CHEMICAL ENGINEERING DEPARTMENT

M.Tech. CHEMICAL ENGINEERING

Course of Study & Scheme of Examination
2019-20

Maulana Azad National Institute of Technology
Bhopal

(SCHEME AND SYLLABUS)

CHEMICAL ENGINEERING DEPARTMENT

CHEMICAL ENGINEERING:

M.Tech. First Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH 511	Optimization Techniques	3	-	-	3
CH 512	Advance Transport Phenomena	3	-	-	3
CH 513	Heterogeneous Catalysis & Reactor Design	3	-	-	3
	Department elective-I	3	-	-	3
	Department elective-II	3	-	-	3
	Open elective-I	-	-	6	3
CH 514	Advance Chemical Engineering Lab.	-	-	4	2
CH 515	Seminar-I and Mini Project	-	2	-	2
					Total Credit-22

M.Tech. Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
CH 521	Advanced Process Dynamics & Control	3	-	-	3
CH 522	Advance Heat & Mass transfer	3	-	-	3
CH 523	Advanced Thermodynamics in Chemical Engineering	3	-	-	3
	Department elective-3	3	-	-	3
	Department elective-4	3	-	-	3
	Open elective-2	3	-	-	3
CH 524	Software Lab	-	-	4	2
CH 525	Seminar-II and Mini Project	-	4	-	2
					Total Credit-22

M. Tech. Third Semester (Chemical Engineering)

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
CH 611	Project Phase -I	-	3	20	23
					Total Credit-23

M. Tech. Fourth Semester (Chemical Engineering)

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
CH 612	Project Phase -II	-	3	20	23
					Total Credit-23

List of department electives

CH531 Polymer Science & Technology	CH532 Nano Technology
CH533 Bioprocess Technology	CH534 Pinch Technology
CH535 Advanced Fluid Dynamics	CH536 Bio-energy Engineering
CH537 Food Processing & Technology	CH538 Advanced Separation Technology
CH539 Textile Technology	CH 540 Advanced Analytical Techniques
CH541 Petroleum Engineering & Technology	CH542 Multiphase flow/CFD of Multiphase reactor

List of open electives

CH 551Pollution control & Engineering and safety	CH 552 Modelling & simulation of chemical engineering systems
CH553 Industrial catalysis	CH554 Trend in healthcare and Technology
CH555 Advance Environmental Biotechnology	CH556 Corrosion Engineering

MTH 511-OPTIMIZATION TECHNIQUES		
Syllabus		
Introduction: Maximization and minimization problems- examples. Basic concept of optimization – Convex and concave functions, Necessary and sufficient conditions for stationary points. Degree of freedom. Formulation: Economic objective function. Formulation of various process optimization problems and their classification. Optimization of unconstrained and constrained search: Optimization of one dimensional function, unconstrained multivariable optimization direct search methods. Indirect first order and second order methods, constrained multivariable optimization - necessary and sufficient conditions for constrained optimum. Linear programming and applications: Geometry of linear programs, Simplex Algorithm its applications. Non- linear programming with constrained and its applications: Quadratic programming, Generalized reduced gradients methods, Successive linear and successive quadratic programming, Dynamic programming, Integer and mixed integer programming. Application of optimization in chemical engineering: Optimization of staged and discrete processes, Optimal shell-tube heat exchanger design, Optimal pipe diameter, Optimal design of an Ammonia reactor. Nontraditional optimization techniques: Introduction and application areas.		
References		
1.	Optimization of Chemical Process, 2nd edition	Edger T. F. and Himmelblau D. M
2.	Optimization Theory and Practice, 1970	Beveridge G. S. and Schechter R. S
3.	Engineering Optimization Methods and Applications	Rekllaities F. V., Ravindan A. and Ragsdell K. M.
4.	Engineering Optimization, 1995	Rao S.

CH 512-ADVANCED TRANSPORT PHENOMENA		
Syllabus		
Summary of vector and tensor Notation: Vector operations from a geometrical view point. Vector operation from an analytical view point, the vector differential operations, second order tensors, vector and tensor components in curvilinear coordinates, differential operations in curvilinear coordinates. Momentum Transport: Viscosity and the mechanism of momentum transport, Newton's law of viscosity Energy Transport: Thermal Conductivity and the Mechanism of Energy Transport: Fourier's Law of heat conduction Mass Transport: Definition of concentrations, velocities and mass fluxes, Fick's law of diffusion, theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids. Turbulence Phenomena: Basic theory of turbulence, time averaging, intensity and correlation coefficients, isotropic turbulence. Equations of continuity, motion and energy for turbulent condition. Reynolds stresses. Phenomenological theories of turbulence, velocity profile in circular conduits. Convective Transport: Free and forced convective heat transfer and mass transfer, interphase mass transport, mass transfer coefficients-individual and overall, mass transfer theories-film, penetration and surface renewal. Macroscopic studies: momentum and heat balance equation, Kinetics energy calculation. Constant area and variable area flow problems. Flow through bends. Time determination for emptying of vessels.		
References		
1.	Transport Phenomena, 2nd edition	Bird R B, Stewart W E and Light fort R N,
2.	Fundamentals of Momentum, Heat and Mass Transfer, Vol - 2	Welty J R, Wilson R E and Wicks C E
3.	Momentum, Energy and Mass transfer in Continua, 1981	John C Slattery.

CH 513-HETEROGENEOUS CATALYSIS AND REACTOR DESIGN		
Syllabus		
Solid Catalyst: Role of catalyst components and other constituents, characterization of catalyst and its support. Heterogeneous Catalysis: Mechanism and kinetic models of surface reactions, determination of kinetics parameters through experiments, analysis of complex reactions, synthesis of kinetic structure. External and Internal Transport Processes: Effect of heat and mass transfer, internal effectiveness factor, generalized effectiveness factor, point effectiveness, multiple reactions, transport criteria. Deactivation of Catalyst: Physical deactivation, surface diffusion. Sintering-mechanism and kinetics, chemical deactivation-types and kinetics, regeneration of catalyst. Selectivity and Stability: Effect of transport processes and deactivation on selectivity and stability of a single pellet Multiphase Reactions: Mass transfer coefficients, effect of transport and global rates. Design of Catalytic Reactors: Design and analysis of fixed bed reactors, auto thermic operation and stability, fluidized bed reactors, two phase and multiphase models. Introduction to slurry reactors and trickle-bed reactors.		
References		
1.	Heterogeneous Reactor Design, 1985	Lee H. H
2.	Chemical Reaction and Reactor Engineering	Carberry J. J. and Verma A.
3.	Heterogeneous Reactions", Vol. 1 and 2	Doraiswamy L. K. and Sharma M.M.,
4.	Three – Phase Catalytic Reactors	Gordon and Breach
5.	Chemical Reactor Analysis and Design, 3rd edition , 2010	Froment G. F. and Bischoff K. V.
6.	Chemical Reactor modeling: Multiphase Reactive Flows, 2nd edition	Jakobsen H. A.

CH 514-ADVANCED CHEMECAL ENGINEERING LABORATORY	
Experiments	
1.	Determination of organic compounds using HPLC
2.	Determination of heavy metals using AAS
3.	Determination of microstructure using SEM
4.	Determination of pollutant concentration using UV Spectro-photometer & other.
5.	The course demands development of new methodology, experimental setup, and related theoretical background.

CH 515-SEMINAR 1 AND MINI PROJECT
Syllabus
Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure

CH 521-ADVANCED PROCESS DYNAMICS & CONTROL

Syllabus

Review of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Control valve types-linear, equal percentage and quick opening valve. Design of valves. Transient response. Block diagrams. Stability Analysis: Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode-Nyquist Plots -Process modelling.

Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, computing relays, simple alarms, Smith predictor, internal model control, theoretical analysis of complex processes.

Multivariable Control Analysis of multivariable systems, Interaction, examples of storage tanks. Review of matrix algebra, Bristol arrays, Niederlinski index - Tuning of multivariable Controllers. Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers.

References

1.	Process Systems analysis and Control, 3rd edition, 2017	D.R. Coughanour
2.	Process Dynamics and Control, 3rd edition 2010	D.E. Seborg, T.F. Edger, and D.A. Millichamp
3.	Principle and Practice of Automatic Process Control, 2003	C.A. Smith and A.B. Corripio
4.	Process Modelling Simulation and Control for Chemical Engineers, 1990	W.L .Luyben

CH 522-ADVANCE HEAT & MASS TRANSFER		
Syllabus		
Conduction: Steady and unsteady state heat conduction, Transient heating and cooling of solid objects. Convection: Heat transfer coefficient, Dimensional analysis in convective heat transfer, Heat transfer during laminar and turbulent flow in closed conduits, empirical correlation, Heat transfer in laminar and turbulent flow over a flat plate, Heat transfer in liquid metals, Analogy between momentum and heat transfer, Heat transfer with phase change: Boiling and condensation heat transfer. Recent developments in heat exchangers: Heat Transfer Augmentation, Recent developments in the design of compact heat exchangers, Introduction to Heat exchanger networks and Pinch technology. Characteristic of Equilibrium stage and Flash calculations, Study of different types of equilibrium cascade configurations and its degrees of freedom analysis, Algebraic method to determine the number of equilibrium stages, Calculation of stage efficiency, tray diameter, pressure drop and mass transfer, Rate based method to design a packed column, Scale up of a column from laboratory data, Estimation of distillation column efficiency using performance data and to develop its empirical correlation, Scale up of distillation column, Rate based method for packed distillation column, Approximate methods for Multicomponent, multistage separations, Use of residue curve for the conceptual design of distillation columns, Pressure swing and azeotropic distillation, Rate based models for distillation, Modeling of batch distillation, Modeling and simulation of absorption and leaching processes. Diffusion in non-ideal system and development of generalized Maxwell-Stefan formulation, Study of Generalized Fick's law, Estimation of binary and multicomponent Diffusion Coefficients, Study of interphase mass and energy transfer.		
References		
1.	Separation Processes and principles, 3rd edition, 2011	J.D Seader, E. J. Henly
2.	Multicomponent Mass Transfer	R. Taylor, R. Krishna
3.	Principles and Modern Applications of Mass Transfer Operations, 3rd edition, 2016	Jaime Bendaitez
4.	Biological and Bioenvironmental Heat and Mass Transfer,2002	Ashim K. Datta,

CH 523-ADVANCED THERMODYNAMICS IN CHEMICAL ENGINEERING		
Syllabus		
Review of Basic Postulates, Maxwell's relations, Legendre Transformation, Pure Component properties, Theory of corresponding states, real fluids Equilibrium, Phase Rule, Single component phase diagrams Introduction to Multicomponent Multiphase equilibrium, introduction to Classical Mechanics, quantum Mechanics, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, Boltzmann, Fermi-Dirac and Bose Einstein Statistics, Fluctuations, Monoatomic and Diatomic Gases, introduction to Classical Statistical Mechanics, phase space, liouville equation, Crystals, Intermolecular forces and potential energy functions, imperfect Monoatomic Gases, Molecular theory of corresponding states, introduction to Molecular Simulations, Mixtures, partial molar properties, Gibbs Duhems equations, fugacity and activity coefficients, Ideal and non-ideal solutions, Molecular theories of activity coefficients, lattice models, multiphase Multicomponent phase equilibrium, VLE/SLE/LLE/VLLE, Chemical Equilibrium and Combined phase and reaction equilibria. Thermodynamics of irreversible processes. Exergy analysis of Chemical Engg Processes.		
References		
1.	Thermodynamics and an Introduction to Thermostatics, 2nd edition, 2006	H. B. Callen,
2.	Molecular thermodynamics of fluid-phase Equilibria, 3rd edition, 1998	J.M. Prausnitz, R.M. Lichtenthaler and E.G. Azevedo,
3.	Introduction to Chemical Engineering Thermodynamics, 3rd edition	J.M. Smith. H.C.V. Ness and M.M. Abott,

CH 524-SOFTWARE LABORATORY
Experiments
Simulation of steady state and Dynamic processes using ASPEN PLUS. Simulation of mass transfer processes using ANSYS. Solving linear and non-linear algebraic equations, matrix operations, differential equations, land parameter estimation by linear and non-linear regression methods and MATLAB

CH 525-SEMINAR 2 AND MINI PROJECTS
Syllabus
Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure.

Department Electives

CH 531- POLYMER SCIENCE AND ENGINEERING		
Syllabus		
Chemistry of Polymerisation Reaction: Functionality, polymerization reactions, polycondensation, addition free radical and chain polymerization, copolymerization, block and graft polymerizations, stereo specific polymerization. Polymerisation Kinetics: Kinetics of radial, chain and ionic polymerization and co-polymerisation systems. Molecular Weight Estimation: Average molecular weight, number average and weight average, theoretical distributions, methods for the estimation of molecular weight Polymerisation Processes: Bulk, solution, emulsion and suspension polymerization. Thermoplastic composites, fibre reinforcement fillers, surface treatment, reinforced thermoset composites-resins, fibers additives, fabrication methods. Rheology: Simple rheological equations, simple linear viscoelastic models-Maxwell, Voigt; materials response time, temperature dependence of viscosity.		
References		
1.	Fundamentals of Polymer Engineering	Kumar A. and Gupta R
2.	Textbook of Polymer Science	Billmayer Jr., F. W.
3.	Fundamentals of Polymer Science	Fried J.

CH 532-NANO TECHNOLOGY		
Syllabus		
Super molecular Chemistry: Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures. Physical Chemistry of Nanomaterials: Students will be exposed to the very basics of nanomaterials; a series of nanomaterials that exhibit unique properties will be introduced. Methods of Synthesis of Nanometerials. Equipment and processes needed to fabricate nano devices and structures such as bio-chips, power devices, and opto-electronic structures. Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches. Biologically-Inspired nanotechnology basic biological concepts and principles that may lead to the development of technologies for nano engineering systems. Coverage will be given to how life has evolved sophisticatedly; molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans. Instrumentation for nanoscale characterization. Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range.		
References		
1.	Supramolecular Chemistry, 2011	Jean-Marie Lehn,
2.	Supramolecular Chemistry, 2nd edition	Jonathan Steed & Jerry Atwood
3.	Intermolecular and Surface Forces, 3rd edition	Jacob Israelachvil,

CH 533-BIOPROCESS TECHNOLOGY

Syllabus

Introduction: Fermentation processes general requirements of fermentation processes – An overview of aerobic and anaerobic fermentation processes and their application in industry - Medium requirements for fermentation processes - examples of simple and complex media Design and usage of commercial media for industrial fermentation. Sterilization: Thermal death kinetics of micro-organisms - Batch and Continuous Heat-Sterilization of liquid Media - Filter Sterilization of Liquid Media and Air. Enzyme technology, Enzymes: Classification and properties -Applied enzyme catalysis - Kinetics of enzyme catalytic reactions - Microbial metabolism - Metabolic pathways – Protein synthesis in cells. Stoichiometry and Kinetics of substrate utilization and Biomass and product formation: Stoichiometry of microbial growth, Substrate utilization and product formation- Batch and Continuous culture, Fed batch culture Recovery and purification of products. Bioreactor and product recovery operations: Operating considerations for bioreactors for suspension and immobilized cultures, Selection, scale-up, operation of bioreactors – Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes; oxygen uptake rates and determination of oxygen transfer rates and coefficients; role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Introduction to Instrumentation and Process Control in Bioprocesses: Measurement of physical and chemical parameters in bioreactors - Monitoring and control of dissolved oxygen, pH, impeller speed and temperature in a stirred tank fermenter.

References

1.	Bio-process engineering, 3rd edition	M. L. Shuler and F. Kargi,
2.	Biochemical Engineering Fundamentals, 2nd edition	J. E. Bailey and D. F. Ollis,
3.	Principles of Fermentation Technology, 3rd edition	P. Stanbury, A. Whitakar and S. J. Hall,

CH 534-PINCH TECHNOLOGY		
Syllabus		
Pinch Location: Locating the pinch, significance of pinch, pinch in grid representation, Threshold problems, capital cost implication of the pinch. Targeting: Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, continuous targeting. Pinch Methodology: Problem representation, temperature enthalpy diagram, simple match matrix. Heat content diagram, Temperature interval diagram, Heuristic approach & PDM, weighted flow rate specific heat method ((WFCPM), Tree searching. Pinch Design and Optimization: Networks for maximum energy recovery, Pinch design method, Flexibility criteria of the pinch, cp table, the tick of heuristic, case studies, optimization of heat exchanger network optimality for a minimum area network, Sensitivity analysis. Energy and Resource Analysis of various processes and Mass Exchange Network: Batch process, flexible process, distillation process, evaporation process, reaction process, process using mass separating agent. Heat pipes and Heat pumps, MEN Network, Waste minimization by using mass separating agents.		
References		
1.	Heat Exchanger network synthesis, 1995	V. Uday Shenoy
2.	User Guide on Process Integration for the efficient use of Energy, 1994	D.W. Linnhoff et al.
3.	Conceptual Design of Chemical Process, 1988	James M. Douglas
4.	Chemical Process Synthesis and Engineering Design, 1982	Anil Kumar

CH 535-ADVANCED FLUID DYNAMICS		
Syllabus		
Properties of fluids and multiphase flow, fluids and fluid properties, Kinematics: Motion, streamlines, pathlines and streaklines, Newtonian, non- Newtonian and non-viscous fluids, Continuity equation in Cartesian, cylindrical and spherical coordinates, Derivation of general momentum equation for Newtonian fluids in Cartesian coordinates, Eulers equation, principles of rotational and irrotational flow, velocity potential, Bernoulli‟s equation, Laplace equations, stream function, vorticity, Cauchy – Rieman equation, Analytical solutions for simple two dimensional incompressible, irrotational fluid flows: flow along two inclined plates, point source or sink in an infinite fluid. Stokes law of viscosity, Navier-stokes equation, creeping flow around a solid sphere, expression for total drag, Turbulent flow: Transition to turbulence, Prandtl‟s mixing length, Turbulence models. Boundary layer on immersed bodies, two dimensional boundary layer equation, laminar boundary layer on flat plate (Blasius‟ exact solution), Von-Karmann‟s integral momentum equation, boundary layer separation flow and pressure drag, Flow of compressible fluids, thermodynamic considerations, continuity and momentum equation for one dimensional compressible flow, one dimensional normal shock, flow through fluidized beds. Navier-Stokes equation and various approaches of simulation (stream velocity, primitive variable).		
References		
1.	Introduction to Fluid Mechanics, 2009	R.W. Fox, A.T. Mc Donald, P.J. Pritchard
2.	Fluid Dynamics and Heat Transfer	J.G. Knudsen and D.L. Katz
3.	Transport Phenomena, 2nd edition	R.B. Bird, W.E. Stewart, and E.N. Lightfoot

CH 536-BIOENERGY ENGINEERING

Syllabus

Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. -Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels-Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass. Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues. Microbial and biochemical aspects- Operating parameters for biogas production. Kinetics and mechanism - Dry and wet fermentation.

Digesters for rural application - High rate digesters for industrial waste water treatment. Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars. Gasohol as a Substitute for Leaded Petrol. - Trans-Esterification of Oils to Produce Bio-Diesel. Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass - Biomass processing for liquid fuel production - Pyrolysis of biomass – Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers. Combustion of Biomass and Cogeneration Systems: Combustion of Woody Biomass: Theory, Calculations and Design of Equipments. Cogeneration in Biomass Processing Industries. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

References

1.	Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes, 1989	Chakraverthy A,
2.	Principles of Solar Engineering, 2nd edition, 2000	D. Yogi Goswami, Frank Kreith, Jan. F .Kreider
3.	Biogas Systems: Principles and Applications, 1996	Mital K.M,.
4.	Biogas Technology, , 2006	Nijaguna, B.T.

CH 537-FOOD PROCESSING & TECHNOLOGY		
Syllabus		
Food Process Engineering - Fundamentals: Raw material and the process-Geometric, Functional and Growth properties of the raw material, Mechanization and the raw material, cleaning - contaminants in food raw materials, function of cleaning and cleaning methods, sorting and Grading of Foods. Unit Operations in Food Processing: Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations to food processing. Heat processing of foods – modes of heat transfer involved in heat processing of foods. Food Canning Technology: Fundamentals of food canning technology, Heat sterilization of canned food, containers - metal, glass and flexible packaging, Canning procedures for fruits, vegetables, meats, poultry and marine produces. Separation And Mixing Process In Food Industries: Conversion operations. Size reduction and screening of solids mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction. Food Biotechnology: Food Biotechnology. Dairy and cereal products. Beverages and food ingredients. High fructose corn syrup. Single cell protein.		
References		
1.	Fundamentals of Food Process Engineering, 4^{th} edition	R. T. Toledo
2.	Fundamentals of Food Canning Technology, 1979	J.M. Jackson & B.M. Shinn
3.	Food Engineering Operations, 1969	J.G. Bernnan, J. R .Butters, N.D. Cowell & A. E. V. Lilley

CH 538-ADVANCE SEPARATION TECHNOLOGY		
Syllabus		
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: Physical factors in membrane separation, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis and electro-dialysis, gas separation using membrane structure and production. Special Processes: Liquid membrane separation, critical extraction, pressure swing adsorption and freeze drying, pervaporation and permeation, nanoseparation.		
References		
1.	Separation Processes, 2nd edition	King C. J.
2.	Separation Process Principles, 3rd edtion.	Seader J. D. and Henley E. J.
3.	Mass Transfer and Separation Processes: Principles and Applications, 2nd edition, 2007	Basmadjian D.,
4.	Multistage Separation Processes, 4th edition, 2014	Khoury F. M.,
5.	Separation Process Engineering, 4th edition.	Wankat P. C.

CH 539-TEXTILE TECHNOLOGY		
Syllabus		
Classification of fibres: Natural fibres of vegetable origin: jute; hemp; sunn; Urena. The leaf fibres : Sisal, Abaca (manila); seed and fruit fibres; cotton. Natural fibres of animal origin: Wool; Mohair; Cashmere; Persion goat hatosilk; vicuna; fur fibres; Man made fibres; Rayon‟s Polyamide fibres; polyester fibres, polyvinyle derivative fibres; polyolefin & Polyurethane fibres. Weaving: Various steps in weaving manufacturing for fibres, design and construction, and weaving fundamentals to the various modern methods of weaving slashing process calculations; woven fabric construction and weaving process calculation & problem solving. Physical Testing of textiles : Introduction: Reasons for textile standardization of testing sampling, measurement errors; Effect of atmosphere on physical properties; Fibre tests; Fibre fitness; Fibre length; yarn tests; Linear density twist, yarn evenness; Hairness, friction, Strength tests; Definition; Load elongation curve. Recycling Textile Wastes: Recycling and recovery strategies turning environmental concern into real profit Re-claimed fibres, the sources and usage; Industrial wastewater minimization and treatment. The fibre industry and water management; Production of high tenacity tapes from polyprophyene. The role of process stabilizers in recycling polyoefins. Modern Textiles: Challenges for Textile research & development in the 21st century; fibres textiles and materials for future military use; Development in man made fibre technology-airbages, Textiles in filterations; Textiles in medicine, defence, transport and geotextiles		
References		
1.	Handbook of Textiles Fibres Vol-I Natural Fibres, Vol-II Man-made fibres.	Gardon Cook
2.	Handbook of waving .	Adanur S
3.	Weavers Handbook of Textile Calculation	Dan J. Mc. Geight, James B. Bradshow, Everett E. Back & Michael
4.	Physical Testing of Textiles, 1999	B.P. Saville

CH 540-ADVANCED ANALYTICAL TECHNIQUES		
Syllabus		
Introduction to spectroscopic methods of analysis, electromagnetic radiation and quantitative spectroscopy, Molecular Spectroscopy, UV, IR, Atomic Spectroscopy: AAS, Electrometric Methods of Analysis, XRD Analysis, Thermal Methods: DSC, DTA, Chromatographic Methods: GC, HPLC.		
References		
1.	Instrumental methods of analysis, 1988	Willard, H.H., Merritt. I.I., Dean J.a., and Settle, F.A
2.	Instrumental Methods of Analysis, 2000	Sharma, B.K.,
3.	Absorption spectroscopy of organic molecules, 1974	Parikh V.M.,.
4.	Fundamentals of Analytical Chemistry,	Skoog D.A. and West D.M.
5.	Fundamentals of molecular spectroscopy, 4^{th} edition, 1994	Banwell, G.

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CH 541-PETROLEUM ENGINEERING & TECHNOLOGY

Syllabus

Origin of Petroleum: Origin and occurrence of petroleum crude, status of petroleum refining in India, composition classification and physical properties of petroleum, evaluation of crude oil and petroleum products, future refining trends. Introduction to petroleum and petrochemical industries, structure of petrochemical industry, product profile of petrochemicals, profile of Indian petrochemical industries, basic building blocks for petrochemical production. Indian and Global Petroleum Industries: An overview, Raw materials for organic chemicals-coal, biomass, petroleum and natural gas, Evaluation of crude oil, Petrochemical feed stocks- Natural gas, NGL, Naphtha, Kerosene, and Pyrolysis gasoline. Crude Oil Distillation Processes: Pretreatment of crude, atmospheric and vacuum distillation process.

Secondary Conversion Processes: Catalytic reforming, catalytic cracking, deep catalytic cracking, alkylation, isomerisation and polymerization, reformulated gasoline and oxygenates. Heavy Residue Up-gradation Technologies: Hydro-treating, hydrocracking, hydro-visbreaking, visbreaking and delayed coking. Lubricating Oil, Wax and Bitumen: Dewaxing, deasphalting, lube hydro-finishing, bitumen air blowing. Sweetening: Desulfurization and hydro-desulfurisation of petroleum products. Hydrogen: Production and management. Aromatics Production: Catalytic reforming, aromatic separation, aromatic conversion processes, Cyclar process.

References

1.	Petroleum Refining: Separation Processes, Vol - 1	Wauquier J. P.
2.	Hand book of Petroleum Refining Processes, 3rd edition	Meyers R. A.,
3.	Modern Petroleum Technology- Part I	Dawe R. A.
4.	Modern Petroleum Technology- Part II	Lucas A. G.,

CH 542-MULTIPHASE FLOW/CFD MULTIPHASE REACTOR

Syllabus

Flow past immersed bodies: Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications. Two-phase flow: Two–phase flow through pipes. Lockhart-Martinelli parameters and their application in analysis of two-phase flows. Interaction of fluids: Mixing of a single fluid; degree of segregation, early and late mixing of fluids, models for partial segregation, mixing of two miscible fluids. Gas-liquid flow phenomenon, Types of regimes formation – trickle, pulse, bubble, dispersed bubble, spray regime etc. Types of Multiphase-Reactors: Various types of multiphase reactors. eg. Packed bed, packed bubble column, trickle bed reactor, three phase fluidized bed reactor, slurry bubble column, stirred tank reactor. Characteristics of above mentioned reactors such as; fluid flow phenomena and flow regimes, flow charts/ correlations, pressure drop, liquid hold up etc. Reactors involving Newtonian and non-Newtonian fluids. RTD in Multiphase Flow systems: Non Ideal Flow: Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, the Dirac delta function, residence time, linear and non-linear processes, models for non ideal flow, dispersion model, N tanks in series model, model for small deviations from plug flow and long tails, conversion in a reactor using RTD data, diagnosing ills of operating multiphase reactors, models for multiphase reactors. Two parameter model; PD model; three parameter models; PE Model.

References

1.	Chemical Reaction Engineering, 3rd edition, 2006	Levenspiel O,
2.	Elements of Chemical Reaction Engineering, 5th edition, 2016	Fogler H Scott
3.	Gas-Liquid-Solid Reactor Design, 1979	Shah Y.T.
4.	Chemical Reactor Design and Operation, 1991	Westerterp K.R., van Swaaij W.P.M., and Beenackers A.A.C.M.,

Open Electives

CH 551-POLLUTION CONTROL & ENGINEERING AND SAFETY		
Syllabus		
Introduction: Environment and environmental pollution from chemical process industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents. Pollution Prevention: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance. Air Pollution Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers. Water Pollution Control: Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation. Biological Treatment: Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying. Solids Disposal: Solids waste disposal – composting, landfill, briquetting / gasification and incineration. Process Safety: Process safety, accident and loss statistics, nature of the accident/hazardous process, hazardous substance classification and hazardous substance rules; Factories Act.		
References		
1.	Pollution Control Acts, Rules, Notifications issued there under" CPCB,	Ministry of Env. and Forest, G.O.I., 3rd Ed. (2006).
2.	Fundamentals of Air Pollution, 5th edition	Vallero D.
3.	Industrial Water Pollution Control, 3rd edition	Eckenfelder W. W.,
4.	Handbook of Solid Waste Management, 2nd edition	Kreith F. and Tchobanoglous G.,

CH 552-MODELING & SIMULATION OF CHEMICAL ENGG. SYSTEMS		
Syllabus		
Introduction to modeling, a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems. Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems. Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples. Solution strategies for lumped parameter models. Stiff differential equations. Solution methods for initial value and boundary value problems. Euler's method. R-K method, shooting method, finite difference methods. Solving the problems using MATLAB/SCILAB. Solution strategies for distributed parameter models. Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and finite volume methods. Sequential modular, simultaneous modular and equation oriented approaches; Partitioning and tearing; Simulation examples of fluid flow, heat transfer, mass transfer and reaction processes; Monte Carlo simulation.		
References		
1.	Process Modelling and Model Analysis, 2001	K. M. Hangos and I. T. Cameron
2.	Process Modelling, Simulation and Control for Chemical Engineers, 1972	W.L. Luyben,
3.	Computational Methods for Process Simulation, 2^{nd} edition, 1997	W. F. Ramirez,
4.	Numerical Methods and Modelling for Chemical Engineers, 1984	Mark E. Davis,

CH 553-INDUSTRIAL CATALYSIS		
Syllabus		
Review of Heterogeneous Catalysis: Role of catalyst components and other constituents, characterization of catalyst and its support. Transport Processes: Analysis of external transport processes in heterogeneous reactions in fixed bed, fluidized bed and slurry reactors. Intrapellet mass transfer, heat transfer, mass transfer with chemical reaction and simultaneous mass and heat transfer with chemical reaction. Catalyst Selectivity: Effect of intrapellet diffusion on selectivity in complex reactions, effect of external mass transfer on selectivity. Catalyst Deactivation: Modes of deactivation – poisoning, fouling and sintering. Determination of deactivation routes, combined effect of deactivation and diffusion on reaction rates, effect of deactivation on selectivity. Reactor Design: Design calculation for ideal catalytic reactor operating at isothermal, adiabatic and non-adiabatic conditions. Deviations from ideal reactor performance. Design of industrial fixed-bed, fluidized bed and slurry reactors. Thermal stability of packed bed and fluidized bed reactors, Overview of various areas of Green chemistry, Successful approaches to Green Chemistry education.		
References		
1.	Chemical Engineering Kinetics, 1970	Smith, J. M.,
2.	Catalytic Reaction Engineering,	Carberry, J. J.,
3.	Heterogeneous Catalytic Reactors,	Butterworth. Lee, H. H.,
4.	Catalytic Reactor Design, 1983	Tarhan, M. O.

CH 554- TREND IN HEALTHCARE AND TECHNOLOGY		
Syllabus		
Practice of the following unit operation in pharmaceutical industries: Heat transfer, evaporation, distillation, dry, mixing size reduction, crystallization, filtration, size separation, conveying, humidification, air conditioning and refrigeration. Formulation, development of sterile dosage forms. Production facilities, environmental control and personnel in the production of sterile dosage form, compounding, processing, filtration, sealing, sterilization, packing and labeling of sterile dosage forms. Quality control tests like sterility, pyrogen, clarify, safety and leakage testing. Types of tablets. Manufacturing of tablets by wet granulation, dry granulation and direct compression. Tablet processing problems and defects, tablet standardization: hardness, friability, weights variation, disintegration, dissolution and content uniformity tests. Capsules: Hard gelatin capsule, capsule size, formulation and preparation of filled hard gelatin capsules, soft gelatin capsule, soft gel – manufacturing procedures. Quality control of capsule. Cosmetics and Toiletries: Introduction, factors to be considered in the formulation of facial cosmetics, dentifrice‟s, deodorant, antiperspirants, shampoos, hairdressing and hair removers. Pharmaceutical packing: Packing components, types of packing containers and closures, materials used for and their pharmaceutical specification, method of evaluation, stability aspects of packaging materials.		
References		
1.	The Theory and Practice of Industrial Pharmacy, 2013	Leon Lachman, H.A. Lieberman, J.L.K.
2.	Unit Process in Pharmacy, Vol - 7	Ganderton
3.	Chemical Engineering in Medicine And Biology, 2013	D. Hershey
4.	Chemical Engineering in Medicine –	Chern. Engg. Progress Syrnp Series No. c 66, Vol 62

CH 555-ADVANCED ENVIRONMENTAL BIOTECHNOLOGY		
Syllabus		
General effluent treatment – nature of sewers, sewage; Methods adopted in effluent treatment; Legal Consideration – Royal Commissions. Current situation in laying of charging ownership, regulations, legislation; Activated sludge process equipment, plant kinetics, CSTR modeling. PFR modeling, recycle stability, washout; Advanced Process – Trickling fitter, moving medium system; Biology of effluent treatment process: Roles of bacteria, fungi and protozoa. Extracellular Polymers, films, flocs, Analysis of effluent; Nutrition, Carbon removal, influences of loading ratio, retention times, season on kinetics and performance, Nitrogen and Phosphorous requirement for adequate plant performance. Nitrification and De-nitrification Anoxic process, extended aeration, high rate process; Sludge disposal methods; Anaerobic processes. Sludge digestion (contact digester), Management of digester sludge. Aerobic effluent treatment. Gas production and utilization, related problem.		
References		
1.	Industrial Microbiology	M.J. Waites, N.L. Morgan, J.S. Rockey, and G. Higton
2.	Biotechnology a Text book of Industrial Microbiology, 1984	W. Grueger and A. Crueger,
3.	Biochemical Engineering Fundamentals, 2nd edition, 1986	J E Bailey and D F Ollis

CH 556-CORROSION ENGINEERING		
Syllabus		
Basic concepts: Definition and importance; Electrochemical nature and forms of corrosion; Corrosion rate and its determination. Electrochemical thermodynamics and kinetics: Electrode potentials; Potential-pH (Pourbiax) diagrams; Reference electrodes and experimental measurements; Faraday's laws; Electrochemical polarization; Mixed potential theory; Experimental polarization curves; Instrumentation and experimental procedure. Galvanic and concentration cell corrosion: Basic concepts; Experimental measurements, and determination of rates of galvanic corrosion; Concentration cells. Corrosion measurement through polarization techniques: Tafel extrapolation plots; Polarization resistance method; Instrumental methods and Errors in measurement of polarization resistance; Commercial corrosion probes; Other methods of determining polarization curves. Passivity: Basic concepts of passivity; Properties of passive films; Experimental measurement; Applications of Potentiostatic Anodic Polarization; Anodic protection. Pitting and crevice corrosion: Basic concepts; Mechanisms of pitting and crevice corrosion; Secondary forms of crevice corrosion; Localized pitting. Metallurgical features and corrosion: Inter-granular corrosion; Weldment corrosion; De-alloying and dezincification. Environmental induced cracking: Stress corrosion cracking; Corrosion fatigue cracking; Hydrogen induced cracking; Some case studies; Methods of prevention and testing; Erosion, fretting and Wear. Environmental factors and corrosion: Corrosion in water and Aqueous S solutions; Corrosion in sulphur bearing solutions; Microbiologically induced corrosion; Corrosion in soil; Corrosion of concrete; Corrosion in acidic and alkaline process streams. Atmospheric and elevated temperature corrosion: Atmospheric corrosion and its prevention; Oxidation at elevated temperatures; Alloying; Oxidizing environments. Prevention and control of corrosion: Cathodic protection; Coatings and inhibitors; Material selection and design.		
References		
1.	Corrosion Engineering, 1986	Fontana, M.G.
2.	Principal and Protection of Corrosion, 2nd edition, 1996	Jones, D.A.,