M.Tech. Program Chemical Engineering
Course Structure

1. A minimum of 64 credits are to be completed by a student for the award of M.Tech. Degree in Chemical Engineering.

   Credit distribution is as follows:

Core Subjects	:	22 Credits
Project	:	26 Credits
Electives	:	12 Credits
Mandatory	:	04 Credits

2. Full time duration : 2 Years
3. Part Time : 3 Years
4. 12 to 18 credits are to be taken by full time student in each semester.
5. Part time student has to take 9 to 12 credits in each semester.
6. Initially total intake = 18 (Full Time 15 + Part Time 3)

Scheme of Course

I Year I Semester						
S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Credits**
1.	ChMC11	Advanced Transport Phenomena	3	0	0	3
2.	ChMC12	Advanced Reaction Engineering	3	0	0	3
3.	ChMC13	Process Modeling & Simulation	3	0	2	4
4.	ChMC14	Advanced Instrumentation Laboratory	0	0	4	2
5.		Elective – I	Separately Given			3
6.		Elective – II	Separately Given			3
		Total	**15**	**0**	**6**	**18**

I Year II Semester						
S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Credits**
1.	ChMC21	Advanced Mass Transfer	3	0	0	3
2.	ChMC22	Advanced Process Control	3	0	0	3
3.	ChMC23	Computational Fluid Dynamics	3	0	2	4
4.	ChMS21	Seminar	0	0	4	2
5.		Elective - III	Separately Given			3
6.		Elective – IV	Separately Given			3
		TOTAL	**15**	**0**	**6**	**18**

II Year I Semester						
S. No.	**Course No.**	**Subjects**	**L**	**T**	**P**	**Credits**
1.	ChMV31	Comprehensive Viva-voce	0	0	4	2
2.	ChMD31	Dissertation Part-A	0	0	20	10
		TOTAL	0	0	24	12

II Year II Semester						
S. No.	**Course No.**	**Subjects**	**L**	**T**	**P**	**Credits**
1.	ChMD41	Dissertation Part-B	0	0	32	16
		TOTAL	0	0	32	16

Abbreviations used:

C Core Subject
Ch Chemical Eng. Department/ Subject
D Dissertation
E Elective Subject
HS Humanities and Social Sciences Dept./Subject
M Master Programme
MT Mathematics Department/Subject
S Seminar
V Comprehensive Viva-Voce

First digit in course number: Stands for semester, like first, second, third etc.
Second digit in course number : Stands for course of the semester, like first, second, third etc.

LIST OF ELECTIVES

I Year I Semester

Elective – I

S. No.	Course No.	Course Name	L	T	P	Credits
1.	ChME11	Advanced Heat Transfer	3	0	0	3
2.	ChME12	Risk Analysis and Hazops	3	0	0	3
3.	ChME13	CAD for Mass Transfer Equipments	2	0	2	3
4.	ChME14	Enzyme Eng. and Technology	3	0	0	3
5.	MTME15	Advanced Numerical Methods	3	0	0	3

I Year I Semester

Elective – II

S. No.	Course No.	Course Name	L	T	P	Credits
1.	ChME16	CAD for Heat Transfer Equipments	2	0	2	3
2.	ChME17	Computer Aided Design in Chemical Eng.	2	0	2	3
3.	ChME18	Modeling and Simulation of Chemical Eng. Systems	2	0	2	3
4.	ChME19	Petroleum Refinery Eng.	3	0	0	3
5.	HSME110	Marketing Management	3	0	0	3

I Year II Semester

Elective – III

S. No.	Course No.	Course Name	L	T	P	Credits
1.	ChME21	Membrane Science and Technology	3	0	0	3
2.	ChME22	Advanced Topics in Separation Process	3	0	0	3
3.	ChME23	Process Integration	3	0	0	3
4.	ChME24	Downstream Processing in Biotechnology	3	0	0	3

I Year II Semester

Elective – IV

S. No.	Course No.	Course Name	L	T	P	Credits
1.	ChME25	Environmental Eng. and Waste Management	3	0	0	3
2.	ChME26	Fundamentals of Fuel Cell Technology	3	0	0	3
3.	ChME27	Heterogeneous Catalysis and Catalytic Processes	3	0	0	3
4.	HSME28	Advanced Course in Entrepreneurship Development	3	0	0	3

SYLLABUS

M.Tech. (Chemical Engineering)

ChMC11 ADVANCED TRANSPORT PHENOMENA (3-0-0) 3

Isothermal systems: Equations of change, Velocity distributions in 2D and 3D for laminar and turbulent flow, Macroscopic balances. Non-Isothermal Systems: Temperature distributions in 2D and 3D for solids, laminar flow and turbulent flow, Macroscopic balances. Concentration distributions in 2D and 3D for solids, laminar flow and turbulent flow, Interphase transport in multi-component systems, Macroscopic balances for multi- component systems.

References:

1. Bird R.B., Stewart W.E. and Light Foot E.N., Transport Phenomena, Wiley International Edition, 2007.
2. Christie J. Geankopolis, Transport Processes and Unit Operations, 4th Edition, Prentice Hall (India) Pvt. Ltd., New Delhi, 2004.
3. William J. Thomson, Transport Phenomena, Pearson Education, Asia, 2001.

ChMC12 ADVANCED REACTION ENGINEERING (3-0-0) 3

Reaction Kinetics with examples, Effect of flow on conversions in PFR and CSTR, Non-Isothermal reaction modeling in CSTR and Semi-Batch reactor, Need for Multi-staging, Optimal Design of Reactors for Reversible exothermic reactions. Design of PFR and packed tubular reactors, Catalytic reactions: theory and modeling, Fluidized bed reactor modeling, Application of Population Balance Equations for reactor modeling, Porous media reactors. Reaction engineering and mitigation of lobal Warming absorption in high pressure water.

References:

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

ChMC13 PROCESS MODELING & SIMULATION (3-0-2)4

Introduction: Introduction to process modeling and simulation. Models: Models, need of models and their classification, models based on transport phenomena principles, scaling, alternate classifications of models, population balance, stochastic, and empirical models. Unit models of simple Chemical Engineering systems and their block diagrams. Modeling of Chemical Engineering Systems: Reactors - fixed bed reactor, fluidized bed reactor, bioreactors (aerobic and anaerobic). Evaporators, cyclone separators, ESPs; Stack dispersion modeling. Modeling of safety systems. Process Simulation: Techniques of digital simulation. Lumped parameter systems, stability, model analysis, discretization, and discrete to continuous systems. Newton's and globally convergent methods for set of nonlinear equations; Use of Runge-Kutta and Gear's methods for solution of staged separation problems, finite difference approximation of partial differential equations and their solutions.

References:

1. Denn M. M., "Process Modeling", Longman, 1986.
2. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill, 1990.
3. Najim K., "Process Modeling and Control in Chemical Eng.", CRC, 1990.
4. Aris R., "Mathematical Modeling, Vol. 1: A Chemical Eng. Perspective (Process System Eng.)", Academic Press, 1990.

ChMC14 ADVANCED INTRUMENTATION LABORATORY (0-0-4)2

Spectroscopic methods: UV-spectrometer; Fourier transform infrared spectroscopy (FTIR). Chromatographic methods: Gas chromatography (GC); High performance liquid chromatography (HPLC); Ion Chromatograph.

Electrochemical methods: Auto titrator; Galvanostat Potentiostat; Electrophoresis.

Miscellaneous: Particle size analyzer; COD/ TOC analyzer; CHNS analyser; AOX analyser; BET surface area, Pore size and pore volume measurement; Temperature programmed reduction (TPR), Temperature programmed desorption (TPD), Temperature programmed oxidation (TPO), H_2-Chemisorption.

Demonstration Equipments: X-ray photoelectron spectroscopy (XPS), Raman, X-ray diffraction (XRD) with Energy-dispersive X-ray spectroscopy (EDAX), Gas chromatography-mass spectrometry (GCMS), Scan electron microscopy (SEM), Transmission electron microscopy (TEM), Thermogravimetric analysis (TGA), Differential scanning calorimetry (DSC).

References:

1. Skoog, Holler and Crouch, **Principles of Instrumental Analysis**, Brooks Cole, 6th edition, 2006.
2. Rouessac and Rouessac**, Chemical Analysis: Modern Instrumentation Methods and Techniques,** Wiley, 2nd edition, 2007.
3. Willard H.H., Merritt J.L., Dean, J.A., Settle, F.A., "Instrumental methods of analysis" CBS Publishers & Distributors Pvt. Ltd. 7th Edition, 2009.

ChMC21 ADVANCED MASS TRANSFER (3-0-0)3

Characterization of Separation processes, Simple equilibrium processes, Multistage separation processes, Binary multistage separation, Binary multistage separations-general graphical approach, Energy requirements of a separation process, Equilibrium and simple distillation - Multi-component, Fractional distillation - Multi- component.

References:

1. C. Judson King, Separation Processes, Tata McGraw Hill Book Company, 2nd Edition, New Delhi, 1983.
2. Mathew Vanwinkle, Distillation, McGraw Hill Chemical Eng. Series, New York, 1967.
3. Charles D. Holland, Multi-component Distillation, Prentice Hall of India Pvt. Ltd., 1981.

ChMC22 ADVANCED PROCESS CONTROL (3-0-0)3

Review of Dynamic Process Models: Linear and non-linear, lumped and distributed parameter systems.

Control of linear systems: Laplace and Z transforms, review of single-loop feedback control systems, stability and controller tuning, Smith compensator for systems with large dead-time and inverse response, multi-loop control-cascade, selective and split-range control, feed-forward control, ratio-control, adaptive control, inferential control, internal model control, model predictive control.

Multivariable Control: Controllability and operability, alternative control configuration, interaction (RGA), variable pairing and decoupling, control of complete plants.

Digital Control: Sampling and reconstruction, discrete-time response and stability, design of controllers, on-line process identification.

Introduction to Control of Non-linear systems.

References:

1. Stephanopoulos, G., "Chemical Process Control", Prentice Hall, 1984.
2. Coughanowr, D.R. and LeBlanc, S., "Process Systems Analysis and Control", 3rd ed., McGraw Hill, 2008.
3. Seborg, D. E., Edgar, T. F. and Mellichamp, D. A., "Process Dynamics and Control", 2nd ed., John Wiley, 2010.
4. Bequette, B.W., "Process Control – Modeling, Design and Simulation", Prentice Hall, 2003.
5. Roffel, B. and Betlem, B., "Process Dynamics and Control-Modeling for Control and Prediction", John Wiley, 2006.

ChMC23 COMPUTATIONAL FLUID DYNAMICS (3-0-2)4

Review of basic fluid mechanics and the governing (Navier-Stokes) equations; Techniques for solution of PDEs – finite difference method, finite element method and finite volume method; Finite volume (FV) method in one-dimension; Differencing schemes; Steady and unsteady calculations; Boundary conditions; FV discretizationin two and three dimensions; SIMPLE algorithm and flow field calculations; variants of SIMPLE. Turbulence and turbulence modeling; illustrative flow computations; Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

Special Topics**:** Case studies using FDM and FVM: Flow and heat transfer in pipes and channels, square cavity flows, reactive flow, multiphase flow, rotary kiln reactors, packed and fluidized bed reactors, furnaces and fire systems.

References:

1. C.A.J Fletcher. Computational Techniques for Fluid Dynamics. Vol. 1: Fundamental and General Techniques, Vol. 2: Specific Techniques for Different Flow Categories. Springer-Verlag, 1998.
2. J.D. Anderson. Computational Fluid Dynamics. McGraw Hill, 1995.
3. P.S. Ghosh Dastidar. Computer Simulation of Flow and Heat Transfer. Tata McGraw Hill, 1998.
4. J.H. Ferziger and M. Peric. Computational Methods for Fluid Dynamics. 3rd editon. Springer, 2002.
5. S.V. Patankar. Numerical Heat Transfer and Fluid Flow. Taylor and Francis, 2004.
6. G.H. Yeoh and K.K. Yuen. Computational Fluid Dynamics in Fire Eng.: Theory, Modelling and Practice. Butterworth-Heinemann, 2009.

ELECTIVE – I

ChME11 ADVANCED HEAT TRANSFER (3-0-0) 3

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; One dimensional conduction with generation; Plane slab; Cylindrical and spherical system; Finite difference methods in steady state conduction; 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, Natural Convection, Forced Convection, Radiation Heat transfer - Concepts, Calculation of the net radiant loss; Net radiant loss from non-gray surfaces; Gas radiation.

References:

1. James Sucec, "Heat Transfer", Jaico Publishing House, 2006.
2. Holman, J.P. and White P.R.S., "Heat Transfer", 7th Edition, Mc-Graw Hill, 2009.
3. John H Lienhard IV and John H Lienhard V, " A Heat Transfer Text Book", Cambrigdge MA, Phlogiston Press, 2008.
4. Mills, A. F., "Heat Transfer", Prentice Hall, 1999.
5. Mills, A. F., "Heat and Mass Transfer", Irwin, Chicago, Ill., 1995.
6. Incropera, F. P., and DeWitt, D. P., "Fundamentals of Heat and Mass Transfer", Wiley, New York, 1996.

ChME12 RISK ANALYSIS AND HAZOPS (3-0-0) 3

Types of Risk analysis, types of failure, dispersion and toxic models, fire and explosion models, Risk Management and ISO14000: Disaster management plan, Emergency Planning, Case studies, Hazard identification, Safety Audits, Checklists, What if Analysis, Vulnerability models, Event tree and Fault tree Analysis, Past accident analysis, Hazops, Principles, Risk ranking, Guide word, Parameter, Deviation, Causes, Consequences, Recommendation, Coarse HAZOP study, Case studies.

References:

1. K. V. Raghavan and A A. Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
2. V. C. Marshal, Major Chemical Hazards, Ellis Horwood Ltd., Chichester, United Kingdom, 1987.
3. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

ChME13 CAD FOR MASS TRANSFER EQUIPMENTS (2-0-2) 3

Basic Design Principles and Methods: Ideal-liquid-solution models, non-ideal thermodynamic property models, and activity-coefficient models for liquid phase. Design variables and their influence on multi-component separation processes, short cut design methods for absorption, stripping, extraction and distillation column.

Multicomponent Separation Processes and CAD of staged-columns: Separation of multicomponent mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions, tridiagonal formulation of component material balances and equilibrium relationships for distillation, absorption and extraction of multicomponent systems. Design of absorbers, distillation columns, strippers and extractors.

Tray Hydraulics: Tray hydraulics and design considerations for various trays.

Packed Columns: CAD of packed columns for various separation processes (Absorption, extraction, distillation using different packings and adsorption).

References:

1. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering, Series", Vol. VI, 4th Ed., Butterworth-Heinemann, 2005.
2. Seader J. D. and Henley E. J., "Separation Process Principles", 2nd Ed., Wiley-India, 2006.
3. Holland C. D., "Fundamentals and Modeling of Separation Processes", Prentice Hall, 1975.
4. Stichlmair, J. G. and Fair J. R., "Distillation Principles and Practices", Wiley-VCH, 1998.

ChME14 ENZYME ENGINEERING AND TECHNOLOGY (3-0-0)3

Introduction and Scope; Chemical and Functional nature of enzymes; Application of enzymes in process industries and health care; Microbial production and purification of industrial enzymes, Kinetics of enzyme catalyzed reactions; Immobilization of enzymes; Stabilization of enzymes. Bioreactors for soluble and immobilized enzymes, Mass transfer and catalysis in immobilized enzyme reactors.Enzyme based biosensors; Enzyme catalyzed processes with cofactor regeneration; Enzymatic reactions in micro-aqueous medium and nonconventional media. Laboratory: assay of enzyme activity and specific activity; Kinetic analysis of an enzyme catalyzed reaction; Immobilization of enzymes by adsorption and covalent binding; Salt precipitation of an enzyme; Immobilization of microbial cells by entrapment; Effect of water activity and solvent on the lipase catalyzed esterification reaction.

References:

1. Bailey, J. E., Ollis, D. F., "Biochemical Engg. Fundamentals". McGraw-Hill Book Company, New York,1985.
2. Shuler, M., Kargi, F., "Bioprocess Engineering, Basic Concepts". Prentice Hall of India Pvt. Ltd. , 2004.
3. Moser,A., "Bioprocess Technology". Springer-Verlag, New York, 1988.
4. Pelczar, M.J., Chan, E.C.S., Krieg, N.R., "Microbiology". McGraw-Hill Book Company, 1986.
5. Aiba, S., Humphrey, A.E., Millis, N.F., "Biochemical Engineering". Academic Press, N.Y., 1965.
6. Fairley, J .L., Kilgour, G. L., "Essentials of Biological Chemistry". Reinhold Publishing Corporation, 1966.
7. Palmer, T., "Understanding Enzymes". Ellis Horwood Limited, Halsted Press, a division of John Wiley & Sons, 1985.

MTME15 ADVANCED NUMERICAL METHODS (3-0-0)3

Interpolation: The difference operators, their properties and applications. Interpolation with equal intervals, Newton's advancing difference formula. Newtons's backward difference formula. Interpolation with unequal intervals. Newton's divided difference formula. Lagrange's interpolation formula. Spline functions. Gauss forward and backward interpolation formula, Sterlings, Bessel's, Laplace and Everetts formulae.

Numerical Solution of Algebraic and Transcendental Equations: Iterative method, Graphic Method, Regula-Fast method, Balzano's Process of bisection of intervals, Newton-Raphson Method and its geometrical significance.

Solution of Linear Systems: Matrix Inversion Method, Gauss Elimination, Gauss – Jordan Method, Modification of the Gausss Method to Compute the Inverse.

Numerical Differentiation and Integration: Numerical Integration, General Quadrature Formula, Simpson's one-third and three-eight rules, Weddles' rule, Hardy's rule, Trapezoidal rule.

Numerical Solution of Ordinary and Partial Differential Equations : Picard's method. Numerical solution of ordinary differential equations, Taylors series method, Euler's method, Runge-Kutta Method. Solution of Parabolic, elliptical and hyperbolic partial differential equations.

References:

1. S.S. Sastry , "Introductry methods in Numerical Analysis", Prentice Hall of India.
2. M.K.Jain, S.R.Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineers", Wiley Eastern Ltd.
3. S.C. Scarborough, "Mathematical Numerical Analysis", Oxford and IBH Publishing Company.
4. T.Veerarjan and T.Ramachandaran, "Theory and Problems in Numerical Methods", Tata McGraw-Hill Publishing Company, New Delhi, 2004.
5. John H. Mathews, "Numerical Methods for Mathematics, Sciences and Engineering, Prentice-Hall of India, New Delhi, 2003.

ELECTIVE -II

ChME16 CAD FOR HEAT TRANSFER EQUIPMENTS (2-0-2) 3

Introduction: Basic design procedure of heat transfer equipment, overall heat transfer coefficient and dirt factors, shell and tube heat exchangers – construction details, selection algorithm, design codes, mean temperature difference.

Heat Exchangers: General design considerations of shell and tubes of heat exchangers, thermo physical properties, design of double pipe heat exchangers, tube-side heat transfer coefficient and pressure drop, shell-side heat transfer coefficient and pressure drop by using Kern, Bell and HTRI methods, CAD of shell and tube heat exchangers; Mechanical and fabrication aspects.

Condensers: CAD of condensers for single vapors, desuperheater-cum-condenser and condenser-cum-sub-cooler, condensers for multicomponent vapours with and without non-condensables.

Reboilers, Vaporizers and Evaporators: Pool boiling, convective boiling, selection and CAD of reboilers, vaporizers and evaporators.

Compact Heat Exchangers: CAD of special heat transfer equipment like plate heat exchangers, finned tube heat exchangers, bayonet heat exchangers, spiral heat exchangers, suction heater, coiled and jacketed heating vessels.

Fired Heaters and Furnaces: CAD of fired heaters and furnaces.

References:

1. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Ed., Butterworth-Heinemann, 2005.
2. Serth R. W., "Process Heat Transfer Principles and Applications", Elsevier Science and Teaching, 2007.
3. Hewitt G.F., Shires G. L. and Bott T. R., "Process Heat Transfer", Begell House, 1994.
4. I.S.: 4503-1967, Indian Standard Specification for Shell and Tube Type Heat Exchangers, 1967.

ChME17 COMPUTER AIDED DESIGN IN CHEMICAL ENGINEERING (2-0-2) 3

Software development for design of various chemical equipments. Design of minimum energy heat exchanger network, sequencing and energy integration in distillation column simulation of process flow sheets using software package, Aspen Plus.

References:

1. Mexandre C. Dimian (Editor),"Integrated Design and Simulation of Chemical Processes" Vol. 13, Elsevier B.V.,2013.
2. Andrzej Kraslawski and Ilkka Turunen, "23 European Symposium on Computer Aided Process Engineering", Volume 32, Elsevier B.V.,2013.
3. Westerberg, A.W. ,"Computer-aided design tools in chemical engineering process design", Vol. 69, Issue 10, pages 1232 - 1239, Proceedings of the IEEE.

4. Mexandre C. Dimian, "Integrated Design and Simulation of Chemical Processes" Elsevier, 2003.
5. Michael E. Hanyak Jr., "Chemical Process Simulation and the ASPEN Hysis Software" Publisher Chemical Engineering Department, Bucknell University, Lewisburg, PA 17837, 1998.
6. William L. Luyben, "Use of Dynamic Simulation to Converge Complex Process Flow sheets", *ChE Division of ASEE, 2004.*
7. Biegler, L.T.; Grossmann, I.E.and Westerberg, A.W., "Systematic Methods for Chemical Process Design", Carnegie Mellon Univ., Pittsburgh, PA , 1997.

ChME18 MODELING AND SIMULATION OF CHEMICAL ENGINEERING SYSTEMS (2-0-2)3

Introduction: Introduction to process modeling and simulation.
Models: Models, need of models and their classification, models based on transport phenomena principles, scaling, alternate classifications of models, population balance, stochastic, and empirical models. Unit models of simple Chemical Engineering systems and their block diagrams
Modeling of Chemical Engineering Systems: Reactors - fixed bed reactor, fluidized bed reactor, bioreactors (aerobic and anaerobic). Evaporators, cyclone separators, ESPs; Stack dispersion modeling. Modeling of safety systems.
Process Simulation: Techniques of digital simulation. Lumped parameter systems, stability, model analysis, discretization, and discrete to continuous systems.
Newton's and globally convergent methods for set of nonlinear equations; Use of Runge-Kutta and Gear's methods for solution of staged separation problems, finite difference approximation of partial differential equations and their solutions.

References:

1. Denn M. M., "Process Modeling", Longman, 1986.
2. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill, 1990.
3. Najim K., "Process Modeling and Control in Chemical Engineering", CRC, 1990.
4. Aris R., "Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press, 1999.

ChME19 PETROLEUM REFINERY ENGINEERING (2-0-2) 3

Introduction : Composition of petroleum, laboratory tests, refinery products, characterization of crude oil. Design of crude oil distillation column. Catalytic cracking. Catalytic reforming. Delayed coking. Furnace design. Hydrogenation and Hydro cracking. Isomerisation, Alkylation and Polymerization.
Lube oil manufacturing. Energy conservation in petroleum refineries. New Trends in petroleum refinery operations. Pyrolysis of Naphtha and light hydrocarbons: modelling (time permitting).

References:

1. Robert A. Meyers, "Handbook of Petroleum Refining Processes" McGraw-Hill Education LLC, 3rd Edition, 2004.
2. W.L..Nelson " Petroleum Refining Engineering " Mc Graw- Hill.
3. R.N.Watkins, " Petroleum Refinery distillation " Gulf Publishing Co.
4. James G Speight " The chemistry and technology of petroleum ".
5. J.H. Gary and G.E. Handwerk " Petroleum Refinery Technologies and Economics ".

HSME110 MARKETING MANAGEMENT (3-0-0) 3

Introduction
Marketing - Definitions, conceptual frame work - Marketing environment: Internal and external Marketing interface with other functional areas - Production, Finance, Human Relations Management, Information system.
Marketing in global environment - Prospects and challenges.

Marketing Strategy
Marketing strategy formations - Key drivers of marketing strategies - strategies for industrial marketing - consumer marketing - service marketing - competitor analysis - analysis of consumer and industrial markets - strategic marketing mix components.

Marketing Mix Decisions
Product planning and development - product life cycle - new product development and management - marketing segmentation - targeting and positioning - channel management - advertising and sales promotions - pricing objectives- policies and methods.

Buyer Behaviour
Understanding industrial and individual buyer behavior - Influencing factors - Buyer Behaviour Models - online buyer behaviour - Building and measuring customer satisfaction - customer relationship management - Customer acquisition, Retaining, Defection.

Marketing Research & Trends in Marketing
Marketing Information system - Research Process - Concept and applications : Product - Advertising - Promotion - Consumer behaviour - Retail research - Customer driven organizations - cause related marketing - Ethics in marketing - Online marketing trends.

References:

1. Philip Kortler and Kevin Lane Keller, "Marketing Management" PHI, 2012.
2. K.S. Chandrasekar, "Marketing Management -Text and cases", Tata McGraw Hill, 2010

ELECTIVE-III

ChME21 MEMBRANE SCIENCE AND TECHNOLOGY (3-0-0)3

Introduction to membrane separation processes, their classification, and applications. General transport theories including theory of irreversible thermodynamics for multicomponent systems. Membrane preparation techniques. Design and analysis and industrial application of various membrane processes such as reverse osmosis, ultrafiltration electrodialysis, dialysis,
liquid membrane separation, gas permeation and pervaporation.

References:

1. Sun-Tak-Hwang and Karl Kammermeyer, "Membranes in Separations", John Wiley & Sons, New York, 1975.
2. Coulson J.M. and Richardson J.F. , "Chemical Engineering: Particle Technology and Separation Processes", Vol. 2, 4th Edition, Asian Books Pvt. Ltd. New Delhi, 1998.
3. Christie J. Geankoplis, "Transport Processes and Unit Operations", 4th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
4. Strathmann H.,Giorno L. and Drioli E., "An Introduction to *Membrane* Science and Technology", Institute of Membrane Technology, CNR-ITM, University of Clabria, Italy, 2006.

ChME22 ADVANCED TOPICS IN SEPARATION PROCESS (3-0-0)3

Introduction: Separation processes in chemical and biochemical industries, categorization of separation processes, equilibrium and rate governed processes.

Bubble and Foam Fractionation: Nature of bubbles and foams, stability of foams, foam fractionation

techniques, batch, continuous, single stage and multistage columns.

Membrane Separation: Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.

Special Processes: Liquid membrane separation, super-critical extraction, adsorptive separation-pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation.

Chromatographic methods of separation: Gel, solvent chromatography

References:

1. King C.J., "Separation Processes", Tata McGraw Hill.
2. Seader J.D. and Henley E.J. "Separation Process Principles", 2nd edition, Wiley-India, 2006.
3. Basmadjian D, "Mass Transfer and Separation Processes: Principles and Applications", 2nd edition, CRC, 2007.
4. Khoury F M, "Multistage Separation Processes", 3rd edition, CRC, 2004.
5. Wankat P C, "Separation Process Engineering", 2nd edition, Prentice Hall, 2006.
6. Sun-Tak-Hwang and Karl Kammermeyer, "Membranes in Separations", John Wiley & Sons, New York, 1975.
7. Strathmann H.,Giorno L. and Drioli E., "An Introduction to *Membrane* Science and Technology", Institute of Membrane Technology, CNR-ITM, University of Clabria, Italy, 2006.

ChME23 PROCESS INTEGRATION (3-0-0)3

Process Integration and its Building Blocks: Definition of process integration (PI), areas of pplication and techniques available for PI.

Pinch Technology: Basic concepts, role of thermodynamics. Data extraction, targeting, designing, optimization-supertargteing. Grid diagram, composite curve, problem table algorithm, grand composite curve.

Targeting of Heat Exchanger Network (HEN): Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.

Designing of HEN: Pinch design methods, heuristic rules, stream splitting, design of maximum energy recovery (MER), design of multiple utilities and pinches, design for threshold problem, loops and paths.

Heat and Mass Integration in process system: Heat engine, heat pump, distillation column, reactor, evaporator, drier, refrigeration system and water recycle and reuse systems.

Heat and Power Integration: Co-generation, steam turbine, gas turbine.

References:

1. Kemp I. C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth-Heinemann, 2007.
2. Smith R., "Chemical Process Design and Integration", 2nd Ed., Wiley,2005.
3. El-Halwagi M. M., "Process Integration", 7th Ed., Academic Press, 2006.
4. Shenoy U. V., "Heat Exchanger Network Synthesis", Gulf Publishing Company, 1995.

ChME24 DOWNSTREAM PROCESSING IN BIOTECHNOLOGY (2-0-2)3

Characteristics of bioproduct, flocculation and conditioning of fermented medium, Revision of mechanical separation (filtration, Centrifugation etc.), cell disruption, Protein precipitation and its separation, Extraction, Adsorption-Desorption processes, Chromatographic methods based on size, charge, shape, biological affinity etc., Membrane separations ultrafiltration and electrodialysis, Electrophoresis, Crystalization, Drying. Laboratory: Conventional filtration, centrifufation in batch and continuous centrifuge, Cell disruption, Ion-exchange chromatography, Membrane based filtration-ultrafiltration in cross flow modules and microfiltration.

References:

1. Shuler, M., Kargi, F., "Bioprocess Engineering, Basic Concept, 2nd Edn.", Prentice Hall PTR, 2004.
2. Bailey, J.E., Ollis, D.F., "Biochemical Engg. Fundamentals, 2nd edn.", McGraw-Hill, 1985.
3. Paul A. Belter, E.L. Cussler, Wei-Shou Hu, "Bioseparations, Downstream Processing for Biotechnology" Wiley-India, 1988.
4. Van Oss, C.J. "A Review of Bioseparations, Downstream Processing for Biotechnology" Wiley-Interscience, New York, 1988.

ELECTIVE-IV

ChME25 ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT (3-0-0)3

Ecology and Environment. Sources of air, water and solid wastes. Air Pollution: Micrometeorology and dispersion of pollutants in environment. Fate of pollutants. Air pollution control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers. Design and efficiencies. Combustion generated pollution, vehicles emission control. Case studies. Water Pollution: Water quality modelling for streams. Characterisation of effluents, effluent standards. Treatment methods.. Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment. Tertiary treatments like ozonization, disinfection etc. Solid wastes collection, treatment and disposal. Waste recovery systems.

References:

1. Stern A. C.; "Air Pollution", Vol. I, II, & III, Academic Press, 1968.
2. Brauer H. and Varma Y. B. G.; "Air Pollution Control Equipment", Springer – Verlag, 1981.
3. Cheremisinoff, Nicholas P., "Handbook of Air Pollution Prevention and Control. USA: Butterworth- Heinemann, 2002.
4. Metcalf and Eddy Inc.; "Waste Water Engineering Treatment and Reuse", Revised by G. Tchobanoglous, F.L. Burton, H,D. Stensel; Tata Mcgraw-Hill, New Delhi, 2003.
5. Henze M., Loosdrecht M.C.M. van, Ekama G.A., Brdjanovic D. "Biological Wastewater Treatment, Principles, Modelling and Design", IWA publishing, London, UK, 2008.
6. Soli J Aeceivala and Shyam R Asolekar, "Wastewater Treatment for Pollution Control and Reuse", Tata McGraw Hill 3rd edition, 2007.
7. Tchobanglais G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill, 1993.
8. Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC, 2005.
9. Tedder D.W. and Pohland F.G. (editors), "Emerging Technologies in Hazardous Waste Management", ACS, 1990.

ChME26 FUNDAMENTALS OF FUEL CELL TECHNOLOGY (3-0-0)3

Overview of fuels cells: Low and high temperature fuel cells: Fuel cell thermodynamics – heat, work potentials, prediction of reversible voltage, fuel cell efficiency; Fuel cell reaction kinetics – electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses – design, activation kinetics, Fuel cell charge and mass transport – flow field, transport in electrode and electrolyte; Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models, Balance of plant; Hydrogen production and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

References:

1. Supramaniam Srinivasan, " Fuel Cells- From Fundamentals to Applications" Springer.
2. Ryan O'Hayre, Suk-Won Cha , Whitney Colella , Fritz B. Prinz, "Fuel Cell Fundamentals", John Wiley & Sons, 2009.
3. Wolf Vielstich , Arnold Lamm , Hubert A. Gasteiger (Editors) , "Handbook of Fuel Cells: Fundamentals, Technology, Applications" 4-Volume Set, John Wiley & Sons, 2013.

ChME27 DESIGN OF EXPERIMENTS AND PARAMETER ESTIMATION (3-0-0)3

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments. **Simple Comparative Experiments**: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means, randomized and paired comparison design. Experiments with Single Factor: Analysis of variance, analysis of fixed effects model, model adequacy checking, nonparametric methods in analysis of variance.

Design of Experiments: Randomized blocks, latin squares and related design, factorial design, two-factor factorial design, blocking in a factorial design, the 2^2 and 2^3 factorial design, the general 2^k factorial design, blocking and compounding in the 2^k factorial design, two-level, three level and mixed level factorial and fractional factorial designs.

Parameter Estimation: Linear regression models, estimation of the parameters in linear regression models, hypothesis testing in multiple regression, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics, testing for lack of fit.

Response Surface Methods and Other Approaches: Response surface methodology, method of steepest ascent, analysis of a second-order response surface, experimental designs for fitting response surfaces, mixture experiments, evolutionary operation, robust design; Taguchi's method for optimization of experiments.

Experiments with Random Factors: Random effect model, two factor factorial with random factors, two-factor mixed model, sample size determination with random effects, approximate F tests.

Design and Analysis: Nested and split-plot design, non-normal responses and transformations, unbalanced data in a factorial design.

References:

1. Lazic Z. R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley, 2005.
2. Antony J.," Design of Experiments for Engineers and Scientists", Butterworth Heinemann, 2004.
3. Montgomery D. C., "Design and Analysis of Experiments", 5th Ed., Wiley, 2004.
4. Roy R.K., Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement, John Wiley & Sons, New York, 2001.
5. Roy R.K., A primer on the Taguchi method, Society of Manufacturing Engineers, Michigan, 1990.

ChME28 HETEROGENEOUS CATALYSIS AND CATALYTIC PROCESSES (3-0-0)3

Basic concepts in heterogeneous catalysis, catalyst preparation and characterization, poisoning and regeneration. Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, commercial reactors (adiabatic, fluidized bed, trickle-bed, slurry, etc.). Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts. Reactor modelling . Emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry. Catalyst deactivation kinetics and modelling.

References:

1. Bruce C. Gates, " Catalytic Chemistry", John Wiley & Sons.
2. Chorkendorff, J.W Niemantsverdriet, "Concept of Modern Catalysis and Kinetics", John Wiley & Sons, 2006.
3. R.A Sheldon, I. Arends, U. Hanefeld, "Green Chemistry and Catalysis", John Wiley & Sons, 2007.
4. M.A. Vennices, "Kinetics of Catalytic Reactions", Springer, 2004.

HSME29 ADVANCED COURSE IN ENTREPRENEURSHIP DEVELOPMENT (3-0-0)3

ENTREPRENEURSHIP

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Entrepreneur– Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth.

ENTREPRENEURAL COMPETENCE

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.

ENTREPRENEURAL ENVIRONMENT

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organizational Services - Central and State Government Industrial Policies and Regulations - International Business.

MOTIVATION

Major Motives Influencing an Entrepreneur – Achievement Motivation Training, self Rating, Business Game, Thematic Apperception Test – Stress anagement, Entrepreneurship Development Programs – Need, Objectives.

BUSINESS PLAN PREPARATION

Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies.

LAUNCHING OF SMALL BUSINESS

Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching.

FINANCING AND ACCOUNTING

Need – Sources of Finance, Financial assistance through SFC's, SIDBI, Commercial banks. Term Loans, Capital Structure, Financial Institution, management of working Capital, Costing, Break Even Analysis, Network Analysis Techniques of PERT/CPM – Taxation – Income Tax, Excise Duty –Sales Tax.

MANAGEMENT OF SMALL BUSINESS

Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Busines.

References:

1. Hisrich, "Entrepreneurship", Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, "Entrepreneurial Development", S.Chand and Company Limited, New Delhi, 2001.
3. Prasama Chandra, "Projects – Planning, Analysis, Selection, Implementation and Reviews",Tata McGraw-Hill, 1996.
4. P.C.Jain (ed.), "Handbook for New Entrepreneurs", EDII, Oxford University Press, New Delhi, 1999