NATIONAL INSTITUTE OF TECHNOLOGY
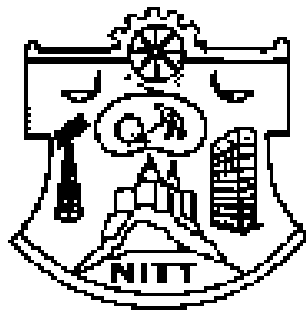# TIRUCHIRAPPALLI - 620 015

(Deemed University)

B.Tech (Chemical Engineering)

Four Year/Eight Semester Course

Semester 3 to 8

Operative from 2007-2008 onwards

Department of Chemical Engineering

The total number of credits for the B.Tech. Program in Chemical Engineering is 176

III SEMESTER

Subject No	Name of the Subject	L	T	P	C
MA201	Transforms, Special Functions and Partial Differential Equations	3	0	0	3
CL201	Organic Chemistry	3	0	0	3
EE227	Digital Electronics	3	0	0	3
CL203	Inorganic Chemical Technology	3	0	0	3
CL205	Momentum Transfer	3	0	0	3
CL207	Process Calculation	3	1	0	4
CE297	Mechanical Engg. Lab	0	0	3	2
EE221	Electrical Engg. Lab	0	0	3	2
	Total	18	1	6	23

IV SEMESTER

Subject No	Name of the Subject	L	T	P	C
MA202	Numerical Techniques	3	0	0	3
CL202	Organic Chemical Technology	3	0	0	3
CL204	Physical Chemistry	3	0	0	3
CL206	Chemical Engineering Thermodynamics	3	1	0	3
CL208	Particulate Science and Technology	3	0	0	3
CL210	Environmental Engineering	3	0	0	3
CL212	Fluid Mechanics Lab	0	0	3	2
CL214	Physical Chemistry Lab	0	0	3	2
	Total	18	1	6	22

Chemical Engineering – B.Tech. Effective from 2007-2008 onwards

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V SEMESTER

Subject No	Name of the Subject	L	T	P	C
CL301	Chemical Reaction Engineering – I	3	0	0	3
CL303	Advanced Programming Languages, C++	3	0	0	3
CL305	Material Science and Technology	3	0	0	3
CL307	Mass Transfer	3	0	0	3
CL309	Heat Transfer	3	0	0	3
CL311	Biochemical Engineering	3	0	0	3
CL313	Mechanical Operations Lab	0	0	3	2
CL315	Technical Analysis Lab	0	0	3	2
	TOTAL	18	0	6	22

VI SEMESTER

Subject No	Name of the Subject	L	T	P	C
HM302	Humanities - I	2	0	0	2
CL302	Process Equipment Design and Drawing	1	0	3	2
CL304	Chemical Reaction Engineering – II	3	0	0	3
CL306	Equilibrium staged Operations	3	1	0	4
CL308	Process Dynamics and Control	3	0	0	3
	Elective 1	3	0	0	3
CL310	Heat Transfer Lab	0	0	3	2
CL312	Chemical Reaction Engineering Lab	0	0	3	2
	TOTAL	15	0	9	21

Chemical Engineering – B.Tech. Effective from 2007-2008 onwards

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VII SEMESTER

Subject No	Name of the Subject	L	T	P	C
CL401	Safety in Chemical Industries	3	0	0	3
CL403	Chemical Process Design and Drawing	1	0	3	2
HM401	Industrial Economics and Management	3	0	0	3
CL405	Project Engineering	3	0	0	3
	Elective 2	3	0	0	3
	Elective 3	3	0	0	3
CL407	Comprehensive Viva-Voce	0	0	0	3
CL409	Mass transfer Lab.	0	0	3	2
CL411	Process Control Lab	0	0	3	2
	Total	16	0	9	24

VIII SEMESTER

Subject No	Name of the Subject	L	T	P	C
CL402	Process Engineering Economics	2	1	0	3
CL404	Transport Phenomena	3	1	0	4
	Elective - 4	3	0	0	3
	Elective - 5	3	0	0	3
CL406	Project Work	0	0	0	6
	Total	11	2	0	19

Chemical Engineering – B.Tech. Effective from 2007-2008 onwards

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LIST OF ELECTIVES

ELECTIVE 1		**L**	**T**	**P**	**C**
CL314	Petroleum and Petrochemical Engineering II	3	0	0	3
CL316	Nuclear Engineering	3	0	0	3
ELECTIVE 2&3					
CL413	Biotechnology	3	0	0	3
CL415	Polymer Technology	3	0	0	3
CL417	Microelectronics processing	3	0	0	3
MT403	Corrosion Engineering	3	0	0	3
CL10	Introduction to CFD	3	0	0	3

Any other elective from other department.

ELECTIVE 4&5					
CL408	Nano Technology	3	0	0	3
CL410	Energy Engineering	3	0	0	3
CL412	Pharmaceutical Engineering	3	0	0	3
IC452	Power Plant Instrumentation & Control	3	0	0	3
ME458	Renewable Energy	3	0	0	3

Any other elective from other department.

RESERVED ELECTIVES

ELECTIVES	L	T	P	C
CL01 Advances in Heat Transfer	2	1	0	3
CL02 Fluidization Engineering	2	1	0	3
CL03 Enzyme Engineering	3	0	0	3
CL04 Process Dynamics and Control - II	2	1	0	3
CL05 Food Technology and Engineering	3	0	0	3
CL06 New Separation Process	3	0	0	3
CL07 Fertilizer Technology	3	0	0	3
CL08 Computer Aided Process Plant Design	2	1	0	3
CL09 Applied Mathematics in Chemical Engineering	3	0	0	3

B.Tech. Chem. Engg. Syllabus for 2007 – 2008 onwards.

MA201 MATHEMATICS III

MA201 TRANSFORMS, SPECIAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform –Convolution theorem-Periodic functions – Application to ordinary differential equation and simultaneous equations with constant coefficients and integral equations.

Z-transforms - inverse Z-transforms - Solution of difference equation with constant coefficients using Z-transforms-Fourier Series – Dirichlet's conditions-Half range Fourier cosine and sine series – Parseval's relation.

Bessel's Equation – Bessel Functions - Recurrence relations-Generating function for Bessel functions - Legendre's equation - Legendre polynomials-Rodrigue's formula-generating function and recurrence relations   for Legendre polynomials - orthogonality property of Legendre polynomials.

Formation of partial differential equations by eliminating arbitrary constants and functions - solution of first order equations - four standard types - Lagrange's equation - homogeneous and non-homogeneous type of second order linear differential equation with constant coefficients.

Applications of Partial Differential Equations - Solution of one-dimensional heat flow equation and two dimensional heat flow equation (Cartesian and Polar form) in steady state by the method of separation of variables using Fourier series.

References.

1. GREWAL, B.S. , Higher Engineering Mathematics, Khanna Publishers.

2. SNEDDON, I. N., Elements of Partial Differential Equations, McGraw Hill.

3. VENKATARAMAN, M. K., Engineering Mathematics, Vol. III, National Publishing Company.

4. VENKATARAMAN, M. K., Higher Mathematics for Engineering and Science, National Publishing Company.

CL201 ORGANIC CHEMISTRY

Organometallic compounds - Grignard reagent - synthesis of different types of compounds like alcohol, aldehyde, acid, amine and organometallic. Acetoacetic ester - tautomerism - base hydrolysis - acid hydrolysis - malonic ester - cyano acetic ester - synthesis of dicarboylic acids and unsaturated acids.

R, S, configuration, mutarotation, conversions - glucose to fructose and vice versa, sucrose - structural elucidation, extraction, reactions, starch and cellulose - structural details, applications.

Alicyclic compounds - nomenclature - synthesis of alicyclic compounds using carbon - acroyloin condensation - Diels Alder reaction, Freunds's synthesis - bayer's strain theory postulates, drawbacks - theory of strainless rings - conformations of cyclohexane. Coal tar distillation, separation of benzene, toluene, phenol and naphthalene - Aromaticity exhibited by these compounds. Fats and oils – Saponification - hydrogenation of oils

Amino acids and proteins- classification - synthesis of amino acids - reactions of carboxyl group and amino group - peptide linkage - end group analysis - colour reaction of proteins- denaturation. Dyes - colors and constitution - chromophores and auxochromes- Quinine theory and electron theory of dyes- preparation-colour and application of azodyes - acidic. basic, mordant, direct azodyes - Triphenylmethane dyes - malachite green, crystal violet, Rosaniline, prosaniline mordant dyes- application, vat dyes-indigo-synthesis and application.

Heterocyclic compounds - synthesis and reaction of pyrrole, furan, thiophene, pyridine, quinine, isoquinoline. Alkaloids - Isolation from natural products - colour reaction - structural elucidation of nicotine. Terpenoids - Isolation - Isoprene rule - structural elucidation of citral.

TEXTBOOKS:
1. *I.L.Finar, "Organic Chemistry", (Vol.I & II) 5th Edn., ELBS, London 1975.*
2. *Morrison and Boyd, "A Text Book of Organic Chemistry", 5th and 6th Edn., Prentice Hall of India, 1996.*

EE227 DIGITAL ELECTRONICS

Basics Of Digital Systems: Introduction, Binary logic, Boolean algebra, Logic Gates - synthesising Basic logic gate circuits, Multiplexers and Demultiplexers, Binary based codes.

Filps - Flops Counters And Memory Devices: Flip - Flops, Shift Registers, Asynchronous counters, Synchronous counters, Semiconductor Memories.

Digital Arithmetic & Data Converters: Addition, Subtraction ALU, Binary Multiplication and Division, Fixed point and Flouting point numbers. DAC and ADC.

Microprocessor Basics: Evolution of Microprocessors, Architecture of IWTEL 8085 - Addressing modes and decoding - Wait, Hold and Halt states - Interrupts, Bus cycles, Transition state diagram.

Microprocessor Programming: Instruction set of INTEL 8085, Writing programs in HEX code, Assembler and Assembler directives.

TEXT BOOK:
1. *William H. Gothmann, "Digital Electronics", 2nd Edn. , Prentice Hall of India (P) Ltd., New Delhi 1986.*

REFERENCE:
1. *Douglas V.Hall, "Microprocessors and Digital systems", 2nd Edn. McGraw Hill Book co., International Student Edn. 1983*

CL203 INORGANIC CHEMICAL TECHNOLOGY

Alkalies: Chlor - alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt.

Acids: Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid.

Cement and Glass: Cement: Types and Manufacture of Portland cement, Glass: Manufacture of glasses and special glasses, Ceramics: Refractories and its classification.

Gases, Water and Paints: Industrial Gases: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene - Water Treatment: Industrial and municipal water treatment - Manufacture of paints - Pigments:

Fertilisers: Nitrogen Fertilisers; Synthetic ammonia, nitric acid, Urea, Ammonium Chloride, CAN, Ammonium Sulphate - Phosphorous Fertilisers: Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate - MAP, DAP, Potassium Fertilisers; Potassium chloride, Potassium sulphate and Bio fertilizers.

TEXT BOOK:
1. N. Shreve, "Chemical Process Industries", 5th Edn., McGraw Hill, New York, 1984.
2. W.V.Mark, S.C. Bhatia " Chemical Process Industries volume I and II", 2nd Edition 2007

REFERENCES:
1. R. Gopal and M. Sittig , " Dryden's Outlines of Chemical Technology", 2nd Ed.n., 1965.
2. S. D. Shukla and G. N. Pandey, "Text book of Chemical Technology", Vol. I, 1977.

CL205 MOMENTUM TRANSFER

Properties of fluids and concept of pressure: Introduction - Nature of fluids - physical properties of fluids - types of fluids. Fluid statics: Pressure - density - height relationships. Pressure Measurement. Units and Dimensions - Dimensional analysis. Similarity - forces arising out of physical similarity - dimensionless numbers.

Momemtum Balance And their Applications: Kinematics of fluid flow: Stream line - stream tube - velocity potential. Newtonian and non-Newtonian fluids - Time dependent fluids - Reynolds number - experiment and significance - Momentum balance - Forces acting on stream tubes - Potential flow - Bernoulli's equation - Correction for fluid friction - Correction for pump work.

Flow of Incompressible Fluids Through Ducts: Flow of incompressible fluids in pipes - laminar and turbulent flow through closed conduits - velocity profile & friction factor for smooth and rough pipes - Head loss due to friction in pipes, fitting etc. Introduction to compressible flow. Isentropic flow through convergent and divergent nozzles and sonic velocity.

Flow of Fluids through Solids: Form drag - skin drag - Drag co-efficient. Flow around solids and packed beds. Friction factor for packed beds. Ergun's Equation - Motion of particles through fluids - Motion under gravitational and centrifugal fields - Terminal settling velocity. Fluidisation - Mechanism, types, general properties - applications.

Transportation and Metering: Measurement of fluid flow: Orifice meter, venturi meter, pitot tube, rotameter, weirs and notches Wet gas meter and dry gas meter. Hot wire and hot film anemometers. Transportation of fluids: Fluid moving machinery performance. Selection and specification. Air lift and diaphragm pump. Positive displacement pumps: Rotary and Reciprocating pumps. Centrifugal pumps and characteristics.

Text books / Reference books:

1. Noel. D. Nevers, "Fluid Mechanics for Chemical Engineers", McGraw Hill, International Edition, 1990.
2. W. L. McCabe, J.C. Smith and P. Harriott , "Unit operations of Chemical Engineering", 5th Edn., McGraw Hill, International Edn.., 1993.
3. .J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol 1, 3rd Edn., Pergamon Press, 1978.

CL207 PROCESS CALCULATION

Stoichiometry: Introduction - Units and Dimensions - Stoichiometric principles - composition relations, density and specific gravity.

Ideal Gases and Vapor Pressure: Behaviour of Ideal gases - kinetic theory of gases - application of ideal gas law - gaseous mixtures - volume changes with change in composition. Vapour pressure - effect of Temperature on vapour pressure - vapour pressure plots - vapour pressure of immiscible liquids - solutions.

Humidity and Solubility: Humidity - saturation - vaporization - condensation - wet and dry bulb thermometry Solubility and Crystallisation - Dissolution - solubility of gases.

Material Balance: Material Balance - Processes involving chemical reaction - Combustion of coal, fuel gases and sulphur - Recycling operations - bypassing streams - Degree of conversion - excess reactant - limiting reactant.

Energy Balance: Thermo chemistry - Hess's law of summation - heat of formation, reaction, combustion and mixing - mean specific heat - Theoretical flame Temperature.

TEXT BOOKS:
1. *O. A .Hougen, K. M. Watson and R. A. Ragatz, "Chemical Process Principles", Vol- I, CBS Publishers and Distributors, New Delhi, 1995.*
2. *Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 7th Edn., Prentice Hall of India Ltd, India 2004.*

REFERENCES:
1. *B. I. Bhatt and S. M. Vora, "Stoichiometry", 4th Edn., Tata McGraw Hill Publishers Ltd., New Delhi, 2004.*
2. *V.Venkataramani and N.Anantharaman,. 'Process Calculations' Prentice Hall of India,Ltd, N. Delhi. 2003*

CE297 MECHANICAL ENGINEERING LAB

1. Load test on Diesel alternator set
2. Heat Balance of Diesel engine
3. Mechanical load test on petrol engine
4. Merse test on multi cylinder petrol engine
5. Volumetric efficiency on Diesel engine
6. Volumetric efficiency on two stage reciprocating compressor
7. COP in compression refrigerator cycle
8. Test on Air conditioning system
9. Viscosity index of lubricant
10. Study of steam power plant
11. Tension test on M.S. Bar
12. Hardness test - Brinell and Rockwell
13. Bending test of M.S. flat
14. Bending test of wooden specimen.
15. Spring test
16. Torsion test

EE221 ELECTRICAL ENGINEERING LAB

1. Open circuit characteristics of DC shunt generators
2. No Load speed characteristics of Dc shunt motor
3. Load test on DC shunt generator
4. Equivalent circuit of single phase transformer
5. Load test on single phase transformer
6. Power measurement in Three phase circuit using two wattmeter method
7. Starting of three phase induction motor
8. Swinburne's test
9. Calibration of watt meter
10. Calibration of Ammeter and Voltmeter

MA202 NUMERICAL TECHNIQUES

Solution of linear system - Gaussian elimination and Gauss-Jordan methods - LU - decomposition methods - Crout's method - Jacobi and Gauss-Seidel iterative methods - sufficient conditions for convergence - Power method to find the dominant eigenvalue and eigenvector.

Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton- Raphson method for $f(x) = 0$ and for $f(x,y) = 0$, $g(x,y) = 0$ - Order of convergence - Horner's method - Graeffe's method - Bairstow's method.

Newton's forward, backward and divided difference interpolation – Lagrange's interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson's 1/3 and 3/8 rules - Curve fitting - Method of least squares and group averages.

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method - Taylor's method and   Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams' methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method - solution of one dimensional heat flow equation - Bender - Schmidt recurrence relation - Crank - Nicolson method - Solution of one dimensional wave equation.

References.

1. *GERALD, C.F., and WHEATLEY, P.O., Applied Numerical Analysis, Addison Wesley.*

2. *JAIN, M.K., IYENGAR, S.R. and JAIN, R.K., Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.*

3. *KANDASAMY, P., THILAGAVATHY, K., and GUNAVATHY, S., Numerical Methods, Chand and Company.*

CL305 MATERIAL SCIENCE AND TECHNOLOGY

Atomic Bonding: Classes of engineering materials - engineering requirement of materials - selection of materials - structure of atoms and molecules - Bonding in solids - types of bonds and comparison of bonds.

Structure And Imperfections in Crystals: Crystal structure Crystal geometry, structure of solids, methods of determining structures. Imperfection in crystals - types of imperfection. Point imperfection, diffusion in solids - self diffusion Fick's law, self diffusion. Applications of diffusion.

Properties and Corrosion Of Material: Mechanical, Electrical and magnetic properties of materials - Deformation of materials - Heat Treatment techniques - corrosion, theories of corrosion - control and prevention of corrosion.

Metals: Engineering materials - ferrous metals - Iron and their alloys Iron and steel Iron carbon equilibrium diagram. Non ferrous metals and alloys - Aluminium, copper, Zinc, lead, Nickel and their alloys with reference to the application in chemical industries.

Non Metals: Inorganic materials: Ceramics, Glass and refractories - organic materials: wood, plastics, and rubber and wood with special reference to the applications in chemical Industries.

TEXT BOOKS:

1. *Lawrence H. Van Vlack, "Elements of Material Science and Engineering", 1971.*
2. *S. K. Hajra Choudhury, "Material Science and processes", 1st Edn. , 1977. Indian Book Distribution Co., Calcutta.*

REFERENCE:
1. *V. Raghavan, Materials Science and Engineering, Prentice Hall*

CL204 PHYSICAL CHEMISTRY

Gaseous State: Vander wall's equation. Law of equipartition principle, Translational, Rotational and vibrational energies of molecules, Joule-Thomson effect, liquefaction of gases. Critical constants.

Reaction Kinetics: Rate order and molecularity of chemical reactions. Methods of their evaluation. Calculation of rate constants. Consecutive - Parallel and opposing reactions. Chain reactions. Energy of activation - Theories on reaction rates. Heterogeneous reactions - zero order reactions.

Phase Equilibria: Phase rule: Application - to one components system (water, sulphur and carbon dioxide), Two component systems (Eutetic, Intermediate compound formation and solid solutions) and simple three component systems. Solutions: Ideal and non-ideal solutions solubility of gases in liquids. Henry's law. Completely miscible liquids - Rauolt's law - vapour pressure and boiling point diagrams. Partially miscible liquids - Critical solution temperature -completely immiscible liquids - Nernst: distribution law - Dilute solution and their colligative properties. Molecular weight determination using these properties.

Electrical Conductance: Debye - Huckell Onsager theory; Ostwald's dilution law - solubility of electrolytes and solubility product – Applications, common ion action - acids, bases - definitions a) based on proton transference, dissociation constant, amphoteric electrolyte - pH - Buffer solutions. Hydrolysis of salts. Decomposition potential, over voltage, definitions of current density, current efficiency, energy consumption; oxidation - reduction redox couple; e.m.f. and energy relations. Conductometry, Potentiometry, Voltammetry, their applications. Fuel cells.

Surface Chemistry: Derivation of Langmuir adsorption isotherm, B.E.T adsorption isotherm, Determination of surface area of solids by B.E.T. method. Catalysis-Homogeneous catalysis, heterogeneous catalysis, Langmuir – Hinshelwood mechanism of a bimolecular surface reaction, Elay – Rideal mechanism of a surface reaction, Enzyme catalysis, Industrial applications of catalysis, zeolites as catalysts, Self-assembled monolayers and Langmuir-Blodgett films, adsorption chromatography.

TEXTBOOKS:
1. *B. R. Puri and SL. R. Sharma, "Principles of Physical Chemistry", Shoban Lal Nagin Chand & Co.*
2. *P.L. Soni, "Text Book of Physical Chemistry ", S. Chand & Co., New Delhi.*

REFERENCES:
1. *K. J. Laidler, "Chemical Kinetics", 3rd Edn., Harper & Row Publishers,1987.*
2. *Atkins, P.W. 'Physical Chemistry', 6th Edn., Oxford University Press, 1998.*

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CL206 CHEMICAL ENGINEERING THERMODYNAMICS

Fundamentals of Thermodynamics: Laws of thermodynamics as applied to open and closed system - reversible and irreversible processes - state and point function - Absolute entropy - Thermodynamic property changes for ideal gas.

Pvt Relations: PVT relationships for gases and liquids - equations of state - Z charts - gas mixtures. Compression - expansion. Refrigeration: Principles and application.

Thermodynamic Relations: Thermodynamic relations - Maxwell's relations - Jacobian algebra - estimation of thermodynamic properties.

Phase Equilibria: Phase equilibria - pure component and mixtures - Latent heat correlation - van Laar, Margules equations - Gibbs' - Duhem equation - consistency tests - partially miscible and immiscible systems - Azeotropes - retrograde condensation - thermodynamic diagrams.

Chemical equilibria - heat effects, industrial reactions - Free energy calculations - Homogeneous and heterogeneous reactions - Industrial reactions like NH_3 synthesis, SO_3 production etc.

TEXT BOOKS:
1. *J. M. Smith and Van Ness, "Introduction to Engineering Thermodynamics", McGraw Hill, New York, 6th Edition, 2004.*
2. *Sundaram, "Chemical Engineering. Thermodynamics", Ahuja Publishers, New Delhi, 1998.*

REFERENCE:
1. *B. F. Dodge, "Chemical Engineering. Thermodynamics, McGraw Hill., New York, 1971.*

CL208 PARTICULATE SCIENCE AND TECHNOLOGY

This course is designed to give conceptual understanding on characterization of particulates, and processes associated with particulate material and synthesis methods to produce particulates of different quality in addition with a brief introduction on handling methods.

Characteristics of Particulate Material: Properties and characterisation of particulate solids, analysis and technical methods for size and surface area distribution of powder; Flow properties of particulates.

Synthesis Methods: Introduction to synthesis of composite material by spray technique, aerosol generation, Introduction to size reduction equipment, energy and power requirement in milling operations, computer simulation techniques for mill performance.

Particulate Processes: Gas-liquid separation methods, Classification by size, agitation of liquids and mixing of solids, Fluidization, encapsulation etc.

Handling of Particulate Material: Conveying methods, Storage methods and design of silo, selection of feeders and elevators.

TEXT BOOKS:
1. *Mc Cabe and J.C .Smith," Unit Operation of Chemical Engineering",   5th Edn., McGraw Hill., New York, 1993.*
2. *M.   Coulson and J.F .Richardson, "Chemical   Engineering",   Vol. II, 4th Edn., Butterworth - Heinemann, 1991*
     .
REFERENCES:
1. *Raymond A.   Kulweic, "Materials Handling Handbook", 2nd Edn,   Wiley-Interscience Publications, 1985.*
2. *Badger and   Banchero, "Introduction to Chemical Engineering", 1st Edn., McGraw Hill, NewYork, 1954*

CL210 ENVIRONMENTAL ENGINEERING

Environment, Environmental quality and degradation, description of environment setting and procedure for environment impact assessment policies and acts.

Sources of air pollution - effects of air pollution on the environment, on materials, on human health, on animals. Analytical methods. Equipments for control of air pollution. Measurements of air pollution.

Sources of water pollution – Effects of water pollution - control of water pollution and treatment methods for effluent water. Measurements of COD & COD.

Sources of noise pollution. Noise pollution measurements - controlling methods of noise pollution. Effects on human being.

Sources and classification public health aspects, methods of collection, disposal methods.

Text Books/References

1. C. S. Rao, "Environmental Pollution Control Engineering", New Age International Pvt. Ltd., 2003.

2. M. N. Rao & H. V. N. Rao, "Air Pollution", Tata – McGrawHill Publishing Ltd., 1993.

3. A. K. De, "Environmental Chemistry", Tata – McGrawHill Publishing Ltd., 1999.

CL212 FLUID MECHANICS LABORATORY

1. Pipe friction
2. Rotameter
3. Floated orifice meter
4. Orifice meter/Venturi meter
5. Efflux time
6. Centrifugal pump
7. Open orifice/weirs and Notches
8. Non- Newtonian flow
9. Helical coil
10. Annular flow
11. Flow through fittings/valves
12. Reciprocating pump
13. Flow through non-circular conduits
14. Flow through packed bed
15. Fluidised bed
16. Semi Fluidised beds

CL214 PHYSICAL CHEMISTRY LABORATORY

1 and 2 Molecular weight Determination
  a Rast's method.
  b B.Pt Depression.
  c B.Pt elevation and
  d Transition temperature methods.

3 and 4 partition experiments.
  (a) Partition coefficient of iodine between two immiscible Solvents.
  (b) Eq. constant of $KI + I = KI$
  (c) Association factor of an organic acid
  (d) Curramorium couples.

5. and 6. Phase rules
  (a) Two component system
  (b) Three component system
  (c) Phenol - water system.

7   Optical experiments.
  a polarimetry
  b Refractometry.

8   and 9. Conductivity experiments.
  a Cell constant.
  b Ostwald Dilution law.
  c Basicity of an organic acid.
  d Conductometric titration.

10 Kinetics.
  a First order reaction.
  b Second order reaction

11 EMF
  a single electro potentials.
  b concentration cells.
  c Titrations
  d pH determination.

12 Miscellaneous.
  a Surface tension.
  b Viscosity
  c Adsorption.

CL301 CHEMICAL REACTION ENGINEERING - I

Basics of Kinetics: Introduction - kinetics of homogeneous reactions: Concentration dependent & Temperature dependent term of rate equation, Searching for a mechanism. Interpretation of Batch Reactor data.

Reactor Design: Introduction to Reactor Design. Single Ideal Reactors.

Design of Reactor for Multiple Reaction: Design for single and multiple Reactions. Size comparison of single reactors for single reactions. Multiple Reactor system for single reactions. Reactions in parallel, reactions in series and series - parallel reactions of first order. Recycle reactor, auto catalytic reactions.

Heat Effects: Temperature and pressure effects on single and multiple reactions.

Flow Behaviour of Reactors: Non - ideal flow: Residence time distribution studies: C, E, F and I curves, conversion calculations directly from tracer studies. Models for non-ideal flow - dispersion and tanks in series multi-parameter models.

TEXT BOOK:
1. *O. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Easter Ltd., New York,1999.*

REFERENCE:
1. *J.M. Smith, "Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.*

CL303   ADVANCED PROGRAMMING LANGUAGE C++

Objects And Classes: Concepts in object-oriented programming, classes and objects, C++ programming basics, object-oriented analysis, object-oriented design methods.

Working With Classes: Operators and Friends: Operator overloading, Friend functions and operators. Arrays, Pointers and References.

Class Inheritance: Derived classes, The protected access specifier, Derived class constructors, overriding member functions, Class hierarchies, Public and Private inheritance, Multiple inheritance.

Polymorphism: Virtual functions, Abstract base classes and pure virtual functions.

Files And Streams: Introduction to object-oriented database - case studies.

TEXT BOOK:
1. *Robert Lafore, "Object Oriented Programming Turbo C++", Gaogotia Pub. 1992.*

REFERENCES :
1. *Neill Graham, "Leaning C++", McGraw Hill Inc. Intl. Edn.,1991.*
2. *Roger S. Pressman, "Software Eng.," A Practitioner's Approach, McGraw Hill 3rd Edn ., 1992.*

CL202 ORGANIC CHEMICAL TECHNOLOGY

Natural Products Processing: Production of pulp, paper and rayon, Manufacture of sugar, starch and starch derivatives, Gasification of coal and chemicals from coal.

Industrial Microbial Processes And Edible Oils: Fermentation processes for the production of ethyl alcohol, citric acid and antibiotics, Refining of edible oils and fats, fatty acids, Soaps and detergents.

Petroleum Refining And Petrochemical Precursors: Petroleum refining to produce naphtha, fuel hydrocarbons and lubricants, Processes for the production of petrochemical precursors: ethylene, propylene, butadiene, acetylene, synthetic gas, benzene, toluene and xylene. (Cracking, Catalytic reforming and separation of products)

Polymer Based Industries And Their Characteristics: Plastics: Production of thermoplastic and thermosetting resins such as polyethylene, polypropylene, phenolic resins and epoxy resins; Polymers and their applications in engineering practice.

Fibre Forming and Electrometric Polymers: Synthetic fibres: polyamides, polyesters and acrylics from monomers. Processes for the production of natural and synthetic rubbers.

TEXT BOOKS:
1. *G.T. Austin, "Shreve's Chemical Process Industries", 5th Edn., Mcgraw Hill Book Co., New York, 1984.*
2. *R. Gopal and M. Sittig, " Dryden's Outline of Chemical Technology," 2nd Edn., Affiliated East-West Publishers, 1970.*

REFERENCE:
1. *S.D. Shukla and G. N. Pandey, "Text book of Chemical Technology", Vol. I, 1977.*

CL307 MASS TRANSFER

Definition, Ficks law, Molecular and eddy diffusion, Diffusion in gaseous mixtures, liquid mixtures and solids, Types of solid diffusion, Pseudo steady state diffusion, measurement and calculation of diffusivities. Ordinary diffusion in multicomponent gaseous mixtures. Unsteady state Diffusion.

Equilibria, Mass transfer coefficients - Individual and overall with relations, Theories of mass transfer, Analogies between momentum, heat and mass transfer to predict mass transfer coefficients.

Absorption – Solubility, theory of gas absorption, Design of absorption towers, Concept of Equilibrium and operating lines. Mass Transfer Equipments- Batch and continuous Stage wise contactors and Differential contactors, Concept of HTU and NTU, Tower packings and packing characteristics, Non-isothermal absorbers, Absorption with chemical reactions.

Humidification Theory, Psychometric Chart, Adiabatic Saturator, Wet Bulb Theory, Methods of Humidification and dehumidification, Cooling tower theory, Design of cooling towers, Industrial cooling towers, Air conditioning process, Recirculating water gas humidification system.

Drying Theory and Mechanism, Drying Characteristics, Estimation of Drying time, Drying rate curve, Classification of Driers, Through circulation driers design, Design of driers, Description and Application of Driers, Analysis of continuous driers.

Crystallization Theory, Solubility curve, Types of crystals, Principles of Crystallization, Supersaturation Theory, Factors governing nucleation and crystal growth. Theory of crystallization, Classification of crystallizers and their applications. Product size distribution by MSMPR model. Industrial crystallizers, Crystallizer Design.

TEXT BOOKS:

1. R. E. Treybal, "Mass Transfer Operations", 3rd Edn., McGraw Hill Book Co., New York, 1981.
2. W .L. McCabe, J.C Smith and P. Harriot, "Unit Operations of Chemical Engineering", 6th Edn., McGraw Hill Book Co., New York, 2001.
3. N. Anantharaman and K.M.Meera Sheriffa Begum, "Elements of Mass Transfer-Part I", Printice Hall of India Pvt. Ltd., New Delhi, 2005.

REFERENCE:
1. J. M. Coulson and J. F. Richardson, "Chemical Engineering.", 4th Edition Vol. III, Pergamon Press, New York, 1991.
2. C.J.Geankoplis, "Transport Processes and Separation Process Principles," IV edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2004.

3. **CL309 HEAT TRANSFER**

Basic modes of heat transfer and the laws governing them. Steady state conduction through plane and composite walls general heat conduction equation, concepts of thermal diffusivity and equivalent thermal conductivity. Radial Heat conduction through thick cylindrical and spherical vessels.

Convection – Dimensional analysis and empirical correlations, critical insulation thickness for cylindrical and spherical surfaces, Hydrodynamic and thermal Boundary layers, physical significance of the dimensionless groups.

Thermal Radiation laws, spectrum of electromagnetic radiation, Black and Gray bodies, and configuration factor – typical examples.

Heat Exchangers – classification and design, overall and individual film coefficients, mean temperature difference, LMTD correction factor for multiple pass exchanger, NTU and efficiency of Heat exchangers, use of efficiency charts.

Evaporation, single and multiple effect operation, material and Energy balance in evaporators, boiling point elevation, Duhrin'gs rule, effect of liquid head, illustrative examples.

TEXT BOOKS:
1. *W. L. McCabe and J. C. Smith, "Unit Operations In Chemical Engineering", 6th Edn., McGraw Hill Publishing Co., 2001.*
2. *Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India (Pvt) Ltd., 2003*

REFERENCES:
1. *S. Foust, L. A. Wenzel, C. W. Clump, Louis maus and L. B. Anderson Principles of Unit Operations'' John Wily,New York.*
2. *D.Q. Kern," Process Heat Transfer," McGraw Hill Publishing Co., New York, 2004.*

CL311 PETROLEUM AND PETROCHEMICAL ENGINEERING

Primary Processing Of Crude Oil: Classification of crude oil, Atmospheric distillation, Vacuum distillation of residue-Products and distillation practice.

Secondary Processing Of Crude Oil: FCCU, Hydro cracking, Visbreaking, Thermal cracking, Coking, Reforming, Alkylation, Polymerisation and Isomerisation process.

Treatment Techniques: Treatment techniques for removal of objectionable gases, Odours, to improve performance, Storage stability, Extraction of aromatics, Olefins and recovery operations from petroleum products.

Petrochemicals: Chemicals from methane and synthetic gas: Ammonia, Methanol and Hydrogen Cyanide, Chemicals from olefins: Ethylene derivatives, Propylene derivatives and Butylenes derivatives, Aromatics, intermediates for synthetic fibres, Plastics and rubber.

Environmental And Safety Aspects In Refinery And Petrochemicals: Waste water and effluent gases treatment from alkylation units and petrochemical units, safety aspects in the above industries.

TEXT BOOKS:
1. *W.L. Nelson, "Petroleum Refinery Engineering", 4th Edn., McGraw Hill, New York,1985*
2. *B. K. Bhaskara Rao, "Modern Petroleum Refining Processes", 2nd Edn., Oxford and IBH Publishing Company, New Delhi, 1990.*

REFERENCES :
1. *G. D. Hobson and W. Pohl., "Modern Petroleum Technology", Gulf Publishers, 2nd Edn., 1990.*
2. *R. A. Meyers, "Hand book of Petroleum Refining Processes", McGraw Hill, 1st Edn., 1980.*

CL313 MECHANICAL OPERATIONS LABORATORY

1. Sphericity factor on friction losses.

2. Agitated vessel

3. Settling studies

4. Drag studies

5. Filtration (constant rate)

6. Filtration (constant pressure)

7. Screening

8. Elutriation

9. Jaw crusher

10. Ball mill

11. Particle size distribution

12. Storage of Solids

CL315 TECHNICAL ANALYSIS LABORATORY

1-6   Analysis of water, oil, soap, cement, sugar, bleaching powder, fertilizer, drugs and vegetables, tannins, ores, alloys, cellulose

7-12   Analysis of products by colorimeter, polarimetry, potentiometric titration, Conductometric titrations, pH meter, gas chromatograph, flame photometer Turbidity meter, conductivity meter, refractometer, etc.

HM 302 HUMAN PSYCHOLOGY & ORGANISATIONAL BEHAVIOUR

Introduction: a. Principles of management, functions of organisations, organisational system - technology, process, design, structure and culture and their impact on the people at work. b. Definition - development of psychology as scientific discipline - methods and applications of psychology in human at work in industry.

Understanding Human Behaviour: Beliefs, values, feelings, perception and attitudes. Process of perception and other factors as above, in shaping human behaviour; Johari Window, FIRO-B, MBTI personality type test. Gestalt approach, attitude development, meaning of intelligence, factors of intelligence, intelligence tests, creativity. Personality - definition, determinants, psychoanalytic theory, assessment.

Motivation, Leadership, Teamwork, Communication: Concept of. Motivation; why to people work; theories on motivation, (Maslow, Herzberg , achievement orientation, expectancy theory, theory x, y, z); techniques of motivating employees, Leadership - role of leader, qualities of a leader; styles of leadership (blake and mouton managerial grid, Frid Fiedler's contingency approach, Rensis Likert's four styles), determinants of leadership style to be adopted, Power, authority and accountability; delegation, Dynamics of groups; work groups, teamwork, Communication - Channels of communication, feedback, Barrier to communication; Non-verbal communication, grapevine, Transactional analysis

Human Engineering: Human and Engineering Factors influencing each other - Ergonomics, Effect of Physical environment - illumination, temperature, noise etc; Social economic and political responsibilities of an engineer.

Psychological Aspects Expounded By Thirukural: Realisation of truth, power of speech (utterances of pleasant words) and Action, Mutual desire, human effort, inconsistent conduct, possession of Decorum manly effort, energy

TEXT BOOKS:
1   *J. Tiffin, and E.J. McCormick, "Industrial Psychology", Prentice Hall of India, 1979 Edn.*
2   *K. Aswathappa,. "Organisational Behaviour Text and Cases", Himalaya Publishing House, 1997.*

REFERENCES:
   1. *S. P. Robbins, "Organisational Behaviour", Prentice Hall of India, 1989 Edn.*
   2. *F. Witting, "Introduction to Psychology", Schaum's outline Series, Tata McGraw Hill, 1974 Edn.*

CL302 PROCESS EQUIPMENT DESIGN AND DRAWING

Design Of Pipe Fittings And Joints: Design and schematic of simple bolts and screws, Riveted joints. Design & Drawing of shafts and couplings.

Design Of Reaction Vessel And Storage Tank: Design and schematic of storage tank, (vertical and horizontal) supports, agitated vessel.

Design Of High Pressure Systems: Design of high pressure vessels and reactors

Design Of Phase Separation Equipment: Design of physical separation equipments such as cyclones, centrifuges, thickeners, filtration equipment, KO drum.

Drawing of Phase Separation Equipment: Drawing of physical separation equipments such as hydro-cyclones, packed towers, plate columns, electrostatic precipitators

TEXT BOOKS:
1. *L. E. Brownell and E.H. Young, "Process Equipment Design - Vessel Design", Wiley Eastern Edn. New York, 1968.*
2. *R. H. Perry, "Chemical Engineers' Handbook", 7th Edn., McGraw Hill , New York, 1998.*

REFERENCES:
1. *J. M. Coulson and J. F. Richardson, "Chemical Engineering.", Vol-VI, Pergamon Press, New York, 1987.*
2. *M. V. Joshi, "Process Equipment Design", 2nd Edn. ,Mac Millan Press, New Delhi, 1996*

CL304 BIOCHEMICAL ENGINEERING

Introduction To Bioscience:Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of Enzymes from cells. Assay of Enzymes.

Functioning Of Cells And Fundamental Molecular Biology: Metabolism and bio-energetics, Photosynthesis, carbon metabolism, EMP pathway, tricarbocyclic cycle and electron transport chain, aerobic and anaerobic metabolic pathways. Synthesis and regulation of biomolecules, fundamentals of microbial genetics, role of RNA and DNA.

Enzyme Technology And Kinetics: Applied Enzyme catalysis, Applications of enzymes in industry and medicine. Immobilization of enzymes. Kinetics of enzyme catalytic reactions involving isolated enzymes. Reversible inhibition.

Reactions Catalysed By Enzymes, Reactors, Analysis: Reactor Design and Analysis for soluble enzyme systems. Cofactor regeneration. Membrane reactor. Effect of mass transfer in immobilised enzyme particle systems. Reactors for immobilised enzyme systems.

BioReactors, Effect Of Transport Processes: Introduction to Bioreactor design: Continuously Stirred aerated tank bioreactors. Mixing power correlation. Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption. Multiphase bioreactors and their applications. Downstream processing and product recovery in bioprocesses.

TEXT BOOKS:
1. *J. E. Bailey and D. F. Ollis. " Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York , 1986.*
2. *Trevan, Boffey, Goulding and Stanbury," Biotechnology", Tata McGraw Hill Publishing Co., New Delhi, 1987.*

REFERENCE:
1. *M. L. Shuler and F. Kargi, "Bio Process Engineering: Basic concepts", 2nd Edn., Prentice Hall of India, New Delhi, 2002.*

CL306 EQUILIBRIUM STAGED OPERATIONS

Principle, theory, Vapour Liquid Equilibria calculations, Effect of Pressure and temperature on VLE, Methods of distillations, batch, continuous, flash, steam, vacuum, molecular distillations. Design of single stage flash and simple distillation columns.

Stage-wise and continuous Differential contact operations, Design calculations using Ponchon-Savarit and Mc-Cabe Thiele Methods, Efficiency interrelations. Reboilers and condensers. Open steam Distillation, Multicomponent Distillation- Azeotropic distillation and Extractive distillation, Multi component Flash and differential distillation.

Liquid - Liquid Equilibria for Different systems, Effect of Pressure and Temperature on LLE, Solubility criteria, Design of Batch and continuous extraction towers for miscible and immiscible systems. Industrial Applications, Design of Extractors with reflux.

Theory, Mechanism, Types of leaching, Solid - Liquid equilibria, Design of Batch and continuous extractors. Equipments and industrial applications.

Types of adsorption, nature of adsorbents, Adsorption isotherms, Operation of adsorption columns. Batch and continuous operations, Design of adsorbers.

TEXT BOOKS:

1. *R. E. Treybal, "Mass Transfer Operations", 3rd Edn., McGraw Hill Book Co., New York, 1981.*
2. *W. L. Mccabe, J. C. Smith and P. Harriot, "Unit Operations in Chemical Engg.", 6th Edn., McGraw Hill Book Co., New York, 2001.*

REFERENCES:

1. *M. Coulson and J. F. Richardson, "Chemical Engineering.", Vol - II, 4th Edn., Pergamon Press, New York, 1991.*
2. *C. J. Geankopolis, "Transport Processes in Chemical Operations", 4th Edn., Prentice Hall of India, New Delhi, 2004.*

Chemical Engineering – B.Tech. Effective from 2007-2008 onwards

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CL308 PROCESS DYNAMICS & CONTROL

Introduction - Control system, components of a feed back control system, Lags in the control system – transfer lag, transportation lag, Pneumatic PID controller, control valve – valve characteristics Laplace transforms - properties of laplace transform, solution of linear differential equations using laplace transform techniques, piecewise continuous functions

Dynamic behaviour of systems - derivation of transfer functions for first and second order systems, liquid level, temperature, pressure, flow and concentration control processes, linearisation of nonlinear systems, interacting and non-interacting systems. Transient response of first and second order systems, natural frequency, damping factor, overshoot, decay ratio, rise time and settling time.

Transient analysis of control systems - block diagram algebra, overall transfer function of closed loop control systems, regulator and servo problems, transient response of first and second order systems with P, PI and PID controller. Definition of stability of control systems, Routh test, limitations of Routh test, Pade's approximation of time delay systems.

Introduction to frequency response - Bode diagrams, Bode diagrams for first and second order systems, P, PI, PID controllers, transportation lag. Bode stability criteria, phase margin and gain margin, Nichols chart, Ziegler - Nichols Optimum controller settings. Nyquist stability criteria, calculation of phase margin, gain margin, peak gain and resonant frequency using nyquist plot.

Introduction to advanced control techniques - feed forward control, cascade control, ratio control, adaptive control, inferential control, selective control.

Text books / Reference books:

1. *'Process Systems analysis and Control', D.R. Coughanour, Mc.Graw Hill, II Edition, 1991.*
2. *'Principle and Practice of Automatic Process Control', C.A.Smith and A.B.Corripio, John Wiley and Sons, 1985.*
3. *'Process Modelling Simulation and Control for Chemical Engineers', W.L.Luyben, McGraw Hill, II Edition, 1990.*
4. *'Process Dynamics and Control', D.W.Seborg, T.F.Edger, and D.A.Millichamp, John Wiley and Sons, II Edition, 2004.*
5. *'Chemical Process Control – Theory and Practice', Stephanopoulous, Prentice Hall of India Ltd.,.1984.*

ELECTIVE I

CL310 HEAT TRANSFER LABORATORY

1. Shell and Tube Heat exchanger

2. Condenser (Vertical)

3. Condenser (Horizontal)

4. Convective heat transfer - Forced & free convection

5. Transient heat conduction

6. Agitated vessel heat transfer

7. Heat Transfer in Jacketed Kettle

8. Thermal Conductivity of metal rod

9. Plate Heat Exchanger

CL312 CHEMICAL REACTION ENGINEERING LABORATORY

1. Reversible reaction in a batch reactor

2. Irreversible reaction in a batch reactor

3. Plug flow reactor

4. Mixed flow reactor

5. Adiabatic reactor

6. Combined reactor: Mixed flow -plug flow

7. Combined reactor: Plug flow -mixed flow

8. Heterogeneous catalytic reactor

9. Biochemical reactor

10. RTD studies

11. Photochemical reactor

12. Segregated flow reactor

13. Semibatch reactor

14. Gas-solid reaction

Chemical Engineering – B.Tech. Effective from 2007-2008 onwards

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CL401   SAFETY IN CHEMICAL INDUSTRIES

Introduction: Industrial safety principles. Site selection and plant layout. Legal Aspects. Design for ventilation, Emergency response systems for hazardous goods basic rules and requirements which governs the chemical industries.

Hazards: Chemical hazards classification. Hazards due to fire, explosion and radiation. Reduction of process hazards by plant condition monitoring, Materials Safety Data sheets and National Fire protection agency's classifications.

Diseases: Dangerous occupational diseases, poisoning, dust effect. The biomedical and engineering response to health hazards.

Control Of Hazards: Engineering control of plants instrumentation. Colour codes for pipe lines. Safety aspects of reactive chemicals.

Operation And Process Hazards: Safety in operations and processes. Runaway reactions, unstable products.

TEXT BOOKS:
1. *H. H. Fawcett and W. S. Wood, "Safety and Accident Prevention in Chemical Operation", 2nd Edn., Interscience, 1982.*
2. *"Loss Prevention and Safety Promotion in Chemical Process Industries", Vol. III, Published by Institution of Chemical Engineers U.K., 1983.*

REFERENCES:
1. *T. Yoshida, "Safety of Reactive Chemicals", Vol. I,   Elsevier, 1987.*
2. *H. Willium , " Industrial Safety Handbook", 2nd   Edn., McGraw Hill, 1968.*

CL403 CHEMICAL PROCESS DESIGN AND DRAWING

Design Of Heat Transfer Equipments: Design and Drawing of Heat Transfer Equipments such as heat exchangers with and without phase change, evaporators, crystallizers.

Design Of Mass Transfer Equipments: Design and Drawing of mass transfer equipments such as distillation columns, absorption columns, extraction columns, dryers and cooling towers.

Targetting: Heat exchanger networks, targeting, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting. Problem representation, temperature enthalpy diagram, simple match matrix Heat content diagram.

Energy Resource Analysis For Various Process: Batch processes, flexible processes, distillation processes, evaporation processes, reaction processes, process using mass separating agents.

TEXT BOOKS:

1. *R .H. Perry, "Chemical Engineers' Hand Book", 6th Edn., McGraw Hill Company, 1984.*
2. *J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 6, Pergamon Press, 1993.*
3. *D.Q.Kerm "Process Heat Transfer", Tata McGraw Hill Edn., 2004.*

REFERENCES:

1. *M. V. Joshi, "Process Equipment Design and Drawing", Mac Millan Press, New Delhi, 1996.*

HM 401 INDUSTRIAL ECONOMICS & MANAGEMENT

Demand and Supply - Forecasting techniques - Cost and Revenues - Competitive nature of the firms – Keynesian economics – National income – Trade cycle – Inflation – Index numbers – Capital budgeting – Cash flow analysis – Balance sheet – Risk and Decision Making – Technological Change in Global Economy – Locating the Firm in a global economy – Taxes and Decision Making - Exchange Rate determination – Marketing - Product life cycle – Marketing research – Branding – Personality - Motivation – Leadership – Working in Teams

TEXT BOOKS:
1. *Burton Genie, Thakur Manab. "Management Today" TMH - 1996 Edn.*
2. *K.K. Dewett, "Modern Economic theory", S.Chand & Co. Ltd., 1999 Edn.*

REFERENCE:
1. *Arun Monappa and Saiyadin "Personnel Management", TMH, Delhi, 1983.*
2. *Ramasamy V.S. and Namakmaris., "Marketing Management, Planning implementation and control "Macmillan - 1996 edn.*

CL405   PROJECT ENGINEERING

Plant location and site selection, plat layout, factors affecting plant location, project planning and scheduling of projects, procurement operations, office procedures, project financing

Process utilities, process water, boiler feed water, water treatment & disposal, steam, steam distribution including appropriate mechanical valves and instrumentation, Furnaces, process pumps, compressors, vacuum pumps, pressurized air distribution systems, Refrigeration plant

Process auxiliaries, piping design, layout, Support for piping insulation, plant constructions, star up and commissioning.

TEXT BOOKS:
1. *J.M. Coulson, JF Richardson, RK Sinnott Butterworth Heinman, Chemical Engineering Volume 6,Revised Second Edition, Butterworth-Heinemann, 1996*

REFERENCES:
1. *Rase and Barrow, Project Engineering of Process Plants, John Wiley.1964*
2. *M. S. Peters & K. D. Timmerhaus, 'Plant design & Economics for Chemical Engg.' McGraw Hill (Japan) 2nd Ed., 1968.*
3. *Industrial Boilers, and Heat recovery Steam Generators Design, Applications and calculations by V.ganapathy, Marcel Dekker, Inc, 2003.*

ELECTIVE 2

ELECTIVE 3

CL407 COMPREHENSIVE VIVA-VOCE

CL409 MASS TRANSFER LABORATORY

1. Simple Distillation
2. Steam Distillation
3. Surface evaporation
4. Leaching
5. Batch adsorption
6. Diffusion
7. Air drying
8. Wetted wall column
9. Vacuum drying
10. H.E.T.P
11. Continuous adsorption
12. Extraction

CL411 PROCESS DYNAMICS AND CONTROL LABORATORY

1. Analog Simulator.
2. Process trainer
3. Interacting & non interacting Systems
4. Control of a thermal system
5. Flapper - Nozzle system
6. Control valve characteristics
7. Level control system
8. Transducer characteristics
9. I & II Order System Dynamics
10. Pressure control system
11. Frequency Response

CL402 PROCESS ENGINEERING ECONOMICS

Value of Money - Equivalence: Value of money, Equations for economic studies and equivalence. Amortization, Capital recovery, Depreciation.

Capital requirements for process plants: Project implementation steps, Feasibility studies, Capital requirements for process plants, Cost indices, Equipment cost, Service facilities. Capital requirements for complete plants, Balance sheet.

Cost, earnings, profits and returns: variable cost, fixed cost, income statement, Economic production charts. Capacity factors, Taxes and insurance.

Economics of selecting alternates: Annual cost method, Present worth method, Equivalent alternates, Rate of return and payment time. Cash flow analysis.

Overall cost analysis and economic trade offs: Economic balance: Economic balance in batch operations, Utility cost, Overhead cost, Plant layout & Overall cost analysis for the plant, Economic trade offs .

TEXT BOOKS:
1. *M. S. Peters and K. D. Timmerhaus, "Plant Design and Economics for Chemical Engineers", 5th Edn., McGraw Hill book Co., New York, 2003*
2. *H. E. Schwyer, "Process Engineering Economics", 1st Edn. McGraw Hill Book Co., New York*

REFERENCES:
1. *F. C. Jelen, and J. H. Black, "Cost and Optimization Engineering", 2nd Edn. McGraw Hill Book Co., New York, 1983.*
2. *Robin Smith, "Chemical Process Design", McGraw Hill   Book Co., New York, 1995.*

CL404 TRANSPORT PHENOMENA

Laminar Flow: Velocity distribution in Laminar flow - Shell momentum balances - Flow through tubes, surfaces. Flow of non - Newtonian fluids.

Equation of Motion: Equation of change for isothermal process - One dimensional equation of motion and continuity - Euler and Navier - Stokes equation. Dimensional analysis of equation of change.

Turbulent Flow: Velocity distribution in turbulent flow - Semi empirical expressions for Reynolds stress. Interphase transport in isothermal system - Ergun's equation.

Heat Transfer analysis: Temperature distribution in solids and fluids in laminar flow - Equations of change for multi component systems.

Mass Transfer analysis: Concentration distribution in solids and in fluids laminar flow - Equations of change for multi component systems.

TEXT BOOKS:
1. *J.L. Stuart etal., "Transport Phenomena", John Wiley, New York, 1982.*
2. *B. R. Bird, W. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, New York, 1960.*

REFERENCE:
1. *C. J. Geankopolis, "Transport Processes in Chemical Operations", 3rd Edn., Prentice Hall of India, New Delhi, 1996.*

ELECTIVE 4

ELECTIVE 5

CL406 PROJECT WORK

L I S T OF E L E C T I V E S

CL314   CHEMICAL REACTION ENGINEERING - II

Modes of contacting different phases: Self mixing of single fluids, mixing of two miscible fluids, Introduction. Design for heterogeneous reacting systems.

Design of reactor for non catalytic reactions: Fluid-particle systems: Models for non-catalytic heterogeneous reactions, their limitations, selection and their applications to design.

Design of Slurry Reactor: Fluid- Fluid Reactions: Rate equations for instantaneous, fast, intermediate, slow, and infinitely slow reactions. Slurry reaction kinetics. Application to design.

Characterisation of catalyst: Catalysis: Introduction. Physical and chemical adsorption catalysts. Preparation and properties. Promoters. Inhibitors. Poisons. Surface area by BET method.   Pore size distribution, mechanism of catalyst deactivation.

Kinetics of heterogeneous chemical reaction: Kinetics and mechanism of heterogeneous catalytic reactions. Various models. Evaluation and elimination of internal and external diffusional resistances, effectiveness factor. Solid catalysed reactions, heat effects, controlling resistances, rates of chemisorption, adsorption isotherms, rates of adsorption and desorption.

TEXT BOOKS:
1. *O. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Eastern, New York, 1999.*
2. *J .M. Smith, "Chemical Kinetics", 3rd Edn., McGraw Hill, New York, 1981.*

CL316 NUCLEAR ENGINEERING

Principles of nuclear power generation, nuclear fission and fusion, energy from fission and fuel burn up.

Radioactivity, neutron energies, thermal neutrons, nuclear cross sections, Fission reactor types, reactor control, fuel arrangements in a thermal reactor.

Pressurized water reactor, PWR power plant, Boiling water reactor, BWR power plant, Gas cooled reactor, high temperature gas cooled reactor.

Concept of breeding, fast breeder reactors, Liquid metal fast breeder reactor and accessories.

Thermal pollution by nuclear power plants, Radio-active pollution of environment by nuclear power plants, radio-active waste disposal.

TEXTS/REFERENCES:

1. *Glasstone, "Nuclear Reactor Engineering".*
2. *M.N. El Vakil, "Nuclear Power Engineering".*
3. *Arora and S. Domkundwar, "Power Plant Engineering", Dhanpat Rai & Sons*

CL413 BIO-TECHNOLOGY

Rates and Patterns of Changes in cell cultures: Kinetics of substrate utilization, biomass and product formation in cellular cultures. Stoichiometry of growth and product formation

Physical Parameters in Bioreactors and Downstream Separations: Transport phenomena and modelling in Bioprocesses. Product recovery operations.

Sensors, Monitoring and control systems in Bioprocesses: Instrumentation and process control in Bioprocesses.

Biochemical Reaction Engineering and Bioreactor design: Design and analysis of Bioreactors. Dynamic models and stability, non-ideal mixing, residence time. Sterilisation reactors. Immobilised bio-catalysts and multiphase bio reactors.

Fermentation Technology and R-DNA Technology: Bio-process Technology and Genetic Engineering.

TEXT BOOKS:

1. *J. E. Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York, 1986.*
2. *M. D. Trevan, S. Boffly, K.H. Golding and P. Stanbury, "Biotechnology", Tata McGraw Publishing Company, New Delhi 1987.*

REFERENCE:
1. *R.Lovitt and M.Jones , "Biochemical Reaction Engineering" in Chemical Engineering, Vol. III, 3rd Edn., Edited by J. F. Richardson and Peacock, Pergamon, London, 1994.*

CL415 POLYMER TECHNOLOGY

Characteristics, Analysis of Polymers: The science of large molecules. Theory of polymer solutions. Measurement of molecular weight and size. Analysis and testing of polymers.

Polymer material structure and Properties: Deformation, flow and melt characteristics. Morphology and order in crystalline polymers. Rheology and the mechanical properties of polymers. Polymer structure and physical properties.

Polymer synthesis and reaction engineering: Condensation polymerization. Addition polymerization. Ionic and coordination polymerization. copolymerisation. polymerization conditions and polymer reactions.

Industrial polymers: Manufacturing processes and applications: Hydrocarbon plastics and elastomers. Other carbon chain polymers. Heterochain thermoplastics. Thermosetting resins.

Processing of polymers: Plastics, Fibres and Elastomers: Polymers developed for synthetic plastics, fibres and elastomer applications. Plastics technology. Fiber technology. Elastomer technology.

TEXT BOOK:
1. *F. W. Billmeyer Jr., "Text Book of Polymer Science", 3rd Edn., Wiley- Inter Science, 1984.*

REFERENCES:
1. *F. Rodriguez, "Principals of Polymer Systems", 4th Edn., Taylor and Francis, Washington, 1996.*
2. *"Encyclopedia of Polymer Science and Technology", John Wiley-Inter Science.*

CL417 MICRO ELECTRONICS PROCESSING

Crystal growth and wafer preparation: silicon crystal growth from the melt, silicon float zone process, material characterization, Gas crystal growth technique. Silicon oxidation: Thermal oxidation, silicon oxidation model, impurity redistribution during oxidation, oxide thickness characteristics.

Photolithography: optical lithography, next generation lithographic methods - electron beam, extreme ultraviolet, X-ray, Ion beam lithographic methods, comparison of various methods.

Etching: wet chemical etching - silicon etching, silicon dioxide etching, silicon nitride and poly silicon etching, Aluminium etching, Gallium Arsenite etching. Dry etching plasma etching, reactive plasma etching.

Diffusion: Basic diffusion processes, Models of diffusion in solids, extrinsic diffusion, Lateral diffusion.

Ion Implantation: Range of implantation ions, Implant damage and annealing, Implantation related processes.

Film deposition: Epitaxial growth techniques, structure and defects in epitaxial layers, Dielectric deposition, Polysilicon deposition, metallization Process integration: Passive components, Bipolar technology, MOSFET Technology, MESFET technology, MEMS technology.

TEXT BOOKS:
1. *G.S.May and S.M.Sze, Fundamentals of semiconductor fabrication, Wiley Student Edition, Singapore, 2004.*
2. *R.C. Jaeger, Introduction to Microelectronic fabrication, II Ed., Prentice Hall, New Jersey, 2002.*

REFERENCES:
1. *H.H.Lee, Fundamentals of Microelectronics processing, McGraw Hill, 1980.*
2. *S.M.Sze, VLSI Technology, Tata-McGraw Hill, New Delhi, 1988.*

CL408 NANO TECHNOLOGY

Supramolecular Chemistry. Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures.

Physical Chemistry of Nanomaterials. Students will be exposed to the very basics of nanomaterials; A series of nanomaterials that exhibit unique properties will be introduced.

Methods of Synthesis of Nanometerials. Equipment and processes needed to fabricate nanodevices and structures such as bio-chips, power devices, and opto-electronic structures. Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches.

Biologically-Inspired Nanotechnology Basic biological concepts and principles that may lead to the development of technologies for nanoengineering systems. Coverage will be given to how life has evolved sophisticatedly; molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans.

Instrumentation for Nanoscale Characterization. Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range.

TEXT BOOKS:
1. *Supramolecular Chemistry by Jean-Marie Lehn,*
2. *Supramolecular Chemistry by Jonathan Steed & Jerry Atwood*
3. *Intermolecular and Surface Forces by Jacob Israelachvili.*

CL410 ENERGY ENGINEERING

Coal: Coal and Coal derived fuels; Characteristics, production methods and uses. Coal combustion technology, waste heat recovery.

Oil And Gases: Fuels from oil and gases: Characteristics, production methods and uses. Technology for combustion of fuels derived from oil and gas.

Solar Energy: Solar energy utilization, Thermal application and photovoltaic applications; wind, geothermal and hydro energy utilization.

Bio Energy: Biomass conversion for fuels; production methods based on thermochemical and bioconversion. Characteristics and uses; Design of digestors.

Nuclear Energy: Nuclear Energy; Nuclear fission fuels processing, Nuclear reactions and nuclear reactors, Nuclear Engineering.

TEXT BOOKS:
1. *G.N.Rai, "Non conventional energy sources," Khanna Publishers, New Delhi.*
2. *Samir Sarkar, "Fuels and Combustion", 2nd Edn, Orient Longman Publication, 1988.*

REFERENCE:
1. *D.Reay, "Industrial Energy Conservation".*
2. *Om Prakash Gupta, "Fundamentals of Nuclear power reactors", Khanna Publishers, New Delhi.*

CL412 PHARMACEUTICAL TECHNOLOGY

Introduction to Physical Pharmaceutics: Metrology and Calculations, Molecular structure, properties and States of Matter, Solutions, Phase Equilibra, Micromeritic and Powder Rheology, Surface and Interfacial Phenomena, Dispersion Systems,

Diffusion & Dissolution, Kinetics and drug stability, Viscosity & Rheology, and Polymer Science and Applications.

Formulations and Development, Packaging, Introduction to Industrial Processing, Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer),

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction), Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying),

Materials of Pharmaceutical Plant Construction, Good Manufacturing Practice (GMP's) Guidelines

TEXT BOOKS:
1. *Physical Pharmacy by Alfred Martin.*
2. *Remington's Pharmaceutical Sciences*

REFERENCES:
1. *Bentley's Pharmaceutics by E A Rawlins*
2. *Cooper and Gunn's Tutorial Pharmacy*

RESERVED ELECTIVES

CL01 ADVANCES IN HEAT TRANSFER

Transient Heat conduction, Extended surfaces and generalized expressions for fins or spines. Effectiveness of fins and spines, Temperature - time response of thermocouples and use of transient heat conduction charts.

Convection - Theory and practice. Energy equation for thermal boundary layer over a flat plate. Data analysis for forced and free convection problems, Analogy between heat, mass and momentum transfer.

Heat Transfer with phase change, Boiling and condensation, Boiling Regimes and types of condensation processes, effect of pressure, turbulence and other factors on boiling and condensation heat transfer.

Advances in heat exchanger design: and compact heat exchangers, Heat transfer in liquid metals. Heat transfer in packed and fluidised beds and Heat transfer process in nuclear reactors.

TEXT BOOKS:
1. *James G. Knudsen and Donald L. Katz, "Fluid Dynamics and Heat Transfer", McGraw Hill Book Company, 1958.*
2. *Antony F. Mills, "Heat Transfer", Richard D. Irwin, Inc., 1992, Homewood, IL60430 and Boston, MA021163.*

REFERENCES:
1. *W. M. Rohsenow and H. Y. Choi,"Heat Mass and Momentum Transfer", PrenticeHall, Inc., 1961.*
2. *W .H. Mc Adams," Heat Transmission", McGraw Hill, New York,195*

CL02   FLUIDIZATION ENGINEERING

Introduction and applications: Introduction to fluidised bed systems. Fundamentals of fluidisation. Industrial applications of fluidised beds - Physical operations. Synthesis reactions, cracking and reforming of hydrocarbons, Gasification, Carbonisation, Gas-solid reactions, calcining and clinkering.

Gross behaviour of Fluidised beds: Gross behaviour of fluidised beds. Minimum and terminal velocities in fluidised beds. Types of fluidisation. Design of distributors. Voidage in fluidised beds. TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.

Analysis of bubble and emulsion Phase: Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase. Emulsion phase: Experimental findings. Turn over rate of solids. Bubbling bed model for emulsion phase Interchange co-efficients.

Flow pattern of Gas and heat & mass transfer in Fluidised beds: Flow pattern of gas through fluidised beds. Experimental findings. The bubbling bed model for gas inter change Interpretation of Gas mixing data. Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer.   Heat and mass transfer rates from bubbling bed model.

Heat transfer between Fluidised beds and surfaces - Entrainment & Elutriation: Heat transfer between fluidised beds and surfaces: Experiment finding theories of bed heat transfer comparison of theories. Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation.

TEXT BOOK:
> 1.   *D. Kunii and O. Levenspiel, "Fluidisation Engineering", 2ⁿᵈ   Edn., Butterworth Heinemann, 1991.*

CL03   ENZYME ENGINEERING

Introduction to Biochemistry, Function and applications: Nature and function of enzyme. Coenzyme / Cofactor. Classification of enzymes. Assay methods and units. Examples of applications of enzymes in industry, analytical techniques medicine and Pharmaceuticals.

Kinetics and mechanism of enzyme catalysis: Enzyme catalysis and controlling factors. Kinetics of enzyme catalysed reactions in solution. Immobilized enzyme reaction kinetics. Effect of mass transfer resistance.

Enzyme production on large scale technology: Isolation and purification of enzymes, protein fractionation methods.

Immobilization technology and developments: Immobilization techniques for enzymes. Characteristics and uses for immobilized enzyme systems.

Industrial bioreactors utilizing isolated enzymes and Biosensors development and applications: Reactor design and analysis for immobilized enzyme reactors. Applications in biosensors. Some modern developments for enzymes in organic synthesis.

TEXT BOOKS:
1. *A. Wiseman, "Hand book of Enzyme Biotechnology", Ellis-Horwood, 1983.*
2. *E. K. Pye and L .B .Wingard, "Enzyme Engineering II", Plenum Press, 1974.*

REFERENCE:
1. *J.E. Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill Publishing Company New York, 1986.*

CL04 PROCESS DYNAMICS AND CONTROL- II

Frequency response: Review of control system design in Lapalace, time, and frequency domains - controller design using Lapalace, time, and frequency response- Analysis of some common loops.

Design of controllers for difficult & complex dynamics: Inverse response systems - controller design - design of inverse response compensator. Time delay systems - controller design - Smith predictor method. Dynamics and control of complex processes - Theoretical analysis of complex processes like jacketed kettle, absorber and heat exchanger.

Multivariable Systems: Feed forward control, cascade and ratio control - Introduction to state-space methods - Design of controllers using state-space methods - Introduction to multiloop systems - Relative gain analysis.

Controller Design and art of process control degrees of freedom analysis - Introduction to distillation system - Controller design for multiloop systems. Interaction and pairing of control loops - Decoupling and controller design. The art of process control.

Design of digital controllers: Supervisory control system - Digital computer control - sampling & filtering of continuous measurements. Development of discrete time models - Dynamic response of discrete time systems. Analysis of sampled data control system - Design of digital controllers

TEXT BOOK:
1. *D. R. Coughanowr, "Process System Analysis and Control", 2nd Edn., McGraw Hill, 1991.*
2. *Stephanopoulas, "Chemical Process Control", Prentice-Hall India, 1984.*

REFERENCES:
1 *D. E. Seborg, T.F. Edgar and D.A. Mellichamp, "Process Dynamics and Control", John Wiley and Sons, 1989.*
2 *B.A.Ogunnaike and W.H.Ray, "Process Dynamics, Modelling and Control", Oxford Press, 1994.*

CL05 FOOD TECHNOLOGY AND ENGINEERING

Food process engineering - Fundamentals: Fundamentals of food process engineering, application of quantitative methods of material and energy balances in food engineering practices.

Unit Operations in food industries: Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations in food processing.

Food canning technology: Fundamentals of food canning technology. Heat sterilization of canned food, containers - metal, glass and flexible packaging. Canning procedures for fruits, vegetables, meats, poultry, marine products.

Mechanical Operations in food processing: Conversion operations, Size reduction and screening of solids, mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction.

Food biotechnology: Food biotechnology, Dairy and cereal products, Beverages and food ingredients, High fructose corn syrup, Single cell protein.

TEXT BOOK:
1. *R. T. Toledo, "Fundamentals of Food Process Engineering", AVI Publishing Co., 1980.*
2. *R. Angold, G.Beech and J.Taggart, " Food Biotechnology", Cambridge University Press, 1989.*

REFERENCES:
1. *J. M. Jackson and B. M. Shinn, "Fundamentals of Food Canning Technology", AVI Publishing Co., 1978.*
2. *J. G. Bernnan, J. R. Butters, N. D. Cowell and A.E.V.Lilley, "Food Engineering Operations", 2nd Edn., Applied Science, 1976.*

CL06 NEW SEPERATION PROCESSES

Thermal Separation: Thermal Diffusion: Basic Rate Law, phenomenological Theories of Thermal Diffusion for gas and liquid mixtures, Equipments design and Applications. Zone Melting: Equilibrium diagrams, Controlling factors, Apparatus and Applications.

Sorption Techniques: Types and choice of adsorbents, Normal Adsorption techniques, chromatographic techniques, types and Retention theory mechanism Equipment and commercial processes, Recent advances and economics, Molecular Sieves.

Membrane Separation Processes: Types and choice of membranes, their merits, commercial, pilot plant and laboratory membrane permeators, Dialysis, Reverse Osmosis, Ultra filtration, Concentration Polarization in Membrane and Economics of Membrane operations.

Ionic Separation: Controlling factors, Applications, Equipments for Electrophoresis, Dielectrophoresis, Electro Dialysis and Ion - Exchange, Commercial processes.

Other Techniques: Adductive crystallization: Molecular addition compounds, Clathrate compounds and adducts, Equipments, Applications, Economics and Commercial processes. Foam Separation: Surface Adsorption, Nature of foams, Apparatus, Applications, and Controlling factors.

TEXT BOOKS:
1. *H. M. Schoen, "New Chemical Engineering Separation Techniques", Inter Science Publications, New York, 1972.*
2. *C. Loeb and R. E. Lacey, "Industrial Processing with Membranes", Wiley Inter Science, 1972.*
3. *B.Sivasankar, "Bioseparations – Principles and Techniques", Prentice Hall of India Pvt. Ltd, New Delhi, 2005.*

REFERENCES:
1. *R.H. Perry and D.W. Green, "Perry's Chemical Engineers Hand book", 6th Edn., McGraw Hill, New York, 1990.*
2. *J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol.II, 4th Edn., Butterworth - Heinemann, London, 1991*

CL07   FERTILIZER TECHNOLOGY

Introduction to Chemical Fertilizers: Chemical inorganic Fertilizers and Organic manures.   Types of fertilizers: Mixed, complex and Granulated, plant nutrients.

Processes for Raw Materials: Processes for manufacture of ammonia, nitric acid, phosphoric acid and sulphuric acid.

Nitrogenous and Potassium Fertilizers: Processes for urea and di-ammonium phosphate. Recovery of Potassium salts, processes for ammonium chloride and ammonium sulphate.

Complex Fertilizers: Processes for nitro - phosphates and complex NPK fertilizers liquid fertilizers

Phosphatic Fertilizers and Indian Fertilizer Industry: Single and Triple Superphosphate, biofertilizer. Fertilizer Industry in India.

TEXT BOOKS:
1. *Strelzoff, "Technology and Manufacture of Ammonia", 2nd Edn., Wiley,   1981.*
2. *L. J. Carpentire, "New Developments in Phosphate Fertilizer Technology", Elsevier, 1971.*

REFERENCES:
3. *"Handbook on Fertilizer Technology", Fertilizer Association of India, Near JNU, New Delhi 1992.*
4. *V. Slack, "Phosphoric Acid", 2nd Edn., Marcell Dekkar , 1968.*

CL08 COMPUTER AIDED PROCESS PLANT DESIGN

Introduction and Properties Evaluation: Spread sheeting, Hierarchy of process Design and the onion model - Flow sheeting - Typical units of CAD system - Process synthesis - Physical properties evaluation – Transport properties & thermodynamic properties of gases and binary mixtures

Basic model development for preliminary systems: Methods of calculating vapour liquid equilibrium data for ideal and non-ideal mixtures - Bubble point and Dew point - Flash and distillation calculations - Equipment design - Development of software programmes for the following systems - Piping system, single phase & two phase.

Cad model for fluid moving machinery & storage design: Separator system - Two phase and three phase - Storage system - Atmospheric, pressurised & cryogenic.

Cad model for heat transfer equipment design: Double pipe - Shell and tube heat exchanger - PHE - Air cooler - Heat integration of evaporators.

Cad model for mass transfer equipment and safety devices design: Binary mixtures - Psudo binary - Multistage distillation system - Heat integration of distillation columns - Absorber and strippers - Liquid-liquid extractors - Safety devices-pressure safety valve & flare system

TEXT BOOKS:
1. *B.C. Bhattacharyya and C.M. Narayanan, "Computer Aided Design of Chemical Process Equipment", Ist Edn., New   Central Book Agency (P) Ltd., New Delhi, 1992.*
2. *James M. Douglas "Conceptual Design of Chemical Processes", McGraw Hill, New York, 1981.*

REFERENCES:
1. *A. Hussein, "Chemical Process Simulation", Wiley Eastern, 1986.*
2. *A.K. Coker, "FORTRAN Programme for Chemical Process Design, Analysis and Simulation", Gulf Publishing Co., 1995.*

CL09 APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

.
Design of engineering experiments: Treatment of experimental data and interpretation of results. Experiments with a single factor: the analysis of variance. Factorial designs. Curve fitting methods, Interpolation and extrapolation.

Formulation of physical problems: Mathematical modelling of chemical engineering processes based on first principles.

Analytical solutions of equations: Separable forms, homogeneous equations, exact solutions, singular solutions.

Numerical solution of non-linear equations: Linearization of nonlinear equations. Numerical solution of ordinary differential equations: Initial value and boundary value problems. Stiff differential equations. Numerical solution of partial differential equations.

Optimization: Types of optimization problems, optimization of a function of single variable, unconstrained minimization, constrained minimization.

TEXT BOOKS/:

1. *Douglas C. Montgomery, "Design and Analysis of Experiments" John Wiley, 5th Edition, 2005*

2. *Harold S. Mickley, Thomas S. Sherwood, Charles E. Reed, "Applied Mathematics in Chemical Engineering" Tata McGraw Hill Publishing Company Limited, Second Edition, 1975.*

3. *Richard G. Rice & Duong D. D, "Applied Mathematics and Modelling for Chemical Engineers" John Wiley & Sons, 1995.*

REFERENCES:

1. *Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.*

2. *S. K. Gupta, "Numerical Techniques for Engineers", Wiley Eastern Ltd., New York, 1995.*

CL10 INTRODUCTION TO CFD

Fluid flow equations: Introduction – Laplace equation – Diffusion equation – Wave equation. Digital methods – Finite difference, Finite Volume Methods

Fluid flow problem formulation. Application of Finite Volume Method – Pressure correction Techniques.

Introduction to Multigrid Methods – Boundary conditions.

Introduction to CAD systems and Structured and unstructured mesh.

Simple Governing Equation for Turbulent and Multiphase flow.
Internal Flows: T-Junction – Manifold, Valves
External Flows: Flow over formed body

TEXT BOOKS

1. H.K. Versteeg & W.Malalasekera, "An Introduction to Compuional Fluid Dynamics - The finite volume approach" Longman, 1995

2. Segerlind.L.J., "Applied finite Element Analysis", 2nd edition, John Wiley, 1984

REFERENCES

1. Anderson, "Computational Fluid Dynamics" McGraw Hill Company, 1995

2. D.A. Caughey and M.M.Hafez, "Frontiers of Computational Fluid Dynamics 1994" John Wiley & Sons, 1994