Malaviya National Institute of Technology Jaipur

Curriculum of B.Tech. Chemical Engineering

B.Tech VIII Semester Chemical Engineering

S.No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	CHD-402	Major Project	Project	Theory	12	0	0	12
2.		Advanced Elective-I	AEC	Theory	3	3	0	0
3.		Advanced Elective-II	AEC	Theory	3	3	0	0
4.		Open Elective-III	OE	Theory	3	3	0	0
5.		Open Elective-IV	OE	Theory	3	3	0	0
Total					24	12	0	12

Advanced Elective-I			**Advanced Elective-II**	
CHT-404	Advanced Separation Processes		CHT-412	Advanced Process Control
CHT-406	Polymer Process Modelling		CHT-414	Applied Statistics for Chemical Engineers
CHT-408	Process Safety and Hazards		CHT-416	Catalytic Processes
CHT-410	Process Piping and Design		CHT-418	Process Modifications for Green Technology and Energy Integration

Syllabus

SEMESTER – VIII

Advanced Elective-I

UG Department: **Chemical Engineering**
Course Code: **CHT404** Course Name: **Advanced Separation Processes**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction
Separation process in chemical and Biochemical Industries, Categorization of separation processes, equilibrium and rate governed processes. Introduction to various new separation techniques e.g. Membrane separation, Ion-exchange foam separation, supercritical extraction, liquid membrane permeation, PSA & Freeze drying.

Membrane based Separation Technique (MBSTs)

Historical background, physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization, various types of membranes and modules. Osmosis and osmotic pressure. Working principle, operation and design of Reverse osmosis, Ultrafiltration, Microfiltration , Electrodialysis and Pervaporation. Gaseous separation by membrances.

Ion Exchange
History, basic principle and mechanism of separation, Ion exchange resins, regeneration and exchange capacity. Exchange equilibrium, affinity, selectivity and kinetics of ion exchange. Design of ion exchange systems and their uses in removal of ionic impurities from effluents.

Introduction to foam separation, micellar separation, supercritical fluid extraction, liquid membrane permeation and chromatographic separation.

Books

1. King, C.J., "*Separation Processes*", Tata McGraw-Hill.

2. Sourirajan, S. and Matsura, T., "*Reverse Osmosis and Ultra-filtration - Process Principles*," NRC Publications, Ottawa, 1985.

3. Porter, M. C., "*Handbook of Industrial Membrane Technology*," Noyes Publication, New Jersey, 1990.

4. Henry, J. D. and Li, N. N., "*New Separation Techniques*", AICHE Today Series, AICHE (1975).

5. Hatton, T. A., Scamehorn, J. F. and Harvell, J. H., "*Surfactant Based Separation Processes*", Vol. 23, Surfactant Science Series, Marcel Dekker Inc., New York 1989.

6. McHugh, M. A. and Krukonis, V. J., '*Supercritical Fluid Extraction*", Butterworths, Boston, 1985.

UG Department: **Chemical Engineering**
Course Code: **CHT406** Course Name: **Polymer Process Modelling**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Classification of Polymer Processing Operations. Simple Model Flows for analyzing processing operations with examples. Extrusion and extruders. Calendering, Roller and Blade Coating, Film Blowing. Fiber spinning injection moulding, blow moulding, thermoforming, rotational moulding. Compression and transfer moulding. Reaction injection moulding. Compounding and mixing. Twin screw extruder. Banbury and other mixing equipments in polymer processing.

Books

1. Middleman, S., "Fundamentals of Polymer Processing," McGraw-Hill Book Company, NY, 1977.
2. Morrison, F.A., “Understanding Rheology,” Oxford University Press, 2001.
3. Tadmor, Z. and Gogos C.G., “Principles of Polymer Processing,” Wiley- Interscience, New York, 1979.

UG Department: **Chemical Engineering**
Course Code: **CH408** Course Name: **Process Safety and Hazards**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Origin of process hazards, Laws Codes, Standards, Case Histories, Properties of Chemicals, Health hazards of industrial substances.
Toxicology: Toxic materials and their properties, effect of dose and exposure time, relationship and predictive models for response, Threshold value and its definitions, material safety data sheets, industrial hygiene evaluation.

Fire & explosion: Fire and explosion hazards, causes of fire and preventive methods. Flammability characteristics of chemical, fire and explosion hazard, rating of process plant. Propagation of fire and effect of environmental factors, ventilation, dispersion, purifying and sprinkling, safety and relief valves.

Other Energy Hazards: Electrical hazards, noise hazard, radiation hazard in process operations, hazards communication to employees, plant management and maintenance to reduce energy hazards.
Risk Analysis: Component and plant reliability, event probability and failure, plant reliability, risk analysis, HAZOP AND HAZAN, event and consequence analysis (vapour cloud modelling) Designing for safety, measurement and calculation of risk analysis.

Hazard Assessment: Failure distribution, failure data analysis, modeling for safety, safety training, emergency planning ad disaster management, case studies.

Books

1. Crawl D.A. and Louvar J.A., “Chemical Process Safety Fundamentals with Applications,” Prentice Hall, 1990
2. Wentz, C.A., “Safety Health and Environmental Protection,” McGraw Hill, 2001.
3. Lees, F. P., "Loss Prevention in Process Industries", Vol.1 and 2, 2nd ed., Butterworth, 1996

UG Department: **Chemical Engineering**
Course Code: **CHT410** Course Name: **Process Piping and Design**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Classification of pipes and tubes, IS and BS codes for pipes used in chemical process industries and utilities.
Pipes for Newtonian and non-Newtonian fluids, sudden expansion and contraction effects, Pipe surface roughness effects, Pipe bends, Shearing characteristics.

Pressure drop for flow of Newtonian and non-Newtonian fluids through pipes, Resistance to flow and pressure drop. Effect of Reynolds and apparent Reynolds number.

Pipes of circular and non-circular cross section velocity distribution average velocityand volumetric rate of flow. Flow through curved pipes (Variable cross sections). Effects of pipe fittings on pressure losses.

Non-Newtonian fluid flow through process pipes, Shear stress, Shear rates behaviour, apparent viscosity and its shear dependence, Power law index, Yield Stress in fluids, Time dependant behaviour, Thixotropic and rheopetic behaviour, mechanical analogues, velocity pressure relationships for fluids, line.

Pipe line design and power losses in compressible fluid flow, Multiphase flow, gas-liquid, solid-fluid, flows in vertical and horizontal pipelines, Lockhart-Martinelli relations, Flow pattern regimes.

Books

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering," Vol. I and VI, Butterworth Heinemann, 1999.
2. Govier, G.W. and Aziz K., "The Flow of Complex Mixtures in Pipe," Krieger Publication, Florida, 1982.
3. Green D.W. and Malony, "Perry's, Chemical Engineers Handbook,"7th ed., McGraw Hill, New York 1997.

Advanced Elective-II

UG Department: **Chemical Engineering**
Course Code: **CHT412** Course Name: **Advanced Process Control**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Control systems with Multiple loops: Cascade control, split range control, Feed-forward and Ratio control. Adaptive and Inferential control systems.
Multiple input multiple output (MIMO) control systems; Interaction and Decoupling of control loops; Digital Control systems, Z- Transforms, Discrete-time response of Dynamic Systems, Design of Digital feedback control systems, Process Identification and Adaptive control; Model predictive control.

Books

1. Stephanopoulos, G., "*Chemical Process Control*", Prentice Hall of India, New Delhi, 1990.
2. Seborg, E., Edgar, J. F. and Mellichamp, D. A., "*Process Dynamics and Control*", John Wiley, 1989.
3. Astron, K. J. and Wittenmark, B., "*Computer Controlled Systems*", Prentice Hall, 1994.
4. Coughanowr, D. R., "*Process Systems Analysis and Control*", 2nd Ed., McGraw Hill, NY, 1991.

UG Department: **Chemical Engineering**
Course Code: **CHT414** Course Name: **Applied Statistics for Chemical Engineers**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Elementary concept of statistics, significance tests, Linear regression, hypothesis testing, analysis of variance.
Design of experiments, Nonlinear parameter estimation, Model building and model discrimination.

Books

1. Box, G.E.P., Hunter, W.G., and Hunter, J.S., "*Statistics for Experimenters*," John Wiley and Sons, 1978.

2. Draper, N.R. and Smith, H., "*Applied Regression Analysis*", Volume 1, Wiley, 1998.

3. Holman, J.P."*Experimental Methods for Engineers*", 7^{th} edition, McGraw-Hill, Singapore, 2001.

4. Himmelblau, D.M., "*Process Analysis by Statistical Analysis*," John Wiley and Sons, 1970.

5. Montgomery, D.C., "*Design and Analysis of Experiments*," John Wiley and Sons, 1984.

6. Feller, W., "*An Introduction to Probability Theory*," Vols. 1 and 2, 3rd ed., John Wiley and Sons, 1968.

UG Department: **Chemical Engineering**
Course Code: **CHT416** Course Name: **Catalytic Processes**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Review of Heterogeneous Catalysis.

Transport Processes: Analysis of external transport processes in heterogeneous reactions in fixed bed, fluidized bed and slurry reactors. Intrapellet mass transfer, heat transfer, mass transfer with chemical reaction and simultaneous mass and heat transfer with chemical reaction.

Catalyst Selectivity: Effect of intrapellet diffusion on selectivities in complex reactions, effect of external mass transfer on selectivities.

Catalyst Deactivation: Modes of deactivation – poisoning, fouling and sintering. Determination of deactivation routes, combined effect of deactivation and diffusion on reaction rates, effect of deactivation on selectivity.

Reactor Design: Design calculation for ideal catalytic reactor operating at isothermal, adiabatic and non-adiabatic conditions. Deviations from ideal reactor performance. Design of industrial fixed-bed, fluidized bed and slurry reactors. Thermal stability of packed bed and fluidized bed reactors.

Books

1. Smith, J. M., "*Chemical Engineering Kinetics*," 3rd ed., McGraw-Hill, 1981.
2. Carberry, J. J., "*Catalytic Reaction Engineering*," McGraw-Hill, 1977.
3. Lee, H. H., "*Heterogeneous Catalytic Reactors*," Butterworth.
4. Tarhan, M. O., "*Catalytic Reactor Design*," McGraw-Hill, NY, 1983.
5. Anderson, J. R. and Boudart, M., "*Catalysis, Science and Technology*," Vol. SpringerVerlag,NY.
6. Thomas, J. M. and Thomas, W. J., "*Introduction to the Principles of Heterogeneous Catalysis*," Academic Press, 1967.
7. Gates, B.C., "Catalytic Chemistry," Wiley, New York , 1992.

UG Department: **Chemical Engineering**
Course Code: **CHT418** Course Name: **Process Modifications for Green Technology and Energy Integration**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Heat Transfer, Mass Transfer, Chemical Technology, Pollution Control, Chemical Reaction Engineering**

Different types of contactors and their characteristic features, sections and subsections of a typical chemical plant, start-up and shut-down procedures, typical trouble shooting options associated with different sections. Demonstration of a collection of typical raw materials, intermediates and finished products.

Critical review of industrial contactors; Solvent selections: economic considerations and process requirements for specific cases. Cooling and chilling processes used in various industries, adsorbent selection for specific use, significance of various parts of binary and multi-component (crude) distillation columns, absorption towers, dryers etc. Design variations for drying of milk, fertilizer powder and granules, soap-lye, bricks, cloth, paper etc.

Introduction to Heat Exchanger Networks- Minimum heating and cooling requirements, Minimum number of exchangers, area estimates, Design of minimum-energy Heat Exchanger Networks, Loops and Paths, Reducing the number of exchangers, Stream splitting, Heat and power integration, Heat and distillation.

Process intensification with ultrasound waves: ultrasound, cavitation, sonochemistry, enhancement of chemical reaction, emerging areas, applications and advantages over conventional processes, scale-up issues and limitations,

Exothermic, catalytic and non-catalytic reactors: design methodology and heat recovery options with reference to specific industries, e.g., SO_2 and NH_3 converters, fluid-bed pyrite roaster, kneeder, etc. Design methodology and mode of heat supply to endothermic reactors: cement kiln, lime kiln, reformer, naphtha cracker, water-gas reactor, etc. Process modifications in chlor-alkali industries. Economic and environmental considerations for ethanol production based on petrochemical and agro feed stocks.

Natural gas and its usage for favorable economic and environmental considerations. Variations in the reactor configurations for polyethylene (HDPE and LLDPE) production. Design considerations of a polypropylene reactor for product particle size control.

Books

1. Rao, M. G. and Sittig, M., “Dryden’s Outlines of Chemical Technology”, Affiliated East West Press, 1997.
2. Douglas, J. M., Conceptual Design of Chemical Processes, McGraw Hill, 1988.
3. Austin, G.T., “Shreve’s Chemical Process Industries”, 5th Edn., McGraw-Hill, 1985.
4. Levenspiel, O., “Chemical Reaction Engineering,” 3rd Edn., John Wiley, 1999.
5. Smith, J. M., “Chemical Engineering Kinetics,” 3rd Edn., McGraw-Hill, 1981.
6. Peters, M. S. and Timmerhaus, K. D., Plant Design and Economics for Chemical Engineers, 3rd ed., 1981.