Malaviya National Institute of Technology Jaipur

Curriculum of B.Tech. Chemical Engineering

B.Tech V Semester Chemical Engineering

S.No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	CHT-301	Mass Transfer-II	PC	Theory	4	3	1	0
2.	CHT-303	Chemical Reaction Engineering-II	PC	Theory	4	3	1	0
3.	CHT-305	Optimization of Chemical Processes	PC	Theory	4	3	1	0
4.	CHT-307	Chemical Engineering Thermodynamics-II	PC	Theory	4	3	1	0
5.	CHT-309	Process Equipment Design	PC	Theory	3	3	0	0
1.	CHP-311	Chemical Reaction Engineering Lab	PC	Lab	2	0	0	3
2.	CHP-313	Mass Transfer Lab	PC	Lab	2	0	0	3
3.	CHP-315	Process Equipment Design Lab	PC	Lab	2	0	0	3
Total					**25**	**15**	**4**	**9**

Syllabus

SEMESTER – V

UG Department: **Chemical Engineering**
Course Code: **CHT301** Course Name: **Mass Transfer-II**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Mass Transfer-I**

Fundamentals of Mass Transfer: Molecular diffusion, fluxes and measurement of diffusivities, Equation of continuity and application to diffusion in fluid and solid systems (stagnant film, equimolar, counter, unsteady state etc.).
Convective Mass Transfer: Mass transfer coefficients, Laminar and turbulent flow situations and correlations.
Interphase Mass Transfer: Two film theory and overall mass transfer coefficients, Penetration and surface renewal theories
Continuous Contacting Operations: Gas absorption - countercurrent isothermal, HETP, design equation, (L/G) min, NTU, HTU calculation of NTU, nonisothermal absorption, co-current operation, similarity of other steady operations to gas absorption (i.e. packed tower distillation, moving bed adsorbers).
Design of Continuous Contacting Equipment: Flooding, ΔP, Liquid and gas distributors, entrainment eliminators.
Estimating Stage Efficiencies: AIChE methods, application to stage design.
Simultaneous Heat and Mass Transfer: Humidification and dehumidification, Cooling towers, Drying theory and design, Crystallization.
Introduction to Membrane Separation Processes.

Books

1. Treybal, R. E., "*Mass Transfer Operations,*" 3rd ed., McGraw Hill, Singapore.
2. Geankoplis, C. J., "*Transport Processes and Unit Operations,*" 3rd ed., PHI, New Delhi, 2000.
3. King, C. J., "*Separation Processes*," 2^{ne} ed.., Tata McGraw Hill, New Delhi, 1982.
4. Skelland, A. H. P. "*Diffusional Mass Transfer,*" John Wiley, NY.

UG Department: **Chemical Engineering**
Course Code: **CHT303** Course Name: **Chemical Reaction Engineering-II**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: Chemical Reaction Engineering-I

Non-ideal Flow: Residence time distribution of fluids, General characteristics, Measurement of RTD, RTD in ideal reactor, Tanks-in-series model, Dispersion model, Conversion using RTD data for first order reactions.

Non-catalytic Gas-Solid Reactions: Progressive conversion model, Shrinking core model; various controlling regimes, design of gas-solid reactors.

Catalysts: Description, methods of preparation and manufacture; catalyst characterization – BET surface area, pore volume, pore size distribution.

Catalyst Reaction Kinetic Models: Physical and chemical adsorption; Determination of rate expressions using adsorption, surface reaction and desorption as rate-controlling steps.

Determination of Global Rate of Reaction: Heterogeneous laboratory reactors; Determination of rate expressions from experimental data.

Effect of Intrapellet Diffusion on Reaction Rates in Isothermal Pellets: concept of effectiveness factor, Thiele modulus, experimental determination of effectiveness factor – Weisz-Prater criteria, Non-isothermal effectiveness factor; Prater number, maximum temperature rise in a pellet, multiple steady-states in heterogeneous reactors.

Gas-Liquid Reactions: Effect of diffusion on rate of reaction, enhancement factor.

Introduction to Design of Heterogeneous Reactors: One-dimensional model for fixed-bed reactors, parametric sensitivity; design of fluidized bed reactors.

Books

1. Fogler, H. S., "*Elements of Chemical Reaction Engineering*," 3rd ed., Prentice-Hall of India, Delhi, 2003.
2. Levenspiel, O., "*Chemical Reaction Engineering*," 3rd ed., John Wiley, 1999.
3. Smith, J. M., "*Chemical Engineering Kinetics*," 3rd ed., McGraw-Hill, 1981.
4. Carberry, J. J., "*Catalytic Reaction Engineering*," McGraw-Hill, 1976.
5. Levenspiel, O., "*The Chemical Reactor Omnibook,*" OSU Bookstores, Corvallis Oregon, 1996.

UG
Course Code: **CHT305**
Credit: **4**
Version: **1**
Prerequisite Course: **Nil**

Department: **Chemical Engineering**
Course Name: **Optimization of Chemical Processes**
L-T-P: **3-1-0**
Approved on:

Formulation of the objective function.
Unconstrained single variable optimization: Newton, Quasi-Newton methods, polynomial approximation methods.
Unconstrained multivariable optimization: Direct search method, conjugate search method, steepest descent method, conjugate gradient method, Newton's method.
Linear Programming: Formulation of LP problem, graphical solution of LP problem, simplex method, duality in Linear Programming, two-phase method.
Non linear programming with constraints: Necessary and sufficiency conditions for a local extremum, Quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method.
Use of MS-Excel and MATLAB for solving optimization problems.
Introduction to global optimization techniques.
Applications of optimization in Chemical Engineering.

Books

1. Edgar, T.F., Himmelblau, D. M., Lasdon, L. S., "*Optimization of Chemical Process*", 2nd ed., McGraw-Hill, 2001.
2. Rao, S. S., "*Optimisation Techniques*", Wiley Eastern, New Delhi, 1985.
3. Godfrey, C.O. and Babu, B.V., "New Optimization Techniques in Engineering", Springer-Verlag, Germany, 2004.
4. Beveridge, G. S. and Schechter, R. S., "*Optimization Theory and Practice*", McGraw-Hill, New York, 1970.
5. Reklaitis, G.V., Ravindran, A. and Ragsdell, K. M., "*Engineering Optimization-Methods and Applications*", John Wiley, New York, 1983.

UG Department: **Chemical Engineering**
Course Code: **CHT307** Course Name: **Chemical Engineering Thermodynamics-II**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Chemical Engineering Thermodynamics-I**

Thermodynamic Properties of Fluids: Fundamental property relations, Maxwell's equations, Residual properties, Clapeyron's Equation, Generalized correlations for thermodynamic properties of gases.
Multicomponent Systems: Chemical potential, ideal-gas mixture, ideal solution, Raoult's Law. Partial properties, fugacity and fugacity coefficient, generalized correlations for the fugacity coefficient, excess Gibbs' energy, activity coefficient.
Phase Equilibria at Low to Moderate Pressures: Phase rule, phase behavior for vapor liquid systems, Margules equation, Van Laar equation, Wilson equation, NRTL equation. Dew point, bubble point and flash calculations.
Solution Thermodynamics: Ideal solution, fundamental residual-property relation, fundamental excess-property relation. Evaluation of partial properties. Heat effects of mixing processes. Partially miscible systems.
Chemical Reaction Equilibria: Reaction coordinate, equilibrium criteria to chemical reactions, standard Gibbs' energy change and the equilibrium constant. Effect of temperature on the equilibrium constant, evaluation of equilibrium constants. Relations between equilibrium constants and compositions: gas-phase reactions, liquid-phase reactions. Calculation of equilibrium compositions for single-phase reactions. Multireaction equilibria.

Introduction to Statistical Thermodynamics.

Books

1. Smith, J. M., Van Ness, H. C. and Abbott, M. M., *"Introduction to Chemical Engineering Thermodynamics*", 6th Ed., McGraw-Hill, 2001.
2. Rao, Y.V.C., "*Chemical Engineering Thermodynamics*", University Press, 1997.
3. Rao, Y. V. C., "*An Introduction to Thermodynamics*," John Wiley, 1993.
1. Kyle, B.G., "Chemical and Process Thermodynamics", 3rd ed., PHI New Delhi

UG Department: **Chemical Engineering**
Course Code: **CHT309** Course Name: **Process Equipment Design**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Heat Transfer, Mass Transfer-I, Mass Transfer-II**

Heat Exchangers: Auxiliary calculations; Review of Kern method; Bell's method and HTRI method of Shell-and-tube heat exchanger design; Plate heat exchanger design; Finned tube heat exchanger; Optimization of shell-and-tube heat exchanger.
Reboilers: Design of kettle and thermosyphon reboilers.
Evaporators: Design of single and multi-effect evaporators.
Agitated Vessels: Design of mixing vessels, gas-spraying systems; impellers, propellers, anchors and helical ribbon-type agitators.
Gas-Liquid Contact Systems: Distillation column, Absorption tower, tray hydraulics of sieve and valve trays; Design of packed bed columns.

Books

1. Sinnott, R.K., "Coulson and Richardson's *Chemical Engineering*," Vol. 6, 3rd ed., Butterworth Heinmann, New Delhi, 2002.
2. Kern, D. Q., "*Process Heat Transfer*," McGraw-Hill, 1950.
3. Evans, F. L., "*Equipment Design Handbook*," 2nd ed., Vol. 2, Gulf Publishing, 1980.
4. Smith, B. D., "*Design of Equilibrium Stage Processes*," McGraw-Hill, 1963.