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

MATHEMATICAL AND STATISTICAL METHODS IN CHEMICAL ENGINEERING

Teaching Scheme: Lecture: 3 hrs/week

Objectives:

1. To give students an insight into various Chemical Engineering Processes using advanced Numerical and Statistical Methods.
2. To provide adequate background of Mathematics to deal with Chemical Engineering Problems
3. To understand research papers on relevant topics involving advanced Mathematics.
4. To study correlation and regression of multivariate data.
5. To evaluate Experimental design methods and statistical quality control measures.

Unit-1: Equation Forms in Process Modeling, Introduction and Motivation, Linear and Nonlinear Algebraic Equation, Optimization based Formulations, ODE-IVPs and Differential Algebraic Equations, ODE-BVPs and PDEs, Abstract model forms.
Fundamentals of Vector Spaces, Generalized concepts of vector space, sub-space, linear dependence, Concept of basis, dimension, norms defined on general vector spaces, Examples of norms defined on different vector spaces, Cauchy sequence and convergence, introduction to concept of completeness and Banach spaces, Inner product in a general vector space, Inner-product spaces and their examples, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, well known orthogonal basis Matrix norms.

Unit-2: Problem Discretization Using Approximation Theory, Transformations and unified view of problems through the concept of transformations, classification of problems in numerical analysis, Problem discretization using approximation theory, Weierstrass theorem and polynomial approximations, Taylor series approximation,
Finite difference method for solving ODE-BVPs with examples, Finite difference method for solving PDEs with examples, Newton's Method for solving non-linear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, Polynomial and function interpolations, Orthogonal Collocations method for solving ODE-BVPs, Orthogonal Collocations method for solving ODE-BVPs with examples.

Unit-3: Solving Linear Algebraic Equations, System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tridiagonal and block tridiagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition,
Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference

equations using Eigen values, Convergence of iterative solution schemes with examples, Convergence of iterative solution schemes.

Unit-4: Solving Non-linear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches, Secant method, regula-falsi method and Wegsteine iterations, Modified Newton's method and qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method, Contraction mapping principle and introduction to convergence analysis.

Unit-5: Solving Ordinary Differential Equations, Initial Value Problems (ODE-IVPs), Introduction, Existence of Solutions (optional topic),Analytical Solutions of Linear ODE-IVPs, Basic concepts in numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods: derivation and examples Runge-Kutta methods, Multi-step (predictor-corrector) approaches: derivations and examples, Multi-step (predictor-corrector) approaches: derivations and examples

References

1. Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).

2. Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic Press, 1996.

3. Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).

4. Gupta, S. K.; Numerical Methods for Engineers.Wiley Eastern, New Delhi, 1995.
5. Linz, P.; Theoretical Numerical Analysis, Dover, New York, (1979).

6. Gilbert Strang , Introduction to Applied Mathematics, Wellesley Cambridge Press (2009)

Outcomes:

At the end of the course the student will be able to

- Understand the principles of modeling and Fundamentals of Vector Spaces (L2)
- Solve system of linear algebraic equations using Gauss elimination, Gauss Jordan, Gauss Siedel methods (L6)
- Solve Non-linear algebraic equations using Secant method, regula-falsi method, Wegsteine iterations, Modified Newton's method and qausi-Newton method (L6).
- Understand about Problem Discretization techniques and also Finite difference methods (L2)
- Solve ordinary differential equations by Euler's method, modified Euler's method, Runge Kutta method, Predictor Corrector method and Milne's method. (L6)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

ADVANCED SEPARATION PROCESSES

Teaching Scheme: Lecture: 3 hrs/week

- **Objectives:**

- To familiarize students with various advanced aspects of separation processes and the Selection of separation processes.
- To make the students understand the fundamental concepts behind the various separation processes. Separation and chromatography and to design an absorber or a membrane unit to achieve a Specified separation.
- Introduce them to new trends used in the separation technologies.

Unit-1: Introduction: Conventional separation processes - Absorption, Adsorption, Conventional separation processes - Distillation, Drying, Conventional separation processes - Extraction, Diffusion, Conventional separation processes - Leaching, Crystallization, separation techniques based on size, Advances in separation techniques based on surface properties, Advances in separation techniques based on ionic properties, Thermodynamic consistency test for VLE data, Phase rule and degrees of freedom estimations. Bubble- point and Dew- point calculations; Flash calculations, Estimation of state of the mixture.

Unit-2: Multi component separation processes: Product qualities and theoretical stages of equilibrium based separations 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

Unit-3: Fundamentals of membrane separations, microfiltration, ultra filtration, osmosis, Reverse osmosis, electro dialysis, gas separation, pervaporation, dialysis (qualitative treatment only). Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fiber membrane reactors.

Unit-4: Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, Liquid membrane separation.

Unit-5: Special Processes: super-critical extraction, Pressure swing adsorption (PSA). Chromatographic Methods of Separation: Gel, solvent, ion and high performance liquid chromatography.

References:

1. King C.J., "Separation Processes", Tata McGraw Hill. 1982.
2. Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992.
3. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
4. Khoury F.M., "Multistage Separation Processes", 3rd Ed., CRC Press. 2004.
5. Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall.2006.
6. Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., Wiley.2006
7. Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., CRC Press.2007.
8. Phillip C. Wankat, Separation Process Engineering (2nd Edition), Prentice Hall, 2007
9. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009.

Outcomes:

After completing the course, the students will be able to:

- List situations where liquid–liquid extraction might be preferred to distillation, make a preliminary selection of a solvent using group-interaction rule. Separation techniques based on surface properties (L1)
- Explain how crystals grow, Explain the importance of super saturation in crystallization. Describe effects of mixing on super saturation, mass transfer, growth, and scale-up of crystallization. (L2)
- Facilitate the students with the novel techniques that are required in downstream processing of biotechnology based industries. (L3)
- Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solute membrane interactions. Distinguish among microfiltration, ultra filtration Nanofiltration, virus filtration, and reverse osmosis in terms of average pore size. Explain common idealized flow patterns in membrane modules. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Technology)
FLUIDIZATION ENGINEERING (Elective-I)

Teaching Scheme: Lecture: 3 hrs/week

Objectives

- To study the phenomenon of fluidization with industrial processing objective
- To study the various regimes of fluidization and their mapping.
- To study the design of equipments based on fluidization technique

UNIT-I: Introduction to fluidization and applications Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

UNIT-II: Mapping of fluidization regimes characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

UNIT-III: Bubbling fluidized beds Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

UNIT-IV: Solids movement and Gas dispersion Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

UNIT V: Fluidized bed reactors Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds. Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts,Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

References

1. Levenspiel O. and Kunnii D., “Fluidization Engineering”, John Wiley, 1972
2. Liang-Shih Fan, “Gas-Liquid-Solid Fluidization Engineering”, Butterworth, 1989.
3. Fluidization Engineering, 2nd ed., D. Kunii and O. Levenspiel, Butterworth-Heinemann, London, 1999.

Course Outcomes:

After completing the course, the students will be able to:

- Learn various industrial applications of fluidization. (L2)
- Explain the various fluidization regimes, classification of particles. (L5)
- Describe the K-L bubbling model. (L2)
- Describe the staging of fluidized beds, and calculation of the exchange coefficient. (L2)
- Understanding the applicability of the fluidized beds in chemical industries. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Technology)
PROCESS MODELING AND SIMULATION (Elective-I)

Teaching Scheme: Lecture: 3 hrs/week

Objective:

- Learn to develop mathematical model for problems.
- Formulate a chemical engineering problem as a mathematical model, and select an appropriate solution method.
- To study the modeling & simulation techniques of chemical processes and to gain skills in using process simulators.
- Understand the computational requirements of various solution options and use this understanding in the selection of the solution method

UNIT I

Introduction: Uses of mathematical models, Principles of formulation
Fundamental laws: Continuity Equations, Energy Equation, Equations of Motion, Transport equations, Equation of state, Equilibrium, Chemical Kinetics.

Classification of mathematical models: steady state Vs dynamic models, lumped Vs distributed parameter models, deterministic Vs stochastic models.

UNIT II

Examples of mathematical models of Chemical Engineering Systems: Series of isothermal, constant- holdup CSTRs, Two heated tanks, Gas- Phase Pressurized CSTR, Non-isothermal CSTR, batch reactor, reactor with mass transfer, ideal binary distillation column.

UNIT III

Numerical solution of partial differential equations: elliptic, parabolic and hyperbolic equations. Finite difference methods, Leibman's method, Crank Nicholson method. Applications to steady state and Unsteady state heat conduction and temperature distribution problems.

UNIT IV

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

UNIT V

Introduction to Computational Fluid Dynamics

Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Governing equations of fluid flow and heat transfer, Mass conversation in three dimensions, Momentum equation in three dimension, Energy equation in three dimension, Equations of state, Navier-Stokes equation, Classification method for PDEs, Conservation of mass, Classification of fluid flow equations, Rayleigh- Ritz method, Method of Least Square, Galerkin method, Collocation method, Finite differences.

TEXTBOOKS:

1. Process modeling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990.
2. An introduction to computational fluid dynamics, H. Versteeg, W, Malalasehra.
3. Computational Fluid Flow and Heat Transfer, K. Muralidhar, T. Sundararajan.

REFERENCES:

1. Numerical Methods for Engineers and Scientists, S.S. Rao
2. Process Plant Simulation, B.V Babu, Oxford University Press, 2004.
3. Process Modeling and Simulation, Amiya K. Jana, 2012.
4. Versteeg, H.K., Malalasekera, W., an Introduction to Computational Fluid Dynamics - The Finite Volume Method, Longman
5. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers- Rudra Pratap.

Course outcomes:

At the end of the course, student will be able to:

- Classify different types of mathematical models (L2)
- Develop mathematical model for the given chemical engineering equipment from basic engineering principles. (L6)
- Solve PDEs using different numerical methods. (L3)
- Simulate binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, and counter-current heat exchanger. (L4)
- Compare and contrast modular approaches with equation oriented approach (L2)
- Learn the basic principles of Computational Fluid Dynamics with some examples and simulate the model equations using numerical methods. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Technology)
BIOCHEMICAL ENGINEERING (Elective-I)

Teaching Scheme: Lecture: 3 hrs/week
OBJECTIVES:

- To introduce the classification of microorganisms based on the structure and characteristics of various types of cells
- To inform the importance of chemicals like lipids, sugars, polysaccharides, amino acids and proteins
- To teach the kinetics of enzyme catalyzed reactions and the effect of various parameters on enzyme activity and kinetics
- To educate the methods of enzyme immobilization and the applications of immobilized enzymes
- To enlighten the students on metabolic stoichiometry and energetics of the cell
- To impart the kinetics of cell growth including substrate utilization and product formation
- To teach the design and analysis of various types of bioreactors
- To train on various downstream processing strategies for product recovery and purification

UNIT I: Introduction to microbiology: Biophysics and the cell doctrine, the structure of cells, important cell types, from nucleotides to RNA and DNA, amino acids into proteins. Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, other patterns of substrate concentration dependence, modulation and regulation of enzyme activity, other influences on enzyme activity.

UNIT II: Immobilized enzyme technology: enzyme immobilization, industrial processes, utilization and regeneration of cofactors. Immobilized enzyme kinetics: effect of external mass transfer resistance, analysis of intraparticle diffusion and reaction.

Kinetics of cellular growth in batch and continuous culture, models for cellular growth – unstructured, structured and cybernetic models. Thermal death kinetics of cells and spores

UNIT III: Introduction to metabolic pathways, biosynthesis, transport across cell membranes, end products of metabolism, stoichiometry of cell growth and product formation.

Design and analysis of biological reactors: batch reactors, fed-batch reactors, enzyme catalyzed reactions in CSTR, CSTR reactors with recycle and cell growth, ideal plug flow reactors, sterilization reactors, sterilization of gases, packed bed reactors using immobilized catalysts. Fermentation technology: medium formulation, design and operation of a typical aseptic, aerobic fermentation process.

UNIT IV: Transport phenomena in bioprocess systems: Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, overall k_La' estimates and power requirements for sparged and agitated vessels, scaling of mass transfer equipment, heat transfer.

UNIT V: Downstream processing: Strategies to recover and purify products; separation of insoluble products-filtration and centrifugation; cell disruption-mechanical and non-mechanical methods; separation of soluble products: liquid-liquid extractions, membrane separation (dialysis, ultra filtration and reverse osmosis), chromatographic separation-gel permeation chromatography, electrophoresis, final steps in purification – crystallization and drying.

TEXT BOOKS:

1. Biochemical Engineering Fundamentals, 2nd ed., J.E. Bailey and D.F. Ollis, Mc-Graw Hill, New York, 1987.

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

REFERENCES:

1. Biochemical Engineering, J. M. Lee, Prentice-Hall, New Jersey 1992.

2. Bioprocess Engineering Principles, P. M. Doran, Elsevier, Gurgaon, 2005.

COURSE OUTCOMES:
After completing the course, the student will be able to:

- Classify microorganisms based on the structure and characteristics of various types of cells (L2)
- Analyze the kinetics of enzyme catalyzed reactions (L3)
- Explain the methods of enzyme immobilization and the applications of immobilized enzymes (L2)
- Evaluate the kinetics of cell growth including substrate utilization and product formation (L6)
- Demonstrate the design and analysis of various types of bioreactors (L3)
- Identify various downstream processing strategies for product recovery and purification (L3)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Technology)
MODERN CONCEPTS IN CATALYSIS AND SURFACE PHENOMENA (Elective-II)

Teaching Scheme: Lecture: 3 hrs/week

Objectives

- To give the students insight into advances in catalytic reaction engineering
- To understand the mechanisms involved in catalytic reactions
- To study the catalyst characterization techniques
- To study the advanced industrial applications in catalysis
- To understand the principles behind catalyst deactivation and study their models.

UNIT-1: Introduction to Catalysis Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

UNIT-2: Adsorption in Catalysis Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbed molecules

UNIT-3: Catalyst Characterization Catalyst Characterization Methods – Their Working Principle and Applications – XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Peroviskites, Spinels, Clays, Pillared Clays, Zeolites

UNIT-4: Significance of Pore Structure and Surface Area Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area – Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volume and Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler's Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

UNIT-5: Industrial applications– Case Studies Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fischer- Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photo catalytic Breakdown of Water and the Harnessing of Solar Energy. Contribution of homogeneous catalytic process in chemical industry: Oxidations of Alkenes such as production of acetaldehyde, propylene oxide etc., Polymerization such as production of polyethylene, polypropylene or polyester production

References:

1. Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954.
2. Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971.

3. Thomas and Thomas - “Introduction to Heterogeneous Catalysts ", Academic Press, London 1967
4. Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
5. Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability –deactivation, Wiley, VCH, 2011.

Course Outcomes: After completing the course, the student will be able to:

- Understand the concepts of homogenous and heterogeneous catalysis, with specific examples. (L2)
- Analyze the reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions. (L4)
- Understand the characterization of catalysts (L2)
- Explain the application and mechanisms of several types of catalysts in chemical industry. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. (Chemical Technology)
ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS (Elective-II)

Teaching Scheme: Lecture: 3 hrs/week

Objective:

1. To give an insight of molecular and statistical thermodynamics.
2. To Acquire the knowledge of Molecular theories of activity coefficients, lattice models, multi-phase multi-component phase equilibrium, VLE/SLE/LLE/VLLE, chemical equilibrium, Chemical Reaction Equilibrium.

UNIT I

Review of basic postulates, Maxwell’s relations, Legendre transformation, , theory of corresponding states pure component properties - entropy change of an ideal gas - the ideal gas - Behavior of real gases - equations of state isothermal and adiabatic compressibility.
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, Azeotropic mixture, the increment of boiling point and decrement of freezing point, phase diagram, properties of composite liquids at critical region. 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 Jersey, 1996``
3. J.M smith. H.C.V. Ness and M.M. Abott, Introduction to Chemical engineering Thermodynamics" Mc-Graw Hill International Edition (5th Edn). 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

Course Outcomes: After completing the course, the student will be able to:

- Understand the thermodynamic basic postulates, Maxwell's relations, Legendre transformation, pure component properties (L2)
- Derive Second Virial Coefficients from Potential Functions(L3)
- Apply the knowledge of mathematics, science and engineering fundamentals to model the phase behavior for VLE system. (L3)
- Communicate effectively the concepts of the phase space, Louiville equation, crystals, intermolecular forces and potential energy functions, imperfect mono atomic gases(L5)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

ADVANCED FLUID DYNAMICS AND HEAT TRANSFER (Elective – II)

Teaching Scheme: Lecture: 3 hrs/week

Objective:

- To teach the properties of Newtonian fluids
- To develop steady state mechanical energy balance equation for fluid flow systems, estimate pressure drop in fluid flow systems and determine performance characteristics of fluid machinery.
- To explain the dynamics of fluid flows and the governing non-dimensional parameters, apply concepts of mass, momentum and energy conservation to flows, Grasp the basic ideas of turbulence.

UNIT I

Properties of fluids and multiphase flow: introduction: fluids and fluid properties, basic equations for flowing streams, flow of incompressible fluids, fundamental Principles of conservation, Reynolds Transport theorem, conservation of mass, conservation of linear momentum, Navier- Stokes equation, Conservation of energy, Newtonian, non- Newtonian and non-viscous fluids, determination of flow properties of fluids, flow in pipes and tanks, flow through packed bed and fluidized beds.

UNIT II

Boundary layer theory and statistical theory of turbulence: laminar flow in closed conduits, potential flow, boundary layer theory, hydrodynamic stability, turbulence-statistical theory, measurement of turbulence intensity, turbulent flow in closed conduits, dimensional analysis in fluid dynamics.

UNIT III

Heat transfer in fluids: Combination of heat transfer resistance, steady and unsteady state heat conduction, Unsteady state heating and cooling of solid objects, Transient heat conduction, Convection heat transfer co-efficient, Dimensional analysis in convection heat transfer, Heat transfer during Laminar and Turbulent flow in closed conduits-Empirical correlation for high Prandtl Number of fluids.

UNIT IV

Analogy and recent developments in heat exchangers: Analogy between momentum and heat transfer. Recent developments in the design of compact heat exchangers, insulation-design and selection.

UNIT V

Heat transfer with phase change: Boiling and condensation heat transfer, Heat transfer in Liquid metals, Flow in shell side of heat exchanger.

TEXT BOOKS

1. J.G. Knudsen and D.L. Katz," Fluid Dynamics and Heat Transfer", McGraw Hill, New York, 1958.
2. O. Levenspiel, Engineering flow and Heat Exchange", Plenum Press, New York, 1998.

REFERENCE BOOKS

1. V. L. Streeter, "Fluid Dynamics", Mc-Graw Hill, New York, 1965.
2. J.P. Hollman, "Heat Transfer", Mc-Graw Hill, New York, 1968

Course outcomes:

After completing the course, the student will be able to

- Understand stress-strain relationship in fluids, classify their behavior and also establish force balance in static systems. Further they would develop dimensionless groups that help in scale-up and scale-down of fluid flow systems and apply Bernoulli principle and compute pressure drop in flow systems of different configurations(L2)
- Understand Properties of fluids and multiphase flow, describe the mechanism of thermal conduction. (L2)
- Analyze the performance aspects of heat transfer with phase change(L4)
- Solve numerical problems involving heat Transfer. (L6)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

CHEMICAL PROCESS SIMULATION LABORATORY (Lab- I)

Laboratory Scheme: Lecture: 4 h/week

Objectives:

- To learn Process Modeling and Simulation of Chemical operations and processes.
- To understand Dynamic Behavior of processes.
- To understand Close loop control of processes.
- To learn Dynamic simulation of chemical processes.
- To get acquainted with Controllability Analysis of chemical processes.

List of experiments: Simulation laboratory practical

1. Thermodynamic property estimations using property estimation and property analysis in Aspen.
2. Simulate Mixer, splitter, heat exchangers, and reactive distillation column.
3. Apply sensitivity, design specification and case study tools in Aspen
4. Solve linear and non-linear programming problems.
5. Controller tuning by Ziegler- Nichol's & Cohen- Coon methods
6. Stability analysis using Bode diagrams for control systems.
7. Simulation of Ideal Binary Distillation Column
8. Simulation of Heat/Mass Transfer coefficient in 3 phase fluidized bed column
9. Simulation studies of various unit operations using CHEMCAD.
10. Modeling and Simulation of cyclone separator

Note: Simulation can be done using C/C++ / MATLAB Package/ ASPEN PLUS/ CHEMCAD

Outcomes: After completing the course, the student will be able to

Carry out thermodynamic property estimations using property estimation and property analysis in Aspen.

- Simulate Mixer, splitter, heat exchangers, reactors, distillation columns. (L6)
- Apply sensitivity, design specification and case study tools in Aspen. (L3)
- Solve linear and non-linear programming problems. (L3)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

ADVANCED SEPARATION PROCESSES (Lab-II)

Laboratory Scheme:
Lecture: 4 h/week

Objectives:

- To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
- To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.
- To introduce them to new trends used in the separation technologies.

List of experiments: Advanced Separation Processes

1. Study the performance of Bubble Cap Distillation.
2. Study the effect of pressure on permeate flux and solution rejection in RO system.
3. Adsorption of dyes from waste water using nano adsorbents
4. Study the reaction with mass transfer: e.g. Synthesis of calcium carbonate.
5. Batch distillation with reflux
6. Liquid- Liquid Equilibria (Tie-line data)
7. Ternary Liquid Equilibria (binodal curve)
8. Determination of stage efficiency using counter-current leaching
9. Preparation of activated carbon from biomass.
10. Separation of moisture from air using silica gel.

Outcomes: After completing the course, the student will be able to

- Knowledge of mass transfer operations and mechanical operations(L1)
- To know the synthesis of materials and applications in separation processes. (L4)
- To provide applicable solutions to separation processes. (L5)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

RESEARCH METHODOLOGY AND IPR

Teaching Scheme: Lectures: 1hrs/week

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.

Course Outcomes:

After completing the course, the student will be able to

- Understand research problem formulation. (L2)
- Analyze research related information(L4)
- Follow research ethics(L2)

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity. (L2)
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits. (L2)

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

ADVANCES IN TRANSPORT PHENOMENA

Teaching Scheme: Lecture: 3 hrs/week

Objectives:

- To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
- To enable students to understand the equations of change for isothermal flow and for non isothermal flow.
- To introduce them details of equations of change for multi component systems.
- To give them insight into properties of two-dimensional flows and aspects of dimensional analysis

Unit-1:Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change. Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow - Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

Unit-2: Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance. Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussine sq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems.

Unit-3: Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in

Solids, Steady Heat Conduction in Laminar, Incompressible Flow. Temperature Distributions in Turbulent Flow - Time Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

Unit-4: Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

Unit-5: Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

References:

1. Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.
2. Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt. Ltd., New Delhi. 2004.
3. Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.

Outcomes: After completing the course, the student will be able to

- Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow. (L2)
- Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale. (L3)
- Solve the governing equations to obtain velocity, temperature and concentration profiles. (L6)
- Model the momentum, heat and mass transport under turbulent conditions. (L6)
- Develop analogies among momentum, energy and mass transport. (L6)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Technology)
ADVANCED REACTION ENGINEERING

Teaching Scheme: Lecture: 3 hrs/week
Course objective:

- To teach the design of reactor especially for heterogeneous reactions.
- To explain the energy balance, temperature and concentration profiles in different reactors, advance design aspects of multiple reactors;
- To give an insight of importance of population balance of particles. Role of Reaction Engineering in mitigation of global warming.

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 reactors for adiabatic, isothermal, non-isothermal conditions; Optimal performance for maximum production rate in batch reactor, CSTR, PFR reactors, Modes of operation and design aspects for semi-batch and semi-continuous reactors.
UNIT-II
Transport Processes in Heterogeneous Reactions
External mass and heat transport: Binary Diffusion, Effect of the reaction rate coefficients for surface reactions and effect of external mass transfer resistance on order of reaction and activation energy of reaction. Design and operation of PFR with recycle for constant and variable density systems. Comparison of reactors and their combinations, multiple reactor configurations.

UNIT-III
Intra-particle Diffusion: Concept of effectiveness factor and Thiele modulus and their relationships, Derivation of differential equation describing diffusion and reaction, solution to the differential Equation for a first order reaction, falsified Kinetics, Internal and external effectiveness factor. Effect of internal resistance on catalyst selectivity and poisoning.

UNIT-IV
Heterogeneous Catalytic Fixed bed Reactor Analysis and Design
Types of reactors and mode of operations: Design considerations, Contour plots of raction rate vs. temperature and extent of reaction for exothermic, reversible reactions. ***Reactor Models***: One Dimensional Models, Two dimensional Models of Pseudo-homogeneous and Heterogeneous with Plug flow.

UNIT-V
Design for Fluidized Bed, Gas-Liquid-Solid Three Phase Reactors
Fluidized bed reactor models: Two phase model, KL model, Operating characteristics of FBRs. Mass Transfer in Fluidized Beds: Gas-Solid Mass Transfer, Mass Transfer between

the Fluidized-Bed Phases, and Reaction in Fluidized Bed. *Trickle bed reactor Models, Slurry reactor models.*

Reference Books

1. R.W. Missen, CA Mims, B A Saville, "Introduction to Chemical Reaction Engineering and Kinetic Wiley & Sons, Inc., 1999.
2. J.M.Smith "Chemical Engineering Kinetics" 3rd ED., Mc Graw Hill, New York 1980
3. Froment G.F. AND Bischoff K.B., "Chemical reactor Analysis and Design" John Wiley, 1990
4. Fogler S.H., Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall, 1999
5. Levenspiel, O., "Chemical Reaction Eng." John Wiley & Sons 1972.
6. RE Hayns and J.P Mmbaga, "Introduction to chemical reactor analysis", 2nd Edn, CRC press, 2012

Course Outcomes:

After completing the course, the student will be able to

- Ability to analyze chemical reactors, types of model reactors and reaction systems(L4)
- Develop experiments involving chemical reactors, and analyzing and interpreting data(L3)
- Understand to solve problems of mass transfer with reaction in solid catalyzed reactions(L2)
- Determine the operating conditions for reactions at which maximum conversion of desired product can be achieved. (L5)
- Catalyst and design multiple reactors and their evaluation of performance, development of concepts of heterogeneous system and applications. (L6)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

AIR AND WATER POLLUTION CONTROL ENGINEERING

(Elective – III)

Teaching Scheme: Lecture: 3 hrs/week

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.

Unit-I

Introduction: Water and Wastewater, Characteristics and monitoring, sampling techniques and sample preparation for water and wastewater, Traditional and advanced analytical techniques for various parameters in water and waste water.

Physicochemical processes for water and waste water quality control: Equalization, Neutralization, Aeration, Sedimentation, Coagulation and Flocculation, Filtration, Disinfection, Adsorption and Ion Exchange.

Unit-II

Biological treatment processes for wastewater quality control: Fundamentals of Monod kinetics and application in bioreactor design principles, concepts, types and modifications of aerobic and anaerobic, suspended- growth and attached- growth treatments, Concepts of natural treatment systems, such as, Aerated lagoons, Stabilization ponds, Oxidation ditches, etc

Unit-III

Sludge Treatment: Chemical, Biological, Incineration and disposal of sludge solids

Advanced Wastewater treatment: Nutrient removal treatments, Membrane Technologies, Advanced Oxidation Processes

Reuses of Wastewater: Concept of gray water, reuse and recycle of wastewater in industrial and agricultural purpose

Unit-IV

Elements of Air Pollution: History of air pollution, Natural versus Polluted atmosphere, Air quality and monitoring, Source of air pollution, Effects of air pollution, regulatory control of air pollution, Stack and ambient air sampling, Collection techniques for gaseous and particulate air pollutants

Engineering Control of Air Pollution: Control of stationery sources and mobile sources, Concept, design of control devices & system like Industrial ventilation system, Settling Chambers, Bag Filters, Inertial devices (Cyclone Separator), Electrostatic Precipitators, Particulate scrubbers etc

Unit-V

Control of Vehicular air Pollution: Vehicle emission standards and fuel quality, Inspection and certification programme, Catalytic converter- Concept, application and design; Various models related to air pollution treatment; Case studies from chemical industries: Air Pollution assessment and control in Petrochemical, Pharmaceutical, dyes and intermediate and other process industries.

Text Books

1. Wastewater Treatment for Pollution Control and Reuse, by Soli J Archeivala Shyam R Asolekar, McGraw Hill Publications
2. Wastewater Engineering: Treatment and Reuse, by George Techobanolous Franklin L. Burton, H David Stensel, Metcalf and Eddy Inc.
3. Air Pollution: Its Origin and Control by Kenneth Wark, Cecil F. Warner, Addlison, Wesley Longman
4. Air Pollution Control Theory by Martin Crawford, McGraw Hill

Course Outcomes: After completing the course, the student will be able to

- Recognize the causes and effects of environmental pollution(L1)
- Analyze the mechanism of proliferation of pollution(L4)
- Develop methods for pollution abatement and waste minimization(L6)

- Understand Water and Wastewater, Characteristics and monitoring, sampling techniques and sample preparation for water and wastewater, Traditional and advanced analytical techniques for various parameters in water and waste water. (L2)
- Acquire the Fundamentals and application in bioreactor design principles, concepts, types and modifications of aerobic and anaerobic, suspended- growth and attached- growth treatments(L1)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Technology)
PROCESS DESIGN AND SYNTHESIS [Elective – III]

Teaching Scheme: Lecture: 3 hrs/week

Objectives:

- To understand the systematic approaches for the development of conceptual chemical process designs
- To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.

Unit-I: Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

UNIT-II: Product design and developments Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

UNIT-III: Reactor Networks Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

UNIT-IV: Synthesis of Separation Trains Criteria for selection of separation methods, select ion of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor ow rates for single columns, Residue curve basics, Non-ideal Distillation - Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure

UNIT-V: Heat Exchanger Network Synthesis Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

References

1. Douglas, J. "Conceptual Design of Chemical Processes",New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.

2. Seider, W. D., J. D. Seader, and D. R. Lewin. "Product and Process Design Principles: Synthesis, Analysis, and Evaluation",. 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.

3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0- 13-064792-6

4. Biegler L.T., Grossmann I.E. and Westerberg A.W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997.

Course Outcomes:

After completing the course, the student will be able to

- Analyze alternative processes and equipment (L4)
- Synthesize a chemical process flow sheet that would approximate the real process(L6)
- Design best process flow sheet for a given product (L6)
- Perform economic analysis related to process design and evaluate project profitability(L3)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

ADVANCED PROCESS CONTROL [Elective – III]

Teaching Scheme: Lecture: 3 hrs/week

Objective:

- Develop mathematical and transfer function models for dynamic processes.
- Analyze process stability and dynamic responses.
- Empirically determine process dynamics for step response data**.**
- Ability to understand feed forward control, cascade control and Smith predictors and their applications.
- Knowledge of real time applications of process control implementation.

UNIT I

Review of single input single out put (SISO) systems: Review of first and second order systems transfer functions, Response of First order system, Properties of Transfer function, Response of First order systems.

Examples of First order systems: liquid level process with constant flow outlet, mixing process, and heating process.

Response of First Order systems in series: Interacting systems & Non-interacting systems, open loop and closed loop stability aspects.

Introduction to Frequency response: Substitution rule, Bode plots.

UNIT II

Internal Model control (IMC): Internal Model control structure, Design of IMC Controller, Design of IMC Controller for the process of First Order, Design of IMC Controller for the process of First Order with transport lag,

Non linear systems and control: Nonlinear control, phase plane analysis, phase plane analysis of damped oscillator, The Damped Oscillator, application to chemical reactors.

UNIT III

Cascade, feed forward and ratio control: Analysis and design of cascade control, feed forward control, Analysis of Feed forward control, Implementing Feedforward Transfer Functions, tuning rules for feedforward feedback control, feedforward rules, 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

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

REFERENCES

1. Chemical Process Control, G. Stephanopoulos, PHI Learning Pvt. Ltd., New Delhi, 2010

Course Outcomes:

After completing the course, the student will be able to

- Develop the transfer functions for first order systems such as liquid level, mixing tank and derive the transfer functions of second order systems(L6)
- Solve the IMC structures, IMC design & implementation Nonlinear control, phase plane analysis, application to chemical reactors Specify the required instrumentation and final elements to ensure that well-tuned control is achieved. (L6)
- Design & Analyze the use of block diagrams & the mathematical basis for the design of control systems, 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(L6)
- Develop the constrained and unconstrained MPC, design and application of MPC, dynamic matrix control & its design procedure, (L6)
- Acquires the knowledge on the State Space representation of physical systems Understand the experimental implementation of advanced process control schemes and the methods for process monitoring and diagnosis(L1)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

PROCESS INTENSIFICATION [Elective – IV]

Teaching Scheme: Lecture: 3 hrs/week

Objectives:

- Understand the concept of Process Intensification.
- Know the limitations of intensification of the chemical processes.
- Apply the techniques of intensification to a range of chemical processes.
- Develop various process equipment used for intensifying the processes.
- Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

UNIT-I: Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit-II: Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit-III: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit-IV: Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit-V: Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids

References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor),Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

Outcomes: At the completion of this course, students will be able to:

- Assess the values and limitations of process intensification, cleaner technologies and waste minimization options. (L4)
- Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle. (L4)
- Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance. (L2)
- Analyze data, observe trends and relate this to other variables. (L4)

- Plan for research in new energy systems, materials and process intensification. (L6)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Technology)
SOLID WASTE TREATMENT AND MANAGEMENT [Elective – IV]

Teaching Scheme: Lecture: 3 hrs/week
Objectives:
- To understand the sources of solid and hazardous wastes.
- To understand methods of solid waste disposal.
- To evaluate the health risks posed by abandoned waste sites and waste disposal operations.
- To evaluate the legislation designed to control the production, cleanup and disposal of solid and hazardous waste disposal operations.

Unit-I
Introduction: Types and sources of solid wastes, Characteristics and collection, Solid waste volume reduction, Storage and transportation

Unit-II
Solid Waste Treatment System: Physical, Chemical and Biological treatment Systems, Reuse and recycling of solid waste- Incineration, Composting and Composting Plants.

Unit-III

Ultimate disposal: Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases, liquids and soil condition.

Unit-IV
Handling of hazardous wastes- Collection of hazardous wastes and care in handling quantities of hazardous wastes generated, Storage of hazardous wastes, Transportation and Shipment of hazardous wastes. Final disposal of hazardous wastes- Site selection, incineration, land filling, Leachates, treatment and disposal

Unit-V
Biomedical waste management- Concepts, treatment, and legislations; Electronic Waste (e-waste) management- Concepts, treatment, and legislations ,case studies based on course content and related to process industries

Text Books

1. Integrated Solid Waste Management Engineering Principles and Management Issues by George Tchobanoglous, Hilary Theisen and Samual A Vigil, McGraw Hill Publishers
2. Hazardous Waste Management by Michael D. LaGrega, Phillip. L. Buckingham and Jeffery C Evans, Waveland Press Inc.

3. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985

Reference books

1. Hazardous Waste Chemistry, Toxicology and Treatment, Stanley E. Manahan, Lewis Publishers, Chelsea, Michigan, 1990.
2. Waste Disposal in Engineered Landfills, Manoj Datta, Narosa Publishing House, 1997

Course outcome:

After completion of the course students should be able to

- Evaluate the subject from the technical, legal and economical points by learning of all terms related to general solid waste management. (L5)
- Understand municipal solid waste management system. Make physical and chemical analysis of municipal solid wastes and apply them for a management system that will be set up. (L2)
- Optimize site selection for a landfill, plan a solid waste management system for decision makers, and collect required data for a Solid Waste Management Plan. (L2)
- Analyze the problems of municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc**.** (L4)
- Knowledge of legal, institutional and financial aspects of management of solid wastes. Become aware of Environment and health impacts solid waste mismanagement, (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

OPTIMIZATION TECHNIQUES IN CHEMICAL ENGINEERING

[Elective – IV]

Teaching Scheme: Lecture: 3 hrs/week

Objective:

- To learn problem formulation of optimization.
- To realize the numerical methods of un-constrained optimization.
- To learn linear programming and its applications
- To understand the use of genetic algorithms in optimization
- To know the applications of numerical optimization.

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, New York, 1970.
2. Rekllitis, 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. Wiley Eastern Ltd,1996
4. Operations Research- Theory & Applications, J. K. Sharma.

Course Outcome: After completion of the course students should be able to

- Apply the knowledge of optimization to formulate the problems. Analyze the optimization criterion for solving problems. (L3)
- Distinguish different methods of optimization and to suggest a technique for specific problem, Apply simplex method for linear optimization problems. (L4)

- Understand advanced optimization techniques like Genetic algorithms; understand how optimization can be used to solve the industrial problems of relevance to the chemical industry. (L2)
- Apply the basic theoretical principles in optimization, formulate the optimization problem, and choose appropriate method/solver for solution of the optimization problem. (L5)
- Analyze of different optimization techniques, Ability to solve various multivariable optimization problems(L4)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

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

ADVANCED CHEMICAL REACTION ENGINEERING LABORATORY [Lab-III]

Teaching Scheme: Lab 4 hrs/week

Objectives: At the end of the course, the student will be able to:

1. To provide through understanding of Reaction Engineering.
2. To design reactor and identity type of reactor by suiting chemical kinetics and using information from thermodynamics, heat and mass transfer economics.
3. Characteristics of a fluidized bed reactor
4. Understanding of corrosion reaction and monolithic catalytic reactors.

List of Laboratory Experiments:

1. Analyze the characteristics of a fluidized bed reactor
2. Kinetics of a (solid-liquid) Esterification reaction in a batch reactor
3. Study the performance of combination of Reactors and RTD analysis
4. Study the kinetics in Adiabatic Batch reactor.
5. Study the performance of Combined Flow Reactor.
6. Studies of Catalyst performance of gas- liquid feed by using Fixed Bed Catalytic Reactor.
7. Studies of Catalyst performance of Liquid- liquid feed by using Fixed Bed Catalytic Reactor.
8. Studies of Catalyst performance in a microwave reactor.
9. Study the performance of Advanced Flow Reactor.
10. Preparation of mixed metallic/ alloy catalysts

    (i) Pd-Cu/Al_2O_3 (ii) Ni-Cu/ Al_2O_3 Ni-Cu/ CrO_2

Outcomes:

1. Students will able to know the solid-liquid, liquid –liquid reactions. (L2)
2. Students will be able to know the micro reactor based process intensification. (L2)
3. Students will be able to know the monolithic catalytic reactors applications. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Chemical Technology)
ADVANCED CHEMICAL ENGINEERING LAB [Lab-IV]

Teaching Scheme: Lab 4 hrs/week

Objectives:

1. Analyze characteristics of a fluidized bed dryer
2. Estimate efficiency of compact heat exchangers
3. Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flow reactor
4. Design controller for a given process
5. Evaluate the performance of membrane separation process for water purification
6. Characterize electrochemical phenomena such as corrosion

List of Laboratory Experiments:

1. Characteristics of a Fluidized bed dryer
2. Helical Coil heat exchanger
3. Rheological studies of Non-Newtonian fluids
4. Cyclone Separator.
5. Reactive distillation in Packed Column
6. Advanced Flow Reactor
7. pH control in a process.
8. High Performance Liquid Chromatography study of two available drugs.
9. Gas Chromatography study of two available drugs.
10. Identification and Estimation of drug molecules by using UV-Visible Spectrophotometer

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – III Sem. (Chemical Technology)
DISSERTATION PHASE – I AND PHASE – II

Teaching Scheme Lab work: 20 and 32 hrs/week for phase I and II respectively

Objectives: At the end of this course, students will be able to

1. Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
2. Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
3. Ability to present the findings of their technical solution in a written report.
4. Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and

productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

1. Relevance to social needs of society
2. Relevance to value addition to existing facilities in the institute
3. Relevance to industry need
4. Problems of national importance
5. Research and development in various domain

The student should complete the following:

1. Literature survey Problem Definition
2. Motivation for study and Objectives
3. Preliminary design / feasibility / modular approaches
4. Implementation and Verification
5. Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.

It may be based on:

1. Experimental verification / Proof of concept.
2. Design, fabrication, testing of Communication System.
3. The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.

During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be

published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.

Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – III Sem. (Chemical Technology)

COMPUTATIONAL FLUID DYNAMICS [Elective – V]

Course objectives:

- To introduce finite element and finite volume methods and governing equations for fluid flow and heat transfer.
- To show unsteady state heat conduction problems in Cartesian, cylindrical and spherical coordinate systems along with necessary boundary conditions and their solution using implicit and explicit methods
- To impart discretizing the equations using Finite difference and volume formulation and their solution using different techniques
- To explain pressure velocity coupling algorithms
- To teach Navier-Stokes equation along with boundary conditions and its applications to fluid flow problems.

Unit-1: Introduction to Computational Fluid Dynamics And Principles Of Conservation: Introduction to Computational Fluid Dynamics, CFD Applications, Numerical Vs Analytical Vs Experimental, Modeling Vs Experimentation, Fundamental Principles Of Conservation, Reynolds Transport Theorem, Conservation Of Mass, Conservation Of Linear Momentum: Navier-Stokes Equation, Conservation Of Energy, General Scalar Transport Equation, Classification Of Pdes, Steady And Unsteady Conduction, Explicit And Implicit Method, Direct And Diiterative Methods Of Solution,

Unit-2: Approximate Solutions Of Differential Equations & Solution Of Systems Of Linear Algebraic Equations: Error Minimization Principles, Functional Involving Higher Order Derivatives, Approximate Solution Of Differential Equations Through Variational Formulation, Boundary Conditions In The Variation Form: Primary And Secondary Variables, Essential And Natural Boundary Conditions, Approximate Solutions Of Differential Equations, Solution Techniques For Systems Of Linear Algebraic Equations: Elimination, Iteration And Gradient Search Method, Elimination Method: Forward Elimination And Backward Substitution, Assessment Of Number Of Computations, L-U Decomposition Technique, Tridiagonal Matrix Algorithm (TDMA), Illustrative Examples Of Jacobi's Method And Gauss-Siedel Method, Relaxation Methods, Preferential Characteristics Of Iterative Methods, Multigrid Method, Line By Line TDMA, ADI (Alternating Direction Implicit) Method, Gradient Search Methods: Steepest Descent Method And Conjugate Gradient Method

Unit-3: Fundamentals Of Discretization & Fluid Flow And Heat Transfer Modelling: Discretization Principles: Pre-Processing, Solution, Post-Processing, Finite Element Method, Finite Difference Method, Well Posed Boundary Value Problem, Possible Types Of Boundary Conditions, Conservativeness, Boundedness, Transportiveness, Finite Differences, Illustrative Examples Finite Difference Applications In Heat Transfer: 1-D Steady State Heat Conduction Without And With Constant Source Term; Advection-Diffusion Problems, Upwinding And Convective Schemes

Unit-4: Finite Volume Method For Diffusion Problems: Some Conceptual Basics And Illustrations Through 1-D Steady State Diffusion Problems: Physical Consistency, Overall Balance, FV Discretization Of A 1-D Steady State Diffusion Type Problem, Composite Material With Position Dependent Thermal Conductivity, Four Basic Rules For FV Discretization Of 2-D Steady State Diffusion Type Problem, Source Term Linearization, Implementation Of Boundary Conditions

Unit-5: Discretization Of Convection-Diffusion Equations & Navier Stokes Equations: A Finite Volume Approach: Finite Volume Discretization Of Convection-Diffusion Problem: Central Difference Scheme, Upwind Scheme, Exponential Scheme And Hybrid Scheme, Power Law Scheme, Generalized Convection-Diffusion Formulation, Finite Volume Discretization Of Two-Dimensional Convection-Diffusion Problem, The Concept Of False Diffusion, QUICK Scheme. Discretization Of The Momentum Equation: Stream Function-Vorticity Approach And Primitive Variable Approach, MAC And SIMPLE Algorithms On Staggered Grids.

Text Books:

1. Patankar, S.V., Numerical Heat Transfer, Taylor And Francis, CRC Press 1980.
2. Muralidhar, K., Sundarajan, T., Computational Fluid Flow And Heat Transfer, Narosa Publishers, 2012
3. Versteeg. H. K and Malalasekera. W. "An introduction to computational fluid dynamics – The finite volume method", Longman Group Ltd 1995
4. Ferziger. J.H, and Peric. M. "*Computational Methods for Fluid Dynamics*," Springer, 2002

Course Outcomes:

At the end of the course, student will be able to:

- Derive governing equations of fluid flow and heat transfer. (L5)
- Discretize the equations using Finite difference and volume formulation (L6)
- Solve the discretized equations using different techniques (L6)
- Apply pressure velocity coupling algorithms (L3)
- Simplify Navier-Stokes equation to a given flow problem along with boundary conditions.(L4)
- Explain grid generation techniques (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – III Sem. (Chemical Technology)

PETROLEUM REFINERY ENGINEERING [Elective – V]

Teaching Scheme: Lecture: 3 hrs/week

Course objectives:

- The course provides engineering and technical basic information necessary to chemical engineers whose work is related to petroleum processing and the petrochemical industry.
- To familiarize students with the application of chemical engineering principles to petroleum refining.
- To introduce them to petroleum products formulation, testing and specifications.
- Formation of capability to apply knowledge in theoretical basics of petroleum refining processes for professional activity and education work.

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. Alternative 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. Rao, B.K.B. “Modern Petroleum Refining Processes”, 4 Edition, Oxford and IBH Publishing, 2002.

2. Nelson, W.L. 'Petroleum Refinery engineering", McGraw Hill, New York 1969.
3. Ilengstebeck RJ., "Petroleum Refining", McGraw Hill, New York 1959.
4. Steiner H, "Introduction to petroleum Chemical Industry", Pergamum, London, 1961.
5. Goldstine. R.F. "The Petroleum Chemicals Industry", Taylor and Francis, London, 1967.

Course Outcomes:

After completion of the course students should be able to

- An overview of the modern, integrated petroleum refinery, its feed stocks, product slate and the processes employed to convert crude oil and intermediate streams into finished products. (L2)
- Demonstrate how a petroleum refinery works and sketch a flow diagram that integrates all refining processes and Mechanism involved during thermal cracking reaction the resulting refinery products. (L2)
- Examine how each refinery process works and how physical and chemical principles are applied to achieve the objectives of each refinery process. (L4)
- Assess implications of changing crude oil feedstock's on refinery configuration and propose strategies to resolve conflicts with degrading crude oil quality and increasingly stringent environmental regulations on petroleum fuels. (L4)
- Know fundamentals of petroleum refining, types of energy resources, fundamentals of crude oil treatment and natural gas processing, fundamentals and purposes of re-refining processes and properties of main oil products. (L2)

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

APPLICATION OF NANOTECHNOLOGY IN CHEMICAL ENGINEERING [Elective-V]

Teaching Scheme: Lecture: 3 hrs/week

Course objectives:

1. To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
2. To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
3. To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

UNIT-I: Introduction: Introduction to nanotechnology, Feynman's Vision-There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

UNIT-II: Approaches to Synthesis of Nanoscale Materials and characterization: Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis usingX-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

UNIT-III: Semiconductors and Quantum dots: Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

UNIT-IV: Polymer-based and Polymer-filled Nanocomposites: Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

UNIT-V: Applications to Safety, Environment and Others: Chemical and Biosensors-Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.

References

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., “Introduction to Nanoscience”, (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805
2. Ajayan P. M., Schadler L. S., Braun P. V., “Nanocomposite Science and Technology”, Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.
3. Kelsall Robert W., Hamley Ian W., GeogheganMark, “Nanoscale Science and Technology”,John Wiley & Sons, Ltd, 2006.
4. Kal Ranganathan Sharma, “Nanostructuring Operations in Nanoscale Science and Engineering”, McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.
5. “Organic and inorganic nanostructures”.-(Artech House MEMS series), Nabok, Alexei, ISBN 1- 58053-818-5, 2005.

Course Outcomes: After completion of the course students will be able to:

- Understanding the different top down and bottom up approaches for nanoparticles(L2)
- Get to know the different applications of nanoparticles in chemical engineering field. (L2)

- Learning the characterization techniques for nanoparticles. (L2)

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

INDUSTRIAL SAFETY AND HAZARD ANALYSIS [Elective-VI]

Course objectives:

- To create awareness of different hazards in process industries and need for process safety
- To educate on of hazards classifications and fire explosions in process industries
- To create awareness on chemical storage and handling and prepare data sheets for safety
- To educate on process safety plan to prepare Hazard and Operability analysis
- To create awareness on Selection of relief valves, rupture disks flame arresters and flare systems in process industries

Unit – I

Introduction, Factors Contributing to the Costs of Accidents, List of some Notable accidents in the process industry/selected case histories, some common features of high cost accidents, reasons for high priority towards safety.

Unit – II

Material hazards1: Introduction Hazardous substances-categories, Toxicity, Radiation, Flammability, Ignition, Fires and explosions.

Unit – III

Material hazards 2: Fire balls, Fire damage, run away chemical reaction, incompatible materials, material safety and data sheets

Process and plant Hazards: Hazards of pressure, causes of over pressures, flow deviations, effects of leakages/releases, hazards of temperatures.

Unit – IV

Hazard analysis: process safety management, process hazards analysis, hazards analysis methods, check list, preliminary hazard analysis, what-if / check list, hazard and operability analysis, FMEA, Fault tree analysis, cause and consequence analysis.

Unit – V

Preventive and protective measures: Safety options, process safety approaches, inherent safety and design, plant layout, inherent security, explosion prevention and protection, personal protective systems, plant modifications and management change, relief valves and rupture discs, breather vents for storage tanks, explosions vents, flame arresters, flare systems

TEXT BOOK:

1. Chemical process industry safety by K S N Raju, Mc-Graw Hill education (India) Pvt.Ltd,2014
2. Chemical process Safety by Crowl, Pearson Prentice Hall; 3 edition (20 May 2011)
3. Chemical process safety by Sanders, 4th Edition, Butterworth-Heinemann, 2015.

Course outcomes:

After completion of the course, the student will be able to:

- Explain different hazards in process industries and the need for process safety (L2)
- Classify different types of hazards and fire explosions in process industries (L2)
- Develop data sheets for safety and procedures for chemical storage. (L6)
- Formulate Hazard and Operability analysis (HAZOP) and HAZAN (Hazard analysis procedures)(L6)
- Select suitable relief valves, rupture disks, flame arresters and flare systems for process industries (L3)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – III Sem. (Chemical Technology)

FUEL CELL TECHNOLOGY [Elective-VI]

Teaching scheme Lecture: - 3 h/week

Course objectives:

- Students gain knowledge on fuel cell principles, kinetics, in-situ and ex-situ characterization, fuel cell power plant and applications.

UNIT I

Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT II

Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

UNIT III

Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modelling and system integration: - 1D model – analytical solution and CFD models.

UNIT IV

Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

UNIT V

Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications

REFERENCES

1. O'Hayre, R.P.,S. Cha,W. Colella, F.B.Prinz, Fuel Cell Fundamentals,Wiley, NY (2006).
2. Bard,A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y.(2004) Ref Book.
3. Basu,S.(Ed) Fuel Cell Science and Technology, Springer, N.Y.(2007).
4. Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006).
5. Fuel cell technology handbook, edited by Gregor Hoogers, CRC Press 2003.

Course outcomes:

At the end of the course, student will be able to:

- Identify the challenges in hydrogen production and its storage. (L3)
- Classify fuel cell types and their applications (L2)

- Demonstrate the working principle of fuel cells. (L2)
- Select suitable materials for electrode and membrane for fuel cells. (L5)
- Calculate the theoretical fuel cell efficiency. (L5)
- Demonstrate the operation of a PEM and a solid oxide fuel cell, identifying all the components associated with it. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – III Sem. (Chemical Technology)
CORROSION ENGINEERING [Elective-VI]

Course objectives:
- To impart basic concepts of corrosion
- To teach the types of corrosion and their control techniques

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.

REFERENCE BOOKS:
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

Course outcomes:
At the end of the course, student will be able to:

- Understand the types of corrosion(L2)
- Analyze corrosion in specific environments(L4)
- Know different corrosion control methods. (L2)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

Audit 1 and 2: English For Research Paper Writing

Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

	Syllabus	
Units	**CONTENTS**	**Hours**
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4
4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5	skills are needed when writing the Methods, skills needed when writing the 4 Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	**4**
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	**4**

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
4. Adrian Wall work , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

AUDIT 1 and 2: Disaster Management

Course Objectives:-Students will be able to:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in Specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Units	Syllabus	Hours
1	Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4
3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4
4	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	4
5	**Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival	4
6	**Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster	4

	Mitigation In India.	

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

Audit 1 and 2: Sanskrit For Technical Knowledge

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Syllabus

unit	content	Hours
1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	**8**
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	**8**
3	• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	**8**

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood

3. Being a logical language will help to develop logic in students

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

AUDIT 1 and 2: Value Education

Course Objectives

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Syllabus

Unit	Content	Hours
1	• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles. • Value judgments	**4**
2	• Importance of cultivation of values. • Sense of duty, Devotion, Self- reliance, Confidence, Concentration.Truthfulness, Cleanliness. • Honesty, Humanity.Power of faith, National Unity. • Patriotism. Love for nature ,Discipline	**6**
3	• Personality and Behaviour Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labor. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. • Doing best for saving nature	**6**
4	• Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Non violence, Humility, Role of Women. • Mind your Mind, Self-control. • Honesty, Studying effectively	**6**

Suggested reading

1 Chakroborty , S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press ,New Delhi

Course outcomes

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

Audit 1 And 2: Constitution Of India

Course Objectives:

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

	Syllabus	
Units	**Content**	**Hours**
1	**History of Making of the Indian Constitution:** History Drafting Committee, (Composition & Working)	4
2	**Philosophy of the Indian Constitution:** Preamble Salient Features	4
3	**Contours of Constitutional Rights & Duties:** • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation • Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties.	4
4	**Organs of Governance** • Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	4

5	**Local Administration:** • District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, Municipal Corporation. • Pachayati raj: Introduction, PRI: Zila Pachayat. • Elected officials and their roles, CEO Zila Pachayat: Position and role. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • Importance of grass root democracy	4
6	**Election Commission:** • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women.	4

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

Audit 1 and 2: Pedagogy Studies

Course Objectives:

Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

	Syllabus	
Units	**Content**	**Hours**

1	• **Introduction and Methodology:** • Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions**.** • Overview of methodology and Searching.	4
2	**Thematic overview:** Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	2
3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? • Theory of change • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	4
	Professional development: alignment with classroom practices follow-up support • Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	4
	Research gaps and future directions • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact.	2

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):
245-261.
2. Agrawal M (2004) curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education
research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of
basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.

5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education.
Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:
Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year (Chemical Technology)
Audit 1 and 2: Stress Management by Yoga

Course Objectives
1. To achieve overall health of body and mind
2. To overcome stress

Suggested reading
1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes:
Students will be able to:
1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Unit	Content	*Hours*
1	• Definitions of Eight parts of yog. (Ashtanga	8
2	• Yam and Niyam. Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8
3	Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types pranayam	8

Suggested reading
1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year (Chemical Technology)

Audit 1 and 2: Personality Development through Life Enlightenment Skills

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Syllabus

Unit	content	Hours
1	Neetisatakam-Holistic development of personality • Verses- 19,20,21,22(wisdom) • Verses- 29,31,32 (pride & heroism) • Verses- 26,28,63,65(virtue) • Verses- 52,53,59 (dont's) • Verses- 71,73,75,78(do's)	8
2	• Approach to day to day work and duties. • Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48, Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,Chapter 18-Verses 45, 46, 48.	8
3	• Statements of basic knowledge. • Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42 • Chapter 4-Verses 18, 38,39 • Chapter18 – Verses 37,38,63	8

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata

2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad- Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.