KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

To be a centre of excellence for development and dissemination of knowledge in Chemical Engineering for the Nation and beyond

MISSION

Department of Chemical Engineering is committed to:

MS1: Impart knowledge to students at all levels through a vibrant, dynamic and state of the art intellectual delivery to ensure the creation of a complete Chemical Engineer with a high sense of social responsibility and professional ethics

MS2: Synergize the efforts of the students and faculty to evolve innovative engineering practices and teaching methodologies

MS3: Generate an environment of continuous learning and research

2018 REGULATIONS

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Post Graduates of Chemical Engineering will

PEO1: Take up professional assignments in design and development of advanced chemical engineering processes, products and equipment by engaging in lifelong learning and advanced research

PEO2: Develop viable solutions for real time problems in chemical process industries with a vision towards a sustainable future

PEO3: Exhibit their technical, soft and managerial skills to improve engineering practices for teaching and learning

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	2	3	3
MS2	2	2	2
MS3	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)

Engineering Post Graduates will be able to:

PO1: Carry out research /investigation and development work to solve practical problems

PO2: Write and present a substantial technical report/document

PO3: Understand the requirement of the industry and perform effectively with the managerial skills

PO4: Design and develop advanced chemical processes, products and equipments for the benefit of society through research and continuous learning efforts

PO5: Improvise and apply their knowledge in various frontiers of chemical engineering and evolve as a successful leader/ teacher / technocrat and scientist

MAPPING OF PEOs WITH POs AND PSOs

PEO\PO	PO1	PO2	PO3	PO4	PO5
PEO1	3	2	2	3	3
PEO2	1	2	3	3	3
PEO3	2	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

CURRICULUM BREAKDOWN STRUCTURE UNDER REGULATION 2018

Curriculum Breakdown System	Curriculum content (% of total number of credits of the program)	Total number of contact hours	Total number of credits
Program Core (PC)	47.22	540	34
Program Electives (PE)	25.00	270	18
Project(s)/Internships(PR)/Others	27.78	300	20
		Total credits	**72**

KEC R2018: SCHEDULING OF COURSES – MTech (Chemical)

Semes ter	Theory/ Theory cum Practical / Practical						Internship & Projects	Special Courses	Credits
	1	2	3	4	5	6	7	8	
I	18MHT11 Momentum Heat and Mass Transfer (PC-3-1-0-4)	18MHT12 Chemical Reaction Engineering and Reactor Dynamics (PC-3-1-0-4)	18MHT13 Chemical Process Design (PC-3-0-0-3)	18MHC11 Modeling in Chemical Engineering (PC-3-0-2-4)	18MHC12 Computer Control of Processes (PC-3-0-2-4)	18MHT14 Environmental Impact Assessment (PC-3-0-0-3)			22
II	18MHT21 Chemical Equipment Design (PC-3-1-0-4)	18MHC21 Advanced Mass Transfer Operations (PC-3-0-2-4)	18MHT22 Chemical Engineering Thermodynamics (PC-3-0-0-3)	Professional Elective - I (PE-3-0-0-3)	Professional Elective - II (PE-3-0-0-3)	Professional Elective - III (PE-3-0-0-3)	18MHP21 Mini Project (PR-0-0-4-2)		22
III	Professional Elective - IV (PE-3-0-0-3)	Professional Elective - V (PE-3-0-0-3)	Professional Elective - VI (PE-3-0-0-3)	18MHL31 Technical Analysis Laboratory (PR-0-0-2-1)			18MHP31 Project Work Phase I (PR-0-0-12-6)		16
IV							18MHP41 Project work Phase II (PR-0-0-24-12)		12

Total Credits: 72

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M.Tech. DEGREE IN CHEMICAL ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18MHT11	Momentum Heat and Mass Transfer	3	1	0	4	50	50	100	PC
18MHT12	Chemical Reaction Engineering and Reactor Dynamics	3	1	0	4	50	50	100	PC
18MHT13	Chemical Process Design	3	0	0	3	50	50	100	PC
18MHC11	Modeling in Chemical Engineering	3	0	2	4	50	50	100	PC
18MHC12	Computer Control of Processes	3	0	2	4	50	50	100	PC
18MHT14	Environmental Impact Assessment	3	0	0	3	50	50	100	PC
	Total				**22**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.Tech. DEGREE IN CHEMICAL ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18MHT21	Chemical Equipment Design	3	1	0	4	50	50	100	PC
18MHC21	Advanced Mass Transfer Operations	3	0	2	4	50	50	100	PC
18MHT22	Chemical Engineering Thermodynamics	3	0	0	3	50	50	100	PC
	Elective - I	3	0	0	3	50	50	100	PE
	Elective - II	3	0	0	3	50	50	100	PE
	Elective - III	3	0	0	3	50	50	100	PE
	Practical								
18MHP21	Mini Project	0	0	4	2	100	0	100	PR
	Total				**22**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.Tech. DEGREE IN CHEMICAL ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – III

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
	Elective - IV	3	0	0	3	50	50	100	PE
	Elective - V	3	0	0	3	50	50	100	PE
	Elective - VI	3	0	0	3	50	50	100	PE
	Practical								
18MHL31	Technical Analysis Laboratory	0	0	2	1	100	0	100	PC
18MHP31	Project Work Phase I	0	0	12	6	50	50	100	PR
	Total				**16**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.Tech. DEGREE IN CHEMICAL ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Practical								
18MHP41	Project Work Phase II	0	0	24	12	50	50	100	PR
	Total				**12**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

Total Credits: 72

LIST OF PROFESSIONAL ELECTIVES						
Course Code	Course Title	Hours/Week			Credit	CBS
		L	T	P		
SEMESTER II						
18MHE01	Advanced Fluidization Engineering	3	0	0	3	PE
18MHE02	Energy Management in Chemical Industries	3	0	0	3	PE
18MHE03	Project Engineering of Process Plants	3	0	0	3	PE
18MHE04	Advanced Separation Techniques	3	0	0	3	PE
18MHE05	Computational Fluid Dynamics	3	0	0	3	PE
18MHE06	Mixing Technology	3	0	0	3	PE
18MHE07	Process Instrumentation and Automation	3	0	0	3	PE
18MHE08	Process Intensification	3	0	0	3	PE
18MHE09	Risk Analysis	3	0	0	3	PE
SEMESTER III						
18MHE10	Chemical Product Design	3	0	0	3	PE
18MHE11	Process Optimization Techniques	3	0	0	3	PE
18MHE12	Bioprocess Engineering	3	0	0	3	PE
18MHE13	Multiphase Flow	3	0	0	3	PE
18MHE14	Piping Flow sheeting Process and Instrumentation Diagrams	3	0	0	3	PE
18MHE15	Industrial Wastewater Treatment	3	0	0	3	PE
18MHE16	Advanced Materials for Chemical Engineers	3	0	0	3	PE
18MHE17	Industrial Drying	3	0	0	3	PE
18MHE18	Design and Analysis of Experiments	3	0	0	3	PE

18MHT11 MOMENTUM, HEAT AND MASS TRANSFER

L	T	P	Credit
3	1	0	4

Preamble	This course provides the student with a vast knowledge about the transport of momentum mass and energy.
Prerequisites	Nil

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: Development of equations of change and solutions to momentum - Mass and heat transfer problems discussed under shell balance by applications of equation of change.

UNIT – IV **9**

Turbulent Flow: Comparison of laminar and turbulent flows - Time-smoothed equations of change for incompressible fluids - Time smoothed velocity - Temperature profile near a wall - Semi-Empirical Expressions for turbulent momentum, heat and mass flux.

UNIT – V **9**

Macroscopic Balance for Steady State System: Macroscopic momentum and mass balance - Overall energy and mechanical balance - Pressure rise and friction losses in sudden enlargement - Performance of a liquid-liquid ejector - Isothermal flow of a liquid through an orifice.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

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

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	understand the phenomena behind the transport of momentum, mass and energy from a first principles perspective and apply the shell balance approach to solve momentum transport problems	Applying (K3)
CO2:	apply the shell balance approach to solve energy and mass transport problems	Applying (K3)
CO3:	utilize equations of change to solve the transport problems	Applying (K3)
CO4:	apply the concept of Turbulent flow	Applying (K3)
CO5:	develop macroscopic balance for steady state system	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3			3	2
CO2	3			3	2
CO3	3			3	2
CO4	3			3	2
CO5	3			3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHT12 CHEMICAL REACTION ENGINEERING AND REACTOR DYNAMICS

L	T	P	Credit
3	1	0	4

Preamble	This course provides an overview about the exploitation of chemical reactions in commercial scale and gives vast understanding about the design and operations of chemical reactors
Prerequisites	Nil

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 - Inhibition.

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.

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 - Modeling diffusion with and without reaction - Construction and operation: Fixed bed Reactors.

UNIT – IV **9**

Fluidized Bed Reactors: Mass and Heat Transfer Correlations - Slurry bed Reactors: Mass Transfer Correlations - Effect of mass transfer on observed rate - Calculation of Global rate - Construction and operation: Fluidized bed Reactors - Surry reactors and Trickle bed reactor.

UNIT – V **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.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Smith J.M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw-Hill, New York, 1981.
2. Fogler H.S., “Elements of Chemical Reaction Engineering”, 4th Edition, Prentice Hall of India, New Delhi, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	demonstrate the preparation of different types of catalysts	Applying (K3)
CO2:	explain the isotherm concepts and analyze the rate controlling mechanism	Analyzing (K4)
CO3:	analyze various models used for heterogeneous reactors	Analyzing (K4)
CO4:	compare the different rate controlling mechanisms in reactor design	Analyzing (K5)
CO5:	design catalytic and multi-phase reactors	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1		1
CO2	2	1	2		
CO3	2	1		1	
CO4	1			3	1
CO5	2			3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHT13 CHEMICAL PROCESS DESIGN

L	T	P	Credit
3	0	0	3

Preamble	This course provides knowledge in selection of a series of processing steps and their interconnection in a flow sheet. It enables the students to make decisions during development of process design.
Prerequisites	Nil

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.

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 - Reaction - Separation and recycle 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 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

REFERENCES:

1. Robin Smith, “Chemical Process Design and Integration”, Wiley India Pvt. Ltd., 2005.
2. Douglas J.M., “Conceptual Design of Chemical Processes”, 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”, 2^{nd} Edition, John Wiley & Sons Inc., 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	explain the fundamentals of chemical process design and apply the approaches to process design	Applying (K3)
CO2:	choose and synthesize reactors	Applying (K3)
CO3:	select separators and synthesize reactor-separation systems	Applying (K3)
CO4:	perform distillation sequencing with thermal coupling	Applying (K3)
CO5:	analyze the performance of heat exchanger network based on energy and capital cost targets	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	3	3
CO2	3	1	2	3	2
CO3	2	1	2	3	2
CO4	3	1	3	2	2
CO5	3	1	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHC11 MODELING IN CHEMICAL ENGINEERING

L	T	P	Credit
3	0	2	4

Preamble	This course makes the students knowledgeable in different aspects of modeling chemical process systems & familiarizes with the numerical simulation of models in fluid flow operations, separation processes and reactors. They will also acquire knowledge on the fundamental concepts of recent techniques in process simulation.
Prerequisites	Nil

UNIT – I **9**

Introduction to Fundamentals of Process Modeling: Introduction - Physical modeling - Mathematical modeling and its classification - Chemical systems modeling - Principles of formulation - Representation of a model - Model building - Boundary conditions - Black box principles - Fundamental laws used in modeling: Continuity equations - Energy equation - Equation of Motion - Transport equations - Equations of state - Equilibrium relations - Chemical kinetics.

UNIT – II **9**

Models in Fluid Flow Operations: The process and the model aspects of : Mixed vessel,laminar flow in pipe, Gravity flow tank, Cone shaped tank, Mixing tank, Stirred tank heater, Two stirred tank heaters, Interacting stirred tank heaters, Interacting and Non-interacting tanks, Agitated tank for solid dissolution

UNIT – III **9**

Mathematical Modeling of Reactors: The Process and the model aspects of Batch reactor, Tubular reactor, Jacketed tubular reactor, CSTR, CSTR with cooling jacket, Two CSTRs, Series of CSTR – three CSTRs, constant and variable holdup, CSTR – isothermal and non-isothermal, Continuous stirred tank bioreactor.

UNIT – IV **9**

Models in Separation Processes: Mathematical model aspects of Multi component flash drum - Single component vaporizer - Refinery debutanizer column - Ideal binary distillation column - Binary continuous distillation column - Gas liquid bubble reactor - Solvent extraction - Steady state single stage and two stage - Absorption column - Triple effect evaporator - Forward and backward feed - Double pipe heat exchanger.

UNIT – V **9**

Process Simulation: Process Simulation - Scope - Formulation of a problem - Steps in Steady state simulation - Simulation approach for steady state process - Process Simulator - Organization and structure - HYSYS: Integrated simulation environment - Products, intuitive and interactive process modeling - Open and extensible HYSYS architecture - ASPEN PLUS: Unit operation models - Selection of EOS - Introduction to Artificial Neural Network – Training, modes and applications.

List of Experiments:

1. Analysis of Physical Properties and Thermodynamic Equilibrium Diagram Construction
2. Estimation of physical property for a non data bank component
3. Simulation of heat exchanger using ASPEN PLUS by short cut and detailed method
4. Simulation of Mixer and Flash separator
5. Simulation of RCSTR Model
6. Simulation of RPLUG Model
7. Simulation of Distillation Column
8. Simulation and analysis of absorption/extraction column
9. Sensitivity analysis and optimization of parameters
10. Simulation of simple flow sheet problems

Lecture: 45, Practical: 30, Total: 75

REFERENCES:

1.	Babu B.V., "Process Plant Simulation", Oxford University Press, New Delhi, 2004.
2.	Luyben W.L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Edition, McGraw Hill Book Company, New York, 1990.
3.	Amiya K. Jana, "Chemical Process Modeling and Computer Simulation", Prentice Hall of India, 2017.
4.	Gaikwad R.W. and Dhirendra, "Process Modeling and Simulation", 2nd Edition, Denett and Company, Nagpur, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the concepts of various mathematical models and fundamentals laws	Applying (K3)
CO2:	develop mathematical models for various chemical systems	Analyzing (K4)
CO3:	develop mathematical models for various types of reactors	Analyzing (K4)
CO4:	build up mathematical models for distillation and separation columns	Applying (K3)
CO5:	apply the concepts of simulations and novel techniques to simulate complex systems	Applying (K3)
CO6:	estimate the unknown physical properties and analyze them	Applying (K3), Imitation (S1)
CO7:	perform the simulation of heat and mass transfer equipment	Applying (K3), Manipulation (S2)
CO8:	perform the simulation of reactors and carry out sensitivity analysis	Applying (K3), Manipulation (S2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		2	2	2
CO2	2		1	3	2
CO3	2		1	3	2
CO4	1		1	3	2
CO5				3	3
CO6	2		1	3	1
CO7	2		1	3	1
CO8	2		1	3	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHC12 COMPUTER CONTROL OF PROCESSES

L	T	P	Credit
3	0	2	4

Preamble	This course enables the students to acquire basic knowledge in recent control strategies of chemical processes, proper input - output pairing for multiple single input - single output controllers and gain exposure on process control with digital computers.
Prerequisites	Nil

UNIT – I **9**

Advanced Control Strategies: Advanced control loops - Cascade, split range and selective control - Feed forward and Ratio control - Adaptive and inferential control.

UNIT – II **9**

Internal Model Control: Model based control - Development and design of IMC structure - IMC based PID controller for stable and unstable process - Model Predictive Control - Dynamic matrix control - Constraints and multivariable systems.

UNIT – III **9**

Multivariable Control: MIMO systems - Control loop interaction - General pairing problem - Relative gain array and application - 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 - Stability analysis of discrete time system.

UNIT – V **9**

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

List of Experiments:

1. Feed Forward Control System
2. Ratio Controller
3. Temperature Control Loop
4. Pressure Control Loop
5. Level Control Loop
6. Flow Control Loop
7. Interacting & Non Interacting System
8. Stability analysis of control system
9. Tuning of Controller
10. SIMULINK Using MATLAB

Lecture:45, Practical:30, Total: 75

REFERENCES:

1. Stephanopoulos G., "Chemical Process Control: An Introduction to Theory and Practice", 1st Edition, Prentice Hall of India, New Delhi, 2015.
2. Wayne Bequette B., "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, New Delhi, 2012.
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		**BT Mapped (Highest Level)**
CO1:	apply the different control configuration for chemical process	Applying (K3)
CO2:	exhibit the model based control for a system	Applying (K3)
CO3:	apply the knowledge for controlling MIMO system and analyze the sensitivity	Analyzing (K4)
CO4:	apply the principles of Z transform for solving discrete systems	Applying (K3)
CO5:	perform the stability of closed loop system and understand the design of digital feedback controller	Evaluating (K5)
CO6:	estimate the control parameters in interacting and non-interacting tanks	Applying (K3), Manipulation (S2)
CO7:	perform experiments on various control loops and analyze their stability	Applying (K3), Manipulation (S2)
CO8:	execute the tuning of controllers and perform the simulation of control loops	Applying (K3), Manipulation (S2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		1	2	2
CO2	2		2	2	2
CO3	3	1	2	3	3
CO4	1			2	2
CO5	2	1	2	3	3
CO6	1			1	1
CO7	2		1	1	1
CO8	2		1	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHT14 ENVIRONMENTAL IMPACT ASSESSMENT

L	T	P	Credit
3	0	0	3

Preamble	This course outlines the means to verify environmental impacts are within predicted or permitted limits and also acquire knowledge on how to take actions to manage unanticipated impacts and unforeseen changes.
Prerequisites	Nil

UNIT – I **9**

Basics of EIA: Introduction to EIA Audit of Environment and 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 and acts: Constitution of India and Environment - Constitution protection to Environment laws - Administrative and legislative arrangement for Environmental production - Indian Standards.

Total: 45

REFERENCES:

1. Canter Larry W., "Environment Impact Assessment", 2nd 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		**BT Mapped (Highest Level)**
CO1:	apply the concept of EIA and management planning for a process industry	Applying (K3)
CO2:	examine the role of EIA on economic growth and the impacts of wastes on water bodies	Analyzing (K4)
CO3:	demonstrate the role of different agencies on EIA	Applying (K3)
CO4:	categorize the concept of audit program for different polluting industries	Analyzing (K4)
CO5:	employ different laws to prevent and control pollution in environment	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1		3		
CO2	1		3		
CO3	1		3		
CO4	1	2	3		
CO5	1		3		

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHT21 CHEMICAL EQUIPMENT DESIGN

L	T	P	Credit
3	1	0	4

Preamble	This course provides a basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment like pressure vessel, heat exchangers, distillation column, absorption column, extractor, crystallizer, cooling tower and dryers. The concepts and skills learnt in process calculations, thermodynamics, momentum transfer, mass transfer and heat transfer will be utilized.
Pre-requisites	Nil

UNIT – I **9**

Design of Pressure Vessel: Introduction- pressure vessel codes and standards- Fundamental principles and equations, Failure mode in pressure vessel. Design of pressure vessels under combined loading and high pressure. Design of storage vessel.

UNIT – II **9**

Design of Heat Transfer Equipment: Process design of Shell and tube heat exchanger, double pipe heat exchanger – estimation of individual and overall heat transfer coefficient, estimation of pressure drop. Design of single effect evaporator – calculation of steam requirement and heat transfer area.

UNIT – III **9**

Design of Mass Transfer Equipment: Design of distillation column- Determination of number of stages, column diameter and height – McCabe Thiele and Ponchon Savarit method. Design of absorption column – Calculation of diameter and height, Absorption factor – estimation of number of plates required.

UNIT – IV **9**

Design of Extractor and Crystallizer: Extractor - Industrial applications of liquid-liquid extraction, choice of solvent, equipment used for liquid-liquid extraction, process design of counter current multistage extractor – steps involved in determination of number of stages. Design of crystallizers – Determination of length and number of sections.

UNIT – V **9**

Design of Miscellaneous Equipment: Design of cooling tower - Calculation of HTU, NTU, Height and diameter. Design of Reboiler – Typical design procedure for thermosyphon reboiler and estimation of various parameters. Design of dryers – Design of rotary dryer – Estimation of length and diameter, Design of fluid bed dryer – calculation of diameter of distributor grid and disengagement zone.

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1. Sinnott Ray and Towler Gavin, "Coulson and Richardson's Chemical Engineering Series Chemical Engineering Design", 5th Edition, Volume 6, 2013.
2. Kern D.Q., "Process Heat Transfer", International Student Edition, McGraw Hill, 2002.
3. Mahajani V.V. and Umarji S.B., Joshi's "Process Equipment Design", 4th Edition, Macmillan Publishers India Ltd., New Delhi, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	determine the plate thickness and various stress analysis of vessels under combined loading and high pressure	Applying (K3)
CO2:	solve and find the design parameters of shell and tube, double pipe heat exchangers and estimate the steam requirement and heat transfer area for a single effect evaporator	Applying (K3)
CO3:	design distillation column using McCabe thiele and Ponchon Savarit methods and estimate the diameter, height of absorption column	Applying (K3)
CO4:	analyze the concepts involved in liquid-liquid extraction process and its industrial applications, estimating the number of stages and designing of crystallizers	Analyzing (K4)
CO5:	examine the process of design of cooling towers, rotary and fluid bed dryers	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1			3	
CO2	1			3	
CO3	1			3	
CO4	1			3	
CO5	1			3	

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHC21 ADVANCED MASS TRANSFER OPERATIONS

L	T	P	Credit
3	0	2	4

Preamble	This course provides an understanding of the multicomponent separation in Conventional distillation columns, Complex columns and system of columns and provides an exposure to multicomponent separation analysis.
Prerequisites	Nil

UNIT – I — 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 – II — 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 – III — 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 – IV — 9

Liquid-liquid Extraction: Stage wise calculations for multi component with multiple feed streams using reflux and mixed solvents. Liquid-liquid extraction with chemical reaction

UNIT – V — 9

Multi Component Gas Absorption: Horton-Franklin method, Edmister method. Mass transfer in gas absorption with and without chemical reaction, model solutions by Dankwerts, Brian, Perry and Pigford.

List of Experiments:

1. Determination of the activity coefficients and Van Laar constant for the given system by performing VLE experiments
2. Estimation of Height Equivalent to a Theoretical Plate and find out % recovery of the overhead and bottom products of given system under total reflux conditions
3. Determination of vaporization efficiency (Ev) and Thermal efficiency (Et) of the given system using steam distillation apparatus
4. Determination of the diffusivity of the given liquid to air
5. Verifying the Raleigh‘s equation for the given system using simple distillation setup
6. Conduction of Simple Leaching studies
7. Conduction of liquid-liquid extraction studies and plot binodal curve for the given ternary system
8. Studying the concept of surface evaporation and finding the constants of Himus Equation
9. Estimation of Mass transfer co-efficient using Wetted wall column
10. Estimation of Mass transfer co-efficient using packed absorption column

Lecture :45, Practical:30, Total: 75

REFERENCES:

1. Dutta B.K., “Principles of Mass Transfer and Separation Processes”, Prentice Hall India Learning Pvt. Ltd., 2009**.**
2. Treybal Robert E., “Mass Transfer Operations”, 3rd Edition, McGraw-Hill Book Company, 1980.
3. Ross Taylor R. Krishna, “Multicomponent Mass Transfer”, Wiley Series in Chemical Engineering, John Wiley & Sons, New York, 1993.
4. Holland, Charles Donald, “Fundamentals of Multicomponent Distillation”, McGraw-Hill, New York, 1997.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	calculate VLE data and enthalpies for multicomponent mixtures	Applying (K3)
CO2:	perform calculations in Multi component distillation	Applying (K3)
CO3:	perform design calculations for distillation with chemical reaction and systems forming azeotropes	Applying (K3)
CO4:	solve problems in multi component with multiple feed streams in Liquid-liquid extraction	Applying (K3)
CO5:	solve problems for multi component gas absorption	Applying (K3)
CO6:	evaluate the performance of drying, humidification and evaporation equipment	Evaluating (K5), Manipulation (S2)
CO7:	generate VLE and LLE data for different systems and analyze them	Analyzing (K4), Precision (S3)
CO8:	assess the performance of simple/packed/steam distillation units	Analyzing (K4), Manipulation (S2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2			3	2
CO2	2			3	2
CO3	2			3	2
CO4	2			3	2
CO5	2			3	2
CO6	2		1	2	1
CO7	2		1	2	1
CO8	2		1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHT22 CHEMICAL ENGINEERING THERMODYNAMICS

L	T	P	Credit
3	0	0	3

Preamble	This course presents the laws of thermodynamics and their applications in process industries
Prerequisites	Nil

UNIT – I **9**

Laws of Thermodynamics: Basic concepts; first law of thermodynamics - applications to closed and open systems; second law of thermodynamics; Carnot theorem; applications of second law to the feasibility analysis of devices and processes; evaluation of entropy change - mixing and separation of gases, mixing and separation of liquids, heating and cooling of process fluids.

UNIT – II **9**

Properties of Solutions: Molar properties and partial molar properties; methods for determination of partial molar properties; ideal and non-ideal solutions; Gibbs-Duhem equation; mixing of liquids - volume change, enthalpy change, Gibbs free energy change.

UNIT – III **9**

Phase Equilibrium: Vapour-liquid equilibrium; fugacity and fugacity coefficient; activity and activity coefficient; Raoult's law; modified Raoult's law; phase diagram of binary system; models for excess Gibbs free energy - Margules two-suffix equation, Van Laar equation, Wilson equation; criterion for equilibrium between phases in multi-component non-reacting system in terms of chemical potential and fugacity; thermodynamic consistency test of VLE data.

UNIT – IV **9**

Chemical Reaction Equilibrium: Thermodynamic analysis of chemical reactions – single reactions, simultaneous parallel reactions, prediction of equilibrium composition of reaction mixture; homogeneous gas phase reactions; homogeneous liquid phase reactions; standard Gibbs free energy change and reaction equilibrium constant; evaluation of standard free energy change; evaluation of equilibrium constant.

UNIT – V **9**

Refrigeration and Liquefaction: Refrigeration principles; Carnot refrigeration cycle; methods of refrigeration – vapour compression refrigeration, absorption refrigeration; evaluation of COP and capacity of refrigeration cycles; air refrigeration; refrigerants for low temperature refrigeration; ozone depletion potential of refrigerants; liquefaction of gases; methods for liquefaction of gases – Claude liquefaction process; Linde liquefaction process.

Total: 45

REFERENCES:

1. Smith J.M., Van Ness H.C., Abbott M.M., Swihart M.T., "Introduction to Chemical Engineering Thermodynamics", 8th Edition, McGraw-Hill Education, 2017.
2. Kyle B.G., "Chemical and Process Thermodynamics", 3rd Edition, Pearson Education India, 2015.
3. Tassios D.P., "Applied Chemical Engineering Thermodynamics", Springer-Verlag, Berlin Heidelberg GmbH, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the laws of thermodynamics to engineering systems	Applying (K3)
CO2:	evaluate the partial molar properties and molar properties of solutions	Evaluating (K5)
CO3:	apply phase equilibrium concepts in the fields of separation of systems involving vapour and liquid, and test the thermodynamic consistency of experimental VLE data	Applying (K3)
CO4:	analyze the homogeneous chemical reactions and predict the equilibrium composition	Analyzing (K5)
CO5:	evaluate the performance of refrigeration and liquefaction processes	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	1	1
CO2	3	1		1	1
CO3	3	1		2	1
CO4	3	1		1	1
CO5	3	1		1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHL31 TECHNICAL ANALYSIS LABORATORY

L	T	P	Credit
0	**0**	**2**	**1**

Preamble	This course covers a variety of methods of analysis in chemical instrumentation used to determine experimentally the various properties of the Waste water, Polymers, chemicals etc.
Prerequisites	Nil

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 wastewater.
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 solid and liquid samples.
11. Atomic Absorption Spectroscopic Analysis of heavy metals in Industrial Wastewater.
12. Infrared (IR) spectroscopic analysis of Organic compounds.

Total: 30

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	understand the principles of instrumental analysis and determine physical, chemical and biological properties of waste water	Applying (K3), Imitation (S1)
CO2:	estimate the physical and chemical properties of organic compounds using various instrumental analyses	Evaluating (K5), Manipulation (S2)
CO3:	examine the kinetics and mechanism of chemical reactions	Analyzing (K4), Imitation (S1)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2	2		2	1
CO2	2	2		2	1
CO3	3	2		2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE01 ADVANCED FLUIDIZATION ENGINEERING		
		L: 3, T: 0, P: 0, Credit: 3
Preamble:	This course provides an overview about the fluidization phenomena and technology. It gives vast knowledge about flow regimes, hydrodynamics of bubbling, turbulent, fast fluidized beds and pneumatic conveying.	
Prerequisites:	Nil	
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 of 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: Heat and Mass 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 distribution of solids 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

REFERENCES:

1.	Kunii Diazo and Levenspiel O., “Fluidization Engineering”, 2nd 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		**BT Mapped (Highest Level)**
CO1:	survey various applications of fluidized beds in industries	Analyzing (K4)
CO2:	explain the types of fluidization, fluidizing regimes and develop model for gas flow	Applying (K3)
CO3:	describe the concept of heat and mass transfer between fluid and solid and determine the design parameters	Applying (K3)
CO4:	analyze the solid flow distribution in circulation systems	Analyzing (K4)
CO5:	design fluidization columns for physical operations and reactions	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1		1
CO2	2	2	2		
CO3	1	2	2	1	
CO4	1	2	2	2	1
CO5		1	1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE02 ENERGY MANAGEMENT IN CHEMICAL INDUSTRIES

L	T	P	Credit
3	0	0	3

Preamble:	This course gives a broad overview about renewable and non-renewable energy resources, energy consumption, planning, energy audit and optimization. It also outlines the need for energy recovery and heat recovery techniques.
Prerequisites:	Nil

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

REFERENCES:

1. Twidell John and Weir Tony, "Renewable Energy Sources", 2nd 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		**BT Mapped (Highest Level)**
CO1:	employ the knowledge about various energy resources and their depletion	Applying (K3)
CO2:	compute the efficiency and socio-economic factor in conventional power generation systems	Applying (K3)
CO3:	describe the importance of harnessing energy from alternative resources and criticize the issues and challenges involved	Analyzing (K4)
CO4:	monitor the energy consumption patterns and perform energy audit to ensure efficient utilization of energy	Applying (K3)
CO5:	develop heat exchangers to avoid waste heat	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1		1
CO2	2	2	2		
CO3	1	2	2	1	
CO4	1	2	2	2	1
CO5		1	1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE03 PROJECT ENGINEERING OF PROCESS PLANTS

L	T	P	Credit
3	0	0	3

Preamble:	This course introduces 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
Prerequisites:	Nil

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, Decommissioning, 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

REFERENCES:

1. Peters M.S. and Timmerhaus K.D., "Plant Design and Economics for Chemical Engineers", McGraw Hill (ISE), 2002.
2. Clements T. and Gido L., "Effective Project Management", Thomson Education Press, New Delhi, 2007.
3. Pathi P.K., "Labour and Industrial Laws", 2nd Edition, Prentice Hall India, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the concepts in project engineering and management	Applying (K3)
CO2:	perform balance sheets, process feasibility analysis and network diagrams	Applying (K3)
CO3:	explain plant engineering management, plant location and layout and select equipment and machineries for process industries	Applying (K3)
CO4:	analyze the projects using cash flow, break-even analysis and acquire knowledge in project financing	Analyzing (K4)
CO5:	apply the legal aspects of business enterprises	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	1	1
CO2	1	2	3	1	1
CO3	1	2	3	1	1
CO4	1	2	3	1	1
CO5	1	2	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE04 ADVANCED SEPARATION TECHNIQUES

L	T	P	Credit
3	0	0	3

Preamble:	This course highlights the recent advancements in separation techniques and provides an exposure with the selection criteria of membrane materials, adsorbents, etc.
Prerequisites:	Nil

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

REFERENCES:

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		**BT Mapped (Highest Level)**
CO1:	apply the recent developments in separation techniques	Applying (K3)
CO2:	analyze various membrane modules and their uses	Analyzing (K4)
CO3:	apply membrane processes for various applications	Applying (K3)
CO4:	apply adsorption and ionic separation processes	Applying (K3)
CO5:	make use of advanced separation methods for various applications	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		1	2	2
CO2	2		1	2	2
CO3	2		1	2	2
CO4	2		1	2	2
CO5	2		1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE05 COMPUTATIONAL FLUID DYNAMICS

(Common to Chemical Engineering and Food Technology branches)

L	T	P	Credit
3	0	0	3

Preamble:	With the advent of high speed computing, CFD has become an integral part of engineering design, simulation and performance analysis. This course deals with the fundamentals of CFD, grid generation, meshing and solution techniques using Finite Volume Method.
Prerequisites:	Nil

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 behavior.

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 discretization 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 – QUICK scheme.

UNIT – III **9**

Solution Algorithms for Pressure-Velocity Coupling in Steady Flows: Staggered grid, momentum equations, SIMPLE algorithm, assembly of a complete method, SIMPLER, SIMPLEC, and PISO algorithms; Solution of discretised equations: tri-diagonal matrix algorithm, application of TDMA to two-dimensional and three-dimensional problems.

UNIT – IV **9**

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

UNIT – V **9**

Turbulence and its Modeling: Transition from laminar to turbulent flow, effect of turbulence on properties of the mean flow, Reynolds-averaged Navier-Stokes equations and classical turbulence models, mixing length model, k-ε model, Reynolds Stress model and Algebraic Stress model.

Total: 45

REFERENCES:

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

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the knowledge of C.F.D techniques in developing fluid flow models	Applying (K3)
CO2:	apply finite volume method for developing solution of steady state diffusion and convection diffusion problems	Applying (K3)
CO3:	demonstrate the application of SIMPLER, SIMPLEC and PISO algorithms for solution of industrial and R & D problems	Analyzing (K4)
CO4:	apply the knowledge of algorithms in solving unsteady flow heat conduction and convection diffusion processes	Applying (K3)
CO5:	demonstrate the application of turbulent flows and models in simulation packages	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		1	2	2
CO2	2		2	3	3
CO3	2		1	3	3
CO4	2		2	3	3
CO5	1		1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE06 MIXING TECHNOLOGY

L	T	P	Credit
3	0	0	3

Preamble:	This course gives a vast knowledge about the importance of mixing in process industries and technical aspects of mixing
Prerequisites:	Nil

UNIT – I **9**

Introduction: Agitation and mixing, Impeller types and 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: Dispersion in mass transfer, Measurement of physical properties of fluid dispersion, 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

REFERENCES:

1. Uhl V.W. and Gray J.B., “Mixing Theory and Practice”, Volume I, II & III, Academic Press Inc., 1966.
2. James Y. Oldshue, “Fluid Mixing Technology”, McGraw Hill, 1983.
3. Shinji Nagata, “Mixing Principles and Applications”, John Wiley & Sons Inc., 1975.
4. Gay B. Tatterson, “Fluid Mixing and Gas Dispersion in Agitated Tank”, McGraw Hill, 1997.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	explain the fundamentals of mixing process and develop power correlation	Applying (K3)
CO2:	describe flow patterns in various agitation and mixing operations and develop flow regimes	Applying (K3)
CO3:	familiarize mass transfer characteristics of mixing ana analyzing fluid dispersion	Analyzing (K4)
CO4:	analyze solid suspension of mixing vessels	Analyzing (K4)
CO5:	apply the scale up methods for agitation and mixing equipment	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1			2	2
CO2	1			2	2
CO3	3			3	3
CO4	3			3	3
CO5	3		2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE07 PROCESS INSTRUMENTATION AND AUTOMATION

L	T	P	Credit
3	0	0	3

Preamble:	The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants. Also to make the students understand the fundamentals of instruments for measuring temperature, pressure, flow, level, etc. The primary objective of this course is to provide knowledge about the fundamentals of automation and various automation systems used in industry such as PLC, DCS and SCADA.
Prerequisites:	Nil

UNIT – I **9**

Instrumentation: 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

REFERENCES:

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.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	employ the concept of measurement systems, automation and advanced control strategies	Applying (K3)
CO2:	assess the methods of controller tuning	Evaluating (K5)
CO3:	analyze the knowledge in selection of DCS	Analyzing (K4)
CO4:	inspect the concepts of PLC and its applications	Analyzing (K4)
CO5:	utilize the principles of SCADA and its protocols	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1			1	3	
CO2	1		1	3	
CO3			1	3	
CO4			1	3	
CO5	1		1	3	

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE08 PROCESS INTENSIFICATION

L	T	P	Credit
3	0	0	3

Preamble	Process Intensification is a collective term which refers to cutting edge technologies implicated to improve the performance of a chemical industry. This course throws light upon various intensification techniques and their applications
Prerequisites	Nil

UNIT – I **9**

Overview of Intensification and Miniaturized Equipment: Introduction - Philosophy, opportunities and merits of Process Intensification; Miniaturization – effects of miniaturized equipment, Implementation of micro systems, Pitfalls and Solutions.

UNIT – II **9**

Intensification of Mixing Operation: Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Principle and applications of High - Gravity Fields Atomizer, Ultra sound Atomization, Nebulizers, High intensity inline Mixers, Static mixers, Ejectors, Tee mixers, Rotor stator mixers, Higee reactors.

UNIT – III **9**

Intensification of Heat Transfer Operations: Compact heat exchangers – Classifications, Heat transfer and Pressure drop in Plate, Spiral and micro channel Heat exchangers, Finned heat exchangers, Phase change heat exchangers, Regenerative heat exchangers for energy conservation, Selection of heat exchanger technology.

UNIT – IV **9**

Process Integration: Combined systems: Integration of heat exchangers in separation systems, Principle and applications of Reactive absorption, Reactive distillation and Reactive Extraction.

UNIT – V **9**

Advanced Fields: Intensification for energy conservation; Sono-chemical systems- Cavitation reactors, Sono-crystallization; Microwave assisted processes, Supercritical fluids in chemical processes.

Total: 45

REFERENCES:

1. Stankiewicz A. and Moulijn, “Reengineering the Chemical Process Plants, Process Intensification”, Marcel Dekker, 2003.
2. Reay D, Ramshaw C, Harvey A., “Process Intensification”, 2nd Edition, Butterworth Heinemann, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	apply the philosophy of process intensification in mini and micro systems	Applying (K3)
CO2:	make use of novel mixers to improve mixing operations	Applying (K3)
CO3:	employ compact heat exchanger and study the conservation of energy in them	Applying (K3)
CO4:	apply the concepts of process integration in separation systems	Applying (K3)
CO5:	attribute the role of ultra sound and microwave assisted processes	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		3	2	2
CO2	2		3	2	2
CO3	2		3	2	2
CO4	1		3	3	3
CO5	2		3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE09 RISK ANALYSIS

L	T	P	Credit
3	0	0	3

Preamble:	This course provides an awareness on the importance of risk assessment and enables the students to understand the methodology of assessing and evaluating risk.
Prerequisites:	Nil

UNIT – I **9**

Introduction: Industrial accidents; accident costs; identification of accident spots; remedial measures; identification and analysis of causes of injury to men and machines; accident prevention; accident proneness; vocational guidance, Fire prevention and fire protection.

UNIT – II **9**

Risk Assessment: Risk methodologies and assessment steps; quantitative risk assessment, rapid risk analysis; comprehensive risk analysis; identification, Probability theory, Interaction between process units, Revealed and Unrevealed failures, Probability of coincidence, Application to chemical process problems.

UNIT – III **9**

Process Safety Analysis and Risk Management: HAZOP, HAZAN, FAULT Tree Analysis. Safety system followed in Ammonia plants, refineries, power plants. Elements of a risk management program, risk assessment and risk management; Relief concepts, Location of relief, Relief types, Relief scenarios, Data for sizing reliefs, Relief systems.

UNIT – IV **9**

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

UNIT – V **9**

Case Studies: Flixborough accident, Bhopal accident, Seveso accident, Binhai,-Tianjin China, Gazipur, Bangladesh and Kaohsiung gas explosions

Total: 45

REFERENCES:

1. Bahr Nicholas J., “System Safety Engineering and Risk Assessment: A Practical Approach”, 1st 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		BT Mapped (Highest Level)
CO1:	demonstrate the awareness on the importance of Risk assessment	Applying (K3)
CO2:	apply the methodology of risk assessment	Applying (K3)
CO3:	analyze the safety in various processes	Analyzing (K4)
CO4:	analyze and evaluate the risk and safety costs	Analyzing (K4)
CO5:	survey various accidents and analyze the risks	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1		
CO2	2	3			
CO3	3	2			
CO4	2	2			
CO5	3	3			

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE10 CHEMICAL PRODUCT DESIGN

L	T	P	Credit
3	0	0	3

Preamble	This course provides understanding of changes in chemical industry and how these changes affect employment.
Prerequisites	Nil

UNIT – I **9**

Needs and Specifications: Customer needs, Consumer Products, Converting needs to specifications, 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 property, Collection of missing information, Final specifications, Development of Microstructured products, Device manufacture and Related approach strategy

UNIT – V **9**

Speciality Chemical Manufacture and Economic Considerations: First steps toward production, Separation, Specialty Scale - up. Product versus Process design, Process Economics, Economics for products.

Total: 45

REFERENCES:

1. Cussler E.L. and Moggridge G.D., "Chemical Product Design", Cambridge University Press, 2001.
2. Richard Turton and Richard C. Bailie, "Analysis, Synthesis and Design of Chemical Processes", Prentice Hall, New Jersey, 2003.
3. Stanley M. Walas, "Chemical Process Equipment Selection and Design", Butterworth-Heinemann Publishers, 2001.

Course Outcomes: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	describe the specifications for product design	Understanding (K2)
CO2:	generate, sort and screen product design ideas	Analyzing (K4)
CO3:	apply thermodynamic and kinetic knowledge for the selection of products	Applying (K3)
CO4:	apply device manufacturing strategies to quantify and meet out the specifications	Applying (K3)
CO5:	perform economic analysis of chemical product design	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	3	3
CO2	3	1	2	3	2
CO3	2	1	2	3	2
CO4	3	1	3	2	2
CO5	3	1	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE11 PROCESS OPTIMIZATION TECHNIQUES

L	T	P	Credit
3	0	0	3

Preamble	Optimization is an integral part in design and operation of a process industry. This course provides knowledge about the fundamentals of optimization techniques and its applications in process industries.
Prerequisites	Nil

UNIT – I **9**

Basic Concepts of Optimization: Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, types of optimization problems.

UNIT – II **9**

Non-linear Unconstrained Optimization: Convex and concave functions unconstrained NLP, Scanning and bracketing procedures, Newton's method, Quasi-Newton's method.

UNIT – II **9**

Non-linear Constrained and Multi-Objective Optimization: Direct substitution, Quadratic programming, Penalty, Barrier and Augmented Lagrangian Methods, weighted Sum of Squares method, Epsilon constraint method and Goal attainment.

UNIT – IV **9**

Linear Programming and Dynamic Programming: Simplex method, Barrier method, sensitivity analysis, Introduction to integer and mixed integer programming.

UNIT – V **9**

Applications of Optimization in Chemical Engineering: Heat transfer and energy conservation, separation processes and chemical reactor design and operation

Total: 45

REFERENCES:

1. Edgar T.F., Himmelblau D.M. and Ladson L.S., "Optimization of Chemical Processes", 2nd Edition, McGraw Hill, New York, 2003.
2. Diwaker U.W., "Introduction to Applied Optimization", 2nd Edition, Springer, 2003.
3. Rao S.S., "Engineering Optimization: Theory and Practice", 4th Edition, New Age Publishers, 2011.

Course Outcomes: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	develop mathematical model of chemical engineering problems	Applying (K3)
CO2:	apply the optimization principles to solve non- linear unconstrained problems	Applying (K3)
CO3:	solve non- linear constrained and multi objective optimization problems	Applying (K3)
CO4:	utilize linear and dynamic programming techniques and perform sensitivity analysis	Applying (K3)
CO5:	perform optimization techniques in chemical engineering systems	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		3	2	2
CO2	2		3	2	2
CO3	2		3	2	2
CO4	1		3	3	3
CO5	2		3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE12 BIOPROCESS ENGINEERING

L	T	P	Credit
3	0	0	3

Preamble	This course provides application of engineering principles to biological processes, to achieve commercial success in designing biochemical reactor with proper knowledge in enzyme engineering
Pre-requisites	Nil

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, Sterilization of fermenter. Fermentation: Medium requirements, Application of fermentation process, Types of fermentation process –aerobic and anaerobic, solid state and submerged fermentation.

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, Introduction to Scale up of bioreactors, criteria for selection of bioreactors

Total: 45

REFERENCES:

1. Rao D.G., "Introduction to Biochemical Engineering", 2nd Edition, Tata McGraw-Hill, New Delhi, 2010.
2. Bailey J. E. and Ollis D.F., "Biochemical Engineering Fundamentals", 2nd Edition, Tata McGraw-Hill, New Delhi, 2010.
3. Palmer T. and Bonner P.L., "Enzymes Biochemistry, Biotechnology, Clinical Chemistry", 2nd Edition, Woodhead Publishing, 2007.
4. Rajiv Dutta, "Fundamentals of Biochemical Engineering", 2nd Edition, Springer Verlag, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the basic principles of enzyme technology	Applying (K3)
CO2:	apply the sterilization and fermentation process in industries	Applying (K3)
CO3:	apply the theories of mass transfer to microbial systems	Applying (K3)
CO4:	identify suitable downstream processing techniques	Analyzing (K4)
CO5:	analyze various aspects of industrial bioreactors	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	1		3	3
CO2	3	1		3	3
CO3	3	1		3	3
CO4	3	1		3	3
CO5	3	1		3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE13 MULTIPHASE FLOW

L	T	P	Credit
3	0	0	3

Preamble	This course provides knowledge about the fundamentals of transfer phenomena in multi phase systems to draw momentum and mass balance. It also gives understanding of design, scaling and application of multi phase reactors.
Prerequisites	Nil

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 Systems: 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 throughput. Velocities in Three phase system. Design of multiphase contactors involving fluidization, pervaporation, lyophilisation and permeation 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 chimneys, absorbers, combustion devices, electrostatic precipitators and filtration / reverse osmosis devices.

Total: 45

REFERENCES:

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		**BT Mapped (Highest Level)**
CO1:	explain the fundamental principles on flow pattern, flow regime and transfer phenomena and develop models	Applying (K3)
CO2:	draw flow-power correlation for a multiphase system	Applying (K3)
CO3:	describe two-phase hydrodynamics and determine the design aspects of a multiphase contactors	Applying (K3)
CO4:	explain three-phase hydrodynamics and estimate the design parameters	Applying (K3)
CO5:	design and develop software programmes used in multiphase flow	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2			3	3
CO2			2	2	3
CO3		1	2	3	
CO4	3			2	
CO5	3	2		2	

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE14 PIPING FLOW SHEETING PROCESS AND INSTRUMENTATION DIAGRAMS

L	T	P	Credit
3	0	0	3

Preamble	This course enables the students to present a process flow diagram and flow sheeting principles from a chemical engineering point of view. The students will be well versed with the development of process flow diagrams and control systems. Main advantage of the course will be to deal with applications of process flow diagrams in design stage. The study further provides a comprehensive exposition to theory and application of P&ID in HAZOPS and Risk Analysis.
Prerequisites	Nil

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&ID): P & I D development, typical Stages of P & ID, P & ID for rotating equipment and static pressure vessels, Process vessels, Absorber, Evaporator.

UNIT – III **9**

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

UNIT – IV **9**

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

UNIT – V **9**

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

Total: 45

REFERENCES:

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.

Course Outcomes: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	employ the methods of presentation of flow sheet for a chemical manufacturing process	Applying (K3)
CO2:	demonstrate the typical stages of PID and its applications in process equipment	Applying (K3)
CO3:	implement control system for heat exchangers and reactors	Applying (K3)
CO4:	develop control system for mass transfer equipment	Applying (K3)
CO5:	examine the applications of PID controllers in design, construction and commissioning	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1			1	3	
CO2			1	3	
CO3			2	3	
CO4			2	3	
CO5			1	3	

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE15 INDUSTRIAL WASTEWATER TREATMENT

L	T	P	Credit
3	0	0	3

Preamble	Waste water treatment constitutes a major role in environmental conservation. This course provides a broad overview about the waste water characterization and treatment practices followed in industries.
Prerequisites	Nil

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 Wastewater 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

REFERENCES:

1. George Tchobanoglous, Franklin L. Burton, “Wastewater Engineering: Treatment and Reuse Metcalf Eddy”, McGraw Hill, 2011.
2. Frank Woodard, “Industrial Waste Treatment Handbook”, Butterworth Heinemann, New Delhi, 2001.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	describe the sources and types of industrial waste water and estimate their physio-chemical properties	Applying (K3)
CO2:	apply the principles of physical and chemical unit operations in waste water treatment	Applying (K3)
CO3:	explain the biological waste water treatment techniques and apply them in industries	Applying (K3)
CO4:	develop advanced waste water treatment methods	Applying (K3)
CO5:	describe various effluent treatment plants and evaluate their operations	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1	1		1	1
CO2	2	1	2	1	1
CO3	2	1	2	1	2
CO4	2	1	2	2	2
CO5	3	1	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE16 ADVANCED MATERIALS FOR CHEMICAL ENGINEERS

L	T	P	Credit
3	0	0	3

Preamble	This course aims to introduce elementary concepts and implicate expertise with selection of materials for prevention and control of corrosion
Prerequisites	Nil

UNIT – I **9**

Materials – Structure & Analysis: Classification of Materials - Functional, Structural; Atomic Structure, Atomic Bonding, Binding Energy and interatomic spacing, Atomic arrangement and Crystal Structure; Imperfections: Point defect, Dislocations, Surface defects; Deformation of Materials – Elastic & Plastic, Deformation of Single and Polycrystalline materials, Recovery, Recrystallization, and Grain growth.

UNIT – II **9**

Fracture Mechanics and Materials Characterization: Fracture – Ductile, Brittle, Fracture Mechanism, Impact Fracture testing; Fatigue – Cyclic stresses, The S-N Curve, Crack initiation and propagation, Factors affecting fatigue life, Fatigue testing; Creep – Creep Behavior, Stress and Temperature effects; MechanicalTesting – Tensile tests, Compression tests, Hardness tests, Creep and Stress rupture tests.

UNIT – III **9**

Ceramics & Polymer: Ceramics: Properties, Synthesis and processing of Ceramic powders, Characteristics – Sintered Ceramics, Grains and Grain Boundaries, Porosity; Inorganic Glasses; Refractories; Polymers: Structure, Polymer Crystallinity, Crystallization, Melting, and Glass Transition Phenomena in Polymers, Polymerization, Forming Techniques for Plastics, Fabrication of Elastomers, Fabrication of Fibers and Films.

UNIT – IV **9**

Composite Materials: Introduction - Particle-Reinforced Composites, Fiber-Reinforced Composites – Influence of Fiber length, Orientation, Concentration , Fiber & Matrix Phase, Polymer-Matrix, Metal-Matrix, Ceramic-Matrix, Carbon–Carbon, Hybrid Composites; Structural Composites: Laminar Composites and Sandwich Panels

UNIT – V **9**

Materials Selection and Design Consideration: Introduction - Materials selection for a torsionallystressed cylindrical shaft; Artificial Total Hip Replacement; Chemical Protective Clothing; Materials for Integrated CircuitPackages; Economic Considerations - Component Design, Materials, Manufacturing Techniques; Environmental and Societal Considerations - Recycling Issues in Materials Science and Engineering

Total: 45

REFERENCES:

1. Donald Askeland and Wendelin Wright, “Essentials of Materials Science and Engineering - SI Edition”, 3rd Edition, Cengage Learning, 2013.
2. William D. Callister, “Materials Science and Engineering”, 7th Edition, John Wiley & Sons Inc., 2007.
3. Smallman R.E., Ngan A.H., “Physical Metallurgy and Advanced Materials”, Butterworth-Heinemann, 2011.
4. Li Lin, Ashok Kumar and Sam Zhang, “Materials Characterization Techniques”, CRC Press, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	adapt the principles of atomic structure and study the defectiveness of materials	Applying (K3)
CO2:	analyze the flaw and mechanical testing of material	Analyzing (K4)
CO3:	demonstrate the properties, characteristics and fabrication of ceramics and polymers	Applying (K3)
CO4:	examine the properties and fabrication of advanced composite materials	Analyzing (K4)
CO5:	inspect the knowledge in material selection and design consideration	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	3	3
CO2	3	1	2	3	3
CO3	3	1	2	3	3
CO4	3	1	2	3	3
CO5	3	1	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MHE17 INDUSTRIAL DRYING

L	T	P	Credit
3	0	0	3

Preamble	The objective of this course is to study the types, selection and applications of industrial dryers.
Prerequisites	Nil

UNIT – I **9**

Fundamentals Aspects of Drying: Principles, classification and selection of dryers. Basic process calculation and transport properties in drying

UNIT – II **9**

Types of Industrial Dryers: Rotary dryer, fluidized bed dryer, industrial spray drying, solar drying, spouted bed drying ,impingement drying and infrared drying

UNIT – III **9**

Dryers for Food and Pharmaceuticals: Drying of food stuff, drying of pharma products, drying of nano size products.

UNIT – IV **9**

Dryers for Textile and Polymers: Drying of textile products, Drying of bio products, drying of polymers.

UNIT – V **9**

Control and Safety Aspects of Industrial Dryers: Drying emission control system control of industrial dryers. Safety aspects of industrial dryers. Cost estimation methods for dryers

Total: 45

REFERENCES:

1. Arun S. Mujumdar, "Handbook of Industrial Drying", 4th Edition, CRC Publishers, 2014.
2. Tadeusz Kudra and Arun S. Mujumdar, "Advanced Drying Technologies", 2nd Edition, CRC Publishers, 2015.
3. Ibrahim Dinces and Calin Zamtiresu, "Drying Phenomena: Theory and Applications", John Wiley Publishers, 2015.
4. Delgdo J.M.P.Q. and Gilson Barbosa, "Drying and Energy Technology", Springer, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	describe the classification, applications of drying and calculate the transport properties	Applying (K3)
CO2:	employ various dryers in process industries	Applying (K3)
CO3:	utilize dryers for pharma and food industries	Applying (K3)
CO4:	apply dryers for drying of bio, polymers and textile products	Applying (K3)
CO5:	comprehend the emission control systems and analyze the safety and economics of dryers	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1				1	1
CO2	2		2	1	3
CO3	2		2	3	3
CO4	2		2	3	3
CO5	3	2	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MHE18 DESIGN AND ANALYSIS OF EXPERIMENTS

(Common to Chemical and Food Technology branches)

Category	L	T	P	Credit
PC	3	0	0	3

Preamble:	This course highlights various techniques for designing and optimizing engineering experiments
Prerequisites:	Nil

UNIT – I **9**

Introduction to Experimental Design: Introduction – Principles and applications of Design of Experiments, Design of a process and product, Guidelines for designing experiments, Using statistical techniques for experimentation, Case studies

UNIT – II **9**

Foundations of Statistics: Sampling and Sampling Distributions, Inferences on Randomized and paired comparison designs, Analysis of Variables, Regression Analysis – Linear, Multiple regression, Testing for lack of fit

UNIT – III **9**

Randomized Complete Block Design: Framing RCBD experiments, Latin Square Desing, Graeco-Latin Square Design,Central Composite Design, Balanced Incomplete Block Design, Model adequacy checking, Leas Square estimation, regression, Case Studies in Chemical Engineering

UNIT – IV **9**

Factorial Experiments: Principles and Merits of Factorial design, Analysis of two factorial experiments, Analysis of two level Fractional factorial experiments, Three level Factorial experiments, Introduction to mixed and non regular factorial designs, Case Studies in Chemical Engineering

UNIT – V **9**

Response Surface Methodology using Software Tools: Introduction to RSM, Steepest Ascent method, Analysis of Second order response surface, Designs for Fitting Response surfaces, Mixture experiments, Case Studies in Chemical Engineering Introduction to software tools – Minitab

Total: 45

REFERENCES:

1. Douglas C. Montgomery, “Design and Analysis of Experiments”, 8th Edition, Wiley, 2017.
2. Angela Dean and Daniel Voss, “Design and Analysis of Experiments”, Springer, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the basic principles and strategies of experimental design to real time experimental data	Applying (K3)
CO2:	apply fundamental concepts of statistics for testing a hypothesis	Applying (K3)
CO3:	formulate and analyze Randomized complete block experiments	Analyzing (K4)
CO4:	analyze Factorial experiments for deriving conclusions	Analyzing (K4)
CO5:	perform response surface analysis using software tools and interpret the results	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	2		2	2	1
CO2	2		2	2	1
CO3	1		2	2	1
CO4	1		2	2	1
CO5	2		2	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy