Dr. Babasaheb Ambedkar Technological Unievsrity, Lonere

Proposed Teaching and Examination Scheme for M. Tech. Chem. Engg. (July 2017 onwards)

Sr. No.	Subject Code and Name	Scheme			Credits	Examination Scheme				
		L	P	T		Theory		CA	PR/OR	TOTAL
						Theory	Test			
First Semester										
1	MCH 101, Advanced Momentum Transfer	3	-	1	4	60	20	20	-	100
2	MCH 102, Elective - I	3	-	-	3	60	20	20	-	100
3	MCH 103, Advanced Reaction Engineering	3	-	1	4	60	20	20	-	100
4	MCH 104, Thermodynamics of Phase Equilibria	3	-	1	4	60	20	20	-	100
5	MCH 105, Elective - II	3	-	-	3	60	20	20	-	100
6	MCH 106, Communication Skills	2	-	-	2	-	-	25	25	50
7	MCH 107, Computational Lab - I	-	3	-	2	-	-	25	25	50
	Total for Semester 1	17	3	3	22	300	100	150	50	600
Second Semester										
1	MCH 201, Advanced Mass Transfer Operations	3	-	1	4	60	20	20	-	100
2	MCH 202, Advanced Separation Techniques	3	-	-	3	60	20	20	-	100
3	MCH 203, Elective - III	3	-	-	3	60	20	20	-	100
4	MCH 204, Elective - IV	3	-	-	3	60	20	20	-	100
5	MCH 205, Seminar	-	4	-	2	-	-	50	50	100
6	MCH 206, Open Elective**	3	-	-	3	60	20	20	-	100
7	MCH 207, Mini Project / Computational Lab. - II	-	4	-	2	-	-	50	50	100
	Total for Semester 2	18	6	1	20	300	120	220	100	700

Third Semester									
1	MCH 301, Project Management and Intellectual Property Rights	-	-	-	2	-	-	50	50	100
2	MCH 302, Project Work (Stage –I)	-	-	-	10	-	-	50	50	100
3	**Total for Semester 3**	-	-	-	12	-	-	100	100	200

Fourth Semester										
1	MCH 401, Project Work (Stage –II)	-	-	-	20	-	-	100	100	200
2	**Total for Semester 4**	-	-	-	20	-	-	100	100	200

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge, skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. Scholarship of Knowledge: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. Critical Thinking: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. Problem Solving: Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. Research Skill: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. Usage of modern tools: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. Collaborative and Multidisciplinary work: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

8. Communication: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. Ethical Practices and Social Responsibility: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. Independent and Reflective Learning: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	Pursue successful industrial, academic and research careers in specialized fields of Chemical Engineering.
PEO2	Apply the knowledge of advanced topics in Chemical Engineering to meet contemporary needs of industry and research.
PEO3	Use modern software tools for design of processes and equipment.
PEO4	Identify issues related to ethics, society, safety, energy and environment in the context of Chemical Engineering applications.
PEO5	Pursue self-learning to remain abreast with latest developments for continuous professional growth.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Model chemical engineering processes including multi-component mass transfer, multi-phase momentum transfer and multi-mode heat transfer from advanced engineering perspective.
PO2	Apply modern experimental, computational and simulation tools to address the challenges faced in chemical and allied engineering industries.
PO3	Implement techniques for minimizing cost and energy requirements in chemical plants.
PO4	Design measures to take care of environment, health and safety issues pertaining to chemical industries.
PO5	Communicate effectively and demonstrate leadership skills
PO6	Carry out research work independently and innovate novel processes and products
PO7	Practice professional ethics
PO8	Pursue life-long learning as a means of updating knowledge and skills

M. Tech. Chemical Engineering Course Structure
(Credit based Program)

1st Semester

Course Code	Name of the Course	Teaching Scheme (Hours per week)			Credits
		L	T	P	
MCH 101	Advanced Momentum Transfer	3	1	-	**4**
MCH 102	Elective - I	3	-	-	**3**
MCH 103	Advanced Reaction Engineering	3	1	-	**4**
MCH 104	Thermodynamics of Phase Equilibria	3	1	-	**4**
MCH 105	Elective - II	3	-	-	**3**
MCH 106	Communication Skills	2	-	-	**2**
MCH 107	Computational Lab - I	-	-	3	**2**
	Total	**17**	**3**	**3**	**22**

L: Lecture, T: Tutorial, P: Practical

List of Elective Courses

Elective I: A.Advanced Heat Transfer, B. Selected Topics in Heat Transfer, C. Conceptual Design of Chemical Processes
Elective II: A. Bioprocess Engineering, B. Process Intensification. C. Project Evaluation

2nd Semester

Course Code	Name of the Course	Teaching Scheme (Hours per week)			Credits
		L	T	P	
MCH 201	Advanced Mass Transfer Operations	3	1	-	**4**
MCH 202	Advanced Separation Techniques	3	-	-	**3**
MCH 203	Elective - III	3	-	-	**3**
MCH 204	Elective - IV	3	-	-	**3**
MCH 205	Seminar	-	-	4	**2**
MCH 206	Open Elective**	3	-	-	**3**
MCH 207	Mini Project (Critical Review of a research publication) / Computational Lab. - II	-	-	4	**2**
	Total	**15**	**1**	**8**	**20**

L: Lecture, T: Tutorial, P: Practical
****- Research Methodolgy, Syllabus as prepared by the department offering the course**

List of Elective Courses

Elective III: A. Risk Analysis and Hazops, B. Reactive Separations and C. Pinch Technology
Elective- IV: A. Computer Control of Process Plants B. Steady State Process Simulation
C. Energy Management

3rd Semester

Course Code	Name of the Course	Teaching Scheme (Hours per week)			Credits
		L	T	P	
MCH 301	Project Management and Intellectual Property Rights (Self Study)*	-	-	-	**2**
MCH 302	Project Work (Stage –I)	-	-	-	**10**
	Total	**-**	**-**	**-**	**12**

*Evaluation at the end of semester.

4th Semester

Course Code	Name of the Course	Teaching Scheme (Hours per week)			Credits
		L	T	P	
MCH 401	**Project Work (Stage – II)**	**-**	**-**	**-**	**20**

Semester 1
Core Courses

MCH 101	ADVANCED MOMENTUM TRANSFER	3 –1 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the analogous mechanism of momentum Transport for steady and unsteady flow.
CO2	Perform momentum balance for a given system at macroscopic and microscopic scale.
CO3	Solve the governing equations to obtain velocity profiles.
CO4	Model the momentum transport under turbulent conditions.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	✓	✓	-	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	-	✓	-	-	-	-

MCH 101 Advanced Momentum Transfer

Unit 1 and 2: Turbulent flow: basics, Reynolds average Navier-Stokes equations, closure problem, Boussinesque hypothesis, Prandtl mixing length theory, turbulence models, energy spectrum, turbulent boundary layer, and universal velocity profile. 12 hrs

Unit 3: Bernoulli's equation and its applications. 08 hrs

Unit 4–6: Gas-liquid and solid-liquid fluidized beds: Characteristics of particles, Principle of fluidization and mapping of various regimes, Two phase theory of fluidization, Bubbles in fluidized bed, Entrainment and Elutriation, Fast fluidized bed, Mixing, segregation and gas dispersion, Heat and mass transfer in fluidized bed, Solid-liquid fluidized bed and three phase fluidized bed, Design of fluidized bed reactors. 18 hrs

Texts/References:

1. Transport Phenomena, R. B. Bird, W. E. Stewart and E.N. Lightfoot, John Wiley, 1960.
2. Transport Phenomena – A Unified Approach, R.S. Brodkey and H.C. Hershey, McGraw Hill, 1988.
3. Momentum, Heat and Mass transfer, C.O. Bennet and J.E. Myers, McGraw Hill, 1993.

MCH 103	ADVANCED REACTION ENGINEERING	3 –1 – 0	4 Credits

Pre-requisites: None

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

CO1	Calculate reactor performance in situations where the observed reaction rate is significantly influenced by internal mass transfer in porous heterogeneous catalytic systems
CO2	Understand the energy balance and concentration profiles of multiphase reactors.
CO3	Estimate the performance of multiphase reactors in the situation such as temperature not uniform within the reactor and three phases are involved
CO4	Understand modern reactor technologies for mitigation of global warming

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	✓	✓	-	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	-	✓	-	-	-	-

Detailed syllabus

Unit 1: Non elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model. Effect of flow on conversions in Reactors: Semi-batch Reactors : Importance and examples of applications , Material Balance on Semi-batch Reactor, Multiple reaction in Semi-batch Reactors, Conversion Vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profiles

Unit 2: Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange, Need for Multi-staging CSTR with multiple stages: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange.

Unit 3: Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, Unsteady state in non isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non isothermal reactors. Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non isothermal reactor design, Adiabatic operation in batch, Heat effects in semi-batch Unsteady state operation. Auto-thermal Plug flow reactors and Packed tubular reactors.PFR with inter-stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semi-batch and CSTR

Unit 4: Exothermic Reactions, Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis . Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example :Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.

Unit 5: Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed

Fluidized bed reactor modeling: Geldart Classification of powders, Fixed bed Vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance of BFB.

Unit 6: Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate.

Reaction engineering and mitigation of Global warming: CO2 absorption in high pressure water, different techniques of mitigation of CO2, methods of separations. Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO2 for thermal power plants.

Text / References:

1. Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.
2. Levenspiel O., Chemical Reaction Engineering, Wiley, 1998.
3. Froment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010.

MCH 104	THERMODYNAMICS OF PHASE EQUILIBRIA	3 – 1 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the thermodynamics of equilibrium
CO2	Study properties from volumetric data and make use of empirical equations to predict fugacity of pure liquid or solid.
CO3	Applications of thermodynamics to predict fugacity of liquid mixtures
CO4	Study the intermolecular forces and theories of corresponding states..

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	✓	✓	-	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	-	-	-	-	-	-

Detailed Syllabi

Unit 1: Introduction to molecular thermodynamics of fluid phase equilibrium, Fundamental concepts of statistical thermodynamics

Unit 2: Classical thermodynamics of phase equilibrium - open and closed systems, Gibbs-Duhem equation, chemical potential, fugacity and activity. Thermodynamic properties from volumetric data / fugacity at moderate pressure, fugacity of a pure liquid or solid

Unit 3: Fugacity in gas mixtures - Virial equation of state, fugacity from Virial equation, third Virial coefficient, chemical interpretations of deviation from gas phase ideality, fugacity at high pressure, Redlich - Kwong equation of state, solubility of solids and liquids in compressed gases 04 hrs

Unit 4: Fugacity in liquid mixtures: excess functions, activity and activity coefficient, testing of equilibrium data, Wohl’s expansion for excess Gibbs energy, equations of van der Waal, Wilson and Renon equations for activity coefficient. Thermodynamic criteria of miscibility 04 hrs

Unit 5: Intermolecular Forces and the theory of corresponding states - potential energy functions for different molecular systems; Polar and non-polar molecules 04 hrs

Unit 6: Liquid phase models: van Laar, Scatchard-Hildebrand theory, Lattice theory, two liquid theories, Flory - Huggins theory. 04 hrs

Text/Reference Books:

1. Chemical Engineering Thermodynamics, Smith and Van Ness
2. Chemical Engineering Thermodynamics, T.E. Daubert
3. Chemical Engineering Thermodynamics, R.E. Balzhiser
4. Chemical Engineering Thermodynamics, S.I. Sandler
5. Molecular Thermodynamics of Fluid Phase Equilibria, J.M. Prausnitz
6. Properties of Gases and Liquids, R.C. Reid and T.K. Sherwood

MCH 106	Communication Skills	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand corporate communication culture
CO2	Prepare business reports and proposals expected of a corporate professional
CO3	Employ appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire corporate email, mobile and telephone etiquette

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	-	✓	-	✓	-
CO2	-	-	-	-	✓	-	✓	-
CO3	-	-	-	-	✓	-	✓	-
CO4	-	-	-	-	✓	-	✓	-
CO5	-	-	-	-	✓	-	✓	-

Detailed Syllabus:

Unit 1: English Language Enhancement: Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English.

Unit 2: Art of Communication, Communication process- Non-verbal Communication- Effective Listening.

Unit 3: Interpersonal and Intra Personal Communication Skills- Self-Awareness- Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles-Leadership.

Unit 4: Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette-Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills.

Unit 5: Interview Handling skills- Effective Resume-- Common Interview Mistakes- Body-language-

Unit 6: Content Aid, Visual Aids- Entrepreneurial Skills Development.

Text / References:

1. Robert M.Sherfield, Developing Soft Skills, Montgomery and Moody 4th Ed. Pearson, 2009.
2. K. Alex, Soft Skills: Know Yourself & Know The world, S. Chand; 2009.
3. Robert Bramson, Coping with Difficult People, Dell, 2009

MCH 107	COMPUTATIONAL LAB-I	0– 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Solve complex chemical engineering problems by applying suitable numerical methods.
CO2	Estimate the thermodynamic properties from implicit equations using C language/MATLAB
CO3	Design the process equipment using C/C^{++} language /MATLAB
CO4	Analyze and formulate a mathematical problem and solve the resulting system of linear set of equations, ODE, PDE using C/C++ programming/MATLAB.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	✓	✓	-	-	-	-	-
CO2	✓	✓	✓	-	-	-	-	-
CO3	✓	✓	✓	-	-	-	-	-
CO4	-	✓	✓	-	-	-	-	-

Detailed syllabus

Estimation of Properties: Estimation of Physical properties, Estimation of properties of mixtures; Estimation of Thermodynamic properties; Vapor Liquid Equilibria calculations.

Optimal Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors.

Text / References:

Laboratory Manual.

Second Semester
Core courses

MCH 201	ADVANCED MASS TRANSFER	3 – 1 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the concept of separation factor and separating agent.
CO2	Determine the degrees of freedom using phase rule and description rule.
CO3	Compare multi-stage operations.
CO4	Design binary distillation column using McCabe Thiele and Ponchon-Savarit methods.
CO5	Design multi-component distillation columns using short cut and rigorous calculation methods.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	✓	-	-	-	-	-	-
CO2	-	✓	-	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	-	-	-	-	-	-
CO5	✓	✓	-	-	-	-	-	-

Detailed syllabus

Unit 1: Characterization of Separation processes: Inherent Separation Factors: Equilibration Processes, Inherent Separation Factors: Rate-governed Processes. Simple equilibrium processes: Equilibrium Calculations, Checking Phase Conditions for a Mixture.

Unit 2: Multistage separation processes: Increasing Product Purity, Reducing Consumption of Separating Agent, Co-current, Crosscurrent, and Countercurrent Flow.

Unit 3: Binary multistage separation: Binary Systems, Equilibrium Stages, McCabe-Thiele Diagram, The Design Problem, Multistage Batch Distillation, Choice of Column Pressure.Binary multistage separations-general graphical approach: Straight Operating Lines, Curved Operating Lines Processes without Discrete Stages, General Properties of the y - x Diagram.

Unit 4: Energy requirements of a separation process: Minimum Work of Separation, Net Work Consumption, Thermodynamic Efficiency, network of potentially reversible process, partially reversible process and irreversible processes.

Unit 5: Multi-component: Equilibrium and simple distillation – Multi-component Flash calculation and

Differential distillation, quantitative relationships.

Unit 6: Ternary and multi-component system fractionation: preliminary calculations, feed condition, column pressure, design procedure, number of equilibrium stages, feed location, estimation of number of theoretical plates – shortcut methods and rigorous calculation methods.

Text / References:

1. King C. J., Separation Processes, Tata McGraw Hill Book Company, 2nd Ed., New Delhi, 1983.
2. Vanwinkle M, Distillation, McGraw Hill Chemical Engineering Series, New York, 1967.
3. Holland C. D., Multi-component Distillation, Prentice Hall of India Pvt. Ltd., 1981.
4. Geankoplis C. J., Transport Processes and Unit Operations, 4thEdition, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

MCH 202	ADVANCED SEPARATION TECHNIQUES	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Classify the membranes.
CO2	Differentiate various membrane processes.
CO3	Understand the methods of membrane preparation.
CO4	Compare membrane process with other methods of separation.
CO5	Evaluate the flux of solvent and solute through membrane.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	✓	-	-	-	-	-	-	-
CO3	-	-	✓	-	-	-	-	-
CO4	-	-	✓	-	-	-	-	-
CO5	-	-	-	✓	-	-	-	-

Detailed syllabus

Unit 1-2: Solute transport parameters for membrane performance prediction in RO/UF systems involving aqueous and non aqueous solution. Physico – chemical. Polar, on-polar criteria governing RO separations – membrane transport mechanism.

Unit 3: Membrane fouling and compaction. TFC membrane development RO/UF/Ed process design and module analysis. RO/F/ED and DD in acid and enzyme recovery from scarified hydrolytes. 10 hrs

Unit 4-5: Membrane techniques in reclamation of water and chemicals along with pollution control from industrial effluents. 08 hrs

Unit 6: Cost benefits analysis in resources cycling and environmental quality improvement by MT. Industrial processing with membranes – membrane reactor concept in biotechnology concentration. Gas separation by RO. 08 hrs

Text / References:

1. S. Sourirajan and T. Matsuuura (Ed.), RO – UF: Principles and Applications, NRCC Publications, Ottawa, Canada (1986).

2. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).

MCH 205	SEMINAR	0– 0 – 3	2 Credit

Pre-requisites: None

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

CO1	Communicate with group of people on different research topics
CO2	Prepare a seminar report that includes consolidated information on a research topic

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	-	✓	-	-	-
CO2	-	-	-	-	-	✓	✓	✓

Detailed syllabus

Any topic of relevance to chemical and allied engineering and science.

MCH 207	COMPUTATIONAL LAB – II/ MINI PROJECT	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Carry out thermodynamic property estimations using property estimation and property analysis in Aspen
CO2	Simulate and design individual Mixer, splitter, heat exchangers, pumps, compressors, flash units, reactors, distillation columns, calculator block, duplicator, multiplier models.
CO3	Simulate processes involving multiple units and apply sensitivity, design specifications and case study tools in Aspen.
CO4	Simulate and optimize process flow sheets including streams containing solids using sequential modular approach as well as equation oriented approach.
CO5	Carry out dynamic simulation, pinch analysis and cost estimation.
CO6	Design heat exchanger using Exchanger design and rating and distillation column using RADFRAC models.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	✓	-	-	-	-	-	-
CO2	✓	✓	-	-	-	-	-	-
CO3	-	✓	-	-	-	-	-	-
CO4	-	✓	-	-	-	-	-	-
CO5	-	✓	✓	-	-	-	-	-
CO6	✓	✓	-	-	-	-	-	-

Detailed syllabus

Units 1- 6:
Solve the following steady state simulation exercises using Aspen software:

- Physical property estimations.
- Simulation of individual units like, mixers, splitters, heat exchangers, flash columns and reactors
- Design and rating of heat exchangers
- Design and rating of distillation columns.
- Mass and Energy balances.
- Handling user specifications on output streams – Sensitivity and design Spec tools.
- Simulation of a flow-sheet and simulation exercises using calculator block

- Optimization Exercises
- Simulation using equation oriented approach
- Simulation of processes involving solids
- Costing and economic analysis using Aspen capital Cost estimation.
- Pinch analysis and design Heat exchanger networks using Aspen Energy Analyser.
- Dynamic Simulation.

Elective Courses

Elective - I

MCH 102	ELECTIVE - I	3 – 0 – 0	3 Credits

A. ADVANCED HEAT TRANSFER

Pre-requisites: None

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

CO1	Derive the governing differential equation for conduction and convection heat transfer
CO2	Solve the differential equation to obtain temperature profile in solid or fluid
CO3	Apply finite difference methods to solve problems in heat transfer
CO4	Calculate the net radiation loss from a surface in an enclosure of many surfaces

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	✓	-	-	-	-	-
CO2	✓	-	✓	-	-	-	-	-
CO3	✓	-	-	-	-	-	-	-
CO4	✓	-						

Detailed syllabus

Unit 1-2: Steady state heat conduction: General conduction equation, side conditions. One dimensional heat conduction without generation, Plane slab, Circular cylindrical shell, Spherical shell, Variable thermal conductivity, Conduction across composite barriers, Critical insulation thickness. Finite difference methods in steady state conduction.

Unit 3: Unsteady state condition: Exact analytical solutions and charts for infinite slab, cylinder and sphere, Semi-infinite slab, Lumped parameter method of transient analysis; Finite difference method; Transient finite difference solutions.

Unit 4: Natural Convection: Governing equations for velocity and temperature fields, partial differential equations, vertical plate solution.

Unit 5: Forced Convection: The fundamental problem, analytical and semi-analytical solutions.

Unit 6: Radiation Heat transfer - Concepts, physical mechanism, properties, radiation shape factors, heat exchange between nonblack bodies, infinite parallel planes, Calculation of the net radiant loss; Net radiant loss from non-gray surfaces.

Text / References:

1. Sucec J, Heat Transfer, Jaico Publishing House, 2006.
2. Holman, J.P. and White P.R.S., Heat Transfer, 7th Ed., McGraw Hill, 2009.

B. SELECTED TOPICS IN HEAT TRANSFER

Pre-requisites: None

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

CO1	Derive the governing differential equation for conduction and convection heat transfer
CO2	Solve the differential equation to obtain temperature profile in solid or fluid
CO3	Apply finite difference methods to solve problems in heat transfer
CO4	Calculate the net radiation loss from a surface in an enclosure of many surfaces

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	✓	-	-	-	-	-
CO2	✓	-	✓	-	-	-	-	-
CO3	✓	-	-	-	-	-	-	-
CO4	✓	-	✓	-	-	-	-	-

Detailed syllabus

Units 1-6: Theoretical background to laminar and turbulent flow, heat transfer and analogies between heat and momentum transfer to non Newtonian fluids in circular tubes; Theoretical relationships for laminar and turbulent flow in tubes and stirred vessels; Heat transfer in particles – fluid systems; Mechanism of heat flow in fixed, fluid, fluidized and moving bed reactors; Heat transfer in dilute phase transport; Applications of basic heat transfer equations for the design of fixed, fluidized and moving beds, and for heat exchangers of non – Newtonian fluids.

Text / References:

J. G. Kundsen and D. L. Katz, Fluid Dynamic and Heat Transfer, McGraw Hill, (1958).

A. H. P. Skelland, Non Newtonian flow and Heat transfer in a Fluidized Bed, Gosener goizdt, Moscow (1963).

C. CONCEPTUAL DESIGN OF CHEMICAL PROCESSES

Pre-requisites: None

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

CO1	Implement the hierarchical approach to conceptual design
CO2	Optimize the input/output and recycle structure of the flow sheet
CO3	Design the best flow sheet using conceptual design
CO4	Synthesize heat exchanger network and separation systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	-	✓	✓	-	-	-	-	-
CO3	-	✓	✓	✓	-	-	-	-
CO4	-	✓	-	-	-	-	-	-

Detailed syllabus

Unit 1: The nature of process synthesis and analysis: Creative Aspects of process design, A Hierarchical approach to conceptual design. Engineering economics: Cost information required, estimating capital and operating costs, total capital investment and total product costs, time value of money, Measures of process profitability, Simplifying the economic analysis for conceptual designs.

Unit 2: Economic decision making: Design of a solvent recovery system, Problem definition and general considerations, Design of a gas absorber, Equipment design considerations, rules of thumb. Developing a conceptual design and finding the best flow sheet: Input information, batch versus continuous.

Unit 3: Input-output structure of the flow sheet: Decisions for the input-output structure, Design variables, Overall material balances, and stream costs, Process Alternatives. Recycle structure of the flow sheet: Decisions that determine the recycle structure, recycle material balances reactor heat effects, equilibrium limitations, compressor design and costs reactor design, recycle economic evaluation.

Unit 4: Separation system: General structure of the separation system, Vapor recovery system, Liquid separation system, Azeotropic systems, Rigorous material balances.

Unit 5: Heat-exchanger networks: Minimum heating and cooling requirements, Minimum number of exchangers, Area estimates, Design of minimum-energy heat exchanger networks, Loops and paths, Reducing the number of exchangers, Stream splitting, Heat and Power integration, Heat and distillation, HDA Process.

Unit 6: Cost diagrams and quick screening of process alternatives: Cost diagrams, cost diagrams for complex processes, quick screening of process alternatives, HDA Process.

Text / References:

1. Douglas J. M., Conceptual Design of Chemical Processes, McGraw Hill, 1988.
2. Dimian A. C., Bidea C. S., Chemical Process Design, Wiley-VCH, 2008.

Elective - II

MCH 105	ELECTIVE - II	3 – 0 – 0	3 Credits

A. BIOPROCESS ENGINEERING

Pre-requisites: None

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

CO1	Understand enzyme kinetics and cell kinetics.
CO2	List the immobilization techniques.
CO3	Calculate the time required for a given conversion of a enzymatic reactions using the kinetic data.
CO4	Select downstream processing method for purification of the product.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	✓	-	✓	-	-	-	-
CO2	✓	✓	-	-	-	-	-	-
CO3	✓	✓	-	✓	-	-	-	-
CO4	✓	-	✓	-	-	-	-	-

Detailed syllabus

Unit 1: Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Unit 2: Enzyme & Cell Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, Other influences on Enzyme Reactions, Experiment: Enzyme Kinetics, Growth Cycle for Batch Cultivation.

Unit 3: Transport Phenomena in Bioprocess Systems, Bioreactor Design and Analysis.

Unit 4: Instrumentation and Control: Introduction, Instrumentation for Measurements of Active Fermentation, Sterilization.

Unit 5: Product Recovery Operations: Strategies to Recover and Purify Products, Separation of Insoluble

Unit 6: Products, Cell Disruption, Separation of Soluble Products, Finishing Steps for Purification, Integration of Reaction and Separation.

Text / References:

1. Veith W. R., Bioprocess Engineering, John Wiley & Sons, 1994.
2. Blanch H. W. and Clark D. S., Biochemical Engineering, Marcell and Dekker Inc., 1997.
3. Shuler M. L., Kargi F., Bioprocess Engineering: Basic Concepts,2nd Edition, Prentice Hall International, 2001.

B. Process Intensification

Pre-requisites: None

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

CO1	Apply process intensification in industrial processes.
CO2	Implement methodologies for process intensification
CO3	Understand scale up issues in the chemical process.
CO4	Gain the scientific background, techniques and applications of intensification in the process industries.
CO5	Identify and solve process challenges using intensification technologies.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	-	✓	✓	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	✓	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-

Detailed syllabus

Unit 1: Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process-Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit 2: Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To

Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit 3: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit 4: Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification.

Unit 5: Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit 6: Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids.

Text / References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.

C. Project Evaluation

Pre-requisites: None

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

CO1	Analyze alternative processes and equipment for manufacturing product
CO2	Perform economic analysis related to process and equipment design
CO3	Estimate the cost of manufacture
CO4	Evaluate project profitability

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	✓	✓	✓	-	-	-	-
CO2	-	-	✓	-	-	-	-	-
CO3	-	-	✓	-	-	-	-	-
CO4	-	-	✓	✓	-	-	-	-

Detailed syllabus

Unit 1: Introduction to Industrial Project Management: Nature of the Industrial Project, The Industrial Project Manager, The Professional Chemical Engineer, The Economic Basis of the Industrial Project. The Mathematics of Finance: The Measurement of Interest, The Present Worth of Cash Flows, Annuities.

Unit 2: Project Evaluation Systematics: Principles of Preliminary Project Evaluation, Marketing Research, Demand Projection, Price Projection, Flow Sheet Development Methods in Cost Estimation. Equipment Design And Costing: Equipment Selection and Sizing for Preliminary Cost Estimates, Estimation of Purchased Cost of Equipment, Effect of Inflation upon Capital Costs, Cost of Equipment Installation, Reliability of Equipment Cost Estimation.

Unit 3: The Direct Fixed Capital Investment: The Estimation of Direct Fixed Capital, The Separate Estimation of Auxiliary Facilities, The Estimation of Piping Systems, Reliability of Capital Estimates. Depreciation: The Economic Impact of Depreciation, Methods of Determining Depreciation Charges.

Unit 4: Cost of Manufacture: The Elements of the Cost of Manufacture, Raw Materials and Utilities, Operating Labor, Regulated and Fixed Charges, The Total Cost for Sale, The Responsibility for Environmental Projection.

Unit 5: The Criterion for Economic Performance: The Capital for Transfer, Return on Investment, Profitability under Variable Conditions, Profitability Criteria Related to ROI, The Costs of Product Transportation.Cash Flow Analysis: Cash Flow Concepts, Net Present Worth, Discounted Cash Flow, Relative Merit of Profitability Criteria, The Analysis of Risk.

Unit 6: The Analysis of Alternatives: The Analysis of Equipment Alternatives, The Analysis of Process and Investment Alternatives, Economic Optimization, Replacement Analysis, Plant Modification Decisions, Engineering Management of Construction Projects, Corporate Performance Analysis, Optimum Design and Design Strategy, Statistical Analysis in Design.

Text / References:

1. Valle-Riestra J. F., Project Evaluation in the chemical process Industries. McGraw Hill Book Co., 1983.

2. Peters M.S., Timmerhaus K. D. and West R. E., Plant Design and Economics for Chemical Engineers, Tata McGraw Hill., 5th Edition, 2011.

Elective - III

MCH 203	ELECTIVE - III	3 – 0 – 0	3 Credits

A. Risk Analysis and Hazops

Pre-requisites: None

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

CO1	Identify the type of risk involved in a chemical plant operation
CO2	Manage risk and prepare disaster management options
CO3	Understand safety, energy and environmental impact audit
CO4	Implement the procedure of root cause/fault tree analysis
CO5	Conduct HAZOP study for 'to be commissioned' chemical plants

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	✓	-	-	-	-
CO2	-	-	✓	✓	-	-	✓	-
CO3	✓	-	-	✓	-	-	✓	-
CO4	-	-	-	✓	-	-	✓	-
CO5	-	-	-	✓	-	-	-	-

Detailed syllabus

Unit 1: Types of Risk analysis: What are Risks, threats and vulnerabilities? What are Risk assessment, Risk management and Risk communication?. Basics and structure of Risk analysis. Qualitative and quantitative risk analysis. Types of failure: What is failure? Design failure, catastrophic failure, compounding failure and Human error failure.

Unit 2: Dispersion and toxic models: Parameters affecting dispersion, Neutrally buoyant dispersion models, Steady-State Continuous Point Release with No Wind, Puff with No Wind, Non-Steady-State Continuous Point Release with No Wind, Steady-State Continuous Point Source Release with Wind, Puff with No Wind and Eddy Diffusivity Is a Function of Direction, Steady-State Continuous Point Source Release with Wind and Eddy Diffusivity Is a Function of Direction, Puff with Wind, Puff with No Wind and with Source on Ground, Steady-State Plume with Source on Ground, Continuous Steady-State Source with Source at Height *Hr* above the Ground, Pasquill-Gifford Model, Puff with Instantaneous Point Source at Ground Level, Coordinates Fixed at Release Point, Constant Wind Only in x Direction with Constant Velocity *u*, Plume with Continuous Steady-State Source at Ground Level and Wind Moving in x Direction at Constant Velocity *u*, Plume with Continuous Steady-State Source at Height *Hr* above, Ground Level and Wind Moving in x Direction at Constant Velocity *u*, Puff with

Instantaneous Point Source at Height *Hr* above Ground Level and a Coordinate System on the Ground That Moves with the Puff, Puff with Instantaneous Point Source at Height *Hr* above Ground Level and a Coordinate System Fixed on the Ground at the Release Point, Worst-Case Conditions, Limitations to Pasquill-Gifford Dispersion Modeling, Dense Gas Dispersion, Toxic Effect Criteria, Effect of release momentum and Buoyancy, Release Mitigation.

Unit 3: Fire and explosion models: The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Liquids, Gases and Vapors, Vapor Mixtures, Flammability Limit, Dependence on Temperature, Flammability Limit Dependence on Pressure, Estimating Flammability Limits, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy, Autoignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions, Detonation and Deflagration, Confined Explosions, Blast Damage Resulting from Overpressure, TNT Equivalency, TNO Multi-Energy Method, Energy of Chemical Explosions, Energy of Mechanical Explosions, Missile Damage, Blast Damage to People, Vapor Cloud Explosions, Boiling-Liquid Expanding-Vapor Explosions.

Unit 4: Risk Management and ISO14000: Disaster management plan: Scale of disaster, elements at risk, aims of disaster management, disaster management cycle, role players in disasters, disaster preparedness, disaster preparedness framework, disaster response activities. Emergency Planning: Internal Emergency Plan (for the employees of the company), Objectives of an internal emergency plan, The Preparation of an Emergency plan, Elements of an Emergency plan, Emergency Organization and Management. External Emergency Plan (for the surrounding communities).

Unit 5: Case studies: Static Electricity, Tank Car Loading Explosion, Explosion in a Centrifuge, Duct System Explosion, Conductor in a Solids Storage Bin, Pigment and Filter, Pipefitter's Helper, Lessons Learned, Chemical Reactivity, Bottle of Isopropyl Ether, Nitrobenzene Sulfonic Acid Decomposition, Organic Oxidation, Lessons Learned, System Designs, Ethylene Oxide Explosion, Ethylene Explosion, Butadiene Explosion, Light Hydrocarbon Explosion, Pump Vibration, Pump Failure, Ethylene Explosion, Ethylene Explosion, Ethylene Oxide Explosion,, Procedures, Leak Testing a Vessel, Man Working in Vessel, Vinyl Chloride Explosion, Dangerous Water Expansion, Phenol-Formaldehyde Runaway Reaction, Conditions and Secondary Reaction Cause Explosion. Fuel-Blending Tank Explosion. Hazard identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods. Safety Audits: Types of audits (Internal &External), Audits objectives, Methodology in Conducting Safety audits (Pre-audit activities, Key on-sites activities and Post-audit activities). Checklists: Process hazard checklists.

Unit 6: What if Analysis: Examination of possible deviations from the design, construction, modification or operating intent of a process. Vulnerability models: Definitions of vulnerability, Characteristics of vulnerability, Types of vulnerability, Conceptual frame-works of vulnerability, Methods of Measuring physical vulnerability, Analytical Methods and Earthquake vulnerability curves. Event tree and Fault tree Analysis: Guidelines, examples, fault tree analysis symbols, building fault tree, DOs and DONOTs in fault tree analysis, Past accident analysis, Hazops, Principles, Risk ranking, Guide word, Parameter, Deviation, Causes, Consequences, Recommendation, Coarse HAZOP study, Case studies

Text / References:

1. Raghavan K. V. and Khan A. A., Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
2. Marshal V. C., Major Chemical Hazards, Ellis Horwood Ltd., Chichester, United Kingdom, 1987.
3. Mannan S., Butterworth Heineman, Lees' Loss Prevention in the Process Industries, 4th Ed.,

Hazard Identification, Assessment and Control, 2012.

B. Reactive Separations

Pre-requisites: None

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

CO1	Understand the need for reactive separation process
CO2	Categorize reactive separation processes.
CO3	Understand the effect of thermodynamics and kinetics on the reactive separation process
CO4	Develop mass and energy balance equations for reactive separation processes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	✓	✓	-	-	-	-	-
CO2	✓	✓	✓	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	-	-	-	-	-	-	-

Detailed syllabus

Unit 1: Reactive Distillation: Definition, introduction to reactive distillation process. Thermodynamic and kinetic effects on the feasible products of RD: introduction, Azeotropes, azheotropes, kinetics azheotropes in reactive membrane separation, Equilibrium theory and nonlinear waves for reaction separation process. Reactive stripping in structured catalytic reactors: introduction, hydrodynamics, Reactive experiments, comparison of different internals.

Unit 2: Reactive Absorption: introduction, reactive absorption equipment, modeling concept, model parameters, case studies. Reactive Extraction: introductions, phase equilibria, reactive mass transfer, hydrodynamics.

Unit 3: Development of reactive crystallization process: introduction, work flow in process development, process synthesis, reactive phase diagrams, kinetic effects, asymmetric transformation of enantiomers.

Unit 4: Reactive extrusion for solvent free processing: introduction, advantages & disadvantages, main reactions in extruders, extruder types, kinetic considerations, heat transfer and thermal instabilities.

Unit 5: Reactive comminution: introduction, mechanical comminution in solids, equipment and processes, applications.

Unit 6: Reactive filtration: introduction, separation of particulates and catalytic reaction of volatiles, separation of particles and reaction of solids. Reactive assisted granulation in fluidized beds: introduction, modeling, experiments.

Text / References:

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

C. Pinch Technology

Pre-requisites: None

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

CO1	Quantify the energy requirement for component equipment of a chemical plant
CO2	Develop the composite curves and locate the pinch point for heat exchanger network
CO3	Minimize energy requirement for the heat exchanger network
CO4	Implement pinch technique for batch and continuous processes
CO5	Optimize energy requirement for a large chemical plant by compartmentalizing appropriately

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	✓	-	✓	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-
CO3	✓	✓	✓	-	-	-	-	-
CO4	-	-	✓	✓	-	-	-	-
CO5	-	-	-	-	-	-	-	-

Detailed syllabus

Unit 1: Introduction: Pinch analysis, History, Concepts of process synthesis, Learning & applying techniques. Key concepts of Pinch analysis: Heat recovery & heat exchange, Significance, Heat Exchanger network design, Implications, Methodology.

Unit 2: Data extraction and energy targeting: Data extraction, Case study – organics distillation plant, Energy Targeting, Multiple utilities, Advance energy targeting, Targeting heat exchange units, area and shells, Super targeting – Cost targeting for optimal difference in temperature, case study – organic distillation plant.

Unit 3: HEN Design Utilities: Introduction, Heat Exchanger equipment, Stream splitting and cyclic matching, Network relaxation, complex design, multiple pinches and near pinches, retrofit design, operability, network design for organics distillation – case study.

Unit 4: Heat and power systems: Introduction, CHP systems, Heat pump & refrigeration system, total site analysis, organic distillation unit, case studies.

Unit 5: Process change and evolution: Introduction, principles, reactor systems, distillation column, separation systems, applications to the organic distillation. Batch and time dependent processes: Introduction, streams in batch processes, time intervals, calculating energy targets, heat exchanger network design, rescheduling, debottlenecking, time dependent applications.

Unit 6: Applying the Technology in Practice: Introduction, Pinch study, heat & mass balance, Stream data extraction, targeting & network design, Targeting softwares, industrial experience. Case Studies: Introduction, crude preheat train, aromatics plant, Evaporation plants, organic chemicals manufacturing site.

Text / References:

1. Kemp I. C., Pinch Analysis and Process Integration, 2nd Ed., 2007, Elsevier Publication.
2. Noureddin M. B., Pinch Technology and Beyond Pinch, New Vistas on Energy Efficiency Optimization, Booktopia 2011.
3. Biegler L. T., Grossmann I. E. and Westerberg A. W., Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

Elective - IV

MCH 204	ELECTIVE - IV	3 – 0 – 0	3 Credits

A. Computer Control of Process Plants

Pre-requisites: None

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

CO1	Apply cascade control, feed-forward control, ratio control, time delay compensated controller strategies to chemical processes.
CO2	Design controllers for multivariable loops.
CO3	Understand dynamic behavior of discrete time processes.
CO4	Design discrete controllers for first order and second order processes.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	✓	-	-	-	-	-	-
CO2	-	✓	-	-	-	-	-	-
CO3	✓	-	-	-	-	-	-	-
CO4	-	✓	-	-	-	-	-	-

Detailed syllabus

Unit 1: Advanced control strategies: Cascade Control, Feed-forward and ratio control, Time delay compensation, Inferential control; Nonlinear control, Adaptive control.

Unit 2: Control of multi input, multi output processes: Process interactions, Control loop interactions; Pairing of controlled and manipulated variables, Singular value analysis,

Unit 3: Tuning of multi-loop controllers, Decoupling, Supervisory control.

Unit 4: Digital computer control: Sampling and filtering of continuous measurements, Analog filters, digital filters, Z-Transforms, Development of discrete time models, Dynamic response of discrete time systems,

Unit 5: Analysis of sampled data control systems, Stability analysis.

Unit 6: Design of digital controllers: Deadbeat, Dalhin and Vogel-Edgar Algorithms, Digital computer simulation of control systems.

Text / References:

1. Seborg D. E., Edgar T. F. and Mellichamp D. A., Process Dynamics and Control, John Wiley and Sons, 2010.
2. Coughnowr D. R. and LeBlanc S., Process Systems Analysis and Control, 3rd Edition, McGraw Hill International, 2011.
3. Stephanopolaus G., Chemical Process Control, Prentice Hall India, 2008.

B. Steady State Process Simulation

Pre-requisites: None

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

CO1	Understand different approaches to simulation and define the problem for simulation.
CO2	Analyse the problem and identify degrees of freedom and understand the importance of property estimation methods.
CO3	Apply mathematical methods suitable for solving explicit iterative loops, sparse sets of equations, partitioning & precedence ordering and to find best tear stream sets.
CO4	Carry out steady state process simulation using sequential modular approach and equation oriented approach.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	✓	-	-	-	-	-	-	-
CO2	✓	-	-	-	-	-	-	-
CO3	✓	✓	-	-	-	-	-	-
CO4	✓	✓	-	-	-	-	-	-

Detailed syllabus

Unit 1: Introduction: Steady-state flow sheeting and the design process, the total design project. Flow sheeting on the computer: Motivation for development, Developing a simulation model, Approaches to flow sheeting systems-examples.

Unit 2: Solving linear and nonlinear algebraic equations: Solving one equation in one unknown, Solution methods for linear equations, General approaches to solving sets of nonlinear equations, Solving sets of sparse nonlinear equations.

Unit 3: Physical property service facilities: The data cycle, Computerized physical property systems, Physical property calculations. Degrees of freedom in a flow sheet: Degrees of freedom, Independent stream variables, Degrees of freedom for a stream and a unit, Degrees of freedom for a flow sheet.

Unit 4: The sequential modular approach to flow sheeting: The solution of an example flow sheeting problem, Other features: Handling design specifications, information streams and control blocks, Convergence of tear streams: Sequential convergence and simultaneous convergence, Partitioning and precedence ordering set of equations and a flow sheet, tearing a flow sheet, Finding the best tear set family.

Unit 5: Flow sheeting by equation solving methods based on tearing: A simple example, An example system based on equation solving, A complex example of selecting decision and tear variables for a flow sheet, Handling the iterated variables.

Unit 6: Simulation by linear methods: Introduction to linear simulation, Application to staged operations, Application to management problem. Simulation by Quasi-linear approach: Introduction to Quasi-linear methods, Simulation of flows in pipe networks, Application to distillation, Application to multiple reaction equilibrium, Towards process simulation by Quasi-linear methods.

Text / References:

1. Westerberg A. W., Hutchison H. P., Motard R. L. and Winter P., Process Flowsheeting, Cambridge University Press, 2011.
2. Benedek P. (Ed), Steady State Flowsheeting of Chemical Plants, Elsevier Scientific Publishing Co., 1980.
3. Babu B. V., Process Plant Simulation, Oxford University Press, 2004.

C. Energy Management

Pre-requisites: None

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

CO1	Implement energy audit for a chemical plant
CO2	Suggest methods of conserving energy requirement
CO3	Evaluate the suitability of renewable energy resources
CO4	Analyze the energy utilization of a process equipment

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	✓	-	-	-	-	-
CO2	-	-	✓	-	-	-	-	-
CO3	-	-	✓	-	-	-	-	-
CO4	-	-	✓	-	-	-	-	-

Detailed syllabus

Unit 1: Energy Scenario: Energy use patterns, energy resources, Oil a critical resource, economic and environmental consideration, Future scenario

Unit 2: Heat & work: First & second law of thermodynamics, Heat Engines.

Unit 3: Energy Audit: Energy conversion, Energy index, Energy consumption representation - pie chart, Sankey diagram & load profile, general audit, detailed audit, waste heat recovery.

Unit 4: Targeting and Conservation: Energy utilization and conversion – thermal efficiency, Heat Exchangers – heat recovery , Air conditioners – supply and removal of heat.

Unit 5: Recent advances in energy: Solar energy, Wind energy, Nuclear energy, Biomass, Geothermal energy, Future Energy Alternatives.

Unit 6: Case Studies: Energy conservation in alcohol industry, fertilizer industry, and pulp and paper industry, Energy conservation in different units of refinery like FCCU, HCU and ADU.

Text / References:

1. Murphy W.R. and Mckay G., Energy Management, Elsevier, 2007.
2. HinrichsR. A. and Kleinbach M. H., Energy: Its Use and the Environment, Cengage Learning, 2012.

MCH 302	PROJECT WORK - STAGE I	0 – 0 – 0	10 Credits

Pre-requisites: None

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

CO1	Identify the problem based on literature survey
CO2	Formulate the problem
CO3	Identify the methods or techniques required for the solution
CO4	Develop the solution methodology

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	-	✓	✓	✓	✓
CO2	✓	-	-	-	✓	✓	✓	-
CO3	✓	✓	-	-	✓	-	-	-
CO4	✓	✓	-	-	✓	✓	✓	✓

MCH 401	PROJECT WORK - STAGE II		0 – 0 – 0	20 Credits

Pre-requisites: MCH 2102 Project Work – Stage I

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

CO1	Implement the methods/techniques identified in dissertation part-A
CO2	Analyze and interpret the results obtained
CO3	Compare the results obtained with literature.
CO4	Demonstrate the original contribution to knowledge

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	✓	-	-	✓	✓	✓	-
CO2	✓	✓	-	-	✓	✓	✓	-
CO3	✓	✓	-	-	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓