JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

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Course Structure and Syllabi for Pre Ph.D

CHEMICAL ENGINEERING (2009-10)

PART – I

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	**Mathematical Methods in Chemical Engineering**	**09PH08101**
2	**Advanced Reaction Engineering & Reactor Design**	**09PH08102**
3	**Process Modeling, Simulation and Optimization**	**09PH08103**
4	**Advanced Transport Phenomena**	**09PH08104**
5	**Industrial Pollution and Control in Process Industries**	**09PH08105**

PART -II

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	**Advanced Biochemical Engineering**	**09PH08201**
2	**Enzyme and Microbial Technology**	**09PH08202**
3	**Advanced Heat Transfer**	**09PH08203**
4	**Advanced Mass Transfer**	**09PH08204**
5	**Rheology of Engineering Fluids**	**09PH08205**
6	**Energy Management**	**09PH08206**
7	**Membrane Technology**	**09PH08207**
8	**Computational Fluid Dynamics**	**09PH08208**
9	**Instrumental Methods of Analysis**	**09PH08209**
10	**Fluidization Engineering**	**09PH08210**
11	**Nanotechnology**	**09PH08211**
12	**Colloidal and Interfacial Science**	**09PH08212**
13	**Advanced Process Control**	**09PH08213**
14	**Advanced Chemical Engineering Thermodynamics**	**09PH08214**
15	**Safety and Risk analysis in Process Industries**	**09PH08215**

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08101) METHEMATICAL METHODS IN CHEMICAL ENGINEERRING

1. Modeling and study of systems in Chemical Engineering leading to systems algebraic, of ordinary differential and partial equations (both linear and non-linear systems). Methods of solution of systems of linear & non linear algebraic equations: Gauss elimination, LU decomposition, single variable Newton raphson, multi variable Newton raphson.
2. Linear homogeneous ordinary differential equations and linear non-homogeneous ordinary differential equations observed in systems of interest to chemical engineers by Ranga-kutta methods.
3. Methods of solution of linear and non-linear finite difference equations, solution of differential – difference equations.
4. Numerical solution to partial differential equations by relaxation method, finite – difference method, introduction to finite element method and application to problems of interest in chemical engineering.
5. Basic statistical concepts: Probability distributions, sampling and sampling distributions; Inferences about the differences in Means.
6. Randomized Designs: Hypothesis Testing – t-test, use of P-values; Confidence intervals, Inferences about the difference in means, paired comparison designs, inferences about the variances of normal distributions F-test
7. Analysis of variance: one-way and two way Analysis. Analysis of fixed effects model – Decomposition of the total sum of squares, statistical analysis. Factorial Experiments: Definitions, Interpretation of main effects and interactions, design with factors at two levels – Calculation of effects and Analysis of variance – Model adequacy testing, Estimating model parameters Analysis of 2^K factional design in detail.
8. Regression Models: Linear Regression Models, Estimation of parameters, Multiple regression, Hypothesis Testing in multiple regression, confidence intervals in multiple

regression. Response Surface Methodology: Introduction, Method of Steepest Ascent, Analysis of a second order response

References:

1. **Mathematical Methods in Chemical engineering by** Jenson and Jeffereys, Academic press, 1963.
2. **Design and Analysis of Experiments**, 5th edition, Douglas C. Montgomery, John Wiley and Sons, 2004.
3. **Mathematical Methods in Chemical Engineering by** S. Pushpavanam, Prentice Hall of India, New Delhi.
4. **Probability and Statistics in Engineering and Management by** W.L. Hines and D.C. Montgomery, John Wiley and Sons, 1980.
5. **Design and Analysis of Industrial Experiments**, 2nd Edition, Ed. Oven L. Davies Longman group, 1978.

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Pre-Ph.D CHEMICAL ENGINEERING

Chemical Engineering

(09PH08102) ADVANCED REACTION ENGINEERING & REACTOR DESIGN

1. Non-Ideal flow: Two- parameter models- Modeling real reactors with combination of ideal reactors, testing a model and determining its parameters.
2. Mixing of fluids: Zero parameter models, segregation model, and maximum mixed ness.
3. Fluid-Particle reactions: Application of design- Various types of contacting in gas- solid operations; Development of performance equation for frequently met contacting pattern assuming uniform gas composition, application to a fluidized bed with entrainment of solid fines.
4. Fluid-Fluid Reactions: Applications to design- Towers for fast reaction; Towers for slow reaction, Mixer- settlers (Mixed flow of both phases), semi- batch contacting patterns, Reactive distillation and extractive reactions.
5. Catalysis and catalytic reactors: Design of reactors for gas- solid reactions. Heterogeneous data analysis for reactor design, catalytic deactivation moving bed reactors, fluidized bed reactors.
6. External diffusion effects on heterogeneous reactions- External resistance to mass transfer.
7. Diffusion and reaction in porous catalysts- Diffusion and reaction in spherical Catalyst pellets, internal effectiveness factor, Falsified kinetics, Overall effectiveness factor, Estimation of diffusion and reaction limited regions, Mass transfer and reaction in a packed bed.
8. Non- isothermal reactor design- energy balance, non- isothermal continuous Flow, reactors at steady state, equilibrium conversion; multiple steady states-heat removed term, heat of generation, ignition- extinction curve.

References:

1. **Elements of Chemical Reaction Engineering**, 2nd Edition, Fogler, H.S, Prentice Hall, New Jersey, 1992.
2. **Chemical Reaction Engineering**, 3rd Edition, Octave Levenspiel, Wiley Eastern University, New Delhi, 1998.
3. **Chemical Engineering Kinetics**, 3rd Edition, Smith J.M, McGraw Hill, 1981.
4. **Chemical Reaction Engineering and Reactor Technology**, T.O. Salmi, J.P. Mikkola, J.P. Warna, CRC Press, 2010.
5. **The Engineering of Chemical Reactions**, 2nd edition, L. D. Schmidt, Oxford University Press, USA, 2004.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08103) PROCESS MODELLING, SIMULATION AND OPTIMIZATION

1. Mathematical models for chemical engineering systems: Principles of Modeling, fundamentals, introduction to fundamental laws: Total Continuity Equation, Equation of Energy, Equation of Motion, Transport laws.
2. Classification of mathematical modeling, static and dynamic models, the complete mathematical model, Boundary conditions, the black box principle. Artificial Neural Networks: Network training, Models of training, Network architecture, Back-propagation algorithm, ANN applications.
3. Models for chemical reaction with diffusion in a tubular reactor, chemical reaction with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction.
4. Models in Heat Transfer Operations: Steady state heat conduction through a hollow cylindrical pipe, unsteady state steam heating of a liquid, heat transfer in a thermometer system, unsteady state heat transfer by conduction.
5. Introduction Process Plant Simulation, various Approaches to Plant Simulation, Steady State Sequential Modular Simulation Techniques. Equation Oriented Simulation Techniques, Simultaneous Modular Simulation Techniques.
6. 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.
7. Unconstrained multivariable optimization- direct search methods Golden section search method, Gradient-based methods: Newton-Raphson method, Multivariable Optimization Algorithms: simplex search method, Constrained Optimization Algorithms: Kuhn-Tucker conditions.
8. 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, other GA operators, Real-coded GAs, Advanced GAs.

References:

1. **Simulation and Control for Chemical Engineers**, **Process Modeling Luyben** by William, McGraw Hill, New York, 1990.
2. **Process Plant Simulation by** B.V.Babu, Oxford University.
3. **Optimization for Engineering Design by** Kalyanmoy Deb, Prentice Hall of India.
4. **Optimization of Chemical Processes by** T.F.Edgar and D.M.Himmelblau, Mc Graw Hill, International editions, chemical engineering series, 1989.
5. **Process Flow sheeting, Westerberg by** A.W., Hutchison, H.P., Motard, R.L. and Winter, Cambridge University Press, Cambridge, 1979.
6. **Numerical methods in engineering by** S.K. Gupta, Tata McGraw Hill.
7. **Mathematical Methods** by S. Pushpavanam, Prentice hall
8. **Modeling, Design and Simulation by** Process Control B. Wayne Bequette, Prentice Hall, 2003.

Discuss

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08104) ADVANCED TRANSPORT PHENOMENA

1. Basic concept and review of classical flow problems using shell balances. Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems, frame of reference (Eularian and Lagrangian).
2. Application of equation of change: Equation of change for isothermal systems – solution of steady state laminar flow problems – including the Newtonian and non- Newtonian Fluids.
3. Equation of Change for non-isothermal system – Solution of steady state problems – Conduction, convection, problems with and without heat generation, limiting Nusselt Numbers for flow through pipes and slits..
4. Equation of change for multi-components – Summary of multi-component fluxes, use of equations of change for mixtures, Stefan-Maxwell equation s, Solution of problem using stream functions.
5. Unsteady State Problems: Unsteady state flow between two parallel plates, oscillating plates, unsteady state flow through a pipe heating of finite slab, cooling of a sphere in contact with well stirred fluid, unsteady state evaporation in a tube of infinite length, gas absorption with rapid chemical reaction.
6. Boundary layer studies**:** Flow near a wall suddenly set in motion, Flow near the leading edge of a plate, heat transfer in laminar forced convection along a heated plate, diffusion and chemical reaction in isothermal laminar flow along a soluble plate, steady state boundary layer theory for flow around objects.

7. Turbulent flow: Time smoothed equations of change for incompressible fluids. Application of empirical expressions to solve turbulent flow problems.
8. Macroscopic balances to set up unsteady state problems: efflux time for flow from vessels of different t genetics – Heating of a liquid in an agitated tank – Disposal of an unsteady waste product – unsteady state operations of packed column.

Note

- Equations of change should be provided during the examinations or paper setter may give the appropriate equations.

References:

1. **An introduction to Fluid Dynamics by** G.K. Batchelor, Cambridge University Press, Cambridge, 1967.
2. **Momentum Energy and Mass Transfer in Continua by** J.C. Salterry, Robert E. Kridger publishing company, New York, 1981.
3. **Fundamentals of Momentum, Heat And Mass Transfer** by James R. Welty, Chrles E. Wicks and Robert E. Wilson, John Wiley & sons, Inc New York.
4. **Transport Phenomena by** R. B. Bird, W. E. Stewart and E. N. Light foot, Wiley international Edition, New York, 2002.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08105) Industrial Pollution and control in Process Industries

1. Environment pollution and social issues of environment: Pollution & its types (Air, water, land, noise, thermal) causes effects and control of these pollutions (case studies), role of man in prevention of pol lution.
2. Introduction to EIA: Introduction to EIA, rapid EIA, comprehensive EIA and case studies to process industries.
3. Design of waste water and industrial effluent treatment: Aerobic and anaerobic biological treatment processes. Design of activated sludge process.
4. Advanced waste water treatment: R. O., Activated carbon, ultra filtration, ion exchange, UV-radiation for disinfection.
5. Air: Pollution and Management: Air pollution control methodologies, particulate emission control techniques like bag filter, electro static precipitator etc., air pollution control equipment, characteristics of air pollutants.
6. Pollution prevention: Pollution prevention and waste minimization; sustainable development; life cycle assessment, noise pollution control measures.
7. Environmental Management: Environmental management system particularly ISO 14000 series. Successful case studies
8. Hazardous waste management: Solid waste disposal: Treatment, storage and disposal of hazardous waste, medical and pharmaceutical solid waste management.

References:

1. **Pollution Control in Process Industries by** S.P. Mahajan, TMH, 1985.
2. **Waste Water Engineering Treatment & Reuse by** 4th Edition, Metcalf & Eddy, TMH, 2003
3. **Waste Water Treatment by** M.Narayana Rao and A.K.Datta, Oxford and IHB publications, New Delhi.
4. **Air Pollution Control by** P.Prathap Mouli and N.Venkata Subbayya, Divya Jyothi Prakashan, Jodhpur.
5. **Environmental Pollution and Control Engineering by** Rao C. S., Wiley Eastern Limited, India, 1993.
6. **Air Pollution Control Hand Book by** Schnell & Brown, CRC Press.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08201) ADVANCED BIOCHEMICAL ENGINEERING

1. Microbial kinetics: unstructured batch growth models, growth of filamentous organisms; structured kinetic models, compartmental models, modeling cell growth as an optimum process, Thermal death kinetics of cells and spores.
2. Enzyme Kinetics: enzyme deactivation, mechanisms and manifestations of protein denaturation, strategies for enzyme stabilization; Case study of commercial enzyme process.
3. Reactor dynamics, dynamic models, stability; Reactors with non ideal mixing, mixing times in agitation tanks, residence time distributions, models for non-ideal reactors; immobilized biocatalysts, formulation and characterization of immobilized cell biocatalysts, applications of immobilized cell biocatalysts; packed bed reactors, bubble column bio reactors, fluidized bed bio reactors.
4. Aeration and agitation in bioprocesses - mass transfer in cellular systems, bubble aeration, swarm of bubbles, aeration by mechanical means, power requirement in aeration, oxygen transfer coefficient and operating variables, bubble aeration and mechanical agitation.
5. Scale Up Operation: physical concept, biological concept, power to unit volume, volumetric oxygen transfer coefficient, and dynamic method.
6. Bioreactors Instrumentation and Control: measurements during fermentation, overview of control of fermentation, sensors for monitoring reactor environment, both physical and chemical, foaming and methods of control, computer controlled bioreactors.
7. Molecular genetics - The process of gene expression, DNA replication and mutation, overview of information flow in the cell, Recombinant DNA technology, Enzymes for manipulating DNA.
8. Case studies in microbial processes – Citric Acid, Penicillin G, Vitamins and Single Cell Protein.

References:

1. **Biochemical Engineering by** Aiba, S., Humphrey, A.E, Academic Press, 1973.
2. **Industrial Microbiology by** Precott, S.C., Dunn, C.G., McGraw-Hill, New York, 1960 & 1983 Eds.
3. **Fundamentals of Biochemical Engineering by** AVN Swamy, B.S.Publications, Hyderabad, 2007.
4. **Biochemical Engineering Fundamentals by** 2nd Ed, Bailey, J.E. and Ollis, D.F., McGraw Hill, New York, 1986.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08202) ENZYME AND MICROBIAL TECHNOLOGY

1. Isolation, development and preservation of industrial microorganisms; substrates for industrial microbial processes.
2. Regulatory mechanisms of metabolic pathways in industrial strains.
3. Analysis of various microbial processes used in production of biomass, primary and secondary metabolites.
4. Microbial leaching of minerals; microorganisms in degradation of xenobiotics and removal of heavy metals; biotransformation.
5. Enzymes as industrial biocatalysts.
6. Production; isolation; purification and application of industrial enzymes; immobilized enzymes.
7. Stabilization of enzymes.
8. Enzyme catalyzed organic synthesis; multi enzyme systems.

References:

1. **A Practical Introduction to Structure, Mechanism, and Data Analysis by** Enzymes:2nd edition, Robert A. Copeland, Wiley-VCH, 2000.
2. **Enzyme Kinetics and Mechanism by** Paul F. Cook, W.W. Cleland, Garland Science, 2007.
3. **Molecular Biology and Biotechnology by** 4th edition, J.M. Walker, R.Rapley, Royal Society of Chemistry; 2001.
4. **Bio Chemical Engineering Fundamentals by** 2nd Edition, Bailey J.E., Ollis, D.F., McGraw Hill International Edition, New York, 1986.
5. **Bioprocess Engineering Basic Concepts by** M.L.Shuler and F. Kargi, Prentice Hall of India, 2002.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08203) ADVANCED HEAT TRANSFER

1. Heat conduction concepts, Thermal resistance, and the overall heat transfer coefficient: The heat diffusion equation, solutions of the heat diffusion equation, Thermal resistance and the electrical analogy, overall heat transfer coefficient.
2. Heat exchanger design: Function and configuration of heat exchangers, evaluation of the mean temperature difference in a heat exchanger, heat exchanger effective ness, and heat exchanger design
3. Analysis of heat conduction and some steady one- dimensional Problems: The well-posed problem, the general solution, dimension analysis, an illustration of dimensional analysis in a complex steady conduction problem, Fin design
4. Transient and heat conduction: Introduction, lumped- capacity solutions, Transient conduction in a one dimensional slab, temperature response charts, one term solutions, transient heat conduction to a semi infinite region
5. Multidimensional heat conduction problems: Steady multidimensional heat conduction, Transient multidimensional heat conduction
6. Convective heat transfer in laminar boundary layers: Some introductory ideas, laminar incompressible boundary layer on a flat surface, the energy equation, the Prandtl number and the boundary layer thicknesses, heat transfer coefficient for laminar, incompressible flow over a flats surface, the Reynolds analogy
7. Natural convection in single phase fluids and during film condensation Scope, the nature of the problems of film condensation and of natural convention, laminar natural convection on a vertical isothermal surface, natural convection in other situations, film condensation

8. Heat transfer in boiling: Nukiyama's experiment and the pool boiling curve, nucleate boiling, peck pool boiling heat flux, film boiling, minimum heat flux, transition boiling and system influences.

References:

1. **Fundamentals of Momentum, Heat And Mass Transfer by** 4th edition, J.R. Witty, R .W .Wilson, John Wiley, New York.
2. **A Heat Transfer Text Book by** 3rd edition, John H. Lienhard IV, John Lienhard V.
3. **Heat Transfer by** 9th edition, J. Holman, McGraw-Hill Science, 2001.
4. **Heat Transfer by** G. Nellis, S. Klein, Cambridge University Press, 2008.
5. **Process Heat Transfer: Principles and Applications by** R.W. Serth, Academic Press, 2007.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08204) ADVANCED MASS TRANSFER

1. Characteristics of separation processes, inherent separation factors for equilibrium processes and rate- Governed processes. Selection of separation processes- Factors influencing the choice of a separation process, case studies
2. Capacity and efficiency of contacting devices. Energy requirements of separation processes.
3. Diffusion-Fick's law, Generalized Fick's Law. Solutions of multi component diffusion problems- Linearized theory, Application of Linearized theory, Effective diffusivity method and its application
4. Maxwell-Stefan Relations. Maxwell-Stefan Equation for binary mixtures and multi component mixture, Matrix formulation of Maxwell-Stefan Equation, Applications of Maxwell-Stefan law.
5. Patterns of change and computational approaches- Binary multistage separations, Multi component multistage separations
6. Multi component distillation – Mass Transfer models, Binary distillation in tray columns, Multi component distillation tray column, Distillation in Packed column Multi component distillation – Non equilibrium models, solving the model equations, Design studies on depropanizer and extractive distillation
7. Adsorption, Ion Exchange and Chromatography: Adsorbents, Equilibrium considerations, pure gas adsorption, liquid adsorption, ion exchange equilibria, equilibria in chromatography, kinetic and transport considerations, external & internal transport, mass transfer in ion exchange and chromatography.
8. Introduction to membrane separation processes, cryogenic distillation, super critical extraction, reactive separation.

References:

1. **Separation Process by** J. Sieder and Henly, Wiley Publishers, 1998
2. **Chemical Engineering Handbook by** Perry, McGraw Hill.
3. **Unit Operations In Chemical Engineering by** 6th edition, McCabe,Smith, McGrawHill.
4. **Membrane Technology in The Chemical Industry by** S.P.Nures and K.V. Peinenon, Wiley-vett.
5. **Mass Transfer Operations by** Treybal, McGraw Hill publishers.
6. **Distillation by** Gilliland.
7. **Transport Processes and Unit operations by** 3rd Edition, G.J. Genkopolis, Prentice hall, NJ, 1993
8. **Equilibrium Staged Separations by** P.H. Wanket, Elsevier, 1988
9. **Separation Process by** C. Judson King, McGraw Hill, 1982.
10. **Multicomponent Mass Transfer by** R.Krishna and Ross Taylor, John Wiley & Sons, 1993.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08205) RHEOLOGY OF ENGINEERING FLUIDS

1. Introduction to rheology, viscosity: rheometry, constitutive equations, variation with shear rate, temperature, pressure. The shear-dependent viscosity of non Newtonian liquids: definition on Newtonian behaviour, the shear thinning non Newtonian liquid, the shear-thickening non Newtonian liquid.
2. Viscometers for measuring shear viscosity: general considerations, industrial shop floor instruments, rotational instruments, general comments, and the narrow gap concentric cylinder viscometer.
3. Linear viscoelasticity: introduction, the meaning and consequences of linearity, the Kelvin and Maxwell models, the relaxation spectrum, oscillatory shear, relationships between functions of linear viscoelasticity, methods of measurement: static methods, dynamic methods-oscillatory strain, steady flow.
4. Normal stresses: the nature and origin of normal stresses, typical behavior consequences of N_1 and N_2, observable consequences of N_1 and N_2, methods of measuring N_1 and N_2-cone and plate flow, relationship between viscometric functions and linear viscoelastic functions.
5. Extensional viscosity: introduction, importance of extensional of flow, theoretical considerations, experimental methods: general considerations, homogeneous stretching method, constant stress devices, some demonstrations of high extensional viscosity behavior.
6. Rheology of polymeric liquids: introduction, general behaviour, effect of temperature on polymer rheology, effect of molecular weight on polymer rheology, effect of concentration on the rheology of polymer solutions, empirical relations between

rheological functions. Practical applications: polymer processing, polymers in engine lubricants, enhanced oil recovery, polymers as thickners of water-based products.

7. Rheology of suspensions: introduction-the the general form of the viscosity curve for suspensions, summary of the forces acting on particles suspended in liquid, rest structures, flow induced structures. The viscosity of suspensions of solid particles in Newtonian liquids: dilute dispersed suspensions, maximum packing fraction, concentrated Newtonian suspensions, concentrated shear thinning suspensions, practical consequences of the effect of phase volume, shear thickening of concentrated suspensions.
8. Theoretical rheology: introduction, basic principles of continuum mechanics, successful applications of the formulation principles, some general constitutive equations.

References:

1. **Understanding Rheology by** F.A. Morrison, Oxford University Press, USA, 2001.
2. **The Rheology Handbook by** 2nd Revised edn, T.G. Mezger, Vincentz, 2006.
3. **Engineering Rheology by** 2nd edition, R.I. Tanner, Oxford University Press, USA, 2000.
4. **An Introduction to Rheology by** H.A.Barnes, JF Hutton, K.Walters F. R.S, Elseveir, Amsterdam, 1989.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08206) ENERGY MANAGEMENT

1. Energy scenario: Introduction, Primary and Secondary Energy, Commercial Energy and Non commercial Energy, Renewable and Non Renewable Energy, Global Primary Energy Reserves, Indian Energy Scenario, Energy Needs of Growing Economy, Long Term Energy Scenario for India, Energy Pricing in India, Energy Sector Reforms, Energy and Environment, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, The Energy Conservation Act, 2001 and its Features
2. Basics of energy and its various forms: Definition, Various Forms of Energy. Electrical Energy Basics, Thermal Energy Basics, Units and Conversions
3. Detailed review of various forms of energy and their significance in present scenario: Solar energy, Wind energy, Nuclear energy, biofuels etc.,
4. Energy management and audit: Definition & Objectives of Energy Management, Energy Audit: Types and Methodology, Energy Audit Reporting Format, Understanding Energy Costs, Benchmarking and Energy Performance, Matching Energy Usage to Requirement, Maximizing System Efficiency, Fuel and Energy Substitution, Energy Audit Instruments
5. Material and energy balance: Basic Principles, The Sankey Diagram and its Use, Material Balances, Energy Balances, Method for Preparing Process Flow Chart, Facility as an Energy System, How to Carryout Material and Energy (M & E) Balance.
6. Energy action planning: Introduction, Energy Management System

7. Financial management: Introduction, Investment Need, Appraisal and Criteria, Financial Analysis, Financial Analysis Techniques, Sensitivity and Risk Analysis, Financing Options. Project management: Introduction, Steps in Project Management.
8. Energy monitoring and targeting: Definition, Elements of Monitoring & Targeting System, A Rationale for Monitoring, Targeting and Reporting, Data and Information Analysis, Relating Energy Consumption and Production, CUSUM, Case Study

References:

1. **Encyclopedia of Energy by** McGraw Hill Publication.
2. **Handbook of Energy Engineering by** Albert Thumann, the Fairmont Press Inc.
3. **Energy Handbook by** Robert L. Loftness, Von Nostrand Reinhold Company.
4. **BP Statistical Review of World Energy**.
5. **The Energy and Resources Institute** (TERI).
6. **Energy Dictionary by** V Daniel Hunt, Van Nostrand Reinhold Company, New York.
7. **Energy Management Handbook by** Wayne C. Turner, John Wiley and Sons.
8. **Guide to Energy Management by** Cape Hart, Turner and Kennedy.
9. **General Aspects of Energy Management and Energy audit** by Beuro of Energy studies.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08207) MEMBRANE TECHNOLOGY

1. Introduction: Separation processes, introduction to membrane processes, history, definition of a membrane, membrane processes.
2. Materials and Material Properties: Introduction, polymers, stereoisomerism, chain flexibility, molecular weight, chain interactions, state of the polymer, effect of polymeric structure on Tg, glass transition temperature depression,
3. Preparation of Synthetic Membranes: Introduction, preparation of synthetic membranes, phase inversion membranes, preparation technique for immersion precipitation, preparation technique for composite membranes,
4. Characterization of Membranes: Introduction, membrane characterization, characterization of porous membranes, characterization of ionic membranes, characterization of non porous membranes.
5. Transport in Membranes: Introduction, driving forces, non equilibrium thermodynamics, transport through porous, non porous, and ion exchange membranes.
6. Membrane Processes: Introduction, osmosis, Pressure driven membrane processes, concentration driven membrane electrically driven processes, membrane reactors.
7. Polarization phenomenon and fouling: introduction, concentration polarization, turbulence promoters, pressure drop, gel layer model, osmotic pressure model, boundary layer resistance model, concentration polarization in diffusive membrane separations and electro dialysis, membrane fouling, methods to reduce fouling, compaction.
8. Module and process design: Introduction, plate and frame model, spiral wound module, tubular module, capillary module, hollow fiber model, comparison of module configurations.

References:

1. **Membrane Technology in the Chemical Industry by** S. P. Nunes, and K. V. Peinemann, Wiley-VCH.
2. **Membrane Process by** R. Rautanbach and R. Albrecht, John Wiley & Sons.
3. **Perevoparation Membrane Separation Processes by** R.Y.M. Huang, Elsevier.
4. **Membrane Processes in Separation and Purification** by J.G. Crespo, K.W. Boddekes.
5. **Membrane Separations by** M.H.V. Mulder, Kluwer Publictions.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08208) COMPUTATIONAL FLUID DYNAMICS

1. Introduction – Finite difference methods – finite element method – finite volume method – Treatment of boundary conditions – Governing differential equations.
2. Finite difference methods – Taylor's series – Errors associated with FDE – FDE formulation for steady state heat transfer problems – Cartesian, cylindrical and spherical co-ordinate systems – boundary conditions – Un steady state heat conduction – Explicit Method – Stability criteria – Implicit Method – Crank Nickolson method – 2-D FDE formulation – ADI – ADE.
3. Finite volume method - Generalized differential equation, Basic rules for control volume approach, Source term linearization, boundary conditions. Un-steady state one, two, three dimensional heat conduction.
4. convection and diffusion, different methods i.e., upwind scheme, Exponential scheme, Hybrid scheme, power law scheme, calculation of flow field, staggered grid method, pressure and velocity corrections, SIMPLE Algorithms & SIMPLER (revised algorithm).
5. Solution methods of elliptical, parabolic and hyperbolic partial differential equations in fluid mechanics – Burgers equation.
6. Formulations for incompressible viscous flows – vortex methods – pressure correction methods.
7. Treatment of compressible flows – potential equation, Navier – Stokes equation – flow field dependent variation methods, boundary conditions.
8. Linear fluid flow problems, 2-D and 3- D fluid flow problems.

References:

1. **Computational Techniques Fluid Dynamics by** Vol 1 and 2, CAJ Fletcher, Springer Verlag, 1991.
2. **Computational Fluid Dynamics by** A Practical Approach, J. Tu, G.H. Yeoh, C. Liu, Butterworth-Heinemann, 2007.
3. **An Introduction to Computational Fluid Dynamics by** The Finite Volume Method, 2nd Edition, H. Versteeg, W. Malalasekra, Prentice Hall, 2007.
4. **Computational Fluid Dynamics** by An Introduction, John F. Wendt, Springer Berlin Heidelberg, 2009.
5. **Numerical Heat Transfer and Fluid Flow** by S.V. Patankar, Henusphere, 1980
6. **Computational Fluid Dynamics** by T.J. Chung, Cambridge University.
7. **Text Book of Fluid Dynamics by** Frank Chorlton, CBS Publishers.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08209) INSTRUMENTAL METHODS OF ANALYSIS

1 Chromatographic techniques-Afinity,adsorption,paper,thin layer chromatography-Column-Ion exchange-gel chromatography.

2 Gas liquid chromatography-instrumentation,applications and High performance liquid chromatography-instrumentaton,applications.

3 General principles – Radiation, energy and atomic structure- types of spectra and their biochemical usefulness – basic laws of light absorption. Electromagnetic radiation & Spectrum, Beer – Lambert's Law and apparent deviations; UV - VIS Spectrophotometer, Spectro fluorimetry, Atomic absorption & Atomic emission spectroscopy, Cirular Dichroism (CD)- principles, instrumentation and applications.

4 Infra Red Spectroscopy. Mass spectroscopy-Introduction, analysis, applications in biology ESR principles - instrumentation-applications

5 High resolution NMR –Chemical shift-Spin-spin coupling Frequency lock- double resonance-applications of proton NMR-quantitative analysis-qualitative analysis, application of NMR in biology and study of macromolecules

6 Principles, Instrumentation and applications of AFM, SEM and TEM

7 Centrifugal dialysis, ultra filtration, electrophoresis and lyophilisation-principle, instrumentation and their applications.

8 P^H Titrations, buffer preparations-action physiological buffers-determination of p^{ka}values- potentiometric titrations.

References:

1. **Chemical Analysis: Modern Instrumentation Methods and Techniques**, 2nd edition, F.Rouessac, A.Rouessac, Wiley, 2007.
2. **Principles of Instrumental Analysis**, 6th edition, D.A. Skoog, F. J. Holler, S.R. Crouch, B.Cole, 2006.
3. **Instrumental Methods for Determining Elements: Selection and Applications by** L.R. Taylor, R.B. Papp, B.D. Pollard, Wiley-VCH, 1994.
4. **Instrumental Methods of Chemical Analysis** by G. Chatwal, S. Anand, Himalaya Publishing House, Bombay.
5. **Instrumental Methods of Chemical Analysis by** B.K. Sharma, Goel Publishing House, Meerut.
6. **Instrumental Methods Analysis by** H. Willard, L. Merritt, J. Dean, F. Settle, CBS Publishers & Distributors, Delhi.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

ANANTAPUR

Pre-Ph.D CHEMICAL ENGINEERING

(09PH08210) FLUIDIZATION ENGINEERING

1. Introduction: The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds.
2. Industrial applications of fluidized beds: Coal gasification; gasoline from other petroleum fractions; Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics; Drying of solids; Synthesis of phthalic anhydride; Acrylonitrile; Polymerization of olefins; FCCU; Fluidized combustion of coal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization.
3. Fluidization and mapping of regimes: Minimum fluidization velocity; Pressure drop vs. velocity diagram; effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity of particles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems; Voidage diagram; Mapping of regimes of fluidization.
4. Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles.
5. Bubbling Fluidized beds: Experimental findings; Estimation of bed porosities; Physical models: simple two phase model; K-L model.
6. Fluidized bed heat transfer: Modes of heat transfer, heat transfer in beds of particles, estimation of bed to surface heat transfer coefficients, heat transfer between bed, distributor, containing walls, immersed tubes.

7. Design of simple fluidized beds, estimation of bed dimensions and fluidizing velocity, TDH.
8. Fluidized bed combustion: introduction, combustion systems for solid fuels, fluidized bed combustion of solid fuels, size of fluidized bed combustion systems, efficiency of fluidized bed combustion systems, combustion of particles in fluidized bed.

References:

1. **Fluidization Engineering**, 2nd edition, D. Kunil and O. Levenspiel, 1991.
2. **Fluidized Bed Technology: Principles & Applications by** JR Howard, Adam Hilger, Bristol, NY, 1989.
3. **Handbook of Fluidization and Fluid-Particle Systems by** W.C.Yang, CRC Press, 2003.
4. **Multiphase Flow and Fluidization: Continuum and Kinetic Theory Descriptions by** D. Gidaspow, Academic Press, 1994.
5. **Fluidization Dynamics by** L.G. Gibilaro, Butterworth-Heinemann, 2001.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08211) NANOTECHNOLOGY

1. Introduction to Nano Technology: Effects of Confinement & Finite size in 1D &2D nanostructures (Concepts of surface & interfacial energy).
2. Inter molecular forces in organic polymerics , Aqueous, Biological , Vander waal, Electro static , Double Layer Forces in Acid Phase and Acid base systems.
3. Depletion interactions, Hydro phobic forces layering, Mesoscale thermodynamics of Nano scale particles.
4. Gibbs treatment of interfaces, Mesoscale fluid dynamics, Thin films.
5. Nano fabrication, nucleation, patterning of soft materials by self organizing.
6. Chemical Self assembly.
7. Synthesis of Nano Particles using solgel, hydro thermal methods, freeze drying attrition, ion implantation, gas phase condensation and Chemical Vapor Deposition.
8. Failure analysis, QA/QC in nanofab: Analysis and metrology techniques in nanotechnology, Imaging using SEM, SPM-AFM, TEM, X-Ray Photo electron and augur spectroscopy, Power X-ray diffractometry, Traditional surface and materials analysis techniques

References:

1. **Nanotechnology - A Gentle Introduction to the Next Big Idea**, 1st edition, Ratner and Ratner, Prentice Hall PTR, 2002.
2. **Engines of Creation by** K E Drexler, Oxford Paperbacks, New York, 1996.
3. **Nano Structures & Nano Materials, Synthesis, Preoperties and Applications by** Guozhong Cao, Imperial College press, 2006.
4. **Nano Material & Introduction to Synthesis, Properties & Application by** Dieter Vollath, Wiley VCH, 2006.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08212) COLLOID AND INTERFACIAL SCIENCE

1. Basic concepts of Colloids and Interfaces: Introduction, Examples of Interfacial Phenomena, Solid-Fluid Interfaces, Colloids.
2. Properties of Colloid Dispersions: Introduction, Sedimentation under Gravity, Sedimentation in a Centrifugal Field, Brownian Motion, Osmotic pressure, Optical properties, Electrical Properties, Rheological Properties of Colloid Dispersions.
3. Surfactants and their properties: Introduction, Surfactants and their Properties, Emulsions and Microemulsions, foams.
4. Surface and Interfacial Tension: Introduction, Surface tension, Interfacial Tension, Contact Angle and Wetting, Shape of the Surfaces and interfaces.
5. Measurement of Surface and Interfacial Tension, Measurement of Contact Angle; Intermolecular and Surface Forces: Introduction, Vanderwalls Forces.
6. Intermolecular and Surface Forces: Electrostatic double layer force, The DLVO theory, Non-DLVO forces.
7. Adsorption at interfaces: Introduction, The Gibbs Dividing surface, Gibbs Adsorption Equation, Langmuir and Frumkin Adsorption Isotherms, Surface Equation of state(EOS), Effect of Salt on Adsorption of Surfactants.
8. Adsorption Isotherms incorporating the Electrostatic Effects, Calculation of Free energy of Adsorption, Adsorption of inorganic salts at interfaces, Dynamics of Adsorption of Surfactants at the interfaces, Adsorption at Solid-Fluid interfaces.

References:

1. **Foundations of Colloid Science by** R. J. Hunter, 2nd edition, Oxford University Press, USA, 2001.
2. **Principles of Colloid and Surface Chemistry**, Third edition, Revised and Expanded, Paul C. Hiemenz and Raj Rajagopalan.
3. **Physical Chemistry of Sciences**, 6th edition, A. Adamson, 1997.
4. **Interfacial Science: An Introduction by** G.Barnes, I.Gentle, Oxford University Press, USA, 2006.
5. **Coloid and Interface Science by** Pallab Ghosh, PHI, NEWDELHI.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08213) ADVANCED PROCESS CONTROL

1. Review of single input single out put (SISO) systems: Review of first and second order systems transfer functions
2. Frequency response Analysis: Bode and Nyquist plots, effect of process parameters on Bode and Nyquist plots, closed loop stability concepts, Bode and Nyquist stability, tuning of PID controllers.
3. Introduction to advanced control systems: Cascade control, feed forward control, Adaptive Control, Inferential control, , Ratio control, Selective and split range control.
4. Internal model Control, Model predictive control, Dynamic matrix control, Plant wide control.
5. 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.
6. Multivariable control: control of interacting systems, Primary and Cross controllers, Relative Gain Analysis (RGA), Response of multi loop control system, Non interacting control: Decouplers. Stability of multivariable control systems.
7. Controllability, observability, stability analysis of systems.
8. Sampling and Z-transforms, Open loop and closed loop response, Modified Z-transforms, Examples of Non-Linear systems.

References:

1. **Process Control: Modeling, Design and Simulation** by B.Wayne Bequette, PHI, 2003.
2. **Process Systems Analysis And Control**, 2nd Edition, Donald R. Coughanowr, McGraw Hill, Inc
3. **Principles & Practice of Automatic Process Control by** CA Smith, A. Corripio.
4. **Chemical Process Control by** George Stephanopolis, Aulto Seborg.
2. **Process Dynamics & Control**, 2nd edition, J. B. Riggs.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08214) ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

1. Fundamental concepts of classical thermodynamics and their review.
2. Fundamental concepts of statistical thermodynamics
3. Intermolecular forces and potential energy functions
4. Molecular theory of corresponding states.
5. Thermodynamic properties and multi component Multiphase equilibria from equations of state
6. Molecular theories of solutions and activity coefficient models
7. Bio-thermodynamics of dilute aqueous systems.
8. Thermodynamics of polymer solutions and colloidal systems.

References:

1. **Molecular Thermodynamics of Fluid Phase Equilibria**, 2nd edition, Prausnitz, J.M., Linchtenthaler R.M and Azevedo, E.G., Prentice hall inc., Englewood Cliffs, New Jercy, 1986.
2. **The Properties of Gases & Liquids**, 4th ed., Reid R.C., Prausnitz, J.M and poling, B.E, McGraw Hill, New York, 1987.
3. **Biothermodynamics**, Edsall J.T and Gutfreund H, John Wiley & Sons Ltd., New York, 1983.
4. **Introduction to chemical engineering thermodynamics**, 5thed, J.M.Smith and HC Van Ness, , McGraw Hill, 1996.
5. **Chemical engineering thermodynamics**, YVC.Rao, University publications.

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Pre-Ph.D CHEMICAL ENGINEERING

(09PH08215) SAFETY & RISK ANALYSIS IN CHEMICAL INDUSTRIES

1. Introduction : Importance of process safety with examples of major accidents; which might cover chemical, petroleum & petroleum chemical Industrial, safety legislation, safety programmes, public perceptions, engineering ethics, Govt. policies on safety.
2. Material Hazards: Flammability, toxicity, Reaction Hazards, Burning Characteristics, Material Properties and Hazards.
3. Hazard Analysis: Hazard identification, preliminary hazard analysis, HAZOP, event tree, fault tree analysis.
4. Process Hazards: Temperature & Pressure effects and deviations, flow, level and other process deviations. Toxic releases to phase phenomena, emission and dispersion models, estimation and prevention.
5. Ignition Sources: Flames, Hot surfaces, static electricity, and the like Explosions: Confined & Unconfined explosions, BLEVES, Dust Explosions. Fire and explosions, chemistry of fire, fire triangle, fire and explosion index (FEI) estimation, heat effect, vapor cloud explosion, boiling liquid expanding, vapor explosion and prevention.
6. Safety Devices & Safety audit: Relief valves and Rupture disks Explosive relief, flare systems. Industrial hygiene, health hazards, evaluation of workers exposure to toxicants, control method.
7. Safety in plant Design & lay-out: Electrical area classification, control of entry to confined spaces. Hazard management-Safety system.
8. Safety Drills: Risk management routines, emergency plans, diaster control ergonomics. Emergency preparedness & handling analysis of major accidents & preventive measures.

References:

1. **Safety in Process Plant Design**, G. L. Wells.
2. **Loss Prevention in Process Industries**, Frank P. Lees, Butterworths, London.
3. **Chemical Process Safety, Fundamentals with Applications**, D. A. Crowl, J. F. Louvar, Printice Hall, 1990.
4. **Safety and Accident Prevention in Chemical Operations**, 2nd edition H.H.Fawcett and W.S.Wood, John Wiley and sons, New York, 1982.
5. **Coulson and Richardson's – Chemical engineering**, Vol.6, R.K.Sinnot, Butterworth-Heinmann Limited, 1996.