# SYLLABUS
# OF
# B.TECH. CHEMICAL ENGINEERING

(Effective from 2005-2006 & onwards)

Approved by
Board of Studies
on
December 23 & 24, 2004

**(Incorporating New Numbering System)**

**BANARAS HINDU UNIVERSITY**
**DEPARTMENT OF CHEMICAL ENGINEERING & TECHNOLOGY**
INSTITUTE OF TECHNOLOGY
Varanasi 221005

# B.TECH. IN CHEMICAL ENGINEERING

## Course Structure

### B.Tech. Part II Semester III

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| AM2102A: Numerical Methods | 3 | 3 |
| EC2102A: Electronics and Instrumentation | 3 | 3 |
| CH2101: Materials Science | 3 | 3 |
| CH2102: Fluid Flow Operations | 3 | 3 |
| CH2103: Process Calculations | 4 | 4 |
| CH2104: Chemical Engineering Thermodynamics | 4 | 4 |
| ***Practical:*** | | |
| EC2302A: Electronic & Instrumentation Laboratory | 3 | 2 |
| CH2301: Computer Applications Laboratory | 3 | 2 |
| **Total for Semester III** | **26** | **24** |

### B.Tech. Part II Semester IV

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| AM2202A: Mathematical Methods | 3 | 3 |
| EE2202A: Electrical Engineering | 3 | 3 |
| CH2201: Physico-Chemical Principles | 3 | 3 |
| CH2202: Fluid Particle Mechanics & Mechanical Operations | 3 | 3 |
| CH2203: Mass Transfer Operations- I | 4 | 4 |
| CH2204: Heat Transfer Operations | 4 | 4 |
| ***Practical:*** | | |
| EE2402A: Electrical Engineering Laboratory | 3 | 2 |
| CH2401: Chemical & Instrumental Analysis Laboratory | 3 | 2 |
| CH2402: Fluid Flow & Mechanical Operations Laboratory | 3 | 2 |
| **Total for Semester IV** | **29** | **26** |
| **Total for B.Tech. Part II** | **55** | **50** |

**B.Tech. Part III Semester V**

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| CH3101: Process Instrumentation | 3 | 3 |
| CH3102: Process Dynamics and Control | 4 | 4 |
| CH3103: Energy Resources and Utilization | 3 | 3 |
| CH3104: Chemical Reaction Engineering - I | 3 | 3 |
| CH3105: Chemical Technology - I | 3 | 3 |
| CH3106: Mass Transfer Operations - II | 4 | 4 |
| ***Practical:*** | | |
| CH3301: Heat Transfer Laboratory | 3 | 2 |
| CH3302: Energy Resources Laboratory | 3 | 2 |
| CH3303: Mass Transfer Laboratory | 3 | 2 |
| **Total for Semester V** | **29** | **26** |

Industrial visit will be organized during the inter-semester break

**B.Tech. Part III Semester VI**

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| HU* Open Elective | 3 | 3 |
| CH3201: Polymer Science and Technology | 3 | 3 |
| CH3202: New Separation Processes | 3 | 3 |
| CH3203: Chemical Reaction Engineering – II | 3 | 3 |
| CH3204: Chemical Technology – II | 4 | 4 |
| CH3205: Equipment Design | 4 | 4 |
| ***Practical:*** | | |
| CH3401: Chemical Reaction Engineering Laboratory | 3 | 2 |
| CH3402: Chemical Technology Laboratory | 3 | 2 |
| CH3403: Instrumentation and Process Control Laboratory | 3 | 2 |
| CH3404: Industrial Visit Viva–voce | - | 1 |
| **Total for Semester VI** | **29** | **27** |
| **Total for B.Tech. Part III** | **58** | **53** |

***** Any one of the following:

HU3201: History of Science and Technology
HU3202: Industrial and Organization Psychology
HU3203: Intellectual Property Rights
HU3204: Energy Management
HU3205: Industrial Sociology
HU3206: Ethics, Philosophy and Values
HU3207: Entrepreneurship Development

**B.Tech. Part IV Semester VII**

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| ME4102A: Engineering Economics and Management | 3 | 3 |
| CH4101: Transport Phenomena | 4 | 4 |
| CH4102: Industrial Pollution and Control | 4 | 3 |
| CH Elective I* | 3 | 3 |
| ***Practical:*** | | |
| CH4301: Project-I | 3 | 2 |
| CH4302: Industrial Pollution and Control Laboratory | 3 | 2 |
| CH4303: Seminar/ Group Discussion | 3 | 2 |
| CH4304: In-Plant Training Viva-voce | - | 2 |
| **Total for Semester VII** | **23** | **22** |

*Any one of the following:

CH4103: Biochemical Engineering
CH4104: Petroleum Refinery Engineering
CH4105: Solar Energy Engineering
CH4106: Corrosion Engineering
CH4107: Fluidization Engineering
CH4108: Fertilizer Technology

**B.Tech. Part IV SemesterV III**

| Subjects | Contact hrs/week | Credits |
|---|---|---|
| ***Theory:*** | | |
| CH4201: Modeling, Simulation and Optimization | 4 | 4 |
| CH4202: Safety and Hazard Analysis | 3 | 3 |
| CH4203: Process Engineering and Plant Design | 4 | 4 |
| CH Elective II** | 3 | 3 |
| ***Practical:*** | | |
| CH4401: Project –II | 9 | 6 |
| CH4402: Computer Aided Design and Simulation Laboratory | 3 | 2 |
| CH4403: Comprehensive Viva -voce | 0 | 2 |
| **Total for Semester VIII** | **26** | **24** |
| **Total for Part IV** | **49** | **46** |
| **Total for B.Tech. Part II - IV** | **162** | **149** |

**Any one of the following:

CH4204: Process Intensification
CH4205: Multicomponent Distillation
CH4206: Computer Process Control
CH4207: Computational Fluid Dynamics
CH4208: Surface Coatings
CH4209: Heterogeneous Catalysis

## Courses of Study

### B.Tech. Part II Semester III

**AM2102A: Numerical Methods (Credits : 3)**

Absolute, relative, round-off, and truncation errors; Significant digits; Estimation of errors; Tabulation of a function.

Interpolation: Ordinary differences; Operators E and D, divided differences; Lagrange's formula; Central differences; Formulae of Gauss, Bessel, and Evertt; Method of least squares; Cubics splines; Inverse interpolation.

Solution of algebraic and transcendental equations: Graphical method; Interactive methods; Newton-Raphson method; Multiple roots.

Solution of systems of linear equations: Method of elimination; Method of relaxation; Iterative methods; Ill-conditioned systems; Computing the inverse matrix; Eigenvalues and eigenvectors; Matrix decomposition.

Numerical differentiation and numerical integration: Finite difference methods; Gaussian quadrature; Euler-Maclaurin series; Asymptotic expansions; Newton-Cotes formula.

Numerical solution of ordinary differential equations: Series solution; Methods of Milne, Adams-Bashforth, Milne-Simpson multi-step, and Runge-Kutta methods.

Differences equations: Numerical solution; Relaxation method.

Solution of partial differential equations by finite difference methods.

Numerical solution of elliptic, parabolic and hyperbolic partial differential equations.

Books:


1. Sastry S.S., "Numerical Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Jain M.K., "Numerical Methods for Scientific and Engineering Computation", New Age International Publishers, New Delhi.


**EC2102A: Electronics and Instrumentation (Credits : 3)**

Semiconductor diode characteristics; Load lime; Half wave and full wave rectifiers; Filters.

Power supply; Regulators (723).

Amplifying devices (BJT, FET) and their characteristic with LF equivalent circuits.

Single stage and multi stage RC coupled amplifiers (including types of coupling); Calculation of voltage gain; Impedance; Frequency response; Feedback; High input impedance circuits.

Oscillators.

Operational amplifiers and its application; Filters; V.C.O. and PLL.

Timer and applications to systems.

Logic gates and basic logic circuits (SSI, MSI and basis systems ICs).

Transducers.

Cathode ray oscilloscope and multimeters (Analogue and digital).

A/D and D/A for instrumentation.

**CH2101: Materials Science (Credits : 3)**

Crystalline state: Atomic bonding: Bravias lattices; Miller indices; Structure of some common

inorganic compounds and elemental solids; X-ray diffraction and Bragg's law.

Structural imperfections: Point defects in crystals; Dislocations; Twins; Stacking faults; Grain boundary.

Elementary ideas about electrical, thermal and magnetic properties of materials

Mechanical properties of metals: Elastic and plastic deformations; Failures in metals; Fatigue; Creep. Phase diagrams: Binary system; Ceramic and ternary phases; Iron - carbon system; Phase transformations.

Thermal processing of metal alloys: Annealing; Thermal treatment of steels; Precipitation hardening.

Ferrous and non-ferrous alloys.

Ceramic: Structure, application and processing; Clays; Refractories; Abrasives; Cement.

Introduction to nano-materials and structure sensitive materials.

Books:


1. Raghavan, V., "Materials Science and Engineering", Prentice Hall of India, New Delhi.
2. VanVlack, L.H., "Materials Science for Engineers", Addison-Wesley Publishing Co.


**CH2102: Fluid Flow Operations (Credits : 3)**

Units and dimensions; Properties of fluids; Classification of fluids; Principles governing fluid flow; Forces acting on fluid element; Fluid statics; Manometers.

Flow of fluids: Laminar and turbulent flows; Pressure drop and friction factor; Velocity profiles; Conservation of mass, momentum and energy- integral and differential approaches; Mechanical energy balance and Bernoulli's equation.

Flow past immersed bodies: Drag force and drag coefficient; Terminal and settling velocities; Hindered settling.

Introduction to boundary layer theory.

Dimensional analysis; Dimensionless numbers and their physical significance; Similitude criterion.

Specifications of standard pipes and tubes; Economic pipe diameter; Pipe fittings and valves; Pressure drop in pipe network system.

Flow of compressible fluid: Isentropic expansion; Adiabatic and isothermal frictional flow.

Flow measuring devices: Area meters; Head meters; Mass flow meter; Hot-wire anemometer.

Mixing of fluids: Types of mixers and their selection; Power requirements.

Pumps, blowers and compressors: Working principles; Characteristics; Selection.

Books:


1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall Inc.
4. Shames, I.H., "Mechanics of Fluids", McGraw-Hill, Inc.


**CH2103: Process Calculations (Credits : 4)**

Unit and dimensions; Conservation of mass and energy; Problem solving techniques; Computer based tools; Sources of data.

Ideal gas law; Real gas relationships; Vapour pressure; Vapour-liquid equilibria for binary and multi-component systems; Saturation; Partial saturation and humidity.

Overall and component material balances; Material balance with and without chemical reactions; Material balance involving multiple subsystems; Recycle, bypass and purge; Material balance involving phase change.

Enthalpy changes; Energy balance with and without chemical reactions; Reversible process and mechanical energy balance; Heats of solution and mixing; Humidity charts and their use in solving humidification, dehumidification and water cooling problems.

Combustion; Adiabatic flame temperature.

Degrees of freedom in steady-state processes; Simultaneous material and energy balance problems using flow sheeting codes; Unsteady state material and energy balances.

Material and energy balance calculations of some selected process plants such as sulfuric acid, ammonia, urea, caustic soda etc.

Books:


1. Bhatt, B.L. and Vora, S.M., "Stoichiometry", Tata McGraw-Hill Publishing Co., New Delhi.
2. Hougen, O.A., Watson. K.M. and Ragatz, R.A., Chemical Process Principles Part-I", John Wiley & Sons, (CBS Publishers & Distributor, New Delhi).
3. Himmelblau, D.M., "Basic Principles and Calculation in Chemical Engineering", Prentice Hall, Inc.
4. "Process Calculation for Chemical Engineering", Second Revised Edition, Chemical Engineering Education Development Centre, I.I.T., Madras.


**CH2104: Chemical Engineering Thermodynamics (Credits : 4)**

Review of laws of thermodynamics and their applications; Tthermodynamic analysis of processes.

Thermodynamic properties of fluids and their interrelationship: PVT behaviour of pure substances; Equation of state; Generalized correlations and acentric factor; PVT behaviour of mixtures; Thermodynamics charts; Estimation of thermodynamic properties.

Solutions: Partial molal properties; Chemical potential; Gibbs-Duhem equation; Ideal and non-ideal solutions; Fugacity and fugacity coefficient; Activity and activity coefficient; Excess properties of mixtures.

Phase equilibra: General criterion for equilibrium and their application; Stability constraints; Gibbs phase rule and its derivation for reacting and non-reacting systems; Vapour-liquid, liquid-liquid, and vapour- solid equilibrium for ideal and non-ideal systems.

Chemical equilibrium: Chemical equilibrium constants; Homogeneous and heterogeneous reactions; Standard Gibbs free energy change; Equilibrium conversion in single and multiple reactions

Statistical thermodynamics: Distribution of molecular states, internal energy and entropy; Partition function; Estimation of mean energies, heat capacities, equation of state, residual entropies, and equilibrium constant.

Books:


1. Smith, J.M., Van Ness, H.C., and Abbott, M.M.,"Introduction to Chemical Engineering Thermodynamics",McGraw-Hill, Inc..
2. Kyle, B.G., "Chemical and Process Thermodynamics", Prentice Hall, Inc.
3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., " Chemical Process Principles Part II", John Wiley & Sons, (CBS Publishers & Distributors, New Delhi).


**EC2302A: Electronic & Instrumentation Laboratory (Credits : 2)**

Selected laboratory experiments based on course EcE-211A: Electronics and Instrumentation.

**CH2301: Computer Applications Laboratory (Credits : 2)**

Solution of some selected chemical engineering problems to develop skill for computer applications, programme writing and numerical analysis.

Use of commercial software packages such as Mathcad, Matlab, Aspan Plus, Design II, etc..

**B.Tech. Part II Semester IV**

**EE2202A: Electrical Engineering (Credits : 3)**

***Electrical circuits:***

Network elements: Voltages and current sources; Kirchoffs voltage and current law; Loop and nodal analysis; Superposition theorem; Thevenin's theorem; Norton's theorem; Maximum power transfer theorem.

Sinusoidal steady state analysis: R, L&C elements; Power and power factor: Phasor diagram; Resonance; Mutual inductance and coefficient of coupling.

Three phase circuits: Line and phase relationship; Power measurement.

***Electrical Machines:***

Constructional features of static and rotating machines; Statically and dynamically induced EMF.

Transformer: Principal of working; EMF equation; Equivalent circuit; Voltage regulation and efficiency; O.C., S.C. and direct load test; Autotransformer.

D.C. Machines: Constructional features of D.C. generator and motor; No-load magnetization; External characteristics; D.C. motor- starting, speed torque characteristics, speed control, applications.

Induction Machines: Principal of operation; Constructional details; Torque-slip characteristics; Starting and speed control.

Synchronous machines: Constructional features; Voltage regulation of alternator and its determination by synchronous impedance method; Synchronous motor- starting, V and inverted V-curves, applications.

Distribution of electrical power: Tariff calculation.

Electrical Measurement: Introduction to indication instruments; Ammeter, voltmeter, wattmeter, energy meter.

Books:


1. Kothari, D.P.and Nagrath, I J, "Electrical Machines", Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. huges, E., "Electrical Technology", Orient Longman.
3. Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall, Inc.
4. Cotton, H., "Advanced Electrical Technology", Isaac Pitman & Sons.


**AM2202A: Mathematical Methods (Credits : 3)**

Differential Equations: Solution in series; Bessel functions of first, second and third kind; Legendre and Hermite polynomials and their elementary properties; Orthogonality of $J_n(x)$ and $P_n(x)$.

Integral Transforms and their applications: Laplace transforms, Z – transforms and Fourier transforms; Convolution; Application to ordinary and partial differential equations; Initial and boundary value problems by operational methods.

Complex Variable: Conformal mapping; Bromwich Contour Integral.

Partial Differential Equations: One dimensional wave and diffusion equations; Laplace equation in cartesian and polar co-ordinates.

Probability and Statistics: Probability distributions and their applications; Binomial, Poisson, Normal, Gamma, and Weibull distributions; Joint probability distributions of two variables; Simple linear regression and correlation analysis.

Books:


1. Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons.
2. Kapur, J. N. and Saxena, H. C. "Mathematical Statistics", S. Chand & Co. Ltd., New Delhi.
3. Miller, I. and Freund, E. F. "Probability and Statistics for Engineers", Prentice Hall, Inc.


**CH2201: Physico-Chemical Principles (Credits : 3)**

Change of state: Pure materials- Phase stability (Solid-liquid, Liquid-gas, Gas-solid, and Gas-liquid-solid equilibria); Bubbles Drops; Capillary action.

Simple mixtures: Partial molar quantities, Theory of mixing; Solution of non-volatile solutes; Colligative properties; Mixture of volatile liquids; Phase rule and phase equilibria.

Ionic equilibria: Activity of common ions in solution; The Deby-Huckel theory; Role of electrodes; Electrical potential at interface; Electrochemical cells; Standard Electrode potential; Reference electrodes; Thermodynamic properties from cell EMF; Simple applications of EMF measurement.

Electro-kinetic phenomena: Ion Transport, Conductivity and Ionic Interactions; Conductometric titration; Processes at electrode (Electrical double layer, Rate of charge transfer, Over potential and other related aspects); Electrochemical processes; Power generation and storage (Fuel cells, Storage batteries); Corrosion and electrolysis (Elementary idea only).

Colloids: Preparation, purification and properties (Structure, surface and stability).

Adsorption at surfaces: Growth and structure of solid surfaces; Physical adsorption, and chemical adsorption; Extent of adsorption and adsorption isotherms; Chromatography and chromatographic methods of analysis.

Atomic and molecular spectra: Spectra of simple and complex atoms; General features of spectroscopy; Rotation and vibration of molecules; Electron Spin and Nuclear Magnetic Resonance, Atomic absorption spectroscopy; UV and Visible spectro-photometry; IR absorption spectroscopy; Fluorescence spectroscopy; Mass spectroscopy; Emission spectroscopy; Introduction to NMR spectroscopy; Raman spectroscopy; Moss Bauer spectroscopy.

Books:


1. Khandpur, R.S., "Handbook of Analytical Instruments", Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Ewing, G.W., "Instrumental Methods of Chemical Analysis", McGraw-Hill Book Co.
3. Atkins, P.W., "Physical Chemistry", Oxford University Press.
4. Barrow, G.M., "Physical Chemistry", McGraw-Hill, Inc.


**CH2202: Fluid Particle Mechanics and Mechanical Operations (Credits : 3)**

Particle size and shape: Measurement and analysis; Screening and screen analysis; Screen effectiveness; Design of industrial screening equipment.

Size Reduction: Crushing, grinding, pulverization, ultrafine grinding, grindability; Crushing efficiency, power requirement and equipment selection.

Particle separation: Sedimentation; Free and hindered settling; Thickeners and settling chambers; Characteristics of rotating fluids; Centrifuges, cyclone separators, bag filters; Electrostatic

precipitator.

Flow through porous media; Constant pressure and constant rate filtration; Compressible and incompressible cakes; Filtration rate calculation; Filtration equipment.

Flow through packed bed; Packing materials and their characteristics; Bed porosity and packing area; Pressure drop, flooding and loading.

Fluidization: Pressure drop and minimum fluidization velocity; Liquid and gas fluidization.

Solid handling: Storage of solids- bins, cellos, hoppers; Transport of solids- screw and belt conveyors, pneumatic and hydraulic transport.

Mixing of solids and pastes.

Books:


1. Coulson, J.M., and Richardson, J.F., "Chemical Engineering, Volume 2", Pergamon Press.
2. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill Inc.
3. Brown, G.G., " Unit Operations", CBS Publishers & Distributors, New Delhi.


**CH2203: Mass Transfer Operations - I (Credits : 4)**

Molecular and eddy diffusion; Mass transfer flux and rate; Diffusivity of gases and liquids.

Interphase mass transfer: Individual and overall mass transfer coefficients; Stagnant film, penetration and surface renewal models; Wetted-wall columns.

Gas-liquid contactors: Sparged vessels; Mechanically agitated vessels; Plate columns; Packed columns.

Gas absorption and stripping: Equilibrium relations; Operating lines; Absorption factor, HETP; Plate efficiency; Design of plate and packed columns.

Humidification and dehumidification operations; Design of cooling towers.

Drying: Internal flow of moisture; Surface evaporation and shrinkage; Drying rates; Batch and continuous driers.

Crystallization: Nucleation and crystal growth; Controlled growth of crystals; Industrial crystallizers.

Books:


1. Trebal, R.E. "Mass Transfer Operations", McGraw-Hill, Inc.
2. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
3. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 1 and 2, Pergamon Press.
4. Foust, A.S. Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., "Principles of Unit Operations", John Wiley & Sons, Inc.
5. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall, Inc.
6. Welty, J.R., Wicks, C.W., Wilson, R.E. and Rorrer, G., "Fundamentals of Momentum Heat and Mass Transfer", John Wiley & Sons.


**CH2204: Heat-Transfer Operations (Credits : 4)**

Mechanism of heat transfer; Heat transfer flux and resistance.

Conduction: Thermal conductivity; Fourier's law of conduction; Conduction through plane, cylindrical and spherical and composite walls; Heat losses and insulation; Critical insulation thickness; Selection of insulating materials

Convection: Natural and forced convection; Individual film and overall heat transfer coefficients;

Convection in laminar and turbulent flows; Introduction to thermal boundary layer.

Heat exchanger: Types of heat exchangers; Co-current and counter-current flows; Equivalent diameter; Fouling factors; Process design of heat exchangers including double pipe heat exchanger, shell and tube heat exchanger, extended surfaces and cross flow heat exchangers.

Batch and unsteady state heat transfer in jacketed and coiled agitated vessels.

Heat transfer with phase change: Filmwise and dropwise condensations; Condensation of single component vapour on plates, and outside and inside tubes; Process design of condensers; Boiling regimes; Reboilers and vaporizers.

Evaporators: Types; Single and multiple effects: Boiling point rise; Feeding; Steam economy; Process design of evaporators.

Heat transfer equipment auxiliaries: Steam trap;

Radiation: Radiant energy-distribution; Black body; Emissive power; Exchange of energy between two surfaces; View factor; Furnace calculations.

Combined heat transfer by conduction, convection and radiation.

Books:


1. Holman J.P. "Heat Transfer", McGraw-Hill, Inc.
2. Kern, D.Q., "Process Heat Transfer", McGraw-Hill, Inc.
3. Coulson, J.M., and Richardson, J.E., "Chemical Engineering", Volume l., Pergamon Press.
4. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall, Inc.
5. Welty, J.R., Wicks, C.W., Wilson, R.E. and Rorrer, G., "Fundamentals of Momentum Heat and Mass Transfer", John Wiley & Sons.


**EE2402A: Electrical Engineering Laboratory (Credits : 2)**

Selected laboratory experiments based on course EE 221A: Electrical Engineering.

**CH2401: Chemical and Instrumental Analysis Laboratory (Credits : 2)**

Selected laboratory experiments involving analysis of industrial raw materials, intermediates, end- and by-products and wastes using chemical and instrumental methods.

**CH2402: Fluid Flow and Mechanical Operations Laboratory (Credits : 2)**

Se1ected laboratory experiments based on flow measurement devices for gases and liquids, compressor and pump characteristics, friction losses and flow behaviour in pipes and fittings, mixing and agitation characteristics, Newtonian and non-Newtonian fluid flow and rheological behaviour, performance of filter equipment, hydrodynamics of packed and fluidized bed, settling characteristics of particles, suspension of slurries, sieving and screen analysis, and size reduction equipment.

## B.Tech. Part III Semester V

**CH3101: Process Instrumentation (Credits : 3)**

Introduction to process variables; Static and dynamic characteristics of instruments and their genera1 classification.

Elements of measuring system and their functions; Signal transmission; Transmitters - Electronic,

pneumatic, transducers.

Principles, construction and operations of instruments for the measurement, transmission, control/ indication/ recording of various process variables such as temperature, pressure, flow, liquid level, humidity and composition.

Principles and construction of electro-pneumatic transducer, pneumatic to electrical converter, multiplexers.

Construction and characteristics of final control elements such as pneumatic control valve, stepper moter, motorized valve.

Principles and construction of pneumatic and electronic controller.

Introduction to data acquisition system and intelligent instruments.

Process instrumentation diagrams and symbols: Instrumentation of process equipments such as distillation column, heat exchanger etc.

Books:


1. Patranabis, D, "Principles of Industrial Instrumentation", Tata McGraw-Hill Publishing Co. Ltd.
2. Beckwith, T.G., Marangoni, R.D. and Lienhard, J.H., "Mechanical Measurements", Addison Wesley.
3. Jain, R.K., "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi
4. Johnson, C.D., "Process Control Instrumentation Technology", Pearson Education, Inc.


**CH3102: Process Dynamics and Control (Credits : 4)**

Dynamic modeling of first and second-order process; Interacting and non-interacting processes; Nonlinear and integrating processes; introduction to non-minimum phase processes; Distributed parameter processes and MIMO processes;Response of first and second order processes with respect to different types of forcing functions.

Experimental estimation of dynamic process parameters and identification.

Modes of control action: Classification of controllers and control strategy.

Closed loop feedback control: Servo and regulator problems; Offset; Selection of mode of control action; Closed loop response; Routh stability criterion; Controller tuning and design:, Online tuning-closed loop and open loop methods.

Frequency response technique: Phase margin and gain margin; Bode stability criterion; Nyquist stability criterion; Controller design.

Root locus plot and stability analysis.

Cascade and feed forward control: Design of controller and analysis of control system.

Ratio, Adaptive, Model-based, Multivariable, Selective and Split range control.

Computer process control

Books:


1. Coughnaowr, D.R., "Process Systems Analysis and Control", McGraw-Hill,Inc.
2. Stephanopolous, G., "Chemical Process Control", Prentice-Hall.
3. Seborg, D.E., Edgar, T., and Mellichamp, D.A., "Process Dynamics and Control", John Wiley and Sons, Inc
4. Bequette, B.W.,"Process Control: Modeling, Design, and Simulation", Prentice-Hall, Inc.


**CH3103: Energy Resources and Utilization (Credits : 3)**

Scenario of conventional and non-conventional energy resources.

Solid fuels: Coal- origin, classification, coal washing and blending; Carbonization; Manufacture of coke and recovery of by-products; Coal gasification; Wood, charcoal, biomass, solid wastes, briquettes; Pyrolysis, gasification & liquefaction of solid fuels to secondary fuels; Refuse derived fuels.

Liquid fuels: Petroleum- origin and production of petroleum; Distillation products and uses; Fuel oils, shale oils; Gashol.

Gaseous fuels: Natural gas, liquefied petroleum gas, coal gas, producer gas, water gas

Proximate and ultimate analysis of fuels; Calorific value; Specification and testing of petroleum fuels.

Combustion of solid, liquid and gaseous fuels; Types of burners.

Nuclear energy: Fission and fusion reactions; Nuclear reactors for power generation.

Hydrogen production, storage and use.

Solar energy: Solar radiation and its measurement; Theory and performance of solar collectors; Solar cells.

Introduction to wind, tidal and geothermal energy; OTEC and MHD; Energy from biomass.

A synergetic approach to the utilization of various energy resources with examples.

Energy conservation; Energy audits.

Environmental issues related to energy resources.

Books:


1. Brame, J.S.S., "Fuel: Soild, Liquid and Gases", Edward Arnold Publishers Ltd.
2. Sarkar, S., "Fuels and Combustions", Orient Longman Ltd.
3. Nelson, W.L., "Petroleum refining engineering", McGraw-Hill Book Co.
4. Bhaskara Rao, B.K., Modern Petroleum Refining Processes", Oxford-IBH Publishing Co. Ltd.
5. Sukhatma, S.P., "Solar Energy: Principles of Thermal Collection And Storage", Tata McGraw-Hill Publishing Co. Ltd..
6. Benedict, M. and Pigford, T.H., "Nuclear Chemical Engineering:, McGraw-Hill Book Co.
7. Bansal, N.K., Kleemann, M. and Meliss M., "Renewable Energy Sources and Conversion Technology", Tata McGraw-Hill Publishing Co. Ltd.


**CH3104: Chemical Reaction Engineering - I (Credits : 3)**

Rate equations of elementary and non-elementary reactions.

Analysis of batch reactor data: Reversible and irreversible single reactions; Homogeneous catalytic reactions; Chain reactions; Series, parallel and series – parallel reactions; Enzymatic reactions.

Behaviour of ideal flow reactors; Design of mixed flow reactors; Plug flow reactors and their combinations for single and multiple reactions (series, parallel and series – parallel); Recycle reactors; Yield and selectivity in multiple reactions.

Non-isothermal operation of reactors: Optimum temperature progression; Adiabatic and nonadiabatic batch, mixed flow and plug flow reactors; Exothermic reactions in mixed flow reactors; Multiple reactions: Yield and selectivity.

Unsteady state operation of reactors: Start-up of a mixed flow reactor; Semi-batch reactor; Non-isothermal batch, mixed flow and plug flow reactors.

Reaction with separation; Reactive distillation.

Non-ideal flow; Residence time distribution; Dispersion and tank in series models; Multi-parameter models; Mixing of fluids; Degree of segregation; Laminar flow reactor; Conversion in segregated

flow; Early and late mixing; Mixing of two fluids - Product distribution in multiple reactions.

Books:


1. Levenspiel. O, "Chemical Reaction Engineering", John Wiley & Sons.
2. Smith. J.M., "Chemical Engineering Kinetics", McGraw-Hill book Co.
3. Fogler, H.C., "Elements of Chemical Reaction Engineering", Prentice-Hall, Inc.


**CH3105: Chemical Technology – I (Credits : 3)**

Indian chemical industry: An overview.

Study of following chemical industries with reference to process technology, availability of raw materials, preparation of flow sheet, production trends and future prospects, pollution and major engineering problems:

Industrial gases: Hydrogen, oxygen and nitrogen, inert gases, synthesis gas etc.

Sulfur and sulfur chemicals: Sulfur, sulfuric acid, SCSA and DCDA processes; Sodium thiosulfate; Alums.

Fertilizers and other chemicals: Ammonia; Urea; Calcium ammonium nitrate; Nitric acid; Phophoric acid; Phosphatic and other fertilizers- SSP, TSP, NPK, UAP, DAP and nitrophosphates; Bio-fertilizers.

Marine chemical industries: Common salt; Chemicals from sea bittern

Chlor alkali industries: Caustic soda; Chlorine; Hydrochloric acid; Bleaching powder; Soda ash.

Ceramic industries: Glass; Refractory; Cements; Enamels, White wares; Porcelain and glazes.

Industrial carbons: Lamp black; Furnace black; Carbon black; Graphite.

Nuclear industries: Processing of nuclear fuels; Separation and purification of isotopes; Heavy water.

Selected inorganic chemicals of aluminium, potassium, barium, boron. chromium, lithium, manganese.

Inorganic Pigments: Titanium Dioxide; Lead based pigments; Zinc based pigments

Books:


1. Austin, G.T., "Shreve's Chemical Process Industries", McGraw-Hill Book Co.
2. Dryden, C.E., "Outlines of Chemical Technology", Affiliated East-West Press.
3. "Chemtech" Volume I-IV, Chemical Engineering Education Development Centre, I.I.T., Madras.


**CH3106: Mass Transfer Operations - II (Credits : 4)**

Characterization of separation processes: Equilibrium and rate governed process; Cascading and interstage flow.

Distillation: Vapour-liquid equilibrium and enthalpy concentration diagrams; Principles of distillation; Batch distillation with and without reflux; Steam distillation; Fractionating columns; Calculation of number of plates by McCabe-Thiele and Ponchon-Savarit methods; Feed plate location; Optimum reflux; Open steam; Bubble cap tray, sieve tray, valve tray and packed columns; Calculation of column diameter; Entrainment; Hold-up; Plate efficiency; Principles of azeotropic and extractive distillations; Multi-component vapour-liquid equilibrium; Approximate calculation method of multi-component distillation columns.

Solid-liquid extraction: Single and multi stage extraction; Number of equilibrium stages

Liquid–liquid extraction: Ternary liquid-liquid equilibrium; Batch and continuous liquid-liquid extraction; Stage calculation; Extraction with intermediate feed and reflux; Selectivity; Rate of

extraction; Systems with complete immiscibility.

Adsorption: Adsorption equilibria; Batch, stagewise and continuous adsorption; Industrial adsorbers; Elution; Ion-exchange.

Books:


1. Trebal, R.E. "Mass Transfer Operations", McGraw-Hill, Inc.
2. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
3. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 1 and 2, Pergamon Press.
4. Foust, A.S. Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., "Principles of Unit Operations", John Wiley & Sons, Inc.
5. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall, Inc.
6. Wilty, J.R., Wicks, C.W., Wilson, R.E. and Rorrer, G., "Fundamentals of Momentum Heat and Mass Transfer", John Wiley & Sons.


**CH3301: Heat Transfer Laboratory (Credits : 2)**

Selected laboratory experiments based on thermal conductivity measurements, different types of heat exchangers, batch and continuous heating / cooling, performance of condensers, evaporators, boiling phenomena, heat transfer in two phase and non- Newtonian systems.

**CH3302: Energy Resources Laboratory (Credits : 2)**

Selected laboratory experiments on analysis of fuels based on ASTM, IP, ISI specifications, estimation of calorific values and combustion characteristics of fuels, distillation of crude oil and characterization of petroleum refinery products, performance of solar collectors, utilization of other non-conventional energy resources.

**CH3303: Mass Transfer Laboratory (Credis : 2)**

Selected laboratory experiments based on measurement of diffusivity, vapour – liquid and liquid – liquid equilbria, differential distillation, azeotropic distillation, performance of plate and packed columns, principles of leaching and solvent extraction, drying of wet solids, membrane separation, mass transfer in agitated equipment.

**B.Tech. Part III Semester VI**

**HU3201: History of Science and Technology**
**HU3202: Industrial and Organization Psychology**
**HU3203: Intellectual Property Rights**
**HU3204: Energy Management**
**HU3205: Industrial Sociology**
**HU3206: Ethics, Philosophy and Values**
**HU3207: Entrepreneurship Development**

**CH3201: Polymer Science and Technology (Credits : 3)**

Classification of polymers: Natural and synthetic polymers; Thermosets and thermoplasts; Copolymers; Terpolymers; Degradable and non-degradable polymers.

Addition polymerization; Condensation polymerization; Ring opening polymerization; Co-polymerization; Polymerization by coordination catalyst; Molecular weight distribution of polymers.

Manufacturing processes of important polymers: Plastics-polyethylene; polypropylene, polyvinyl chloride and copolymers, polystyrene; phenol-formaldehyde, epoxides; urethane; teflon; Rubbers and elastomers; Fibres - cellulosic (rayon), polyamides (6;6 Nylon), polyesters (Dacron), acrylic; Polymeric oils.

Micro-structure of polymer chains: Configuration and conformation; Simple and hindered rotation; End-to-end distances;

Crystallinity and melting; Glass transition temperature; Physical states of polymers and mode of motion of polymer chains; Measurement of viscosity; Cohesive energy density; Compatibility and solubility parameters; Polymer additives, blends and composites.

Flow properties of polymers: Bulk deformation, elongational and shear flow; Non-Newtonian flow.

Polymer fabrication techniques: Formation of flat sheets and films; Laminations; Foam formation; Extrusion, injection molding, blow molding, compression and transfer molding; Spinning of fibres

Mechanical properties of polymers: Rheology of polymers; Rubber elasticity; Visco-elasticity; Creep and stress relaxation; Dynamic behavior; Stress and fracture of rubber and glassy polymers.

Polymer degradation.

Conducting polymers; Smart polymers.

Ecology and environmental aspects of polymer industries.

Books:


1. Fried, J.R., "Polymer Science and Technology", Prentice Hall, Inc.
2. McCrum, N.G., Buckley, C.P. and Bucknall, C.B., "Principles of Polymer Engineering", Oxford University Press.
3. Tadmore, , and Gogvs, C.G., "Principles of Polymer Processing" John Wily & Sons.
4. Billmeyer, F.W., "Text Book of Polymer Science", John Wiley & Sons.


**CH3202: New Separation Processes (Credits : 3)**

Principle of membrane separations process; Classification, characterization and preparation of membrane.

Reverse osmosis, ultrafiltration, micro-filtration, nano-filtration and dialysis; Analysis and modeling of membrane separation processes; Membrane modules and application; Ion selective membranes and their application in electro-dialysis; Pervaporation and gas separation using membranes; Electrophorosis; Liquid membranes and its industrial applications.

Foam and bubble separation: Principle; Classification; Separation techniques; Column operations.

Zone melting, zone refining and zone leveling.

Pressure and temperature swing adsorption.

Cryogenic separation; Super- critical extraction.

Parametric pumping: Batch, continuous and semi-continuous pumping; Thermal, pH and heatless parametric pumping.

Multicomponent separation.

Books:


1. Seader, J.D, and Henley E.J., "Separation Process Principles", John Wiley & Sons, Inc.
2. King, C.J., "Separation Processes", McGraw-Hill, Inc.


**CH3203: Chemical Reaction Engineering - II (Credits : 3)**

Heterogeneous processes; Catalysis and adsorption; Classification and preparation of catalysts; Promoters and inhibitors

Catalyst characterization: Surface area and pore size distribution; Introduction to other charaterization techniques (XRD, electron microscopy, electron spectroscopy, thermal analysis, desorption spectroscopy.)

Rate equations of fluid-solid catalytic reactions; Hougen-Watson and power law models; Procurement and analysis of kinetic data; Kinetics of catalyst deactivation and regeneration.

External transport processes and their effects on heterogeneous reactions; Yield and selectivity.

Reaction and diffusion in porous catalysts; Isothermal and non-isothermal effectiveness factors; Effect of intra-phase transport on yield, selectivity and poisoning; Global reaction rate.

Design of catalytic reactors: Isothermal and adiabatic fixed bed reactors; Staged adiabatic reactors; Non-isothermal non-adiabatic fixed bed reactors; Fluidized bed reactors; slurry reactors; Trickle bed reactors; Reactors with novel configurations- radial flow reactors, honey-comb reactors, membrane reactors.

Models for fluid-solid non-catalytic reactions; Controlling mechanisms and global reaction rates; Reactor design for fluid solid reactions including fludized bed reactors with and without elutriation.

Gas-liquid and liquid-liquid reactions; Rate equations based on film theory; Reactor design for instantaneous reactions and slow reactions.

Books:


1. Levenspiel O, "Chemical Reaction Engineering", John Wiley & Sons.
2. Smith, J.M., "Chemical Engineering Kinetics", McGraw-Hill Book Co.
3. Fogler, H.C., "Elements of Chemical Reaction Engineering", Prentice-Hall, Inc.


**CH3204: Chemical Technology - II (Credits : 4)**

Study of following chemical industries with reference to process technology, availability of raw materials, preparation of flow sheet, production trends and future prospects, pollution and major engineering problems:

Pulp and paper industry: Different pulping process; Recovery of chemicals from cooking liquors; Paper making; Role of additives.

Oil, fats and waxes industry: Physical and chemical properties of oils and fats; Interesterification, transesterification and randomisation; Winning of oils and fats from vegetables and animal source; Refining; Vanaspati, margarine etc.; Waxes; Soaps.

Food and food by-product industry: Sugar, glucose, fructose, starch; Food processing and preservation; Food by- products.

Wood and wood chemicals industry: Composite wood, plywood etc.; Manufacture of oleoresin, turpentine, menthol, rosin, and tall oil; Ethanol production; Essential oils, perfumes, flavours and cosmetics.

Leather industry: Skin and hides; Tanning processes; Leather making; Embossing; Leather chemicals.

Petrochemical and synthetic chemical industries: Petrochemicals derived from $C_1$ to $C_4$ chemicals;

BTX; Separation of xylenes.
Surface coating industries: Types of surface coating; Paints, varnishes, distempers and enamels.
Dyes and dye intermediates industry: Classification of dyes; Dye and dye intermediates; Production of some important dyes, lacquers and toners.
Pharmaceutical industries: Classification of drugs; Drug production based on some selected unit processes.
Agrochemical industries: Manufacturing process of some important pesticides, insecticides, fungicides, fumigants, plant growth regulators, yield stimulators and herbicides.

Books:


1. Austin, G.T., "Shreve's Chemical Process Industries", McGraw-Hill Book Co.
2. Dryden, C.E., "Outlines of Chemical Technology", Affiliated East-West Press.
3. "Chemtech" Volume I-IV, Chemical Engineering Education Development Centre, I.I.T., Madras.


**CH3205: Equipment Design (Credits : 4)**

Stress-strain relationships of elastic materials subjected to tensile, compressive and shear forces; Membrane stresses in shells of revolutions; Theories of failures.

General design considerations; Design codes

Unfired pressure vessel: Pressure vessel codes; Design of cylindrical and spherical shells under internal and external pressures; Selection and design of flat plate, torispherical, ellispoidal, and conical closures; Shell design of tall vertical vessels; Compensations of openings.

Vessel supports: Design of skirt, lug, and saddle supports.

Bolted flanges: Types of flanges, and selection; Specifications of standard flanges.

Liquid storage tanks: Storage tank codes; Classification; Design of shell, bottom plates, self supported, and column supported roofs; Wind girder; Nozzles and other accessories.

Fabrication of equipment: Major fabrication steps; Vessel lining; Materials used in fabrication of equipment of some selected chemical industries.

Detailed process and mechanical design of some selected process equipment such as shell and tube heat exchanges, evaporators, plate and packed distillation and absorption columns, reboilers, condensers, packed and fluidized bed reactors, crystallizers.

Design of piping network.

Books:


1. Bhattacharyya, B.C., "Introduction to chemical Equipment Design: Mechanical aspects", CBS Publishers & Distributors, New Delhi.
2. Bhattacharyya, B.C. and Narayanan, C.M., "Computer Aided Design of Chemical Process Equipment", New Central Book Agency (P) Ltd., Calcutta.
3. Brownell, H. and Young, E.H., "Process Equipment Design: Vessel Design", John Wiley & sons.
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering", Volune 6, Pargamon Press.
5. Kenn, D.Q., "Process Heat Transfer", McGraw-Hill.
6. Ludwig, E.E., Applied Process Design for Chemical and Petrochemical Plants", Volume I, II, and III, Gulf Publishing Co.
7. IS Codes.


**CH3401: Chemical Reaction Engineering Laboratory (Credits : 2)**

Selected laboratory experiments based on performance of batch and continuous reactors, residence time distribution, kinetics of homogeneous and fluid – solid reactions, photochemical and biochemical reactions, characterization of porous heterogeneous catalysts.

**CH3402: Chemical Technology Laboratory (Credits : 2)**

Selected laboratory experiments based on preparation of important industrial chemicals such as iodized table salt, pigment, dyes, soap, pharmaceutical products, cosmetics, etc. in pilot plant or laboratory scale to demonstrate the unit processes involved in process technology.

**CH3403: Instrumentation and Process Control Laboratory (Credits : 2)**

Selected laboratory experiments based on calibration of pressure gauges, pneumatic differential pressure transmitters, dynamics of filled thermometer, pressure tank and proportional controller, characteristics of pneumatic control valve, feed back control of liquid level and temperature systems, computer control of temperature and pressure.

**CH3404: Industrial Tour Viva-voce (Credit : 1)**

Each student is required to submit a report based on the observations and information collected on different process plants during their industrial visits.

**B.Tech. Part IV Semester VII**

**ME4102A: Engineering Economics and Management (Credits : 3)**

Engineering management and their relation with other fields.

Management functions: Planning, organizing, leading and controlling; Traditional management theories; Contemporary management.

Financial Engineering: Types of organization; Sources of capital; Financial statements- balance sheets, profit and loss accounts; Cash flow; Depreciation and taxes; Absorption costing; Marginal costing; Break even analysis; Time value of money; Net present value; Internal rate of return; Pay back period.

Labour standards: Methods of analysis; Time study; Incentives.

Materials management: Purchasing; Inventory policies and control; Materials requirement planning.

Quality control: Statistical quality control; Acceptance sampling; T Q M concepts and tools.

Project management: CPM and PERT techniques; Crashing.

Overview of chemical industries.

Books:


1. Davis, G.S., " Chemical Engineering Economics and Decision Analysis", CENDC, I.I.T., Madras.
2. Holand , E.A., Watson, F.A. and Wilkinson, J.K., " Introduction to Process Economics", John Wiley & Sons.
3. Sumanth, D.T., "Production Engineering and Management", McGraw-Hill Inc.
4. Shukla, M.C.,"Business Organization and Management", Sultan Chand and Sons, New Delhi.
5. Peters, M.S.and Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineers",

McGraw-Hill, Inc.

**CH4101: Transport Phenomena (Credits : 4)**

Molecular transport of momentum, energy, and mass and concept of viscosity, thermal conductivity, and diffusivity.

Shell momentum, energy, and mass balance and distribution of velocity, temperature, and concentration in one dimension.

Equations of changes for isothermal, non-isothermal, and multicomponent mixtures.

Velocity, temperature, and concentration distributions with more than one independent variable; Boundary layer theory.

Turbulent transport: Laminar-turbulent transition; Basic characteristic features of turbulent flow; Time smoothed equation of changes; Eddy viscosity, thermal conductivity and diffusivity; Distribution of velocity, temperature, and concentration in turbulent flows.

Interphase transport: Friction factor; Heat transfer coefficient; Mass transfer coefficient.

Macroscopic balances and its applications in analysis and solution of process engineering problems.

Transport phenomena in non-Newtonian fluids.

Momentum, heat and mass transport analogies.

Books:

1. R.B. Bird, W.E. Stewart and E. W.Lighfoot, "Transport Phenomena", John Wiley & Sons.
2. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena", McGraw-Hill
3. Welty, J.R., Wicks, C.W., Wilson, R.E. and Rorrer, G., "Fundamentals of Momentum Heat and Mass Transfer", John Wiley & Sons.

**CH4102: Industrial Pollution and Control (Credits : 4)**

Air Pollution: Sources; Types of air pollutants; Classification of industries and area.

Atmospheric dispersion: Micrometeorology; Lapse rate; Atmospheric classes; Plume and type of plume; Dispersion models; Ground and elevated sources with and without reflection; Calculation for plume rise and stack gas flow rates.

Gaseous pollutants: Sources; Emission factors and control technology.

Particulate pollutants: Major sources; Effects; Emission factor and emission limits; Combustion generated pollutants and control; Particulate emission control equipment- Design and efficiency of centrifugal collectors, electrostatic precipitators, bag filters and scrubbers**;** Vehicular emission control.

Water Pollution: Sources; Pollution laws and limits; Water quality modeling for streams; Characterization and classification of effluents; Effluent standards; Pretreatment and primary treatment methods; Physico-chemical methods of water pollution control; Biological wastewater treatment processes; Advanced treatment methods; Disinfections; Typical industrial and municipal applications.

Odour Pollution: Causes, effects and control methods.

Solid waste: Collection, treatment and disposal.

Noise Pollution: Measurements; Effects; Control.

Waste recovery system; Case studies.

Books:

1. Peavy, H.S., Rowe D.R. and Tchobanoglous, G., "Environmental Engineering", McGraw-Hill Book Co.
2. Metcalf &Eddy, Inc., "Waste Water Engineering-Treatment, Disposal, Reuse", Mcgraw-Hill, Inc.
3. Nevers, Noel de, "Air Pollution Control Engineering", McGraw-Hill, Inc.

**CH4103: Biochemical Engineering (Credits : 3)**

Introduction to microbiology and biochemistry; Classification and characteristics of microorganism; Essential chemicals of life- lipids, sugars and polysaccharides, RNA and DNA, amino acids and proteins; Cell metabolism; Regulation; Stoichiometry; End products.

Cell growth kinetics; Product formation kinetics.

Transport phenomena in cellular systems; Oxygen transfer rates; Mass transfer coefficient and interfacial area; Mechanical agitation and power requirement.

Thermal death kinetics; Media and air sterilization.

Enzymes and their classification; Enzyme kinetics; Immobilization of enzymes and whole cells; Immobilized enzyme kinetics.

Bioreactors: Type, design, operation and scale-up; Instrumentation and control.

Down-stream processing

Industrial production of ethanol, anti-biotics, single cell protein.

Bioleaching.

Books:

1. Bailey, J.E. and Ollis, D.F., "Biochemical Engineering Fundamentals", McGraw-Hill.
2. Aiba, S., Humphery, A.E. and Milli, N.R.,"Biochemical Engineering ", Academic Press.

**CH4104: Petroleum Refinery Engineering (Credits : 3)**

History and development of refining; Composition of crude oil; Evaluation of oil stocks; Refinery and distillation processes; Auxiliary process and operations; Refinery products and test methods; Physical properties of petroleum oil; Light, middle and heavy distillates; Lubricating oil.

Chemical treatment; Extraction process; Dewaxing, visbreaking, reforming, coking, polymerization, alkylation and dehydrogenation processes; Natural and refinery gases; Recent advances on refinery operations; Environmental impacts.

Designing of refinery equipment.

Books:

1. Nelson, W.L., "Petroleum Refinery Engineering", McGraw-Hill Book Co.
2. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi.

**CH4105: Solar Energy Engineering (Credits : 3)**

Solar radiation, available solar radiation and measurement; Radiation transmission through covers and absorption by collectors; Theory of flat plate collectors and their performances; Solar concentrators; Solar heating systems and design; Application to solar cooling; Mechanical energy and solar industrial process heating; Solar pumps; Solar refrigerators; Solar ponds; Chemical storage systems; Photochemical conversion; Solar cells

Solar process economics.

Books:


1. Sukhatma, S.P., "Solar Energy: Principles of Thermal Collection And Storage", Tata McGraw-Hill Publishing Co. Ltd..
2. Agarwal, M.P., "Solar Energy",S. Chand & Co.. Ltd.
3. Meinel, A.B. and Meinel, M.P.,"Applied Solar Energy: An Introduction", Addison Wesley Publishing Co.
4. Kreider, J.F. and Kreith, F., "Solar Heating and Cooling: Engineering, Practical Design and Economics", McGraw-Hill Book Co.


**CH4106: Corrosion Engineering (Credits : 3)**

Basic concepts: Definition and importance; Electrochemical nature and forms of corrosion; Corrosion rate and its determination.

Electrochemical thermodynamics and kinetics: Electrode potentials; Potential-pH (Pourbiax) diagrams; Reference electrodes and experimental measurements; Faraday's laws; Electrochemical polarization; Mixed potential theory; Experimental polarization curves; Instrumentation and experimental procedure.

Galvanic and concentration cell corrosion: Basic concepts; Experimental measurements, and determination of rates of galvanic corrosion; Concentration cells.

Corrosion measurement through polarization techniques: Tafel extrapolation plots; Polarization resistance method; Instrumental methods and Errors in measurement of polarization resistance; Commercial corrosion probes; Other methods of determining polarization curves.

Passivity: Basic concepts of passivity; Properties of passive films; Experimental measurement; Applications of Potentiostatic Anodic Polarization; Anodic protection.

Pitting and crevice corrosion: Basic concepts; Mechanisms of pitting and crevice corrosion; Secondary forms of crevice corrosion; Localized pitting.

Metallurgical features and corrosion: Inter-granular corrosion; Weldment corrosion; De-alloying and dezincification.

Environmental induced cracking: Stress corrosion cracking; Corrosion fatigue cracking; Hydrogen induced cracking; Some case studies; Methods of prevention and testing; Erosion, fretting and Wear.

Environmental factors and corrosion: Corrosion in water and Aaqueous Ssolutions; Corrosion in sulphur bearing solutions; Microbiologically induced corrosion; Corrosion in soil; Corrosion of concrete; Corrosion in acidic and alkaline process streams.

Atmospheric and elevated temperature corrosion: Atmospheric corrosion and its prevention; Oxidation at elevated temperatures; Alloying; Oxidising environments.

Prevention and control of corrosion: Cathodic protection; Coatings and inhibitors; Material selection and design

Books:


1. Fontana, M.G., "Corrosion Engineering", McGraw-Hill.
2. Jones, D.A., "Principal and Protection of Corrosion", Prentice-Hall


**CH4107: Fluidization Engineering (Credits : 3)**

Phenomenon of fluidization; Fluidization regimes; Types of fluidization operations; Typical industrial applications of fluidized beds.

Gross behaviour of fluidized beds: Minimum fluidization velocity; Distributor and bubble formation; Bed voidage; Transport disengaging height (TDH); Bulk viscosity, fluidity and power consumption.

Bubble behaviour and models of bubbling beds.

Flow pattern of gas and solid in fluidized bed and freeboard region.

Heat and mass transfer in fluidized bed.

Entrainment and elutriation from fluidized bed.

Residence time distribution and size distribution of solids in fluidized bed.

Circulating fluidized bed; Pneumatic transport of solids.

Design of fluidized bed for physical operations, catalytic reactions and non-catalytic reactions.

Books:


1. Kunii, D. and Levenspiel, O., "Fluidization Engineering", John Wiley & Sons, Inc.
2. Leva, M., "Fluidization", McGraw-Hill Book Co.
3. Davidson, J.F. and Harrison, D., "Fluidized Particle", Cambridge University Press.


**CH4108: Fertilizer Technology (Credits : 3)**

Overview: Development of fertilizer industry; Fertiliser production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.

Nitrogenous fertilizers: Ammonia from natural gas, associated gas, coke oven gas, naphtha, fuel oils, and petroleum heavy stock; Nitric acid, ammonium sulphate, ammonium nitrate, calcium ammonium nitrate, urea, ammonium chloride.

Phosphatic fertilizers: Phosphoric acid, single super phosphate, triple superphosphate

Potassic fertilizers: Potassium chloride, potassium sulphate

Complex fertilizers: Ammonium phosphate sulphate, MAP/ DAP, nitrophosphates, urea-ammonium phosphates

Miscellaneous fertilizers: Biofertilizers, liquid fertilizers, controlled release fertilizer.

Design aspects of ammonia synthesis converters, urea autoclave, pipe reactors, prilling tower. Retrofitting, upgrading and modernization of existing plants.

Fertilizer storage and handling; Corrosion problems in fertilizer industries; Fertilizer plants effluent treatment and disposal.

Case study of selected fertilizer plants with environmental aspects.

Books:


1. "Handbook of Fertilizer Technology", Fertilizer Association of India, New delhi
2. "Production of Fertilizers(Booklets 1 to 8)", European Fertilizer Manufacturers' Association.
3. "Mineral Fertilizer Production and the Environment (Part 1 & 2)", International Fertilizer Industry Association.
4. "Pollution Prevention and Abatement Handbook", The world Bank Group.


**CH4301: Project-I (Credits : 2)**

Each student is required to do process and mechanical design with engineering drawing of some selected process equipment.

**CH4302: Industrial Pollution and Control Laboratory (Credits : 2)**

Selected laboratory experiments based on sampling and analysis of air and water samples, particulate pollutants and control, physico-chemical and biological methods of waste water treatment.

**CH4303: Seminar and Group Discussion (Credits : 2)**

Each student is required to deliver a seminar on pre-assigned topic. Group discussion will be organized to develop skill of presentation, organization and impromptu discussion.

**CH4304: In-Plant Training Viva-voce (Credits : 2)**

Each student is required to submit report based on six weeks in-plant training.

**B.Tech. Part IV Semester VIII**

**CH4201: Modeling, Simulation and Optimization (Credits : 4)**

Modeling: Classification of models; Models based on transport phenomena principles and applications; Population balance models and applications; Empirical models; Model parameters estimation.

Simulation: Sequential modular, simultaneous modular and equation oriented approaches; Partitioning and tearing; Simulation examples of fluid flow, heat transfer, mass transfer and reaction processes; Monte Carlo simulation.

Optimization: Objective function and its properties; Optimization of one dimensional unconstrained function: Analytical methods, Region elimination methods. Newton, quasi-Newton and secant methods; Polynomial approximation methods; Unconstrained multivariable optimization: Direct and indirect methods; Linear programming and applications; Introduction to dynamic programming.

Books:


1. Edgar, T.F. and Himmelblau, D.M.; "Optimization of Chemical Processes", McGraw-Hill Book Co.
2. Rao, S.S., "Engineering Optimization: Theory and Practice", New Age International (P) Ltd. Publishers, New Delhi.
3. Luyben, W.L., "Process Modelling, Simulation and Control", McGraw-Hill Book Co.
4. Ramirez, W. "Computational Methods in Process Simulation", Butterworths Publishers.


**CH4202: Safety and Hazard Analysis (Credits : 3)**

History of safety movement; Development of safety programmes in process industry.

Accident causation: Heinrich-Domino theory; Human error model; Petersen's accident/ incident model; Epidemiological models; System models; Multiple causation.

Systems safety management: Management task; Managerial roles and skills; Management by objective.

Hazard: Identification; Occupational hazard; Preliminary hazard analysis; Hazard and operability review (HAZOP).

Hazard control: Engineering and management controls; Fault tree analysis; Risk analysis and management.

Fire prevention and protection: Chemistry of fire; Production of fire; Fire development; Severity and duration; Effect of enclosure and heat transfer.

Industrial hygiene; Routes of entry of foreign substance; Long term medical disorders and

epidemiology; Stress and the workplace ; Industrial noise; Hazardous waste.

Case studies of safety and hazard assessment in different industries; Disaster management planning; Insurance tariffs in hazardous industries; Design for safety, maintenance and fault diagnosis.

Books:


1. Wills, G.L., "Safety in Process",
2. Lees, F.P., "Loss Prevention in Process Industries",Volume I & II, Butterworth Heinemann.
3. Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc.
4. Pandey, C.G., "Hazards in Chemical Units: a Study",Oxford IBH Publishing Co., New Delhi.


**CH4203: Process Engineering and Plant Design (Credits : 4)**

System approach to process design; Structure of systems and subsystems; System analysis and interactions; Information flow structure; Degrees of freedom in a system; Design variable selection; Evaluation of design criteria.

Generation of alternatives; Synthesis, screening and analysis of alternative process systems; Optimum design strategy; Synthesis of flow-sheet.

Heat exchange networks; Mass exchange network; Distillation sequencing; Reaction-separation system; Heat integration of reactors, distillation columns, evaporators.

Decision making involving risk and uncertainty.

Principles of scale-up for fluid mechanical, heat transfer, mass transfer equipment and homogeneous and heterogeneous chemical reactors; Selection and specifications of process equipment and utilities; Plant location and layout; Start-up and shut-down; Cost estimation, capital investment, and profitability; Construction of P&I diagram.

Books:


1. Rudd, D.F. and Watson, C.C., "Strategy of Process Engineering", John Wiley & Sons, Inc.
2. Smith, R., "Chemical Process Design", McGraw-Hill Co. Inc.
3. Sieder, W.D., Seader, J.D. and Lewin, D.R., "Product & Process Design Principles", John Wiley & Sons, Inc.
4. Douglas J.M., "Conceptual Design of Chemical Processes", McGraw-Hill, Inc.
5. Peters, M.S. and Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineers", McGraw-Hill, Inc.
6. Euzen, J.P., Trambouze, P. and Wauquier, J.P., "Scale-Up Methodology for Chemical Processes", Editions Technip.


**CH4204: Process Intensification (Credits : 3)**

Introduction: Definition of process intensification; Benefits and drawbacks; Techniques for PI application – passive and active techniques.

Mixing, flow patterns, heat transfer: Scales of mixing; Flow patterns in reactors, Mixing in stirred tanks, Scale up of mixing; Mixing in intensified equipment; Heat transfer.

High intensity inline reactors: Static mixers; Ejectors; Tee mixers; Impinging jets; Rotor stator mixers; Principles of operation; Applications; Performance envelopes.

Combined chemical reactor heat exchangers and reactor separators.

Spinning disc reactors; Rotating packed bed; Oscillatory flow reactor; Compact heat exchangers

Enhanced fields: Sono-chemistry; Microwaves; Electrostatic fields.

Intensified separation: Higee; Compact separation; Crystallization and extraction.

Books:

1. Stankiewicz, A. and Moulijn, (Eds.), "Reengineering the Chemical Process Plants. Process Intensification", Marcel Dekker.

**CH4205: Multicomponent Distillation (Credits : 3)**

Fundamental concepts in multicomponent distillation; Design variables and degrees of freedom

Thermodynamics of vapour-liquid equilibria of multicomponent mixtures; Correlation of vapour-liquid eqluilibria data for multicomponent mixtures.

Bubble point and dew point; Equilibrium flash distillation- isothermal, adiabatic, Multicomponent hydrocarbon-water mixtures.

Approximate methods: Key components; Feneske – Underwood – Gilliland method; Hengstebeck's pseudo binary method.

Rigorous methods: Lewis – Matheson method; Thiele – Gaddes method; Relaxation methods; Linear algebra methods; θ-method of convergence.

Equilibrium-based methods: Theoretical model for an equilibrium stage; strategy of mathematical solution; Equation-tearing procedures- tridiagonal matrix algorithm, bubble point and sum rates method; Simultaneous correction procedures; Inside-out method.

Rate-based models and methods of calculation.

Batch distillation: Differential distillation; Shortcut method for batch rectification with constant reflux; Stage by stage methods for batch rectification.

Books:

1. Seader, J.D, and Henley E.J.,"Separation Process Principles", John Wiley & Sons, Inc.
2. King, C.J., "Separation Processes", McGraw-Hill, Inc.
3. Holland, "Multicomponent Distillation", Prentice-Hall, Inc.
4. Smith, B.D., "Design of Equilibrium Stage Processes", McGraw-Hill BookCo. Inc.
5. Hengstebeck, R.J., "Distillation: Principals and Design Procedures", Reinhold Book Co.
6. Coulson, J.M. and Richardson, J.F., "Chemical Engineering", Volune 6, Pargamon Press.

**CH4206: Computer Process Control (Credits : 3)**

Computer control vs. analog control; Advantage and limitations; Basic concepts of computer hardware and software; Theory and implementation; Introduction to A/D, D/A, multiplexing, sample and hold, and signal conditioning; Schematic and block diagram representation of computer controlled system.

Z-transformation: Z-transform; Inverse Z-transform; Modified Z-transform; Inverse of modified Z-transformation and their properties; Pulse transfer function.

Digital control algorithm: Conversion of analog PI, PD, PID into digital; Direct synthesis method; Deadbeat control; Dahlin's algorithm and Kalman's approach to digital controller design; Control algorithm for load changes; Ringing problem and its elimination.

Sampling theorem; Aliasing; Selection of sampling period.

Open and close loop response of sampled data system; Stability analysis.

Implementation of control algorithm and realization of discrete transfer function.

Introduction to the implementation of various control strategies – feed forward, cascade, adaptive and model-based control using digital computer.

Introduction to DDC, DCS, supervisory, optimizing and hierarchical computer control.

Books:


1. Astrom, A.J. and Wittenmark, B., "Computer Controlled Systems: Theory and Design", Prentice-Hall, Inc.
2. Singh, S.K. "Compuer Aided Process Control" Prentice-Hall of India Pvt. Ltd.


**CH4207: Computational Fluid Dynamics**

Conservation equations for mass, momentum and energy; Comparison of various numerical techniques for CFD; Review of finite difference and finite element methods; Solution to discretised algebric equation; Finite-volume method for diffusion problems; Finite-volume method for convection and diffusion problems – pressure velocity coupling; Construction of geometry and discreation using Gambit-Fluent's manuals; Commercial CFD solvers; Turbulance modeling; Implementation of boundary conditions; Introduction to multiphase flow; Customizing commercial CFD solver; Unsteady state simulations.

Books:


1. Anderson, J.D., "Computational Fluid Dynamics: The Basics with Application" McGraw-Hill Co. Inc.
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., "Computational Fluid Mechanics and Heat Tranasfer", Hemisphere Publishing Corporation.
3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation.
4. Ferziger, J.H. and Peric, M., "Computational Methods for Fluid Dynamics", Springer.
5. Versteeg, H.K. and Malalasekera, W., " An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Prentice-Hall Inc.


**CH4208: Surface Coating (Credits : 3)**

Survey of paint industry and its scope in India.

Pigments and their classification; Methods of manufacture for white, coloured, metallic and luminous pigments.

Classification of paints; Oil, emulsion, and water soluble paints and their manufacturing processes; Drying oils; Natural and synthetic resins; Solvents and plasticizers.

Definition and classification of varnish; Oleoresinious and spirit varnishes; Manufacture of different types of varnishes.

Ceramic coating; Glazing and enamelling.

Metallic coating; Electroplating; Galvanizing; Tinning.

Polymeric coating; Protective and decorative coatings.

Powder Coating.

Books:


1. Noel, H., "Out of Paint Technology", Charles Griffin and Co., Ltd.
2. Morgans, W.M., "Outlines of Paint Technology", Vol.I, Charles Griffin and Co.
3. Bidlack, C. and Edgar W. P., "Paints and Varnish Production Manual", Chapman & Hall Ltd.
4. Turner, G.P.A., "Introduction to Paint Chemistry Principles of Paint Technology", Oxford University Press.

**CH4209: Heterogeneous Catalysis (Credits : 3)**

Survey of industrial catalytic processes; Theories of heterogeneous catalysis; Classification of catalysts and supports

Catalyst preparation techniques: Impregnation, adsorption, sol – gel, chemical vapour deposition; Factors governing catalytic activity.

Catalyst characterization: Bulk characterization; Physiosorption technique; Surface area and pore size distribution; Chemisorption; Desorption spectroscopy; Thermal analysis; X-ray diffraction; Electron microscopy; Electron spectroscopy.

Synthesis, characterization and modification of mircroporous and mesoporous zeolites; Heteropoly compounds; Pillared clays.

Mechanism and kinetics of activation, deactivation and regeneration of catalysts; Sintering of supported metal catalysts.

Electro catalysis and fuel cell; Photocatalysis for the removal of air and water pollutants and conversion of solar energy; Polyfuctional catalysts.

Synthesis, characterization and activity of nano-particles and nano-clusters.

Books:


1. Thomas, J.M. and Thomas W.J., Introduction to Principles of Heterogeneous Catalysis", Academic Press.
2. Butt, J.B. and Peterson, E.E., "Activation, Deactivation and Poisoning of Catalysts", Academic Press.
3. Anderson, R.B.(Ed.), "Experimental Methods in Catalytic Research" Volume I to III, academic Press.
4. Becker, E.R. and Pereira, C.J.(Eds.), "Computer Aided Design of Catalysts", Marcel Dekker Inc.


**CH4401: Project –II (Credits : 6)**

Each student is required to carry out detailed process design and economic evaluation of a chemical plant and submit a report. The report should contain selection of alternatives, flowsheet, material and energy balances, sizing and specification of all major units, instrumentation and control, waste disposal and pollution control scheme, cost analysis, lay out and safety.

**CH4402: Computer Aided Design and Simulation Laboratory (Credits : 2)**

Selected laboratory experiments on simulation and design of process equipment.

**CH4403: Comprehensive Viva-voce (Credits : 2)**

Students will appear for a comprehensive viva – voce examination for the assessment of over-all level of proficiency and scholastic attainment of student in various subjects studied during the course.

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