

REVISED SYLLABUS OF MASTER OF CHEMICAL ENGINEERING

First semester

Category -Departmental / Specialization Basket

PAPER-I

PG / ChE / T / 111A -Advanced Chemical Engineering Thermodynamics

Review of first and second laws of thermodynamics, General methods of deriving thermodynamic formulae; Partial molal quantities-Gibbs-Duhem equation; Equilibrium and free energy, fugacity and activity; Chemical reaction equilibrium constants; fugacity in mixture; effect of pressure, volume, temperature on thermodynamic properties such as enthalpy, entropy, internal energy etc. chemical potential in mixtures; vapour-liquid equilibrium, Correlation of data from Van taaar and other equations. Elements of irreversible and statistical thermodynamics.

PG / ChE / T / 111B -Advanced Chemical Engineering Kinetics and Reactor Design

Kinetics of Fluid-solid and fluid-fluid catalytic and non-catalytic reactions; Heterogenous catalysis, Reaction and diffusion with porous catalyst, solid catalysed reactions, Mass and heat transfer in catalytic beds; Effects of pressure drop on performance of Fixed bed Catalytic Reactor; Mechanism and Kinetics of Catalyst Deactivation; Case Studies on Moving Bed and Circulating Fluidized Bed Reactors;

Non-ideal reactor performance. Design of stirred reactors; Bubble column reactors, Slurry reactors, adiabatic and programmed reactors.

Modelling of Multi-phase Reactors; Dynamic behaviour of CSTRs in series and single non-isothermal CSTR and determination of transfer functions, Reactor optimization and scale up (Batch, CSTR, PFR, PBR).

Local Stability analysis of Reactors, Parametric sensitivity in Autothermal Reactors, multiplicity and Hysteresis in CSTR and PFR, Bifurcation Theorem with special emphasis on Hopf Bifurcation.

PG / ChE / T / 111C -Process Dynamics and Control

Process dynamic analysis by State variable technique. Definition of state, state matrix, solution of differential equations, Open loop and close loop system representation, Lumped parameter, Lumped parameter with stages, distributed parameter systems. Controllability, observability. Solution through simulator like MATLAB.

Process identification methods-time domain and frequency domain methods, OFF- line and OB-line methods.

Design techniques-Direct substitution method (Dahlin's Algorithm), Internal Model reference method.

Analysis and design of advance control strategies-Feed forward, Cascade, Smith's Predictor Algorithm, Adaptive control strategies-self Tuning regulators, Model reference Adaptive control strategies – self tuning regulators, Model reference adaptive algorithm.

Optimal control-criteria of optimality.

Introduction to Nonlinear systems – Describing function technique, phase plane analysis, Liapunov's stability criterion-exothermic reactor system.

Plant wide process control-Analysis and synthesis through example case studies. Discrete systems, sampled data systems, Z-transform – Pulse transfer function, modified sort form, Controller synthesis, stability analysis. Computer based controlsystem.

PAPER-II

PG / ChE / T/ 112A -Advanced Heat Transfer

General equation of heat conduction. Application of general heat conduction equation under steady state heat conduction with internal heat generation in large slab, cylinder, hollow cylinder etc. Transient heat conduction numerical and analytical methods for the solution of transient heat conduction problems. Series-parallel resistances and contact resistances in heat transfer concept of conduction shape factor, critical radices and optimum thickness of insulation.

Free convective heat transfer under different situations and application of dimensional analysis to estimate the convective heat transfer coefficients. Forced convective heat transfer in laminar-transition and Turbulent zone.

Heat transfer factor Reynolds No. plot. Analogy equation for Heat Momentum Transfer. Convective heat transfer in molten metal. Boiling heat transfer with particular reference to Nucleate and film boiling and estimation of boiling heat transfer coefficient. Heat transfer from condensing vapors. Nusselt equation for film type condensation of vapors over vertical surfaces and inclined tubes.

Selection and design of condensers, single pass and multipass heat exchangers. Radiation heat transfer. Estimation of view factors and emissivity factors for different situation. Radiation shield and radiation error in pyrometry.

Combined conduction, convection and radiation heat transfer. Convection and Radiation heat transfer furnaces.

PG / ChE / T/ 112B -Advanced Mass Transfer

Simulation of cascade processes by Stage to stage calculations;

Lewis-matheson method Thiele-Geddes method

Matrix methods; BP method; Napthali Sandholm method

Incorporation of tray efficiencies in matrix method

Supercritical extraction

Adsorption: Fundamentals of adsorption including phase diagrams, estimation of phase equilibrium by Langmuir, Freundlich, Ideal adsorbed solution theory etc.

Fixed bed adsorbers basic concepts, Dynamic modeling of fixed bed adsorbers

Temperature swing adsorption

pressure swing adsorption; PSA cycles – basic principles

Dynamic modeling of PSA system

Simulated continuous countercurrent systems

Simulation by McCabe Thiele and Kremser method, SMB

Chromatography

Hybrid processes; reaction distillation, membrane distillation etc. Estimation of multi-component mass transfer rates Maxwell Stefan relations; Estimation of diffusion constants, effective diffusivity methods Mass transfer coefficients; Bootstrap problem Process Intensification

PG / ChE / T/ 112C -Advanced Fluid Dynamics

Vector and Tensor Methods

The Physical Properties of Fluids

Kinematics of the Flow Field: Specification of the flow field, conservation of mass, Analysis of relative motion near a point,

Expression for the velocity distribution with specified rate of expansion and vorticity, Sources and Sinks, The vorticity distribution, velocity distribution with zero rate of expansion and zero vorticity.

Equations Governing Motion of a Fluid: Material Integrals in a moving fluid, The Equation of motion, The expression for the stress tensor, Constitutive relationships, Non-Newtonian Fluids, Navier Stokes Equation, Bernoulli's theorem for steady flow of a frictionless non-conducting fluid, Boundary conditions for real fluid, Fluid mechanics at the interface.

Flow of a Uniform Incompressible Viscous Fluid: Steady unidirectional flow, Unsteady unidirectional flow, Flow with circular streamlines, Flow fields in which inertial forces are negligible, Flow due to moving body at small Reynolds number, The viscosity of dilute suspension of small particles.

Flow at Large Reynolds Number: Vorticity dynamics, Kelvin's circulation theorem, vorticity laws for an inviscid fluid, Steady two dimensional flow in a converging or diverging channel.

Boundary Layers: Integral methods, Scaling, Blasius flow, Falkner-Skan flow, Separation of boundary layer

Transition and Turbulence: Turbulent flow fluctuating velocity, turbulent stress, mean fluctuating velocity, mixing length, Prandtl's and Karman's theories, theory of momentum transfer

Two phase flow conditions at gas liquid interface: equation for mean velocity of two phase streams, flow in their film, wave formation on surface, frictional losses.

Hydrodynamic instabilities in open and closed flows: Linear instability concept, Nonlinear instability concept

Text Book:

An Introduction to Fluid Dynamics, G.K. Batchelor, Cambridge University Press, Indian Edition 1993, Reprint 1997.

References:

Physical Fluid Dynamics, D. J. Tritton, Oxford Univ. Press., 1988.

Analysis of Transport phenomena, M. Deen, Oxford University Press, 1998

Ideal and Incompressible fluid dynamics, M. E. O'Neill, F. Chorlton, John Wiley & Sons.

Hydrodynamics and Nonlinear Instabilities, Claude Godriche, Paul Manneville, Cambridge University Press, 1998.

PAPER-III

PG / ChE / T/ 113A -Advanced Transport Phenomena

Diffusive fluxes and material properties

Conservation Equations fundamentals of heat, mass, momentum transfer

Scaling and approximation techniques

Solution of Unsteady state heat, mass and momentum diffusion problems in more than one dimensions in spherical and cylindrical co-ordinates.

Unidirectional and nearly unidirectional flow, creeping flow

Problems involving non Newtonian fluids.

Analysis of compressible flow.

Differential and integral analysis of momentum, thermal and concentration boundary layers and their approximate and exact solutions. Heat, mass momentum analogy

Turbulent boundary layers.

Forced convection heat and mass transfer in laminar flow

Transport in buoyancy driven flow

Simultaneous heat, mass and momentum transfer.

Case study of simultaneous heat, mass and momentum transfer with phase change

PG / ChE / T/ 113B -Numerical Methods for Chemical Engineering

Numerical solution of nonlinear algebraic equations : types of roots and their approximation; Regula Falsi, Newton-Raphson and Greffe's methods; Newton's methods for real and complex roots and simultaneous nonlinear algebraic equations.

Numerical solution of simultaneous linear algebraic equations : consistency of equations and existence of solution; Gauss elimination method; Gauss-Jordan reduction method with matrix inversion; Gauss-Seidel substitution method.

Homogeneous algebraic equations and characteristic-value: Faddeyev-Leverrier method, elementary similarity transformation, the QR algorithm of successive factorization.

Finite difference methods : symbolic operators; various differences; difference equations and their solutions; interpolating polynomials; interpolation; orthogonal polynomials.

Numerical solution of ordinary differential equations : classification, transformation to canonical forms; linear ordinary differential equations, integration formulas.

Nonlinear ordinary differential equations-initial value problems : The Euler's methods, the Runge- Kutta methods; simultaneous ordinary differential equations. Nonlinear ordinary differential equations-boundary value problems : The Newton's method, finite difference method, collocation methods. Error propagation, stability and convergence. Stiff differential equations.

Numerical solution of partial differential equations : classification, initial and boundary conditions; finite difference method of solution for elliptic, parabolic and hyperbolic partial differential equations. Irregular boundary and polar coordinate system. Nonlinear partial differential equations; finite element method.

Linear and nonlinear regression analysis : process analysis, mathematical analysis and regression analysis; statistical terminology; derivation of normal equations and properties of estimated vector of parameters for linear regression. The Gauss-Newton method, steepest descent method and the Marquardt method for nonlinear analysis; analysis of variance and other statistical tests of the regression results.

Category:- Inter-Disciplinary Basket

PAPER-IV

Any one subject from the inter-disciplinary basket of ME, IE, CE, EE, ETCE, MetE Departments.

PAPER-V

PG / ChE / T/ 115A -Environmental Pollution Control

Definition, Glossaries on different Environmental Descriptors, Natural and Anthropogenic pollution, Sustainable development, Procedural interaction with legal authorities, Environmental protection Acts, Rules. Statutory standards, conceptual aspects of EIA, ES, EMP, Hazardous substances & Risk analysis.

Water and Atmospheric pollution – types, causes sources, primary and secondary pollutants, effects, dispersion of Air pollutants, rudiments of control measures, standards solid waste-classification, collection and disposal management, Noise pollution – causes and effects, control measures, global atmosphere change.

Industrial waste source, Nature and characteristics, quantity and quality of industrial wastes and their impact on the environment,

Nuclear waste and Radio-active waste. Biomedical waste and BMW- Rules, Municipal solid waste management Rules – Legislation for E-waste and radioactive waste.

Concept of Ecology and ecosystem, Productivity Cycle, Food chain, limnology, Nutrient cycle, Eutrophication, Ecopond system, case studies related to environmental issues of different process Industries.

PG / ChE / T/ 115B -Interfacial Science and Engineering

Physics of surfaces

Surface and Interface- molecular origin, the work of cohesion and adhesion Interaction forces and potential, chemical and physical interaction, classification of physical forces. Van der Waals force, interaction between surface and particles – Lifshitz theory, hydrodynamic flow effects in interfacial interactions

Electrostatics forces and electric double layer, DLVO theory, Boltzmann distribution, Debye length, specific ion adsorption, ion adsorption, Stern layer, Electrophoresis

Theory of capillarity – Young Laplace equation, capillary flow and spreading process, wetting and spreading, contact angle and its measurement technique, contact angle hysteresis, Thermodynamics of wetting, Nanostructure influence on wetting: Lotus effect, and insects, Marangoni effect.

Young's equation, spreading coefficient Equilibrium dynamics and stability of free liquid surfaces- Micro and Nano Scale Hydrodynamics with and without Free Surfaces, Interfacial instability, Linear Stability Analysis

Chemical equilibrium across a curved interface, generalized Kelvin equation, Oswald ripening, Capillary condensation, Theory of heterogeneous nucleation

Effects of solutes on surface tension, Adsorption, Gibbs surface excess, Gibbs adsorption equation, Adsorption isotherms, surfactant adsorption

Surfactants, self assembly thermodynamics, bilayers, vesicles,

Engineering Applications - emulsions, microemulsions, foams, aerosols, polymers at interface, heterogeneous catalysis, Impregnation, floatation, detergency.

Case studies on enhanced oil recovery.

Alternately, any one subject from the inter-disciplinary basket of ME, IE, CE, EE, ETCE, MetE Departments.

PAPER-VI

Any one subject from the inter-disciplinary basket of ME, IE, CE, EE, ETCE, MetE Departments.

Category:- Sessional Courses

Sessional I

Chemical Engineering Laboratory PG / ChE / S / 111-Laboratory

1. Particle size measurement of nanomaterials
2. Zeta potential measurement: determination of isoelectric point
3. Experiment on Adsorption: Effects of pH, concentration, loading etc.
4. Determination of calorific value of solid fuel.
5. Experiment on electrocoagulation process
6. Design of experiment for High Performance Liquid Chromatography (HPLC) analysis

Sessional II

PG / ChE / S / 112-Seminar

Second Semester

Category:- Departmental / Specialization Basket

PAPER-VII

PG / ChE / T/ 127A -Modern Energy Engineering and Energy Management

Concept of “waste to energy”; Thermochemical and biochemical conversion of Biomass; Kinetics of incineration, Pyrolysis and Gasification (low and medium Joule) of Biomass and polymeric Wastes; Design of incinerator, Green House effect of Incineration; Design of Updraft, downdraft and fluidized bed Gasifiers for Biomass; Design of low temperature pyrolyser and Fast/Flash Pyrolyser; Kinetics of Biogas generation from wastes; Design of Bio-digesters for the generation of Biogas; Gas Turbines and Dual-fuel IC engines for power generation from low and medium Joule gases; use of Natural gas for the substitution of liquid fuels; Dehydration and Desulfurization processes of natural gas; gathering and transport of natural gas and Biogas;

Hydrogen energy: Production, storage, applications, concept and operation of fuel cell; Polymer Electrolyte Fuel Cells, Solid Oxide Fuel Cells (SOFCs), Alkaline Electrolyte Fuel Cells (AFCs).

Design and scale-up of solar appliances including photovoltaics; co-generation: Theory and practice; energy system control and management; codes, standard and legislation for energy usage; Energy auditing in process industries; waste heat recovery.

Case study on sugar industry.

PG / ChE / T/ 127B -Pollution Control and Safety in Process Industries

Water Resources and water quality for domestic, Industrial uses. Water treatment methods.

Physical and chemical characteristics of waste water, measurement of organic content-BOD. COD, TOC etc. Biological Protista, characteristics of waste water, Microorganisms, Prokaryotic and Eucaryotic cells.

Waste water treatment and Physical Unit Operations, Screening Flocculation, Sedimentation Flotation, Filtration, Disposal of sludge, Chemical treatment, Chlorination, Biological treatment Cell physiology, aerobic and anaerobic cycles, growth kinetics, activated biological sludge process, trioxle filter, stabilization ponds and other processes and design considerations.

Advanced waste water treatment, processes for industrial effluents.

Zero polluting industry concept \Reuse and recycle of waste water.

Treatment and disposal of sludge and solid wastes. Sanitary landfill and composting. Incinerators design, Pyrolysis and other energy recovery processes. Treatment of agricultural wastes and manure. Biogas.

Air environment and its management. Nature of air pollutants and their effects. Sampling and array methods. Particulates and their removal methods-mechanical removal devices and electrostatic precipitators-design considerations. Reduction of automobile engine exhaust emissions.

Treatment of flue gases. Process design considerations for reducing emission.

Case studies of treatment technology of various Industrial waste like dairy, sugar, paper, distillery, textile, tannery, food processing, fertilizer, pharmaceutical etc. Safety and HAZOP analysis of different process Industries.

PG / ChE / T/ 127C -Petroleum Refinery Engineering and Petrochemicals

Origin, formation and composition of petroleum. Evaluation of crude oil. Properties and testing of petroleum products. Pretreatment of crude oil and crude oil distillation. Fuel quality management of transportation fuels. Secondary conversion processes in petroleum refineries – cracking, alkylation, isomerisation, polymerization, hydrocracking, coking, visbreaking etc. Treatment and purification of petroleum products. Corrosion in refineries. Design of pipe-still heaters and multicomponent distillation systems. Case studies on refinery operations e.g. improved distillation procedure, steps in reforming operation to boost octane number, improvement in flare operation to reduce hydrocarbon loss, improved fire safety measures to ensure safe operation and so on.

Scope of petrochemical industry, Feedstock identification – conventional and alternate. Synthesis gas and chemicals from petroleum hydrocarbons. Case studies on production of vinyl chloride, benzene (through hydrodealkylation of toluene), ethyl benzene to compare advantages and disadvantages of alternative routes. Polymers of olefins. Synthetic fibres. Synthetic rubber. Plastics, synthetic detergents, and petroleum coke & carbon black.

PAPER-VIII

PG / ChE / T/ 128A -Computational Fluid Dynamics

OVERVIEW OF CFD: Role of CFD

Problem solving in CFD Components of CFD Softwares GOVERNING EQUATIONS

Complete Navier-Stokes Equations Complete Energy Equations

Complete Mass conservation Equations Parabolized Navier-Stokes Equations Euler Equations

Turbulence Modeling

CONSERVATION LAWS AND CONSERVATION FORM OF EQUATIONS

Conservative and non-conservative forms Source terms and boundary conditions

MATHEMATICAL BEHAVIOUR OF PARTIAL DIFFERENTIAL EQUATIONS

Classification and general behavior of different classes of partial differential equations: hyperbolic equations, parabolic equations and elliptic equations.

Well-posed problems

BASIC ASPECTS OF DISCRETIZATION

Difference equations, explicit and implicit approaches, discretization and round-off errors,

analysis of stability of a numerical scheme: von Neumann stability method

consistency and convergence of a numerical scheme

APPROXIMATION OF GOVERNING EQUATIONS

Finite difference methods Finite Volume methods Finite Element methods GRID

GENERATION

Structured Grid generation Unstructured Grid generation Adaptive Grid generation

SOLUTION ALGORITHMS AND TECHNIQUES

LU decomposition Approximate factorization Relaxation algorithms Hybrid Schemes

CFD METHODS FOR THE EULAR EQUATION

Linearization and Jacobian Matrix Eigenvalues and Eigenvectors Flux splitting methods

CFD METHODS FOR NAVIER-STOKES EQUATIONS

Pressure correction method, Beam-Warming algorithm

CASE STUDY: Solution for an incompressible Couette flow using an implicit method and the pressure correction method

PG / ChE / T/ 128B -Optimization Methods

Introduction to optimisation.

Classical optimisation techniques.

Linear programming.

Nonlinear programming: One dimensional, Constrained and unconstrained optimisation technique.

Geometric Programming.

Dynamic Programming.

Integer Programming: Linear and nonlinear.

Stochastic Programming.

Calculus of variation, PERT & CPM, game theory, Quadratic Programming.

PG / ChE / T/ 128C -Modeling and Simulation of Chemical Processes

Introduction to process modeling and simulation, Use and scope of mathematical models in chemical Engg. practice. General Modeling principles, Dynamic Modeling, Simulation and IFD, Planning and Calculation, Theoretical Models and Parameter Estimation, Models and their Classification, Balances and conservation principles, Transport phenomena models, Population balance models, Empirical Models, Strategies of Simplifying models,

Mathematical tools and simulation techniques in chemical engineering process plants and their design

Steady state and dynamic behavior, step response analysis, phase plane analysis, Stability analysis, Multiple steady states, bifurcation theory and application

Modeling and simulation of Thermodynamics and property of fluids, Fluid flow system, Heat exchange Equipment, Separation processes: Distillation, Absorption, Extraction, Chemical Reactors: ideal and nonideal CSTR, batch and semi-batch reactor, tubular reactor, Polymerization Reactor

Case study of Industrial process plant.

PG / ChE / T/ 128D -Applied Statistics for Chemical Engineering Concept of Histogram, Frequency polygon and other pictorial representations; Central Tendency;

Dispersion measure;

Testing of hypothesis: Z, t, F, Chi-square distributions;

Annova Analysis of variant;

Contingency Test & goodness of fit;

Non parametric method (H, U);

Nonlinear least square technique – parametric sensitivity;

Problems related to Chemical Processes.

PAPER-IX

PG / ChE / T/ 129A -Biochemical Engineering

Introduction to the Kinetics of Bioprocesses; Enzyme Kinetics; Cell

Growth Kinetics; Kinetics of metabolic Product Synthesis by cells; Introduction of Segregated and Non-segregated Models; Kinetics of Immobilized Enzymes and cells; scale-up and control of Bioreactors; Parametric sensitivity and Multiplicity in

Biosystems; Global and Local stability analyses of Bioreactors; Kinetics and Reaction engineering of genetically modified cell cultures, Recombinant DNA technology, Downstream processing in Bioprocesses; Industrial Application of Bioprocesses.

PG / ChE / T/ 129B -Membrane Science and Engineering

Membrane Separation Process and types of membrane separation processes. Reverse Osmosis Process, important terminology, theory, applications and case study on water desalination. Ultrafiltration process, Important terminology, Theory, Membrane fouling parameters, Membranes and module design, Application and Case study on dairy waste. Microfiltration process, Important terminology, Theory, Dead-end Microfiltration, Cross-flow Microfiltration, Application and Case study on fruit juice clarification. Emulsion Liquid membrane (ELM), Important terminology, Theory, Design Consideration and Application.

Gas separation: Effusion and Permeation Pervaporation..

Dialysis/ Electro-dialysis, Theory and Application; Case studies on dialysis.

New membrane separation processes

Membrane modifications for Advanced membrane separation process

MRB, EMR, PMR and nanocomposite membranes for targeted separation.

PG / ChE / T/ 129C -High Polymer Engineering

Fundamental concepts of High polymers, classification of High polymers, polymerization methods, kinetics of course

Addition, Condensation and Ring opening polymerization, Reactor Design, Determination of Molecular weight and Molecular weight distribution, Rubbery State and compounding of natural and synthetic rubber, classification of polymer forming operations, Principles of Injection Moulding, Extrusion, Calendering, Blow moulding, Lamination.

Category:- Inter-Disciplinary Basket

PAPER-X

PG / ChE / T/ 1210A -Bioenergetics and Bioprocess Engineering

Biochemical reaction engineering, Kinetics of homogeneous reactions, reaction mechanism, Temperature dependency from Arrhenius law, Interpretation of batch kinetic data, Kinetics of enzyme catalyzed reaction in free and immobilized states, Michaelis -Menten kinetics of substrate utilization, product formation and biomass production, Monod growth model and its various modifications with special reference to inhibition by substrate, product and toxic materials, structured and unstructured kinetic rate model, thermal death kinetics of cells and spores, Different types of bioreactors for suspension and immobilized cultures, solid state fermentation, protein-protein and protein-DNA interaction, basics of genetic engineering, Chemical mechanisms of biological energy conversion in mitochondria and chloroplasts, application of bioprocesses in energy generation (generation of bioethanol, biodiesel, biogas etc., microbial fuel cell), introduction to algal biotechnology, factors affecting algal growth, photobioreactors, photosynthesis in high density medium.

Case study of pretreatment methods of lignocellulosic biomass for bioethanol and renewable chemicals synthesis.

Alternately, any one subject from the inter-disciplinary basket of ME, IE, CE, EE, ETCE, MetE Departments.

Category:- Sessional Courses

Sessional I

PG / ChE / S / 121-Term Paper Leading to Thesis

Sessional II

PG / ChE / S / 122-Seminar

THIRD and FOURTH SEMESTER

Category:- Sessional Courses

Sessional I

PG / ChE / TH / 21-Thesis Work

Sessional II

PG / ChE / VV/ 22-Viva-voce