	3	0	0	3	50	50	100
	PRACTICAL							
11MH205	Instrumental Analysis Laboratory	0	0	3	1	100	0	100
				Total	**21**			

CA – Continuous Assessment, ESE – End Semester Examination

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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	3	0	0	3	50	50	100
	Elective –V	3	0	0	3	50	50	100
	Elective – VI	3	0	0	3	50	50	100
	PRACTICAL							
11MH301	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							
11MH401	Project Work – Phase – II	0	0	24	12	100	100	200
				Total	**12**			

CA – Continuous Assessment, ESE – End Semester Examination

LIST OF ELECTIVES					
Course Code	**Course Title**	**L**	**T**	**P**	**C**
11MH011	Pilot Plant and Scale up Methods	3	0	0	3
11MH012	Chemical Product Design	3	0	0	3
11MH013	Chemical Engineering Applications in Micro Electronics Processing	3	0	0	3
11MH014	Mixing Technology	3	0	0	3
11MH015	Optimization Techniques	3	0	0	3
11MH016	Multiphase Flow	3	0	0	3
11MH017	Polymer Science and Engineering	3	0	0	3
11MH018	Petroleum Refinery Engineering	3	0	0	3
11MH019	Food Process Engineering and Technology	3	0	0	3
11MH020	Environmental Impact Assessment	3	0	0	3
11MH021	Fluidization Engineering	3	0	0	3
11MH022	Energy Management in Chemical Industries	3	0	0	3
11MH023	Modelling in Chemical Engineering	3	0	0	3
11MH024	Mechanics and Particle Suspensions	3	0	0	3
11MH025	Risk Analysis	3	0	0	3
11MH026	Multicomponent Distillation	3	0	0	3
11MH027	Piping, Flow Sheeting, Process and Instrumentation Diagrams	3	0	0	3
11MH028	Advanced Chemical Engineering Thermodynamics	3	0	0	3
11MH029	Computational Fluid Dynamics for Chemical Engineering	3	0	0	3

11ED101 APPLIED MATHEMATICS FOR ENGINEERING AND TECHNOLOGY

(Common to Engineering Design, CAD/CAM & Chemical Engineering branches)

3 1 0 4

Objective:

On completion of the course the students are expected

- To understand the concept of the variational problems.
- To understand the concept of linear and non linear equations and its solutions.
- To know the concept of numerical differentiation and integration.
- To understand the concept of boundary value problems and to find its solutions.
- To acquire knowledge about the partial differential equations and its solutions.

MODULE - I **15**

Calculus of variation: Functional –definition-Variational problem: Euler Lagrange equation-Solutions of Euler Lagrange equation – Variational problems involving one& Several unknown functions – Functionals dependent on higher order derivatives – Variational problems involving Several independent variables.

Solution of system of simultaneous equations: Linear equations: Direct methods – Gauss Elimination, Gauss Jordon, Iterative methods- Gauss Jacobi, Gauss Seidal method. Non-linear equations- Newton Raphson method.

MODULE – II **15**

Numerical Differentiation and Integration: Equal intervals – Newton's forward and backward interpolation formula – unequal intervals – Newton's divided difference formula. Newton-Cotes integration formulas, Trapezoidal rule, Simpson's rules, Gaussian quadrature.

Ordinary Differential Equations: Single step methods for Taylor series method – Euler method – Modified Euler method – Runge-Kutta Method of Fourth order .

MODULE -III **15**

Partial Differential Equations: Solving boundary value problems by finite difference method –Finite difference solution for one dimensional heat equation by Implicit and Explicit methods – One dimensional wave equation – Two dimensional Laplace and Poisson equations.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS

1. Gerald, Curtis F and Wheatley, Patrick O, "Applied Numerical Analysis", Pearson Education, New Delhi, 2002.
2. Jain, M.K. Iyengar, S.R.K and Jain R.K., "Numerical Methods for Scientific and Engineering Computation", New Age International (P) Ltd., Publishers, 2008.
3. Venkataraman, M. K, "Numerical Methods", National Publishing Company, Chennai, 2000.
4. Venkataraman. M.K, "Higher Mathematics for Engineering & Science", National Publishing Company, 2006.

11MH101 ADVANCED TRANSPORT PHENOMENA

3 1 0 4

Objectives:

This course provides the student with an introduction to the transport of momentum, mass and energy from a first principles perspective. The emphasis is on physical concepts and the posing of problems. The simplification of the equations using stressed. The necessary mathematical concepts are introduced and handled via homework problems.

MODULE- I **15**

Momentum Transfer in Laminar Flow: Introduction to 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.

Mass and Energy Transfer in Laminar Flow Mass flux and concentration profile for diffusion in stagnant gas, systems involving reactions. Heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous and chemical; forced and free convection.

MODULE- II **15**

Applications of Equations of Change: Development of equations of change and solutions to momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change.

Turbulent Flow: 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.

MODULE- III **15**

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 Coefficients for forced convection in tubes, around submerged object, packed bed.

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 ed.). John Wiley & Sons, 2002.
2. Welty**,** J.R.**,** Wicks**,** C. E. and Wilson**,** R. E.**, "**Fundamentals of Momentum, Heat Mass Transfer**",** 5th Edition., John Wiley and Sons, 2007**.**

11MH102 ADVANCED CHEMICAL REACTION ENGINEERING

3 1 0 4

Objective:

- To know the exploitation of chemical reactions on a commercial scale.
- To get the knowledge for the design and operation of chemical reactors
- To expose with the frequent comparison of capabilities of the major reactor types etc.

MODULE- I **15**

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

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.

MODULE- II **15**

External Diffusion Effects in Heterogeneous Reactions: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.

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, fluidized and static reactors

MODULE- III **15**

Heterogeneous Catalytic Reactors-I: slurry reactors, trickle bed reactor.

Heterogeneous Catalytic Reactors-II: Three phase fluidized bed reactor, packed bed reactor.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS

1. Levenspiel O, "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons, Singapore, 1999.
2. Smith J M, "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill, New York, 1981.
3. Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd Edition, Prentice Hall Inc. New Jersey, 1999.

11MH103 ADVANCED SEPARATION TECHNOLOGY

3 0 0 3

Objectives:

On completion of the course the students are expected

- To know the recent advancements in separation techniques
- To expose with the selection criteria of membrane materials, adsorbents etc.
- To design simple membrane based processes and to workout the economics

MODULE- I **15**

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.

Adsorption based Processes: Types and choice of adsorbents, Affinity chromatography and immuno chromatography

MODULE - II **15**

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.

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

MODULE- III **15**

Ionic Separation Processes: Working principle, controlling factors, equipment employed for electrophoresis, Dielectrophoresis, Ion exchange chromatography and electro dialysis.

Other Separation Processes: Separations involving Iyophilisation, Prevaporation 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", 7th Edition, McGraw Hill, New York, 1997.
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.

11MH104 PROJECT ENGINEERING OF PROCESS PLANTS

3 0 0 3

Objectives: To introduce the basic concepts of Project Engineering and Management to the students to enable them to apply these techniques during the construction of chemical process plants. After undergoing this course, students will be able to develop PERT/CPM networks, prepare project reports and evaluate the economic viability of projects.

MODULE- I **15**

Introduction: Project definition, Project Profile and standards, Feed back information (MIS), Evaluation And Modification, Selection, Criteria. planning the process.

Project Engineering: Strategic and Managerial Planning, Organizing the process planning, cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods(PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost –Benefit Ratio Analysis, Project Budgeting.

MODULE-II **15**

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

Financial Aspects: Capital Requirements, Capital Market, Cash Flow Analysis, Break even strategies Product planning and development.

MODULE - III **15**

Project Financing: defining project financing, typical project stages, setting up a basic project finance structure, risk management in context of project financing.

Government Policies and Regulations: 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. Ckements .T and Gido.L. “Effective Project Management” Thomson Education press, New Delhi, 2007.
2. Peters, M.S. and Timmerhaus, K.D., “Plant design and Economics for Chemical Engineers, McGraw Hill (ISE)”, 4th Edition, 1991.
3. Perry, J. H. “Chemical Engineer’s Hand Book”, 6th Edition, McGraw-Hill, New York, 1987.

11MH105 CHEMICAL ENGINEERING LABORATORY

0 0 3 1

LIST OF EXPERIMENTS*

1. Heat transfer in Compact Heat Exchanger / Packed Bed Heat Transfer
2. Mass Transfer in Rotating Disc Contactor / Sieve Plate Distillation
3. Flow and level control studies
4. Temperature and pressure control studies
5. Control valve characteristics
6. Feed Forward Control loop
7. Ratio Control loop
8. Process Simulation using HYSYS Software
9. Process Simulation using ASPEN Software
10. Process modeling using gPROM
11. Viscosity measurement
12. Jet Mixing studies
13. Catalytic / Non Catalytic reactor
14. Cascade control using DCS(Demonstration)

*Minimum TEN experiments shall be offered

11MH201 ADVANCED BIOCHEMICAL ENGINEERING

3 0 0 3

Objective:

- To impart knowledge on the role of micro organism in different types of Bio-chemical reaction
- To design Bio-chemical reactors with proper knowledge on Enzyme Engineering

MODULE – I **15**

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.

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.

MODULE - II **15**

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.

MODULE – III **15**

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

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.

TOTAL : 45

REFERENCE BOOKS

1. Rao, D. G., “Introduction to Biochemical Engineering”, Tata McGraw-Hill, New Delhi, 2006.
2. Lee, J. M., “Biochemical Engineering”, Prentice Hall, New Jersey, 1992.
3. Bailey, J. E. and Ollis, D. F., “Biochemical Engineering Fundamentals”, Second Edition, McGraw-Hill, New York, 1986.
4. Shuler, M.L and Kargi, F., “Bioprocess Engineering: Basic principles”, Prentice Hall India, New Delhi, 2002.

11MH202 COMPUTER CONTROL OF PROCESSES

3 1 0 4

Objectives:

On completion of the course the students are expected

- To know about the recent advancements in control of processes
- To know about the design of control systems for multi variable processes
- To expose with process control with digital computers

MODULE – I **15**

Analysis and Design of Advanced Control Systems: Processes with large dead time-Dead time compensation-Control of systems with inverse response. Control systems with Multiple Loops: Cascade Control-Selective control systems-Split-Range control.

Feed Forward and Ratio control: Logic of Feed forward control-Problem of designing feed forward controllers-Practical aspects on the design of feed forward controllers-Feed forward cum feedback control-Ratio Control. Adaptive and Inferential Control Systems: Adaptive control-Inferential control –Examples

MODULE – II **15**

Design of Control Systems for Multivariable Processes: Synthesis of Alternative Control Configurations for Multiple-Input, Multiple-output Processes: Design Questions for MIMO control systems-Degrees of freedom and the number of controlled and manipulated variable-Generation of alternative loop configurations-extensions to systems with interacting units

Interaction and Decoupling of Control Loops: Interaction of control loops-Relative gain array and the selection of loops- Design of Non interacting control loops

MODULE- III **15**

Process Control Using Digital Computers: Continuous to Discrete time systems: Sampling continuous signals-Reconstruction of continuous signals from their discrete time values-Conversion of continuous to discrete time models. Z-Transforms: Definition-Basic functions-Properties- Inversion of Z transforms.

Discrete time Response of Dynamic Systems: Response of discrete dynamic systems – Discrete time analysis of continuous systems- Discrete time analysis of close loop systems –Stability analysis of Discrete time systems.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS

1 Stephanopoulos, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.
2 Chidambaram, M., "Computer Control of Processes", Narosa Publishing, New Delhi, 2002.
3 Sigh, S.K., "Computer - Aided Process Control", Prentice Hall India, New Delhi, 2003.

11MH203 CHEMICAL PROCESS DESIGN

3 1 0 4

Objective:

- To know the selection of series of processing steps and their interconnection into a flow sheet
- To make decisions during development of process design to transform raw materials into products.

MODULE – I **15**

Introduction to Process Design and Choice of Reactors : Overall process design-The Hierarchy of Chemical Process Design – Approaches to process Design. Design layout importance in Projects. Reaction Path, Reactor Performance, Reactor concentration, Temperature, pressure and phase, Practical Reactors.

Choice of Separators: Separation of Heterogeneous Mixtures, Homogenous Fluid Mixtures, Selection and choice of distillation, absorption, evaporators, dryers.

MODULE - II **15**

Synthesis of Reaction – Separation Systems: Vapor and liquid recycles, Batch Process, Process Yield.

Distillation sequencing: Using Single Columns, Practical constrains, Using Column with more than two products, Distillation Sequencing using Thermal Coupling , Optimization of a reducible structure.

MODULE - III **15**

Heat Exchanger Network and Utilities – Energy Targets: Heat recovery pinch, the problem table algorithm, utilities selection, energy targets.

Capital And Total Cost Targets: Number of heat exchanger units, area targets, number of Shells targets, capital cost targets, total targets.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS

1. Smith, Robin, “Chemical Process Design”, McGraw Hill International, New York, 1995.
2. Douglas J.M., “Conceptual Design of Chemical Process”, McGraw-Hill, New York, 1995

11MH204 INDUSTRIAL WASTEWATER MANAGEMENT

3 0 0 3

Objectives: To introduce the concepts of waste water treatment and management to the students to enable them to apply these techniques to specific industrial needs.

MODULE- I **15**

Sources and types of Industrial Wastewater : Sources and types of industrial wastewater – Environmental impacts – Regulatory requirements – generation rates – characterization – Toxicity and Bioassay tests.

Industrial Pollution Prevention: Prevention vs Control of Industrial Pollution– Source reduction techniques – Waste Audit-Evaluation of pollution prevention options.

MODULE-II **15**

Waste minimization - Equalization - Neutralization – Oil separation – Flotation –Precipitation – Heavy metal Removal – adsorption.

Aerobic and anaerobic biological treatment – Sequencing batch reactors – High Rate reactors - Chemical oxidation –Ozonation – Photocatalysis – Wet Air Oxidation – Evaporation – Ion Exchange – Membrane Technologies – Nutrient removal

MODULE – III **15**

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 manufacturing: 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, ISO 14000:2003 – Waste Audit.

TOTAL: 45

REFERENCE BOOKS

1. Eckenfelder, W.W., Industrial Water Pollution Control, McGraw-Hill, 1999.
2. Arceivala, S.J., Wastewater Treatment for Pollution Control, McGraw-Hill, 1998.
3. Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001.

11MH205 INSTRUMENTAL ANALYSIS LABORATORY

0 0 3 1

Objective:

- This course covers a variety of methods of analysis in chemical instrumentation.
- To determine experimentally the various properties of the Waste water, Polymers, chemicals etc.
- To have a thorough understanding on the behaviors and characteristics of sub materials at different operating conditions.

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

11MH011 PILOT PLANT AND SCALE -UP METHODS

3 0 0 3

Objective:

- To impart knowledge on scale up techniques
- To understand the application of scale up of Chemical equipments

MODULE – I **15**

Fundamentals of Scale up: Principals of Similarity, Pilot Plants and Models, Introduction to Scale-up Methods

Dimensional Analysis and Scale-up Criterion: Dimensional Analysis, Regime Concept, Similarity Criterion and Scale up Methods Used in Chemical Engineering.

MODULE - II **15**

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

Scaling up of reactors: Scale-up Techniques available for different types of chemical Reactors.

MODULE – III **15**

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

Scale up and limitations: Scaling up of other Chemical Engineering systems, 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, "Dimensional Analysis and Scale-up in Chemical Engineering.", Springer - Verlag, Berlin, Germany, 1986.
3. Donald G. Jordan, "Chemical Process Development", Part -1 and 2, Intersciences Publishers, 1988.

11MH012 CHEMICAL PRODUCT DESIGN

3 0 0 3

Objective: An advance technology inculcating the various methodologies in chemical product design for Process Technicians and Chemical Engineers. Marketing and Research helps to guide the students in chemical Industries and Chemical business.

MODULE – I **15**

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

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

MODULE - II **15**

Selection Criteria: Selection based on thermodynamics, Selection based on Kinetics.

Loss and risk: Loss objective criteria, risk associated with product selection.

MODULE – III **15**

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

Specialty Chemical Manufacture and Economic Considerations: First steps towards production, separation specialty Scale – up. Product versus process design, process Economics, Economics for products.

TOTAL : 45

REFERENCE BOOKS

1. Cussler E.L. and Moggridge G.D., "Chemical Product Design", Cambridge University Press, 2001.
2. Ulrich, K.T.and Eppinger, S.D. "Product Design and Development", Second Edition, .McGraw-Hill, New York, 2000.

11MH013 CHEMICAL ENGINEERING APPLICATIONS IN MICRO ELECTRONICS PROCESSING

3 0 0 3

Objective:

- To study the semiconductor fabrication technology from crystal growth to integrated devices and circuits.
- To know more about the major fabrication steps including crystal growth, silicon oxidation, photolithography, etching, diffusion, ion implantation, thin film deposition and the various methods for IC manufacturing.

MODULE – I **15**

Introduction: Semiconductor Process Technology, Basic fabrication steps.

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

MODULE – II **15**

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

Ion implementation: Range of implemented ions, Implement damage and Annealing, Implementation - related processes, Explicit Growth techniques.

MODULE – III **15**

Film Deposition: Dielectric deposition, Polysilicon deposition, Metallization, Equilibrium constants for homogenous and heterogeneous reactions

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.

11MH014 MIXING TECHNOLOGY

3 0 0 3

Objectives:
On completion of the course the students are expected:

- To have a complete idea about various parameters to be considered for the design of agitated vessel for any given process fluids
- To know about various flow patterns involved in agitation and mixing of low viscous and high viscous fluids
- To know about the inter-phase mass transfer between continuous and dispersed phase during agitation
- To know about Scale-up of equipment for agitating liquids

MODULE – I **15**

Introduction to Mixing: Mixing-Application, Fluid Motion and Mixing – Description of diffusion and Mixing Process, Criteria for mixing, Laminar and Turbulent mixing. Impeller Characteristics – Power theory, Power correlations

Flow Patterns, and Flow Velocities for Low Viscous Fluids:
Flow pattern and Power, Fluid property effects- Impeller and Power process selection. Relationship between flow pattern, fluid velocities, flow rates and mixing, Impelled discharge rates, Batch mixing and continuous mixing in agitated vessel, Flow regime and Flow map in agitated vessel.

MODULE- II **15**

Mixing of High Viscosity Fluids: Mixing of high viscosity materials – Fundamental Concepts, equipment, evaluation of goodness of mixing.

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.

MODULE – III **15**

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, Zwietering criteria of solid suspension.

Scale-Up of Equipment for Agitating Liquids: Principles of similarity, design correlations, Common rules of thumb, agitation intensity, Scaling based on tests Procedure for scale-up.

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. Nagata S.., “Mixing Principles and Applications”, Kodansha Ltd., Tokyo, 1975
3. Nauman, “Chemical Reactor Design: Optimization and Scale-up”, McGraw Hill, New York, 1995

11MH015 OPTIMIZATION TECHNIQUES

3 0 0 3

Objective:

- To get introduced with the necessary tools for problem solving
- To provide an exposure to formulate optimization problems and choice of optimization technique.

MODULE – I **15**

Developing Models for Optimization: Scope and hierarchy of optimization, Building a model, Factorial experimental designs, and Degree of freedom. Formation of objective function, continuity of functions.

Basic concepts and Optimization of Unconstrained search: NLP problem statement, convexity and applications, Interpretation of objective function based on its Quadratic approximation. Methods for one dimensional search, Polynomial approximation methods.

MODULE - II **15**

Unconstrained Multivariable Optimization: Methods using function value only, methods using first derivative, Newton's method, Quasi – Newton methods.

Linear Programming: Simplex method, Barrier method, sensitivity analysis, Examples.

MODULE – III **15**

Nonlinear Programming with Constrains: Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

Multiobjective Optimization: Weighted Sum of Squares method, Epsilon constrains 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 Practice", McGraw Hill International, II edition, New York: 2003.
2. Diwaker, Urmila M., "Introduction to Applied Optimization", Kluwer Academic Publication: 2003.
3. Joshi, M.C. and Kannan M. Moudgalya, "Optimization: Theory and Practice", Narsoa Publication, New Delhi, 2004.

11MH016 MULTIPHASE FLOW

3 0 0 3

Objective:

On completion of the course the students are expected

- To know about the fundamentals on transfer phenomena, occurring in systems exhibiting at least two phases.
- Draw momentum and mass balance for a multiphase system
- To learn the classification of flow and flow correlations.
- Display knowledge of design, scaling and applications of multiphase reactors.

MODULE – I **15**

Flow Classification: Fluid – solid systems, Mobile and stagnant solids, Flow through porous media, Capillary Tube model, Application for flow through packed bed, filters, fluidized beds, Solid – fluid Convening, Settling and Sedimentation, Fluid – fluid systems, Flow patterns and flow regimes, Analysis of annular, stratified and bubble flow, Formation of bubbles and drops. Their size distribution and volume distribution.

Two – phase co – current flow of gas liquid, Gas/Solid and Liquid/Liquid, Upward and Downward Flow in vertical pipes, Suspensions of sand, gravel coal etc., and their transport in horizontal Pipes, Drag reduction phenomena, Laminar, Turbulent, Creeping flow regimes, Suspension Rheology, Deterministic and stochastic flow system. Models for chemical reactors - Prevention of circulatory flow, Role of draft tubes and wall baffles, Diffusion model and bubbling bed model for gas interchange and gas mixing, Axial mixing correlations.

MODULE - II **15**

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.

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.

MODULE – III **15**

Flow in 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, prevaporation, Lyophilisation and permeatation for solids, liquids and gases.

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.

11MH017 POLYMER SCIENCE AND ENGINEERING

3 0 0 3

Objective:

- An advance technology inculcating the various methodologies in polymers for process technicians and engineers.
- Characterization and testing helps to guide the students in analyzing products and formulations.
- End use of commercial polymers highlights the viability of replacements from metals and alloys.

MODULE – I **15**

Science of Large Molecules: Basic concepts - Macromolecular science - Molecular weight & its distribution; Polymerization- Step; Radical; Co-ordination and Co-polymerization with kinetic treatment.

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, X-ray diffraction analysis, Thermal analysis: DSC, DTA and TGA

MODULE - II **15**

Homochain polymers: Polyolefins polymers, Diene polymers, Vinyls polymers, Acrylics polymers, Fluorocarbon polymers, Acrylonitrile – Butadiene – Styrene group polymers.

Heterochain Polymers: Polyester polymers, Polyether polymers, Polysaccharide polymers, Polyamide polymers, Silicone polymers, Aldehyde condensation polymers.

MODULE - III **15**

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.

Polymer Processing: Plastics technology-Molding, extruding, Calendering, Casting, Forming; Additives and compounding: Fiber technology – Fabric properties, spinning, Fiber after treatments; Elastomer technology-Vulcanization reinforcement, Elastomer properties and compounding.

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, 2002
3. Williams, D.J.; “Polymer Science and Engineering ", Prentice Hall, New York, 1971
4. Rodriguez. F, Cohen, C, Ober, C, and Archer, L.A., “Principles of Polymer Systems”, Fifth Edition, Taylor and Francis, Great Britain, London, 2003.

11MH018 PETROLEUM REFINERY ENGINEERING

3 0 0 3

Objective:

- To introduce petroleum formation and processing Methods
- To provide an exposure on various fractionation and treatment techniques relevant to petroleum refining

MODULE – I **15**

Formation and Composition of Petroleum: Origin and formation of petroleum, reserves and deposits of world, composition of petroleum.

Petroleum Processing Data: Evaluation of petroleum, thermal properties of petroleum, fractions, product properties specifications of petroleum products and test methods.

MODULE - II **15**

Fractionation of Petroleum: Dehydration and desalting of crude, heating of crude-pipe still heaters, and their design distillation of Petroleum. Blending of gasoline.

Treatment Techniques: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes, wax and purification.

MODULE - III **15**

Thermal and Catalytical Process: Cracking, catalytic cracking, catalytic reforming, naphtha cracking, coking, hydrogen processes, alkylation processes, isomerisation processes, polymer gasolines. Application of molecular sieve for refinery processes

Hydro cracking and Asphalt Technology: Source of asphalt, air blowing of bitumen, up gradation of heavy crudes.

TOTAL : 45

REFERENCE BOOKS

1 Nelson WL, “Petroleum Refining Engineering”, Fourth Edition., McGraw-Hill company, 1958.

2 Bhaskara Rao B.K., “Modern Petroleum Refining Processes”, Fourth Edition. Oxford & IBH Publishing, 2002.

11MH019 FOOD PROCESS ENGINEERING AND TECHNOLOGY

3 0 0 3

Objective:

- To create awareness on the need for processing and preservatives of Foods.
- To design processing equipments for Food Industries.

MODULE - I **15**

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

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.

MODULE - II **15**

Preservation Operations: 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.

MODULE - III **15**

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, Ricebran Tocopherols.

Quality control,analysis and safety: Quality Control in Food Industry, Dose Response Relationship, Health Problem, Chemical and Micro biological aspects, Food analysis, Instruments & Enzymatic Analysis, Food Safety.

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.

11MH020 ENVIRONMENTAL IMPACT ASSESSMENT

3 0 0 3

Objective:

- To understand the means to verify the environmental impacts are within predicted or permitted limits.
- Knowledge on how to take action to manage, unanticipated impacts or other unforeseen changes.

MODULE – I **15**

EIA and Society: EIA and industrial development and Economic growth, Social issues.

Basics of EIA: Introduction to EIA Audit of Environment & Industries, Input information, Plant operation, Environmental Management planning, Waste Streams impact on water bodies.

MODULE – II **15**

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.

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.

MODULE – III **15**

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 , Pollution control acts in India , critical appraisal ,fiscal incentives for environmental protection

International standards and Global issues: EIA practices in developed countries, World Bank and multilateral institution standards, Global issues.

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, 2001.

11MH021 FLUIDIZATION ENGINEERING

3 0 0 3

Objective:

On completion of the course the students are expected

- Demonstrate basic knowledge of fluidized bed phenomena and technology;
- Demonstrate comprehension of different flow regimes and their attributes in fluidization;
- Hydrodynamics of bubbling, turbulent, and fast fluidized beds, and pneumatic conveying.

MODULE – I **15**

Hydrodynamics of Fluidization Systems: The Fluidized state, Nature of hydro dynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems.

Pressure drop and hold –up in Fluidization System: General bed behaviour, pressure drop, Flow regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques, Empirical Correlations for Solids holdup, liquid holdup and gas holdup. Flow models – generalized wake model, structural wake model and other important models.

MODULE - II **15**

Solid mixing and Heat Transfer in Fluidization System: Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase Mixing and gas phase mixing.

Mass Transfer in Fluidization System : Mass transfer – Gas Liquid mass transfer, Liquid Solid mass transfer and wall to bed mass transfer, Heat transfer – column wall – to – bed heat transfer, Immersed vertical cylinder to bed heat transfer, Immersed horizontal cylinder to bed heat transfer.

MODULE - III **15**

Miscellaneous Systems: Conical Fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor

Phase and semifluidisation: Two phase and Three phase inverse fluidized bed, Draft tube systems, Semifluidized bed systems.

TOTAL: 45

REFERENCE BOOKS

1. Liang, Shih., “Gas- liquid Solid Fluidization Engineering”, Fan, Butterworths, 1989,
2. kwauk , Mosoon., “Fluidization Idealized and Bubbleless: with applications”, Science Press, 1992
3. Levenspiel, O. and Kunii, D, “Fluidization Engineering”, John Wiley, New York, 1972.

11MH022 ENERGY MANAGEMENT IN CHEMICAL INDUSTRIES

3 0 0 3

Objectives:

On completion of the course the students are expected:

- To know the power generation using renewable and nonrenewable energy sources
- To understand energy consumption and planning
- To know about the conduction of energy audit and optimize energy usage
- To know about the need for energy recovery, and heat recovery methods in Chemical Industries

MODULE – I **15**

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

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.

MODULE- II **15**

Alternative Energy Sources: 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.

Energy Consumption and Planning: Energy Consumption, Demand Pattern, Energy Planning – Short term and Long Term.

MODULE – III **15**

Energy Audit: Various types of Energy audit, Advantages of each type; Bureau of Energy Efficiency; Energy Conservation act of 2001.

Energy Monitoring, Targeting and Waste Avoidance: Concept of monitoring and targeting, energy targets, reporting techniques, waste avoidance, prioritizing. Waste Heat Recovery: Need for Energy Recovery, Recuperative and Regenerative Heat Exchangers. Design of heat exchanger trains: optimization of distillation columns and pinch point.

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.

11MH023 MODELLING IN CHEMICAL ENGINEERING

3 0 0 3

Objective:

- This course makes the students knowledgeable in different aspects of Modelling Chemical Process Systems and also familiarizes the numerical simulation of models.
- To familiarize: Basics of Modelling, Modelling of Reactors, Modelling of Vaporizer and Distillation Column.

MODULE – I **15**

Modelling Aspects: Introduction, Physical Modelling, Mathematical Modelling, Chemical Systems Modelling - Principles of Formulation - Fundamental Laws used in Modelling, Representation of Model, Model Building, Types of Modelling Equations.

Mathematical Modelling: 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.

MODULE - II **15**

Modelling of Reactors: Mathematical model aspects of Tubular reactor, Continuous stirred tank Reactor, Jacketed Tubular Reactor, Nonisothermal CSTR, Continuous Stirred Tank Bioreactor.

Modelling 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.

MODULE - III **15**

Modelling 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.

Process Simulation: Introduction, Scope of process simulation, Formulation of problem, Simulation approach for steady state process – Modular Approaches to Process Simulation, Equation Solving Approach.

TOTAL: 45

REFERENCE BOOKS

1. Amiya K. Jana, "Chemical Process Modelling and Computer Simulation', Prentice Hall of India, New Delhi, 2008.
2. Gaikwad R.W and Dhirendra, "Process Modeling and Simulation", Second Edition, Denett & Co., Nagpur, 2006.
3. Luyben W.L, "Process Modelling, 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.

11MH024 MECHANICS AND PARTICLE SUSPENSIONS

3 0 0 3

Objective:

- To impart knowledge on the mechanics and flow behaviour of particle suspensions
- To design fluidization columns

MODULE – I **15**

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

Fluidisation and Analysis of Different Phases: Cross Behaviour of Fluidised Beds. Bubbles in Dense Beds. The Emulsion Phase in Dense Bubbling Beds. Flow Pattern of Gas through Fluidised Beds.

MODULE - II **15**

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.

Elutriation and Entrainment: TD and also distribution of solid in a fluidised bed. Circulation systems.

MODULE - III **15**

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.

11MH025 RISK ANALYSIS

3 0 0 3

Objective:

- To get awareness on the importance of Risk assessment. To understand the methodology of assessing and evaluating the risk.

MODULE - I **15**

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

MODULE - II **15**

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

MODULE - III **15**

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

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.

11MH026 MULTICOMPONENT DISTILLATION

3 0 0 3

Objective:

- To understand the multicomponent separation in Conventional distillation columns, Complex columns and system of columns
- To get exposed with tools like theta method of convergence Applicable to multicomponent separation analysis

MODULE – I **15**

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

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.

MODULE - II **15**

Conventional Distillation Columns: Formation, application and convergence characteristics of theta method of convergence, K_b Method, the constant – composition method.

Complex Columns and System of Columns: 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.

MODULE - III **15**

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.

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.

11MH027 PIPING, FLOW SHEETING, PROCESS AND INSTRUMENTATION DIAGRAMS

3 0 0 3

Objective:

To present process flow diagram and flow sheeting principles from a Chemical Engineering viewpoint. The Students will be well versed with the development of process flow diagram and control system and they apply for practical purpose. Main advantage will be to deal with application of process flow diagram in design stage. The study further provides a comprehensive exposition to theory and application of P & I D in HAZOPS and Risk analysis.

MODULE – I **15**

Flow Sheets: Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols, Process Flow Diagram- Synthesis of Steady State Flow sheet.

Process Flow Diagram: Flow sheeting software. P & I D objectives, guide rules, Symbols, Line numbering, Line Schedule.

MODULE - II **15**

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

Control System: Control System for Heater, Heat exchangers, reactors.

MODULE - III **15**

Control System and Applications of P & I D: Control System for dryers, Distillation Column, Expander.

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, 1991.
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.

11MH028 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

3 0 0 3

Objective: To present thermodynamic principles from a Chemical Engineering viewpoint. The Students will be well versed with the behavior of fluids under PVT conditions and also apply them for practical purpose. Main advantage will be to deal with power production and refrigeration processes. The study further provides a comprehensive exposition to theory and application of solution thermodynamics.

MODULE – I **15**

Basic Concepts and Applications of Thermodynamics to Flow Processes: Review of basic concepts, Laws of Thermodynamics, Chemical potential, Activity, Raoult's Law, Fugacities in gas mixtures- Viral equations of state

Solution Thermodynamics: Fugacities in liquid mixtures - ideal solutions, Compression processes, Duct flow of compressible fluids, Expanders, Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing processes.

MODULE - II **15**

Phase Equilibrium in Mixtures: Phase Equilibrium Criteria for single and Multi component System, Gamma/phi formulation of VLE, VLE from cubic equation of state, Equilibrium and stability,

Applications of Phase Equilibrium: Liquid-liquid equilibrium, Vapour-liquid-liquid equilibrium, Solid-liquid equilibrium, Solid-vapour equilibrium, Equilibrium adsorption of gases on solids, VLE by Molecular Simulation, Osmotic equilibrium and osmotic pressure.

MODULE - III **15**

Chemical Equilibrium and Thermodynamic Analysis of Steady-State Flow Processes: Chemical equilibrium criteria, Heterogeneous Chemical Reactions, Combined Chemical and Phase Equilibrium,

Applications of Chemical Reaction Equilibrium: The balance Equations for a tank-Type and Tubular Chemical Reactor, Multi reaction Equilibrium and Simultaneous reaction, Concept of ideal work, lost work, thermodynamics efficiency, availability.

TOTAL: 45

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.

11MH029 COMPUTATIONAL FLUID DYNAMICS FOR CHEMICAL ENGINEERING

3 0 0 3

Objectives:

On completion of the course the students are expected:

- To have an idea about various phenomena involved in the flow of fluids of low and high viscosities
- To know about various equations governing the flow patterns of fluids at different flow conditions
- To understand the patterns of three dimensional boundary layer flow and compressible viscous flow
- To become familiar with the preliminary computational techniques for various flow models

MODULE – I **15**

Fluid Dynamics, Governing Equations and Transformation Relationships: Advantages of Fluid dynamics, Typical Complex problem - complex geometry, simpler geometry, Preliminary computational Techniques - Discretisation, and approximation to derivatives and other related methods.

Equation of motion, evaluations of the transformations parameters - finite element evaluation finite volume evaluation grid generation by partial differential equation solution and algebraic mapping.

MODULE- II **15**

Boundary Layer Flow and Flow Governed by Reduced Navier Stroke Equations: Simple boundary layer flow-implicit scheme, LAMEL, Keller box scheme. Complex boundary layer flow - change of variables, Davis coupled scheme.

Introduction. Fourier analysis for qualitative solutions behaviour, order of magnitude analysis, THRED-Thermal entry problem. Internal flow-internal swirling flow, flow in straight rectangular duct. External Flow- supersonic flow, subsonic flow.

MODULE – III **15**

Three Dimensional Boundary Layer Flow Compressible Viscous Flow: three dimensional Boundary layer flows - Sub characteristic behavior, implicit split marching algorithm.

Introduction to compressible viscous flow - Physical Simplification-eddy viscosity turbulence modeling, thin layer approximation, Explicit scheme-explicit MacCormack scheme Implicit scheme- Implicit MacCormac scheme Groupe finite Element method.

TOTAL: 45

REFERENCE BOOKS

1. Fletcher C.A.J., "Computational Techniques for Fluid Dynamics", Volume I & II, Springer-Verlag, Berlin, 1991.
2. Thomasset F., "Implementation of Finite Element Method for Navioer-Stroke Equations", Springer-Verlag, Berlin, 1991.