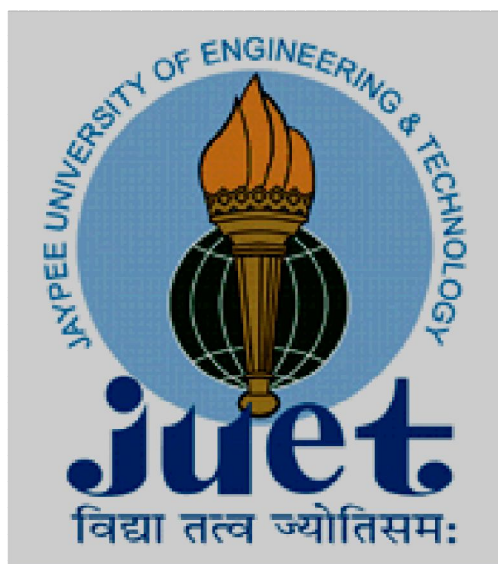


SYLLABI

M. Tech

IN

CHEMICAL ENGINEERING



2016

Department of Chemical Engineering

JAYPEE UNIVERSITY OF ENGINEERING & TECHNOLOGY

A-B ROAD, RAGHOGARH, DIST. GUNA-473226 MP, INDIA

TEACHING SCHEME

Master of Technology (M. Tech.)

Branch – CHE**Year/Sem: 1st Year/ 1st Sem**

S. N.	Course Code	Course Title	Type	L	T	P	Credits
1.	14M11CL111	Advanced Transport Phenomena	Core	3	0	0	3
2.	14M11CL112	Process Modelling and Optimization	Core	3	0	0	3
3.	14M11CL113	Chemical Reaction Engineering	Core	3	0	0	3
4.	14M11CL114	Advanced Separation Processes - I	Core	3	0	0	3
5.	14M1GCL13x	Elective-I	Elective	3	0	0	3
6.	14M17CL171	Chemical Reaction Engineering Laboratory	Core	0	0	4	2
Sub Total							17

Year/Sem: 1st Year/ 2nd Sem

S. N.	Course Code	Course Title	Type	L	T	P	Credits
1.	14M11CL211	Advanced Separation Processes - II	Core	3	0	0	3
2.	14M11CL212	Advanced Thermodynamics	Core	3	0	0	3
3.	14M11CL213	Environmental Eng. & Waste management	Core	3	0	0	3
4.	14M11CL214	Process Dynamics & Control	Core	3	0	0	3
5.	14M1GCL23x	Elective II	Elective	3	0	0	3
6.	14M19CL291	Seminar / Term Paper	Core	0	0	4	2
Sub Total							17

Year/Sem: IInd Year/ IIIrd Sem

S. N.	Course Code	Course Title	Type	L	T	P	Credits
1.	14M1GCL33x	Elective-III	Elective	3	0	0	3
2.	14M1GCL33x	Elective-IV	Elective	3	0	0	3
3.	14M19CL391	Project Seminar	Core	0	0	4	2
4.	14M19CL392	Thesis	Core	0	0	24	12
Sub Total							20

Year/Sem: IInd Year/ IVth Sem

S. N.	Course Code	Course Title	Type	L	T	P	Credits
1.	14M1GCL43x	Elective-V	Elective	3	0	0	3
2.	14M1GCL43x	Elective-VI	Elective	3	0	0	3
3.	14M19CL491	Project Seminar	Core	0	0	4	2
4.	14M19CL492	Thesis**	Core	0	0	28	14
Sub Total							22
Total Credits =							76

Notes:

1. Thesis ** to be continued from III Semester
2. Final evaluation of the dissertation will be based on the cumulative performance in all III and IV Semesters
3. It is desirable to have one publication from the dissertation

LIST OF ELECTIVES

S. No.	Elective No.	Code	Title
1	Elective I	14M1GCL131	Wastewater Treatment
2		14M1GCL132	Air Pollution Control
3		14M1GCL133	Cleaner Technology
4	Elective II	14M1GCL231	Process Plant Simulation
5		14M1GCL232	Colloid and Interfacial Engineering
6		14M1GCL233	Advances in Process Control
7		14M1GCL234	Applied Optimization & Operations Research
8	Elective III	14M1GCL331	Petroleum Refinery Operations
9		14M1GCL333	Polymer Science & Engineering
10		14M1GCL334	Combustion Processes
11		14M1GCL335	Environmental Management
12	Elective IV	14M1GCL332	Fluidization Engineering
13		14M1GCL336	Multiphase Contactors
14		14M1GCL337	Catalysis & Surface Chemistry
15		14M1GCL338	Reaction Engineering in dispersed phase systems
16	Elective V	14M1GCL431	Process Engineering
17		14M1GCL432	Conceptual Design of selected separation processes.
18		14M1GCL433	Safety & Hazards analysis and assessment
19		14M1GCL434	Nanotechnology and applications
20	Elective VI	14M1GCL435	Advanced Process Synthesis
21		14M1GCL436	Bioprocess principles
22		14M1GCL437	Bio separations

SYLLABI

Master of Technology (M.Tech.)

Branch - CHE

Year/Sem : Ist Year/Ist Sem

14M11CL111/Advanced Transport Phenomena

Preliminaries: Introduction, Vector and tensor algebra: Geometric view point, addition of vectors, multiplication by scalar, scalar product, cross product, analytical view point: Kronecker delta, alternative unit tensor for cross product, cross product between two unit vectors, vector operations in terms of components, vector addition, multiplication by scalar, scalar product between vectors, vector product, identities for ϵ_{ijk} . Vector Differential operations: Del operator, gradient of scalar, divergence of a vector, curl of a vector, Laplacian of a scalar, material derivative of a scalar. Tensors: second order tensor, dyadic product, unit tensor, transpose of tensor, addition, dot product, double dot product, vector product, divergence of a tensor, trace, determinant. Integral Theorems: Divergence theorem, curl theorem, Leibnitz rule. Cylindrical coordinates: Del operator in cylindrical coordinates, derivatives of unit vectors, Kinematics: Eulerian & Lagrangian view point, relationship between Eulerian and Lagrangian view points, Reynolds transport theorem, Motion near a point, relative velocity, vorticity tensor,

Fluid Mechanics: Governing equations: conservation of mass, continuity equation, conservation of linear momentum, conservation of angular momentum, stress tensor, Cauchy's 1st & 2nd laws, Navier-Stokes equations, unidirectional flows, flow down an inclined surface, flow of generalized Newtonian fluid in cylindrical tube, flow with central plug region, tangential annular flow, velocity in the limit of narrow gap, flow due to wall suddenly set in motion, unsteady flow between parallel plates, two dimensional flows, stream function, stream lines, dimensional analysis approximation, dimensionless governing equations, creeping flow, velocity of particle falling from rest, flow in slow varying channels, in viscous flow, potential flow past a cylinder, boundary layer theory, flow past a flat plate, converging flow, diverging flow, turbulent flow, transition to turbulence, turbulence models

Heat Transfer: Governing equations: energy balance equations, conservation of energy law, heat flux at any point, mechanical energy balance, constitutive equations for conduction, boundary conditions, steady state conduction through a composite wall, temperature profile in an electric wire, unsteady state conduction in a slab, heat conduction with generation in a slab, viscous dissipation, heat transfer from a cooling fin, forced convection in a pipe, macroscopic energy balance, free convection, free convection between vertical parallel plates, free convection near a heated vertical plate, free convection heat transfer from a vertical plate, dimensionless parameter for heat transfer, Radiation.

Mass Transfer: Governing equations: species mass balance, Concentration, velocities and mass fluxes, constitutive equations, boundary conditions, Complete solutions: diffusion through a stagnant film, diffusion of gas with heterogeneous reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film, diffusion and reaction in a spherical droplet, diffusion and reaction in a porous catalyst pellet, Simultaneous heat and mass transfer, condensation in the presence of non condensable gases.

14M11CL112/Process Modelling and Optimization

Introduction: Mathematical models for chemical engineering systems: Fundamentals, introduction to fundamental laws. Examples of mathematical models of chemical engineering systems, constant hold up CSTRs, Gas pressurized CSTR, non-isothermal CSTR. Examples of single component vaporizer, Batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with hold up. **Classification of Mathematical Modelling:** Classification of mathematical modelling, static and dynamic models, the complete mathematical model, Boundary conditions, the black box principle. Artificial Neural Networks: Network training, Models of training, Network architecture, Back-propagation algorithm, ANN applications.

Simulation of Chemical Process: Computer Simulation: Simulation examples of Three CSTRs in series, Gravity Flow tank, Binary distillation column, Non-isothermal CSTR. Models for chemical reaction with diffusion in a tubular reactor, chemical reaction with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction. **Introduction to Optimization:** Introduction to process optimization; formulation of various process optimization problems and their classification. Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points. **Optimization Techniques for Single Variable:** Optimization of one dimensional function, unconstrained multi variable optimization. Bracketing methods: Exhaustive search method, Bounding phase method Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method. Indirect first order and second order method. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cubic search method. Root-finding using optimization techniques. **Optimization Techniques for Multivariable:** Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method. Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Sensitivity analysis and Direct search for constraint minimization: Variable elimination method, complex search method. Successive linear and quadratic programming, optimization of staged and discrete processes.

14M11CL113/Chemical Reaction Engineering

Kinetics of Gas Absorption with Chemical Reaction: Introduction, development of rate equation for gas absorption accompanied by chemical reaction, Application of the film theory to mass transfer accompanied by a single second order reaction, solution by Hikita and Asa approximation, role of gas film resistance, flow chart for regime identification, computer program for regime identification, extension to reaction orders different from unity, role of gas film resistance, computer flow chart for calculation of rate of absorption in the case of A (m,n) order gas liquid reaction, Application of penetration and the surface renewal theories to gas absorptior with chemical reaction, penetration theory solution to the instantaneous reaction regime penetration theory solution to the depletion regime using the Hikita-Asai approximation, surface renewal theory solution for the pseudo first order reaction regime, Mass Transfer accompanied by A(0,0) order reactions, mass transfer accompanied by a (m,0) order reaction, mass transfer accompanied by a (0,n) order reaction.

Kinetics of Two fluid reactions, both gas-liquid and liquid-liquid: Rate equation: for straight mass transfer (absorption) of A, mass transfer of A followed by reaction with B, special cases,

Models for ideal gas-liquid reactors: Introduction, mechanically agitated semi batch gas-liquid contactor design, instantaneous reaction regime, fast reaction regime, slow reaction regime,

bubble column reactor design: Instantaneous reaction regime, fast reaction regime, slow reactor regime,

Design of mechanically agitated continuous flow reactor: Instantaneous reaction regime, fast reaction regime, slow reaction regime,

Counter current plate column design: Instantaneous reaction, fast reaction regime, slow reactor regime,

Packed Column design: Instantaneous reaction regime, fast reaction regime,

Design of gas-liquid and liquid-liquid reactors: Factors to consider in selecting a contractor, plug flow gas/ plug flow liquid, plug flow gas/ mixed flow liquid: mass transfer in bubble tank, mixed flow gas/batch uniform liquid : mass transfer to a stirred batch of liquid, plug flow gas/plug flow liquid: mass transfer plus reaction in a counter current and co-current tower, mixed flow gas/mixed flow liquid: mass transfer plus reaction in an agitated tank contactor, plug flow gas/mixed flow liquid: mass transfer plus reaction in bubble tank contactors, mixed flow gas/batch uniform liquid: absorption plus reaction in a batch agitated tank contactor, to find the time needed for a given operation,

Modelling of Complex Irreversible gas liquid reactions: Irreversible consecutive reactions, irreversible reaction of A(g) with two reacting solvents, consecutive reactions of A(g) and C(l) reacting with single solvent, absorption and reaction of two gases ,

Theory of mass transfer accompanied by reversible reactions: Fast reaction regime, instantaneous reaction, fast-instantaneous reaction regime,

14M11CL114/Advanced Separation Processes-I

PHYSICAL - CHEMICAL PHENOMENA: Diffusivity and mechanism of mass transport, Equation of continuity and equation of change, Diffusion, Dispersion, Diffusivity measurements and prediction in non-electrolytes and electrolytes, Solubility of gases in liquids. Interphase mass transport, in two-phase system and in multi-component systems, Role of diffusion in reaction systems, Mass transfer theories-film, Higbie and surface renewal models and their application.

MASS TRANSFER WITH AND WITHOUT CHEMICAL REACTION: Fluid-fluid reactions involving diffusional transfer, Physical absorption and absorption accompanied by chemical reaction, Application of mass transfer to reacting systems. Residence time distribution analysis, Mass transfer coefficients, Determination and prediction in dispersed multi-phase contactors under conditions of free forced convection, prediction of mean drop/bubble size of dispersions.

SELECTION - CLASSIFICATION OF MASS TRANSFER - EQUIPMENT: Choice of techniques, Selection of equipments for gaseous, particulate and liquidous effluent of various industries such as extractive hydro metallurgy, leaching of ores/leach liquors, Selection of equipment based on Mechanical/non-mechanical, Floor area/Height requirement considerations. Optimum energy/cost considerations.

DESIGN OF MASS TRANSFER EQUIPMENT: Design and analysis of various mass transfer equipment involving multi-component, multi-phase situations, Design of multi component columns and process strippers, Selection of column diameter and height in stage-wise and differential column contactors.

14M17CL171/Chemical Reaction Engineering Laboratory

List of Experiments

1. Determination of Arrhenius parameters.
2. Study of order of a reaction.
3. Study the performance of combination of reactors.
4. Study the performance of PFR
5. Performance Study of Trickle bed reactor
6. Performance Study of fluidized bed reactor
7. RTD Studies in a Mixed Flow Reactor/CSTR.
8. RTD Studies in a Plug Flow Reactor (PFR)
9. RTD Studies in Combined Reactor (PFR Followed by MFR/CSTR)
10. RTD Studies in Mixed Flow Reactors in Series (3 MFR/CSTR)
11. Study the kinetics in packed bed reactor.
12. Study the kinetics in adiabatic batch reactor
13. Study of homogeneous catalyzed reaction

14M1GCL131/Wastewater Treatment

Sampling, measurements & standards of water quality: Physical impurity: TDS, suspended solids, colour, taste and odour, temperature, Turbidity. Chemical impurity: chlorides, fluoride, metals, alkalinity, DO, nitrogen, phosphorus, hardness, MLSS, ML VSS etc. Biological impurity: BOD, COD, TOC , pathogens etc. **Biological treatment methods:** Introduction to microbial metabolism, bacterial growth and energetic, microbial growth kinetics, suspended growth and

attached growth process, aerobic and anaerobic system. **Natural treatment methods:** Wetland treatment method, septic tank, infiltration and overland flow. **Advanced treatment methods:** Membrane filtration, adsorption, gas stripping, ion exchange, advanced oxidation process etc. **Design of wastewater treatment plant:** Wastewater reclamation and reuse, effluent treatment and disposal. **Design of wastewater treatment plant:** Wastewater reclamation and reuse, effluent treatment and disposal. **Design of wastewater treatment plant:** Wastewater reclamation and reuse, effluent treatment and disposal. **Design of wastewater treatment plant:** Wastewater reclamation and reuse, effluent treatment and disposal.

14M1GCL132/Air Pollution Control

Sources and effect of air pollution

Sources of air pollution-stationary and mobile, fugitive emissions, secondary pollutants; Effects of air pollution in regional and global scale, air pollution episodes; Emission factors, inventory and predictive equations. Atmospheric meteorology, wind profiles, turbulent diffusion, topographic effects, separated flows, temperature profiles in atmosphere, inversions, plume behaviour.

Air quality monitoring:

Objectives, time and space variability in air quality; air sampling design, analysis and interpretation of air pollution data, guidelines of network design in urban and rural areas. Stack monitoring. Air pollution standards and indices.

Air pollutants and modelling-Basic concepts:

Dispersion of air pollutants and modelling-Basic concepts, inversion layer and mixing height, atmospheric stability classes, theory and application of acoustic sounding (SODAR) technique. Box model, The Gaussian dispersion model-point, area and line sources. Prediction of effective stack height-physics of plume rise, Holland's equation, Brigg's equation, etc modification of Gaussian dispersion models; indoor air quality models.

Review of general principles of air pollution control:

Design and operation of gravity settling chambers, Design and operation of cyclones. Design and operation of wet dust scrubbers-column scrubbers, jet scrubbers, vortex scrubbers, rotating disc scrubbers, and venture scrubbers. Design and operation of fabric filters. Design and operation of electrostatic precipitators, design and operation of mist separators-baffled mist separators, pressure separators. Control devices for gaseous pollutants with special emphasis on absorption, adsorption and mass transfer consideration, and combustion, control of motor vehicle emissions, indoor air pollution control

14M1GCL133/Cleaner Technology

Sustainable development: Sustainable development - Indicators of Sustainability - Sustainability Strategies. Barriers to Sustainability - Industrial activity and Environment - Industrialisation and sustainable development - Industrial Ecology. **Cleaner production control:** Definition - Importance - Historical evolution - Benefits - Promotion - Barriers - Role of Industry, Government and Institutions - Environmental Management Hierarchy- Source Reduction techniques - Process and equipment optimization, reuse, recovery, recycle, raw material substitution - Internet information & Other CP Resources. Cleaner Production (CP) in Achieving Sustainability - Prevention versus Control of Industrial Pollution - Environmental Policies and Legislations - Regulation to Encourage Pollution Prevention and Cleaner Production **Cleaner production project development & implementation:** Overview of CP Assessment Steps and Skills, Preparing for the Site Visit, Information gathering, and Process Flow Diagram, Material Balance, CP Option Generation Technical and Environmental Feasibility analysis. **Evaluation:** Economic valuation of alternatives - Total Cost Analysis - CP Financing - Establishing a Program - Organizing a Program - Preparing a Program Plan - Measuring Progress Pollution Prevention and Cleaner Production Awareness Plan - Waste audit Environmental Statement. **Life cycle assessment & environmental management systems:** Elements of LCA - Life Cycle Costing - Eco Labeling - Design for the Environment International Environmental Standards - ISO 14001 - Environmental audit. **Case studies:** Industrial Applications of CP, LCA, EMS and Environmental Audits.

Year/Sem: Ist Year/IInd Sem

14M11CL211/ Advanced Separation Processes-II

Introduction:

Separation processes, introduction to membrane science and technology; classification of membrane and membrane based processes; membrane materials: ceramic membrane, polymeric membrane, composite membrane, liquid membrane

Preparation of Membranes:

Preparation of polymeric, ceramic and composite membranes by different methods. Advantages & disadvantages of various methods. Controlling pore size, porosity etc of membrane during preparation.

Characterization of Membranes:

Determination of pore size, pore size, thickness, permeability, membrane resistance, ionic characteristics, mechanical, thermal, chemical resistance etc by various methods and analysis of results by various methods.

Module and process design:

Introduction, plate and frame model, spiral wound module, tubular module, capillary module, hollow fiber model, comparison of module configurations.

Transport in Membranes:

Theory and applications of membrane processes: micro filtration, ultra filtration, nano filtration, reverse osmosis, electro dialysis, dialysis, pervaporation, gas separations, membrane distillation & ion exchange membranes.

Polarization phenomenon and fouling:

Concentration polarization, turbulence promoters, pressure drop, gel layer model, osmotic pressure model, boundary layer resistance model, concentration polarization in diffusive membrane separations and electro dialysis, membrane fouling, methods to reduce fouling, compaction.

Other separation Processes:

Pressure swing adsorption, reactive distillation, separation using surfactants, Cloud point extraction, Supercritical fluid extraction etc.

Advanced analytical instruments:

Theory and working principle of UV-Vis spectrophotometer, HPLC, GC, LCMS, LPSA, DLS, SI etc.

14M11CL212/Advanced Thermodynamics

Introduction: Basic concepts of thermodynamics, Applications of thermodynamics to flow processes: Compression processes, Duct flow of compressible fluids, Expanders, Thermodynamic analysis steady-state flow processes: Concept of ideal work, lost work, thermodynamics efficiency, availability

Solution Thermodynamics: Applications of solution thermodynamics: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing processes

Vapour liquid Equilibria: Chemical reaction equilibria: Multi-reaction equilibria, Fuel cells, Topical phase equilibria: Gamma/phi formulation of VLE, VLE from cubic equation of state, Equilibrium and stability, Liquid-liquid equilibrium, Vapour-liquid-liquid equilibrium, Solid-liquid equilibrium, Solid-vapour equilibrium, Equilibrium adsorption of gases on solids, Osmotic equilibrium & osmotic pressure

Molecular Thermodynamics: Introduction to molecular thermodynamics: Molecular theory of fluids, Second virial coefficients from potential functions, Internal energy of ideal gases: microscopic view, Thermodynamic properties and statistical mechanics, Hydrogen bonding and charge transfer complexing, Behaviour of excess properties, Molecular basis for mixture behaviour and VLE, molecular simulation

14M11CL213/Environmental Engineering and Waste Management

Nexus between energy, environment and development: Human population issues. Environmental ethics and environmental quality **Types of pollution:** Definition of pollution, Different types of pollution - Air, Water and soil and their local, regional and global aspects. **Air pollution:** Sources of air pollutants, their sources and behaviour in the atmosphere. Effects of air pollutants on humans, animals, plants and properties. Control approaches. **Water pollution:** Sources, consequences, control of water pollution **Soil pollution:** Sources and nature of soil pollution and its harmful effects. Environmental problems associated with noise pollution, oil pollution and radioactive pollution **Solid waste management principles:** Sources and generation of solid waste, their nature and chemical composition. Their characterization and classification. Different methods of dispersal and management of solid wastes. Recycling of waste materials.

14M11CL214/Process Dynamics & Control

Preliminaries: Review of basic concepts in process control: Laplace transformation, first order systems, second order systems & their dynamics, Open loop & closed loop control system frequency response of closed-loop systems, Bode diagram, stability criterion, Nyquist diagram. Tuning of controller settings.

Advanced Control Systems: Introduction to multiple loop control systems, Cascade control, feed forward control, Inferential control, Adaptive & ratio control with chemical engineering applications.

Multivariable Processes: Model based control; Multivariable control strategies; Model predictive control; Analysis of Dynamic Matrix Control (DMC) & Generalized Predictive Control (GPC) schemes; Controller tuning & robustness issues. Extensions to Constrained & Multivariable cases

Applications: Examples for control of heat exchangers, distillation column & reactors.

Use of Computers: Introduction to microprocessors & computer control of chemical processes.

Elective II

14M1GCL231/Process Plant Simulation

Introduction: Introduction to Process Synthesis, Analysis, Design and Simulation

Mathematical Modelling: Classification of Mathematical Modelling, Similarity Criteria, Variables, Parameters, etc.

Chemical Systems Modelling: Modelling of various Chemical systems covering heat, mass, and momentum transfer, and reactions.

Modular Approaches to Process Simulation: Sequential and Simultaneous Modular Approaches to be used in process plant simulation

Equation Solving Approach: Partitioning, Decomposition, Disjointing, PTM, SWS-, Steward-, and Rudd-Algorithms, Sparsity, Direct Methods, Pivoting, Iterative methods, BTF, BBTF, Block Back Substitution, BTS, etc.

Decomposition of Networks: Tearing Algorithms in decomposition of networks, digraph, MCN, signal flow graph, B&M Algorithm, BTA, K&S Algorithm, M&H-1 & -2 Algorithms, and related problems.

Convergence Promotion: Convergence Promotion methods such as Newton's method, Direct substitution, Wegstein's method, Dominant Eigen value method, Quasi-Newton methods, Acceleration criterion, etc.

Physical and Thermodynamic Properties: Sources and data banks of physical & thermodynamic properties, Modularity & Routing.

Optimization Techniques: Importance & applications, limitations, types, methods, direct search routines, Lagrangian multiplier method, Gradient methods (Method of steepest descent & sequential simplex method); Non-traditional optimization techniques such as simulated annealing, genetic algorithms, differential evolution, etc.

Specific Purpose Simulation: Case studies such as Cascale converter for ammonia production, etc. on specific purpose simulation, and use of professional simulation packages.

Dynamic Simulation: Case studies such as dynamic distillation modelling and simulation, etc. on Dynamic Simulation, and use of professional simulation packages.

14M1GCL232/Colloidal and Interfacial Engineering

Fundamental of Interfacial Tension: Introduction to Interfacial Phenomena , Interfacial Tension qualitative Considerations , Interfacial Tension: Thermodynamic Approach , Vapor Pressure of Drop , Interfacial Tension: Mechanical Approach, Locating the Dividing Surface , Density and Concentration Profiles , Equilibrium Shapes of Fluid Interfaces, Dimensions of a Sessile Drop Shape of a Soap Film between Parallel Rings, Methods of Measuring Interfacial Tension , Capillary Rise in Air-Water and Oil-Water , Surface Tension of Binary Mixtures , Surface Tension of Ideal Binary , Surface Tension of Regular Solutions, Surfactants, Solid-Fluid Interfaces

Fundamentals of Wetting, Contact Angle, and Adsorption: Introduction , Young's Equation , Work of Adhesion and Work of Cohesion, Phenomenological Theories of Equilibrium Contact Angle , Acid-Base Interaction , Contact Angle , Hysteresis, Impurities on the Surface, Effect of Adsorption , Surface Roughness , Adsorption, Langmuir Adsorption Isotherm , The Brunauer-Emmett-Teller Isotherm , Density Profiles in Liquid Films on Solids, Characterizing Solid Surfaces

Colloidal Dispersion: Introduction , Attractive , Electrical Interaction, Colloids of All Shapes and , Combined Attractive and Electrical Interaction: DLVO , Effect of Polymer Molecules on the Stability of Colloidal Dispersions , Kinetics of Coagulation

Surfactants: Introduction , Micelle Formation, Estimation of Micelle Aggregation Number and CMC, CMC of , Variation of CMC for Pure Surfactants and Surfactant Mixtures , Other Phase Involving Surfactants, Cylindrical Micelles, Formation of Complexes between Surfactants and Polymers , Surface Films of Insoluble Substrates, Solubilisation and Micro emulsions , Phase Behaviour and Interfacial Tension for Oil-Water-Surfactant Systems, Effect of Composition Changes, Effect of Composition and Temperature on Optimal Salinity, Thermodynamics of Micro emulsions, Applications of Surfactants: , Applications of Surfactants: Detergency, Chemical Reactions in Micellar Solutions and Micro emulsions

Interfaces in Motion: Stability and Wave Motion: Background , Linear Analysis of Interfacial Stability , Differential Equations, Boundary Conditions, Stability Condition and Wave Motion for Superposed , Characteristics of Wave Motion for Free Interfaces , Damping of Capillary Wave Motion by Insoluble Surfactants, Characteristics of Wave Motion for Inextensible Interface Instability of Fluid Cylinders or Jets, Oscillating Jet , Surface Tension of Oscillating Jets , Stability and Wave Motion of Thin Liquid Films: Foams and Wettability, Stability of a Liquid Film, Energy and Force Methods for Thermodynamic Stability of Interfaces , Energy Method for Stability of Superposed Fluids , charged interfaces

Interfacial Stability for Fluids in Motion: Kelvin-Helmholtz: Instability , Kelvin-Helmholtz Instability for Air-Water System , Peak Heat Flux , Waves on a Falling Liquid Film, Wave Motion on a Falling Water Film

Transport Effects on Interfacial Phenomena: Interfacial Tension Variation, Interfacial Species Mass Balance and Energy Balance , Interfacial Instability for a Liquid Heated from Below or Cooled from Above , Conditions for Development of Marangoni Instability, Interfacial Instability during Mass Transfer , Other Phenomena Influenced by Marangoni Flow, Non-equilibrium Interfacial Tensions Effect of Surfactant Transport on Wave Motion , Stability of Moving Interfaces with Phase

Transformation, Characteristics of Interfacial Instability during Solidification, Stability of Moving Interfaces with Chemical Reaction, Intermediate Phase Formation, Transport-Related Spontaneous Emulsification, Interfacial Mass Transfer Resistance, Other Interfacial Phenomena Involving Dispersed Phase Formation

Dynamic Interfaces: Introduction, Surfaces, Basic Equations of Fluid Mechanics, Flow Past a Droplet, Asymptotic Analysis, Dip Coating, Spherical Drop Revisited, Surface Rheology, Drainage of Thin Liquid Films, Dynamic Contact Lines, Slip, Thin and Ultrathin Films.

Colloids in Drug Delivery: Surfactants and block copolymers in drug delivery, Application of colloids in drug delivery, Micelles: multifunctional nano carrier for colloidal drug delivery, colloids in aerosol drug delivery systems, colloidal carrier for drug delivery in dental tissue engineering, classification and application of colloidal drug delivery system

14M1GCL233/Advances in Process Control

Introduction to process control: Dynamic and steady state processes, development of block diagram and its reduction, PID control algorithm, rough stability criteria, bode plots, root locus

Introduction to Advanced Controller: Feed forward, ratio controller, cascade controller, adaptive controller, inferential controller.

SISO and MIMO: Review of Single Input Single Output (SISO) Control; Model Based Control Multivariable control strategies Internal Model Control Preliminaries & Model Predictive Control Model forms for Model Predictive Control.

Automatic controllers: Analogue & digital signals, process actuators & control equipment Electronic, Controllers, Operational amplifier, Electronic controller input & output, PID & on-off control models, Microprocessors, General architecture, Algorithms, Application in Chemical Process Control.

Process control using digital computers: Characteristics & performance of control computer signals –types, Signal transmission, Analog feedback control systems; The direct digital control concept, Advantages of DDC, Computer process interface for data acquisition & control Computer control loops.

ANN and Fuzzy Logic: Introduction to computer control using artificial neural network (ANN), fuzzy logic applied to chemical processes. Examples of advanced control applied to a small unit in a process plant.

14M1GCL234/Applied Optimization & Operations Research

Optimization techniques: Function, Analysis and numerical methods for single variable and multivariable system, constrained optimization Problems

Application of optimization: Heat transfer and energy conservation, Separation techniques, Fluid flow systems, Chemical Reactor design

Mathematical programming: Introduction, Linear Programming, Solution by simplex method Duality, Sensitivity analysis, Dual simplex method, Integer Programming, Branch and bound method, Integer Programming, Branch and bound method

Dynamic programming: Elements of DP models, Bellman's optimality criteria, Recursion formula, solution of multistage decision problem by DP method

Pert, cpm: Network representation of projects, critical path calculation, construction of the time chart and resource levelling, Probability and cost consideration in project scheduling, Project control

Elements of queuing theory: Basic elements of the Queuing model, M/M/1 and M/M/C Queues

Elements of reliability theory: General failure distribution, for components, Exponential failure distributions, General model, Maintained and non maintained systems.

Elective III

Year/Sem: IInd Year/IIIrd Sem

10M1GCL331/Petroleum Refinery Operations

Petroleum Refining: Pre-treatment and Distillation, Stripping, Rerunning, Stabilization and Light End Removal, Super fractionation, Azeotropic Distillation and Extractive Distillation

Thermal Cracking: Introduction, Thermal Cracking, Visbreaking, Coking, Delayed Coking, Fluid Coking and Flexicoking

Catalytic Cracking: Introduction, Fixed Bed Processes, Moving Bed processes, Fluid Bed processes, Reaction chemistry of FCC, Mechanism and Kinetics, Process Variables: Feedstock Quality, Feedstock Preheating, Feedstock Pressure, Feedstock Conversion, Reactor Temperature, Recycle Rate, Space Velocity, Catalyst Activity, Catalyst Oil Ratio, Regenerator Temperature, Regenerator Air Rate. Catalysts for Cracking.

Hydrotreating: Introduction, Hydrodesulfurization: Process configuration, Reaction chemistry and Kinetics, Down flow Fixed Bed Reactor, Up flow expanded Bed Reactor, Demetallization Reactor (Guard Bed Reactor), Catalysts. Distillate Hydrosulfurization, Residuum Hydrodesulfurization, Ultra low sulphur Diesel.

Hydrocracking: Introduction, Processes and Process Design: Reaction chemistry and Kinetics, CANMET, Gulf HDS, H-G Hydrocracking, H-Oil. IFP Hydrocracking, Isocracking, LC fining, MAK, HDC, Microcat RC, Mild Hydrocracking, MRH, RCD, Unibon (BOC), Residfining, Residue Hydroconversion, Unicracking, Veba, Combi-Cracking

Next Generation Processes: Introduction, Thermal (Carbon Rejection) Processes: Asphalt Coking Technology Process, Comprehensive Heavy Ends reforming Refinery Processes, Deep Thermal Conversion Process, ET -II Process, Eureka Process, Fluid Thermal Cracking Process, High Conversion Soaker Cracking Process, Catalytic Cracking Processes: Asphalt Residue Treating Process, Heavy Oil Treating Process, Reduced Crude Oil Conversion Process, Residual Fluid Catalytic Cracking Process, Shell FCC Process, S&W Fluid Catalytic Cracking Process, Hydrogen Addition Processes, Asphaltenic Bottoms Cracking Process, Hydro visbreaking (HYCAR) Process, Solvent Processes: Deasphalting Process, Deep Solvent Deasphalting Process, Demax Process

Product Improvement: Desulfurization and Heteroatom Removal: Hydrotrating, Hydrogen Sulphide Removal Reforming: Thermal Reforming, Catalytic reforming, Dehydrogenation, Catalysts, Reformulated Gasoline and other oxygenates like MTBE and others.

Isomerisation, Alkylation and Polymerization: Process Types, Chemistry, Commercial Processes, Catalysts

Hydrogen Production: Introduction, Feed stocks, Process Chemistry, Commercial Processes: Heavy Residue Gasification and Combined Cycle Power Generation, Hybrid Gasification Process, Hydrocarbon Gasification, Hydro Process, Shell Gasification (Partial Oxidation) Process, Steam Methane Reforming, Steam Naphtha Reforming, Synthesis Gas Generation, Texaco Gasification (Partial Oxidation) Process. Catalysts, Hydrogen Purification

Alternative sources of Petroleum based applications: Hydrogen production and Fuel cells, Gas to Liquid Fuels, First & Second Generation Bio fuels

14M1GCL333/Polymer Science & Engineering

Introduction to Polymer Science: Classification of polymers, polymer structure, molecular weight, chemical structure and thermal transition

Synthesis of Polymers: Step growth polymerization : condensation polymerization , non condensation polymerization , kinetics of step growth polymerization, Chain growth

polymerization: free radical polymerization & its kinetics, Anionic polymerization and its kinetics, Cationic polymerization and its kinetics, Copolymerization & its kinetics, Coordination polymerization and its kinetics.

Polymerization Techniques: Bulk polymerization, solution polymerization, suspension polymerization & Emulsion polymerization.

Solution properties and molecular weight determination: Solution properties, membrane osmometry, vapour pressure osmometry, end group analysis, light scattering method, intrinsic-viscosity Measurement, sedimentation transport, gel-permeation chromatography.

Solid-state properties of polymers: Amorphous state, chain entanglements & reptation, glass transition, crystalline state, crystalline melting temperature, crystallization kinetics, techniques to determine crystallinity

Thermal transition & properties: Fundamental thermodynamic relationship, thermal transition in polymeric material, determination of T_g by dilatometry and calorimetry.

Mechanical properties: Test to determine mechanical performance in polymers, Static test: tensile, shear, Transient test: creep test, stress relaxation, impact & cyclic test

Viscoelasticity: Introduction to viscoelasticity, Dynamic-mechanical analysis, Mechanical models of viscoelastic behaviour

Polymer Rheology: Introduction to Polymer Rheology, Analysis of Simple Flows, Rheometry.

Polymer degradation, stability and environmental issues: Thermal degradation oxidative & UV-stability, management of plastics in environment.

Polymer additives: Fillers, plasticizers, stabilizers, colorants, flame retardant

Commercial polymers: Thermoplastics, Thermosetting polymers, Elastomers, Vulcanization

Engineering and specialty polymers: Self study

Polymer processing: Extrusion, moulding, spinning calendaring, coating.

14M1GCL334/Combustion Processes

Combustion Fundamentals: Introduction, Energy Sources, Fuels, Fuel cells, Combustion Stoichiometry and Thermo chemical Calculations, Chemical Kinetics and Equilibrium: Kinetic theory of gases, Chemical kinetics, Reaction kinetics, Equilibrium composition and temperature Conservation, energy and equilibrium equations, Transport Phenomena, and Modelling of Reaction gases, Transport properties of multi-component mixtures, Combustion Generated Air Pollutants Formation and Oxidation Kinetics, Pollutant Emissions Reduction Techniques. **Laminar Premixed Flames:** Introduction, Flammability limits, Laminar flame stabilization, Flame temperature, Burning velocity of a premixed flame, Stationary methods, Propagation method Ignition. Theory and Kinetics of Laminar Premixed Flames, Simple Fuels-N₂-O₂ Flames, Hydrogen-oxygen-nitrogen flames, Hydrogen-H₂O-CO-O₂-N₂ flames, Methane-oxygen-nitrogen flames, Methanol-air flames, Methanol-water-air flames, Propane-air flames, Ethane-air flames, Natural gas air flames, Generalization of Flame Characteristics, Effect of Fuel Type and Additives on Emission and Flame Characteristics. **Turbulent Premixed and Diffusion Flames:** Characteristics of Diffusion Flames, Turbulent Burning, Turbulence Models Interaction Between Turbulence and Chemical Kinetics, Flame Stabilization, Turbulent Premixed Flames. **Characteristics of Turbulent Combustion Diffusion Flames:** Mixing and Flow Fields of Jets, Swirling Flows in Combustion Systems, Flow and Mixing in Cold Models, Characteristics of Confined Flames, Emission and Combustion Modelling of Flames. **Combustion, Heat Transfer, Emission in Boilers and Furnaces:** Steam Boilers, Tangentially Fired Furnaces (TFFs), Fluidized-Bed Furnaces (FBFs)

14M1GCL335/Environmental Management

Introduction to different types of pollution: Air, Water and soil and their local, regional and global aspects. Sampling and analysis techniques. Human population issues. Environmental ethics and environmental quality. **Air pollution:** Sources of air pollutants, their sources and behaviour in the atmosphere. Effects of air pollutants on humans, animals, plants and properties. Control approaches. **Water pollution:** Sources, consequences, control of water pollution. Sources and nature of soil pollution and its harmful effects. Environmental problems associated with noise pollution, oil pollution and radioactive pollution. **Solid waste:** Sources and generation of solid waste, their nature and chemical composition. Their characterization and classification. Different methods of dispersal and management of solid wastes. Recycling of waste materials. Impact assessment. National and International regulations. ISO series. **Conventional and non-conventional energy resources:** Bio gas, Solar Power, wind power, life cycle analysis. Environmental audit. Sustainable development. Case studies.

Elective IV

10M1GCL332/Fluidization Engineering

Introduction: Phenomenon of fluidization, Behaviour of a Fluidized Bed, Comparison with other contacting methods, Advantages and Disadvantages of Fluidized Beds for Industrial Operations, Fluidization Quality, Selection of a Contacting Mode for a given Application.

Industrial Applications of Fluidized Beds: Coal Gasification, Gasoline from other Petroleum Fractions, Gasoline from Natural and Synthesis Gases, Synthesis Reactions, Metallurgical and Other Processes, Physical Operations, Cracking of Hydrocarbons, Combustion and Incineration, Carbonization and Gasification and Reactions Involving Solids, Bio-fluidization

Fluidization and Mapping of Regimes: Characterization of Fixed Beds of Particles, Fluidization without Carryover of Particles: Minimum Fluidizing Velocity, Pressure Drop-versus-Velocity Diagram, Effect of Pressure and Temp. on Fluidized Behaviour, Sintering and Agglomeration of Particles at High Temperature. Type of Gas Fluidization with and without Carryover, Turbulent and Churning Fluidization, Pneumatic Transport of Solids, Fast Fluidization, Voidage Diagrams for Solids, Regimes, The Mapping of Fluidization Regimes

Bubbles in Dense Beds: Single Rising Bubbles: Rise Rate of Bubbles, Evaluation of Models for Flow at Bubbles, The Wake Region and the Movement of Solids at Bubbles, Solids within Bubbles, Coalescence and Splitting Bubbles: Interaction of Two Adjacent Bubbles, Coalescence, Bubble Size and Bubble Frequency, Splitting of Bubbles and Maximum Bubble Size, Bubble Formation above Distributor, Slug Flow

Bubbling Fluidized Beds: Emulsion Movement for small and Fine Particles, Emulsion Movement for Large Particles, Emulsion gas flow and Voidage, Effect of Pressure on Bed Properties, Estimatic Bed Properties: Gas Flow in the emulsion phase, Bubble Gas Flow, Bubble Size and Bubble growth, Bubble Rise Velocity, Beds with Internals, Physical Models: Scale up and scale down

Flow Models for Bubbling Beds: General Interrelationship among Bed Properties, Simple Two phase Model, K-L Model with its Davidson Bubbles and Wakes

High Velocity Fluidization: Turbulent Fluidized Beds, Experimental Findings, Fast Fluidization, Freeboard Entrainment Model Applied to Fast Fluidization, Design Considerations, Pressure Drop in Turbulent and Fast Fluidization

Circulation Systems: Circuits for the Circulation of Solids, Finding Required Circulation Rates, Flow of Gas-Solid Mixtures in down comers: Downward discharge from a Vertical Pipe, Moving Down flow, Fluidized Down flow, Fluidized Down flow in Tall Down comers. Flow in Pneumatic Transport Lines: Vertical Up flow of Solids, Horizontal Flow, Safe Gas Velocity for Pneumatic Transport, Pressure Drop in Pneumatic Transport, Pressure drop in Bends, Practical Considerations

Design of Fluidized bed Reactors: Design of catalytic and non-catalytic fluidized bed reactors.

14M1GCL336/Multiphase Contactors

Mathematical Models for Gas-Liquid-Solid Reactors: Models based on effectiveness of contact, with no external mass transfer resistances (models for trickle-bed reactors) , Reactor performance based on residence-time distribution , Model when reactant present in both liquid and vapor phases ,Models for no isothermal trickle-bed reactors, Models which include external mass-transfer effects, Models for three-phase slurry reactors, Models for the packed-bubble-column gas- liquid reactors.

Fixed Bed Catalytic Reactors: Systems and mathematical models, general concepts, outline of the procedure for model building, basic principles of mathematical modelling for industrial fixed bed reactors.

Practical Relevance of Bifurcation, Instability And Chao in Catalytic Reactors: Sources of multiplicity: isothermal multiplicity, concentration multiplicity, thermal multiplicity, multiplicity due to reactor configuration, quantitative discussion of the multiplicity phenomenon, bifurcation and stability, steady state analysis and dynamic analysis.

Optimization of The Performance of Industrial Fixed Bed Catalytic Reactors: Objective functions, optimal and suboptimal temperature control policies, optimization of reversible reactions, Pontryagin maximum principle and simple optimality criterion for exothermic reversible reaction, modelling, simulation and optimization of industrial fixed bed catalytic reactors, case studies: mathematical modelling of high/low temperature water-gas shift converter, modelling of ammonia converters, precise modelling of industrial steam reformers and methanators.

Design of Multiphase Reaction Processes: Multiphase Reaction Processes and Chemical Engineering, Reason for Adopting Multiphase Reactors.

Model Description of Multiphase Processes: Governing Equations for State Variables of Each Phase, Dispersed Phase Modelling and Population Balance, Relationship between the Multi-stage Cell model and the Continuous model.

Mechanical and Morphological Variety of Each Phase and Contacting Mode Parameters: Relations between Parameters, Behaviour of an Isolated Particle (Solid Particle, Bubble and Droplet), Behaviour of Multi-particle Systems, Behaviour of Solid Dispersed Systems, Mass Transfer Volumetric Coefficient and Gas Exchange Coefficient, eddy diffusivity, The importance of the State of the Interface.

Concepts of Multiphase Reaction Processes: Alternatives to the State of the Interface, Systems with Flat Interfaces, Systems with One or More Phases Dispersed, Systems with Stabilized Dispersions, Systems with Forced Mechanical Dispersion, Contacting Systems with a Porous Material.

Options for Reacting Systems and Reactor Structures: Batch/Semi-batch (Semi-continuous) / Continuous, Entrained Flow/Separate Flow, Complete Mixing / Incomplete Mixing / Plug Flow, Co-current/ Counter current /Cross Current, Uniform Reactions/Zone Reactions/Surface Reactions, Micro Mixing/Macro Mixing, and Molecular Diffusion/Eddy Diffusion, Statics/Dynamics/ Stability.

Development and Scale-Up of Multiphase Reactors: The Nature of Development and Scale-up Issues, Methodology of Development and Scale-up.

Dynamics of the Gas-Liquid Suspended-solid Column: Introduction, Hydrodynamics, Gas, liquid , and solid holdups, Axial dispersion in the gas, liquid, and solid phases, Gas-liquid interface mass transfer, Liquid- solid mass transfer, Wall mass transfer in the slurry column, Heat transfer.

14M1GCL337/Catalysis & Surface Chemistry

History of Catalysis: Introduction, Industrial Catalysis, Catalytic Processes In The Oil Refinery, Total Isomerization Process of Paraffins, Isotactic Polypropylene, Catalysts For Automotive Pollution Control.

Chemical Kinetics of Catalysed Reactions: Rate Expression (Single Site Model), Rate Determining Step, Adsorption Isotherms, Rate Expression (Other Models), Initial Rate Expressions, Temperature Dependency, Sabatier Principles – Volcano Plot.

Bonding And Elementary Steps In Catalysis: Bonding, Bonding To Transition Metal Surfaces, Chemical Bonding In Organometallic Coordination Complexes And On Surfaces of Transition Metal Compounds, Elementary Steps In Organometallic Complexes, Creation of A Vacant Site, Coordination Of The Substrate, Insertions And Migrations, β -Elimination And Deinsertion, Oxidative Addition, Reductive Elimination, α -Elimination Reactions, Cyclometallation, Activation Of Substrate Towards Nucleophilic Attack, Σ -Bond Metathesis, Heterolytic Cleavage of Dihydrogen, Elementary Reaction Steps On Surfaces: Metal Catalyzed Reactions, Mechanism of The Reaction on Oxides, Catalysis By Solid Acids.

Heterogeneous Catalysis: Synthesis Gas Reactions, Fischer-Tropsch Synthesis of Hydrocarbons, Modification of The Catalyst By Alloying Metals And By Using Promoters And Supports, Hydro-Dehydrogenation Reactions on Metals, Catalytic Oxidation.

Homogeneous Catalysis With Transition Metal Complexes: Rhodium Catalyzed Hydroformylation: Rhodium Based Hydroformylation, Ligand Effects, Phosphine Effects, Ligand Effects In Rhodium Catalyzed Hydroformylation, The Characterization of Intermediates, Zirconium Catalyzed Polymerization Of Alkenes : Supported Titanium Catalysts, Isotactic Polypropylene, The Cossee-Arman Mechanism, Homogeneous Versus Heterogeneous Catalysts, Site Control Versus Chain-End Control, Chain-End Control: Syndiotactic Polymers, Chain-End Control: Isotactic Polymers, Site Control: Recent history Site Control: Isotactic Polymers Asymmetric Hydrogenation: Cinnamic Acid Derivatives, Naproxen and ibuprofen, Binap catalysis

Preparation of Catalyst Supports And Zeolites: Introduction, Preparation of Silica Gel Catalyst Supports, Preparation of Silica Gel, Preparation of Alumina Catalyst Supports, Preparation of γ - Al_2O_3 and η - Al_2O_3 , Structure of γ - Al_2O_3 And η - Al_2O_3 , Zeolite Synthesis, Synthesis of Zeolite A, Synthesis of Zeolite Y, Synthesis of Mordenite, Synthesis of ZSM-5, Catalyst Shaping: Introduction, Spray Drying, Granulation, Pelletization, Extrusion, Oil-Drop Method/Sol-Gel Method.

Preparation of Supported Catalysts: Introduction, Selective Removal, Application On A Separately Produced Support, Support Surface Chemistry, Impregnation, Deposition-Precipitation.

Catalyst Characterization With Spectroscopic Techniques: Introduction, Aim of Catalyst Characterization, X-Ray Diffraction (XRD), Electron Microscopy, Temperature Programmed Techniques, Surface Spectroscopy, Infrared Spectroscopy, Extended X-Ray Absorption Fine Structure (EXAFS), Techniques, Mossbauer Spectroscopy.

The Use of Adsorption Methods For The Assessment of The Surface Area And Pore Size Distribution of Heterogeneous Catalysts: Introduction, Physical Adsorption, Adsorption Isotherms, Classification of Pore Sizes, Porosity of Porous Substances, The Yardstick In The Determination of Surface Areas, The Langmuir Adsorption Isotherm (Monolayer Adsorption) And The Bet Equation (Multilayer Adsorption), The Concept of A Standard Isotherm; The T Method, Micro porosity, Hysteresis Loops, The Corrected Kelvin Equation.

Elective V

Year/Sem: IInd Year/IVth Sem

14M1GCL431/Process Engineering

Product and Process Invention: Objectives, design Opportunities, steps in product and process design, environmental protection, safety considerations, engineering ethics, role of computers

Molecular Structure Design: Objectives, Introduction, Property Estimation, Optimization to locate molecular structure

Process Creation: Preliminary database creation, Preliminary process synthesis, Development of base case design, Generalization of the Resolution Based Synthesis procedure for development of flow sheet for a chemical plant,

Simulation to assist in process creation: Principles of steady state flow sheet – simulation, principles of batch process simulation

Heuristics for process synthesis: Raw materials and chemical reactions, distribution of chemicals, separations, heat removal from and addition to reactors, heat exchangers and furnaces, pumping, compression, pressure reduction, vacuum, and conveying of solids

Reactor Design and Reactor Network Synthesis: Reactor models, Stoichiometry, extent of reaction, equilibrium, kinetics, ideal kinetic reaction models – CSTRs and PFRs, reactor design for complex configurations, reactor design using the attainable region

Synthesis of Separation Trains: Feed separation systems, phase separation of reactor effluent, industrial separation operations, criteria for selection of separation methods, selection of equipment, sequencing of ordinary distillation columns for the separation of nearly ideal fluid mixtures, Sequencing of operations for the separation of non ideal fluid mixtures, separation systems for gas mixtures, separation sequencing for solid-fluid systems

Heat and Power Integration: Minimum utility targets, networks for maximum energy recovery, minimum number of heat exchangers, threshold approach temperature, optimal approach temperature, Heat integrated distillation trains

14M1GCL432/Conceptual Design of Selected Separation Processes

Strategy for process synthesis and analysis:

Creative aspects of process design, a hierarchical approach to conceptual design

Engineering economics

Cost information required, estimating capital and operating cost, total capital investment and total product cost, time value of money, measures of process profitability

Developing a conceptual design and finding best flow sheet:

Input information and batch versus continuous, Input output structure of the flow sheet: design variable, overall material balance and stream costs, process alternatives, recycle structure of the flow sheet: recycle material balance, heat effects, equilibrium limitation, recycle economical and cost

Design of chemical processes

Design of distillation tower, azeotropic system, solvent extraction, membrane separation, reactive distillation, absorption

14M1GCL433/Safety and Hazards Analysis and Assessment

Introduction and Concepts of Safety: Definitions. Types of Accidents. Causes and direct & indirect effects of accidents, Types of damages. Role of safety considerations in chemical plant design & operations. Protective & safety equipments. Measure of Risk. Liabilities of accidents. Laws. Rules, Regulations (concerning safety in chemical process plant) for the prevention of accident. Managerial aspects of safety, General aspects of post disaster mitigation and management within an organization & in society at large. **Toxicology and industrial hygiene:** Typical toxins and their biological effects. Outline of their ingestion to and elimination from biological systems. Toxicological Parameters - Their definitions and outline of the measurement methods. Evaluation of exposure to toxicants and its impact. Source Models - Release & flow of toxic gases & liquids, flashing liquids, boiling liquids, etc. Dispersion Models - factors affecting dispersion and their modelling. Design & Equipment for prevention of toxic release in chemical plants. Management of toxic release scenario. **Fires and explosion:** The fire triangle and factors contributing to fire & explosions. Definition. Relevant material characteristics & properties. Concepts of Ignition, Ignition Energy. Phenomena and Source of Ignition auto ignition, auto oxidation, adiabatic compression, electrostatic ignition, role of fuel sprays, mists, dusts on ignition process. Explosions - various types & conditions for their occurrence. Inerting & Purging of equipment, Ventilation of rooms, Control of static electricity process control systems, Sprinkler systems, Fire fighting systems **Relief and relief systems:** Definitions. Relief requiring scenarios. Relief types & locations. Relief systems, various options and their sizing and applications for single and multiphase flows. Deflagration venting for dust & vapour explosions. **Hazard identifications:** HAZOP, HAZAN and such methods. Safety Review & other methods, examples. Safety Audit. **Risk assessment:** Review of probability theory in respect of failures, coincidences etc. Leading to unsafe situation. Concepts of event trees & fault trees. Analysis of trees for risk assessment, its advantages & disadvantages for simple examples of application of Risk Assessment technique. **Accident investigations:** Learning from accidents Methods of investigating and diagnosing. Aids for recommending case studies of well known accidents such as Flixborough. Bhopal etc.

14M1GCL434/Nanotechnology and Applications

Introduction to nanotechnology: Definition, history of nanotechnology. Properties in nano scale: Extensive and Intensive properties, change in physical properties like colour, melting point, electrical, magnetic, and mechanical. Crystal structure; free electron theory of metals; band theory of solids; metals and insulators; semiconductors: classification, electrons and holes, transport properties; size and dimensionality effects - quantum wells. **Synthesis of nano materials:** Synthesis of nano materials, different approaches of synthesis (physical techniques and Chemical Techniques. Equipment and processes needed to fabricate nano devices and structures. **Thin Films and Thick Films:** Deposition of thin film and thick films, Physical vapour Deposition (PVD) and Chemical Vapour Deposition **Characterization techniques of nano materials:** SEM, STM, AFM, XRD etc. Electronic, Magnetic, Optical, Chemical and Mechanical properties of nano materials. **Applications of different nano materials in Chemical and Environmental engineering:** Discovery, preparation, properties, applications of carbon nano tubes. Inorganic nano wires, Biological and bio-inspired materials, Metallic nano materials, Different shape nano materials. Nano material based biosensors: bio functionalization of nano materials, advantages over other sensors, Field effect transistor based biosensors. Application in cholesterol, blood sugar, single virus detection: Semiconductor nano particles and Quantum dots. Application of quantum dots. Application of nano particles in catalysis.

Elective VI

14M1GCL435/Advanced Process Synthesis

Heuristics for Process Synthesis: Objectives, Introduction, Raw Materials and Chemical Reactions, Distribution of Chemicals: Inert species, purge streams, recycle to extinction, selectivity, Reactive Separations, Optimal conversion, Separations: separation involving liquid and vapour, mixtures, separation involving solid particles, heat removal from and addition to reactors, heat exchanger and furnaces, pumping, compression, pressure reduction, vacuum, and conveying of solids, changing the particle size of solids and size separation of particles, removal of particles from gases and liquids.

Reactor Design and Reactor Network Synthesis: Reactor design for complex configuration, reactor network design using the attainable region, construction of the attainable region, the principles of reaction invariants.

Synthesis of separation trains: Sequencing of operations for the separation of non ideal fluid mixtures, Heuristics for determining favourable sequences, complex and thermally coupled distillation columns, sequencing of operation for the separation of Non ideal fluid mixtures: azeotropy, residue curves, computing azeotropes for multi component mixtures, heterogeneous distillation, pressure swing distillation, membranes, absorbers, auxiliary separators, reactive distillation, separation train synthesis, Separation systems for gas mixtures, separation sequencing for solid-fluid systems.

Reactor- separator-recycle networks: Introduction, locating the separation section with respect to the reactor section, trade off in processes involving recycle.

Heat and Power Integration: Network for maximum energy recovery: mixed integer linear programming, Minimum number of heat exchangers: stream splitting, Optimal temperature approach, superstructures for minimization of annual costs, Heat integrated distillation trains: impact of operating pressure, multiple effect distillation, heat engines and heat pumps: positioning heat engines and heat pumps, optimal design.

Mass Integration: Introduction, minimum mass separating agents: approach to phase equilibrium, concentration interval method, composite curve methods, mass exchange networks for minimum external mass separating agents, minimum number of mass exchangers, breaking mass loops.

Optimization of process flow sheets: Introduction, general formulation of the optimization, classification of optimization problems, linear programming, nonlinear programming, optimization algorithm, flow sheet optimization: case studies.

Integration of process design and process control: Introduction, control system configuration, classification of process variables, selection of controlled output variables, selection of manipulated variables, selection of measured variables, degree of freedom analysis, qualitative plant wide control system, qualitative plant wide control system synthesis.

14M1GCL436/Bioprocess Principles

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: 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.

Control in Bioprocesses: 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.

14M1GCL437/Bio-separations

Introduction: Bio-separations: an overview, Analytical methodologies, and separation and purification methods.

Purification and Analysis by HPLC: Analysis of protein impurities in pharmaceuticals derived from recombinant DNA, Basic chromatographic terms and concepts, the chemical structure of polypeptide and protein, Physicochemical Factors That Underpin Ligand Interactions with Polypeptides and Proteins in HPLC Separation Systems , Strategic Considerations behind the HPLC Separations, Specific Physicochemical Considerations on the Individual Chromatographic Modes, The Effect of Temperature and the Thermodynamics of Polypeptide- or Protein-Ligand Interactions

Processing Plants and Equipment: Introduction, Industries Using Bio separations, Process-Scale Bio separations, Process-Scale Considerations

Process Control of Bioseparation Processes: Need for Process Control in Bio separations, Brief Overview of Current Control Methods, Application Examples, Opportunities for Continuing Development

Economics of Bioseparation Processes: Drugs Market and Sales, Applications of Models and Flow Sheets in Bioseparation Economics

