SIXTH SEMESTER

CHU311 MASS TRANSFER II

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Module 1  
(14 hours)

Module 2  
(10 hours)
Liquid extraction - liquid-liquid equilibrium data, single stage extraction, counter-current multistage extraction (without reflux only) stage efficiency, stage type extractors: agitated vessel, mixer settler cascades, sieve tray towers, spray towers, packed towers. Design of extraction towers.

Module 3  
(9 hours)
Leaching - solid-liquid equilibria, leaching equipment for batch and continuous operations, calculation of number of stages. Leaching by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (Shanks process), equipments for leaching operation, multistage continuous cross current and counter current leaching, stage calculations, stage efficiency.

Module 4  
(9 hours)
Adsorption – types, nature of adsorbents, adsorption equilibria, effect of pressure and temperature on adsorption isotherms, adsorption operations – stagewise operations, steady state moving bed and unsteady state fixed bed adsorbers, break through curves. Novel separation processes - reverse osmosis, dialysis, membrane separation, ion exchange - techniques and applications.

TEXT BOOKS

REFERENCE BOOKS
Module 1
Introduction - kinetics of homogeneous reaction, law of mass action, definition of the rate of reaction, reaction rate constant and the reaction order, elementary reaction and molecularity, non-elementary reaction, search for a mechanism, enzymatic reaction fundamentals, temperature dependency from Arrhenius law, collision theory and transition state theory.

Module 2
Analysis of rate data - batch reactor data, differential method of rate analysis, integral method, method of initial rates, method of half lives and least square analysis with linearization of the rate law, finding the rate law. Conversion and reactor sizing - general mole balance equation, batch reactors, continuous flow reactors, industrial reactors, definition of conversion and design equations for batch and flow systems, applications for space time and space velocity, stoichiometric table.

Module 3
Isothermal reactor design - design structure for isothermal reactors, scale-up of liquid phase, batch reactor data to design of a CSTR, batch operation, design of CSTRs, tubular reactors, multiple reactors system, mixed flow reactors of different sizes in series, design for multiple reactions, conditions for maximizing the desired product in parallel reactions, maximizing the desired product in series reactions, conditions for maximizing the desired product in series and parallel reactions.

Module 4
Non-ideal flow - residence time distribution studies, C, E, F and I curves, conversion calculations directly from tracer studies, models for non-ideal flow-dispersion and tanks in series multi-parameter models.

TEXT BOOKS


REFERENCE BOOKS

Module 1 (12 hours)
General principles of process control, basic control elements, degree of freedom and fixing of control parameters, simple system analysis, Laplace transformation and transfer functions, block diagrams, linearization. Response of first order systems - transfer function, transient response, step response, impulse response, sinusoidal response. Physical examples of first order systems - liquid level, mixing process, linearization. Response of first order systems in series - non-interacting systems, interacting systems, higher order systems - second order and transportation lag, under damped systems, step response, impulse response, sinusoidal response.

Module 2 (11 hours)
The control system - block diagram, servo problem and regulator problem, negative feed back and positive feed back. Controllers and final control elements - ideal transfer functions, proportional, proportional integral and proportional integral derivative controllers, on-off controllers, supervisory control and data acquisition (SCADA), distributed control system (DCS).

Module 3 (10 hours)
Control system design by frequency response - Bode stability criterion, gain and phase margins, Z-N controller settings, advanced control strategies - cascade control, feed forward control, ratio control, Smith predictor, internal model control

Module 4 (9 hours)
Control tuning and process identification - tuning rules (Ziegler-Nichol Rules and Cohen-Coon rules), process identification, step testing, semi-log plots for modeling. Control valves - control valve construction, valve sizing, valve characteristics, effective valve characteristics.

TEXT BOOKS

REFERENCE BOOKS

Module 1
Air pollution - introduction, sources and effects in relation to chemical industry. Behaviour and fate of air pollutants, photochemical smog, effects of air pollution on human beings, plants, animals and materials. Meteorological aspects of air pollution - temperature lapse rates, adiabatic lapse rate, atmospheric stability, inversions, wind velocity and turbulence, topographical effects, plume behaviour, dispersion of air pollutants - fixed box models, diffusion models, Gaussian plume model, plume rise. Air pollution sampling and measurement - types of pollutant sampling and measurement, ambient air sampling - collection of gaseous air pollutants, collection of particulate air pollutants, stack sampling - sampling system, particulate sampling, gaseous sampling, analysis of air pollutants - sulphur dioxide, nitrogen oxides, carbon monoxide, oxidants and oases, hydrocarbons, particulate matter.

Module 2
Air pollution control methods and equipment - source correction methods: raw material changes, process changes, equipment modification, cleaning of gaseous effluents, particulate emission control - collection efficiency, control equipment like gravitational settling chambers, cyclone separators, fabric filters, electrostatic precipitator and their constructional details and design aspects, scrubbers - wet scrubbers, spray towers, centrifugal scrubbers, packed beds and plate columns, venturi scrubbers, their design aspects, control of gaseous emissions absorption by liquids, absorption equipment, absorption by solids, equipment and the design aspects. Control of specific gaseous pollutants - control of sulphur dioxide emissions: extraction of sulphur from fuels, sulphur reduction during combustion, desulphurization of the flue gases. Nitrogen oxides - modification of operating conditions, modification of design conditions, effluent gas treatment methods, carbon monoxide and hydrocarbons, pollution from mobile sources and its control.

Module 3
Sources and classification of water pollutants - water resources, origin of wastewater, types of water pollutants and their effects, water pollution laws and standards. Wastewater sampling and analysis - sampling and methods of analysis, determination of organic matter: dissolved oxygen, BOD, COD, TOC, determination of inorganic matter: nitrogen, phosphorous, trace elements, physical characteristics - suspended solids, colour and odour, bacteriological measurements, water quality standards. Wastewater treatment - basic processes of waste water treatment, primary treatment: pre-treatment, sedimentation, floatation, secondary treatment - activated sludge process, trickling filters, sludge treatment and disposal, advanced waste water treatment - removal of suspended solids, removal of dissolved solids, absorption, solvent extraction, ion exchange, reverse osmosis, electro dialysis, advanced biological systems, recovery of materials from process effluents.

Module 4
Solid waste management - sources, classification and public health aspects of solid waste, methods of collection and disposal, sanitary landfills, incineration and composting, advanced methods of disposal. Hazardous waste management: nuclear wastes - health and environmental effects, sources and disposal methods, chemical wastes - health and environmental effects,
treatment and disposal - treatment and disposal by industry, off site treatment and disposal, treatment practices in various countries, biomedical wastes: types of wastes and their control.

**TEXT BOOK**


**REFERENCE BOOKS**

CHU315 CHEMICAL PROCESS EQUIPMENT DESIGN AND DRAWING

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Module 1  
(3 + 9 hours)  
Design of pressure vessels, tall vessels, self supporting vessels, design of skirt (and other support for vertical vessels).

Module 2  
(4 + 12 hours)  
Process and mechanical design of heat exchangers, evaporators and dryers.

Module 3  
(4 + 12 hours)  
Process and mechanical design of tray and packed distillation and absorption columns.

Module 4  
(3 + 9 hours)  
Process and mechanical design of reactors and filters.

REFERENCE BOOKS

CHU393 MASS TRANSFER LABORATORY

1. Distillation
2. Diffusivity coefficient determination
3. Mutual solubility data
4. Extraction
5. Batch drying
6. Mass transfer in packed tower
7. Mass transfer in spray tower
8. Ion-exchange apparatus
9. V.L.E data
10. Adsorption
11. Absorption studies in packed bed
12. Batch crystallizer
13. Cooling tower
14. Leaching

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1. Estimation of COD, BOD and DO
2. Estimation of alkalinity, hardness and chloride ions in water
3. Characterization of wastewater
4. Estimation of ferrous and sulphate ions in a given sample using spectrophotometer
5. Sampling and analysis of solid waste
6. Sampling and analysis of flue gas
7. Bacterial growth kinetics
8. Electro-deposition of heavy metals
9. Flocculation studies
10. Clarifier
11. Bio-leaching
12. Determination of Sludge Volume Index
The mini project work can be a design/experimental/analytical/simulation project in any topic of Chemical Engineering interest. The work can be done individually or by a group of students under the guidance of a faculty of the department. Maximum number of students in a group shall be three. The faculty coordinator will coordinate the work of all students. Usually, the mini project is allotted at the beginning of the sixth semester and shall preferably be completed before the end of the sixth semester. A committee consisting of three or four faculty of the department will carry out assessment of all mini projects. Students shall present the work carried out by them before the committee. They shall also prepare and submit a project report to the department through their guide.

Industrial training shall be as per norms of the institute. The list of industries where students can undergo training will be approved and published by the department. Period of training will be during vacation without affecting regular class work/examination. During the training, the student shall study/analyse the operation/process/design or the complete industry in detail. They shall submit a report in detail identifying the problems with their suggestion for solution and conclusions to the department through the faculty coordinator assigned for the same at the end of the training period. The minimum duration of industrial training is 4 weeks. A committee consisting of three or four faculty of the department will carry out assessment of the training. Students shall make a presentation before the committee.

**Note:** Industrial Training and Mini Project are two separate credit courses carrying one credit each. Any one of the two is compulsory for the B.Tech programme. Students can also opt for registering and crediting both Mini Project and Industrial Training.