B.Tech. Chemical Engineering

(Effective from the admitted Batch in 2006-07 on wards)

I/IV B.Tech. (Year - Wise)
COMMON FOR ALL BRANCHES

II/IV B.Tech. (First Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-211	Mathematics-III	3	1	-	4	30	70	100	4
CHE-212	Inorganic Chemistry	3	1	-	4	30	70	100	3
CHE-213	Physical Chemistry	3	1	-	4	30	70	100	4
CHE-214	Strength of Materials	3	1	-	4	30	70	100	4
CHE-215	Mechanical Engineering	3	1	-	4	30	70	100	4
CHE-216	Basic Electrical Engineering	3	1	-	4	30	70	100	4
CHE-217	Physical and Analytical Chemistry Lab.	-	-	3	3	50	50	100	2
CHE-218	General Engineering lab.	-	-	3	3	50	50	100	2
Total		**18**	**6**	**6**	**30**	**280**	**520**	**800**	**27**

II/IV B.Tech. (Second Semester)

Code and Title of the Course		Periods (L-Lect.; T-Tuto.; P-Pract.)				Marks (S-Sess.; EE-External Exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-221	Mathematics-IV	3	1	-	4	30	70	100	4
CHE-222	Organic Chemistry	3	1	-	4	30	70	100	3
CHE-223	Chemical Process Calculations	3	1	-	4	30	70	100	4
CHE-224	Fluid Mechanics	3	2	-	5	30	70	100	4
CHE-225	Mechanical Operations	3	1	-	4	30	70	100	4
CHE-226	Environmental Studies	3	-	-	3	30	70	100	2
CHE-227	Organic Chemistry Lab.	-	-	3	3	50	50	100	2
CHE-228	Fluid mechanics Lab.	-	-	3	3	50	50	100	2
CHE-229	Mechanical Operations Lab.	-	-	3	3	50	50	100	2
Total		**18**	**6**	**9**	**33**	**330**	**570**	**900**	**27**

III/IV B.Tech. (First Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-311	Chemical Engineering Thermodynamics-I	3	2	-	5	30	70	100	4
CHE-312	Mass Transfer-I	3	2	-	5	30	70	100	4
CHE-313	Heat Transfer	3	1	-	4	30	70	100	4
CHE-314	Inorganic Chemical Technology	3	1	-	4	30	70	100	4
CHE-315	Process Instrumentation	3	1	-	4	30	70	100	4
CHE-316	Elective-I	3	1	-	4	30	70	100	4
CHE-317	Mass Transfer Lab.-I	-	-	3	3	50	50	100	2
CHE-318	Heat Transfer Lab.	-	-	3	3	50	50	100	2
CHE-319	Soft Skills	-	-	3	3	100	-	100	1
Total		**18**	**8**	**9**	**35**	**380**	**520**	**900**	**29**

III/IV B.Tech. (Second Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-321	Chemical Engineering Thermodynamics-II	3	2	-	5	30	70	100	4
CHE-322	Mass Transfer-II	3	2	-	5	30	70	100	4
CHE-323	Material Science and Engineering	3	2	-	5	30	70	100	4
CHE-324	Organic Chemical Technology	3	1	-	4	30	70	100	4
CHE-325	Biochemical Engineering principles	3	1	-	4	30	70	100	4
CHE-326	Elective-II	3	1	-	4	30	70	100	4
CHE-327	Mass Transfer Lab.-II	-	-	3	3	50	50	100	2
CHE-328	Chemical Technology Lab.	-	-	3	3	50	50	100	2
Total		**18**	**9**	**6**	**33**	**280**	**520**	**800**	**28**

Note: There is Industrial Training at the end of III year II Semester for a minimum of three weeks during summer vacation. Assessment for the Industrial Training is made during IV year I Semester.

IV/IV B.Tech. (First Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-411	Transport Phenomena	3	2	-	5	30	70	100	4
CHE-412	Chemical Engineering mathematics	3	1	-	4	30	70	100	4
CHE-413	Chemical Reaction Engineering	3	2	-	4	30	70	100	4
CHE-414	Industrial Management	3	1	-	4	30	70	100	4
CHE-415	Process Dynamics and Control	3	2	-	5	30	70	100	4
CHE-416	Elective-III	3	1	-	4	30	70	100	4
CHE-417	Chemical Reaction Engineering Lab.-I	-	-	3	3	50	50	100	2
CHE-418	Process Dynamics and Control Lab.	-	-	3	3	50	50	100	2
CHE-419	Industrial Training	-	-	-	-	100	-	100	2
CHE-420	Project Seminar	-	-	3	3	100	-	100	3
Total		**18**	**9**	**9**	**36**	**480**	**520**	**1000**	**33**

IV/IV B.Tech. (Second Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-421	Chemical Process Equipment Design	3	2	-	5	30	70	100	4
CHE-422	Process Optimization	3	2	-	5	30	70	100	4
CHE-423	Process Engineering Economics	3	1	-	4	30	70	100	4
CHE-424	Chemical Process Equipment Design Lab.			6	6	50	50	100	2
CHE-425	Project			6	6	50	50	100	8
Total		**9**	**5**	**12**	**26**	**240**	**360**	**600**	**22**

LIST OF ELECTIVEVS TO BE OFFERED BY THE DEPT. OF CHEMICAL ENGINEERING

Elective-1:	1.Oracle	2.Visual Basic.net
	3.Java	4.MATLAB
	5. C #	6.Fortran
Elective-2:	1.Polymer Technology	2.Computer Applications
	3.Paper Technology	4. Protein Engineering
	5.Computational Fluid *Dynamics*	6.Finite Volume Method
Elective-3:	1.Computer Aided Design	2.Fludization Engineering
	3. Industrial Pollution & Control Engineering	4.Multicomponent Separation Processes
	5. Numerical Heat Transfer	6.Computer Process Control.

B.Tech. Chemical Engineering
(Effective from the admitted batch of 2006-2007)
2/4 B.Tech. Chemical Engineering (First semester)

CHE-211 MATHEMATICS -III L: 4

Vector and Tensor Calculus : Scalar, Vector fields, Gradient, Divergence, curl, directional derivative, identities, irrotational and solenoid vector fields, line integral, surface integral and volume integral, introduction of orthogonal curvilinear coordinates: Cylindrical, spherical and polar coordinates, introduction to tensors, quotient law.

Complex Analysis: Differentiability, Cauchy-Riemann equations, analytic functions Cauchy Theorem, Cauchy integral formula, Taylor and Laurent expansions, (without proofs), singularities, Residue Theorem, contour integration, geometric representation of f(z), conformal transformation, some standard transformations: (1) $w = z + c$, (2) $c z$, $W = 1/Z$ $u = (a z + b) / (c z + d)$, $W = Z^2$, and $W = e^z$.

Fourier Transforms: Fourier Integral, Sine and Cosine Integrals, Complex forms of Fourier Integral, Fourier Transforms, Fourier and Cosine Transforms, Finite Fourier Sine and Cosine Transforms. Properties of F-Transforms, Convolution Theorem for F-Transforms, Parseval's identity for F-Transforms, Fourier Transforms of the derivatives of a function, applications to boundary value problems, using inverse Fourier Transforms only.

Z-Transforms: Some standard Z-transforms, Linear property, Damping rule, Shifting Rules, initial and final value theorems, Formation of difference equations, Solution of difference equations, linear difference equations, rules for finding CF and PI. Difference equations reducible to linear form, Simultaneous difference equations with constant coefficients, application to deflection of a loaded string. Applications of Z-Transform to difference equations.

Textbook: Scope as given in:

1. Higher Engineering Mathematics, by Dr B.S Grewal, Khanna Pub New Delhi - 110 006, 34 edition, 1998.

Reference:

1. Higher Engineering Mathematics, by M.K. Venkataraman, National Pub Co Madras.
2. Advanced Engg Maths, by Erwin Kreyszig, Wiley Eastern Pvt Ltd, New Delhi-49
3. Engineering Mathematics by P.P. Gupta, Krishna Prakasam Media P Ltd, Meerut Vol-2.

CHE-212 INORGANIC CHEMISTRY L: 4

1. **Atomic Structure and Periodic Table:** early models of atom: Rutherford's model, Bohr's model, Bohr-Sommerfeld model- Quantum numbers and their significance, dual nature of matter. Failure of Classical Mechanics. Louis de Broglie wavelength, the Uncertainty principle-Schrodinger Wave equation (derivation not required), the meaning of wave Function. Quantum mechanical model of the Hydrogen atom-some general conclusions. Radial dependence, radial probability distribution curves and angular dependence curves-electronic configuration of elements – the Modern Periodic Table (a brief discussion on the arrangement of elements)-classification of elements-periodic properties: Ionization Energy, electron affinity, electronic structure and color, electronic structure and magnetism.

2. **Chemical Bonding and Molecular Structure:** The Covalent Bond: The simplest molecule H^+ ion its exact description, dative Bond and its influence on Covalence-the concept of resonance and Hybridization. Multiple bonding characters of second period and higher period elements and the difference between the two. Pauling's electro-neutrality principle, valence shell, electron pair repulsion method. Molecular Orbital theory for homonuclear diatomic molecules only-Electro-negativity (Milliken approach)-Fajan's rules for the prediction of non-polar character.

3. **Chemistry of Transition Elements and Co-ordination Compounds:** First Transition series and their general physical and chemical properties-Oxides, Halides, Sulphides. Chemistry in aqueous solution of first transition metals. Co-ordination compounds. Nomenclature, Werner's Theory, isomerism in coordination compounds: Valence Bond theory-Crystal field theory, Colors of Transition metal complexes-stability of complexes.

4. **Analytical Chemistry:** Titrimetric Analysis, Classification of reactions in titrimetric analysis-Standard solutions, Equivalents, normalities and Oxidation Numbers. Preparation of Standard solutions, Primary and Secondary standards-classification of errors-accuracy, precision-minimization of errors,significant figures and computation-mean and standard deviation-reliability results-confidence interval.

Text Books:

1. University General Chemistry, CNR Rao, Macmillan India Ltd-Hyderabad
2. Concepts and Models of Inorganic Chemistry B.E Douglas, D.H McDaniel and J. Alexander. 3rd edition; John Wiley & Sons Inc., New York
3. Concise Inorganic Chemistry. J.D.Lee, Fourth Edn.,Chapman & Hall

CHE-213 PHYSICAL CHEMISTRY L: 4

1. **Liquid State:** Liquefaction of Gases, Critical constants, Classius-Clayperon Equation; Vapor pressure of Liquids, Salt hydrates, Variation of vapor-Pressure with temperature. Elementary treatment of vapor pressure-composition diagrams of Binary liquid mixtures. Azeotropic and Zeotropic mixtures, Fractional distillation and Steam Distillation.
2. **Physical Properties of Liquids:** Surface tension, explanation, measurement, effect of temperature on surface tension, applications. Viscosity: definition, measurement, applications. Intermolecular forces in liquids-Hydrogen Bond.
3. **Thermodynamics and Thermochemistry: First law**-Internal Energy, Work and Heat changes, Enthalpy, reversible changes, maximum work. Heat capacities at constant pressure and volume, adiabatic changes. Heat of Reaction, heat of Formation, Heat of Combustion, Thermo-chemical Laws, effect of temperature on Heat of Reaction. Second law of Thermodynamics,
   spontaneous processes, Entropy and Entropy change for an ideal gas. Entropy change accompanying phase change, physical significance of entropy, Gibb's Free Energy and applications.
4. **Chemical Equilibrium:** Reversible reactions, Law of Mass action, Homogeneous equilibria in gaseous and liquid systems and simple example of Heterogeneous equilibria. Effect of temperature on equilibrium-VantHoff's equation.
5. **Electrochemistry:** Laws of Electrolysis and their applications. Difference between Galvanic and Electrolytic cells, electrode reactions, polarized electrode, Decomposition potential, Over voltage and its applications.
   E.M.F. Galvanic cells, Free Energy changes in cells, Reversible electrode potentials, Single electrode potential and its determination. Nernst Equation and its derivation, Reference (Hydrogen and Calomel) electrode. EMF series and its applications. Primary and Secondary galvanic cells (acid and alkaline)-Lead Acid battery, Fuel Cells and applications.
6. **Phase Rule:** Definition and explanation of terms involved in Phase Rule, Derivation of the Phase Rule. One component systems (Ag-Pb and KI-H_2O). Eutectic point and its significance.
7. **Chemical Kinetics and Catalysis:** Order and molecularity of a reaction. Specific reaction rate and its determination. First Order and Second Order reactions, Half-Life period. Pseudo first order and second reactions-Effect of temperature on reaction rate. Energy of Activation-elementary treatment of collision theory and activated complex theory.
   Catalysis: Types, characteristics of a catalyst, Enzyme catalysts, Industrial applications of Catalysts.

Suggested Reading:

1. Elements of Physical Chemistry by Samuel Glasstone and David Lewis Macmillan & Co.Ltd., London.
2. Physical Chemistry (3 rd. Edition) by P.W.Atkins, Oxford University Press.
3. Text Book of Physical Chemistry by Bahl & Tuli.

CHE-214 STRENGTH OF MATERIALS L: 4

Axial loads: Simple stress and strain, Hook's law, load extension diagram for Mild steel. Stress in compound assemblies, Thermal stresses

Transverse loads: Shear force and bending moment diagrams for a) cantilevers b) simply supported beams c) Over-hanging beams due to i) concentrated loads and U D L s only

Theory of simple bending: Relation between i) f and y ; ii) M and I ; iii) E and R. Distribution of shear stress in common shapes of cross-section.

Principal stresses and principal planes, Maximum shear stress and its plane- Mohar's Circle of stress.

Torsion of solid and hollow circular shafts- transmission of horse power, Design of flange coupling, closed coil helical spring i) under axial load, ii) under axial twist. Riveted joints- design of lap joints.

Stress in thin i) cylindrical shells ii) spherical shells - stress in thick cylinders, compound cylinders, pressure due to shrink-fitting.

Textbook:

1. Strength of Materials., Ramamrutaham

Reference Books:

1. Elements of Strength of Materials. S.P.Timoshenko and Young D.H., East West Press, New Delhi.

1. **Thermodynamics:** Definitions-Systems-classification of Thermodynamic Systems, Cycle, and Zeroth Law of Thermodynamics-First Law of Thermodynamics-closed system-Flow processes.-open systems with steady flow process-applications of steady flow energy equation to engineering systems.

2. **Second Law of Thermodynamics**-Carnot cycle-inequality of Clasius-Reversible Carnot Cycle-Entropy: Relation between Heat and Entropy-general expression for Entropy Change-Entropy change of a perfect gas during various Thermodynamic processes-air standard cycles: Otto-Diesel-dual combustion cycles.

3. **Properties of Steam and use of Steam tables** –Boilers-classification steam boilers –simple vertical –Cocheran locomotive boiler-Babcock and Wlcox boiler –Steam generation –Rankine Cycle.

4. **Impulse and Reaction Turbine**-classification of Steam Turbines-Velocity diagram and power produced in Impulse Turbine-performance of Steam Turbines-reduction of Rotor speed.

5. **I C engines:** classification-main composition of IC engines-carburetter-Fuel Pump injector-cooling systems for IC engines-working of 2-stroke and v4-stroke petrol and Diesel Engines-Power and efficiency of IC engines.

6. **Reciprocating Air-compressors:** Single stage –work done during cycle-effect of clearance-two stage compressors-condition for minimum work-effect of Inter-cooling-Efficiency.

7. **Drives:** Belts-expression for the ratios of tension on the slack and tight side.-power transmitted –V-Belts, Chain drives-Gears: Spur –Helical, Bevel gear –trains simple and compound.

Text Books:

1. A Text Book of Thermal Engineering by R.S.Khurmi and J.K.Gupta
2. Theory of Machines by R.S.Khurmi

Reference Books:

1. Engineering Thermodynamics by P.K.Nag
2. Engineering Thermodynamics by J.B.Jones and R.E.Dugar
3. Engineering Thermodynamics by R.K.Rajput
4. Theory of Machines by Balani

Magnetic Circuits: Definitions of magnetic circuit, Reluctance, magneto motive force (mmf), magnetic flux, Simple problems on magnetic circuits, Hysterisis loss (chapter 8, page Nos. 155-175).

Electromagnetic Induction: Faraday's laws of Electromagnetic Induction, Induced E.M.F., Dynamically induced E.M.F, statistically induced EMF, self inductance, Mutual inductance. (Chapter 9, page Nos. 176-190).

D.C. Generators: D.C Generator principle, construction of D.C generator, E.M.F equation of D.C generator, types of D.C generators, Armature reaction, Losses in D.C generator, efficiency, characteristics of D.C generators, applications of D.C generators (chapter 10, 11, pages 208-238).

D.C. Motors: D.C motor principle, working of D.C motors, significance of back, E.M.F, Torque equation of D.C motors, types of D.C motors, characteristics of D.C Motors, speed control methods of D.C motors, applications of D.C motor, Testing of D.C machines : Losses and Efficiency, direct load test and Swinburne's test. (Chapter 12, 13, page Nos. 239-269).

A.C Circuits: Introduction to steady state analysis of A.C circuits, single and balanced 3 phase circuits (chapter 16, page Nos. 323-348).

Transformers: Transformer principle, EMF-equation of transformer, transformer on load, equivalent circuit of transformer, voltage regulation of transformer, losses in a transformer, calculation of efficiency and regulation by open circuit and short circuit tests. (Chapter 20, page Nos. 423-455).

Three Phase Inductance Motor: Induction motor working principle, construction of 3phase induction motor, principle of operation, types of 3 phase induction motor, Torque equation of induction motor, Slip-Torque characteristics, Starting Torque, Torque under running condition, maximum Torque Equation, power stages of induction motor, efficiency calculation of induction motor by direct loading. (Chapter 21, page Nos. 463-489).

Altemator: Altenator working principle, EMF equation of Altenator, voltage regulation by Sync. Impedance method. (Chapter 23, page Nos. 505-515).

Synchonous Motor: Synchronous Motor principle of operation, construction, methods of starting of synchronous motor. (Chapter 24, page Nos. 516-526).

Textbook:

1. Elements of Electrical Engineering and Electronics by V.K. Mehta S.Chand & Co.

Reference Book:

1. A first course in Electrical Engineering, by Kothari.

CHE-217 PHYSICAL AND ANALYTICAL

CHEMISTRY LABORATORY

1. Determination of dissolved oxygen percent in a given water sample (Winkler's method)

2. Estimation of Nickel using Erico-T as an indicator.

3. Determination of the strength of HCl solution using a standard solution of Sodium Hydroxide p^H metrically.

4. Estimation of Mohrs Salt by titrating against a standard solution of Potassium Dichromate potentiometrically.

5. Determination of conductance of a given sample of water with a Conductivity Meter.

6. Determination of partition coefficient of Iodine between Carbon Tetrachloride and Water.

7. Determination of reaction rate constant of an acid catalyzed hydrolysis of an ester.

8. Determination of the coefficient of viscosity of the given liquid by Ostwald Viscometer.

Suggested Books:

1. Vogel's Text Book of Quantitative Chemical Analysis,5 th. Edition.,Longman
2. Laboratory Manual on Engineering Chemistry, Dr. Sudha Rani, Dhanpat Raj Publishing Company (P) Ltd., New Delhi.

CHE-218 GENERAL ENGINEERING LABORATORY

Mechanical Engineering lab:

1. Find the viscosity of the given sample of oil using redwood Viscometer-1
2. Find the viscosity of the given sample of oil using redwood Viscometer-II
3. Find the Flash point of the given sample of oil using Abel's Flash point tester
4. To calibrate pressure gauge using standard pressure and standard weights.
5. Draw the Valve timing diagram of a 4-stroke Diesel Engine and port timing diagram of a 2-stroke petrol engine.
6. Perform Load Test at Full Load, Half Load, ¼ th.Load on a 4-stroke Ruston Engine and draw the performance curves.
7. Find the Volumetric efficiency, Isothermal Efficiency of the given Compressor.
8. To determine the Moment of Inertia of a Fly-Wheel and Shaft experimentally and compare the values with the calculated values.
9. To determine experimentally the Calorific Value of a gaseous fuel by using Junkers gas Calorimeter.
10. To determine the Modulus of Rigidity of the material of the Wire by Torsional Oscillators.

Electrical Engineering Lab:

1. Study and calibration of Ammeter.
2. Study and calibration of Voltmeter.
3. Study and calibration of Wattmeter.
4. Study and calibration of Energy meter.
5. Measurement of low resistance (armature)
6. Measurement of medium resistance (field)
7. Measurement of insulation resistance.
8. Measurement of filament resistance.
9. Verification of KCL and KVC
10. Superposition theorem.
11. Parameters of a Choke coil
12. OC and SC tests on transformer
13. Load test D.C. Shunt Machine.
14. OC test on DC,. Separately excited machine.
15. Swinburne's test.
16. 3-phase induction motor (No load and rotor block tests)
17. Alternator regulation by Syn.Impedance method.

CHE-221 **MATHEMATICS -IV** **L: 4**

Numerical Analysis: Solution of non-linear equations of one variable using false position, secant and Newton-Raphson methods, Solution of linear algebraic equations using jacobi, Gauss-Seidel iterative methods, eigen values, eigen vectors using power method, Numerical integration using trapezoidal, Simpson's and other quadrature formulae.

Partial Differential Equations and Applications: Introduction, first and second order equations, method of separation of variables, vibrations of a stretched string-wave equation, one-dimensional and two-dimensional heat flow equations, solution of Laplace equation, Laplace equation in polar coordinates.

Numerical Solutions of ODE's and PDE's : Numerical solutions of ODE's by Picard's method, Euler's method, Runge-Kutta method and numerical methods for solution of PDE's (1) Elliptic (Liebmann iteration process) (2) Parabolic (Schmidt explicit formula) (3) Hyperbolic and (4) Poisson's equations (Gauss-Siedel method).

Statistics : Review of probability distributions (not to be examined). Sampling Theory: Sampling distribution, standard error, testing of hypothesis, level of significance, confidence limits, simple sampling of attributes, sampling of variables , large samples and small samples, student's t-distribution, f-distribution, Fisher's Z-distribution and Chi-square distribution

Textbook: Scope as given in:

1. Higher Engineering Mathematics (34 edition.. 1998) by B.S. Grewal

Reference:

1. Higher Engineering Mathematics by M.K. Venkata Raman
2. Numerical methods for Scientific and Engineering Computation by M.K. Jain, S.R.K. Iyengar, R.K. Jain, publishers New Age International (p) Ltd, New Delhi.
3. Numerical Methods for Engineers by Santosh K. Gupta, Pub. New Age International (p) Ltd, New Delhi.
4. Numerical Analysis by G. Shankar Rao, Publishers New Age International New Delhi.

CHE-222 ORGANIC CHEMISTRY L: 4

UNIT-1

Numerical problems: Determination of percentage composition of Carbon, Hydrogen and Nitrogen. Molecular weights determination by depression in freezing point and elevation of boiling point methods. Molecular weight of acids by Silver salt method; Molecular weight of bases by Chloroplatinate method; Determination of Molecular formula of a compound; Problems relating to reactions of Carboxylic acids, functional derivatives of acids, Carbonyl compounds, Alcohols, Amines, Phenols, Diazonium salts applications, Alkenes and their laboratory tests.

Nomenclature of Alkanes, Alkenes, Alkynes, Dienes, Cyclic Aliphatic hydrocarbons, structure of Benzene, nomenclature of Benzene derivatives, Arenes; Industrial preparation of Ethylene, Acetylene; sp, sp^2 and sp^3 hybridization; preparation and chemical reactions; conformational analysis of Ethane, Propane and Butane. Wurtz reaction, Diels-Alder reaction. Aromaticity Morkovinkov Rule; Clemmensen and Wulf-Kishner reduction.

UNIT-2

Electro-philic and Nucleo-philic Aromatic substitution; Orientation in desubstituted Benzenes, mechanism of Nitration, Halogenation, Sulphonation, Friedel-Craft's alkylation and acylation reactions. Nomenclature of Alkyl halides, preparation and chemical reactions, mechanisms of SN_1, SN_2, E_1, E_2 reactions. Nomenclature of Aryl halides, Preparation and chemical reactions: Low reactivity of Vinyl and Aryl halides; Sandmeyer reaction.

UNIT-3

Nomenclature of Alcohols; industrial preparation of Ethyl alcohol, preparation and chemical reactions, Lucas Test. Nomenclature of Mono, Dicarboxylic acids, Industrial preparation of Formic, Acetic, Benzoic, Pthalic, Salicylic acids, preparation and chemical reactions. Mechanism of Hvz reaction and Claisen condensation; Nomenclature of Functional derivatives of acids, preparation and chemical reactions, Mechanism of Hoffmann Bromamide reaction, acid and base catalyzed hydrolysis of Ester. Nomenclature of Ethers and Epoxides; Industrial preparation of Ether and Ethylene Oxide, preparation and chemical reactions; Williamson's synthesis.

UNIT-4

Nomenclature of Aldehydes and Ketenes; Industrial preparation of Formaldehyde, Acetaldehyde, Benzaldehyde, Salicyaldehyde, Acetone; preparation and chemical reactions; mechanisms of Cannizaro, Aldol, Reformatsky and Wittig reactions. Reactions without mechanisms, Perkin, Cope, Knoevenagel and Pinacol-Pinacolone reactions, Difference between Aldehyde and Ketone. Nomenclature of Phenols, Industrial preparation of Phenol, preparation and chemical reactions, mechanisms of Fries rearrangement, Kobe reaction, Reimer-Tiemann reaction. Classification of Carbohydrates, Structure of Glucose and Fructose, reactions of Glucose and Fructose,

Ruff degradation, Wohls degradation, Kiliani-Fisher synthesis, Glucose into Fructose, Fructose into Glucose, Glucose to Vitamin C, mechanism of Osazone formation.

UNIT-5

Nomenclature of Amines, Industrial preparation of Aniline , preparation and chemical reactions ; Exhaustive Methylation, mechanism of Hoffmann elimination, Benzedene rearrangement without mechanism, Hinsberg test, differentiation test using Nitrous acid, preparation of Diazonium salts and Synthetic applications, preparation of Sulphanilamide, Sulphaguanidine, Sulphamerazine, Sulphapyridene (Sulpha drugs), mode of action of Sulpha drugs.

UNIT-6

Preparation of Soaps and Detergents; mode of action of soaps, differences between soaps and detergents; preparation of Malonic, Acetoacetic ester and their synthetic applications; Preparation of Grignard reagents and their synthetic applications, preparation of Polyethylene, Polystyrene, Teflon, PVC, Polyvinyl Cyanide,Rubber-vulcanisation, Styrene-Butadiene rubber , Polychloroprene, Bakelite, Nylon 6 and Nylon 6-6, Plexiglas, Terylene, Ziegler-Natta polymerization, definition of Thermoplastics and Thermosetting plastics.

UNIT-7

Isomerism: Structural and optical isomerism, geometrical isomerism, E Z configuration, sequence rules, R & S configuration, Racemic mixture and their separation, Asymmetric synthesis: Fischer projection Formula, definitions of Axial and Equatorial bonds, 1-3-diaxial interaction, Enatiomers, Diastereomers, Mesomers. Isomerism in Cyclic compounds, Chair, Boat and Twisted Boat structures (1-Methylcyclohexane, 1, 2-Cyclohexane Diol). Synthetic applications of:
Zn/Hg, Na-NH_3 $LiAH_4$, $NaBH_4$, Diborane and Zinc dust, Soda lime, OsO_4, Hydroxylamine, Acetic anhydride, Benzoylchloride and PCl_5.

Recommended Books:

1. Text Book of Organic Chemistry by Morrison & Boyd
2. Text Book of Organic Chemistry by Bahl & Tuli
3. Text Book of Organic Chemistry by M.K.Jain
4. Text Book of Organic Chemistry by I.L.Finar (Vols.1&2 as **reference books**)

Stoichiometry and composition relationships, the gram-mole and pound-mole. Limiting reactant, Excess reactant- Degree of completion. Basis of calculation. Weight percent, volume percent and mole percent. Density and specific gravity: Baume and API gravity scales.

Behavior of ideal gases, application of the ideal-gas law. Dalton and Amagat laws to gaseous mixtures. Composition of gases on dry basis and on wet basis.

Vapor pressures. Effect of temperature on vapor pressure. Antoine equation. Reference substance vapor pressure plots. Vapor pressure of immiscible liquids. Ideal solutions and Raoult's law. Non-volatile solutes.

Humidity: Percentage saturation. Relative saturation or relative humidity. Dew point, Vaporization, Condensation. Wet and dry bulb temperatures. Adiabatic vaporization and adiabatic saturation temperature.

Material balances. Tie substance, Yield, Conversion. Processes involving chemical reactions. Material balance- calculations involving drying, dissolution, and crystallization. Processes involving recycle, bypass and purge.

Heat capacities of gases and gaseous mixtures. Effect of temperature on heat capacity of gas. Mean heat capacity of gas. Kopp's rule, Latent heats, Heat of fusion. Heat of vaporization, Trouton's rule. Kistyakowsky equation for non-polar liquids. Estimation of latent heat of vaporization using Classius-Clayperon equation. Enthalpy of humid air, and humid heat capacity.

Standard heat of reaction. Standard heat of formation. Laws of thermochemistry. Standard heat of combustion. Calculation of heat of formation from heats of combustion. Calculation standard heat of reaction from heats of formation, and from heats of combustion. Standard integral heat of solution. Effect of temperature on heat of reaction. Kirchoff's equation. Adiabatic and non-adiabatic reactions. Theoretical and actual flame temperatures.

Textbook:

1. Chemical Process Principles Part-I Material and Energy balances, by Olaf A Hougen, Kwenneth M. Watson, and Roland A Ragatz, CBS Publishers and Distributors (1995)

Reference Books:

1. Basic principles and calculations in chemical engineering by David M Himmelblau, Prentice Hall of India Pvt Ltd (1995).
2. Stoichiometry, by B.I. Bhatt, and S.M. Vora (Third Ed), Tata McGraw Hill Publishing Company Limited, New Delhi (1996).
3. Stoichiometry for chemical engineers, by Williams and Johnson, McGraw Hill.

Units and dimensions, dimensional analysis, similarity, types of fluids, hydrostatic pressure, pressure distribution in a static fluid, pressure measuring devices.

Introduction to fluids in motion, concept of stream lines, stream tubes, viscosity, types of fluids, flow in boundary layers, its formation and growth in tubes and on plates, basic equations of fluid flow: continuity, motion, momentum and Bernoulli's equation.

Flow of incompressible fluids in pipes, relation between skin friction - wall shear, laminar flow in pipes, Hagen-Poiseulle equation, turbulent flow in pipes, velocity distribution equation, friction factor, friction from changes in velocity or direction, flow of compressible fluids, basic equations, flow through variable area conduits, adiabatic and isothermal frictional flow.

Flow past immersed bodies, Drag, drag coefficient, friction in flow through beds of solids, motion of particles through fluids, its mechanics, terminal velocity, fluidization, mechanism of fluidization, pressure drop in fluidization, applications of fluidization.

Transportation and metering of fluids, pumps , fans, blowers and compressors, reciprocating, rotary and centrifugal types, characteristics and calculations regarding power and efficiency. Flow measuring devices, venturi, orifice, pitot tube, rotameter, notches and weirs.

Textbook:

1. Unit Operations of Chemical Engineering. Warren L.McCabe and Julian C.Smith 7 th Edition.

Reference Book:

1. Unit Operations, Brown et al., Asian Publishing House.
2. Fluid Dynamics and Heat Transfer, Knudsen and Katz.

Characteristics of solid particles - shape – size, Differential and cumulative screen analysis - specific surface area - particle population - different mean diameters for a mixture of particles.

Principles of comminution - laws of crushing, description and working of size reduction equipment - jaw, gyratory and roll crushers - Hammer mill - revolving mills - attrition mills - fluid energy mill - cutting machines - open and closed circuit grinding - wet and dry grinding - Grindability Index.

Size separation - screening - industrial screens - grizzly - gyratory and vibratory screens - revolving screens - trommels - capacity and effectiveness of screens - Magnetic separation - Electrostatic separation - froth flotation.

Filtration - description and working of filtration equipment - plate and frame filter press, shell and leaf filters, Rotary drum filter - filter aid - centrifugal filtration - Top suspended batch centrifuge - Theory of filtration - washing of cakes.

Motion of particles through fluids - drag - free and hindered settling - settling velocities-classification - sink and float methods - differential setting methods - jigging and Tabling - cyclone separators.

Batch sedimentation - Thickeners - Flocculation - Centrifugal sedimentation - gravity and centrifugal decanters.

Agitation of liquids - power consumption in agitated vessels - scale up of agitation equipment - Mixing equipment for mixing of solids and pastes - mixers for dry powders - Mixing index.

Conveying - Types of conveyors - Mechanical - belt, chain, screw conveyors, elevators - pneumatic conveyors. Size enlargement - need and applications.

Textbooks:

1. Unit Operations of Chemical Engineering" McCabe, W.L., Smith J.C, and Harriot P., McGraw- Hill Book Co.

Reference Books:

1. Chemical Engineering {Vol.2}, J.H.Coulson and Richardson, J.F., Pergaman press and ELBS.
2. Chemical Engineer's Hand Book ., Perry R.H, {ed} McGraw-Hill Book Co;
3. Unit Operations, Brown., et al., Asian Publishing House.
4. Introduction to Chemical Engineering., Badger and Banchero, McGraw-Hill Book Co;

CHE-226 **ENVIRONMENTAL STUDIES** **L: 3**

(2006-2007)

(COMMON FOR ALL BRANCHES)

CHE-227 **ORGANIC CHEMISTRY LABORATORY**

List of Experiments:

1. Preparation of Aspirin
2. Preparation of Benzanilide
3. Preparation of m-dinitrobenzene
4. Preparation of Benzoic acid
5. Preparation of Phthalimide
6. Preparation of Methyl Orange
7. Preparation of Parabenzoquinone
8. Preparation of nerolin
9. Detection of Extra elements
10. Analysis of Compound -1
11. Analysis of Compound -2
12. Analysis of Compound -3
13. Analysis of Compound -4
14. Analysis of Compound -5
15. Analysis of Compound -6

CHE-228 **FLUID MECHANICS LABORATORY**

List of Experiments:

1. Identification of laminar and turbulent flows (Reynolds apparatus)
2. Measurement of point velocities (Pitot tube)
3. Verification of Bernoulli's equation
4. Calibration of Rotameter
5. Variation of Orifice Coefficient with Reynolds Number
6. Determination of Venturi Coefficient
7. Friction losses in fluid flow in pipes
8. Pressure drop in a packed bed for different fluid velocities.
9. Pressure drop and void fraction in a fluidized bed
10. To Study the coefficient of contraction for a given open orifice
11. To Study the coefficient of discharge in a V - notch
12. To Study of the characteristics of a centrifugal pump.

CHE-229 MECHANICAL OPERATIONS LABORATORY

List of Experiments:

1. To take a representative sample from a bulk by two methods, viz. Riffle and Cone & Quartering and to find out the average size {volume-surface mean diameter} of the samples.
2. To determine the Grindability Index {G.I} of coal by Hard Groove Machine.
3. To determine the time of grinding in a ball mill for producing a product with 80% passing a given screen.
4. To verify the laws of crushing using any size reduction equipment like crushing rolls, ball mill or vibrating mill and to find out the work Index {W.I} of the material.
5. To compare open circuit and closed circuit grinding by means of a ball mill.
6. To determine the optimum time of sieving for a given sample of material.
7. To find the effectiveness of hand screening of a given sample by a given screen.
8. To find the screen effectiveness of a trommel.
9. To separate a mixture of coal into two fractions using sink and float method.
10. To separate a mixture of coal into two fractions using froth flotation technique.
11. To find the size analysis of a given fine sample using beaker decantation method.
12. To separate a mixture of particles by jigging.
13. To concentrate a given material by means of tabling.
14. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.
15. To determine the specific cake resistance and filter medium resistance of a slurry in plate and frame filter press.

B.Tech. Chemical Engineering
(Effective from the admitted Batch of 2006-07)
III/IV B.Tech. (First Semester)

ChE-311 Chemical Engineering Thermodynamics-I

The first law and other basic concepts: Joule's experiments, internal energy, the first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state, steady-flow process, equilibrium, the phase rule, the reversible process, constant-V and constant-P processes, heat capacity.

Volumetric properties of pure fluids: PVT behavior of pure substances, virial equations, the ideal gas, application of the virial equations, cubic equations of state, generalized correlations for gases, generalized correlations for liquids, molecular theory of fluids, second virial coefficients from potential functions.

Heat effects: Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard of heat of formation, standard heat of combustion, temperature dependence of heat effects of industrial reactions.

The Second law of thermodynamics: Statement of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and ideal-gas scale, entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point.

Thermodynamic properties of fluids: Property relations for homogeneous phases, residual properties, two-phase systems, thermodynamic diagrams, generalized property correlations for gases.

Thermodynamics of flow processes: Equations of balance, duct flow of compressible fluids, turbines (expanders), compression processes.

Refrigeration and liquefaction: - The Carnot refrigerator, the vapor compression cycle-comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes.

Textbook:

1. `Introduction to Chemical Engineering Thermodynamics' by J.M.Smith, H.C.Van Ness and M.M.Abbott, 6th Edition, McGraw-Hill International Editions, 2000.

Reference Books:

1. `Chemical Engineering Thermodynamics' by B.F.Dodge, McGraw-Hill Book Co.,
2. `Schaum Outline of Theory and Problems of Thermodynamics' by Michael M. Abbott and Hendrick C.VanNess, McGraw-Hill International Book Co., Singapore, 1981.

CHE-312 Mass Transfer-I

Introduction: Mass transfer Operations.

Molecular diffusion in fluids: Binary solutions, Fick's law, equation of continuity, Steady state equimolal counter current diffusion, Stefan's diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion.

Mass transfer coefficients: Mass transfer coefficients in turbulent flow, theories of mass transfer, analogy between momentum, heat and mass transfer in laminar and turbulent flow, correlations for mass transfer coefficients in simple situations, diffusion in solids.

Interphase mass transfer: Concept of equilibrium, diffusion between phases, two resistance theory, material balances in steady state co-current and counter-current stage processes, Murphy stage efficiency.

Equipment for gas-liquid operations: Sparged vessels, mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve tray for absorption and distillation, venturi scrubbers, spray towers and spray chambers, packed towers for absorption and distillation, tray towers versus packed towers.

Humidification operations: Definition of fundamental terms, Psychrometric charts, theory of adiabatic saturation and wet bulb temperature, Lewis relation, gas-liquid contact operations, water cooling with air, dehumidification of air-water-vapor mixture, cooling towers, evaporative cooling.

Absorption: Solubility's of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, on-isothermal operation, tray efficiency, continuous contact equipment, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

Distillation: Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

Textbook:

1. Mass transfer Operations, Robert E. Treybal, 3rd edition, McGraw-Hill Book Co.,

Reference Book:

1."Unit Operations in Chemical Engineering" by McCabe,W.L.,Smith,J.C.and Harriot,P., 5^{th} Edition, McGraw-Hill Book Co.,
2. "Chemical Engineering Hand Book" by J.H. Perry.

ChE-313 Heat Transfer

1. Basic Concepts: Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow.

2. Conduction: One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through plane wall, variable thermal conductivity, conduction through cylindrical wall, spherical wall, combined mechanism of heat transfer (conduction-convection systems), conduction through composite slab, cylinder and sphere, thermal contact resistance, critical radius of insulation, heat transfer from a rectangular fin, fin effectiveness and efficiency, unsteady state heat conduction, negligible internal heat resistance and lumped heat analysis, response time of a temperature measuring instrument, unsteady state heat conduction through a semi-infinite slab, three dimensional heat conduction equations in cartesian, cylindrical and spherical coordinates.

3. Convection: The convective heat transfer coefficient, thermal boundary layers for the cases of flow of fluid over a flat plate and flow through pipe, dimensionless numbers in heat transfer and their significance, dimensional analysis, Buckingham's phi theorem, application of dimensional analysis to forced convection and natural convection.

4. Forced Convection: Correlation equations for heat transfer in laminar and turbulent flows in a circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, heat transfer to liquid metals and heat transfer to tubes in cross flow.

5. Natural Convection: Natural convection from vertical and horizontal surfaces, Grashoff and Rayleigh numbers.

6. Heat transfer by radiation: Concept of black body, intensity of radiation, Laws of black body radiation, non-black surfaces, emissivity, Kirchhoff's law, radiation between black surfaces and gray surfaces, radiation shape factor, radiation between large parallel plates, concentric cylinders and spheres, radiation between a small gray body and a large gray enclosure.

7. Boiling and Condensation: Pool boiling, pool boiling curve for water, maximum and minimum heat fluxes, correlations for nucleate and film pool boiling, dropwise and filmwise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation.

8. Heat Exchangers: Types of heat exchangers, log-mean temperature difference, overall heat transfer coefficient, fouling factors, LMTD method for heat exchanger analysis, heat transfer in kettles.

9. Evaporation: Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single effect evaporator, multiple effect evaporators, forward and backward feeds, capacity and economy of evaporators.

Text Books:

1. `Fundamentals of engineering heat and mass transfer (SI Units)' by R. C. Sachdeva, New Age International (P) Limited, Publishers, New Delhi (2001) (For items 1 to 8, heat transfer portion)
2. `Unit Operations of Chemical Engineering', ***6***th Ed. by W. L. McCabe, J. C. Smith and P. Harriot (For item 9, evaporation)

Reference Books:

1. `Heat Transfer–A Conceptual Approach' by P. K. Sarma and K. Ramakrishna, New Age International (P) Limited, Publishers, New Delhi (2001)
2. `Process Heat Transfer' by D. Q. Kern.

ChE-314 Inorganic Chemical Technology

Water: Sources of water, hardness, treatment for different end uses, municipal water conditioning, industrial waste water treatment.

Sulphur and sulphuric acid: Sources of sulphur-sulphuric acid, different processes of manufacturing-contact process, DCDA process for sulphuric acid manufacture.

Nitrogen industries: Manufacture of ammonia, nitric acid, urea and ammonium nitrate.

Phosphorous and phosphoric acid industries: Methods for production of phosphorous and phosphoric acid, manufacture of super phosphate and triple super phosphate.

Chloro-alkali industries: - Manufacture of soda ash, caustic soda and chlorine.

Cement: Types of cement, manufacture of ordinary portland cement [opc], slag cement.

Fuel and industrial gases: Production of water gas, producer gas and coke oven gas, production of acetylene, oxygen and nitrogen.

Metallurgy: Manufacture of pig iron, cast iron, methods of making steel, open hearth process, production of aluminium by electrolytic process.

Textbooks:

1. "Dryden's Outlines of Chemical Technology" by Gopala Rao, M & Marshall Sitting {Eds}.Affiliated East West Press Pvt. Ltd.
2. "Shreve's Chemical Process Industries" by Austin, G.T., McGraw Hill Book.

Reference Books:

1. " Encyclopedia of Chemical Technology" by Kirk, R.E. & Othmer, D.F.{eds} Interscience.

ChE-315 Process Instrumentation

Qualities of measurement: The elements of instruments, static and dynamic characteristics, dynamic response of first order and second order instruments.

Expansion thermometers: Temperature scales, constant-volume gas thermometer, pressure spring thermometer, theory of volumetric and pressure thermometers, static accuracy of thermometer, comparison of pressure-spring thermometers.

Thermoelectric temperature measurement: Thermoelectricity, industrial thermocouples, thermocouple lead wires, thermal wells, response of thermocouples, the millivoltmeter.

Resistance thermometers: Thermal coefficient of resistance, industrial resistance thermometer bulbs, resistance thermometer circuits, null-bridge resistance thermometers, deflectional resistance thermometers.

Radiation temperature measurement: Introduction, blackbody devices and radiation receiving elements, radiation pyrometers, photoelectric pyrometers and optical pyrometers.

Methods of Composition analysis: Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew-point method for moisture analysis in gases, measurement of moisture in paper, textile and lumber.

Measurement of pressure and vacuum: Pressure, vacuum and head, liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measurement of absolute pressure, measurement of pressure in corrosive fluids, static accuracy of pressure gauges.

Measurement of Head and Level: Density and specific gravity, direct measurement of liquid level, pressure(level) measurement in open vessels, level measurement in pressure vessels, density measurement, level measurement by weighing.

Textbooks:

1. Industrial Instrumentation, Donald P.Eckman.,Wiley Eastern Ltd.,

Reference Books:

1. Hand Book of Instrumentation and control, Considine.

ChE-316 MATLAB (Elective-I)

Introduction, Tutorial lessons: MATLAB session, working with arrays of numbers, creating and printing simple data, saving and executing a script file, creating and executing function files, working with files and directories.

Interactive computation: Matrices and vectors, matrix and array operations, creating and using inline functions, using built in functions and online help, saving and loading data, plotting simple graphs.

Script files, function files, language specific features, advanced data objects.

Applications: linear algebra, curve fitting and interpolation, data analysis and statistics, numerical integration, ordinary differential equations, nonlinear algebraic equations.

Basic 2D plots, using subplot to layout multiple graphs. 3-D plots, symbolic Math tool box: two useful tools in symbolic Math tool box, using symbolic Math tool box.

Text Book:

`Getting started with MATLAB: A quick introduction for scientists and engineers' by Rudra Pratap, Oxford University press, 2003

ChE-316 Java (Elective-I)

Fundamentals of object oriented programming, overview of java language, constants, variables and other data types, operators and expressions, decision making and branching, classes, objects and methods, arrays, strings and vectors, managing input/output files in java.

Interfaces: multiple inheritance.

Text Book: `Programming With Java', a Primer 3rd Edition by E.Bala Guruswamy, Tata McGraw-Hill Publishing Company Limited, New Delhi.

ChE-316 FORTRAN (Elective-I)

Fortran programming preliminaries, constants and variables, arithmetic expressions, input-output statements, control statements, the do statements, format specification, functions and subroutines, FORTRAN program examples.

Text Book: `Principles of Computer Programming' by V.RajaRaman

ChE-317 Mass Transfer Laboratory – I

List of Experiments:

1. Steam distillation
2. Differential distillation
3. Height equivalent to a theoretical plate
4. Vapor-liquid equilibria
5. Determination of liquid diffusion coefficient
6. Determination of vapor diffusion coefficient
7. Surface evaporation
8. Height of a transfer unit

ChE-318 Heat Transfer Laboratory

List of Experiments:

1. Determination of total thermal resistance and thermal conductivity of composite wall.
2. Determination of the thermal conductivity of a metal rod.
3. Determination of the natural convective heat transfer coefficient for a vertical tube.
4. Determination of critical heat flux point for pool boiling of water.
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
6. Determination of over-all heat transfer coefficient in double pipe heat exchanger.
7. Study of the temperature distribution along the length of a pin fin under natural and forced convection conditions.
8. Estimation of unsteady state film heat transfer coefficient between the medium in which the body is cooled.
9. Determination of Stefan-Boltzmann constant.
10. Determination of emissivity of a given plate at various temperatures.
11. Determination of radiation constant of a given surface.

ChE-319 Soft Skills

Communication:
Importance of communication
Non verbal communication
Personal appearance
Posture
Gestures
Facial expressions
Eye contact
Space distancing

Goal setting:
Immediate, short term, long term,
Smart goals, strategies to achieve goals

Time management:
Types of time
Identifying time wasters
Time management skills

Leadership and team management:
Qualities of a good leader
Leadership styles
Decision making
Problem solving
Negotiation skills

Group discussions:
Purpose (Intellectual ability, creativity, approach to a problem, solving, tolerance, qualities of a leader)
Group behaviour, Analysing performance

Job interviews:
Identifying job openings
Preparing resumes & CV
Covering letter
Interview (Opening, body-answer Q, close-ask Q),
Types of questions

Reference books:

1. 'Effective Technical Communications' by Rizvi M. Ashraf, McGraw–Hill Publication
2. 'Developing Communication Skills' by Mohan Krishna & Meera Banerji, Macmillan
3. 'Creative English for Communication' by N.Krishnaswami & T.Sriraman, Macmillan
4. 'Professional Communication Skills' by Jain Alok, Pravin S.R. Bhatia & A.M. Sheikh, S.Chand & Co.

B.Tech. Chemical Engineering
(Effective from the admitted batch of 2006-07)
III/IV B.Tech. (Second semester)

ChE–321 Chemical Engineering Thermodynamics-II

Solution thermodynamics: Theory: Fundamental property relation, chemical potential as a criterion for phase equilibria, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for a pure species, fugacity and fugacity coefficient for species in solution, generalized correlations for the fugacity coefficients, the ideal solution, excess properties, behaviour of excess properties of liquid mixtures,

Solution thermodynamics: Applications: Liquid-phase properties from VLE data, models for the excess Gibbs Energy, property changes of mixing, heat effects of mixing processes,

VLE at low to moderate pressures: The nature of equilibrium, the phase rule, Duhem's theorem, VLE- qualitative behavior, the gamma/phi formulation of VLE, dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems,

Thermodynamic properties and VLE from equations of state: Properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type, VLE from cubic equations of state,

Topics in phase equilibria: Equilibrium and stability, liquid/liquid equilibrium(LLE), vapor/liquid/liquid equilibrium(VLLE), solid/liquid equilibrium (SLE), solid/vapor equilibrium (SVE),

Chemical reaction equillibria: The reaction coordinate,–application of equilibrium criteria to chemical reactions, the standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants, relation of equilibrium constants to composition, equilibrium conversions for single reactions, phase rule and Duhem's theorem for reacting systems, multi reaction equilibria,

Thermodynamic analysis of processes: Calculation of ideal work, lost work, thermodynamic analysis of steady-state flow processes.

Text book:

1. `Introduction to Chemical Engineering Thermodynamics' by J.M.Smith, H.C.Van Ness and M.M.Abbott., 6th Edition, Tata McGraw-Hill Edition 2003

Reference books:

1. `Chemical Engineering Thermodynamics' by Y.V.C.Rao, University Press (India) Ltd., Hyderabad 1997

ChE-322

Mass Transfer-II

Liquid-liquid operations: Extraction: Introduction, liquid-liquid equilibria, analytical and graphical solutions for single and multistage operations, continuous counter current operation without and with reflux, fractional extraction, equipment for liquid-liquid contacting operations, single stage, multistage and continuous contacting equipment,

Leaching: Preparation of solid, steady and unsteady state operation, equipment, analytical methods both theoretical and problematic approaches for single and multistage operations,

Adsorption: Theory of adsorption, Industrial adsorbents, adsorption equilibria, Freundlich equation, single and multistage operations, unsteady state adsorption, equipment for single stage and continuous contact, ion-exchange,

Drying: Equilibria, drying rate curve, batch and continuous drying, time of drying and calculations, mechanism of batch drying, equipment's for batch and continuous drying operations,

Crystallization: Equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, incorporation of principles into the design of the equipment,

Less conventional operations: Dialysis, thermal diffusion, mass diffusion,

Membrane separation processes: Separation of gases, separation of liquids, dialysis, membranes for liquid extraction, pervaporation, reverse osmosis.

Text book:

1. 'Mass Transfer Operations', by Robert E.Treybal, III Edition, McGraw-Hill Book Co.

Reference books:

1. 'Unit Operations in Chemical Engineering' by McCabe,W.L., Smith, J.C. and Harriot, P., 5th Edition, McGraw-Hill Book Co.

2. 'Chemical Engineering Hand Book' by J.H.Perry

ChE–323

Material Science and Engineering

A brief re review on bonding, bond Energy, $?H_{crystal,}$ $_{?}$ $H_{lattice,}$

Crystal structure: Symmetry, elements of symmetry in cubic crystals-space lattices two and three dimensiona, unit cell, crystal, Bravais lattices, crystal systems with examples, lattice coordinates, Miller and Miller –Bravais indices for directions and planes, linear density of atoms, planar density of atoms-close packed directions and planes, atomic and ionic packing fractions, densities of metals and ionic structures, covalent structures, close packed structures, crystal structure determination,

X-ray diffraction: Powder method, ionic covalent and metallic structures, structure determination of cubic crystals, Ligancy and limiting radii ratio,

Basic thermodynamic functions: Impure phases, solid solutions, alloys, single phase and multi phase alloys, crystal defects, point imperfections, classification, application of configurational entropy to estimate vacancy concentration and other defect concentrations, defect structures, line imperfections, edge and screw dislocations –their nature, Burgers circuit and Burgers vector, dislocation reaction, dislocation motion, multiplication of dislocations during deformation, role of dislocations in determining crystal properties, twining – surface defects, grains and grain boundary, dislocation energy, stress required to move a dislocation, dislocation density,

Elasticity, plasticity, stress, strain: True stress, true strain, Poissons ratio, elastic compliances, strain energy, stress-strain diagrams for ductile and brittle materials, proof stress, yield stress, plastic stress, modulus of elasticity, rigidity, bulk modulus– relationship between the three, plastic deformation, uniform elongation and necking strain hardening, work hardening as strengthening mechanism, plastic deformation by slip-slip systems and planes, critical resolved shear stress (CRSS), cold working, dynamic recovery, re-crystallization, grain growth, grain size and yield stress, Hall-petch equation, single crystal, polycrystalline material, comparison of stress – strain diagrams, anelasticity, elastic after effect, damping, internal friction, energy loss, viscoelasticity, viscoelastic models,

Composite materials: Fibrous, particulate, their properties and Young's modulus of composites when axially and transversely loaded, fraction of the load taken by fiber and matrix,

Fracture, ductile and brittle: Griffth's criterion for brittle failure, ductile brittle transition temperature, creep, mechanisms of creep, creep resistance materials, creep rate and related equations to find creep rates, fatigue-mechanism-factors to increase fatigue resistance,

Transition between states of matter: Energetics of transitioin, structure of solids, nucleation, mechanisms, nucleation rates, homogeneous and heterogeneous nucleation, phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic, eutectic phase diagrams, Cd-Bi, Pb-Sn, Cu-Ni, Ag-Cu, Fe-C or Fe-Fe_3C-phase transformations, time temperature, transformation curves for eutectoid steels, plain carbon steels, effect of

addition of alloying elements on the properties of steels, types of steels used in Chemical industries.

Text books:

1. `Materials Science & Engineering' by V.Raghavan, Prentice Hall of India Ltd, New Delhi.

2. `Elements of Materials Science & Engineering', 5th Edition, Lawrence H.VanVlack, Addision-Weley Publishing Co.

Reference books:

1. `Science of Engineering Materials', Vols.1-3, by Manas Chanda, McMillan Company of India, Delhi

2. `Principles of Materials Science & Engineering', William F.Smith, McGraw-Hill Publishing Co.

3. `Essentials of Materials Science' by A.G. Guy.

ChE-324

Organic Chemical Technology

Coal and Coal chemicals: Types of coal, different uses, distillation of coal, treatment of products, low and high temperature carbonization of coal, coal tar distillation,

Petroleum: Origin, classification, composition of crude oil, production of crude oil, distillation of crude petroleum, refining-methods, uses of products,

Extraction of vegetable oils: Purification, acid value, hydrogenation of oils,

Iodine value: Manufacture of fatty acids and soaps, saponification value, detergents-classification and manufacture.

Paints and varnishes: Constituents of paints, functions of paint, manufacturing procedures, Pigments-manufacture of lithophone, varnishes,

Manufacture of pulp: Kraft process and sulphite process, production of paper,

Manufacture of cane sugar: Refining, manufacture of starch, dextrin and dextrose, production of ethanol by fermentation, manufacture of pencillin,

Polymerisation: Different methods, manufacture of polyethylene, phenol formaldehyde, SBR, synthetic fibres, rayon, 6-nylon, 6,6-nylon, polyesters.

Text books:

1.`Dryden's out lines of chemical Technology' by Gopala Rao, M. & Marshall Sitting, .Affilated East West Press Pvt.Ltd.

2.`Shreve's Chemical Process Industries' Austin,G.T,,. Mcgraw Hill Publishers

Reference book:

1.`Encyclopedia of Chemical Technology' by Kirk.R.E & othmer,D.F., Inter Science.

ChE-325

Bio-chemical Engineering –Principles

Introduction to biochemical engineering – Comparison of chemical and biochemical processes, industrially important microbial strains used for different bio products,

Chemicals of life –Carbohydrates, proteins, lipids, nucleic acids, their classification and functions,

Biology of microbes – Protist kingdom, classification and structure of different cells,

Introduction to enzymes – Classification, kinetics of enzyme catalyzed reactions, factors affecting E.S complex, derivation of Michaelis Menten equation for single substrate, determination of M.M parameters, enzyme inhibition – types, immobilization of enzymes, methods, immobilized enzyme kinetics, applications of immobilized enzymes,

Kinetics of cell growth – Growth phases, yield coefficient, Monod growth kinetics, ideal bioreactors – batch –mixed flow and plug flow reactors, their analyses,

Transport phenomenon across the cell – Active, passive and facilitated diffusion, gas liquid mass transfer in cellular systems, determination of k_La values,

Sterilization - Media and air, methods,

Down stream processing – Special reference to membrane separation and chromatographic techniques, important industrial bio products – ethanol – penicillin – citric acid – acetic acid, effluent treatment, production of biogas.

Text book:

1. 'Biochemical Engineering Fundamentals' by J.B.Bailey and D.F.Ollis, McGraw Hill Inc.

Reference books:

1. 'Biochemical Engineering' by A.Aiba, E.Humphrey and N.R.Milli
2. 'Bioprocess Engineering - Basic Concepts' by M.L.Shuler and F.Kargi
3. 'Biochemical Engineering' by J.M.Lee
4. 'Biochemical Engineering' by H.W.Blanch and D.S.Clark

ChE-326

Polymer Technology (Elective-II)

Introductory concepts and fundamentals: Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity, Classification of polymers, methods of determining molecular weights of polymers-

(i) Methods based on colligative properties
(ii) Sedimentation velocity method
(iii) Sedimentation equilibrium method
(iv) Gel-chromatography method
(v) Light scattering analysis method
(vi) End-group analysis method

Natural polymers- brief study of rubber, shellac, rosin, cellulose, proteins, Lignin's,

Chemistry of polymerization: Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining Tg, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects,
Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer,

Methods of polymerization: Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization,

Methods of manufacture, properties and uses of the following addition products;
Polyethylene (LDPE and HDPE) , polypropylene, PVC and its copolymers, Polystyrene and its copolymers, acetals and PTFE (polytetraflouroethylene),

Methods of manufacture, properties and uses of the following condensation products: (i) Polyesters-PMMA, PET and ALKYO, (ii) PF-, UF- and MF-resins (iii) epoxy resins, polyurethanes and silicones,

Description of the following processing methods: (with the principles involved and equipments used) Mixing and compounding, extrusion, calendaring, laminating, moulding-compression, transfer, injection and blow moulding.

Text books:

1. `Plastic Materials' by J.A.Brydson, Newnes-Butterworths (London) 1989
2. `Textbook of Polymer Science', Billymeyer, F.W.Jr., 3rd edition, John Wiley & Sons,

Reference books:

1. 'Introduction to Plastics' by J.H.Briston and C.C. Gosselin, Newnes, London
2. 'Polymeric Materials' by C.C.Winding and G.D.Hiatt, McGraw-Hill Publishers

ChE-326

Computer Applications (Elective-II)

Roots of algebraic and transcendental equations: Iteration methods, Regula-Falsi method, Newton Rapson method, roots of simultaneous sets of transcendental and algebraic equations,

System of linear equations and their solution by different techniques, numerical differential and integration, regression analysis, least squares and orthogonal polynomial approximation,

Numerical solution of ordinary differential equations,

Numerical solution of partial differential equations (simple case studies),

Application of the above techniques to problems of interest in Chemical Engineering.

Text book:

1. 'Digital computation for chemical engineers' by Leaon Lapidus, McGraw Hill Book Company

Reference books:

1. 'Applied Numerical Methods' by Camehanet, McGraw Hill Book Co.

2. 'Applied Numerical Methods with Personal Computers, by Constantinides, McGraw Hill Book Co, New York

ChE-326

Paper Technology (Elective-II)

History: Importance of paper industry, historical background of paper making, development of paper industry in India,

Different types and uses of paper: Different types and uses of papers and paper boards, composition, method of making different types of papers and boards,

Raw materials for paper making: Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock)

Preparation of raw materials: Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips)

Pulping processes: Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors,

Pulp bleaching: Bleaching agents, bleaching methods – single stage and multi stage bleaching,

Stock preparation: Beating and refining, sizing and loading (filling),

Manufacture of paper: Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section,

Testing of different properties of pulp and paper: Testing and evaluation of pulp, various properties of pulp and paper and their testing.

Text books:

1. 'Handbook of Pulp and Paper Technology' by Kenneth W.Britt, Vols.I&II

2. 'Modern Pulp and Paper Making' edited by John B.Calkin

3. `Pulp and Paper: Science and Technology - Vols.I&II' by E.Libby, McGraw Hill Books Co.

4. 'Pulp and Paper Manufacture- Vols. I & II' by R.C.McDonald & Others, McGraw Hill Books Company.

CHE-327

Mass Transfer Laboratory-II

List of experiments:

1. Ternary liquid equillibria (Binodal curve)
2. Liquid-liquid equilibria.
3. Limiting flow rates in spray tower
4. Hydrodynamics of perforated plate tower
5. Volumetric mass transfer coefficients in perforated plate tower
6. Dynamics of liquid drops (Single drop extraction tower)
7. Studies of axial mixing characteristics in a packed bed
8. Gas-liquid mass transfer in packed tower
9. Drying characteristics of a given material

ChE-328

Chemical Technology Laboratory

List of experiments:

A. Analysis of water:

1. Total solids, dissolved solids,pH
2. Chlorides and sulphates
3. Temporary, permanent and total hardness.

B. Analysis of oils:

4. Acid value
5. Iodine value
6. Saponification value

C. Miscellaneous analysis:

7. Analysis of coal: Proximate analysis
8. Analysis of lime: Estimation of acid insolubles, available lime and calcium carbonate
9. Analysis of bleaching powder: Estimation of chlorine content.
10. Analysis of starch/glucose: Estimation of total reducing sugars
11. Analysis of saw dust: Estimation of total cellulose and –cellulose

E. Miscellaneous preparations:

12. Preparation of soap
13. Preparation of copper pigment
14. Preparation of chrome yellow pigment
15. Preparation of phenol formaldehyde resin

B.Tech. Chemical Engineering

(Effective from the admitted Batch in 2006-07 on wards)

IV/IV B.Tech. (First Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-411	Transport Phenomena	3	2	-	5	30	70	100	4
CHE-412	Chemical Engineering mathematics	3	1	-	4	30	70	100	4
CHE-413	Chemical Reaction Engineering	3	2	-	4	30	70	100	4
CHE-414	Industrial Management	3	1	-	4	30	70	100	4
CHE-415	Process Dynamics and Control	3	2	-	5	30	70	100	4
CHE-416	Elective-III	3	1	-	4	30	70	100	4
CHE-417	Chemical Reaction Engineering Lab.-I	-	-	3	3	50	50	100	2
CHE-418	Process Dynamics and Control Lab.	-	-	3	3	50	50	100	2
CHE-419	Industrial Training	-	-	-	-	100	-	100	2
CHE-420	Seminar	-	-	3	3	100	-	100	3
Total		**18**	**9**	**9**	**36**	**480**	**520**	**1000**	**33**

IV/IV B.Tech. (Second Semester)

Code and Title of the Course		Periods (L-lect.; T-tutor.; P-pract.)				Marks (S-sess.; EE-external exam)			No. of Credits
Code	**Title**	**L**	**T**	**P**	**Total**	**S**	**EE**	**Total**	
CHE-421	Chemical Process Equipment Design	3	2	-	5	30	70	100	4
CHE-422	Process Optimization	3	2	-	5	30	70	100	4
CHE-423	Process Engineering Economics	3	1	-	4	30	70	100	4
CHE-424	Chemical Process Equipment Design Lab.			6	6	50	50	100	2
CHE-425	Project			6	6	50	50	100	8
Total		**9**	**5**	**12**	**26**	**240**	**360**	**600**	**22**

Elective-III: 1.Computer Aided Design 2. Fludization Engineering 3. Industrial Safety and Pollution 4. Multicomponent Separation Processes Control Engineering 5. Computer Process Control.

CHE-411 **L: 4 T: 1**

Transport Phenomena

Momentum Transport: Viscosity and the Mechanism of Momentum Transport (i) Newton's Law of Viscosity, (ii) Non-Newtonian fluids.

Velocity distributions in laminar flow: (i) Shell momentum balances boundary conditions (ii) Flow of a falling film, (iii) Flow through a circular tube (iv) Flow through an annulus.

The Equations of change for isothermal systems: (i) The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, (ii) Use of the equations of change to set up steady flow problems (iii) Dimensional analysis of the equations of change.

Velocity distributions with more than one independent variable (i) Flow near a wall suddenly set in motion. (ii) Unsteady laminar flow in a circular tube.

Velocity distributions in Turbulent flow: (i) Fluctuations and timesmoothed quantities, (ii) Time-smoothing of the equations of change for an incompressible fluid, (iii) Semiempirical expressions for the Reynolds stresses.

Interphase transport in isothermal systems : (i) Definition of friction factors (ii) Friction factors for flow in tubes (iii) Friction factors for flow around spheres.

Energy Transport: Thermal conductivity and the mechanism of energy transport: (i) Fourier's law of heat conduction.

Temperature distributions in solids and in laminar flow: (i) Shell energy balances - boundary conditions (ii) Heat conduction with an electrical heat source (iii) Heat conduction with a viscous heat source (iv) Heat conduction through composite walls (v) Forced convection and (vi) Free convection.

The equations of change for non-isothermal systems : (i) The equation of energy in rectangular and curvilinear coordinates, (ii) the equations of motion for forced and free convection in non-isothermnal flow (iii)Tangential flow in an annulus with viscous heat generation. and (iv) Dimensional analysis of the equations of change.

Temperature distribution with more than one independent variable : Heating of a semi-infinite slab only.

Temperature distribution in turbulent flow: (i) Temperature fluctuations and time-smoothed temperature, (ii) Time smoothing the energy equation (iii) Semi empirical expressions for the turbulent energy flux.

Interphase transport in non-isothermal systems : (i) Definition of the heat transfer coefficient (ii) Heat transfer coefficients for forced convection in tubes and around submerged objects, and (iii) Heat transfer coefficients for free convection.

Mass Transport: Diffusivity and the mechanism of mass transport : (i) Definitions of concentrations, velocities, and mass fluxes (ii) Fick's law of Diffusion.

Concentration distribution in solids and in laminar flow : (i) Shell mass balances - boundary conditions, (ii) Diffusion through a stagnant gas film, (iii) Diffusion with heterogeneous chemical reaction (iv) Diffusion with homogeneous chemical reaction and (v) Diffusion into a falling liquid film.

The equations of change for multicomponent systems : (i) The equations of continuity for a binary mixture (ii) The equations of continuity of A in curvilinear coordinates and (iii) Dimensional analysis of the equations of change for a binary isothermal fluid mixture.

Concentration distributions in turbulent flow : (i) Concentration fluctuations and the time smoothed concentration (ii) Time-smoothing of the equation of continuity of A.

Interphase transport in multicomponent systems: (i) Definition of binary mass transfer coefficients in one phase, (ii) Correlations of binary mass-transfer coefficients in one phase at low mass-transfer rates (iii) Definition of binary mass-transfer coefficients in two phases at low mass-transfer rates, and (iv) Definition of the transfer coefficients for high mass transfer rates.

Text Book:

1. Transport Phenomena - R Byron Bird, Warran E Steward and Edwin N Lightfoot, John Wiley & Sons, Inc. New York.

Reference Books:

1. Transport Phenomena - Robert S Brodkey and Harry C Hershey, Mc Graw Hill Book Company, New York Tokyo-Toronto.
2. Transport Phenomena for Engineers - Louis Theodore, International Text-book Company, London.
3. Transport Phenomena - W.J. Book and K.M.K. Multzall, John Wiley & Sons Ltd, London, New York;
4 Fundamentals of Momentum, Heat and Mass Transfer - Mames R Welty, Charles E Wicks and Robert E Wilson, John Wiley & Sons Inc. New York.
5. Fluid Dynamics and Heat Transfer by James G Knudsen and Donald L. Katz, McGraw Hill Book Co. Inc., New York.

CHE-412 **L : 4 T : 1**

Chemical Engineering Mathematics

Mathematical formulation of the physical problems:
(i) Applicaetion of the law of conservation of mass - Salt accumulation in stirred tank - Starting an equilibrium still - Solvent extraction in N stages - Diffusion with chemical reaction.
(ii) Application of the law of conservation of energy - Radial heat transfer through a cylindrical conductor - Heating a closed kettle - Flow of heat from fin.

Analytical (explicit) solution of ordinary differential equadtions encountered in Chemical Engineering problems:
(i) First order differential equations - Method of separation of variables - Equations solved by integration factors - Certain examples involving mass and energy balances and reaction kinetics.
(ii) Second order differential equations - Non-linear equations - Linear equations - Simultaneous diffusion and chemical reaction in a tubular reactor - Continuous hydrolysis of tallow in a spray column.

Partial Differential equations:
(i) Formulation of partial differential equations - Unsteady-state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equation.
(ii) Boundary conditions : Function specified, derivative specified and mixed conditions.
(iii) Particular solutions of partial differential equation: Compounding the independent variable into one variable, superposition of solutions, The method of Images and particular solution suggested by the boundary conditions.

Finite Differences:

(i) The difference operator - Properties of the difference operator - Difference tables - other difference operators.
(ii) Linear finite difference equations - complementary solution - particular solution - simultaneous linear difference equations
(iii) Non-linear finite difference equations - analytical solutions.

Solutions for the following type of problems by finite difference method:
(a) Calculation of the number of plates required for an absorption column
(b) Calculation of the number of theoretical plates required for distillation column
(c) Calculation of number of stages required for a counter current extraction and leaching operation.

Application of Statistical Methods:
(i) Propagation of errors of experimental data.
(ii) Parameter estimation of algebric equations encountered in heat and mass transfer, kinetics and thermodynamics by
(a) Method of averages
(b) Linear least squares and
(c) Weighted linear least squares methods
(iii) Design of experiments: Factorial and Fractional factorial methods.

Text Books:

1. Jenson V.G., and G.V Jeffreys, "Mathematical Methods in Chemical Engineering", Academic press, London and New York.

Reference Books:

1. Harold S. Mickley, Thomas S Sherwood and Charles E Reed, "Applied Mathematics in Chemical Engineering", Tata McGraw Hill Publication.
2. Volk, W., "Applied Statistics", 2nd edition, McGraw-Hill Chemical Engineering series.
3. Alkis Constantinides, S. "Applied Numerical Methods with Personal Computers", McGraw Hill, Chemical Engineering series, 1987.

CHE-413 L: 3 T: 2

Chemical Reaction Engineering

Batch Reactors: Introduction and Overview of the subject, kinetics of homogeneous reations, non elementary reactions,Collision theory and Transistion-state theory, Arrhenius relation, various methods of analysis of batch reactor data (Including variable volume and variable pressure data). Isothermal batch ractor design.

Homogeneous flow reactors: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor(CSTR), data analysis in flow reactors, Design of PFR,CSTR, cascade of CSTR's and combination fo PFR and CSTR. (Design for autocatalytic reactions is not included)

Multiple reactions: Design for multiple reactions, parallel reactions,series reactions (Omit reversible and series-parallel reactions).

Non-isothermal design: Energy balance equations for batch, PFR and CSTR under non-isothermal conditions, Equilibrium conversion under adiabatic conditions, Design of the homogeneous reactors under adiabatic conditions.

Non-ideal flow :residence time distribution curves E,F and C; Interpretation of the response data for the "Dispersion" and "Tanks-in-series" models(Omit multiparameter models).

Heterogeneous Catalysis: Catalyst properties,physical adsorption and chemisorption, adsorption isotherm, Derivation of rate equations for various mechanisms(Adsorption, surface reaction and desorption controlling etc.,) , Data analysis for heterogeneous laboratory catalytic reactors, Isothermal packed bed (PFR) reactor design, effectiveness factor and internal pore diffusion, Criteria for internal pore diffusion limitation.

Text Book:

1. "Chemical Reaction Engineering". ,Levenspiel, Octave., 3rd Edition, John Wiley , 1999.

Reference Books:

1. "Elements of Chemical Reaction Engineering".,Fogler,H.S, 2nd Edition,Printice Hall India, 1992.
2. " Chemical Engineering Kinetics". Smith, J.M., 3rd Edition. McGraw Hill. 1981.

CHE-414 **L: 3 T: 1**

Industrial Engineering and Management

Management - Elements of Management, planning, coordinating, motivating, controlling, management needs - Role of Manager - Skills of Manager. 2. Pioneers in management - Scientific management - Taylor's Gilberts - Blackett's and George Dantzig's contribution to the management development.

Production system - Operation Manager's activities -Types of operations - classification of production system - manufacturing and service units - Mass, jobbing and batch type production systems.
Ownership - form of ownership - proprietoryship - partnership business owned by the company cooperation and Government owned enterprises.
Internal organisation - Organisation chart - types of formal organisation - Line Taylor's functional and line and staff type organisation - Principles of organisation.

Process planning - process charts - Group technology, Product development - product life cycle concept, perato analysis standardisation.

Work study - Method study and work measurement , Plant layout - objectives - Planning problems - Layout problems - types of layout Production planning and control - forecasting - controlling and intermediate production system - functions under PPC.

Text Book:

1. Industrial Engineering and Management by O.P. Khanna, Dhanpat Raj and Sons.

Reference books:

1. Works Organisation and Management, Basu, K.C Sahu, N.K. Dutta, Oxford Publications.
2. Modern Production Management, Buffa Wiley Eastern Edition.
3. Essentials of Management, Koontz and O'Donnel, McGraw Hill.

CHE-415 **L : 3 T : 2**

Process Dynamics and Control

Linear Open-loop Systems: Response of First-Order Systems, Physical examples of First-Order systems, Response of First-Order Systems in series, Second-Order Systems, Transportation Lag.

Linear Closed-Loop Systems: The control system, Controllers and Final Control lements, Block diagram of a Chemical-Reactor Control system, Closed-Loop transfer functions, Transient response of simple control systems, Stability, Root Locus.

Frequency Response: Introduction to frequency response, Control system design by frequency response.

Process Applications: Cascade control, Feed forward control, Ratio control, Dead time Compensation, Internal Model Control, Controller tuning and Process identification, Control valves, Theoretical analysis of complex process like, steam-jacketed kettle and Heat Exchanger.

Text Book: Process System Analysis and Control., 2 Edn. Donald R.Coughnowr, McGraw-Hill Inc., 1991.

Reference Books:

1. Chemical Process Control: An Introduction to Theory & Practice, George Stephanopoulos, Prentice - Hall of India Private Limited, New Delhi, 1993.
2. Principles and Practice of Automatic Process Control, Carlos A. Smith and Armando B. Corripio, John Wiley & Sons, New York, 1985.

CHE-416-1 **L: 4 T: 1**

Elective-III: Computer Aided Design

CAD of fluid flow system: Flow of Newtonian fluids in pipes. Pressure drop in compossible flow. Flow of non-Newtonian fluids in pipes. Pipe network calculations. Two phase flow system.

CAD of heat transfer equipment: Shell and tube exchangers without phase change. Condensers, Reboilers. Furnaces.

CAD of mass transfer equipment: Distillation, gas absorption and liquid extraction.

CAD of chemical Reactors: Chemical reaction equilibrium analysis of rate data, ideal reactor models. Non-ideality in chemical reaction. Performance analysis using residence time distribution. Temperature effects in homogeneous reactors. Heterogeneous systems. Fluidized bed reactors.

Text Book:

1. Chemical Process Computation by Raghu Raman, Elsevier Scientific Publishers, London, 1987.

Reference Books:

1. Fundamentals and Modelling of Separation Process by C.D. Holland, Prentice Hall, Inc. New Jercey, 1975.
2. Catalytic Reactor Design by Orhan, Tarhan McGraw Hill, 1983,
3. Chemical Engineering, Vol. 6 by Sinnot, pergamon Press, 1993.

CHE-416-2 **L: *3*, T: 1**

Elective-III: Fluidization Engineering

Introduction: Phenomena of Fluidization, liquid like behavior of fluidized beds, advantages and disadvantages of fluidized beds, different types of fluidized beds and applications of fluidization technique in process industries.

Fixed Beds: Derivation of fixed bed pressure drop equations from fundamental characteristics - Kozeny-Carman equation and Ergun's equation, effects of particle size, sphericity, vesicularity, wall effect, surface roughness and voidage on fixed bed pressure drop.

Minimum Fluidization : Derivation for minimum fluidization mass velocity and pressure drop equation for minimum fluidization.

Fluidization: Types of fluidization - batch, continuous and semi fluidizations, *classifications based on particle diameter and moment,* pressure drop-flow diagrams, slugging, channeling, effect of L/d, fluid distributors, mode of fluidization, power consumption and pumping requirements, *hindered and free settling, stratification, voidage function, fluidization efficiency, fluctuation ratio. Liquid fluidized beds - Rechardson and Zaki correlation*.

Bubbles in dense beds : Single rising bubble, two dimensional Davidson model, *Stream of bubbles from a single source, bubble volume and frequency, bubbles in ordinary bubbling beds* and bubbling bed model for the bubble phase.

Emulsion phase in dense bubbling beds: Movement of individual particles, turn over rate of solids, residence time distribution, Diffusion model and bubbling bed model.

Flow pattern of gas: Stimulus response studies, diffusion model for gas flow , ideal mixing stage model, two region model and bubbling bed model.

Terminal velocity : *Derivation for terminal velocity*

Entertainment and Elutriation : Transport disengaging height (TDH), entrainment at or above TDH for single size of solids and for size distribution of solids, entrainment below TDH, elutriation rate equation, elutriation of fines, entrainment for an infinite free board and a small free board.

Flow of High Bulk Density and Low Bulk Density Mixtures: Pressure drop in stick-slip flow and aerated flow and their equations, downward discharge from a vertical pipe, flow in a horizontal pipe, Saltation velocity (horizontal flow), choking velocity (vertical flow), pressure drop in pneumatic conveying, pressure drop in bends and cyclones in fluidized bed reactors.

Spouted bed: Pressure drop-flow diagram, minimum spouting correlation and spouting requirements.

Heat and Mass Transfer in Fluidized Beds : Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes. Models proposed by (i) Wicke-Fetting, (ii) Mickley and Fair Banks and (iii) Levenspiel and Walton. Heat transfer in fixed and fluidized beds. Definition and evaluation of mass transfer coefficient.

Text Books:

1. Fluidization Engineering by Diazo Kunii, and Octave Levenspiel (Chapters 1, 2, 3, 4,5,6,7, 9,10 and 12).
2. Fluidization by Max Leva (Chapters 2, 3, 4, 5 and 7).

CHE-416-3 **L: 4 T: 1**

Elective-III: Industrial Safety and Pollution Control Engineering

Section A

Industrial Safety: Why safety, Accidents, causes and remedial measures, safety aspects of site selection, Plant Layout and Unit plot planning.

Hazards of commercial chemical operations and reactions, Safety aspects of process design, Instrumentation for safe operations, Safety aspects in design and Inspection of pressure vessels, Effect of toxic agents, Toxicity vs. Hazards, Respiratory hazards, Safe experimentation and testing of reactions and materials for safety.
Flamable materials, Fire extinguishing agents and their application, Eye safety in chemical processing, Personnel protective equipment, Permit systems, Hazard evaluation Techniques, Modern safety management systems, Safety effectiveness.

Section B

Types of emission from Chemical Industries and their effects on environment, Environmental legislation , Noise pollution, occupational health hazards.

Materiological factors in pollution dispersion (ALP and ELP), Plume behaviour and characteristics, chimney design considerations: Plume rise, effective stack height.

Methods of analysis of air pollutants, particulate matter, SO_X , NO_X , CO_X analysis.
Removal of particulate matters: principles and design of settling chambers, solid traps, cyclone separators, fabric and fibre filters, scrubbers and electrostatic precipitators.

General methods of control and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects.

Sources of waste waters, Effluent guidelines and standards, characterisation of effluent streams, Oxygen demanding wastes, Oxygen sag curves, BOD curve.Analysis of water pollutants.

Methods of primary treatment: Screening, sedimentation, floation and Neutralization, Biological treatment : Bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth processes, with design aspects. Trickling filters, rotary drum filters, fluidized bed contactators, Anaerobic processes.

Methods of tertiary treatment.: carbon adsorbtion, ion exchange, reverse osmosis, ultra filtration, chlorination, Ozonation,& sonozone process, sludge treatment and disposal.

Solid waste management: Solid waste collection, Transportation, solid waste processing and recovery.

Hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, Case studies for pollutants removaland safety measures in Fertilizer Industry, Petroleum Refinery & Petrochemical , Paper, and Pharmaceutical Industries.

Text book:
For Section A:
1. Safety and Accident prevention in Chemical Operations by Fawcett and Wood
2. Loss prevention in Chemical Industries by Frank P.Lees

Section B:

1. Environmental pollution control., By C.S.Rao., Wiely Eastren Ltd.,

Reference Books :

1. S.P.Mahajan., " Pollution control in process Industries." Tata McGraw Hill Publishing Co.,
2. Arcadio P. Sincero and Geogoria Sincero ., "Environmental Engineering"

CHE-416-4 **L: 4 T: 1**

Elective-III: Multicomponent Separation Processes

Multicomponent vapor-liquid equilibria: Ideal mixtures at low pressures - Non-ideal mixtures - Activity coefficient models - Wilson, NRTL, UNIQUAC and UNIFAC equations - Evaluation of model constands from binary experimental data - prediction of multicomponent VLE from the model constants of the constituent binaries.

High pressure equilibria - vaporisation constants, K - Thermodynamic methods for K. - Graphical charts - Chao-Seader Correlation.

Equilibrium and Simple Distillation : Multicomponent Equilibrium Flash vaporisation (EFV) - multicomponent differential distillation.

Design considerations in fractionating processes : Quantitative relationships - Temary and multicomponent system fractionation - Key Fractionation concepts - Selection of key components - Column pressure - Material balance rigorous and approximate minimum reflux calculations - Recommended short-cut methods for minimum reflux minimum plates at total reflux - FUG method-Smith Brinkley method.

Multicomponent Fractionation Rigorous Design procedures : Sorel method - Lewis Metheson method - Thiele - Geddes method and its versions in distillation column design - Techniques of seperating azeotropic and close boiling mixtures by fractional distillation - Azeotropic and Extractive Distillation - Selection of solvents - Design considerations -Pseudo binary methods - Solvent recovery.

Tray Design and Operation : The common Tray types - Tray capacity limits - Tray hydraulics parameters - Flow regimes on trays - Column sizing - Tray efficiency - Fundamentals - Tray efficiency prediction.

Packing Design and Operadtion : Packing types - Packing Hydraulics - Comparing packings and trays - Packing efficiency and Scale-up.

Text Books:

1. Distillation, M. Van Winkle, McGraw Hill Co 1967
2. Phase Equilibria in Chemical Engineering S.M. Walas, Butterworth Publishers, 1985.
3. Distillation Design, Henry Z Kister, McGraw Hill Book Co. 1992.

CHE-416-5 **L: 3 T: 1**

Elective-III: Computer Process Control

Sampled data control systems - Sampling and Z-transforms - Open loop and closed loop response - Stability - Modified Z-transforms.

Sampled data control of a first order process with transport lag - Design of sampled data controllers.

State space representation of physical systems -0 Transfer function matrix - Multi variable control.

Non-linear control - Examples of non-linear systems - Methods of phase plane analysis The describing function technique - Digital computer simulation of control systems.

Control and heat exchangers, distillation columns and chemical reactors.

Text Books:

1. For Units I to IV : Chapters 22 - 34 in Process Systems Analysis and Control - Donald R .Coghanour.
2. For Unit V : Chapters 11, 14 and 15 in Process Control by Peter Harriot.

CHE-416-6 **L: 3 T: 1**

Elective-III: Petroleum Engineering (Reservoir Engineering)

Fundamental Concepts of Reservoir Engineering: Porosity, fluid saturation, permeability, flow through layered beds, flow through series beds, Klinkenberg effect. Effective permeability, Relative permeability calculating relative permeability data, phase behavior.

Oil Reservoirs: Reservoir driving mechanisms, basic equation and tools. Volatile oil reservoirs. Identification of volatile oil reservoirs. Ultimate recovery. Predicting reservoir behavior.

Depletion drive reservoirs: Predicting reservoir performance. Mechanics of reservoir performance, prediction procedure. Procedure for reservoir performance prediction. Limitation of predictions. Relating reservoir performance to time. Factors affecting ultimate recovery. Analyzing gas oil ratio history.

Water drive reservoirs: Effect of free gas saturation on recovery. Predicting reservoir performance, calculating water influx. Use of the unsteady state equation in predicting reservoir performance, validity of performance prediction. Limitations in predicting reservoir performance. The material balance equation as a straight line.

Gravity drainage reservoirs: Permeability in the direction of dip. Dip of the reservoir. Reservoir producing rates. Oil viscosity. Relative permeability characteristics. Fundamental recovery process. Predicting reservoir performance. Apparent relative permeability. Oil saturation method.

Combination drive reservoirs: Index of drives. Equations used. Material balance equations. Instantaneous gas oil ratio equation.

Pressure maintenance: Pressure maintenance by gas injection. Condensing gas drive. Predicting performance by gas injection. Injected gas drive index. Pressure maintenance by water injection. Predicting performance by water injection. Index of injected water drive. Control of the gas cap. Typical water injection pressure maintenance operations.

Improving oil recovery: Improving oil recovery by fluid injection immiscible gas-water. Miscible fluid injection thermal oil recovery. Predicting recovery form fluid injection products.

Stiles's method of water flood prediction. Derivation of water out and recovery equations. Frontal advance technique for predicting results of either water or gas injection. Well arrangements, peripheral water flooding. Predicting behavior of peripheral water floods. Special consideration involved in water flooding. Water flood case history. Predicting the results of water flooding.

Text Book:

1. Reservoir Engineering Manual, 2nd Edition, Frank W. Cole, Gulf Publishing Company, Houston, Texas 1989.

CHE-416-7 **L: 4 T: 1**

Elective-III: Biotechnology
(Bio-Chemical Engineering & FermentationTechnology)

Review of elementary concepts of chemical reactions engineering as applied to biological reactions, kinetics of enzyme catalysed reactions - Michaelis - Menten Equation,estimation of M-M parameters - Line weaver burk plot, enzyme inhibitions - M-M form of equations for enzyme inhibitions.

Immobilised biocatalysts - Methods of immobilisation of enzymes and whole cells - Immobilised enzyme kinetics.

Bioreactor configuration - bactch fermenter - continuous stirred tank fermenter (CSTF), tabular fermenter, fludised bed fermenter, trickel bed fermenter, air left fermenter.

Microbial growth - Monod growth kinetics - substrate and product inhibition - Yield coefficients for biomass and products -Growth kinetics in batch fermenter - continuous culture of micro organisms in stirred tank fermenters - Critical dilution rate - Wash out - Continuous stirred tank fermenters in series - plug flow fermenter.

Continuous sterilisation of air and media, aeration and agitation in bio-reactors, scale up concepts.

Fermentation technology and industrial fermentations - Production of antibiotics - Penicillin, citric acid, baker's yeast and Ethanol - Aneorobic fermentation - production of biogas.

Text Books:

1. "Biochemical Reaction Engg (Chapter-5) in "Chemical Engineering, vol. 5", Coulson J.H and Richardson J.F, ELBS and Pergamon Press.
2. Biochemical Engineering, Fundamentals", Bailey J.E and Ollis, D.F, McGraw Hill Book Co.
3. Biochemical Engineering, Aiba, Humphery and Mills Academic Press.

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Reaction Engineering Laboratory

1. Determination of the order of a reaction using a batch reactor and analysing the data by (a) differential method (b) integral method.
2. Determination of the activation energy of a reaction using a batch reactor.
3. To determine the effect of residence time on conversion and to determine the rate constant using a CSTR.
4. To determine the specific reaction rate constant of a reaction of a known order using a batch reactor.
5. To determine the order of the reaction and the rate constant using a Tubular reactor.
6. Determination of RTD and Dispersion number in aTubular reactor using a tracer.
7. Mass transfer with chemical reaction (solid-liquid system) - Determination of Mass Transfer Co-efficient.
8. Axial mixing in a packed bed. Determination of RTD and the dispersion number for a packed-bed using tracer..
9. Langmuir Adsorption isotherm:Determination of surface area of activated charcoal.
10. Performance of reactors in series:
    (i) A plug-flow reactor followed by a CSTR
    (ii) A CSTR followed by a plug flow reactor.

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Process Dynamics & Control Laboratory

List of Experiments:

1. Response of Resistance Thermometer
2. Response of Thermometer with and without Thermal Well.
3. Response of Manometer
4. Response of Single-Tank Liquid-level system.
5. Response of Two-Tank Liquid-level system.
6. Calibration of Thermocouples.
7. Response of mixing process.
8. Calibration of Rotameter with compressible fluid.
9. Study of ON-OFF control action.

CE419 INDUSTRIAL TRAINING

The students are supposed to submit a detailed report covering the following aspects related to civil engineering projects that are relavant to the industry in which they received training:

IV/IV B.Tech. (II Semester)

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Chemical Process Equipment Design

Introduction to plant design. Process design development: Design project procedure, design information from the literature, flow diagrams, preliminary design, comparison of different processes, equipment design, scale-up in design, safety factors, specifications, materials of construction.

General design considerations: Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling.
Materials and fabrication selection: Materials of construction, selection of materials, fabrication of equipment.

Mechanical design of process equipment: Pressure vessels – calculation of thickness of cylindrical and spherical shells subjected to internal pressure, heads or covers. Storage vessels – storage of nonvolatile liquids, storage of volatile liquids, storage of gases. Supports for vessels – bracket or lug supports, leg supports, skirt supports, saddle supports.

Material transfer, handling and treatment equipment: Pumps and piping, flow measuring equipment, design of filters.
Heat transfer equipment design: Basic theory of heat transfer, consideration in selection of heat transfer equipment, evaporators.

Mass transfer equipment design: Finite-stage contactors- bubble cap tray, sieve tray and vbalve tray units, maximum allowable vapor velocities, plate and column efficiency, other design factors. Continuous contactors – types of packing, liquid distribution, pressure drop, packing efficiencies. Relative merits of plate and packed towers.
Reactors: Batch reactors, tubular plug flow reactors, back mix reactors expressions for r_i, mechanical features of reactor design.

Text Books

1. “Plant Design and Economics for Chemical Engineers” by M. S. Peters and K. D. Timmerhaus, McGraw-Hill (1991)
2. "Process Equipment Design" by M. V. Joshi, 3rd Edition, Macmillan India Limited 2003.

Reference Books:

1. Backhurst, J.R And Harker, J. H - Process Plant Design, Heieman Educational Books, London (1973).

2. Coulson J.M. and Richardson J.F Chemical Engineering Vol. VI (An introduction to Chemical Engineering Design) Pergamon Press, 1993.

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Process Optimization

Monotonic function - Unimodal function - Stochastic process - Deterministic process - Convex and Concave sets - Feasible and infeasible regions - State and control variables Lagrange multipliers - Saddle point - Sensitivity analysis - Iterative rule - Slack variable Principle of optimality - Design constraints - Constraint surface - Objective function - Classification of optimisation problems - Basic and non-basic variables - Functions of one variable - Methods based on interval of uncertainty - Sequential search methods - Dichotomous search method - Fibonacci search method - Golden section search method - Quadratic interpolation - Qubic interpolation - Regular Falsi Technique.

Non-linear programming - Unconstrained optinmisation techniques - Univariat methods
Functions of several variables - Alternate variable search method - Exploratory and pattern moves method -Rosenbrock's method of rotating coordinates -Steepest ascent/descent methods - Conjugate gradient method - Quasi Newton methods - Variable metric method - Powell's method - Newton-Raphson method.

Constrained optima - Pivot operation - Linear programming - Simplex method - Revised simplex method - Dual relations - Dual simplex method -Decomposition principle - Changes in the right hand side constraints - Changes in the cost coefficients -
Addition of new variables - Changes in the constraint coefficients - Addition of constraints - Kuhn - Tucker conditions.

Transformation techniques - Checking the convergence of constrained optimization problems - Basic concepts of probability theory - Stochastic linear programming - stochastic non-linear programming.

Polynomial - Solution of an unconstrained geometric programming problem - Solution of a constrained geometric programming problem - Dynamic programming - Multi-stage optimisation - Stochastic dynamic programming - Integer linear programming - Gomory's cutting plane method - Integer non-linear programming - Network problems - CPM and PERT methods -Transportation problems.

Text Books:

1. Optimisation theory and applications by S.S. Rao, 2nd edition Wiley Eastern Limited.
2. Optimisation Techniques for Chemical Engineers by Asghar Hussain and Kota Gangiah
3. Formulation and Optimisation of Mathematical Models by Smith, C.L., R.W. Pike and P.W. Mur

CHE-423 **L: 4 T: 1**

Process Engineering Economics

Value of money equivalence: Value of money, equations for economic studies, equivalence, types of interest, discrete, continuous. Annuities; Relation between ordinary annuity and the periodic payments. Continuous cash flow and interest compounding, present worth of an annuity, perpetuities and capitalised costs. Bonds and debentures; value of a bond and yield rate.

Depreciation: Types and various methods of calculating depreciations, depreciation accounting.
Cost accounting : Basic relationship in accounting, balance sheet and income statement. Various ratios to study the balance sheet and income statements.
Cost estimation: Cash flow for industrial operations, factors affecting investments and production costs - estimation of capital investment, cost indices, cost factors in capital investment, methods of estimating capital investment.
Estimation of total product cost: Manufacturing costs and general expenses.

Profitability, alternate investments and replacements. Mathematical methods for profitability evaluation.
Economic production chartsfor plants operating below 100% , above 100% and under dumping conditions., General procedure for determining optimum conditions. Break even chart for production schedule and its significance for optimum analysis.

Economic balance in fluid flow, heat transfer and mass transfer operations: Optimum economic pipe diameter in fluid dynamics, optimum flow rate of cooling water in condenser in heat transfer and optimum reflux ratio in distillation operadtion.

Economic balance in cyclic operations and semi continuous cyclic operations. Economic balance in yield and recovery, economic balance in chemical reactors, batch and flow reactors.

Text Books:

1. Plant Design and Economics for Chemical Engineers (Fourth Edition) by Max S Peters and Klans D.Timmerhans (Chapters 5 to 11) McGraw Hill Book Company.
2. Process Engineering Economics by Herbest E Schweyer McGraw Hill Book Company.

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Chemical Process & Equipment Design Lab.

The following equipment shall be designed in detail.

1. Sensible Heat Exchangers (1-2 or 2-4)
2. Condenser and Reboiler
3. Multiple Effect Evaporator
4. Fractionating Column- Plate and Packed columns
5. Packed bed absorber
6. Continuous tubular reactor (Homogeneous and Heterogeneous)

Practical Exam : 3 Hrs. duration open book.

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Project Work

The project work should consists of a comprehensive design project of a chemical plant in the form of a report with the following chapters.

1. Introduction
2. Physical and Chemical Properties & Uses
3. Literature survey for different processes
4. Selection of the process
5. Material and Energy Balances
6. Specific Equipment Design (Process as well as mechanical design with Drawing)
7. General Equipment Specifications
8. Plant Location and Layout
9. Materials of construction
10. Health and Safety factors
11. Preliminary cost estimation
12. Bibliography.