B.E Chemical Engineering Syllabus

ENGINEERING MATHEMATICS – III

Subject Code	: 10MAT31	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Fourier Series: Periodic functions, Fourier expansions, Half range expansions, Complex form of Fourier series, Practical harmonic analysis. **7 Hours**

UNIT 2:

Fourier Transforms: Finite and Infinite Fourier transforms, Fourier sine and consine transforms, properties. Inverse transforms. **6 Hours**

UNIT 3:

Partial Differential Equations (P.D.E): Formation of P.D.E Solution of non homogeneous P.D.E by direct integration, Solution of homogeneous P.D.E involving derivative with respect to one independent variable only (Both types with given set of conditions) Method of separation of variables. (First and second order equations) Solution of Lagrange's linear P.D.E. of the type P $p + Q q = R$. **6 Hours**

UNIT 4:

Applications of P.D.E: Derivation of one dimensional wave and heat equations. Various possible solutions of these by the method of separation of variables. D'Alembert's solution of wave equation. Two dimensional Laplace's equation – various possible solutions. Solution of all these equations with specified boundary conditions. (Boundary value problems). **7 Hours**

PART – B

UNIT 5:

Numerical Methods: Introduction, Numerical solutions of algebraic and transcendental equations:- Newton-Raphson and Regula-Falsi methods. Solution of linear simultaneous equations: - Gauss elimination and Gauss Jordon methods. Gauss - Seidel iterative method. Definition of eigen values and eigen vectors of a square matrix. Computation of largest eigen value and the corresponding eigen vector by Rayleigh's power method. **6 Hours**

UNIT 6:

Finite Differences (Forward and Backward differences): Interpolation, Newton's forward and backward interpolation formulae. Divided differences – Newton's divided difference formula. Lagrange's interpolation and inverse interpolation formulae. Numerical differentiation using Newton's forward and backward interpolation formulae. Numerical Integration – Simpson's one third and three eighth's value, Weddle's rule. (All formulae / rules without proof). **7 Hours**

UNIT 7:

Calculus of Variations: Variation of a function and a functional Extrenal of a functional, Variational problems, Euler's equation, Standard variational problems including geodesics, minimal surface of revolution, hanging chain and Brachistochrone problems. **6 Hours**

UNIT 8:

Difference Equations and Z-transforms: Difference equations – Basic definitions. Z-transforms – Definition, Standard Z-transforms, Linearity property, Damping rule, Shifting rule, Initial value theorem, Final value theorem, Inverse Z-transforms. Application of Z-transforms to solve difference equations. **7 Hours**

Text Book:

1**. Higher Engineering Mathematics**, Dr. B.S. Grewal , 36th Edition, Khanna Publishers.

Reference Books:

1. **Higher Engineering Mathematics**, B.V. Ramana Tata-McGraw Hill, 2006**.**
2. **Advanced Modern Engineering Mathematics,** Glyn James, 3rd Edition, Pearson Education, 2004.

Note:

1. One question is to be set from each unit.
2. To answer Five questions choosing at least Two questions from each part.

MOMENTUM TRANSFER

Subject Code	: 10CH32	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Fluid Statics and its Applications: Concept of unit operations, Concept of Momentum Transfer, Nature of fluids and pressure concept, Variation of pressure with height – hydrostatic equilibrium, Barometric equation, Measurement of fluid pressure – manometers. Continuous gravity decanter, Centrifugal decanter. **6 Hours**

UNIT 2:

Fluid flow phenomena: Types of fluids – shear stress and velocity gradient relation, Newtonian and non – Newtonian fluids, Viscosity of gases and liquids. Types of flow – laminar and turbulent flow, Reynolds stress, Eddy viscosity. Flow in boundary layers, Reynolds number, Boundary layer separation and wake formation. **6 Hours**

UNIT 3:

Basic equations of fluid flow: Average velocity, Mass velocity, Continuity equation, Euler and Bernoulli equations, Modified equations for real fluids with correction factors. Pump work in Bernoulli equation. Angular momentum equation. **6 Hours**

UNIT 4:

Flow of incompressible fluids in conduits and thin layer: Laminar flow through circular and non-circular conduits. Hagen Poiseuille equation, Laminar flow of non-newtonian liquids, Turbulent flow in pipes and closed channels, Friction factor chart. Friction from change in velocity or direction. Form friction losses in Bernoulli equation. Flow of fluids in thin layers.
6 Hours

PART – B

UNIT 5:

Flow of compressible fluids: Continuity equation, Concept of Mach number, Total energy balance, Velocity of sound, Ideal gas equations. Flow through variable-area conduits. Adiabatic frictional flow. Isothermal frictional flow (elementary treatment only). **6 Hours**

UNIT 6:

Flow of fluid past immersed bodies: Drag, Drag coefficient, Pressure drop – Kozeny-Carman equation, Blake-Plummer, Ergun equation, Fluidizaion, Conditions for fluidization, Minimum fluidization velocity, Types of fluidization, **4 Hours**

Metering of fluids: Pipes, Fitting and valves, Measurement of liquid and gas flow rates by orifice meter, venturi meter, rotameter and pitot tube. **4 Hours**

UNIT 7:

Flow through open channels – weirs and notches. **2 Hours**

Transportation of fluids: Elementary concept of target meter, vortex shedding meters, turbine meters, positive displacement meters, magnetic meters, coriolis meters and thermal meters. Performance and characteristics of pumps – positive displacement and centrifugal pumps. Fans, compressor and blowers. **6 Hours**

UNIT 8:

Dimensional analysis: Dimensional homogeneity, Rayleigh's and Buckingham's II – methods. Significance of different dimensionless numbers. Elementary treatment of similitude between model and prototype. **4 Hours**

Introduction to unsteady state flow: Time to empty the liquid from a tank. **2 Hours**

Text Books:

1. **Unit Operations of Chemical Engineering,** McCabe. W.L., et. al. 6th edn., McGraw Hill, New York, 2001.
2. **Engineering Fluid Mechanics,** Kumar K. I.,3rd Edition, Eurasia Publishing House (p) Ltd., New Delhi,1984.

Reference Books:

1. **Chemical Engineering, Vol. 1.,** Coulson J. II and Richardson. J.F.., 5th edn., Asian Books (p) Ltd., New Delhi, 1998.
2. **Introduction to Chemical Engineering,** Badger. W.I., and Banchero J.T., Tata McGraw Hill, New York, 1997.

CHEMICAL PROCESS CALCULATIONS

Subject Code	: 10CH33	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Units and dimensions: Fundamental and derived units, Conversion. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. **6 Hours**

UNIT 2:

Basic chemical calculations: Concept of mole, mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, ppm. Use of semi-log, log-log, triangular graphs. Ideal gas law calculations, **6 Hours**

UNIT 3:
Vapour pressure concepts, humidity, humidity chart, humidification and dehumidification, calculation of humidity. **7 Hours**

UNIT 4:
Material balance without reaction: General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying. **7 Hours**

PART – B

UNIT 5:
Steady state material balance for mixing and evaporation. Elementary treatment of material balances involving bypass. Recycle and purging. **6 Hours**

UNIT 6:
Steady state material balance with reaction: Principles of stoichiometry, Concept of limiting and excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, related problems. **7 Hours**

UNIT 7:
Ultimate and proximate analyses of fuels, Calculations involving combustion of solid, liquid and gaseous fuels, excess air. **6 Hours**

UNIT 8:
Energy balance: General steady state energy balance equation, Thermo physics. Thermo chemistry and laws. Heat capacity. Enthalpy, Heat of formation, Heat of reaction, Heat of combustion and Calorific values. Heat of solution. Heat of mixing, Heat of crystallization. Determination of ΔH_r at standard and elevated temperatures, flame temperature. **7 Hours**

Text Books:

1. **Stoichiometry (SI Units),** Bhatt B.L. and Vora S.M, Third Edition, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
2. **Chemical Process Principles Part – I Material and Energy Balances,** Hougen O.A., Waston K.M. and Ragatz R.A., 2nd Edition, CBS publishers and distributors, New Delhi, 1995.
3. **Basic Principles and Calculations in Chemical Engineering,** Himmelblau D.M., 6th Edition, Prentice Hall of India, New Delhi, 1997.

TECHNICAL CHEMISTRY

Subject Code	: 10CH34	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Colligative properties: Concept of mole and mole fraction. Colligative properties - Meaning and types, Lowering of vapour pressure, Raoult's law - statement, limitations. Determination of molecular weight by lowering of vapour pressure, problems. Ostwald's and Walker's method, Elevation in boiling point of a solvent – derivation, Experimental determination of molecular weight by ebulliscopic method, problems. Isotonic solutions – abnormal molecular weight. Osmosis and Osmotic pressure - Explanation of the terms, effect of concentration and temperature and simultaneous effect of concentration and temperature on osmotic pressure. Determination of molecular weight - Berkeley and Hartley's method and problems. **8 Hours**

UNIT 2:

Principles of valence bond theory and molecular orbital theory: Introduction to chemical bonding - Formation of ionic bond, covalent bond and co-ordinate bond with examples; Energies of covalent bond formation, Valence bond theory – postulates and explanation, Types of covalent bonds: -σ and -π bonds; Molecular orbital theory – postulates, Linear combination of atomic orbitals (LCAO), conditions for effective combination of atomic orbitals. Molecular orbital configuration of simple molecules (H_2 and He_2); Similarities and distinctions between valence bond theory and molecular orbital theory; Polar and non polar covalent bonds. **6 Hours**

UNIT 3:

Surface chemistry: Introduction, Types of adsorption – Physisorption and chemisorption, adsorption isotherm, isobar, isotere, Langmuir adsorption isotherm, BET isotherm, BET equation for surface area, Langmuir-Hinshelwood, and Langmuir-Rideal mechanisms, kinetic effects of surface heterogeneity, surface inhibition and activation energies, unimolecular and bimolecular surface reactions, reactions between two adsorbed molecules, Transition state theory of surface reactions, Mechanism of chemisorption and rates of chemisorption and desorption. **7 Hours**

UNIT 4:

Catalysis: Basic principles, classification of catalytic systems; Homogeneous catalysis: Homogeneous catalysis involving gases, Homogeneous catalysis in the liquid phase with examples including Wilkinson's catalyst; Heterogeneous catalysis- Explanation with examples including Ziegler-Natta catalyst; Mechanism of acid-base catalysis, Catalytic reactions- Hydrogenation, transfer hydrogenation, hydroformylation, isomerization, Wacker's process- acetic acid from ethylene; Negative catalysis and its mechanism. **6 Hours**

PART – B

UNIT 5:

Dyes: Colour and constitution - chromophore, and auxochrome theory , modern theory of colour, classification of dyes - by structure and by methods of application. Synthesis of dyes - Methyl orange, Congo red, Malachite green, Indigo and Alizarin. **6 Hours**

UNIT 6:

Reaction mechanism: Concept of reactive intermediates- carbanions, carbocations, inductive and resonance effects; Mechanism of nucleophilic substitution (SN_1 and SN_2) in alkyl halides; Mechanistic concept of elimination reactions (E_1 and E_2); Mechanism of electrophilic substitution in benzene - Nitration, sulphonation, halogenation, Friedel-Crafts alkyl and acylation reactions; Electronic interpretation of orienting influences of substituents in aromatic electrophilic substitution of toluene, chlorobenzene, phenol and nitrobenzene. **7 Hours**

UNIT 7:

Insecticides: Definition, classification – i) Internal or Stomach insecticide ii) External or Contact Insecticides iii) Fumigants - Explanation with examples; Organic insecticides – DDT, Chlordane, Nitrophenol, BHC (Gammexane), Aldrin, Schradan, Parathion, Malathion and Baygon - synthesis and their applications; Rodenticides, Fungicides, and Herbicides – Definition, examples and their applications. **6 Hours**

UNIT 8:

Oils and fats-Vegetable oils- Examples; Analysis of oils- Saponification value,iodine value and acid value - their determination, Extraction of oils- Solvent extraction, Refining of oils, Hydrogenation - manufacture of Vanaspati.

Soaps and detergents – Manufacture of soap by hot process; Types of soaps - Liquid soap, Toilet soaps-opaque and transparent; Mechanism of cleansing action of soap; Synthetic detergents– Ionic detergents-anionic and cationic; Nonionic detergents-Manufacture. **6 Hours**

Text Books:

1. **Organic Chemistry**, Morrision B.R. and Boyd L.L., 6th Edition, ELBS, New Delhi, 1999.
2. **Physical Chemistry,** Puri L.R. and Sharma B.R., 14th Edition, Chand S. and Co., New Delhi, 1998.

Reference Books:

1. **Modern Synthetic Reactions,** House, H.O., ULBS Publishers, New Delhi.
2. **Organic Reactions Mechanism,** Sykes Peter, 2nd Edition, ULBS Publishers, New Delhi, 2003.
3. **Organic Chemistry**, Finar, Vol 1 and 2, ULBS Publishers, New Delhi.
4. **Industrial Chemistry,** Sharma B.K., 11th Edition, Chand S. and Co. New Delhi, 2001.
5. **Organic Chemistry,** Tiwari Melhrotra and Vishnoi, 7th edition, Chand S. and Co., New Delhi, 1996.
6. **A Text Book of Organic Chemistry,** Arun Bahl and Bahl B.S., 15th Edition, S. Chand and Company, New Delhi, 1998.
7. **Surface Chemistry: Theory and applications**, J.J. Bikerman, 2nd Edition, Academic press, New York, 1972.
8. **Physical Chemistry of Surfaces**, A.W. Adamson, 3rd Edition, Interscience publishers Inc., New York, 1960.

MECHANICAL OPERATIONS

Subject Code	: 10CH35	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Particle technology: Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, standard screen, screens – ideal and actual screens, differential and cumulative size analysis, specific surface of mixture of particles, Number of particles in a mixture, effectiveness of screen, **5 Hours**

UNIT 2:

Industrial screening equipment, Motion of screen, Grizzly, Gyratory screen, Vibrating screen, Trommels, Sub sieve analysis – Air permeability method, Sedimentation and elutriation methods. **5 Hours**

UNIT 3:

Size reduction: Introduction – Types of forces used for comminution, Criteria for communition, characteristics of comminuted products, Laws of size reduction, Work Index, Energy utilization, Methods of operating crushers – Free crushing, Choke feeding, Open circuit grinding, Closed circuit grinding, Wet and dry grinding, Equipment for size reduction – Blake jaw crusher, Gyratory crusher, Smooth roll crusher, Toothed roll crusher, Impactor, Attrition mill, Ball mill, Critical speed of ball mill, Ultra fine grinders, Fluid energy mill, Colloid mill, Cutters – Knife cutter. **8 Hours**

UNIT 4:

Motion of particles through fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal velocity, Drag coefficient, Motion of spherical particles in Stoke's regime, Newton's regime and Intermediate region, Criterion for settling regime, Hindered settling, Modification of equation for hindered settling,

Sedimentation: Coe and Clevenger theory, Kynch theory, Batch settling test, Application of batch settling test, Determination of thickener area. **8 Hours**

PART – B

UNIT 5:

Filtration: Introduction, Classification of filtration, Cake filtration, Clarification, Batch and continuous filtration, pressure and vacuum filtration, Constant rate filtration, characteristics of filter media, industrial filters, sand filter, Filter press, leaf filter, Rotary drum filter, Horizontal belt filter, Bag filter, Centrifugal filtration – Suspended batch centrifuge, Filter aids, Application of filter aids. **7 Hours**

UNIT 6:

Agitation and mixing: Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and power calculation, Mixing of solids, Types of mixers – Change can mixers, Muller mixers, Mixing index, Ribbon blender, Internal screw mixer, Tumbling mixer. **6 Hours**

UNIT 7:

Sampling, storing and conveying of solids: Sampling of solids, storage of solids, Open and closed storage, Bulk and bin storage, Conveyors – Belt conveyor, Chain conveyor, Apron conveyor, Bucket conveyor, Bucket elevator, Screw conveyor, Slurry transport, Applications of fluidization, Pneumatic conveying. **6 Hours**

UNIT 8:

Miscellaneous separation: Magnetic separation, electrostatic separation, Jigging, Heavy media separation, Froth floatation process, Additives used during floatation, Floatation cells, Typical floatation circuits, Size enlargement (only principle and equipment) – Flocculation, Briquetting, Pelletization, Granulation, Settling chambers, Centrifugal separators, Cyclones and Hydro cyclones, Electrostatic Separator, Venturi scrubber. **7 Hours**

Text Books:

1. **Unit Operations of Chemical Engineering**, McCabe W.L., et.al., V Edn., McGraw Hill International, New york, 2000.
2. **Introduction to Chemical Engineering**, Badger, W.L. and Banchero J.T, 3rd Edition, McGraw Hill International Edition, Singapore, 1999.
3. **Coulson and Richardson's Chemical Engineering Vol. 2 Particle Technology and Separation Processes**, Coulson J.M. and Richardson J.F., 4th Edition, Asian Books Pvt. Ltd, New Delhi, 1998.

Reference Books:

1. **Unit Operations**, Brown. G.G. et.al., 1st Edition, CBS Publishers, New Delhi, 1995.
2. **Perry's Chemical Engineers' Handbook**, Perry R and Green W.D., 1st Edition, McGraw Hill International, New York, 2000.
3. **Principles of Unit Operations**, Foust A. S. et.al., 3rd Edition, John Wiley and Sons, New York, 1977.

COMPUTER AIDED CHEMICAL EQUIPMENT DRAWING

Subject Code	: 10CH36	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 03
Total No. of Hours	: 39	Exam Marks	: 50

Sectional views: Representation of the sectional planes, Sectional lines and hatching, selection of section planes and types of sectional views. **6 Hours**

Proportionate drawing of process equipment: Equipment and piping symbols, Vessel component; Vessel opening, Manholes, Vessel enclosures, Vessel support, Jackets, Shell and tube heat exchanger, Reaction vessel and Evaporator. **12 Hours**

Assembly drawing: (i) ***Joints***: Cotter joint with sleeve, cotter joint, Socket and Spigot joint, Flanged pipe joint, Union joint, Stuffing box and Expansion joint (Screw type or Flanged type).
(ii) ***Valves***: Stop valve, Globe valve, Stop cock and Gate valve, Screw down Stop valve, Rams Bottom safety valve, Non-return valve.
(iii) ***Pumps***: Centrifugal pump, Gear pump. **21 Hours**

Note: 1. Assignments to be given to students to practice all the drawings and weightage shall be given to these assignments while awarding IA marks.
2**.** Examination consists of one question on proportionate drawing (15 marks) and one question on Assembly drawing (35 Marks). Weightage must be given for proportionate sketching drawn on paper.

Software: Solid Edge or Equivalent Software

Text Books:

1. **Machine Drawing**, Gopal Krishna, 9th Edition, K.R, Subhas Stores, Bangalore 1995.
2. **Machine Drawing,** Bhatt, N.D., 29th Edition, Charotar Publishing House, Anand, 1995.
3. **Process Equipment Design**, Joshi, M.V., 3rd Edition, Macmillian India publication", New Delhi, 2000.

Reference Books:

1. **Chemical Process Equipment,** Walas, S.M., Butterworth Heinemann Pub. 1999.
2. **Applied Process Design,** Ludwig E.E., 3rd Edition, Gulf Professional Publising, New Delhi, 1994.

MOMENTUM TRANSFER LAB

Subject Code	: 10CHL37	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 03
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Friction in circular pipes
2. Friction in non circular pipes
3. Friction in helical / spiral coils
4. Flow rate measurement using venturi / orifice meters (incompressible fluid)
5. Local velocity measurement using pitot tube
6. Flow over notches
7. Hydraulic coefficients – open orifice
8. Packed bed
9. Fluidized bed
10. Characteristics for centrifugal pump
11. Study of various pipe fittings and their equivalent lengths
12. Compressible fluid flow measurement using venturi / orifice meters
13. Reynolds apparatus
14. Air lift pump

Note: Minimum of 10 experiments are to be conducted.

TECHNICAL CHEMISTRY LAB – I

Subject Code	: 10CHL38	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 03
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Estimation of HCl and CH_3COOH in a given acid mixture conductometrically.
2. Determination of sulphate and nitrate in the given sample of water using Nephelometer and spectrophotometer.
3. Determination of chloride content in the given sample of water using N/40 $AgNO_3$ solution and KCl crystals.
4. Determination of partition coefficient of iodine between water and carbon tetrachloride.
5. Study of kinetics of the reaction between $K_2S_2O_8$ and KI.
6. Determination of percentage of nitrogen in ammonium fertilizers, using 1 N NaOH solution and standard HCl solution.
7. Determination of percentage composition of binary mixture using Ostwald's viscometer.
8. Effect of salt on the critical solution temperature of phenol-water system.
9. Determination of molecular weight of a non-volatile solute by elevation in boiling point. (Using McCoy's apparatus).

10. Determination of nickel as nickel dimethylglyoximate gravimetrically (after separating iron) in the given stainless steel solution.
11. Determination of iron as ferric oxide gravimetrically (after separating copper) in the given chalcopyrites ore solution.
12. Determination of zinc in the given brass solution volumetrically (after separating copper).

Note: Minimum of 10 experiments are to be conducted.

ENGINEERING MATHEMATICS - IV

Subject Code	: 10MAT41	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Numerical Methods: Numerical solutions of first order and first degree ordinary differential equations – Taylor's series method, Modified Euler's method, Runge – Kutta method of fourth order, Milne's and Adams-Bashforth predictor and corrector methods (All formulae without Proof). **6 Hours**

UNIT 2:

Complex Variables: Function of a complex variable, Limit, Continuity Differentiability – Definitions. Analytic functions, Cauchy – Riemann equations in cartesian and polar forms, Properties of analytic functions. Conformal Transformation – Definition. Discussion of transformations: $W = z^2$, $W = e^z$, $W = z + (I/z)$, $z \neq 0$ Bilinear transformations. **7 Hours**

UNIT 3:

Complex Integration: Complex line integrals, Cauchy's theorem, Cauchy's integral formula. Taylor's and Laurent's series (Statements only) Singularities, Poles, Residues, Cauchy's residue theorem (statement only). **6 Hours**

UNIT 4:

Series solution of Ordinary Differential Equations and Special Functions: Series solution – Frobenius method, Series solution of Bessel's D.E. leading to Bessel function of fist kind. Equations reducible to Bessel's D.E., Series solution of Legendre's D.E. leading to Legendre Polynomials. Rodirgue's formula. **7 Hours**

PART – B

UNIT 5:

Statistical Methods: Curve fitting by the method of least squares: $y = a + bx$, $y = a + bx + cx^2$, $y = ax^b$ $y = ab^x$, $y = ae^{bx}$, Correlation and Regression.

Probability: Addition rule, Conditional probability, Multiplication rule, Baye's theorem. **6 Hours**

UNIT 6:

Random Variables (Discrete and Continuous) p.d.f., c.d.f. Binomial, Poisson, Normal and Exponential distributions. **7 Hours**

UNIT 7:

Sampling, Sampling distribution, Standard error. Testing of hypothesis for means. Confidence limits for means, Student's t distribution, Chi-square distribution as a test of goodness of fit. **7 Hours**

UNIT 8:

Concept of joint probability – Joint probability distribution, Discrete and Independent random variables. Expectation, Covariance, Correlation coefficient.

Probability vectors, Stochastic matrices, Fixed points, Regular stochastic matrices. Markov chains, Higher transition probabilities. Stationary distribution of regular Markov chains and absorbing states. **6 Hours**

Text Books:

1. **Higher Engineering Mathematics, Dr. B.S. Grewal, 36th Edition, Khanna Publishers.**
2. **Probability by Seymour Lipschutz** (Schaum's series)

Reference Books:

1. **Higher Engineering Mathematics** , B.V. Ramana, 5th Edition, Tata-Macgraw Hill, 2006.
2. **Advanced Modern Engineering Mathematics**, Glyn James, 3rd Edition, Pearson Education, 2004.

Note:

1. One question is to be set from each unit.
2. To answer Five questions choosing at least Two questions from each part.

MATERIAL SCIENCE

Subject Code	: 10CH42	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Introduction: Introduction to material science, classification of engineering materials, Level of structure, Structure property relationships in materials. **2 Hours**

Crystal Geometry And Structure Determination Geometry of crystals-the Bravais lattices, Crystal directions and planes-the miller indices, Structure determination-X-Ray diffraction-Bragg law, The powder method, Scanning electron microscope. **4 Hours**

UNIT 2:

Atomic Structure, Chemical Bonding And Structure Of Solids: Structure of atom, Periodic table, Ionization potential, Electron affinity and electro-negativity, Primary and secondary bonds, Variation of bonding character and properties, Covalent solids, Metals and alloys, Ionic solids, Structure of silica and silicates, Polymers. **6 Hours**

UNIT 3:

Crystal Imperfections: Point imperfections, Line imperfections-edge and screw dislocations, Surface imperfections. **5 Hours**

UNIT 4:

Phase Diagram and Phase Transformations: Phase rule, Single component systems, Binary phase diagrams, Lever rule, Typical phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron – Carbon systems, Nucleation and growth, solidification, Allotropic transformation, Cooling curve for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT Curves), Eutectic, Eutectoid, Peritectic, Peritectoid reactions. **8 Hours**

PART – B

UNIT 5:
Deformation of Materials and Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture. **7 Hours**

UNIT 6:
Heat Treatment: Annealing Normalizing, Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Carburising, Cyaniding, Nitriding, Flame hardening. **6 Hours**

UNIT 7:
Corrosion and its Prevention: Direct corrosion, Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, Factor influencing corrosion rate, Control and prevention of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, Protective coatings, glass lining, lead lining, FRP lining. **6 Hours**

UNIT 8:
Typical Engineering Materials: Ferrous metals, Non ferrous metals and alloys – Aluminium and its alloys, Copper and its alloys, Lead and its alloys, Tin, Zinc and its alloys, Alloys for high temperature service, Ceramic materials – Structure of ceramics, Polymorphism, Mechanical, electrical and thermal properties of ceramic phase. **8 Hours**

Text Books:

1. **Materials Science and Engineering – A First Course**, Raghavan V, 3rd Edn., Prentice Hall of India Pvt. Ltd., New Delhi, 1996.
2. **Material Science and Processes,** Hajra Choudhury S.K., 2nd Edition, Indian Book Distributing Co., 1982.

Reference Books:

1. **Elements of Material Science,** Van Valck H.L., 2nd Edn., Addision – Wesly Publishing Company, New York, 1964.

CHEMICAL ENGINEERING THERMODYNAMICS

Subject Code	: 10CH43	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Basic Concepts: System, surrounding and Processes, Closed and Open systems, State and Properties, Intensive and Extensive Properties, State and Path functions, Equilibrium state and Phase rule, Zeroth law of thermodynamics, Heat reservoir and Heat engines, Reversible and Irreversible processes.

First Law of Thermodynamics: General statement of First law of thermodynamics, First law of cyclic process and non – flow processes, Heat capacity. Derivation for closed system & steady state flow process-flow calorimeter & heat capacity. **6 Hours**

UNIT 2:

P-V-T Behaviour: P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes. Equations of state for real gases: Vander Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation. Compressibility charts: Principles of corresponding states, Generalized compressibility charts: Principles of corresponding states, Generalized compressibility charts. Thermodynamics diagrams. **6 Hours**

UNIT 3:

Second law of thermodynamics: General statements of the Second law, concept of Entropy, The Carnot Principle, Calculation of entropy changes, Clausius Inequality, Entropy and Irreversibility, Third law of thermodynamics. **6 Hours**

UNIT 4:

Thermodynamic Properties of Pure Fluids: Reference Properties, Energy Properties, Derived Properties, Work function, Gibbs free energy, Relationships among thermodynamic properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for Internal energy and enthalpy, Effect of temperature on internal energy, enthalpy, and entropy, Relationships between C_P and C_V, Gibbs-Helmholtz equation. **8 Hours**

PART – B

UNIT 5:

Properties of Solutions: Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, Property changes of mixing, excess properties. (Qualitative treatment) Activity & activity coefficient. **7 Hours**

UNIT 6:

Phase Equilibria: Criteria of phase equilibria, Criterion of stability, Duhem's theorem, Vapour – Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, Consistency test for VLE data, Calculation of Activity coefficients using Gibbs – Duhem equation, Liquid-Liquid equilibrium diagrams. **6 Hours**

UNIT 7:

VLE Correlations Equations: Van Laar, Margules, and Willson equations. **6 Hours**

UNIT 8:

Chemical Reaction Equilibria: Reaction Stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, pressure on equilibrium constants and other factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous reaction equilibria, phase rule for reacting system. **7 Hours**

Text Books:

1. **Introduction to Chemical Engineering Thermodynamics**, Smith J.M. and Vanness H.C., Fifth edition, McGraw Hill, New York, 1996.
2. **Chemical Engineering Thermodynamics**, Rao, Y.V.C., New Age International Publication, Nagpur, 2000.
3. **Textbook of Chemical Engineering Thermodynamics**, Narayanan, K.V., 8th Edition, Prentice Hall of India Private Limited, New Delhi, 2001.

PROCESS HEAT TRANSFER

Subject Code	: 10CH44	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Introduction: Various modes of heat transfer Viz. Conduction, Convection and Radiation. **Conduction:** Fouriers law, Steady state unidirectional heat flow through single and multiple layer slabs, Cylinders and spheres for constant and variable thermal conductivity. **8 Hours**

UNIT 2:
Insulation: Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation. **4 Hours**
Extended Surfaces: Fins – Types of fins, Derivation of fin efficiency for longitudinal fins, Fin effectiveness. **2 Hours**

UNIT 3:
Elementary treatment of unsteady state heat conduction. **2 Hours**
Convection: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor. **4 Hours**

UNIT 4:
Dimensionless numbers, - Dimensional analysis, Empirical correlation for forced and natural convection. **6 Hours**

PART – B

UNIT 5:
Analogy between momentum and heat transfer – Reynolds, Coulburn and Prandtl analogies.
Heat Transfer with Phase Change: Boiling phenomena, Nucleate and film boiling, Condensation – Film and Drop wise condensation, Nusselts equations. **5 Hours**

UNIT 6:
Heat Transfer Equipment: Double pipe heat exchangers, Shell and tube heat exchangers – Types of shell and tube heat exchangers, Construction details, Condenser – types of condensers. **6 Hours**

UNIT 7:
Design of Heat Transfer Equipment: Elementary design of double pipe heat exchanger, shell and tube heat exchanger and condensers. **4 Hours**
Evaporators: Types of evaporators, performance of tubular evaporator – Evaporator capacity, Evaporator economy, Multiple effect evaporator. **5 Hours**

UNIT 8:
Radiation: Properties and definitions, Absorptivity, Reflectivity, Emissive power and intensity of radiation, Black body radiation, Gray body radiation, Stefen – Boltzmann law, Wien's displacement law, Kirchoffs law, View factors, Radiation between surfaces- different shapes, Radiation involving gases and vapours, Radiation shields. **6 Hours**

Text Books:

1. **Process Heat Transfer**, Kern D.Q., Mc Graw Hill., 18th Reprint, 2008.
2. **Unit Operations of Chemical Engineering**, McCabe, W.L., et.al, 5th Edn, McGraw Hill, New York 2000.
3. **Unit Operations of Chemical Engineering**, Coulsion J.M. and Richardson J.F., Vol. 1, 5th Edn, Chemical Engineering Pergamon and ELBS, McGraw Hill, New York 2000.

Reference Book:

1. **Heat Transfer,** Rao., Y.V.C., 1st Edn., University Press (India) Ltd., New Delhi, 2000.

COMPUTATIONAL METHODS

Subject Code	: 10CH45	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Algorithms and C Programs - Simultaneous linear algebraic equation: Jacobi and Guass-Seidel, Jordan iterative methods (material balances etc).

Non-linear algebraic equation: Newton Raphson Method, Modified Newton Raphson, Method of False Position (Molar Volume of non-ideal gases, Settling velocity, heat loss from pipes, vapor pressure estimation etc). **7 Hours**

UNIT 2:

Interpolation: Newton-Gregory Forward and Backward Interpolation, Lagrange's Interpolation formula, Newton divided difference interpolation formula. (Estimation of thermo-physical properties). **6 Hours**

UNIT 3:

Numerical Integration: Gaussian Quadrature, Trapezoidal Rule and Simpson's 1/3 rule and 3/8 rule. **6 Hours**

(Solutions of Rayleigh's equation, average heat capacity equation, batch/PFR design equation)

UNIT 4:

Ordinary differential equations: Euler and Modified Euler method, Runge-Kutta method of Fourth order, (rate equations Solution of Boundary Value problems, Finite difference method. (Temperature calculations at nodes on flat slab and pipes etc). **7 Hours**

PART – B

UNIT 5:

Curve fitting by the method of Least Squares linear.(Heat capacity vs temperature, f vs Nre, Arrhenius equation, settling velocity vs Diameter of particle etc). **6 Hours**

UNIT 6:

P – X,Y and T – X,Y evaluation for binary mixtures: Calculation of Bubble Pressure and Bubble Point. Dew Pressure and Dew point for Ideal Binary and multi-component system. Flash Vaporization for multi-component system. (Algorithm and C Program). **7 Hours**

UNIT 7:

Solution of Design Equations: Adiabatic Batch Reactor, PFR, CSTR. Adiabatic Flame Temperature (Algorithm and C Program). **6 Hours**

UNIT 8:

Design : Double pipe Heat Exchanger (Area, Length and Pressure drop). Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop) (Algorithm and C Program). **7 Hours**

Text Books:

1. **Computer Oriented Numerical Methods**, V. Rajaraman, 2nd Edition, Prentice Hall of India, 1981.
2. **Applied Mathematics in Chemical Engineering,** Mickley, Sherwood, and Reed, 2nd Edition, Tata McGraw Hill, 1990.

Reference Books:

1. **Numerical methods of Engineering and Science**, B.S.Grewal, Khanna Publishers
2. **Advanced Modern Engineering Mathematics,** Glyn James, PearsonEducation,3rd Edition.
3. **Probability and Statistics with Reliability,** Queing and Computer Applications, Trivedi K.S., Prentice Hall of India.

INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

Subject Code	: 10CH46	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

General Introduction To Spectroscopy: Types of spectroscopy, representation of a spectrum, nature and interaction of electromagnetic radiation, energies corresponding to various kinds of radiations, atomic and molecular transitions, selection rules, spectral width, factors influencing positions and intensity of spectral lines. **3 Hours**

Electronic Spectroscopy: Quantitative aspects of absorption measurements – Beer Lambert's law- definition, derivation and its limitations, terminology associated with electronic spectroscopy-(Molar absorptivity, bathochromic effect, hypsochromic effect) types of absorption bands and theoretical interpretation, effect of solvent and structure on λ_{max}-. polar and non polar solvents, various electronic transitions, effect of solvent on the energy of $n \tilde{} \pi^*$ and $\pi \tilde{} \pi^*$ transitions, Woodward – Fieser rules for calculating λ_{max} of $\pi \tilde{} \pi^*$ transitions, Instrumentation- Source, monochromator- entrance and exit slits, mirror, dispersion, detector. Qualitative and Quantitative analysis, structure determination- based on bonding, electron transitions and group frequencies. **4 Hours**

UNIT 2:

Infrared Spectroscopy: Introduction – Regions of infrared region spectrum, Requirement of IR absorption (selection rule) – correct wavelength of radiation and change in electric dipole moment of a molecule. Theory of IR absorption. Types of vibrations - Stretching vibrations – symmetrical stretching and antisymmetrical stretching and Bending vibrations – scissoring, rocking, wagging and twisting vibrations. Fundamental modes of vibrations – Linear and non

linear molecules. Factors affecting the group frequencies – coupled interactions, electronic effects and hydrogen bonding. Instrumentation - IR radiation source, monochromator, and detectors. FTIR Instrument and its advantages, sample handling techniques – solution, nujol mull and KBr pellet.. Characteristic group infrared absorption for organic molecules. Applications of IR to structural elucidation of simple organic molecules. **7 Hours**

UNIT 3:

Nuclear Magnetic Resonance Spectroscopy: The nuclear spin, Larmor precession, the NMR isotopes, energy levels for a nucleus with spin quantum number I = ½ , $^{3}/_{2}$ and $^{5}/_{2}$, theory of population of nuclear spin levels, spin-spin and spin-lattice relaxation, chemical shift – definition, causes, measurement and advantages of TMS as a reference compound, factors affecting chemical effect, shielding and deshielding mechanisms, correlation of chemical shifts with chemical environment – aliphatic, alkenic, alkynic, aldehydic, ketonic, aromatic, alcoholic, phenolic, carboxylic, amino protons, spin – spin coupling, spin – spin splitting, intensity ratio of multiplet- Pascal's triangle method, chemical exchange, effect of deuteration, classification of spin systems (AX, AMX, AB, ABC), first order spectra, low and high resolution spectra, determination of peak areas, coupling constants-short and long range couplings, introduction to ^{13}C spectra of simple molecules. **7 Hours**

UNIT 4:

Mass Spectrometry: Introduction, basic principles, instrumentation, methods of generating positively charged ions – electron impact, chemical ionization, field desorption, and fast atom bombardment techniques, mass analysers – types, resolving power, molecular ion peak, base peak, metastable peak and isotopic peak, modes of fragmentation, factors affecting fragmentation, mass spectral fragmentation of organic compounds – aromatic compounds, alcohols, carbonyl compounds, carboxylic acids, esters, McLafferty rearrangement, determination of molecular weight and molecular formula, nitrogen and ring rule. **5 Hours**

PART – B

UNIT 5:

Flame Photometry and Atomic Absorption Spectroscopy: Introduction, principle, flames-ionization and dissociation in flames, types of flames used in AAS and flame spectra, variation of emission intensity with flame, metallic spectra in flame, flame ground, role of temperature on absorption emission and fluorescence Comparative study of flame emission spectroscopy (FES) and Atomic absorption spectroscopy (AAS). Instrumentation- line sources, source modulation in AAS. Application – Qualitative and Quantitative determination of alkali and alkaline earth metals. **8 Hours**

UNIT 6:

Polarography: Principles of polarographic measurements, polarograms, Description and working of dropping mercury electrode. Current and concentrations relationship. Supporting electrolyte. Limiting current, half wave potential. Factors affecting half wave potential. Migration current, Residual current and diffusion current. Measurements of wave heights, Evaluation of quantitative results- Wave height-concentration method, internal standard (pilot) method and standard addition method. Modes of operation. Rapid scan polarography,differential pulse polarography, sinusoidal a.c. polarography. Applications of polarography-Identification and determination of concentration of analyte. **6 Hours**

UNIT 7:

Introduction to Chromatrography: Classification - Theory - distribution coefficient, rate of travel, retention time, adjusted retention time, retention volume, adjusted retention volume, net retention volume, specific retention volume, column capacity, separation number, peak capacity, shapes of chromatic peak, column efficiency, resolution, optimization of column performance, Numerical problems. **3 Hours**

Thin Layer Chromatography: Stationary phase, mobile phase, sample application, development techniques – evaluation and documentation, advantages and disadvantages, sintered layers used in TLC. **3 Hours**

UNIT 8:

Gas Chromatography: Principle, carrier gas, stationery phase, instrumentation, sample injection, column detectors (TCD, FID, ECD, atomic emi+ssion detector), effect of temperature on retention, qualitative and quantitative analysis, pyrolysis GC, GC-MS, complementary and related techniques. **3 Hours**

High Performance Liquid Chromatography: Principle, instrumentation, column, sample injection, detectors (absorbance, refractive index, electrochemical), mobile phase selection, ion pair chromatography, HPLC-MS chromatography with chiral phases. **3 Hours**

TEXT BOOKS:

1. **Spectrometric Identification of organic compounds,** R.M. Silverstein and W.P. Webster, 6th Edition, Wiley & Sons, 1999.
2. **Instrumental Methods of Analysis,** H.H.Willard, L.L. Merritt and J.A. Dean and F. A. Settle, CBS Publishers, 7th Edition, 1988.

REFERENCE BOOKS:

1. **Instrumental methods of Chemical Analysis**, G.W. Ewing, 5th Edition, McGraw-Hill, New York, 1988.
2. **Principles of Instrumental Analysis,** Skoog, D.A, S.J. Holler, T.A. Nilman, 5th Edn., Saunders college publishing, London, 1998.
3. **Instrumental Methods of Chemical Analysis,** Chatwal Anand, 3rd Edition ,Himalaya Publishing House,1986.
4. **Principles of Electroanalytical Methods,** T. Riley and C. Tomilinsom, John Wiley and Sons, 2008.
5. **Instrumental Methods of Chemical Analysis,** K. Sharma, Goel Publishing House Meerut 2000.
6. **Vogel's Text Book of Quantitative Inorganic analysis,** Jaffery, Gill, Basset. J *et al* 5th Edn., 1998 ELBS.

MECHANICAL OPERATIONS LABORATORY

Subject Code	: 10CHL47	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 03
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Air elutriation

2. Air permeability
3. Ball mill
4. Batch sedimentation
5. Beaker decantation
6. Cyclone separator
7. Drop weight crusher
8. Froth floatation
9. Grindability index
10. Gyratory crusher
11. ICI sedimentation
12. Jaw crusher
13. Leaf filter
14. Plate and frame filter press
15. Rod mill
16. Screen effectiveness
17. Sieve analysis

Note: Minimum of 10 experiments are to be conducted.

TECHNICAL CHEMISTRY LABORATORY – II

Subject Code	: 10CHL48	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 03
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Preparation of acetanilide by acetylation of aniline using acetic anhydride.
2. Preparation of p-bromoacetanilide by bromination of acetanilide.
3. Preparation of o-phenylenediamine by the reduction of o-nitroaniline.
4. Preparation of benzoic acid by the oxidation of benzaldehyde.
5. Preparation of benzene diazonium chloride by diazotisation of aniline and preparation of p-hydroxy azobenzene by coupling with phenol.
6. Estimation of alcohol by acetylation.
7. Estimation of amino group by acetylation.
8. Estimation of phenol by bromination.
9. Estimation of carboxylic acid by iodometric titration.
10. Estimation of esters by hydrolysis.
11. Analysis of oil - determination of acid value and saponification value.
12. Analysis of milk - determination of lactose in the given sample of milk.

Note: Minimum of 10 experiments are to be conducted.

V SEMESTER

MANAGEMENT & ENTREPRENEURSHIP

Subject Code	: 10AL51	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

MANAGEMENT

UNIT 1:

Management: Introduction: Meaning – nature and characteristics of Management, Scope and functional areas of management – Management as a science, art or profession – Management & Administration – Roles of Management, Levels of Management, Development of Management Thought – early management approaches – Modern management approaches. **7 Hours**

UNIT 2:

Planning: Nature, importance and purpose of planning process – Objectives – Types of plans (Meaning only) – Decision making – Importance of planning – Steps in planning & planning premises – Hierarchy of plans. **6 Hours**

UNIT 3:

Organising And Staffing: Nature and purpose of organization – Principles of organization – Types of organization – Departmentation – Committees – Centralization Vs Decentralization of authority and responsibility – Span of control – MBO and MBE(Meaning only) Nature and importance of Staffing – Process of Selection & Recruitment (in brief). **7 Hours**

UNIT 4:

Directing & Controlling: Meaning and nature of directing – Leadership styles, Motivation Theories, Communication – Meaning and importance – Coordination, meaning and importance and Techniques of Co – ordination. Meaning and steps in controlling – Essentials of a sound control system – Methods of establishing control (in brief). **6 Hours**

PART - B

ENTREPRENEURSHIP

UNIT 5:

Entrepreneur: Meaning of Entrepreneur; Evolution of the Concept, Functions of an Entrepreneur, types of Entrepreneur, intrapreneur – an emerging emerging Class. Concept of Entrepreneurship – Evolution of Entrepreneurship, Development of Entrepreneurship. **6 Hours**

UNIT 6:

Small Scale Industry: Definition; Characteristics; Need and rationale: Scope; role of SSI in Economic Development. Advantages of SSI. Steps to Start and SSI – Government policy towards SSI; Different Policies of S.S.I.; Government Support for S.S.I. during 5 year plans. Impact of Liberalization, Privatization, Globalization on S.S.I., Effect of WTO/GATT Supporting Agencies of Government for S.S.I., Meaning; Nature of Support; Objectives; Functions; Types of Help; Ancillary Industry and Tiny Industry (Definition only). **6 Hours**

UNIT 7:

Institutional Support: Different Schemes; TECKSOK; KIADB; KSSICE; KSIMC; DIC Single Window Agency: SISI; NSIC; SIDBI; KSFC. **8 Hours**

UNIT 8:

Preparation Of Project: Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission Identification of Business Opportunities:

Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. **6 Hours**

Text Books:

1. **Principles of Management,**P.C. Tripathi, P.N.Reddy; 3rd Edition ,Tata McGraw Hill, 2005.
2. **Dynamics of Entrepreneurial Development & Management,** Vansant Desai, 4th Edition , Himalaya Publishing House, 2001.
3. **Entrepreneurship Development,** Small Business Enterprise, Poornima M Charantimath, 1st Edition ,Pearson Education, 2006.
4. **Management and Enterprenurship,** NVR Naidu and Krishna Rao, I K International, 2008.

Reference Books:

1. **Management Fundamentals,** Concepts, Application, Skill Development, Robert Lusier, 4th Edition, Thomson, USA.
2. **Entrepreneurship Development,** S S Khanka, S Chand & Co., 2006.
3. **Management,** Stephen Robbins, 17th Edition, Pearson Education/PHI, 2003.

CHEMICAL PROCESS INDUSTRIES

Subject Code	: 10CH52	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Sulfur: Elemental Sulfur mining, Sulfur from ores, Oxides of Sulfur (SO_2, SO_3).
Industrial Gases: CO_2, H_2, O_2, N_2, Water gas and Shift gas. **7 Hours**

UNIT 2:

Acids: Sulfuric, Nitric, Hydrochloric, phosphoric acid.
Chlor-Alkali Industries: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder. **6 Hours**

UNIT 3:

Fertilizers: Ammonia, Urea, Ammonium chloride, Ammonium nitrate, Ammonium phosphate, Ammonium sulfate, DAP, Biofertilizers. **7 Hours**

UNIT 4:

Phosphorous Industries: Manufacture of white and Red Phosphorus, Pentoxide, Phosphatic Fertilizers, Super Phosphate and Triple Super Phosphate. **6 Hours**

PART - B

UNIT 5:

Fermentation Industries: Production of alcohol, acetic acid and citric, penicillin. **6 Hours**

UNIT 6:

Petroleum Industries: Constituents of crude petroleum refining and processing. Production of Ethylene, Propylene. **7 Hours**

UNIT 7:
Polymers and Rubber: Polymerization, PVC, LDPE, Polyproylene, cross linked polymers, natural rubber, synthetic rubber and rubber compounding. **6 Hours**

UNIT 8:
Miscellaneous Industries: Paints, Pigments, Vanishes, Enamel, Lacquers - White Lead and Zinc oxide, Hydrogen peroxide (H_2O_2), Silicon carbide (SiC), Glass, Cement, Chlorine and Fluorine based industries. **7 Hours**

Text Books:

1. **Chemical Process Industries,** Shreve's, 4th Edition, McGraw Hill.
2. **Dryden – Outlines of Chemical Technology for 21st Century,** Gopal Rao & Marshall Sittig, 3rd Edition., EWP.
3. **Unit Processes in Organic Chemical Industries**, Desikan and Sivakumar (Eds.), CEDC, IITM, 1982.

Reference Book:

1. **Encyclopedia of Chemical Technology**, Kirk and Othmer, 27 volume set, 5th Edition, Wiley, 2004.

MASS TRANSFER – I

Subject Code	: 10CH53	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction: Types of diffusion in fluids. Types of diffusion in solid. Measurement and calculations of diffusivities. **6 Hours**

UNIT 2:
Eddy Diffusion: Mass transfer coefficients and their correlations. Theories of mass Transfer. Interphase mass transfer. J_d factor, Analogies in mass, heat and momentum transfer processes. **6 Hours**

UNIT 3:
Stage-Wise Operations: Material balance for co-current, cross-current and counter-current operations. Concept of stages, cascades operation, NTU and HTU concepts. **6 Hours**

UNIT 4:
Humidification: General theory. Psychrometric chart. Concepts in humidification, dehumidification. Design of cooling towers. **8 Hours**

PART - B

UNIT 5:
Drying: Introduction, Equilibria, Drying rate curves. Mechanism of drying, types of dryers. Design of batch and continuous dryers. **7 Hours**

UNIT 6:
Crystallization: Factors governing nucleation and crystal growth rates. Controlled growth of crystals. Incorporation of principles into design of equipment. Different types of crystallizer equipment. **6 Hours**

UNIT 7:
Adsorption: Theories of adsorption. Isotherms, Industrial adsorbents. Equipment, Batch & continuous multistage Adsorption. **7 Hours**

UNIT 8:
Introduction to Novel Separations: Ion exchange**,** Membrane processes - Reverse Osmosis, Dialysis, Ultra and Micro-filtrations, Super-critical fluid extraction. (Working principles and operations only) **6 Hours**

Text Books:

1. **Mass Transfer Operations -** Robert E Treybal, 3rd Edition, McGraw Hill, 1981.
2. **Unit Operations in Chemical Engineering -** McCabe & Smith, 6th Edition, McGraw Hill, 2001.

Reference Books:

1. **Chemical Engineering Vol I, II, IV and V -** Coulson and Richardson, 4th Edition, Pergamon Press, 1998.
2. **Introduction to Chemical Engineering -** Badger & Banchero, TMH 6th Reprint 1998.
3. **Principles of Unit Operation -** Foust et.el., 2nd Edition, John Wiley, 1994.
4. **Transport Processes and Unit Operation -** Geankoplis C J, Prentice Hall (I), 2000.
5. **Applied process design for Chemical and petrochemical plant** Ludwig, 2nd Edition, Gulf Publishing, 2002.

CHEMICAL REACTION ENGINEERING – I

Subject Code	: 10CH54	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction: Scope of Chemical Reaction Engineering. Classification of reactions. Rate equation and rate of reaction. Factors affecting rate of reaction. Chemical kinetics and Thermodynamics Equilibrium. Temperature dependency of rate constant from Arrhenius, Collision and Transition state theories. Molecularity and order of reaction. **6 Hours**

UNIT 2:
Non-Elementary Reactions: Difference between elementary and non-elementary reactions. Kinetic models and mechanisms for non-elementary reactions. Types of reactors. **6 Hours**

UNIT 3:
Homogeneous Reactions: Interpretation of batch reactor data. Constant & Variable Volume batch reactor. Analysis : Differential method, Integral method, half-life method. Method of excess and method of isolation (For Reversible and Irreversible reactions up to second order). Autocatalytic reactions. **7 Hours**

UNIT 4:
Design Of Ideal Reactors: Concept of ideality. Development of design equations for batch, tubular and stirred tank reactors for both constant and variable volume reactions. Evaluation of rate equations from data obtained in these reactors. **7 Hours**

PART - B

UNIT 5:
Comparison Of Ideal Reactors: General graphical comparison.
Multiple Reactor Systems: Plug flow and/or Mixed flow reactors in Series, parallel and series parallel. Reactors of different types and sizes in series. **6 Hours**

UNIT 6:
Design Of Reactors For Multiple Reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel, Series and Series-Parallel reactions (Only irreversible reactions must be considered). **7 Hours**

UNIT 7:
Non-Isothermal Reactors: Introduction, effect of temperature on equilibrium constant and heat of reaction, Material and Energy balances, conversions in adiabatic and non-adiabatic reactors. **7 Hours**

UNIT 8:
Analysis Of Non Isothermal Reactor: Design procedure (For single/ simple reactions only). Optimum temperature Progression. **6 Hours**

TEXT BOOKS:

1. **Chemical Reaction Engineering,** Octave Levenspeil, 3rd edition, John Wiley & Sons, 2001.
2. **Elements of Chemical Reaction Engineering,** H. Scott Fogler, 3rd edition, Prentice Hall 2001.

REFERENCE BOOK:

1. **Chemical Engineering Kinetics,** J.M. Smith, 3rd Edition, McGraw Hill, 1984.

POLLUTION PREVENTION AND CONTROL EINGINEERING

Subject Code	: 10CH55	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction: Importance of environment for mankind. Biosphere and layers of atmosphere. Hydrological cycle and nutrient cycles. Types of pollution. Damages from environmental pollution. Need of environmental legislations and environmental Acts in India. Functions of central and state pollution control boards. **6 Hours**

UNIT 2:

Sources, Sampling and Analysis Of Wastewater: Water resources. Origin of wastewater. Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Types of water pollutants and their effects. Sampling, and methods of analysis. **7 Hours**

UNIT 3:
Wastewater Treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Sludge treatment and disposal. Advanced wastewater treatment. Recovery of materials from process effluents. **7 Hours**

UNIT 4:
Applications To Industries: Norms and standards of treated water. Origin, characteristics, and treatment methods in typical industries – petroleum refinery, pulp and paper, fertilizer, distillery, tannery, and textile processing. **6 Hours**

PART - B

UNIT 5:
Air Pollution Aspects: Nature of air pollution. Classification of air pollutants. Sources of air pollutants. Air quality criteria and standards. Plume behaviour and dispersion of air pollutants. Effects of air pollution on health, vegetation, and materials. **7 Hours**

UNIT 6:
Air Pollution Control: Sampling of pollutants. Methods of estimation of air pollutants. Automobile pollution. Control methods for particulates and gaseous pollutants. Origin, control methods, and equipment used in typical industries – Thermal power plants, metallurgical industries, and cement industries. **7 Hours**

UNIT 7:
Solid Waste Treatment: Origin, Classification and microbiology. Properties and their variation. Engineered systems for solid waste management – generation, onsite handling, storage, collection, transfer and transport, composting, sanitary land filling. **6 Hours**

UNIT 8:
Noise Control: Sources and definitions. Determination of noise levels. Noise control criteria and noise exposure index. Administrative and engineering controls. Acoustic absorptive materials. **6 Hours**

Text Books:

1. **Environmental Pollution Control Engg,** C.S. Rao, 2nd Edition, New Age International Reprint, 2002.
2. **Pollution Control in Process Industries,** S.P. Mahajan, Tata Mc Graw Hill, 22nd Reprint, 1999.

Reference Books:

1. **Principles and Practices of Air Pollution Control and Analysis,** J.R. Mudakavi, I.K. International Publishing Home Pvt. Ltd., New Delhi, 2010.
2. **Air Pollution,** H.C. Perkins, McGraw Hill, 1974.
3. **Solid Waste Management,** D.J. Hagery et.al., Van Nostrand Reinhold, 1973.
4. **Industrial Pollution Control Handbook,** Lund, H.F., 6th Edition, Vol.1, McGraw Hill, 1971.
5. **Noise Abatement,** Duerden, Buttreworth, 1970.

6. **Introduction to Environmental Engg,** Davis., 3rd Edition, McGraw Hill, 1998.
7. **Waste Water Engineering Treatment Disposal Reuse,** Metcalf and Eddy, 4th Edition, Tata McGraw Hill, 2003.
8. **Environmental Engineering,** G.N. Pandey and G.C. Carney, Tata McGraw Hill, 11th Reprint, 2002.
9. **Integrated Solid Waste Management,** George Tchobanoglous et al, 2nd Edition, McGraw Hill & Co, 1993.

CHEMICAL EQUIPMENT DESIGN

Subject Code	: 10CH56	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction: Basic considerations in design. General design procedure. Equipment classification. Various components of process equipment. Design parameters. Pressure vessel codes. **6 Hours**

UNIT 2:
Design Considerations: Material selection. Factors affecting design. Stresses due to static and dynamic loads (Internal & External). Temperature effects. Economic considerations. **6 Hours**

UNIT 3:
Design of Pressure Vessels: Design parameters, conditions & stresses. Design of shell, and other vessel components. Vessel at low & high operating temperatures. Design problems using given process parameters. **7 Hours**

UNIT 4:
Vessel Component Design: Design of supports for vessels - Bracket, Lug, Leg, Saddle and Skirt supports. Design of flanges & nozzles – Classification of flanges. Flange thickness calculation, Gasket selection and design, Bolt selection and calculation. Nozzle design. Design of vessel closures – Flat plates, Formed heads, Elliptical & Hemispherical heads. **7 Hours**

PART - B

UNIT 5:
Storage Vessels: Process conditions and design parameters for storage of volatile, non-volatile fluids & gases. Design of cylindrical tanks with fixed roofs. Design of partially filled spherical tanks. Design of components, supports and selection of vessels accessories & mountings. Numerical problems. **7 Hours**

UNIT 6:
Reaction Vessels: Design of reaction tanks with agitation and jacket. Types of agitators, baffles. Power requirement calculations. Design of tank dimensions and agitation system components. Drive calculations & selection of accessories. Design of jackets. Support calculations for the system. Numerical problems. **7 Hours**

UNIT 7:

Tall Vertical Vessels: Vessels subjected to various loads, Multi shell constructions. Determination of shell thickness. Supports for columns. **6 Hours**

UNIT 8:

Pipe Line Design: Pipe line sizing, Condensate and steam pipe design, Optimum size of delivery line in pumping operations. Concepts of P & I Diagrams, P & I Diagram for simple processes. **6 Hours**

Text Books:

1. **Process Equipment Design** - M. V. Joshi, 3rd Edn., Macmillan & Co. India, Delhi, 1998.
2. **Process Equipment Design – Vessel Design,** Brownell & Young, John Willey, 1959.
3. **Process Design of Equipment – Vol 1,** S. D. Dawande, 3rd. Edn, Central Techno Publications. 2003.

Reference Books:

1. **Chemical Engineers Handbook,** Perry & Green, 7th Edn, McGraw Hill, 1997.
2. **Pressure Vessel Code – IS 2825,** IS Code, B.I.S., New Delhi, 1969.
3. **Flow of Fluids through Valves, Fittings & Pipes**, Crane Amazon, 2006.

POLLUTION CONTROL AND INSTRUMENTATION ANALYSIS LABORATORY

Subject Code	: 10CHL57	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Analysis of effluents for pH, alkalinity and turbidity
2. Determination of COD and BOD
3. Volatile, Fixed, Filterable and Dissolved solid analysis
4. Analysis by ion selective electrode (any two anions)
5. Measurement of particulate matter in Air
6. Measurement of SO_2 in air
7. Analysis of exhaust be Orsat apparatus
8. Analysis of flue gases by Gas chromatograph
9. UV Spectrophotometer
10. KF Auto titrator
11. Flame photometer
12. Turbidometer
13. Dissolved Oxygen measurement
14. Bomb calorimeter
15. Viscometer
16. Polarograph
17. Potentiometer titration

Note: Minimum of 10 experiments are to be conducted.

HEAT TRANSFER LABORATORY

Subject Code	: 10CHL58	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Natural Convection in Bare and Finned tube
2. Vertical Shell and tube Heat exchanger (Condenser)
3. Horizontal Shell and tube Heat exchanger (Condenser)
4. Helical Coil Heat exchanger
5. Emissivity Determination
6. Effect of Geometry on Natural convection
7. Heat Transfer in Packed Beds
8. Double Pipe Heat Exchanger
9. Heat Transfer in Jacketed Vessel
10. Determination of Insulation Thickness
11. Transient Heat Conduction
12. Heat Transfer in Fluidized Beds
13. Evaporator
14. Solar Heater
15. Spiral Plate Heat Exchanger
16. Cross Flow Heat Exchanger

Note: Minimum of 10 experiments are to be conducted.

VI SEMESTER

CHEMICAL PLANT UTILITIES AND SAFETY

Subject Code	: 10CH61	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Introduction: Different utilities. Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities.

Water: Water resources. Process water, Cooling water, drinking water and boiler feed water Quality Standards. Water treatment processes for drinking, process and boiler feed. Storage and handling of water. Types and selection of pumps, piping and accessories. Water pre treatment, **7 Hours**

UNIT 2:

Air: Compressed air, blower air, fan air. Types of compressor and vacuum pumps and selection. Power requirements, performance and related calculations. Booster and receivers. Quality of compressed air for instruments and processes. Compressed air distribution system- piping and accessories. Air-water vapour system: humidification/ dehumidification and evaporative cooling-related calculations. **6 Hours**

UNIT 3:

Steam And Power: Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels-types, emissions and global warming, green fuels. Calorific value. Proximate and

ultimate analysis. HHV, LHV and related calculations. Cogeneration power plants. CHPs and Boiler performance. Related Calculations. Economy of steam generation with different fuels, related calculation. Steam storage and handling-piping and accessories. **7 Hours**

UNIT 4:

Refrigeration: Different refrigeration systems and their characteristics. Air-conditioning systems. Coefficient of performance. Power requirements and refrigeration effect- related calculations for each type of refrigeration system. Refrigerant properties and selection. Some commonly used refrigerants and secondary refrigerants. **6 Hours**

PART - B

UNIT 5:

Insulation: Insulation Materials & Selection- Economics of insulation. Insulating factors. Properties & Classification. Cold insulation and cryogenic insulation. **6 Hours**

UNIT 6:

Introduction To Process Safety: Intrinsic & Extrinsic Safety. The Hazards- Toxicity, Flammability, Fire , Explosions. Sources of ignition, Pressure. Hazard and risk assessment methods. MSDS. **6 Hours**

UNIT 7:

Safety Devices: Pressure relief valves. Ruptures discs. Blow down systems. Flare systems. Flame arrestors. Deflagration arrestors and explosion suppression. Personal safety devices. **7 Hours**

UNIT 8:

Process Safety Analysis: HAZAN and HAZOP comparison.. Risk analysis and estimation. Safety check list. Computer based quantitative risk analysis. **7 Hours**

Text Books:

1. **Thermal Engineering,** B.K. Sarkar, Tata Mc Graw Hill, 8th Reprint, 1998.
2. **Heat Engines,** K.P. Roy, Media Promoters and Publishers, 1995.
3. **Power Plant Engineering,** P.K. Nag, 2nd Edition ,Tata Mc Graw Hill, 1998.
4. **Water and Waste water engineering- Vol 2,** Gordon M Fair, John C. Geyer and Daniel A Okun, Jhon Hutey,1996.
5. **Water and waste water Technology,** Mark J. Hammer Jr.,4th Edition, Prentice Hall, 1997.
6. **Chemical Engineers Handbook,** Perry, 8th Edition, 2007.
7. **Chemical Engineering- Vol 6,** R.K. Sinnot, Coulson and Richardson's, 3rd Edition, BH, Reprint, 2000.
8. **Loss prevention in chemical process industries, Vol. 1,2,3,** Frank P Lees, Butterworth-Heiremann,1980.

MASS TRANSFER – II

Subject Code	: 10CH62	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Gas Liquid Contacting Systems: Types, construction and working of plate and packed columns, types and properties of industrial packings, plate efficiencies, HETP and HTU concepts. **7 Hours**

UNIT 2:
Absorption: Absorption. Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors. **7 Hours**

UNIT 3:
Packed Tower Absorption: Liquid phase hold up and pressure drop in absorption towers. Design of packed towers (process design-height and diameter). Multi-component absorption. Absorption with chemical reaction. **6 Hours**

UNIT 4:
Distillation: Introduction. Vapour liquid equilibria (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Steam distillation**,** Flash and simple distillation. **6 Hours**

PART - B

UNIT 5:
Distillation (Contd.):. Multi-stage rectification column. Design using McCabe Thiele and Lewis-Sorel methods for binary mixtures. **6 Hours**

UNIT 6:
Distillation (Contd.): Ponchon-Savarit method. Introduction to Multicomponent distillation., Vacuum, molecular, extractive and azeotropic distillations. **7 Hours**

UNIT 7:
Liquid-Liquid Extraction: Ternary equilibrium. Solvent selection. Single stage. Multi-stage cross-current, counter-current extraction. Equipment for liquid-liquid extraction. **7 Hours**

UNIT 8:
Leaching Operation: Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. Calculation of single stage and multi-stage leaching operation. **6 Hours**

Text Books:

1. **Mass Transfer Operations,** Robert E Treybal, 3rd Edition, McGraw Hill 1981.
2. **Unit Operations in Chemical Engineering,** McCabe & Smith, 6th Edition, McGraw Hall, 2001.

Reference Books:

1. **Chemical Engineering Vol I, II, IV and V,** Coulson and Richardson, 4th Edition, Pergmon Press, 1998.
2. **Introduction to Chemical Engineering,** Badger & Banchero, TMH 6th Reprint, 1998.
3. **Principals of Unit Operation,** Foust et.el., 2nd Edition, John Wiley, 1994.
4. **Transport Processes and Unit Operation,** Geankoplis ,C J, Prentice Hall (I), 2000.

CHEMICAL REACTION ENGINEERING – II

Subject Code	: 10CH63	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Basics of Non Ideal Flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. Dispersion model. Tanks in series model. Conversion in non- ideal flow reactors for simple systems. **7 Hours**

UNIT 2:
Introduction to Heterogeneous Systems: Rate equations, contacting patterns, fluid-particle noncatalytic reactions, URC model, Spherical particles of unchanging size, shrinking spherical particles, determination of rate controlling steps. **7 Hours**

UNIT 3:
Fluid-Fluid Non Catalytic Reactions: Kinetic regimes for mass transfer and reaction; rate equations. **6 Hours**

UNIT 4:
Catalysis: Introduction to catalysis. Properties of catalysts. Estimation methods for catalytic properties. Promoters, inhibitors etc, Mechanism of catalysis. Rate equations for different rate controlling steps **6 Hours**

PART – B

UNIT 5:
Deactivation: Deactivating catalyst. Mechanism, rate & performance equation. **6 Hours**

UNIT 6:
Solid Catalyzed Reactions: Heterogeneous reactions-Introduction., Kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Thiele modulus and enhancement factor, Porous catalyst particles. Heat effects during reaction. **7 Hours**

UNIT 7:
Solid Catalyzed Reactions (Contd.): Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates. Packed bed catalytic reactor & reactors with suspended solid catalyst. Fluidized reactors of various type. **7 Hours**

UNIT 8:
Gas-Liquid Reactors: Trickle bed, slurry reactors. Three phase fluidized bed. **6 Hours**

Text Books:

1. **Chemical Reaction Engineering,** Octave Levenspiel, 3rd Edition, John Wiley & Sons, 2001.
2. **Chemical Engineering Kinetics,** J.M. Smith, 3rd Edition, McGraw Hill.
3. **Elements of Chemical Reaction Engineering,** H. Scott Foggler, 3rd Edition, Prentice Hall, 2001.

Reference Book:

1. **Chemical & Catalytic Reaction Engineering,** James J. Carberry, McGraw Hill, 1976.

ENERGY TECHNOLOGY

Subject Code	: 10CH64	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Introduction To Energy Sources: Conventional energy sources; non-conventional energy sources; advantages; limitations. **4 Hours**

UNIT 2:

Solar Energy: Solar radiation and its measurement – solar constant, solar radiation at earths surface, solar radiation geometry, solar radiation measurement. Introduction to solar energy. Applications – solar water heating, space heating, space cooling, solar thermal electric conversion. Agriculture and industrial process heating, solar distillation, solar pumping, solar cooking. **8 Hours**

UNIT 3:

Energy from Biomass (Bio-Energy): Introduction. Biomass conversion Technologies. Wet processes. Dry processes. Biogas generation. Factors affecting biodigestion or generation of gas. Classification of biogas plants. Advantages and disadvantages of floating drum plant. Advantages and disadvantages of fixed dome type plant. Types of biogas plants (KVIC model & Janata model). Selection of site for biogas plant. **8 Hours**

UNIT 4:

Bio-Energy (Thermal Conversion): Methods of obtaining energy from biomass. Biodiesel, Thermal gasification of biomass. Classification of biomass gasifiers. Chemistry of gasification process. Applications of the gasifiers. **6 Hours**

PART - B

UNIT 5:

Wind Energy: Introduction. Basic components of WECS (wind energy conversion system). Classification of WECS. Types of wind machines- horizontal axis machines, vertical axis machines. Applications of wind energy. **8 Hours**

UNIT 6:

Energy Form The Oceans: Introduction. Ocean thermal electric conversion (OTEC). Methods of ocean thermal electric power generation. Open cycle OTEC system. Closed or Anderson OTEC cycle, hybrid cycle. Application of energy from oceans. **6 Hours**

UNIT 7:

Energy From Tides: Basic principles of tidal power. Components of tidal power plants. Operation methods of utilization of tidal energy. Advantages and limitations of tidal power generation. Applications of tidal energy. **6 Hours**

UNIT 8:

Fuels: Introduction. Classification of fuels. Calorific value. Characteristics of good fuels. Comparison between solid, liquid and gaseous fuels. **6 Hours**

Text Books:

1. **Non-Conventional Energy Sources,** G.D. Rai, 4th Edition, Khanna Publications, Second Reprint, 1997.
2. **Engineering Chemistry,** P.C. Jain & M. Jain, 10th Edition, Dhanpat Rai & Sons, 3rd Reprint, 1995.

Reference Books:

1. **Solar Energy, Second Edition,** S.P. Sukhatme, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
2. **Solar Energy Utilization,** G.D. Rai, 4th Edition, Khanna Publications,2006.

PROCESS EQUIPMENT DESIGN & DRAWING

Subject Code	: 10CH65	IA Marks	: 25
No. of Lecture Hours/Week	: 02 + 02	Exam Hours	: 04
Total No. of Lecture Hours	: 26 + 26	Exam Marks	: 100

Detailed chemical engineering process design of the following equipment. Necessary aspects studied in "10CH56 Chemical Equipment Design" are to be applied for mechanical design. Standard code books are to be used. The detailed proportionate drawings shall include sectional front view, full top/side view depending on equipment and major components.

1. Double pipe Heat exchanger
2. Shell and Tube Heat exchanger
3. Condensers – Horizontal and vertical
4. Evaporator – Single effect
5. Bubble Cap Distillation Column
6. Packed Bed Absorption Column
7. Rotary Dryer.

Note: 1. **Class work:** Students are to be trained in the computer lab using the software for making the drawings after the design. They shall also be trained to draw free hand proportionate sketches.

2**. Final Examination:** Students have to answer any one of the two questions given in the examination. After completing the design, free hand proportionate sketches are to be drawn as required.

Software: Solid Edge or Equivalent Software

Reference Books:

1. **Chemical Engineers Handbook,** R.H. Perry & D.W. Green, 7th Edition, McGraw Hill, 1998.
2. **Process Heat Transfer,** Donald Q. Kern, McGraw Hill, 1997.
3. **Mass Transfer Operations,** Robert E, Treybal, McGraw Hill, 1981.
4. **Chemical Engineering- Vol 6,** J.M. Coulson & J.F. Richardson, Pergemon Press, 1993
5. **Shell & Tube Heat Exchanger- IS Code, IS 4503**, BIS, New Delhi, 1969.
6. **Process Equipment Design,** Brownell & Young, Vessel Design, John Wiley, 1951.
7. **Process Equipment Design,** M.V. Joshi, McMillan & Co., India, Delhi, 3rd Edition, Reprint, 1998.

8. **Process Design of Equipment**, S.D. Dawande, Vol II, 3rd Edition, Central Techno Publications, 2003.

ELECTIVE - I (Group A)

PETROLEUM REFINERY ENGINEERING

Subject Code	: 10CH661	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Indian Petroleum Industry: Prospects & Future. Major companies. World production, Markets, Offshore and onshore, Oil well technology. **6 Hours**

UNIT 2:
Composition Of Crude: Classification. Evaluation of petroleum. UOP-k factor. TBP analysis. EFV analysis. Average boiling point. ASTM curves. Thermal properties of petroleum fractions. **6 Hours**

UNIT 3:
Product Properties And Test Methods: Gas. Various types of gas and LPG. Reid vapor pressure analysis. Gasoline and naptha. Octane No. Oxidation stability. Additives for gasoline. Kerosene. Characterization for flash point or fire point, volatility, burning qualities etc, Diesel, octane testing, viscosity etc. Grades of diesels e.g. HSD, LDO. Diesel additives. Lube oils : Types, tests-carbon residue and viscosity index. **7 Hours**

UNIT 4:
Crude Pretreatment: Pumping of crude oils. Dehydration of crude by chemical, gravity, centrifugal, electrical de-salter and comparision of each. Heating of crude- heater, different types of pipe still heaters including box type, cylindrical etc. Crude distillation, arrangement of towers for various types of reflux. Design aspects for atmospheric and vacuum column. Atmospheric distillation distillation unit: internals and operational. **7 Hours**

PART - B

UNIT 5:
Treatment Techniques: Types of impurities present and various desulfurisation processes. Production and treatment of LPG. LNG technology. Sweetening operations for gases including merox, ethanolamine, copper chloride, stertford etc. Catalytic de sulphonisation. Treatment of kerosene, De-aromatisation and merox. Treatment of diesel, naptha: desulpurisation by hydrogen and catalysts. Treatment of lubes: sulphuric acid, clay treatment, solvent treatment-phenol, furfural. **6 Hours**

UNIT 6:
Thermal Processes: Thermal cracking reactions- theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials. Visbreaking, dubbs two coil cracking process. **6 Hours**

UNIT 7:
Catalytic Cracking: Comparision of thermal and catalytic cracking. Carbonium ion chemistry. Feedback requirements. Cracking conditions. Commercial cracking analysis. Various catalytic

cracking processes. Fixed bed crackers. Moving bed crackers. Fluid catalytic cracking-flexi cracking-ortho-flow reactor. Theory of coking: various types of coking processes. Delayed coking, fluid coking, contact coking, flexi coking. Naptha cracking, naptha cracking for ethylene as feed selection and gas yield. Hydro cracking. Theory of hydro cracking. Catalysts for hydro cracking. **7 Hours**

UNIT 8:

Catalystic Reforming: Theory of reforming. Factors influencing reforming, reforming catalysts, feedstock requirements. Plat-forming, isoplus hondriforming, refining forming, power forming and flexi forming etc. **7 Hours**

Text Books:

1. **Petroleum Refinery Engineering**, Nelson, 4th Edition, McGraw Hill, 14th Reprint, 1982.
2. **Modern Petroleum Refining Processes,** Bhaskara Rao, 3rd Edition, Oxford & IBH Publication, Reprint, 1999.

Reference Books:

1. **Petroleum Refining Technology,** Ram Prasad, I Edition, Khanna Publishers, 2000.
2. **Challenges in Crude Oil Evaluation,** Nagnal J.M., Gate, McGraw Hill, 1996.
3. **Petroleum Processing,** Bland W.F. and Davidson R.L. McGraw Hill, 1967.

OPERATIONS RESEARCH

Subject Code	: 10CH662	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Introduction: Definition. Scope of Operations Research (OR). Approach and limitations of O.R. Models. Characteristics and phases of O.R.

Linear Programming Problems: Mathematical formulation of L.P. Problems. Graphical solution method. **7 Hours**

UNIT 2:

The Simplex Method: 1 & 2 – slack, surplus and artificial variables. Dual simplex method. Degeneracy and procedure for resolving degenerate cases. **7 Hours**

UNIT 3:

Assignment Problems: Balanced and Unbalanced assignment problems. Maximization assignment problems. Travelling salesman problems. **6 Hours**

UNIT 4:

Transportation Problem: Basic feasible solutions by different methods. Finding optimal solution. MODI method. Degeneracy. Unbalanced transportation problems. Maximization Problems. **6 Hours**

PART – B

UNIT 5:

Sequencing: Johnson's algorithm. n jobs - 2 machines, n jobs -3 machines, and n jobs-n machines without passing sequence. 2 jobs-n machines. Graphical solutions. **6 Hours**

UNIT 6:
Deterministic Models: Inventory, EOQ Models. With and without shortages. Ordering cost. Carrying cost. **6 Hours**

UNIT 7:
PERT-CPM Techniques: Network construction. Determining critical path. Variance and probability of completing the project. Calculation of different floats. Project duration. Crashing of simple networks. **8 Hours**

UNIT 8:
Waiting Lines: Queuing systems and their characteristics. Poisson queues. M/M/1 queuing system. **6 Hours**

Text Books:

1. **Introduction to Pert and Cpm,** L. S. Srinath, 3rd Edition, East West, 1998.
2. **Operation Research,** Kantiswaroop, P. K. Gupta and Manmohan, 9th Edition, S Chand & Co. 1999.
3. **Scientific Inventory Management,** Joseph Buchan and Earnest Koenigberg, 1989.
4. **Operation Research,** S. D. Sharma, 8th Edition, Kedarnath & Co, 2003.

PHARMACEUTICAL TECHNOLOGY

Subject Code	: 10CH663	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Electrophilic Substitution Reaction: Preparation of cyclo alkane. Bayer's strain theory and orbital picture of angle stream. **6 Hours**

UNIT 2:
Electrophilic Substitution Reaction Mechanism & Application: Dehydrogenation of alkyl halides. 1-2 elimination kinetics: E2 and E1 mechanisms. Isotope effect. Dehydration of alcohols. Ease of dehydration. **6 Hours**

UNIT 3:
Nucleophilic Addition Reaction: Mechanism. Important chemicals. Oxidation-Reduction reactions. **6 Hours**

UNIT 4:
Rheology of Fluids in Mixing and Blending. **8 Hours**

PART - B

UNIT 5:

Preparation: Test for purity and medical uses of Chlorobutal, Dimercopral, Glycerol trinitrate. **7 Hours**

UNIT 6:

Preparation: Test for purity and medical uses of Urea, ethylene diamine dihydrate, vanillin, paraldehyde. **7 Hours**

UNIT 7:

Preparation: Test for purity and medical uses of lactic acid, citric acid, salicylic acid, saccharin sodium. **6 Hours**

UNIT 8:

Preparation: Test for purity and medical uses of Ethyl borate, dimethyl phthalate, aspirin. **6 Hours**

Text Books:

1. **Organic Chemistry,** T.R. Morisson and R. Boyd, 6th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 1992.
2. **Organic Chemistry Fundamentals,** I. L. Finar, 2nd Edition, ELBS, Pergemon Press, 1965.

POLYMER TECHNOLOGY

Subject Code	: 10CH664	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Principles of Processing Of Polymers: Melt processing of thermoplastics. Classification of processes. Thermoset plastics processing, crystallization, orientation & shrinkage, co polymers blendings, compounding for engineering application, stress – strain behavior, WLF equation, practical assessment for long term behavior. **6 Hours**

UNIT 2:

Polymer Extrusion: Requirements of Polymer for extrusion. Single screw and double screw plasticating extruder zones in extrusion, breaker plates, extruder screw, power calculation. PVC extruder. Die and calibration equipment prime mover for extrusion, co extrusion, extrusion coating, extrusion film blowing reactive extrusion. Extrusion blow moulding for PET bottles, wire drawing-PVC, spinning – various types and applications. Application of various extruded products. Rheological aspects of extrusion and extrusion defects. Operational and maintenance of extrusion equipments, pultrusion. **7 Hours**

UNIT 3:

Injection Moulding: Polymer characteristics for injection moulding. Reciprocating screw injection moulding. Single impression mould. Multi impression moulds. Cooling requirements in moulds. Hot runner moulds, gate, mould clamping force calculations. Control of pressure, temperature and time of injection thermostat and fiber reinforced polymer injection moulding, sandwich moulding and injection blow moulding. Rheological aspects and defects of injection. Comparision of injection moulding and extrusion of injection. Operational and maintenance of injection moulding equipments. Reaction injection moulding. Applications. **8 Hours**

UNIT 4:

Compression Moulding: Applications. Principles. Comparison with other processing methods. Derivation of compression mould thickness or compaction force. Transfer moulding. **5 Hours**

PART – B

UNIT 5:

Calendering: Characteristics of polymer for calendering. Principles and operation of calendaring. Derivation of film thickness and pressure required for rollers. Guage control during calendaring. Application of PVC calendered products. **6 Hours**

UNIT 6:

Thermoforming: Basic principles. Vacuum forming. Pressure forming. Description of operations. Product design. Application. Derivation of thermoformed product thickness.**7 Hours**

UNIT 7:

Rotational Moulding: Principles. Operation & applications. Thickeness. Cooling calculations. **6 Hours**

UNIT 8:

Testing Of Plastics: Thermal, electrical, optical, mechanical properties testing. **7 Hours**

Text Books:

1. **Principles of Polymer Processing,** Morton Johnes chapman, Hall 1989.
2. **Plastic Engineering,** R.J. Crawford, 3rd Edition Research Studies,1996.

Reference Books:

1. **Principles of Polymer Engineering,** N.G. McCrum,Vol.1, C.P. Buckley Oxford University Press, 1988.
2. **Polymer Materials –**Vols. 1,2 & 3, Manas Chanda , Springer, Univ Press,1997.

CHEMICAL REACTION ENGINEERING LABORATORY

Subject Code	: 10CHL67	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Batch Reactor
2. Isothermal plug flow reactor
3. Mixed flow reactor
4. Semi batch reactor
5. Heterogeneous catalytic Reactor
6. Segregated flow reactor
7. Adiabatic Reactor
8. Packed bed Reactor
9. RTD Studies in Tubular Reactor
10. Effect of temperature on Rate of reaction
11. Bio Chemical Reaction (Batch)
12. Enzyme catalyzed reactions in batch reactor
13. RTD Studies in mixed flow reactor
14. Sono-chemical reactor.

15. Photochemical reactor

Note: Minimum of 10 experiments are to be conducted.

MASS TRANSFER LABORATORY

Subject Code	: 10CHL68	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Diffusion of organic vapours in air
2. Simple Distillation
3. Packed column/ plate column distillation
4. Steam distillation
5. Solid – liquid leaching
6. Surface evaporation
7. Tray dryer
8. Adsorption studies
9. Liquid-liquid/Vapour –liquid equilibrium
10. Liquid extraction – (cross current: 1 and 2 or 3 stage)
11. Hold up studies in packed columns
12. Rotary/ vacuum dryers
13. Wetted wall column
14. Cooling tower
15. Solid dissolution
16. Gel-electrophoresis

Note: Minimum of 10 experiments are to be conducted.

Note: In-Plant Training/Industrial Visit (10CH87) is to be taken up during the vacation of this semester or next semester.

VII SEMESTER

CHEMICAL PROCESS INTEGRATION

Subject Code	: 10CH71	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction to Process Integration: Graphical Techniques. Overall mass targeting. **6 Hours**

UNIT 2:
Synthesis of Mass Exchange Network: . Graphical approach. Direct recycle strategies.**7Hours**

UNIT 3:

Visualisation Strategies: for development of mass integrated system. Algebraic approach to targeting direct recycles. **6 Hours**

UNIT 4:
Algebraic Approach: to targeting mass exchange. Network. Recycle strategies using property integration. **7 Hours**

PART - B

UNIT 5:
Heat Integration: Combined heat and power integration. **6 Hours**

UNIT 6:
Optimization: Mathematical approach to direct recycle. Graphical method, simplex method, single variable optimization, multivariable optimization. **7 Hours**

UNIT 7:
Mathematical Techniques: for synthesis of mass & heat exchange excluding Lingo optimization techniques. **6 Hours**

UNIT 8:
Mathematical Techniques: for mass integration. Initiatives and applications. Case studies. **7 Hours**

Text Books:

1. **Chemical Process Design & Integration,** Robin Smith, 2nd Edition, Wiley, 2005.
2. **Pinch Analysis and Process Integration -** A user guide on process integration for efficient use of energy, Kemp I.C, 2nd Edition, Butterworth, Heinneman, 2006.
3. **Process Integration -** Mahmoud. M., El – Hawalgi, Vol. 7, Academic Press, 2006.

INSTRUMENTATION AND PROCESS CONTROL

Subject Code	: 10CH72	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Instrumentation: Fundamentals Static and dynamic characteristics. Indicators and recorders. Pressure measurement- Bourdon, diaphragm and bellow type gages. Vacuum measurements. Temperature measurement- Bimetal and resistance thermometers, thermocouples and pyrometers. **6 Hours**

UNIT 2:
First Order Systems: Thermometer, level, mixing tank, STR, Linearisation, I order systems in series. Response for various input forcing functions. **6 Hours**

UNIT 3:
Second Order Systems: Characteristics of manometer and damped vibrator. Transfer functions. Response for various input forcing functions, response for step input for under damped case – Terms associated with it. Transportation lag. **7 Hours**

UNIT 4:
Closed Loop System: Basic components. Servo and regulator control. Controllers – P, I, D and On –Off modes. Controller combinations - Final control elements - Valves, actuators and valve positioners. **7 Hours**

PART - B

UNIT 5:
Closed Loop Response: Block diagram, Closed loop transfer function, Transient response of servo and regulator control systems with various controller modes and their characteristics. **7 Hours**

UNIT 6:
Stability: Stability of linear control systems. Routh Test. Frequency Response – Bode diagrams. **6 Hours**

UNIT 7:
Control System Design By Frequency Response: Bode criterion. Gain and Phase margins. Ziegler – Nichols controller tuning, Cohen-Coon controller tuning. **7 Hours**

UNIT 8:
Root Locus: Rules for plotting and problems. **6 Hours**

Textbook:
1. **Process System Analysis and Control,** Coughner & Koppel, II Edition, McGraw Hill, New Delhi,1991.

Reference Books:
1. **Process Modelling, Simulation & Control for Chemical Engineers,** Luyben, II Edition, McGraw Hill, 1990.
2. **Chemical Engineering Vol. III, III Edition,** Coulson & Richardson, Pergamon Press, 1998.
3. **Chemical Process Control-**An Introduction to Theory & Practical, George Stephanopoules, Vol.3, Prentice Hall, New Delhi, 1998.

COMPUTER APPLICATIONS AND MODELING

Subject Code	: 10CH73	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

Note: Algorithm and C Program for Cases of Unit 2 to Unit 6

PART - A

UNIT 1:
Review of Computational Methods: Simultaneous linear algebraic equation – Gauss Jordan. Non-linear algebraic equation-Newton Raphson. Ordinary Differential Equation- R-K Method. Numerical Integration-Simpson's 1/3 Rule. Curve Fitting-Least Squares. **7 Hours**

UNIT 2:
Applications: Vapor- Liquid equilibria for binary mixtures. Calculation of Bubble Pressure and Bubble Point. Dew Pressure and Dew point for Ideal Binary and multi-component system. **7 Hours**

UNIT 3:
Flash Vaporization: for multi-component system. Design of Adiabatic Batch Reactor. **6 Hours**

UNIT 4:
Design of Adiabatic PFR, Adiabatic CSTR and Combinations. **6 Hours**

PART - B

UNIT 5:
Design: Double Pipe Heat Exchanger (Area, Length and Pressure drop). Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop. **6 Hours**

UNIT 6:
Absorption & Distillation Columns: Calculations for Plate and Packed Columns. **6 Hours**

UNIT 7:
Modeling: Models and model building, principles of model formulations, precautions in model building, Fundamental laws: Review of shell balance approach, continuity equation, energy equation, equation of motion, transport equation of state equilibrium and Kinetics, classification of mathematical models. **7 Hours**

UNIT 8:
Mathematical Modeling and Solutions to the Following: Basic tank model – Level V/s time. Batch Distillation – Vapor composition with CSTRs in series time. **7 Hours**

Text Books:
1. **Computer based Numerical Analysis,** M. Shanthakumar, First Edition, KPS Publisher, 1987.
2. **Introduction to Chemical Engineering and Computer Calculations,** Myers, A.L and Seider W.D, Prentice Hall,1976.
3. **Process Modeling Simulation and Control for Chemical Engineering,** William. L Luyben, 2nd Edition., McGraw Hill, 1990.

Reference Books:
1. **Elements of Chemical Reaction Engineering,** H. Scott Fogler, 2nd Edition, Prentice Hall, 2001.
2. **Introduction to Chemical Engineering Thermodynamics,** Smith J. M. and H. C. Vanness, 5th Edition, McGraw Hill, 1996.

BIOCHEMICAL ENGINEERING

Subject Code	: 10CH74	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:
Introduction: Bioprocess engineering and technology. Role of a Chemical engineer in bioprocess industry. An introduction to basic biological sciences. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Taxonomy, control of microorganisms – physical and chemical methods. **7 Hours**

UNIT 2:

Biochemistry: Chemicals of Life: Lipids, Sugars, Polysaccharides, Amino acids. Vitamins, Biopolymers, Nucleic Acids: RNA, DNA and their derivatives (Structure, Biological function and Importance for life only to be studied). **6 Hours**

UNIT 3:

Enzymes and Proteins: Detailed structure of proteins and enzymes. Functions. Methods of Production and purification of Enzymes. Nomenclature and Classification of enzymes. Kinetics and mechanism of Enzyme action: Michaelis–Menten and Briggs-Haldane approach. Derivation. **6 Hours**

UNIT 4:

Kinetics of Enzyme Action: Reversible Enzyme. Two-substrate. Multi-complexes enzyme kinetics (Derivation of rate equations). Experimental determination of rate parameters: Batch and continuous flow experiments. Lineweaver–Burk, Eadie-Hofstee and Hanes-Woolf Plots. Batch Kinetics (Integral and Differential methods). **7 Hours**

PART - B

UNIT 5:

Enzyme Inhibition: Effect of Inhibitors (Competitive, noncompetitive, uncompetitive, substrate and product inhibitions), Temperature and pH on the rates enzyme catalyzed reactions. Determination of kinetic parameters for various types of inhibitions. Dixon method. Enzyme immobilization: Uses. Methods of enzyme immobilization. **7 Hours**

UNIT 6:

Fermentation Technology: Ideal reactors: A review of Batch and Continuous flow reactors for bio kinetic measurements. Microbiological reactors: Operation and maintenance of typical aseptic aerobic fermentation processes. Formulation of medium: Sources of nutrients. Alternate bioreactor configurations. Introduction to sterilization of bioprocess equipment. **7 Hours**

UNIT 7:

Growth Kinetics of Microorganisms: Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Models with growth inhibitors, Logistic equation, Filamentous cell growth model. Continuous culture: Optimum Dilution rate and washout condition in Ideal Chemostat. Introduction to Fed-batch reactors. **6 Hours**

UNIT 8:

Downstream Processing: Strategies and Steps involved in product purification. Methods of Cell disruption, Filtration, Centrifugation, Sedimentation, Chromatography, Freeze drying / lyophilization. Membrane separation Technology: Reverse Osmosis, Ultra filtration, Micro filtration, Dialysis. **6 Hours**

Text Books:

1. **Biochemical Engineering Fundamentals,** Bailey and Ollis, II Edition, McGraw Hill,1976.
2. **Bioprocess Engineering,** Shuler M. L. and Kargi F., 2nd Edition, Prentice Hall, 2002.

Reference Books:

1. **Biochemical Engineering,** James Lee, Prentice Hall, 1992.
2. **Biochemical Reactors,** Atkinson B, Pion Ltd., London, 1974.
3. **Industrial Microbiology,** Casida, wiley, New York, 1968
4. **Principles of Fermentation Technology,** Stanbury and Whitekar, 2nd Edition, Butterworth-Heinemann An Imprint of Elsevier

ELECTIVE - II (Group B)

FOOD TECHNOLOGY

Subject Code	: 10CH751	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART - A

UNIT 1:

Introduction and Quality Attributes of Food: Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods – introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. **6 Hours**

UNIT 2:

Formation and Chemistry of Food: Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals. **4 Hours**

UNIT 3:

Food Processing and Preservation: Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices. **8 Hours**

UNIT 4:

Enzymatic and Non-Enzymztic Reactions During Storages: Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esterace, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalose, peroxidase, lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions. **8 Hours**

PART - B

UNIT 5:

Food Additives: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti choking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. **8 Hours**

UNIT 6:

Food Contamination and Adulteration: Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. **8 Hours**

UNIT 7:

Environmental Concerns And Food Safety: Water in food production. Properties and requirements of processing water. Environmental concerns – solid waste disposal, wastewater properties, wastewater treatment. Safety hazards and risks. Food related hazards. Processing and handling. Cleaning and sanitizing. **5 Hours**

UNIT 8:

Modern Trends In Food Science: Biotechnology in food. Biofortification. Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition labelin. Careers in food science and food industries. **5 Hours**

Reference Books:

1. **Food Science,** B. Srilakshmi, 4th Edn, New Age International, 2007.
2. **Foods: Facts and Principles,** N. Shakuntala Manay and M. Shadaksharamurthy, New Age Publishers, 2005.
3. **Introduction to Food Science,** Rick Parker, Thomsan Detmer, 2001.
4. **Food Processing and Preservation,** G. Subbulakshmi and Shobha A. Udupi, New Age International, 2001.
5. **Food Science,** Norman N. Potter and Joseph H. Hotchkin,1st Edition, Avi Publishing Co, 1968.
6. **Principles of Food Chemistry,** John M DeMan, 3rd Edition, Springer,1999.

MULTICOMPONENT DISTILLATION

Subject Code	: 10CH752	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Introduction: Phase Equilibria for Multi component distillation. Thermodynamic relationships for multi component mixture, prediction of phase equilibria. **6 Hours**

UNIT 2:

Phase Equilibria: Use of fugacities and activities. Introduction to the method of convergence characteristics. The Theta method for converging temperature. Profile-Development & application to conventional distillation columns. The 2N Newton-Raphson method- Introduction and the Algorithm. The method of successive approximations. **7 Hours**

UNIT 3:

Methods Of Multicomponent Distillation: Azeotropic and extractive distillation process-qualitative characteristics and applications. **6 Hours**

UNIT 4:

Phase Behaviour At Constant Pressure: Homogeneous and Heterogeneous azeotropes. **7 Hours**

PART – B

UNIT 5:

Reactive Distillation: Distillation accompanied by chemical reaction. Application of the theta method of convergence in reactive method. **7 Hours**

UNIT 6:

Reactive Distillation: Formulation of N[r+2] Newton Raphson method. **6 Hours**

UNIT 7:
Complex Mixture: Determination of minimum number of stages required to effect a specified separation. **6 Hours**

UNIT 8:
Complex Mixture: Optimum and economic design of distillation column for the complex mixtures. **7 Hours**

Reference Books:

1. **Fundamentals of multicomponent distillation,** C.D. Holland, McGraw Hill, 1997.
2. **Separation processes**, C.J. King, 2nd edition, Tata McGraw Hill, 1980.
3. **Distillation,**Van Winkel, McGraw Hill, 1967.
4. **Distillation Engineering,** R. Billet, Chem. Publ. Co., NY,1979.

ELECTROCHEMICAL TECHNOLOGY

Subject Code	: 10CH753	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Introduction To Theoretical Aspects: Faradays laws, mechanism of conduction in solids, liquids and gases and in ionic melts. Conduction in metals and semiconductors. **6 Hours**

UNIT 2:
Reversible electrodes and potentials, electrode processes and electrode kinetics. **6 Hours**

UNIT 3:
Various types of overpotentials. Polarisation. **6 Hours**

UNIT 4:
Butler-volmer for one electron and mute electron steps. Models of electrical Double layer. **8 Hours**

PART – B

UNIT 5:
Applied aspects: Potentiometry and ion-selective electrodes. Polaroraphy. **6 Hours**

UNIT 6:
Electrode deposition of metals and alloys. **6 Hours**

UNIT 7:
Primary and Secondary Fuel Cells. **6 Hours**

UNIT 8:
Corrosion And Its Prevention: Electro winning. Electro organic and inorganic synthesis (and some typical examples). Environmental electrochemistry. Bio-electro chemistry**.** **8 Hours**

Text Books:

1. **Modern Electrochemistry,** J.O.M., Bockris & A.K.N. Reddy, Vol.1 & 2, Plenum, New York 2002.
2. **Industrial Electrochemical Processes,** A. Kuhn, Elsevier, Amsterdam, 1971.

Reference Books:

1. **Electro Analytical Chemistry,** J.J. Lingane, Wiley, New York, 1958.
2. **Electrochemistry, Principles and Applications,** E.C. Potter, Cleaverhume Press, London 1956.
3. **Organic Electrochemistry,** M.M. Baizer, Marcel Dekker, 3rd Edition, New York, 1991.

INTERFACIAL PHENOMENA AND SURFACE ENGINEERING

Subject Code	: 10CH754	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Introduction: Concept of Interface and its formation with examples. Mechanical and Thermodynamic approaches to Interface. Equivalence in the concepts of surface energy and surface tension. Applications. **6 Hours**

UNIT 2:

Excess Pressure: Generalized equation for excess pressure across a curved surface- the equation of Young and Laplace. Pressure jump across cylindrical surface, flat surface. Vapor pressure of a drop Solubility of drops. Ostwald ripening. Capillary condensation. Super saturation. Nucleation. **6 Hours**

UNIT 3:

Measurement of Interfacial Tension: Capillary rise method. Drop weight method, Wilhemy plate method, du Nuoy method. Methods based on shape of static drops or bubbles. Dynamic methods-Flow and capillary waves. **6 Hours**

UNIT 4:

Thermodynamics of Interfaces: Thermodynamic treatment of interfaces. Free energy at interface. Temperature dependence of the surface tension. Effect of pressure on interfacial tension. Effect of curvature on surface tension. Thermodynamics of binary systems-Gibbs Equation. Surface excess concept. Verification of Gibbs equation. Gibbs monolayers. **8 Hours**

PART – B

UNIT 5:

Wetting Fundamentals and Contact Angles: Work of adhesion, cohesion. Criteria for spreading of liquids. Kinetics of spreading. Lens formation- three phase systems. Young's equation. Neumann triangle. Theories of equilibrium contact angles. Contact angle hysteresis. **5 Hours**

UNIT 6:

Electrical Aspects of Surfaces: The electrical double layer. Stern treatment of electrical double layer. Free energy of a diffused double layer. Repulsion between two plane double layers. Colloidal dispersions. Combined attractive and electrical interaction-DLVO theory. Kinetics of coagulation. **8 Hours**

UNIT 7:

Surfactants: Anionic and non ionic. Other phases involving surfactant aggregates. Surface films of insoluble surfactants. Thermodynamics of microemulsions. Phase behaviour of oil-water-surfactant systems. Effect of composition changes. Applications of surfactants-emulsions and detergency. **6 Hours**

UNIT 8:

Introduction to Interfaces in Motion: Linear analysis of interfacial stability. Damping of capillary wave motion by insoluble surfactants. Stability and wave motion of thin liquid films-foams. Interfacial stability for fluids in motion. **7 Hours**

Text Books:

1. **Interfacial Phenomena, Equilibrium and Dynamic Effects,** C.A. Miller & P. Niyogi, Vol. 17, Marshel Deckder, 1985.
2. **Physical Chemistry of Surfaces,** A.W. Adamson, John Wiley, 5th Edition, 1997.

Reference Books:

1. **Surface Activity,** Millet J.L., 2nd Edition, Van Nostrad, 1961.
2. **Surafce Active Chemicals -** Garrett H.E., Pergamon Press, 1974.

ELECTIVE - III (Group C)

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

Subject Code	: 10CH761	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Mathematical Formulation of the Physical Problems: Applications of laws of conservation of mass, energy. Statement of the problem. Modeling. Examples and problems. **7 Hours**

UNIT 2:

Ordinary Differential Equations: Formulations of ordinary differential equations involving chemical engineering problems. Solutions- Equations of first order and first degree. **6 Hours**

UNIT 3:

Ordinary Differential Equations: Solutions - Equations of first order and second degree. Bernoulli equation. Euler equation. Simultaneous linear differential equations. **6 Hours**

UNIT 4:

Partial Differential Equations: Formulations of partial differential equations involving chemical engineering problems. Solutions. Fourier series. **7 Hours**

PART – B

UNIT 5:

Numerical Methods: Solutions of ordinary differential equations for chemical engineering problems. **6 Hours**

UNIT 6:
Numerical Methods: Solutions of partial differential equations for chemical engineering problems. . **6 Hours**

UNIT 7:
Finite Differences: Difference operator, linear difference equations, analysis of stage-wise, Processes. **7 Hours**

UNIT 8:
Laplace transforms and their applications to chemical engineering. **7 Hours**

Text Books:

1. **Applied Mathematics in Chemical Engineering,** H.S. Mickley, T.K. Sherwood and C.E. Reed, 3rd Edition, Tata McGraw Hill, 1999.
2. **Mathematical Methods in Chemical Engineering,** V.G. Jenson & G.V. Jeffreys, Academic Press, London, 1977.
3. **Mathematical Methods in Chemical Engineering,** S. Pushpavanam, Eastern Economy Edition, 2004.

Reference Book:

1. **Applications of Mathematical Modeling to Process Development and Design,** L.M. Rose Applied Science Publishers Ltd., London, 1998.

SUGAR TECHNOLOGY

Subject Code	: 10CH762	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Sugar Industry In India: Chemical and physical properties of sucrose and reducing sugars. Sources for sucrose. Formation of sucrose plants. Non-sugar compounds of sugarcane. Inorganic constituents of sugar cane juices and sugars analytical methods used in sugar industry. **6 Hours**

UNIT 2:
Purification: Chemical technology of the purification process. Fundamental reactions and physical chemistry aspects of clarification, liming, sulphitation and carbonation process. Filtration of sugar juice. **8 Hours**.

UNIT 3:
Evaporation: Evaporation of sugar juice. Heat transfer in evaporations. Evaporation equipment and auxiliaries. **6 Hours**

UNIT 4:

Evaporation (Contd..): Methods of obtaining steam, and quality of steam. Steam economy. Chemistry of the evaporation process. **6 Hours**

PART – B

UNIT 5:
Crystallography: Solubility of sucrose. Nucleation in super saturated solutions – kinetics and growth of crystallization. Chemistry of crystallization. **7 Hours**

UNIT 6:
Crystallography: Control methods and equipment in sugar crystallization, technology of sugar crystallization. Evaporation and circulation in vacuum pans. **7 Hours**

UNIT 7:
Centrifugation: Theory of the centrifugal process, centrifugal operation. **4 Hours**

UNIT 8:
Centrifugation: Engineering principles of sugar centrifugals and the centrifugal equipment and auxiliaries. Production of final molasses and molasses's utilization. Grading of sugar. **8 Hours**

Text Books:

1. **Principles of Sugar Technology,** Honing P., Vol. I to III, Elsevier Publishing Company, 1953.
2. **Introduction to Cane Sugar Technology,** Jenkinos.G.H, Elsevier,1966.

Reference Books:

1. **Handbook of Cane Sugar Technology,** Mathur R.B.L, 2nd Edition, Oxford and I.B.H. Publishing Co.,1997.
2. **Hand book of Sugars,** Pancoast, H.M, and Junk, W.R., 2nd Edition, AVI Publishing Co. Inc., Connecticut, 1981.

PETROCHEMICALS

Subject Code	: 10CH763	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Definition of Petrochemicals: Petrochemical. Industries in India. Principal raw materials. Introduction to chemicals from C1, C2, C3 and C4 compounds. **6 Hours**

UNIT 2:
Chemicals from C1 Compounds: Manufacture of methanol and chloromethanes. Manufacture of perchloro ethylene. **6 Hours**

UNIT 3:
Chemicals from C2 Compounds: Ethylene and acetylene, ethanol, polyethylene, ethylene dichloride, acetaldehyde, vinyl chloride, ethylene oxide, ethanol amines, vinyl acetate, acetic acid. **7 Hours**

UNIT 4:
Chemical from C3 Compounds: Isopropanol, acetone, lumen (isopropyl benzene), acrylonitrile, isoprene, polypropylene, epichlorohydrin, propylene oxide. **7 Hours**

PART – B

UNIT 5:
Chemical from C4 Compounds: Butadiene dehydrogenation of butane (Houdry). Dehydrogenation of butylenes. Dehydrogenation-dehydration of ethanol. Steam cracking of hydrocarbons. **7 Hours**

UNIT 6:
Chemicals from Aromatics: Primary raw material. Hydroalkylation. **6 Hours**

UNIT 7:
Manufacture of phenol – 5 methods. Styrene – 2 methods. Phthalic anhydride maleic anhydride, nitrobenzene, aniline. **7 Hours**

UNIT 8:
Manufacture of industrial dyes based on petroleum feed stocks**.** **6 Hours**

Text Books:

1. **Petrochemicals,** B.K. Bhaskar Rao, CRC Press,1990.
2. **Chemicals from Petroleum,** A.L. Waddams, 2nd Edition, ELBS, London, 1970.

Reference Books:

1. **Dryden's Outlines of Chemical Technology,** Gopal Rao M and Marshall Sittig, 3rd Edition, East-West Press, 1997.
2. **Chemical process industries,** 5th edition, Shreve and Austin, McGraw Hill, 1984.
3. **Chemical Technology,** G.N. Pandey, 3rd Edition, Vikas Publishing House Pvt. Ltd., 1977.
4. **Chemical Technology,** Mukhlyonov, Mir Publications, 1982.

OILS AND FATS

Subject Code	: 10CH764	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Introduction: Classification of fats and oil. Characteristic of oils. Utilization of fat and oils. Composition of oils (general). **6 Hours**

UNIT 2:
Obtaining Oils and Fats from Source Materials: Mechanical pretreatment. Mechanical expression. Solvent extraction (two types of extractors). **7 Hours**

UNIT 3:
Process Techniques: Refining and hydrogenation (H_2 production and catalyst). **7 Hours**

UNIT 4:
Process Techniques (contd.) : Degumming. Alkali refining and bleaching. **6 Hours**

PART – B

UNIT 5:
Deodorization: Theoretical consideration and operation of commercial deodorizer. **6 Hours**

UNIT 6:
Vegetable Oils: Composition. Extraction. Refining processes and uses of coconut oil, cottonseed oil. **7 Hours**

UNIT 7:
Vegetable Oils: Refining processes and uses of palm oil, Soya been oil, peanut oil, sunflower oil. **7 Hours**

UNIT 8:
Marine Oils: Composition. Extraction. Refining processes and uses of fish oils. **6Hours**

Text Book:

1. **Basily Industrial Oil and Fat Products – Vol I to V,** Y.H.Hery John Wiley International, 2nd Edition,1976.

Reference Books:

1. **Chemistry and Technology of Oil and Fats,** Devine J and Williams P.N, 1961.
2. **Chemical process Industries,** Austin G. T., Shreve's Fifth Edition, McGraw-Hill international Book Company, Singapore, 1984.
3. **Outlines of Chemical Technology,** Dryden C. E., Edited by Gopala Rao. M and M. Sittig, Second Edition, Affiliated East West Press, 1993.
4. **Hand Book of Industrial Chemistry**, Kent J.A (Ed) Riegel's Van Nostrand Reinhold, 1974.

PROCESS CONTROL LABORATORY

Subject Code	: 10CHL77	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

1. Thermometer
2. Single tank - Step Response
3. Non Interacting Tanks - Step Response
4. Interacting Tanks - Step Response
5. Pressure Tank
6. U – Tube Manometer
7. Single tank - Impulse Response

8. Non Interacting Tanks - Impulse Response
9. Interacting Tanks - Impulse Response
10. Level/Flow/Pressure/pH/Temperature control – P controller
11. Level/Flow/Pressure/pH/Temperature control – PI controller
12. Level/Flow/Pressure/pH/Temperature control – PD controller
13. Level/Flow/Pressure/pH/Temperature control – PID controller
14. Valve characteristics.
15. Flapper Nozzle System
16. Valve Positioner.

Note: Minimum of 10 experiments are to be conducted.

COMPUTER APPLICATIONS & SIMULATION LABORATORY

Subject Code	: 10CHL78	IA Marks	: 25
No. of Practical Hours/Week	: 03	Exam Hours	: 04
Total No. of Hours	: 39	Exam Marks	: 50

The experiment should be based on the following topics;

PART – A

NUMERICAL METHODS AND COMPUTER APPLICATIONS

20 Marks

1. Non-linear algebraic equation- Newton Raphson (Specific volume of binary mixture)
2. Ordinary Differential Equation- R-K Method ($dCa/dt=kCa^2$)
3. Numerical Integration- Simpson's 1/3 Rule (Batch Reactor to find time)
4. Curve Fitting-Least Square (Nre vs f)
5. Calculation of Bubble Point and Dew Point for Ideal multi-component system
6. Flash Vaporisation for multi-component system
7. Design of Adiabatic Batch Reactor, PFR
8. Adiabatic Flame Temperature
9. Double pipe heat exchanger (Area, Length and Pressure drop)
10. Distillation Column (Bubble cap)

PART – B

SIMULATION

30 Marks

1. Introduction to suggested software available (flow sheeting)
2. Simulations Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater.
4. Process simulation study involving mixing, reactor, distillation, heat exchanger for any of the following:
    a) Ethylene Glycol from Ethylene oxide
    b) Atmospheric distillation of crude oil
    c) Propylene Glycol from Propylene oxide
    d) Aromatic stripper with recycle stream (Benzene, Toluene, Xylene)
    e) Styrene from Ethyl Benzene

SOFTWARES SUGGESTED

1. HYSYS
2. CHEMCAD

3. DESIGN-II
4. PROSIM
5. ASPEN PLUS

Note: Minimum of 6 experiments are to be conducted from Part – A and all from Part – B.

Note: Project work (10CH85) is to be assigned at the beginning of this semester.

VIII SEMESTER

PROCESS ENGINEERING ECONOMICS

Subject Code	: 10CH81	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Process Design Development: Overall planning of a plant involving chemical processes - Types of designs, feasibility studies, process development, material & energy balance, equipment sizing & selection, process flow sheet and P&I Diagram. Plant location and layout – Case studies of petroleum and Fertilizer industries, Factors affecting plant design. **7 Hours**

UNIT 2:

Cost Analysis: Factors involved in project cost estimation, methods employed for the estimation of the capital investment. Estimation of working capital. **6 Hours**

UNIT 3:

Time value of money and equivalence. **6 Hours**

UNIT 4:

Depreciation And Taxes: Depreciation calculation methods. Equivalence after Taxes. Cost comparison after taxes. **7 Hours**

PART – B

UNIT 5:

Profitability: Methods for the evaluation of profitability. **7 Hours**

UNIT 6:

Replacement and alternative investments. **7 Hours**

UNIT 7:

Financial Statements: Cash flow diagrams. Break-even analysis. **6 Hours**.

UNIT 8:

Design Report: Types of reports. Organization of report. **6 Hours**

Text Books:

1. **Plant Design and Economics for Chemical Engineers,** M.S. Peters and K.D. Timmerhaus, 4th Edition, McGraw Hill, 1991.
2. **Industrial Organization and Engineering Economics,** T.R. Banga and S.C. Sharma, 22nd Edition, Khanna Publishers, 1999.

TRANSPORT PHENOMENA

Subject Code	: 10CH82	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Introduction: Momentum Energy and Mass Transport Newton's law of viscosity (NLV). Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction (FLHC). Fick's law of diffusion (FLD).Effect of temperature and pressure on transport properties of fluids. Numerical problems on the application and use of NLV, FLHC and FLD. **7 Hours**

UNIT 2:

Velocity Distribution in Laminar Flow: Different Flow situations, Steady state Shell momentum balances, Boundary conditions applicable to momentum transport problems, Flow over a flat plate, Flow through a circular tube, Flow through Annulus, Flow between parallel plates and a slit. Numerical problems using the equations derived in the above situations. **6 Hours**

UNIT 3:

Steady State Shell Energy Balances: General Boundary conditions applicable to energy transport problems of chemical engineering. Heat conduction through compound walls. Overall heat transfer coefficient. **4 Hours**

Temperature Distribution in Solids and in Laminar Flow: Different situations of heat transfer: Heat conduction with internal generation by electrical and nuclear energy sources. **2 Hours**

UNIT 4:

Temperature Distribution in Solids and in Laminar Flow (contd.): Different situations of heat transfer: Heat conduction with internal generation by viscous energy source. Numerical problems using the equations derived in the above heat transfer situations. Heat conduction in a cooling fin: Forced and free convection heat transfer. **7 Hours**

PART – B

UNIT 5:

Concentration Distributions in Laminar Flow: Steady state Shell mass balances. General Boundary conditions applicable to mass transport problems of chemical engineering. Diffusion through stagnant gas and liquid films. Equimolar counter diffusion. Numerical problems. **6 Hours**

UNIT 6:

Concentration Distributions in Laminar Flow: Diffusion with homogeneous and heterogeneous reaction. Diffusion into falling film – Forced convection mass transfer. Numerical problems for above. **7 Hours**

UNIT 7:

Analogies between Momentum, Heat and Mass Transport: Numerical problems using Reynold's, Prandtl's and Chilton & Colburn analogies. **6 Hours**

UNIT 8:

Equations of Change: Equation of continuity Equation of motion; Navier – Stokes equation. Application of these equations in solving simple steady state problems previously discussed**.** 7 **Hours**

Text Book:

1. **Transport Phenomena,** Bird, Stewart and Lightfoot, Academic Press, 1994.

Reference Books:

1. **Momentum Heat and Mass Transport,** Welty, Wikes and Watson, 4th Edn., John Wiley, 2000.
2. **Principles of Unit Operations in Chemical engineering,** Foust et al, 2nd Edition, John Wiley, 1990.
3. **Transport Phenomena – A Unified Approach,** Robert S. Brodley and Henry C. Hershley, Vol.2, Brodkey Publishing, 2003.

ELECTIVE - IV (Group D)

NANOTECHNOLOGY APPLICATIONS IN CHEMICAL ENGINEERING

Subject Code	: 10CH831	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART A

UNIT 1:
Introduction to Physics of the Solid State: Structure, Energy Bands, Localized Particles.
Methods of Measuring Properties: Atomic size, crystallography, Particle size determination, Surface structure, Microscopy- Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy; Spectroscopy- Infrared and Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic resonance. **7 Hours**

UNIT 2:
Properties of Individual Nanoparticles: Metal nanoclusters, Semiconducting nanoparticles, Rare gas and molecular clusters, methods of synthesis- RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods. **6 Hours**

UNIT 3:
Carbon nanostructures: Carbon molecule, Clusters, Carbon nanotubes, Applications
Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals.
6 Hours

UNIT 4:
Nanostructured Ferromagnetism: Basics of ferromagnetism, Effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets.
Optical and vibrational spectroscopy: Infrared frequency range, luminescence, nanostrucures in zeolite cage. **7 Hours**

PART B

UNIT 5:
Quantum wells, wires and dots: Preparation of quantum nanostructures, Size & dimensionality effects, Excitons, Single electron tunneling, Applications, superconductivity. **6 Hours**

UNIT 6:

Self assembly: Process of self assembly, semiconductor islands, monolayers.
Catalysis: Nature of catalysis, Surface area of nanoparticles, porous materials, pillered clays, Colloids. **7 Hours**

UNIT 7:
Organic compounds and Polymers: Forming and characterizing polymers, Nanocrystals, Polymers, Spramolecular structures.
Biological materials: Biological building blocks, biological nanostructures. **7 Hours**

UNIT 8:
Nanomachines and nanodevices: Microelectromechanical systems (MEMSs), Nanoelectromechanical Systems (NEMSs) - Fabrication, Devices. Molecular and Supramolecular Switches. **6 Hours**

Text Book:

1. **Introduction to Nanotechnology**, Charles P. Poole, Jr., Frank J. Owens, John Wiley and Sons, 2009.

Reference Book:

1. **Handbook of Nanostructured Materials and Nanotechnology,** Vol. 1-5, Academic Press, Boston, 2000.

ADVANCED BIOPROCESS ENGINEERING

Subject Code	: 10CH832	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Introduction to Genetic Engineering (GE): Aim. Techniques. Achievements and prospects of GE;Translation & Transcription of genetic code. DNA Replication and Mutation and Alteration of cellular DNA. Viruses and Phages. Genetic manipulation: Plasmids. Recombinant DNA Technology. **7 Hours**

UNIT 2:
Design and Analysis of Biological Reactors: Review of Ideal bio reactors: Fed-Batch reactor. Sterilization of Reactors. Sterilization of Medium (Batch and continuous).
Review of Cell Growth Kinetics: Unstructured Models and Introduction to Structured models of Cell Growth. **6 Hours**

UNIT 3:
Transport Phenomena in Bioprocess Systems: Gas liquid mass transfer in Cellular Systems. Determination of O_2 transfer rates. Mass transfer of freely rising or falling bodies. Forced Convection Mass Transfer: Overall K_{la} Estimates, and power requirements for sparged and agitated vessels. Mass transfer across free surfaces. Other factors affecting K_{la}, Models, Power Consumption and Mass transfer for Non Newtonian fluids. General heat transfer correlations applicable to biological systems. **7 Hours**

UNIT 4:

Enzyme Immoblisation: Review of methods. Immobilised enzyme kinetics: Effects of diffusion and reaction on kinetics of immobilized enzymes, Effect of other environmental parameters like pH and temperature.
Immobilized Cells: Formulations, Characterization and Applications. **6 Hours**

PART – B

UNIT 5:
Multiphase Bioreactors: Packed, fluidized and trickle bed reactor. Bubble column reactor (design equations)
Fermentation Technology: Animal and Plant Cell Reactor Technology.Medical Applications of bioprocess engineering. **7 Hours**

UNIT 6:
Mixed Cultures: Introduction. Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model Web Interaction, Population dynamics in models of mass action form. **6 Hours**

UNIT 7:
Mixed Culture in Nature: Introduction and industrial utilization. **Biological Waste Treatment:** An overview. Activated sludge Process. Types of Equipment used. Advanced waste water treatments: Nitrification, Denitrification. Conversion of waste water to useful products. **6 Hours**

UNIT 8:
Industrial Bioprocess: Anaerobic process: Ethanol, lactic acid, acetone-butanol production. Aerobic Processes: Citric Acid, Baker's Yeast, Penicillin, High fructose corn syrup production. **7 Hours**

Text Book:

1. **Biochemical Engineering Fundamentals,** Bailey and Ollis, 2nd Edition, McGraw Hill, 1976.

Reference Books:

1. **Bioprocess Engineering**, Shuler M L and Kargi F, 2nd Edition, Prentice Hall, 2002.
2. **Biochemical Engineering,** S. Aiba et al, 2nd Edition, Academic Press, London, 1965.
3. **Biochemical Reactors,** Atkinson , Vol. 2, A Pion Ltd, London. 1975.
4. **Microbiology Concept and Application,** Pelczar, 5th Edition, McGraw Hill, 2001 Reprint.
5. **Bioprocess Engineering,** Pauline M. Doran, 2nd Edition, Prentice Hall, 2009.
6. **Principles of Fermentation Technology,** Stanbury and Whitekar, 2nd Edition, Butterworth-Heinemann An Imprint of Elsevier.

NOVEL SEPARATIONS TECHNIQUES

Subject Code	: 10CH833	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Adsorptive Separations: Review of fundamentals. Mathematical modeling of column factors. Pressure swing & thermal swing adsorption. Counter current separations. **6 Hours**

UNIT 2:
Chromatography: Chromatography fundamentals. Different types. Gradient & affinity chromatography. Design Calculations for chromatographic columns. **7 Hours**

UNIT 3:
Membrane Separation Processes: Types, Thermodynamic considerations. Mass transfer considerations. Design of RO &UF. Ion selective membranes. Micro filtration. Electro dialysis. Pervaporation. Gaseous separations. **7 Hours**

UNIT 4:
External Field Induced Separations: Electric & magnetic field separations. Centrifugal separations and calculations. **6 Hours**

PART – B

UNIT 5:
Surfactant Based Separations: Fundamentals. Surfactants at inter phases and in bulk. Liquid membrane permeation. Foam separations. Micellar separations. **7 Hours**

UNIT 6:
Super Critical Fluid Extraction: Thermodynamics and physico chemical principles. Process description. Application. Case Study. **7 Hours**

UNIT 7:
Mechanical–Physical Separation Process: Introduction, Classification, Filtration in solid liquid separation. Settling & sedimentation in particle fluid separation. **6 Hours**

UNIT 8:
Other Separations: Separation by thermal diffusion, Electrophoresis, crystallization. **6 Hours**

Reference Books:

1. **Handbook of Separation Process Technology,** R.W.Rousseu, John Wiley & Sons,1987.
2. **Encyclopedia of Chemical Technology,** Kirk-Othmer, John Wiley & Sons,2001.
3. **Rate Controlled Separations,** Phillip C Wankat, Kluwer Academic Pub, 1990.
4. **Transportation and Separation Process,** Gaenkopolis, Printice Hall, 2003.
5. **Large Scale Adsorption Chromatography,** P C Wankat, CRC Press, 1986.
6. **Reverse Osmosis and Ultra Filtration Process Principle,** S. Sourirajan & T. Matsura, NRC Publication, Ottawa, 1985.
7. **Surfactant Based Separation,** T.O. Hatton, Vol 23.
8. **Supercritical Fluid Extraction**, M A McHugh & V. J. Krukonis, Butterworth, 1987.

COMPOSITE MATERIALS

Subject Code	: 10CH834	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Synthesis and Fabrication: of advanced and future materials with emphasis on ceramic, Semi-conducting and Super-conducting materials with superior structural, optical and electrical properties. **6 Hours**

UNIT 2:

Preparation Techniques: Techniques for preparation of ultra-pure, ultra-fine powders: of oxides, nitrides, carbides etc., with very well defined characteristics and superior properties. **7 Hours**

UNIT 3:

Processing Techniques: Techniques such as sintering, hot pressing, hot isostatic pressing, tape-casting, sol-gel processing for the formation of monolithic ceramics. Composites (ceramic, ceramic metal, as well as metal matrix). SiO2. Glasses from above powders**.** **6 Hours**

UNIT 4:

Processing Techniques Based on Reaction Methods: such as Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI). Self propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibres and semi conducting materials such as Si and Gallium Arsenide. **7 Hours**

PART – B

UNIT 5:

Synthesis and processing of mixed ceramic oxides with high temperature super conducting properties. **6 Hours**

UNIT 6:

Reinforcement, additives, fillers for polymer composite, master batch & compounding. **7 Hours**

UNIT 7:

Polymer composite. Fibre reinforced composites. Stress – Strain modulus relationship Nano composites. **6 Hours**

UNIT 8:

Characteristics & applications in marine, aerospace, building & computer industry. Manufacturing methods, hand layouts, filament winding, pultrusion, SMC, DMC. **7 Hours**

Text Books:

1. **Introduction to Ceramics**,W.D. Kingrey, 2nd Edn., John Wiley, 1976.
2. **Advanced Composites,** Chawla, Kluner, Academic Publisher, 2003.

Reference Books:

1. **Introduction to Material Science for Engg.,** James T. Schockel Ford, 2nd Edition, McMillan Publications.
2. **Elements of Material Science and Engineering,** L.H. Van Vlack, 4th Edition, 1980.
3. **Fibre Reinforced Plastic Deskbook,** Nicholas P, Paul N, Chermisinoff, Ann Arbor science publishing Inc, 1978.

ELECTIVE - V (Group E)

PILOT PLANT AND SCALE UP METHODS

Subject Code	: 10CH841	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Pilot Plants: Evolution of process system. Need of pilot plants. Concept of prototypes, models, scale ratios, element. **5 Hours**

UNIT 2:
Principles Of Similarity: Geometric similarity. Distorted similarity. Static, dynamic, kinematics, thermal and chemical similarity with examples. **6 Hours**

UNIT 3:
Dimensional Analysis: (Review of Rayleigh's, Buckingham ∏ methods), Differential equation for static systems, flow systems, thermal systems, mass transfer processes, chemical processes-homogeneous and heterogeneous. **7 Hours**

UNIT 4:
Regime Concept: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects. **8 Hours**

PART – B

UNIT 5:
Scale up of mixing process, agitated vessel. **5 Hours**

UNIT 6:
Scale up of chemical reactor systems-Homogeneous reaction systems. Reactor for fluid phase processes catalysed by solids. Fluid-fluid reactors. **8 Hours**

UNIT 7:
Stagewise mass transfer processes. Continuous mass transfer processes. **8 Hours**

UNIT 8:
Scale up of momentum and heat transfer systems. Environmental challenges of scale up.
5 Hours

Text Books:

1. **Scale up of Chemical Processes** ,Attilio Bisio, Robert L. Kabel, John Wiley & Sons, 1985

2. **Pilot Plants Models and scale up method in Chemical Engineering,** Johnstone and Thring, McGraw Hill, 1957.

Reference Book:

1. Pilot Plants and Scale up Studies, Ibrahim and Kuloor.

SOLID WASTE MANAGEMENT

Subject Code	: 10CH842	IA Marks	: 25

No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Introduction: Definition, characteristics and perspectives of solid waste. Types of solid waste. Physical and chemical characteristics. Variation of composition and characteristics. Municipal, industrial, special and hazardous wastes. **6 Hours**

UNIT 2:
General Aspects: Overview of material flow in society. Reduction in raw material usage. Reduction in solid waste generation. Reuse and material recovery. General effects on health and environment. Legislations. **7 Hours**

UNIT 3:
Engineered Systems: Typical generation rates. Estimation and factors effecting generation rates. On site handling. Storage and processing. Collection systems and devices. Transfer and transport. **7 Hours**

UNIT 4:
Processing Techniques: Mechanical volume reduction. Thermal volume reduction. Component separation. Land filling and land forming. Deep well injection. **6 Hours**

PART – B

UNIT 5:
Material Recovery: Mechanical size alteration. Electromagnetic separation. Drying and dewatering. Other material recovery systems. Recovery of biological conversion products. Recovery of thermal conversion products. **7 Hours**

UNIT 6:
Energy Recovery: Energy recovery systems and efficiency factors. Determination of output and efficiency. Details of energy recovery systems. Combustion incineration and heat recovery. Gasification and pyrolysis. Refuse derived fuels (RDF). **7 Hours**

UNIT 7:
Hazardous Wastes: Classification. Origin and reduction at source. Collection and handling. Management issues and planning methods. Environmental Acts. **6 Hours**

UNIT 8:
Case Studies: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units. **6 Hours**

Text Books:

1. **Integrated Solid Waste Management,** George Tchobanoglous et al, 2nd Edition, McGraw Hill & Co, 1993.
2. **Industrial Solid Waste Management and Land Filling Practice,** Dutta et al, Narosa Publishing House, 1999.

Reference Books:

1. **Waste Treatment Plants,** Sastry C.A. et al, Narosa Publishing House, 1995.

2. **Hazardous Waste Management**, Lagrega, McGraw Hill, 1994.

SAFETY AND ENVIRONMENTAL AUDIT OF CHEMICAL PROCESS INDUSTRIES

Subject Code	: 10CH843	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:
Hazard identification methodologies, risk assessment methods-PHA, HAZOP, MCA, ETA, FTA. **6 Hours**

UNIT 2:
Consequence analysis, Probit Analysis. Hazards in work places. Workers' exposures to hazardous chemicals. Hazards in industries. **7 Hours**

UNIT 3:
Guidelines for safeguarding personnel. Safety education and training-Safety managements, fundamentals of safety tenets. **6 Hours**

UNIT 4:
Measuring safety performance, motivating safety performance, legal aspects of industrial safety, safety audits. **7 Hours**

PART – B

UNIT 5:
Introduction and need for impact assessment. Legislation and pollution control acts and Regulations.
Methodologies - collection of data and analysis, cost benefit analysis. **6 Hours**

UNIT 6:
Applications of Impact assessment methods in specific developed projects, advantages and disadvantages of different methods. **7 Hours**

UNIT 7:
Applicability of specific methods with examples. **6 Hours**

UNIT 8:
Clean technology Option: Clean technology and clean up technology, material reuse, waste reduction at source and clean synthesis. **7 Hours**

Textbooks:
1. F.P.Lees, Loss prevention in process industries, 2nd Edition, Butterworth-Heinemann, 1996.
2. EIA, Theory and Practice, Peter Wathern, Unwin Hyman Ltd., 1988.

Reference Book:
1. **Environmental Health and Safety Auditing Handbook,** Lee Harrision, 2nd Edition, McGraw Hill, Inc., New York, 1994.

PULP AND PAPER TECHNOLOGY

Subject Code	: 10CH844	IA Marks	: 25
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total No. of Lecture Hours	: 52	Exam Marks	: 100

PART – A

UNIT 1:

Wood Chemistry: Chemical composition- cellulose, hemi cellulose, lignin, wood extractives, raw material. Quality parameters under evaluation. Yield of raw material. **5 Hours**

UNIT 2:

Pulping: General principle of pulping. Types of pulping processes: mechanical, chemical, semi-chemical, sulphate process, Kraft process. Process calculations. Raw material utility requirements. Process flow sheet and description. Washing and bleaching. Common unit operation. Wood treatment, digestion, evaporation, drying with equipments used. **7 Hours**

UNIT 3:

Treatment of Pulp: Screening, washing, refining, thickening of pulp. Bleaching- conventional and non-conventional bleaching techniques. **6 Hours**

UNIT 4:

Paper Making: Preliminary operations on pulp. Beating and refining of pulp. Non-fibrous materials. Fillers and loading material. Internal sizing. Wet and additive surface treatment. Paper coloring. Surface sizing. **8 Hours**

PART – B

UNIT 5:

Paper Drying and Finishing: Types of dryers. Calendaring. Reeling and winding. Paper machine drives, cutting, winding and rewinding. Conversion of papers. **6 Hours**

UNIT 6:

Paper Quality of Grades: Different grades of paper quality. Parameters and their evaluation. Saturation of paper. Special grade papers. Recycling of waste papers. **8 Hours**

UNIT 7:

Supportive Operations: Chemical recovery – water balance, oxidation, evaporation of black liquor, lime recovery. Quality control and safety aspects. **8 Hours**

UNIT 8:

Environmental Aspects: Effluent characteristics of pulp and paper industries. Treatment methods. **4 Hours**

Text Book:

1. **Pulp and Paper Chemistry and Technology**, Casey, J.P., 2nd Edition, Inter Science, 1960.

Reference Books:

1. **Handbook of Pulp and Paper Technology**, Britt K.W., Reinhold Publication Corp., 1964.
2. **Pulp and Paper Science and Technology**, Libby C.E. Vol 1 to 3, McGraw Hill, 1962.

PROJECT

Subject Code	: 10CH85	IA Marks	: 100
		Exam Hours	: 03
		Exam Marks	: 100

The students in a group will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the seventh semester. The project group should complete the preliminary literature survey & plan of project and submit the synopsis at the end of seventh semester. The project work should be carried out and completed at the end of eighth semester.

SEMINAR

Subject Code	: 10CH86	IA Marks	: 50
No. of Hours/Week	: 03		

The students are required to give the comprehensive presentation in the form of seminar on the project work carried out in the eighth semester. The seminar shall be evaluated as internal assessment. While evaluating, emphasis shall be given on the presentation and communication skills.

IN-PLANT TRAINING/INDUSTRIAL VISIT

Subject Code	: 10CH87	IA Marks	: 50

The students are expected to undergo in-plant training in any chemical industry or in a reputed research laboratory with pilot plant facility. This shall be for a minimum period of two weeks during the vacation of sixth or seventh semester. If it is not possible, the students may be permitted to go on industrial visit for a period of two weeks and they should visit a minimum of five major chemical industries. Each student should submit a report separately, at the beginning of the eighth semester, which is evaluated by a committee constituted by the HoD for internal assessment.

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