JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

(Established by an Act No.30 of 2008 of A.P. State Legislature)

Kukatpally, Hyderabad – 500 085, Andhra Pradesh (India)

M.TECH. (CHEMICAL ENGINEERING)

COURSE STRUCTURE AND SYLLABUS

I Year - I Semester

Code	Group	Subject	L	P	Credits
		Advanced Chemical Engineering Thermodynamics	3	0	3
		Advanced Transport Phenomena	3	0	3
		Advanced Chemical Reaction Engineering	3	0	3
		Optimization Techniques in Chemical Engineering	3	0	3
	Elective -I	Petroleum refinery Engineering Electrochemical Engineering Computational Fluid Dynamics	3	0	3
	Elective -II	Polymer Technology Corrosion Engineering Applied Numerical Methods	3	0	3
	Lab	Chemical Engineering Lab.- I	0	3	2
		Seminar	-	-	2
		Total Credits	18	3	22

I Year II Semester

Code	Group	Subject	L	P	Credits
		Separation Processes	3	0	3
		Advanced Process Control.	3	0	3
		Process Modeling & Simulation	3	0	3
		Environmental Engineering			
	Elective-III	Colloidal Interfacial Engineering Bioprocess Engineering Nanotechnology	3	0	3
	Elective -IV	Industrial Safety Design & Analysis of Experiments Fluidization Engineering	3	0	3
	Lab	Chemical Engineering Lab.- II	0	3	2
		Seminar	-	-	2
		Total Credits	18	3	22

II Year - I Semester

Code	Group	Subject	L	P	Credits
		Comprehensive Viva	-	-	2
		Project Seminar	0	3	2
		Project work	-	-	18
		Total Credits	-	3	22

II Year - II Semester

Code	Group	Subject	L	P	Credits
		Project work and Seminar	-	-	22
		Total Credits	-	-	22

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

UNIT I
Review of basic postulates, Maxwell's relations, Legendre transformation, pure component properties, theory of corresponding states.

Equilibrium, phase rule, single component phase diagrams, introduction to multi -component multi -phase equilibrium.

UNIT II
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, VLE by Molecular Simulation

UNIT III
Phase equilibria at low to moderate pressures: Phase behavior for VLE system, Margule's equation, Van Laar equation, Wilson equation. NRTL equation, UNIFAC method, Dew point, Bubble point and flash calculations

UNIT IV
Introduction to classical statistical mechanics, phase space, Louiville equation, crystals, intermolecular forces and potential energy functions, imperfect mono atomic gases, molecular theory of corresponding states, introduction to molecular simulations.

UNIT V
Molecular theories of activity coefficients, lattice models, multi-phase multi-component phase equilibrium, VLE/SLE/LLE/VLLE, chemical equilibrium, Chemical Reaction Equilibria.

TEXT BOOKS:
1. D.A. McQuarrie, Statistical Thermodynamics, Harper and row Pub. New York, 1973.
2. J.M. Prausnitz, R.M. Lichtenthaler and E.G. Azevedo, Molecular thermodynamics of Fluid-phase Euilibria (3rd edition) Prentice Hall Inc., New Jersery, 1996``
3. J.M smith. H.C.V. Ness and M.M. Abott, Introduction to Chemical engineering Thermodynamics" McGraw Hill International Edition (5th ed). 1996.

REFERENCE BOOKS:
1. H. Terrel, An Introduction to Statistical Thermodynamics, Dover, 1960
2. M.P. Allen, DJ Tildesley, Computer Simulation of Liquids, Oxford, 1989

Objective: This subject will provide sound knowledge of different thermodynamic principles in process industries. It is a fundamental in knowing properties of all liquids and gases.
Outcome: Students will be able to understand the role and relevance of Chemical Engineering Thermodynamics.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

ADVANCED TRANSPORT PHENOMENA

UNIT I
Application of equation of change: Equation of change for isothermal systems – Dimensional analysis, solution of steady state laminar flow problems including Newtonian and non-Newtonian fluids. Equation of change for non-isothermal system-solution of steady state problems- conduction, Convection, problems with and without heat generation.

UNIT II
Multi component mixtures: Equations of change for multi-component mixtures: Dimensional analysis, Stefan-Maxwell equations, use of equations of change to setup diffusion problems, simultaneous heat & mass transfer, thermal diffusion, pressure diffusion, forced diffusion, three component ordinary diffusion with heterogeneous chemical reaction.

UNIT III
Unsteady state problems: Unsteady state flow between two parallel plates, oscillating plates, unsteady state flow through a pipe, heating of finite slab, cooling of a sphere in contact with well stirred fluid, unsteady state evaporation in a tube of infinite length, gas absorption with rapid chemical reaction.

UNIT IV
Boundary layer studies and Turbulent flow: Flow near a wall suddenly set in motion, flow near the leading edge of a plate, heat transfer in laminar forced convection along heated plate, diffusion and chemical reaction in isothermal laminar flow along a soluble flat plate. Time smoothed equation of change for incompressible fluids, application of empirical expression to solve turbulent flow problems.

UNIT V
Macroscopic Balances: Macroscopic balances to set up steady state problems, efflux time for flow from funnel, Heating of liquid in a agitated tank, disposal of an unstable waste product, unsteady state operations of packed column.

TEXT BOOK:
(1) R.B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, second edition, John Wiley and Sons, 2003.
(2) R.B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, first edition, John Wiley and Sons, 2003.

Objective: Understands the co-existence of flow, heat and mass transfer. Solves for velocity profiles in flow inside the tubes and determines the utility of heat transfer coefficients in flow systems. Develops equations for mass transfer in stationary and moving fluids using diffusion concepts.

Outcome: Ability to analyze processes involving simultaneous flow, heat and mass transfer.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Chemical Engg.)

ADVANCED CHEMICAL REACTION ENGINEERING

UNIT I

Preliminary Considerations in Chemical Reaction Engineering

Process design consideration for batch reactor, CSTR, PFR, Fluidized bed reactor and other reactors. Design and operation of batch reactor for adiabatic, isothermal, non-isothermal conditions; Optimal performance for maximum production rate.

Modes of operation and design aspects for semi-batch and semi-continuous reactors.

UNIT II

General design considerations, MEB and design for single stage CSTR for constant and variable density systems. Design and operation of multistage CSTR for isothermal constant density system, optimal operation.

Design and operation of PFR with and without recycle for constant and variable density systems.

Conversion and concentration profiles in LFR, General design considerations, size and performance of LFR. Comparisons of ideal reactors and their combinations, multiple reactor configurations.

UNIT III

Reactor Design for Complex Reactions; Reactor Models for Non Ideal Flow

Choice of reactor and design considerations for reversible, parallel, series and series-parallel reactions networks

Non-ideal flow, mixing, segregation, RTD; Models from RTD analysis: one parameter models - DPFM, TISM; SFM, MMM and Compartment models for the analysis of reactor performance.

UNIT IV

Reactors for Fluid-Fluid Fluid-Solid Non- Catalytic Reactions

Design of fluid –fluid reactors for straight mass transfer and for mass transfer with not very slow reactions - choice of tower and tank reactor.

Design of fluid – solid reactors: Continuous and semi-continuous reactor models, mixed, plug flow of particles of single sized feed and size mixture of particles with unchanging and changing sizes in uniform gas flow.

UNIT V

Reactors for Fluid – Solid Catalytic Reactions

Surface catalysis, Kinetics in porous catalyst particles, Design and operation of reactors containing porous catalyst particles, Experimental methods for finding rates, Catalyst deactivation and regeneration, Reactors with suspended solid catalyst.

REFERENCES

1. Levenspiel, O., "Chemical Reaction Eng."3rd ed. John Wiley & Sons 1999,
2. R.W. Missen, C A Mims, B A Saville, “Introduction to Chemical Reaction Engineering and Kinetics” John Wiley &Sons, Inc., 1999
3. J.M.Smith “Chemical Engineering Kinetics” 3rd Ed., Mc. Graw Hill, Newyork 1980
4. Fogler S.H., "Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall,1999.

Objective: This subject enables the students to learn about the different types of reactions underlying a chemical process and thereby design chemical reactors.

Outcome: Selection of catalyst and design multiple reactors and their evaluation of performance, development of concepts of heterogeneous system and applications.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

OPTIMIZATION TECHNIQUES IN CHEMICAL ENGINEERING

UNIT I
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.

UNIT II
Single variable optimization methods: Bracketing methods, Exhaustive search method, Bounding phase method, Region elimination methods, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method.

UNIT III
Gradient-based methods: Newton- Raphson method, Bisection method, Secant method, Cubic search method.
Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Gradient-based methods: Cauchy's (steepest descent) method, Newton's method.

UNIT IV
Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Sensitivity analysis,
Direct search for constraint minimization: Variable elimination method, complex search method. Successive linear and quadratic programming, optimization of staged and discrete processes.

UNIT V
Specialized **&** Non-traditional Algorithms: Integer Programming: Penalty function method. Non-traditional Optimization Algorithms: Genetic Algorithms: Working principles. differences between GAs and traditional methods, similarities between GAS and traditional methods, GAs for constrained optimization.

TEXT BOOKS
1. Kalyanmoy Deb ,Optimization for engineering design.,, Prentice Hail of India
2. T. F.Edgar and D.M.Himmelhlau, optimization of chemical processes, Mc Graw Hill, international editions, chemical engineering series, 1989.

REFERENCE BOOKS:
1) G.S. Beveridge and R.S. Schechter, Optimization theory and practice, Mc Graw Hill, Newyork, 1970.
2) Reklljtis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization- Methods and Applications, John Wiley, New York, 1983.
3) S.S Rao, Optimization Theory and Applications.

Objective: To acquaint the student with the concepts and techniques of single and multivariable optimization techniques using numerical search and analytical methods.

Outcome: The student will enable to optimize the problems related to design, planning and operations involved in a chemical industry

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

PETROLEUM REFINERY ENGINEERING (ELECTIVE –I)

UNIT I
Past, present and future of petrochemicals, Refining of Petroleum, Characterization of complex feed stocks, Simple methods to define conversion of complex feed stocks. Altenative sources and strategies to meet future needs of chemical process industries, various processes and techniques involved in thermal cracking, Catalytic cracking, Fluidized catalytic cracking, Steam reforming and partial oxidation.

UNIT II
Mechanism involved during thermal cracking reaction, Details of thermal cracking to produce light olefins from various feed stocks, Ethanol dehydration process to produce ethylene.

UNIT III
Effect of various parameters- temperature, residence time, HCCP and **C/**H ratio on yields of important products from various feed stocks during thermal cracking, R-K theory to predict product yields from various feed stocks during thermal cracking.

UNIT IV
Coke formation during thermal cracking and catalytic cracking reactions from Various petrochemical feed stocks, Simple models of coke formation during thermal cracking reactions to produce maximum light olefins. Various structures of deposited coke during pyrolysis, various ways to inhibit coke formation.

UNIT V
Industrial process of hydro cracking and reforming, Global economic scenario of petrochemical industry, newer materials of construction, Environmental aspects of petrochemical industry in general.

TEXT /REFERENCE BOOKS:

1. Petroleum Refining, Dr B.K, Baskara Rao.
2. Petrochemicals, Dr B.K. Baskara Rao.
3. Nelson, W.L. 'Petroleum Refinery engineering", McGraw Hill, New York 1961.
4. Ilengstebeck RJ., "Petroleum Refining", McGraw Hill, New York 1959.
5. Steiner H, "Introduction to petroleum Chemical Industry", Pergamon, L:ondon, 1961.

Objective: To understand the various feed stocks of refinery and petroleum products and get acquainted with basic separation and conversion processes used in refining of crude oil. To get familiarized with challenges involved in refining from viewpoint of environment.

Outcome: The student would be in a position to have advanced knowledge of feed-stocks used in the refinery, various conversion processes used to produce various petroleum products.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

ELECTROCHEMICAL ENGINEERING
(ELECTIVE –I)

UNIT I

Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

UNIT II

Thermodynamics- I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

UNIT III

Thermodynamics- II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

UNIT IV

Kinetics of Corrosion Processes and Evans Diagrams: Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.
Measurements and Systems Analysis: Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

UNIT V

Potential relations in corrosion cells potentials, pH diagrams in corrosion.
Corrosion theory: Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion: Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion.Selective leaching, stress corrosion cracking. Conditions leading to pitting attack. environmental factors, hydrogen damage. Corrosion inhibition and prevention: Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paints: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

TEXTBOOKS:

1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.
2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

REFERENCE BOOKS:

1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.
2. Electrochemistry - Bookris and A.K.Reddy.
3. Electrochemical Engineering by C.L.Mantell.
4. Principles of Electrochemical Engineering by L.W.Shemilt.
5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.
6. Fontanna and Grene 'Corrosion Engineering'.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

COMPUTATIONAL FLUID DYNAMICS
(ELECTIVE-I)

UNIT I
Introduction - Finite difference methods- finite element method - finite volume method- Treatment of boundary conditions- Governing differential equations. Finite difference methods - Taylor's series - Errors associated with FDE- FDE formulation for steady state heat transfer problems.

UNIT II
Cartesian, cylindrical and spherical coordinate systems- boundary conditions- Un steady state heat conduction Explicit Method - Stability criteria - Implicit Method - Crank Nickolson method - 2-D FDE formulation ADI- ADE. Finite volume method - Generalized differential equation, Basic rules for control volume approach, Source term linearization, boundary conditions. Un-steady state one, two, three dimensional heat conduction.

UNIT III
Convection and diffusion, different methods i.e., upwind scheme, Exponential scheme, Hybrid scheme, power law scheme, calculation of flow field, staggered grid method, pressure and velocity corrections, SIMPLE Algorithms & SIMPLER (revised algorithm). Solution methods of elliptical, parabolic and hyperbolic partial differential equations in fluid mechanics - Burgers equation.

UNIT IV
Formulations for incompressible viscous flows - vortex methods -pressure correction methods.

UNIT V
Treatment of compressible flows- potential equation, Navier - Stokes equation - flow field dependent variation methods, boundary conditions. Linear fluid flow problems, 2-I) and 3- 1) fluid flow problems.

TEXT BOOKS:

1. Numerical heat transfer and fluid flow - S.V. Patankar
2. Computational Fluid Dynamics, T.J. Chung, Cambridge University
3. Text Book of Fluid Dynamics, Frank Chorlton, CBS Publishers

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

POLYMER TECHNOLOGY
(Elective- II)

UNIT I

Introduction: definitions; polymer& macro molecule, monomer, functionality, average functionality, co-polymer, polymer blend, plastic and resin.

Classification of polymers: based on source, structure, applications, thermal behavior, mode of polymerization. Concept of average molecular weight of polymers, molecular weight distribution, poly disparity index. Determination of average molecular weights: End group analysis, osmometry, light scattering techniques, viscometer, Gel permeation chromatography.

UNIT II

Natural polymers: brief study of i) Natural rubber ii) shellac iii) rosin iv) cellulose v) proteins.
Mechanism and kinetics of: Addition or chain polymerization
a) Free radical addition polymerization b) Ionic addition polymerizations
c) Coordination polymerization d) Coordination or step growth or condensation polymerization.

UNIT III

Methods of polymerization: mass or bulk polymerization process, solution polymerization process, suspension polymerization process and emulsion polymerization method comparison of merits and demerits of these methods. Properties of polymers: crystalline and amorphous status, melting and glass transition temperatures and their determination, effect of polymer structure on mechanical, physical, chemical and thermal properties.

UNIT IV

Degradation of polymers, Role of the following additives in the polymers: i) Fillers and reinforcing fillers ii) Plasticizers iii) Lubricants iv)Antioxidants and UV stabilizers v) Blowing agents vi)Coupling agents vii)Flame retardants viii) Inhibitors

Brief description of manufacture, properties and uses of: i) Polyethylene (HDPE&LDPE), ii) Poly propylene iii) Polyvinylchloride iv) Polystyrene v) Polytetra fluoroethylene vi) Polymethyl mehacrylate vii) Polyvinylacetate & Polyvinylalcohol.

UNIT V

Brief description of manufacture, properties and uses of: i) Polyesters (Polyethylene terephthalate polycarbonate and unsaturated polyesters) ii) Nylon(Nylon 66) iii) Phenol- Formaldehyde resins iv) Epoxy resins v) Polyurethane vi) Silicones

Compounding of polymer resins, brief description of: i) Compression and transfer moulding ii) Injection moulding iii) Extrusion iv) Blow moulding v) Calendaring vi) Laminating and pultrusion

TEXT BOOKS:

1. Polymer Science & Technology, 2nd ed., J.R. Fried, PHI Learning Pvt. Ltd., New Delhi, 2009
2. Plastic materials, J.A. Brydson, Newnes-Butterworth (London) 1989.

REFERENCES:

1. Text book of polymer science, F.W.Jr. Bill Meyer, (3rd ed.) John Wiely&sons 1984
2. Introduction to Plastics, J.H. Brison and C.C. Gosselin, Newnes-Butterworth, London 1968.

Objective: The course aims to offer a sound base in the knowledge of various polymers and plastics used in industries, their properties etc.

Outcome: The student will be able get the knowledge on different types of polymers and polymerization processes.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Engg.)

CORROSION ENGINEERING
(ELECTIVE - II)

UNIT I
Introduction: Corrosion principles, Electro- chemical aspects of Corrosion -environmental effects, Metallurgical aspects- corrosion rate expressions- methods of estimation of corrosion rates.

UNIT II
Forms of corrosion 1: uniform attack, galvanic, crevice, pitting Corrosion.
Forms of corrosion 2: Inter –granular corrosion, selective leaching, erosion- corrosion and stress corrosion cracking and remedial measures in brief.

UNIT III
Corrosion testing procedures
Corrosion prevention: Material selection, alteration of environment-organic and inorganic coatings, linings, cladding, Passivity

UNIT IV
Design principles, Cathodic Protection and Anodic Protection.

UNIT V
Modern Theory, Mixed potential theory, Principles, Thermodynamics and Electrode Kinetics.
Predicting corrosion behavior, corrosion prevention and rate measurement.

TEXT BOOK:
1. Corrosion Engineering, 3rd ed., M.G. Fontana, McGraw Hill.

REFERENCES:
1. Corrosion and Corrosion Control, H.H Uhlig
2. Handbook of Corrosion Engineering, Pierre Roberge, McGraw-Hill, New York, 2000.
3. Corrosion Basics: An Introduction, 2nd ed., Pierre Roberge, NACE Press Book, 2006.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Chemical Engg.)

APPLIED NUMERICAL METHODS
(ELECTIVE - II)

UNIT I

Eigen values and Eigen vectors: Introduction, Calculation of Largest and smallest Eigen Values and Corresponding Eigen vectors using power method.

Linear Algebraic Equations: Introduction, Gauss- Elimination, LU Decomposition, Gauss-Jordan Elimination, Gauss- Siedel methods.

UNIT II

Nonlinear Algebraic Equations: Introduction, single variable successive substitutions (Fixed point method), single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.

UNIT III

Regression Analysis: Introduction, least squares curve-fit (linear regression), Newton's forward formulae, Newton's backward formulae.

Interpolation Polynomial, Lagrangian Interpolation (Unequal Intervals),Pade' approximations,(upto second order both in numerator and denominator)

UNIT IV

Ordinary Differential Equations-Initial Value Problems (ODE-IVPs): Introduction, explicit and implicit Euler's method, Runge- Kutta fourth order method.

Ordinary Differential Equations- Boundary Value Problems (ODE-BVPs): Introduction, Galerkin Finite Element (GFE) Technique, Shooting Techniques.

UNIT V

Advanced methods for Differential Equations: Introduction, the finite difference technique (method of lines), Orthogonal Collocation, Finite Volume Method.

TEXT BOOKS:

1. Numerical Methods in Engineering, S.K. Gupta., Tata McGraw Hill.,1998,1st Edition.

REFERENCE BOOKS:

1. Numerical Methods in Engineering &Science, B.S.Grewal ,Khanna Publisher, 6th Ed. 2005.

Objective: This course trains the students in learning and applying the numerical techniques to solve the chemical engineering problems.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Chemical Engg.)

CHEMICAL ENGINEERING LAB- I

LIST OF EXPERIMENTS:

1. Study the performance of combination of Reactors.
2. RTD studies in CFSTR
3. Study the kinetics in Packed Bed Reactor.
4. Study the kinetics in Adiabatic Batch reactor.
5. Study the performance of Single Effect Evaporator.
6. Heat Transfer through Helical coil Heat Exchanger.
7. Study of the performance of a Cyclone Separator.
8. Drying Characteristics in a fluidized bed dryer
9. Reverse Osmosis System for treatment of water
10. Analysis of gaseous & liquid pollutants
11. Batch distillation with reflux
12. Estimation of the brake through curve in fixed bed reactors
13. Rheological studies of Non-Newtonian fluids

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Chemical Engg.)

SEPARATION PROCESSES

UNIT I

Introduction: Classification of separation processes; Equilibrium – Review of vapor liquid equilibrium and other equilibrium. Thermodynamic consistency test for VLE date, Phase rule and degrees of freedom estimations. Equilibrium ratio concept and its estimation from Depriesters charts. Bubble- point and Dew-point calculations; Flash calculations, Estimation of state of the mixture.

UNIT II

Binary separation process: Common approach for process design estimation of feed location, product qualities and theoretical stages of equilibrium based separations: single stage-single component and Multistage single component separation processes involving absorption, stripping, liquid-liquid immiscible extraction, adsorption and distillation Kermer-Brown equation and its limitation process design (estimation of feed location, product qualities and theoretical stages) of multistage multiple feeds and side stream process.

UNIT III

Multi component separation process: Multi component Distillation Introduction. Key components; Estimation of minimum theoretical stages (Fenske's equation, Distribution of non-key components in overhead and bottom products at total reflux. Determination of minimum reflux ratio (Underwood's method); Approximate calculation shortcut methods for multicomponent, multistage distillation (estimation of actual reflux ratio and theoretical stages): Fenske-Underwood-Gilliland method; Feed- Stage Location (Kirke-Bride's equation); Distribution of non-key component at actual reflux; Batch Multicomponent Distillation with Reflux: Shortcut method for multicomponent Batch Distillation with constant reflux, Stage-by-stage method for Multicomponent Distillation.

UNIT IV

Capacity and efficiency of contacting devices, energy requirements of separation process, selection of separation process- factors influencing the choice of a separation process-case studies.

UNIT V

Introduction to membrane separations, microfiltration, ultra filtration, osmosis, Reverse osmosis, electro dialysis, gsa separation, pervaporation, dialysis (qualitative treatment only)

TEXT / REFERENCE BOOKS:

1. J.D.Seader and E.J.Henley, Separation Process Principles, John wiley, 1998.
2. Lacey, R.E and S.Loacb, industrial processing with membranes, Wiley-inter science, NY, 1972.
3. Mulder M, Basic Membrane Technology, Kluwer publications, 1996.
4. R.E. Trey bal, Mass Transfer operation, 3rd edition MC Graw – Hill 1980
5. P.C. Wankat, Equilibrium Stage Separation, Elsevier Publication, 1988
6. C.Judson King, Separation Processes, Mc- Graw – Hill, 1982.

Objective: Through study of this subject students will get a thorough acquaintance of the separation process widely used in reverse osmosis, dialysis etc.

Outcome: Student will be able to learn the methodology for process design of equipments like extractors, distillation columns and selection of adsorbents in chemical industries.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

ADVANCED PROCESS CONTROL

UNIT I
Review of single input single out put (SISO) systems: Review of first and second order systems transfer functions, open loop and closed loop stability aspects.
Frequency response Analysis: Bode plots

UNIT II
Internal Model control (IMC): IMC structures, IMC design & implementation
Non linear systems and control: Nonlinear control, phase plane analysis, application to chemical reactors

UNIT III
Cascade, feed forward and ratio control: Analysis and design of cascade control, feed forward controllers and their derivation based on dynamic models, tuning & design of feed forward controllers, ratio control schemes with application.

UNIT IV
Model Predictive Control (MPC): constrained and unconstrained MPC, design and application of MPC, dynamic matrix control & its design procedure

UNIT V
State space methods: State Space representation of physical systems: State variables, State space description, Selection of state variables, Transfer function matrix, Transition matrix, Solution of state space models.

TEXT BOOKS
Process control: Modeling, Design and simulation, B.Wayne Bequette PHI, 2003.
Process systems analysis and control- Donald R. Coughanowr –Mc-Graw Hill, Inc 2nd Edition,1991

REFERENCES
Chemical process control – George Stephanopolis, Aulto Seborg.

Objective: To provide a sound knowledge of different control systems, controllers and control valves that are used in industries.
Outcome: Ability to design advanced control system for complex and normal processes and design feedback control system for chemical, mechanical & electrical engineering systems.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

PROCESS MODELING AND SIMULATION

UNIT I
Mathematical models for chemical engineering systems: classification of mathematical models-steady state Vs dynamic models, lumped Vs distributed parameter models, deterministic Vs stochastic models.

Examples of mathematical models- Two heated tanks, batch reactor, constant volume CSTRs, non-isothermal CSTR, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup.

UNIT II
Empirical model building- method of least squares, linear, polynomial and multiple regression, non-Linear regression. **Solution of Non- Linear Algebraic equations**- bisection, false position, Quasi Newton and Newton- Raphson methods.

UNIT III
Numerical integration- Trapezoidal rule, Simpson's rule and Newton– Cotes formula. **Numerical solution of differential equations**- Euler's method, Runge- Kutta methods, predictor corrector methods.

UNIT IV
Numerical solution of partial differential equations- elliptic, parabolic and hyperbolic equations. finite difference methods, Leibman's method, Crank Nicholson method. Apllications to steady state and Unsteady state heat conduction and temperature distribution problems.

UNIT V
Process Simulation examples: VLE dew point and bubble point calculations, binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, countercurrent heat exchanger.

Process simulation using modular and equation for solving approaches: Developing a simulation model, a simple flow sheet, Sequential modular approach, Simultaneous modular approach, Equation solving approach.

TEXTBOOKS:
1. Process modeling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990.
2. Numerical Methods for Engineers, S.K. Gupta, Wiley Eastern, New Delhi, 1995.

REFERENCES:
1. Numerical Methods for Engineers and Scientists, S.S. Rao
2. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI learning Pvt. Ltd., New Delhi, 2010
3. Process Modeling and Simulation, Amiya K. Jana, 2012.

Objective: To establish to students the basis of chemical process design by taking into account technical elements as well as economic aspects. Students will appreciate how process modeling has been playing a key role in the design, planning and operation of chemical and related processes.

Outcome: The student will be able to learn the basic principles of modeling with some examples and simulate the model equations using numerical methods.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

ENVIRONMENTAL ENGINEERING

UNIT I
Air pollution, sources, classification of air pollutants, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solution. Gaussian plume model.

UNIT II
Design concepts for pollution abatement systems for particulates and gases. Gravity chambers, cyclone separators, filters, electrostatic precipitators, adsorption and absorption, thermal oxidation.

UNIT III
Waste water treatment processes: Design concepts for primary treatment, sedimentation, flotation. Secondary treatment methods: Activated sludge process, trickling filters.

UNIT IV
Advanced waste water treatment: Removal suspended & dissolved solids. Study of environment pollution from process industries and their abatement. Fertilizer, paper and pulp industries, petroleum and petrochemicals, recovery of materials from process effluents.

UNIT V
Solid and Hazardous waste management: Sanitary land fill, Hazardous waste classification and rules, management strategies. Incineration, solidification and stabilization, and disposal methods.

TEXTBOOKS
1. Environmental pollution control engineering, 2nd edition (in press), by C.S.Rao.
2. Pollution control in process industries by S.P**.** Mahajan.
3.

REFERENCES
1. N.L.Nernerow, **"**Liquid waste of industry- theories, Practices and Treatment", Addison Wesley, New York, 1 971.
2. W.J.Weber, "Physico-Chemical Processes for water quality control", Wiley lnterscience, New York, 1969.

Objective: The course will provide knowledge of the various pollutants, the regulatory standards, cleaning up technologies and the removal methods of various pollutants from industries.

Outcome: Understand the causes, effects and controlling measures of different types of environmental pollutions with some case studies and discuss the benefits of sustaining each of the following types of resources; food, health, habitats, energy, water, air, soil and minerals.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

COLLOIDAL INTERFACIAL ENGINEERING (ELECTIVE - III)

UNIT I
Introduction to Interface and Colloidal Science: Examples of surface and colloidal phenomena in industry and nature, Historical perspective.Areas where future research is needed, nature of interfaces, Surface free energy, Work of cohesion and adhesion, Surface activity and surfactant structures, Physical and chemical interactions between atoms and molecules interactions between surfaces and particles, Surface tension.

UNIT II
Adsorption: Gibbs Surface Excess, Gibbs Adsorption Isotherm, Adsorption at solid-vapour interface, Energetic considerations, Physical adsorption versus chemisorption, Chemisorption and catalysis.
Solid-Vapor adsorption isotherms: Langmuir, Freundlich, BET, Adsorption at solidliquid interfaces. Adsorption at liquid-liquid interfaces, Gibbs monolayers.

UNIT III
Capillarity: Capillary flow, Driving forces, Interfacial tension, Contact angle, Laplace expression for pressure difference across a curved interface, Capillary flow and spreading processes, Contact angle effects, Some practical capillary systems such as wetting in woven fibers and papers, repellency control, detergency, enhanced oil recovery.

UNIT IV
Electrostatic Forces and Electrical Double Layer: Sources of interfacial charge, Electrostatic theory, Coulomb's law, Boltzmann's distribution
and the Electrical double layer, Double layer thickness, Specific ion adsorption and the stern layer, Overview of electrokinetic phenomena (Electro-osmosis and Electrophoresis).
Colloids and Colloidal Stability: Working definition of colloids, Practical applications of colloids and colloids phenomena. Mechanisms of colloid formation, Sources of colloidal stability, Steric or entropic stabilization, Coagulation kinetics, DLVO theory and its applications.

UNIT V
Emulsions: Emulsion formation, Classification of emulsifiers and stabilizers, Flocculation and coalescence. Adsorption at liquid-liquid interfaces, General considerations of emulsion formation and stability. Mechanistic details of stabilization, Solubility parameters, Hydrophilic-Lipophile balance. Phase inversion temperature, Association colloids such as micelles, Ionic and nonionic surfactants.Kraft temperature, Critical micelle concentration, Microemulsions.

REFERENCE BOOKS:
1) Drew Myers, "Surfaces, Interfaces and Colloids: Principles and Applications", Second Edition, Wiley-VCH, 1999.
2) Adamson Arthur M.and Gast A.P., "Physical Chemistry of Surfaces", Sixth Ed, John Wiley & Sons, 1997
3) Hiemenz P. C., Rajagopalan R., "Principles of Colloid and Surface Science", Third Edition, Marcel Dekker, 1997.

Objective:
1) To understand the basic terminology used in interface and colloid science.
2) To get acquainted with formation and stability considerations in case of a colloidal System.
3) To get familiarized with basic governing equations for interfacial phenomena.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

BIOPROCESS ENGINEERING
(ELECTIVE - III)

UNIT I

Introduction: Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics.

Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

UNIT II

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids.

UNIT III

Recovery and purification of products: Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

UNIT IV

Bioprocess considerations in using animal cell cultures: Structure and biochemistry of animal cells, methods for the cultivation of animal cells, bioreactors for animal cell culture, products of animal cell culture.

Bioprocess considerations in using plant cell cultures: Plant cells in culture compared to microbes, bioreactors for plant cell cultures.

UNIT V

Genetically engineered organisms: Influence of product on process decisions, guidelines for choosing host- vector systems, metabolic engineering, protein engineering.

Mixed cultures: Simple models describing mixed culture interactions, mixed cultures in nature, industrial utilization of mixed cultures. Biological wastewater treatment – an example of industrial utilization of mixed cultures.

TEXT BOOK:

1. Bioprocess Engineering, 2nd ed., M. L. Shuler and F. Kargi, PHI Learning Pvt. Ltd, NewDelhi,2009

REFERENCES:

1. Biochemical Engineering Fundamentals, 2nd ed., J.E. Bailey and D.F. Ollis, McGraw-Hill, New York,1987.
2. Bioprocess Engineering Principles, P. M. Doran, Elsevier, Gurgaon, 2005.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

NANOTECHNOLOGY
(ELECTIVE -III)

Unit I

Introduction: History and Scope, Can Small Things Make a Big Difference? Classification of Nanostructured Materials, Fascinating Nanostructures, Applications of Nanomaterials, Nature: The Best of Nanotechnologist, Challenges and Future Prospects.

Unit II

Unique Properties of Nanomaterials: Microstructure and Defects in Nanocrystalline Materials:Dislocations, Twins,stacking faults and voids, Grain Boundaries, triple and disclinations. **Effect of Nano-dimensions on Materials Behavior:** Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, Enhanced solid solubility.

Magnetic Properties: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

Unit III

Synthesis Routes: Bottom up approaches: Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method ,Self assembly,

Top down approaches: Mechanical alloying, Nano-lithography.

Consolidation of Nanopowders: Shock wave consolidation, Hot isostatic pressing and Cold isostatic pressing Spark plasma sintering.

Unit IV

Tools to Characterize nanomaterials: X-Ray Diffraction (XRD), Small Angle X-ray scattering (SAXS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP), Nanoindentation.

Unit V

Applications of Nanomaterials: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nanosensors, Nanocatalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water- Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defence and Space Applications, Concerns and challenges of Nanotechnology.

TEXT BOOKS

1. Text Book of Nano Science and Nano Technology – B.S. Murthy, P. Shankar, Baldev Raj, B.B. Rath and James Munday, University Press-IIM.
2. Introduction to Nanotechnology – Charles P. Poole, Jr., and Frank J. Owens, Wley India Edition, 2012.

REFERENCES:

1. Nano: The Essentials by T.Pradeep, Mc Graw- Hill Education.
2. Nanomaterials, Nanotechnologies and Design by Michael F. Ashby, Paulo J. Ferreira and Daniel L.Schodek
3. Transport in Nano structures- David Ferry, Cambridge University press 2000
4. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S.,S. R. Kumar, J. H. Carola.
5. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
6. Electron Transport in Mesoscopic systems - S. Dutta, Cambridge University press.

Objective: Nano Technology is one of the core subjects of multidisciplinary nature. This has extensive applications in the field of energy, electronics, Biomedical Engg. Etc. Built to specifications by manufacturing matter on the atomic scale, the Nano products would exhibit an order of magnitude improvement in strength, toughness and efficiency. The objective here is to impart the basic knowledge in Nano Science and Technology.

Outcome: The present syllabus of "Introduction to Nano Technology" will give insight into many aspects of Nano science, technology and their applications in the prospective of materials science.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

INDUSTRIAL SAFETY (ELECTIVE- IV)

UNIT I
Introduction: Importance of process safety with examples of major accidents; which might cover chemical, petroleum & petroleum chemical Industrial.

UNIT II
Material Hazards : Flammability, toxicity. Reaction Hazards, Burning Characteristics, Material Properties and Hazards. Process & Pressure effects and deviations, flow, lwvel and other process deviations.

UNIT III
Ignition Sources: Flames, Hot surfaces, static electricity, and the ike Explosions Confined & Unconfined explosions, ILEVES, Dust Explosions

UNIT IV
Hazard Analysis' Check — lists, fault trees, cause **—** consequence diagrams, HAZOP and other methods of study. Dow procedures for safety assessment.
Safety Devices: Relief valves and Rupture disks Explosive relief, flare systems

UNIT V
Safety in plant Design & lay-out : Electrical area classification, control of entry to confined spaces. Emergency preparedness & liandling analysis of major accidents & preventive measures.

TEXT BOOKS:
1. Chemical process Safety by Crowl
2. Chemical process safety by Sanders

Objective: To train the students regarding industrial hazards and prevention methods and model and government regulations.

Outcome: The student will be equipped with the knowledge by which thorough safety is ensured in the organization.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

DESIGN AND ANALYSIS OF EXPERIMENTS
(ELECTIVE - IV)

UNIT I
Introduction to the role of experimental design; basic statistical concepts; sampling and sampling distribution;
Testing of hypotheses about differences in means- randomized designs and paired comparison designs; testing of hypotheses about variances

UNIT II
Analysis of variance (ANOVA) –one-way classification ANOVA; analysis of fixed effects model; comparison of individual treatment means; the random effects model; the randomized complete block design

UNIT III
Factorial design of experiments; two-factor factorial design-fixed effects and random effects model; General factorial design; analysis of 2^k and 3^k factorial designs.

UNIT IV
Conforming in the 2^k factorial design in 2p block; confounding in the 3^k factorial design in 3p block; Fractional replication of the 2^k factorial design and the 3^k factorial design.

UNIT V
Regression analysis- Simple and multiple linear regression and hypothesis testing; response surface methodology-the method of steepness ascent : response surface designs for first-order and second-order models. Evolutionary operation(EVOP)

TEXT BOOK:
1. Design and analysis of experiments , 2^{nd} edn., D.C.Montgomery,John Wiley and Sons, New York, 2003.

Objective: The objective of this course is to enable the student to learn the importance of design of experiments and obtaining maximum information about a process with minimum experimental work.

Outcome: The student will learn about design of experiments and analysis using ANOVA & factorial designs

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Engg.)

FLUIDIZATION ENGINEERING
(ELECTIVE - IV)

UNIT I
Introduction: The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds.

UNIT II
Industrial applications of fluidized beds: Coal gasification; gasoline from other petroleum fractions; Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics; Drying of solids; Synthesis of phthalic anhydride; Acrylonitrile; Polymerization of olefins; FCCU; Fluidized combustion of coal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization.

UNIT III
Fluidization and mapping of regimes: Minimum fluidization velocity; Pressure drop vs. velocity diagram; effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity of particles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems; Voidage diagram; Mapping of regimes of fluidization.

UNIT IV
Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles.
Bubbling Fluidized beds: Experimental findings; Estimation of bed porosities; Physical models: simple two phase model; K-L model.
High velocity Fluidization: Turbulent fluidized bed; Fast fluidization pressure drop in turbulent and fast fluidization.

UNIT V
Solids Movement, Mixing, Segregation and staging: Vertical movement of solids; Horizontal movement of solids; Staging of fluidized beds.
Gas Dispersion and Gas interchange in Bubbling Beds: Dispersion of gas in beds; Gas interchange between bubble and emulsion; Estimation of gas interchange coefficients.
Particle to Gas Mass Transfer**:** Experimental interpolation of mass transfer coefficients; Heat transfer; Experimental heat transfer from the bubbling bed model.

TEXT BOOK
1. Fluidization Engineering, 2nd ed., D. Kunii and O. Levenspiel, Butterworth-Heinemann, London,1999.

Objective: To teach the student about the basic principles of fluidization and its application in chemical industry.

OUTCOME: The student will enable to learn the importance and applications of fluidization in chemical and allied industries.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Chemical Engg.)

CHEMICAL ENGINEERING LABORATORY-II

LIST OF EXPERIMENTS:

1. Controller tuning by Ziegler- Nichol's & Cohen- Coon methods
2. Stability analysis using Bode diagrams for control systems.
3. Simulation of Ideal Binary Distillation Column using C/ C
4. Simulation of Non Isothermal CSTR using C/C
5. Simulation of Batch Reactor using C/C .
6. Heat/Mass Transfer coefficient in 3 phase fluidized bed column
7. Heat/Mass Transfer coefficient in 3 phase fluidized bed column
8. Heat/Mass Transfer coefficient in case of flow through impinging
9. Mass transfer studies in LSCFB
10. Hydrodynamic studies in Gas-solid CFB
11. Estimation of Adsorption isotherms
12. Reactive distillation