Malaviya National Institute of Technology Jaipur

Curriculum of B.Tech. Chemical Engineering

B.Tech IV Semester Chemical Engineering

S.No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	CHT-202	Heat Transfer	PC	Theory	4	3	1	0
2.	CHT-204	Chemical Reaction Engineering-I	PC	Theory	4	3	1	0
3.	CHT-206	Industrial Pollution Abatement	PC	Theory	3	3	0	0
4.	CHT-208	Fluid Particle Mechanics	PC	Theory	4	3	1	0
5.	CHT-210	Mass Transfer-I	PC	Theory	4	3	1	0
1.	CHP-212	Fluid Particle Mechanics Lab	PC	Lab	2	0	0	3
2.	CHP-214	Heat Transfer Lab	PC	Lab	2	0	0	3
3.	CHP-216	Industrial Pollution Abatement Lab	PC	Lab	2	0	0	3
Total					**25**	**15**	**4**	**9**

Syllabus

SEMESTER – IV

UG	Department: **Chemical Engineering**
Course Code: **CHT202**	Course Name: **Heat Transfer**
Credit: **4**	L-T-P: **3-1-0**
Version: **1**	Approved on:
Prerequisite Course: **Nil**	

Introduction: Modes of heat transfer: conduction, convection, radiation.
Steady-State Conduction in One Dimension: Fourier's Law, thermal conductivity, steady-state conduction of heat through a composite solid, cylinder and sphere. Steady-state heat conduction in bodies with heat sources: plane wall, cylinder and sphere.
Heat Transfer Coefficient: Convective heat transfer and the concept of heat transfer coefficient, overall heat transfer coefficient, heat transfer from extended surfaces, thermal contact resistance, critical insulation thickness, optimum insulation thickness.
Forced Convection: Flow over a flat plate, thermal boundary layer, flow across a cylinder. Dimensional analysis: Buckingham Pi theorem, Dimensional groups in heat transfer. Correlations for the heat transfer coefficient: Laminar flow through a circular pipe, turbulent flow through a circular pipe, flow through a non-circular duct, flow over flat plate, flow across a cylinder, flow past a sphere, flow across a bank of tubes, heat transfer coefficient in a packed and fluidized bed.
Double-pipe heat exchanger in parallel and counter-current flow.
Free Convection: Introduction, heat transfer correlations for free convection: flat surface, cylinder, sphere, enclosure. Combined free and forced convection.
Boiling and Condensation: Boiling phenomenon, nucleate boiling, Correlations for pool boiling heat transfer: Nucleate boiling, critical heat flux, stable film boiling. Forced convection boiling, condensation phenomena, film condensation on a vertical surface, turbulent film condensation, condensation outside a horizontal tube and tube bank. Condensation inside a horizontal tube, effect of non-condensable gases. Dropwise condensation.
Radiation Heat Transfer: Basic concepts of radiation from a surface: black body radiation, Planck's Law, Wien's Displacement Law, Stefan-Boltzmann Law, Kirchoff's Law, Gray body. Radiation intensity of a black body, spectral emissive power of a black body over a hemisphere. Radiation heat exchange between surfaces – the view factor. Radiation exchange between black bodies and between diffuse gray surfaces.
Heat Exchangers: Construction of a shell-and-tube heat exchanger, fouling of a heat exchanger, LMTD, temperature distribution in multi-pass heat exchangers, individual heat transfer coefficients. Types of shell-and-tube heat exchanger.
Evaporators: Types of evaporators: Natural-circulation evaporators, forced--circulation evaporators, falling film evaporators, climbing-film evaporators, agitated thin-film evaporators and plate evaporators. Principles of evaporation and evaporators; Single and multiple effect evaporators, Capacity and economy, Boiling point rise, heat transfer coefficient enthalpy of a solution. Calculations of a single effect evaporator.

Unsteady-State Heat Conduction: Mathematical formulations and initial and boundary conditions. Analytical solution, numerical solution.

Books

1. Dutta, B. K. “Heat transfer: Principles and Applications”, PHI, New Delhi, 2001.

2. Holman, J. P., “Heat Transfer”, McGraw Hill, New York.

3. Chapman, A. J., “Heat Transfer”, Maxwell Macmillan, 1984.

4. Kern, D. Q., “Process Heat Transfer”, Tata- McGraw Hill, 1950.

5. Hewitt, G. F. Sires, G. L. and Bott, T. R. “Process heat transfer”, CRC Press 1994.

UG Department: **Chemical Engineering**
Course Code: **CHT204** Course Name: **Chemical Reaction Engineering-I**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction: Definition of reaction rates, variables affecting reaction rates, classification of reactions, order, molecularity.

Kinetics of Homogenous Reactions: Concentration dependent term of a rate equation, temperature dependent term of a rate equation, searching for a mechanism, reaction mechanism for biochemical and polymerization reactions.

Interpretation of Batch Reactor Data: Constant volume batch reactor, variable volume batch reactor, temperature and reaction rate.

Introduction to Reactor Design

Ideal reactors for single reaction: Ideal batch reactor, steady state Mixed Flow Reactor, steady state PFR, Holding time and space time for flow systems.

Design for single reactions: Size comparison, multiple reactor systems, recycle reactor, auto catalytic reactions.

Design for multiple reactions: Reactions in parallel, reactions in series, series- parallel reactions.

Temperature and Pressure Effects on Reactions: Single reactions: Heat of reaction, equilibrium constants, graphical design procedure, optimum temperature progression, adiabatic operations. Multiple reactions: Product distribution and temperature.

Stability of Multiple Steady-States: Multiple steady-states of a CSTR with a first order reaction; Ignition-extinction curve.

Books

1. Levenspiel, O., "*Chemical Reaction Engineering*" ,3rd ed., John Wiley & Sons, Singapore, 1999.
2. Fogler, H. S., "*Elements of Chemical Reaction Engineering*," 3rd ed., Prentice Hall of India, 2003.
3. Smith, J. M., "*Chemical Engineering Kinetics*", 3rd ed. McGraw Hill, 1981.
4. Richardson, J.F., and Peacock D.G., "*Coulson and Richardson's Chemical Engineering,"* vol. 3, 3rd ed., Asian Books Pvt. Ltd., New Delhi, 1998.

UG Department: **Chemical Engineering**
Course Code: **CHT206** Course Name: **Industrial Pollution Abatement**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction

Wastewater Treatment: Characterization of Industrial wastewater, primary, secondary and tertiary treatment, segregation, screening, equalization, coagulation, flocculation, precipitation, flotation, sedimentation, aerobic treatment, anaerobic treatment, absorption, ion exchange, membrane filtration, electrodialysis, sludge dewatering and disposal methods.

Air Pollution Control: Sources and classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, pollutants from automobiles. Air pollution meteorology, plume and its behavior and atmospheric dispersion, control of particulate emissions by gravity settling chamber, cyclones, wet scrubbers, bag filters and electrostatic precipitators. Control of gaseous emissions by absorption, adsorption, chemical transformation and combustion.

Solid Waste Management: Hazardous and non-hazardous waste, methods of treatment and disposal, land filling, leachate treatment and incineration of solid wastes.

Legislation, standards for water and air.

Books

1. Metcalf & Eddy, Inc., "*Wastewater Engineering: Treatment and Reuse*", 4th ed., Tata McGraw Hill, New Delhi, 2003.
2. Modi, P. N., "*Sewage Treatment and Disposal and Waste Water Engineering*," Vol. II, Standard Book House, Delhi , 2001.
3. Peavy, H. S., Rowe, D. R. , Tchobanoglous, G. , "*Environmental Engineering*" ; McGraw Hill, 1995.
4. De Nevers, N., "*Air Pollution Control Engineering*", 2nd ed., McGraw-Hill, 2000.
5. Bhatia, S.C., "*Environmental Pollution and Control in Chemical Process Industries,"* Khanna Publishers, Delhi, 2001.
6. Mahajan, S. P., "*Pollution Control in Process Industries*," Tata McGraw-Hill, New Delhi, 1998.

UG Department: **Chemical Engineering**
Course Code: **CHT208** Course Name: **Fluid Particle Mechanics**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Size Reduction: Principles of crushing and grinding, Determination of mean particle size and size distribution, Laws of crushing and grinding, Energy required for size reduction, crushing and grinding equipment, closed and open circuit grinding.

Screen Analysis and Size separation: Types of screens, mesh number and size distribution, different types of screening, effectiveness of screen, Particle size analysis, separation efficiency and screening equipment.

Solid-Liquid Separation: Theory of Filtration, Filtration equipment, equations for compressible and incompressible cakes, Constant volume and Constant Pressure Filtration, Press Filter, Rotary drum and vacuum filter. Fiber and fabric filters, sedimentation, classifiers and thickeners, Centrifuges- Principles and applications.

Solid-Gas Separation: Cyclone separators and electrostatic precipitator- Principles and applications.

Fluidization: Fluidization of solids and its applications, Hydraulic and Pneumatic transport of solids.

Mixing: Mixing of liquids and solids, Power requirement in mixing.

Storage and Handling of Materials: Hoppers and bins, Mechanical and pneumatic conveying systems.

Books

1. McCabe, W.L., Smith, J.C., and Harriott, P., "*Unit Operations of Chemical Engineering*", 6th ed., McGraw Hill, 2001.
2. Brown, G. G., et al, "*Unit Operations*," CBS Publishers & Distributors, New Delhi, 1995.
3. Coulson, J. H. and Richardson, J. F., Backhurst, J. R., and Harker, J.H., "*Coulson & Richardson's Chemical Engineering*," Vol. 2, 4th ed., Asian Books Private Ltd., New Delhi, 1998.
4. Perry, R. H. and Green, D.W., "*Perry's Chemical Engineers' Handbook*," 7th ed., McGraw-Hill, 1998.
5. Foust, A.S., et al., "*Principles of Unit Operations*", 2nd ed., John Wiley, Singapore.
6. Chattopadhyay, P. "*Unit Operations of Chemical Engineering*", Vol. I., Khanna Publishers, Delhi, 1998.

UG Department: **Chemical Engineering**
Course Code: **CHT210** Course Name: **Mass Transfer-I**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Physico-chemical basis of separation processes- thermodynamic considerations, stage and continuous contacting operations, concepts of equilibrium stage, operating line and tie line.
Binary Distillation: Ideal and non- ideal stages; definitions of point, stage and column efficiencies. Single stage calculations: differential (Rayleigh) and simple (flash) distillation, liver rule. Steam distillation. McCabe-Thiele diagram; plate calculations, simple and complex fractionators. Ponchon-Savarit Diagram: Adiabatic and non-adiabatic. Absorption, liquid-liquid extraction, adsorption and leaching.
Batch leaching and its similarity to simple leaching. Calculation of stages in a sequence with and without reflux.
Design of Gas-Liquid and Liquid-Liquid Plate Contactors. Flooding, tray layout, ΔP, tray hydraulics, column height and overall design. Flashing equipment design, Multi-component distillation, Azeotropic and extractive distillation, Variable specification and key components, Short-cut methods: Underwood and Gilliland, Feed plate location, Product composition, Matrices and Plate to Plate Calculations: Thiele-Geddes Method.

Books

1. Treybal, R. E., "*Mass transfer operations*", 3rd ed. McGraw-Hill, NY, 1980.
2. King, C. J.," *Separation Processes*", McGraw-Hill, NY.
3. Smith, B. D., "*Design of Equilibrium Stage Processes*", McGraw-Hill, NY.
4. McCabe, W. L., Smith, J. C. and Harriot, P., "*Unit Operations of Chemical Engineering",* 6th ed., McGraw-Hill, NY.
5. Coulson, J. M. and Richardson, J. F., " *Chemical Engineering*", Vol. I and II, 4th ed., Asian Books Pvt. Ltd., New Delhi.