DMCHE 401:Chemical Engineering Mathematics

UNIT-I

Mathematical formulation of the physical problems:(i) Application of the law of conservation of mass - Salt accumulation in stirred tank - Starting an equilibrium still - Solvent extraction in N stages- Diffusion with chemical reaction. (ii) Application of the law of conservation of energy - Radial heat transfer through a cylindrical conductor - Heating a closed kettle - Flow of heat from fin.

UNIT-II

Analytical (explicit) solution of ordinary differential equations encountered in Chemical Engineering problems:(i) First order differential equations-Method of separation of variables-Equations solved by integration factors-Certain examples involving mass and energy balances and reaction kinetics. (ii) Second order differential equations-Non-linear equations-Linear equations-Simultaneous diffusion and chemical reaction in a tubular reactor-Continuous hydrolysis of tallow in a spray column.

UNIT-III

Partial Differential equations:(i) Formulation of partial differential equations - Unsteady-state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equation.(ii) Boundary conditions : Function specified, derivative specified and mixed conditions.(iii) Particular solutions of partial differential equation: Compounding the independent variable into one variable, superposition of solutions, The method of Images and particular solution suggested by the boundary conditions.

UNIT-IV

Finite Differences:(i) The difference operator - Properties of the difference operator-Difference tables-other difference operators.(ii) Linear finite difference equations - complementary solution - particular solution - simultaneous linear difference equations(iii) Non-linear finite difference equations - analytical solutions.

Solutions for the following type of problems by finite difference method:(a) Calculation of the number of plates required for an absorption column(b) Calculation of the number of theoretical plates required for distillation column(c) Calculation of number of stages required for a counter current extraction and leaching operation.

UNIT-V

Application of Statistical Methods:(i) Propagation of errors of experimental data.(ii) Parameter estimation of algebric equations encountered in heat and mass transfer, kinetics and thermodynamics by(a) Method of averages(b) Linear least squares and (c) Weighted linear least squares methods(iii) Design of experiments: Factorial and Fractional factorial methods.

Text Books:1.Jenson V.G., & G.V Jeffreys, "Mathematical Methods in Chemical Engineering", Academic press, London and New York.

Reference Books:1. Harold S. Mickley, Thomas S Sherwood and Charles E Reed, "Applied Mathematics in Chemical Engineering", Tata McGraw Hill Publication.

2. Volk, W., "Applied Statistics", 2nd edition, McGraw-Hill Chemical Engineering series.

3.Alkis Constantinides,S."Applied Numerical Methods with Personal Computers",MGH, Chemical Engineering series, 1987.

DMCHE 402: Mass Transfer – II

UNIT-I

Humidification: Operations : definition of fundamental terms, Psychometric charts, theory of adiabatic saturation and wet bulb temperature, Lewis relation, gas-liquid contact operations, water cooling with air, dehumidification of air - water - vapor mixture., cooling towers, evaporative cooling.

Drying: Equilibria, Drying rate curve, Batch & continuous drying, Time of drying &calculations, mechanism of batch drying, equipment's for batch and continuous drying operations.

UNIT-II

Liquid - liquid Operations: Extraction: Introduction, liquid-liquid equilibria, analytical and graphical solutions for single and multistage operations, continuous counter current operation without and with reflux, fractional extraction, equipment for liquid-liquid contacting operations, single stage, multistage and continuous contacting equipment.

UNIT-III

Leaching: preparation of solid, steady and unsteady state operation, equipment, analytical methods both theoretical and problematic approaches for single and multistage operations.

Adsorption: Theory of adsorption, Industrial adsorbents, adsorption equilibrium, Frendlich equation, single and multistage operations, Unsteady state adsorption, equipment for single stage and continuous contact, Ion-Exchange.

UNIT-IV

Crystallisation: equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, Incorporation of principles into the design of the equipment, Less conventional operations: Dialysis, Thermal diffusion, Mass Diffusion.

Membrance Seperation Processes : Seperation of gases, seperation of liquids, Dialysis, membrances for liquid extraction, pervaporation, reverse osmosis.

Text Book:1. Mass Transfer Operations .,Robert E.Treybal,III Edn, McGraw-Hill Book Co.,

Reference Book:1."Unit Operations in Chemical Engineering"., McCabe, W.L ., Smith,J.C. and Harriot, P.,5th Edn,MG-Hill Book Co.,2. "Chemical Engineering Hand Book " J.H.Perry.

DMCHE 403:Chemical Process Equipment Design

UNIT – I

Introduction to plant design. Process design development: Design project procedure, design information from the literature, flow diagrams, preliminary design, comparison of different processes, equipment design, scale-up in design, safety factors, specifications, materials of construction.

UNIT – II

General design considerations: Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling.

Materials and fabrication selection: Materials of construction, selection of materials, fabrication of equipment.

UNIT – III

Mechanical design of process equipment: Pressure vessels – calculation of thickness of cylindrical and spherical shells subjected to internal pressure, heads or covers. Storage vessels – storage of nonvolatile liquids, storage of volatile liquids, storage of gases. Supports for vessels – bracket or lug supports, leg supports, skirt supports, saddle supports.

UNIT – IV

Material transfer, handling and treatment equipment: Pumps and piping, flow measuring equipment, design of filters.

Heat transfer equipment design: Basic theory of heat transfer, consideration in selection of heat transfer equipment, evaporators.

UNIT – V

Mass transfer equipment design: Finite-stage contactors- bubble cap tray, sieve tray and vbalve tray units, maximum allowable vapor velocities, plate and column efficiency, other design factors. Continuous contactors – types of packing, liquid distribution, pressure drop, packing efficiencies. Relative merits of plate and packed towers.

Reactors: Batch reactors, tubular plug flow reactors, back mix reactors expressions for r_i, mechanical features of reactor design.

Text Book:1.Peters M.S&Timmerhaus K.D-Plant design&Economics for Chemical Engineers,
4th edn, MGH Co.2. Joshi M.V-Process Equipment Design 3nd EdnMacMillan India Ltd 1981.

ReferenceBooks:1.Backhurst,J.R&Harker,J.H-Process-Plant-Design,HeiemanEdn Lon(1973).
2. Coulson J.M.&Richardson J.F Chemical Engineering Vol.VI (An introduction to Chemical Engineering Design) Pergamon Press, 1993.

DMCHE 404:Chemical Reaction Engineering

UNIT-I

Batch Reactors: Introduction and overview of the subject, kinetics of homogeneous reactions, non elementary reactions, Collision theory and Transistion-state theory, Arrhenius relation, various methods of analysis of batch reactor data (including variable volume and variable pressure data). Isothermal batch reactor design.

UNIT-II

Homogeneous flow reactors: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor(CSTR), data analysis in flow reactors, Design of PFR,CSTR, cascade of CSTR's and combination for PFR and CSTR.

UNIT-III

Multiple reactions: Design for multiple reactions, parallel reactions, series reactions (Omit reversible and series-parallel reactions).

Non-isothermal design: Energy balance equations for batch, PFR and CSTR under non-isothermal conditions, Equilibrium conversion under adiabatic conditions, Design of the homogeneous reactors under adiabatic conditions.

UNIT-IV

Non-ideal flow: residence time distribution curves E,F and C; Interpretation of the response data for the "Dispersion" and "Tanks-in-series" models(Omit multi parameter models).

UNIT-V

HeterogeneousCatalysis: Catalyst-properties,physical-adsorption-&-chemisorption, adsorption isotherm, Derivation of rate equations for various mechanisms(Adsorption, surface reaction and desorption controlling etc.,)Data analysis for heterogeneous laboratory catalytic reactors, Isothermal packed bed (PFR) reactor design, effectiveness factor and internal pore diffusion, Criteria for internal pore diffusion limitation.

Text Book:1."Chemical Reaction Engineering",Levenspiel, Octave.,3rdEdn,John Wiley,1999.

Reference Books:1."Elements of Chemical Reaction Engineering"Fogler,HS,3rd Edn,PHI,2K.

2. " Chemical Engineering Kinetics". Smith, J.M., 3rd Edition. McGraw Hill. 1981.

DMCHE 405: Instrumentation and Process Control

UNIT-I

Instrumentation: Principles of measurement, temperature measurement-Expansion thermometers, thermoelectric temperature measurement, resistance thermometers, radiation temperature measurement.

UNIT-II

Measurement of Pressure and Vaccumm, Measurement of Head and level, Measurement of Humidity and pH **Process control : Linear Open loop systems:**

UNIT-III

Simple first and second order system, Physical examples of first and second order systems, response of first order systems in series, Transportation lag

Linear closed loop systems : The control systems, controllers, final control element, block diagram of chemical reactor control systems, closed loop transfer functions, transient response of simple control systems.

UNIT-IV

Stability Stability. Root locus. Frequency resonse. Control system design by frequency resonse. Bode's diagram. Bode stability criteria.

UNIT-V

Analysis and design of feed-back control systems. Concept of feedback control. Types of feedback controllers. Measuring devices. Transmission lines. Final control elements. Dynamic behaviour of feedback controlled process. Block diagram and closed loop response. Effect of P.I & D control action on the response of a controlled process.

Analysis and Design of Control systems : Feed-back control of systems with large dead time of inverse response. Cascade control. Feed forward control. Ration control. Splitrange control. Override control.

Te**xt Book:** 1. Industrial instrumentation, Donald P. Eckmen, Wiley eastern limited
2. Process Systems Analysis and Control., 2 Edn. Donald R.Coughnowr, MGHill Inc., 1991.

DMCHE 406: Transport Phenomena

UNIT-I

Momentum Transport: Viscosity and the Mechanism of Momentum Transport (i) Newton's Law of Viscosity, (ii) Non-Newtonian fluids and (iii) Pressure and Temperature dependence of Viscosity.

Velocity distributions in laminar flow: (i) Shell momentum balances boundary conditions (ii) Flow of a falling film, (iii) Flow through a circular tube (iv) Flow through an annulus.

The Equations of change for isothermal systems: (i) The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, (ii) Use of the equations of change to set up steady flow problems (iii) Dimensional analysis of the equations of change.

Velocity distributions with more than one independent variable (i) Unsteady viscous flow.

Velocity distributions in Turbulent flow: (i) Fluctuations and time smoothed quantities, (ii) Time-smoothing of the equations of change for an incompressible fluid, (iii) Semi empirical expressions for the Reynolds stresses.

Interphase transport in isothermal systems : (i) Definition of friction factors (ii) Friction factors for flow in tubes (iii) Friction factors for flow around spheres.

UNIT-II

Energy Transport: Thermal conductivity and the mechanism of energy transport: (i)Fourier's law of heat conduction (ii) Temperature and pressure dependence of thermal conductivity in gases and liquids.

Temperature distributions in solids and in laminar flow: (i) Shell energy balances-boundary conditions (ii) Heat conduction with an electrical heat source (iii) Heat conduction with a viscous heat source (iv) Heat conduction through composite walls (v) Forced convection and (vi) Free convection.

The equations of change for non-isothermal systems : (i) The equation of energy in rectangular and curvilinear coordinates, (ii) the equations of motion for forced and free convection in non-isothermal flow (iii) Use of the equations of change to set up steady state heat transfer problems, and (iv) Dimensional analysis of the equations of change. **Temperature distribution with more than one independent variable:** (i) Unstate heat conduction in solids. **Temperature distribution in turbulent flow:** (i) Temperature fluctuations and the time-smoothed temperature, (ii) Time smoothing the energy equation (iii) Semi empirical expressions for the turbulent energy flux. **Interphase transport in non-isothermal systems :** (i) Definition of the heat transfer coefficient (ii) Heat transfer coefficients for forced convection in tubes and around submerged objects, and (iii) Heat transfer coefficients for free convection.

UNIT-III

Mass Transport: Diffusivity & mechanism of mass transport :(i) Definitions of concentrations, velocities, mass fluxes(ii)Fick's law of Diffusion(iii)Temperature & pressure dependence of mass diffusivity.

Concentration distribution in solids and in laminar flow: (i) Shell mass balances - boundary conditions, (ii) Diffusion through a stagnant gas film, (iii) Diffusion with heterogeneous chemical reaction (iv) Diffusion with homogeneous chemical reaction and (v) Diffusion into a falling liquid film.

The equations of change for multicomponent systems:(i) The equations of continuity for a binary mixture (ii) The equations of continuity of A in curvilinear coordinates and (iii) Dimensional analysis of the equations of change for a binary isothermal fluid mixture.

Concentration distributions in turbulent flow:(i)Concentration fluctuations and the time smoothed concentration (ii) Time-smoothing of the equation of continuity of A.

Interphase transport in multicomponent systems:(i)Definition of binary mass transfer coefficients in one phase, (ii) Correlations of binary mass-transfer coefficients in one phase at low mass-transfer rates (iii) Definition of binary mass-transfer coefficients in two phases at low mass-transfer rates, and (iv) Definition of the transfer coefficients for high mass transfer rates.

Text Book:1 Transport Phenomena-R Byron Bird, Warran E Steward&Edwin N Lightfoot, John Wiley & Sons, Inc. New York.

Ref.Books:1.Transport Phenomena-Robert S Brodkey & Harry C Hershey,MGH Co, NY 2.Transport Phenomena for Engineers-LouisTheodore,Int-book Company,London.3. Transport Phenomena-W.J.Book and K.M.K.Multzall,JW&Sons-Ltd,London,; 4.Fundamentals of Momentum, Heat and Mass Transfer-Mames R Welty, Charles E Wicks, Robert E Wilson, J W & Sons Inc. N Y.5. Fluid Dynamics and Heat Transfer by James G Knudsen and Doald L. Katz, MGH Co. Inc., NY.

DMCHE 407: Engineering Economics and Management
(Common with ECE, EEE and Chemical branches)

Unit - I

Fundamentals of Economics: Wealth and Welfare Definitions, Robbins' Scarcity Definition; Micro and Macro Economics; Nature of Economics –Economics as a social science, Laws of Economics, Assumptions in Economics; Mixed Economies; Basic elements of Supply and Demand –Elasticity of Demand and its cases and types, Factors determining price elasticity of Demand.

Unit – II

Industrial Policy of the Government, New Industrial Policy-1991; **Forms of Business Ownership** – Private, Public, and Joint Sector Management; Capital Requirement and Methods of Financing Industry; Cost Concepts – Elements of Costs.

Unit – III

Evolution of Management Thought (schools of thought); Principles and Functions of Management; Forms of Organization; Decision Making Process; Production Planning and Control.

Unit - IV

Plant Location and Plant Layout; Materials Management; Purchasing Organizations; Inventory Control and ABC Selective Control Policy; Break – even Analysis.

Unit - V

Leadership – Characteristics, Formal and Informal leaders and responsibilities and qualities of leadership; **Motivation** – Characteristics, importance, and kinds of motivation; **Communication** –Nature, Process, forms, and steps for making communication effective; wages and Methods of wage payment; Industrial Disputes and their Settlement; Provisions of Factories Act.

Text Books:

1. Sharma, S.C. & Banga, T.R., - Industrial Organization & Engineering Economics
2. Dewett, K.K. – Modern Economic Theory

References:

1. Dwivedi, D.N., Managerial Economics
2. Goal, B.S., Production Operation Management
3. Tara Chand Engineering Economics
4. Allen, L.A. Management and Organization

DMCHE 408: Chemical Reaction Engineering Laboratory

1. Determination of the order of a reaction using a batch reactor and analyzing the data by (a) Differential method (b) integral method.
2. Determination of the activation energy of a reaction using a batch reactor.
3. To determine the effect of residence time on conversion and to determine the rate Constant using a CSTR.
4. To determine the specific reaction rate constant of a reaction of a known order using a batch reactor.
5. To determine the order of the reaction and the rate constant using a Tubular reactor.
6. Determination of RTD and Dispersion number in a Tubular reactor using a tracer.
7. Mass transfer with chemical reaction (solid-liquid system) - Determination of Mass Transfer Co-efficient.
8. Axial mixing in a packed bed. Determination of RTD and the dispersion number for a packed- bed using tracer.
9. Langmuir Adsorption isotherm: Determination of surface area of activated charcoal.
10. Performance of reactors in series: (i) A plug-flow reactor followed by a CSTR (ii) A CSTR followed by a plug flow reactor.

DMCHE 409: Process Dynamics & Control Laboratory

List of Experiments:

1. Response of mercury-in glass thermometer
2. Response of mercury-in glass thermometer with Thermal well.
3. Calibration & Response of Resistance Thermometer
4. Response of Manometer
5. Calibration of Thermocouples
6. Response of Single-Tank Liquid-level system
7. Response of Two-Tank non-interacting Liquid-level system.
8. Response of two tank interacting liquid level system
9. Study of ON-OFF control – Control leroff position.
10. Valve characteristics of equal % control valve
11. Valve characteristics of linear control valve
12. On-Off control – controller on position.
13. Studies on hysteresis characteristics of Bourdon pressure gauze
14. Hysteresis characteristics of equal % control valve
15. Studies on hysteresis characteristics of linear control valve
16. Response studies for different types of controller (P, PI, PID) using PID control trainer.
17. Level Control Trainer
18. Pressure control Trainer
19. Temperature control trainer

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DMCHE 410:Chemical Process & Equipment Design Lab.

The following equipment shall be designed in detail.

1. Double pipe heat exchanger
2. Shell and tube Heat Exchangers (1-2 or 2-4)
3. .Condenser and Reboiler.
4. .Single/Multiple Effect Evaporator
5. Fractionating Column-Plate column
6. .Packed bed absorber
7. .Continuous tubular reactor (Homogeneous and Heterogeneous)

Practical Exam : 3 Hrs. duration open book.

DMCHE 411: Project Work

The project work should consists of a comprehensive design project of a chemical plant in the form of a report with the following chapters.

1. Introduction
2. Physical & Chemical Properties & Uses
3. Literature survey for different processes
4. Selection of the process
5. Material & Energy Balances
6. Specific Equipment Design (Process as well as mechanical design with Drawing)
7. General Equipment Specifications
8. Plant Location and Layout
9. Materials of construction
10. Health and Safety factors
11. Preliminary cost estimation
12. Bibliography.