Malaviya National Institute of Technology Jaipur

Curriculum of B.Tech. Chemical Engineering

B.Tech VI Semester Chemical Engineering

S.No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	CHT-302	Process Engineering and Plant Design	PC	Theory	3	3	0	0
2.	CHT-304	Petroleum Refining	PC	Theory	3	3	0	0
3.	CHT-306	Mathematical Methods in Chemical Engineering	PC	Theory	3	3	0	0
4.	CHT-308	Process Dynamics and Control	PC	Theory	4	3	1	0
5.	CHT-310	Chemical Technology	PC	Theory	3	3	0	0
6.	CHT-312	Transport Phenomena	PC	Theory	4	3	1	0
1.	CHP-314	Petroleum Lab	PC	Lab	2	0	0	3
2.	CHP-316	Process Dynamics and Control Lab	PC	Lab	2	0	0	3
3.	CHP-318	Process Engineering and Plant Design Lab	PC	Lab	2	0	0	3
Total					**26**	**18**	**2**	**9**

Syllabus

SEMESTER – VI

UG Department: **Chemical Engineering**
Course Code: **CHT302** Course Name: **Process Engineering and Plant Design**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Chemical Process Calculations, Heat Transfer, Mass Transfer-I, Mass Transfer-II**

Process Design and Development: General design considerations; The hierarchy of chemical process design, the nature of process synthesis and analysis; Developing a conceptual design and finding the best flowsheet: input information and batch versus continuous, Input/output structure of the flowsheet; Recycle structure of the flowsheet; Separation system; Heat Exchanger Networks.
Plant Design: Process design development and general design considerations.
Process Economics: Economic feasibility of project using order-of-magnitude cost estimates, plant and equipment cost estimation, product cost estimation.
Cash Flows: Time value of money, investment, costs, sales, profits, taxes, depreciation.
Profitability Analysis: Rate of return, payback period, discount rate of return, net present worth, internal rate of return, comparing investment alternatives.

Books

1. Douglas, J. M., "*Conceptual Design of Chemical Processes*," McGraw-Hill, 1989.

2. Peters, M. S., Timmerhaus, K. D., and West, R,E., "*Plant Design and Economics for Chemical Engineers*," 5th ed., McGraw-Hill, 2003.

3. Biegler, L., Grossmann, I. E. and Westerberg, A. W., "*Systematic Methods of Chemical Engineering and Process Design*," Prentice Hall, 1997.

4. Seider, W.D., Seader, J.D., and Lewin, D.L., "Product and Process Design Principles: Synthesis, Analysis, and Evaluation," John-Wiley, 2003.

UG Department: **Chemical Engineering**
Course Code: **CHT304** Course Name: **Petroleum Refining**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction: World petroleum resources, petroleum industry in India, origin, exploration, drilling and production of petroleum crude, transportation and pre-treatment of crude oil. Composition and classification of petroleum crude, ASTM, TBP and FEV distillation of crude oil. Properties and specification of petroleum products – LPG, Gasoline, naphtha, kerosene, diesel oil, lubricating oil, wax etc.

Separation Processes: Design and operation of topping and vacuum distillation units. Tube still furnaces. Solvent extraction processes for lubricating oil base stocks and for aromatics from naphtha and kerosene, solvent dewaxing.

Conversion Processes: Thermal and catalytic cracking, vis-breaking and coking processes, reforming, hydro processing, alkylation, polymerization and isomerisation.

Safety and pollution considerations in refineries.

Books

1. Nelson, W. L., "*Petroleum Refinery Engineering*," 4th ed., McGraw Hill, 1987.
2. Garry, J. H. and Handwrek, G. E., "*Petroleum Refining, Technology and Economics*", 2nd ed., Marcel-Dekker.
3. Rao, B.K.B., Modern Petroleum Refining Processes, 4th ed., Oxford, IBH, 2002
4. Watkins, R.N. Petroleum Refinery Distillation, 2nd ed., Gulf Publishing, Houston, TX, 1981
5. Kobe, K. A. and McKetta, J. J., "*Advances in Petroleum Chemistry and Refining*", Wiley Interscience.

UG	Department: **Chemical Engineering**
Course Code: **CHT306**	Course Name: **Mathematical Methods in Chemical Engineering**
Credit: **3**	L-T-P: **3-0-0**
Version: **1**	Approved on:
Prerequisite Course: **Nil**	

Ordinary differential equations (ODE) – Solution of first order and second order differential equations, simultaneous ODEs. Solution by Laplace Transformation. Series solution method.

Complex Algebra: Introduction; The complex number; the Argand diagram; principle values; Algebraic operations on the Argand diagram; Conjugate numbers; De Moivere's theorem; the nth roots of unity; complex number series; Trigonometrical exponential Identities; Derivatives of a complex variable; Analytic functions; complex variable and Cauchy's theorem, Laurent's expansion, and theory of residues. Laplace inverse by Contour integration, Bromwich's integral formula.

Functions and Definite Integrals: Introduction, error function, gamma function, beta function, other tabulated functions defined by integrals; Definite integrals by contour integration.

Vector Analysis: Addition and Subtraction of vectors, Multiplication of vectors, Scalar triple product, Vector triple product, Differentiation of vectors, Partial differentiation of vectors, Divergence, Continuity equation, Curl of a vector, Line integral, Vector area and Surface integral, Gauss' Divergence theorem, Green's theorem. Spherical and Cylindrical coordinate systems. Stream function, Creeping flow around a sphere.

Partial differential equations (PDE)- Classifications of PDEs, Formulating PDEs, Separation of variables method, Orthogonal functions and Sturm-Liouville conditions, The Laplace transform method.

Books

1. Jenson, V.G. and Jeffreys, G.V., "*Mathematical Methods in Chemical Engineering*,"2nd ed., Academic Press, New York, 1977.
2. Rice, R. G. and Do, D. D., "*Applied Mathematics and Modeling for Chemical Engineers*", John Wiley & Sons, New York, 1995.
3. Varma, A. and Morbidelli, M., "*Mathematical Methods in Chemical Engineering*," Oxford University Press, New York, 1997.
4. Kreyszig, E., "*Advanced Engineering Mathematics*," 8th ed., John Wiley & Sons, 2000.
5. Mickley, H.S., Sherwood, T.K., and Reed, C.E., "*Applied Mathematics in Chemical Engineering*," McGraw-Hill, 1957.

UG Department: **Chemical Engineering**
Course Code: **CHT308** Course Name: **Process Dynamics and Control**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction to process control and review of Laplace transforms.

Linear Open-Loop Systems

First-Order Systems: Transfer function, transient response (step response, impulse response, sinusoidal response), examples of first-order systems, response of first-order systems in series: non-interacting systems and interacting systems.

Second-Order Systems: Transfer function, step response, impulse response, sinusoidal response, transportation lag.

Linear Closed-Loop Systems

Control system: Components of a control system, block diagram, negative feedback and positive feedback, servo problem and regulator problem.

Controller and final control element: Mechanism of control valve and controller, transfer functions of control valve and controllers (P, PI, PD, PID) Example of a chemical-reactor control system.

Closed-Loop Transfer Functions: Overall transfer function for single-loop systems, overall transfer function for set-point change and load change, multi-loop control systems.

Transient Response of Simple Control Systems: P and PI control for set-point change and for load change.

Stability: Concept of Stability; Stability criteria; Routh test for stability; Root Locus.

Frequency Response

Introduction to Frequency Response, Bode Diagrams for first- and second-order systems, Bode Stability Criteria, Ziegler-Nichols and Cohen-Coon Tuning Rules.

Books

1. Coughanowr, D. R., "*Process Systems Analysis and Control*", 2nd ed., McGraw Hill, 1991.
2. Stephanopoulos, G., "*Chemical Process Control*", PHI, New Delhi, 1984.
3. Luyben, W. L., "*Process Modeling, Simulation and Control for Chemical Engineers*," McGraw Hill, 1973.

UG Department: **Chemical Engineering**
Course Code: **CHT310** Course Name: **Chemical Technology**
Credit: **3** L-T-P: **3-0-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

Introduction to Chemical Engineering: Unit operations and unit processes, functions of a Chemical Engineer, new emerging areas.

Study of the following chemical industries/processes involving process details, production trends, thermodynamic considerations, material and energy balances, flow sheets, engineering problems pertaining to materials of construction, waste regeneration/recycling, and safety, environmental and energy conservation measures.
Industrial Gases: Hydrogen, producer gas and water gas.

Nitrogen Industries: Ammonia, nitric acid, nitrogenous and mixed fertilizers.

Chlor-Alkali Industries: Common salt, caustic soda, chlorine, hydrochloric acid, soda ash.

Sulphur Industries: Sulphuric acid, oleum.

Cement Industries: Portland cement.

Petrochemicals: Formaldehyde, ethylene oxide, ethylene glycol, acrylonitrile, styrene, butadiene.
Agrochemicals: Important pesticides, BHC, DDT, Malathion.

Alcohol Industries: Industrial alcohol, Absolute alcohol.

Oils and Fats: Oils, Fats and Waxes, Soaps and Detergents.

Pulp and Paper Industry

Books

1. Rao, M.G. and Sittig, M., "*Dryden's Outlines of Chemical Technology*", Affiliated East West Press, 1997.
2. Austin, G.T., "*Shreve's Chemical Process Industries*", 5th ed., McGraw-Hill, 1985.
3. Faith, W.L., Keyes, D.B. and Clark, R.L., "*Industrial Chemicals*", 4th Ed., John Wiley.
4. Kirk-Othmer Encyclopedia of Chemical Technology.

UG Department: **Chemical Engineering**
Course Code: **CHT312** Course Name: **Transport Phenomena**
Credit: **4** L-T-P: **3-1-0**
Version: **1** Approved on:
Prerequisite Course: **Nil**

1. Continuum fluids, Newton's law of viscosity, Introduction to non-Newtonian fluids, pressure and temperature dependency of viscosity, viscosity of gases at low density, Laminar flow, shell momentum balance, boundary conditions, selected applications. Equations of change for isothermal systems – Navier-Stokes equation, use of equations of change to set up steady state flow problems with Newtonian fluids, friction factor, similarity and dimensionless parameters, Buckingham pi-theorem, Microscopic mass, momentum and energy balance for isothermal systems, Bernoulli's equation, compressible flow, pipe flow.
2. Shell energy balances, Fourier's Law of heat conduction, boundary conditions. Application to steady and unsteady problems, convective heat transfer, heat transfer coefficients for forced convection around submerged objects, for free convection for condensation of pure vapours on solid surface. Macroscopic energy balance, Bernoulli's Equation, parallel/counter flow heat exchanger – concepts, heating of a liquid in an agitated tank, similarity parameter.
3. Fick's Law of diffusion, analogy with heat transfer, shell mass balances, boundary conditions, applications, species continuity equation, conductive mass transfer, mass transfer coefficients, applications, correlations, macroscopic balances and application to solve steady state problems.

Books

1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "*Transport Phenomena*," 2nd ed., John Wiley, Singapore, 2002.

2. Thomson, W. J., "*Introduction to Transport Phenomena*," Pearson Education Asia, 2000.

3. Brodkey, R. S. and Hershey, H. C., "*Transport Phenomena: A Unified Approach*," McGraw-Hill, NY, 1988.