DR. A.P.J ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

PROPOSED STUDY & EVALUATION SCHEME

FOR

III YEAR B.TECH.

(CHEMICAL ENGINEERING)

ON

CHOICE BASED CREDIT SYSTEM (CBCS)

[EFFECTIVE FROM THE SESSION 2018-19]

FIFTH SEMESTER									
SI. No.	**Subject Code**	**Subject Name**	**Department**	**L-T-P**	**Th/Lab Marks**	**Sessional**		**Total**	**Credit**
					ESE	**CT**	**TA**		
1	RAS501	Managerial Economics	Applied Science	3--0--0	70	20	10	100	3
2	RAS502/RUC501	Sociology /Cyber Security	Applied Science	3--0--0	70	20	10	100	3
3	RCH501	Chemical Reaction Engineering	Core Deptt.	3--0--0	70	20	10	100	3
4	RCH502	Mass Transfer– II	Core Deptt.	3--1--0	70	20	10	100	4
5	RCH503	Chemical Technology	Core Deptt.	3--0--0	70	20	10	100	3
6	RCH051-054	Deptt Elective Course-1	Core Deptt.	3--1--0	70	20	10	100	4
7	RCH 551	Chemical Reaction Engg Lab	Core Deptt.	0--0--2	50		50	100	1
8	RCH 552	Mass Transfer Lab - II	Core Deptt .	0--0--2	50		50	100	1
9	RCH 553	Chemical Technology Lab	Core Deptt.	0--0--2	50		50	100	1
10	RCH 554	Soft Computing Lab	Core Deptt.	0--0--2	50		50	100	1
	TOTAL				620	120	260	1000	24

Deptt. Elective:

RCH051: Computational Fluid Dynamics

RCH052: Optimization Techniques

RCH053: Numerical Methods for Chemical Engineer

RCH054: Statistical Design of Experiments

Sixth Semester									
SI. No.	**Subject Code**	**Subject Name**	**Department**	**L-T-P**	**Th/Lab Marks**	**Sessional**		**Total**	**Credit**
					ESE	**CT**	**TA**		
1	RAS601	Industrial Management	Applied Science	3--0--0	70	20	10	100	3
2	RUC601/RAS 602	Cyber Security /Sociology	Applied Science	3--0--0	70	20	10	100	3
3	RCH601	Transport Phenomena	Core Deptt.	3--0--0	70	20	10	100	3
4	RCH602	Process Dynamics & Control	Core Deptt.	3--1--0	70	20	10	100	4
5	RCH603	Chemical Reaction Engineering -II	Core Deptt .	3--0--0	70	20	10	100	3
6	RCH061-064	Deptt Elective Course-2	Core Deptt .	3--1--0	70	20	10	100	4
7	RCH651	Flow Sheeting Lab	Core Deptt.	0--0--2	50		50	100	1
8	RCH652	Process Dynamics & Control Lab-I	Core Deptt.	0--0--2	50		50	100	1
9	RCH653	Process Dynamics & Control Lab -II	Core Deptt.	0--0--2	50		50	100	1
10	RCH654	Chemical Reaction Engineering Lab -II	Core Deptt.	0--0--2	50		50	100	1
	TOTAL				620	120	260	1000	24

Deptt Elective:

RCH061: Process Flow Sheet Simulation

RCH062: Process Integration

RCH063 Process Utility & Safety in Chemical Plants

RCH064: Intellectual Property Rights & Standardization

RCH501: CHEMICAL REACTION ENGINEERING (3:0:0)

UNIT 1

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

UNIT 2

Interpretation of variable volume batch reactions for zero, first and second order reactions, design equation for batch, continuous stirred tank, plug flow reactors for isothermal reaction.

UNIT 3

Optimum reactor size, plug flow/mixed flow reactors in series and parallel, recycle reactor.

UNIT 4

Design of reactors for multiple reactions, parallel and series reactions. Temperature and pressure effects for single reaction.

UNIT 5

Residence time distribution of fluids in vessels, E, F and C curves, Dispersion model, Tank in series model. Non Isothermal PFR and CSTR, Safety issues in Non Isothermal Reactors.

Text Books:

1. Smith, J, M, "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill (1990).
2. Levenspiel, O., "Chemical Reaction Engineering", 3rd Edition, John Wiley (1998).
3. Fogler, H.S., 2016. Elements of chemical reaction engineering.

Reference Book:

1. Keith J. Laidler, "Chemical Kinetics" 3rd Edition, Pearson (2013)

RCH502: Mass Transfer– II (3:0:0)

UNIT 1

Distillation: Basic fundamentals of distillation, Pressure-composition, Temperature-concentration, Enthalpy- concentration diagrams for ideal and non-ideal solutions, Raoult's law and its application, Maximum and minimum boiling mixtures, concept of relative volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation.

UNIT 2

Continuous Distillation of Binary Mixtures : Multistage contact operations, Characteristics of multistage tower, McCabe Thiele method, Ponchon Savarit method, Reflux, maximum, minimum and optimum reflux, Use of open steam, Tray efficiency, Determination of height and column diameter, Multistage batch distillation; Principles of azeotropic and extractive distillation, Introduction & Design of multicomponent distillation system.

UNIT 3

Liquid-Liquid Extraction: Ternary liquid equilibria, Triangular graphical representation concept of theoretical or ideal stage, Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation Super critical fluid extraction.

UNIT 4

Solid /Liquid Extraction: Leaching, Solid liquid equilibrium, Equipment used in solid – liquid extraction, Single and multistage cross current contact and counter current operations. Concept of an ideal stage, Overall stage efficiency, Determination of number of stages.

UNIT 5

Adsorption: Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents adsorption equilibria and adsorption hysteresis, Stage wise and continuous

contact adsorption operations, Determination of number of stages, Ion exchange Equipments, Equilibrium relationship, Principle, techniques and applications of Ion-exchange, , Principles and application of Dialysis, Osmosis, Reverse osmosis, Thermal diffusion, Sweep diffusion.

Text Books:

1. Treybal, R "Mass Transfer Operations", 3rd Editon, New York: McGraw-Hill, (1980).
2. Sherwood T. K., Pigford R. L. and Wilke P. "Mass Transfer" McGraw Hill (1975)

Reference Books:

1. Foust A. S. et.al., "Principles of Unit Operations" John Wiley (1980).
2. Geankoplis, C.J.. "Transport Processes and Unit Operations", 3rd Editon, Prentice Hall. (1993)
3. Coulson, J. M. and Richardson J. F., "Chemical Engineering" Vol. I, II, IV & V: Pergamon Press.
4. Phillip C. Wankat, "Separation Process Engineering Includes Mass

RCH502: Mass Transfer– II (3:0:0)

Transfer Analysis, 3rd Editon, Pearson

RCH 503: Chemical Technology (3:0:0)

Introduction of CPT with reference to Indian resources, industries, trade and export potential, small scale industries and rural development. Preparation of process flow diagrams, Instrumentation diagrams and Process symbols. ; Introduction to the following industries lying emphasis on process flow sheet, material requirements, process conditions, material of construction and design aspects.

UNIT 1

Introduction - Mono and Disaccharides - Important reactions - Polysaccharides - Starch and Cellulose - Derivatives of Cellulose - Carboxy Methyl Cellulose and gun cotton - Structural aspects of cellulose.

UNIT 2

Sugar, Glucose, Starch, Fermentation products such as Alcohol,
Acetic acid, Citric acid and antibiotics

UNIT 3

Soap and Surfactants, Glycerin, Fatty acids, Hydrogenation of edible oils, paper and pulp

UNIT 4

Synthetic and natural fibers: Nylon, Dacron, Terylyne, Polyester and other new products, Viscose rayon, acetate rayon , synthetic rubber with special reference to manufacture, vulcanization and reclaiming of rubber, SBR, Plastics, Thermosetting and Thermo Plastics (PVC, Polyethylene, Polyurethane, Teflon)

UNIT 5

Crude oil distillation, Thermal conversion processes (visbreaking, coking), Catalytic conversion processes (fluid catalytic cracking, catalytic reforming, hydro cracking, alkylation, isomerisation, polymerization) Finishing processes, sulphur removal process, lub oil manufacture; Petrochemicals (ethylene, propylene, formaldehyde, methanol, ethylene oxide, ethanolamine, cumene, ethylene glycol, ethyl benzene)

Text Books:

1. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M. Gopala Rao and M. Sittig) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).
2. Austin G. T. Shreve’s Chemical Process Industries”, 5th Edition, McGraw Hill (1984).
3. O P Gupta, "Chemical Process Technology", Khanna Publishing House.

RCH 051: Computational Fluid Dynamics (3:1:0)

UNIT 1

Basic Concepts of Fluid Flow: Philosophy of computational fluid dynamics, conservation principles of mass, energy, and momentum, simplified flow models such as incompressible, inviscid, potential and creeping flows, classification of flows.

UNIT 2

Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time- averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The k-e model, Reynolds stress equation models, Algebraic stress equation models.

UNIT 3

Grid Generation: Structured and unstructured grids, choice of grid, general transformation of equations, some modern developments in grid generation in solving the engineering problems.

Finite Difference Method: Discretization of ordinary and partial differential equations, approximation of first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.

UNIT 4

Finite Volume Method: Discretisation methods, approximations of surface integrals and volume integrals, interpolation and differentiation practices, implementation of boundary conditions, applications to the engineering problems. Introduction, one-dimensional steady state diffusion, two-dimensional diffusion problems, three-dimensional diffusion problems. The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: On e-dimensional unsteady heat conduction .

UNIT 5

Special Topics: Flow in a sudden pipe contraction / expansion, flow and heat transfer in a complex tubes and channels, reactive flow, multiphase flow, and turbulent flow processes.

Books:

1. Sengupta T. K., "Fundamentals of Computational Fluid Dynamics", University Press. 2013

2. Anderson Jr J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill. 1995
3. Muralidhar K. and Sundararajan T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House. 2003
4. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method, Longman scientific & technical publishers, 2007

RCH 051: Computational Fluid Dynamics (3:1:0)

5. Ferziger J. H. and Peric M., "Computational Methods for Fluid Dynamics", 3rd Ed., Springer. 2002
6. Ranade V. V, "Computation Flow Modeling for Chemical Reactor Engineering", Academic Press. 2002

RCH-052: Optimization Techniques (3:1:0)

Unit 1
Analytical Method Necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems.

Unit 2
Unconstrained One Dimensional Search Newton, Quasi-Newton and Secant method for unidimensional search, Region elimination methods (Golden Section, Fibonacci, Dichotomous. etc.)

Unit 3
Linear Programming, Graphical simplex method, revised simplex method, duality and transportation problems. Unconstrained Multi Variable Search, Direct methods, Indirect method.

Unit 4
Finite difference approximation, Dynamic Programming.

Unit 5
Principle of optimality, Discrete and continuous dynamic programming.

Books:

1. T. F. Edgar and D. M. Himmelblau Optimization of Chemical Processes – McGraw Hill (1989)
2. K. Urbanier and C. McDermott - Optimal Design of Process Equipment – John Wiley (1986)

RCH-053: Numerical Methods for Chemical Engineer (3:1:0)

UNIT I

Ordinary Differential Equations, Separable equations, Equations made separable by change of variables, Homogeneous Equations, Equations with first order and first degree with linear coefficients, Exact equations, Linear equation of first order, Bernoulli's equation, Other integrating factors, Integration of Exact equations, Equations of first order and higher degree, Clairaut's equation, Singular solutions, Equations with missing terms, General properties of Linear equations, Linear equations with constant coefficients, Determination of the complementary function, exponential functions, Determination of the particular integral, the Euler equation, Simultaneous Linear Differential equations.

UNIT II

Power series method, theory of the power series method, Legendre's equation, Legendre's Polynomials, Frobenius Method.

UNIT III

Bessel's equation, Bessel Functions $J_v(x)$, Bessel Functions $J_v(x)$ for any $v \geq 0$. Gamma Function, Solution $J_{-v}(x)$ of the Bessel Equation, Backbones of Bessel's Theory, $J_v(x)$ with $v = \pm 1/2, \pm 3/2, \pm 5/2$.

UNIT IV

Definition of matrix, Some special definitions and operations involving matrices, Determinants, Theorems on determinants, Inverse of a matrix, Orthogonal and unitary matrix. Orthogonal vectors, System of linear equations, Systems on n equations with n unknowns, Cramer's Rule, Eigen values and eigen vectors.

UNIT V

Analysis of Stagewise Processes by the Calculus of Finite Differences, Countercurrent Liquid- Liquid Extraction, Solution of Difference Equations, Stirred-tank Reactor System, Distillation in a Plate Column, Unsteady-state Operation, Starting a Stirred-tank Reactor, Rate at which a Plate Absorber Approaches Steady State.

BOOKS:

1. Mickley, Reid and Sherwood, "Applied Mathematics in Chemical Engineering", Tata McGraw Hill, New Delhi (1981).

2. E. Kreyszig, "Advanced Engineering Mathematics", 8th edition, John Wiley and Sons (1999).

3. M. R. Spiegel, "Advanced Mathematics for Engineers and Scientists", Schaum Outline Series, McGraw Hill, (1971).

4. Chandrika Prasad, Reena Garg, "Advanced Engineering Mathematics", Khanna Publishing house.

RCH-054: Statistical Design of Experiments (3:1:0)

UNIT 1

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments;

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means, randomized and paired comparison design.

Experiments with Single Factor: Analysis of variance, Covariance and analysis of covariance, analysis of fixed effects model, model adequacy analysis, non-parametric methods.

UNIT 2

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

UNIT 3

Parameter Estimation: Linear regression models, estimation of the parameters in linear regression models, hypothesis testing in multiple regression, non-linear regression, logistic and weighted regression, Chi-squared tests, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics, testing for lack of fit.

UNIT 4

Response Surface Methods: Central composite and Box-Behnken designs, method of steepest ascent, analysis of a second-order response surface, experimental designs for fitting response surfaces, mixture experiments, Simultaneous optimization of several responses, Simplex method, evolutionary operation, robust design.

UNIT 5

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

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

Books:

1. Lazic Z. R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley, 2005.
2. Antony J.," Design of Experiments for Engineers and Scientists," Butterworth Heinemann, 2004,
3. Montgomery D. C., "Design and Analysis of Experiments", 5th Ed., Wiley, 2004.

RCH-551: Chemical Reaction Engg Lab (0:0:2)

1. Find out kinetic constant and study conversion of a given reaction in a batch reactor
2. Find out kinetic constant and study conversion of a given reaction in a plug flow reactor
3. Find out kinetic constant and study conversion of a given reaction in a CSTR
4. Study and operation of an adiabatic batch reactor
5. Study of a reversible reaction in a batch reactor
6. To determine energy of activation of reaction of ethyl acetate with sodium hydroxide
7. Find out specific rate contant and activation energy of a reaction in a plug flow reactor
8. To determine reaction equilibrium constant of reaction of acetic acid with ethanol.
9. To determine changes in free energy, enthalpy and entropy for the reaction of potassium iodide with iodine.
10. Study and operation of a cascade CSTR

The reaction of disappearance of phenolphthalein in NaOH solutions may be used for experiments 1, 2 and

RCH-552: Mass Transfer Lab - II (0:0:2)

1. Determination of ternary curve for the system acetic acid-water-carbon tetrachloride.
2. Determination of distribution coefficient of a solute in two immiscible liquids.
3. Solid-Liquid extraction – Soxhlet's experiment.
4. Liquid - liquid extraction in packed bed.
5. Determination of adsorption kinetics and isotherm at solid-liquid interface.
6. Determination of the rate of drying in a tray dryer.
7. Estimation of efficiency of the fluidized bed dryer

RCH-553: CHEMICAL TECHNOLOGY LAB (0:0:2)

Preparation and Quality evaluation of following items:-

1. Cement Paint
2. Dry Distemper
3. Oil bound Distemper
4. Plastic Emulsion Paint
5. Polystyrene by Bulk Polymerization Technique
6. PMMA by Bulk Polymerization Technique
7. Transparent Soaps
8. Powdered Detergent
9. Liquid Detergent

RCH-554: SOFT COMPUTING LAB (0:0:2)

Use of following Techniques in C/C++ Language

1. Solution of single non-linear algebraic equations by Newton Raphson method.

2. Solution of single non-linear equations by Regulafalsi method.

3. Solution of system of linear simultaneous by Gauss Elimination method.

4. Solution of system of linear simultaneous equation by gauss seidel method and successive over relaxation method.

5. Solution of single first order ordinary differential equations by fourth order Runge-Kutta method.

6. Solution of Heat equations (Parabolic equations) by finite difference method.

7. Solution of Laplace equations (elliptic equation) by finite difference method.

8. Solution of wave equations (Hyperbolic equation) by finite difference method.

9. Finding Newton's interpolatory polynomial for n points.

10. Finding Newton's interpolatory polynomial based on finite difference table for n points.

11. Simpson's 3/8-rule.

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RCH-601: TRANSPORT PHENOMENA (3:0:0)

UNIT 1

Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity.

UNIT 2

Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces, Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal).

UNIT 3

Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change (non-isothermal), equation of continuity, equation of motion for forced and free convection, equation of energy (non-isothermal).

UNIT 4

Shell mass balances, concentration profiles, average concentration, mass flux at surfaces, Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component).

UNIT 5

Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory.

Text Book:

1. Byron, R. B., Stewart, W. E., Lightfoot, E. N., "Transport Phenomena", John Wiley & Sons, 1960.

RCH-602: Process Dynamics & Control (3:1:0)

UNIT 1

Dynamic modeling of first and second-order process; Interacting and non-interacting processes; Nonlinear and integrating processes; introduction to non-minimum phase processes; Distributed parameter processes and MIMO processes; Response of first and second order processes with respect to different types of forcing functions.

UNIT 2

Experimental estimation of dynamic process parameters and identification. Modes of control action: Classification of controllers and control strategy.

UNIT 3

Closed loop feedback control: Servo and regulator problems; Offset; Selection of mode of control action; Closed loop response;

UNIT 4

Routh stability criterion; Controller tuning and design:, Online tuning- closed loop and open loop methods. Frequency response technique: Phase margin and gain margin; Bode stability criterion; Nyquist stability criterion; Controller design. Root locus plot and stability analysis.

UNIT 5

Cascade and feed forward control: Design of controller and analysis of control system. Ratio, Adaptive, Model-based, Multivariable, Selective and Split range control. Computer process control

Text Book:

1. Coughnaowr, D. R., “Process Systems Analysis and Control”, McGraw-Hill, Inc.
2. Stephanopolous, G., “Chemical Process Control”, Prentice-Hall.

Reference Books:

1. Seborg, D. E., Edgar, T., and Mellichamp, D. A., “Process Dynamics and Control”, John Wiley and Sons.
2. Bequette, B. W., “Process Control: Modeling, Design, and Simulation”, Prentice-Hall, Inc.
3. Chidambaram, M., “Computer Control of Processes” Narosa Publishing House Pvt. Ltd., Ind.
4. D.C. Sikdar, " Instrumentation and Process Control", Khanna Book Publishing

RCH-603: CHEMICAL REACTION ENGINEERING -II (3:0:0)

UNIT 1

Introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, Fluid-fluid reactions: kinetics and design.

UNIT 2

Fluid-solid reactions, experimental methods for finding rates, selection of a model, shrinking-core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling step, kinetic and design, Design of packed bed and fluidized bed reactors.

UNIT 3

Nature of catalysis, Determination of surface area, void volume and solid density, pore-volume distribution, physical and chemical adsorption, adsorption isotherms, Physical properties of catalysts, preparation, testing and characterization of solid catalysts, catalyst selection, catalyst preparation, promoters and inhibitors, catalyst poisoning and mechanisms of catalytic reactions, catalyst deactivation.

UNIT 4

Reaction and diffusion within porous catalysts, effectiveness factor, various resistances to transfer of reactants to the catalyst site, intrinsic and global rate of reaction, kinetic regimes, heat effects during reaction, Performance equations for reactors containing porus catalyst particles, design of solid catalytic reactors.

UNIT 5

Biochemical reactors, polymerization reactors.

Books:

1. Smith, J, M, “Chemical Engineering Kinetics”, 3rd Edition, McGraw-Hill (1990).
2. Levenspiel, O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley, (1998).

Reference Books:

1. Daizo Kunii & Octave Levenspiel, “Fluidization Engineering” 2nd Edition, Elsevier (India Print 2005)
2. Coulson and Richardson's Chemical Engineering Volume 3 - Chemical and Biochemical Reactors and Process Control (3rd Edition)

DEPARTMENT ELECTIVE 2:
RCH-061: Process Flow Sheet Simulation (3:1:0)

UNIT 1

Introduction to Process Simulation: Background and history of process simulation; Steady State and Dynamic Simulation; Different approaches to process simulation; modules and components in a process simulation package, integration of simulation tools, structure and functionality of commercial simulation tools, selection of flowsheet and simulation software.

Process Flow sheeting: Approaches to flowsheeting, collection and estimation of thermo-physical properties for the chemical species of the system, thermo-physical properties banks, Flow sheet presentation, manual flow sheet calculations, computer aided flow-sheeting, manual calculations with recycle streams, partitioning and tearing a flowsheet.

UNIT 2

Fundamentals of systems engineering: system definition, system properties, aggregation/decomposition, hierarchies of systems; introduction of canonical modeling concepts: devices, connections, equations, variables; formalizing the modeling process: methods of structuring complex chemical processes, procedures for process modeling; degrees of freedom in a flow sheet. numerical properties of the model equations, numerical methods for steady-state and dynamic systems, Differential Algebraic Equations; Synthesis of reaction systems and synthesis of azeotropic separation systems.

UNIT 3

Processing Simulation with software's such as : ASPEN PLUS/Hysis/PRO II/Design II/UniSim/OLI Pro/Aspen Custom Modeler/TK-Solve r: Introduction to the Simulation Package; Features of simulation packages; Introduction to the simulation package Graphical User Interface; Example-1: Flashing of Light Hydrocarbons; Survey of unit operation models; Example-2: Vinyl chloride monomer (VCM) flowsheet.

UNIT 4

Flowsheet Calculations and Model Analysis Tools: Sensitivity and case-study runs; Design specifications and calculator blocks; Example-3: VCM flowsheet sensitivity run / design-spec run. Inorganic chemicals and electrolyte modeling; Example-4: sour water systems (CO2 and H2S removal for example)

UNIT 5

Physical Properties: Overview of physical property system; Property model specifications; Property data requirements and input; Physical property analysis; Example-1: Introducing a non-databank component. Multistage Separation: RADFRAC: Rigorous rating and design fractionation model; Example-2: Using RADFRAC in the VCM flowsheet. Introduction to ICARUS (an economic evaluation package inside ASPEN PLUS), Flowsheet Convergence: Example-3: VCM flowsheet convergence, Introduction to overall Plant automation through simulation, molecular modeling and how it will compliment standard simulators and dynamic simulation.

Case Study: Design and simulation of some of the inorganic and organic process plants such as sulphuric acid, ammonia.

Books and Resources:

1. Dimian A. C., "Integrated Design and Simulation of Chemical Processes", Elsevier, 2003
2. Westerberg, A. W., Hutchison, H. P., Motard, R. L. & Winter, P., "Process Flowsheeting", Cambridge University Press,1979.
3. Kumar, A., "Chemical Process Synthesis and Engineering Design", Tata McGraw Hill, 1981.
4. K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Academic Press, 2001
5. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed., Butterworths, 1997
6. A.W. Westerberg, et al, "Process Flow Sheeting", Cambridge University Press, 1990

Resources:

DEPARTMENT ELECTIVE 2:
RCH-061: Process Flow Sheet Simulation (3:1:0)

- ✓ SCILAB, available at http://www.scilab.org, is an open-source simulation package, quite similar to MATLAB.
- ✓ Netlib online repository for numerical and scientific computing: http://www.netlib.org/
- ✓ Numerical Recipes: The art of scientific computing website: http://www.nr.com/
- ✓ CANTERA, Object-Oriented Software for Reacting Flows: http://www.cantera.org/
- ✓ Practice problems: http://www.che.eng.kmutt.ac.th/cheps/ChE656.htm

RCH-062: Process Integration (3:1:0)

UNIT 1

Process Integration and its Building Blocks: Definition of Process Integration (PI), Areas of application and Techniques available for Process Integration, Role of thermodynamic laws.

UNIT 2

Basic Elements of Pinch Technology: Data extraction, Targeting, Designing,Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.

UNIT 3

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

UNIT 4

Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches.

UNIT 5

Heat Integration of Equipments: Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems.

Books:

1. Linnhoff, B. Townsend D.W., Boland D., Hewitt G.F., Thomas, B.E.A., Guy, A. R. and Marsland, R. H., "A User's guide on process integration for the efficient use of energy", Inst. of Chemical Engineers, London (1982).
2. V. Uday Sheno, Heat Exchanger network synthesis, Gulf Publishing Co, USA, 1995
3. James M. Douglas Conceptual Design of Chemical Process, McGraw Hill, New York, 1988.
4. Smith, R., "Chemical Process Design", McGraw Hill (1995).

RCH-063 PROCESS UTILITY & SAFETY IN CHEMICAL PLANTS (3:0:0)

Unit 1

Various process utilities, their role and importance in chemical plants. Water Sources of water and their characteristics: Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water: Water resource management.

Unit2

Steam Generation and Utilization

Steam Generation and its application in chemical process plants, distribution and utilization: Design of efficient steam heating systems: steam economy, steam condensers and condensate utilization Expansion joints, flash tank design, steam traps their characteristics, selection and application, waste heat utilisation; Lagging, selection and thickness. Selection and sizing of boilers; waste heat boilers.

Unit3

Compressors, blowers and Vacuum Pumps

Compressors, blowers and vacuum pumps and their performance characterisstics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps. Air filters. Air gas leakage. Inert gas systems. Compressed air for process, Instrument air.

Insulation

Importance of insulation for meeting the process requirements, installation materials and their effect on various material of equipment piping, fitting and valves etc, insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation.

Unit4

Elements of safety

Elements of safety, safety and site selection; Plant and unit plot planning; Definition of risk and hazard Identification and assessment of the hazard and risk, Industrial between hazards and risk, Industrial hgiene, toxicological studies, Hazard operability (HAZOP) hazard analysis (HAZAN); Assessment of the risk, fault tree, event tree, scope of risk assessment; control of hazards, controlling toxic chemicals and controlling flammable materials. Prevention of losses Prevention of losses, Pressure relief, fire & explosions, Provision of fire fighting equipments, Technology selection and transfer, choosing the right process.

Unit 5

Control of Process

Control of process, Prevention of hazardous deviation in process variable, e.g. pressure, temperature flow by Provision of automatic control systems-interlocks, alarms, trips together with good operating practices and management. Accidental analysis, Regulations and legislation, Role of gevemment role, risk management routines and tackling disaster,case studies.

Text Books:

1. Nordell Eskel, “Water Treatment for Industrial and Other Uses”, Reinhold Publishing Corporation, New York. (1961)
2. Crowl, D.A. & Louvar, J.F.. “Chemical Process Safety: Fundamentals with applications”, New Jersey: Prentice-Hall. (1989)
3. Goodall, P.M., “The Efficient use of Steam” IPC Science and Technology (1980)
4. O P Gupta, "Chemical Process Technology'" Khanna Publishing House

RCH-064: INTELLECTUAL PROPERTY RIGHTS & STANDARDIZATION (3:1:0)

Unit I

Introduction: Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

Unit II

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, Patent and kind of inventions protected by a patent, ownership rights and transfer. Case studies of patents.

Unit III

Industrial Designs: Introduction, need to protect industrial design, **industrial designs protection law.**

Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Unit IV

Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

Unit V

New developments: New developments in trade mark law; copy right law, patent law, intellectual property audits. International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law.

TEXT BOOKS

1. P. Ganguli; Intellectual property right – Unleashing the knowledge economy, Tate McGraw Hill Publishing company ltd.
2. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000

REFERENCE BOOKS

1. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010
2. Deborah. E. Bouchoux; Intellectual property right, Cengage learning.
3. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd , 2006

RCH-651: Flow Sheeting Lab (0:0:2)

1. Flowsheet preparation and drawing
2. Equipment selection, Equipment numbering, stream designation
3. Preparation of plant layouts
4. Piping layouts
5. Steady state flowsheeting using propositional logic in process synthesis
6. Steady state flowsheeting using resolution based synthesis procedure
7. Steady state flowsheeting of processes with recycle (recycle calculation sequence)
8. Network of heat exchangers
9. Sequencing of distillation columns
10. Development of process flowsheet for a specific chemical plan

Recommended to be done using a simulation package/ programming environment

RCH-652: Process Dynamics & Control Lab-I (0:0:2)

1. Transient response to single tank system with storage & Flow to (a) step change (b) impulse change in put.
2. Transient response of non-interacting system in series.
3. Transient response of interacting system in series.
4. Study the operation of ON-OFF electronic temperature controller & determination of its performance to control the temperature of a system having capacity to store thermal energy.
5. Study the principle of operation & working of pneumatic servo system with various input functions.
6. Transient response of a CSTR System to step change.
7. Controlling a batch reactor using digital PID controller.
8. Study the dynamics of parallel & counter flow shell & tube heat exchanger.
9. Controlling of Parallel Flow & counter flow STHE using digital PI controller to have desired output.
10. Dynamics characteristics of mercury & water manometers.
11. Study of control value characteristics.

RCH-653: Process Dynamics & Control Lab-II (0:0:2)

1. Study the performance of cascade control system & to maintain desired level in a tank, with flow.
2. Study the dynamics of bubble cap distillation column.
3. Control of a bubble cap distillation column using digital PID controller.
4. Study of effect of PID controller on pressure process trainer.
5. 16 Calibration of thermocouple/Bimetallic thermocouple/Resistance thermocouple.
6. Calibration of Pressure gauge/ Pnuematic pressure recorder/ Differential pressure recorder.
7. Calibration of Orificemeter/Venturimeter /Rotameter/ Gas flow meter.
8. Estimation of viscosity by Redwood/Saybolt/Ostwald viscometer.
9. Calibration of pH meter.
10. Calibration of conductivity meter.

RCH-654: Chemical Reaction Engineering Lab-II (0:0:2)

1. Study and operation Trickle bed reactor
2. Study and operation Condensation polymerization reactor
3. Study and operation Emulsion polymerization reactor
4. RTD study in a CSTR
5. RTD study in a plug flow reactor
6. Study and operation of a coiled tubular reactor
7. Study of heterogeneous catalytic reactor
8. Determination of porosity and pore volume of a substance. (kieselguhr, alkaline earth or alumina may be used as substance)
9. To study toluene hydrogenation over Raney nickel catalyst
10. To study acetaldehyde decomposition over copper gauze catalyst