

Chemical Engineering Curriculum

Second Year (Third and Fourth Semesters)

Sub. Code	Name of Subject	Sub Code	Name of Subject
MAT 201	Engineering Mathematics III	MAT 202	Engineering Mathematics IV
CHM 201	Chemistry II	CHM 202	Chemistry III
CHE 201	Introduction to Chemical Engineering	CHE 202	Mass Transfer I
CHE 203	Momentum Transfer	CHE 204	Chemical Engg. Thermodynamics II
CHE 205	Mechanical Operations	CHE 206	Heat Transfer Operations
CHE 207	Chemical Engg. Thermodynamics I	CHE 208	Object Oriented Computing
CHE 209	Chem.Engg. Drawing	CHE 210	MT and MO Lab
CHM 203	Chemistry II Lab	CHE 212	Object Oriented Computing Lab
		CHM 204	Chemistry III lab

Third Year (Fifth and Sixth Semesters)

Sub. Code	Name of Subject	Sub. Code	Name of Subject
CHM 301	Chemistry IV	CHE 302	Process Design and Drawing of Chemical Equipment
CHE 301	Simultaneous Heat and Mass Transfer	CHE 304	Pollution Control and safety
CHE 303	Energy Engineering	CHE 306	Chem. Reaction Engg. II
CHE 305	Chem. Reaction Engg. I	CHE 308	Transport Phenomena
CHE 307	Mass Transfer II	CHE 310	Process Dynamics and Control
CHE 309	Process Plant Materials	CHE 312 E	Elective I
CHE 311	Heat Transfer Lab	CHE 314	Mass Transfer Lab
CHM 303	Chemistry IV Lab	CHE316	Seminar I

Fourth Year (Seventh and Eighth Semesters)

Sub. Code	Name of Subject	Sub. Code	Name of Subject
HUM 401	Essentials of Management	CHE 402	Industrial Training
CHE 401	Process Engineering Economics	CHE 404	Seminar II
CHE 403	Process Modeling and Simulation	CHE 499	Project Work
CHE 405	Chemical Process Industries		
CHE 407 E	Elective II		
CHE 409 E	Elective III		
CHE 411	Process Modeling and Simulation Lab		
CHE 413	Reaction Engg. and Process Dynamics Lab		

MAT-201 Engineering Mathematics III [3 1 0 4]

Fourier Series – Periodic Functions – Euler's formulae – Fourier series of odd and even functions with arbitrary period – Half range expansions – Fourier sine and cosine transforms and Fourier Integrals

Partial differential equations - Basic concepts – Solutions of equations involving derivatives with respect to one variable only – Solutions by indicated transformations and separation of variables

Derivation of one dimensional wave equation (vibrating string) and its solution by using the method of separation of variables – Simple problems – D'Alembert's solution of wave equation – Derivation of one dimensional heat equation using Gauss divergence theorem and solution of one dimensional heat equation – Solution by separation of variables

Interpolation and applications – Finite differences – Newton-Gregory and Lagrange's interpolation formulae – Inverse interpolation – Numerical differentiation
Numerical Integration – Trapezoidal and Simpson's 1/3 and 3/8th rule

Bessel and Legendre's equations – Solution - Orthogonal properties – Data analysis – Curve fitting and regression analysis

Recommended Books:

Erwin Kreyszig : Advanced Engg. Mathematics, 5th edn, 1985, Wiley Eastern.
S.S.Sastry : Introductory Methods of Numerical Analysis, 2nd edn., 1990, Prentice Hall.
B.S.Grewal, Higher Engg.Mathematics, 34th edn, Khanna publications.
Gerald C.F. and Partrick D.Wheatley, Applied Numerical Analysis, 3rd edn., 1984, Addison Wesley
Francis Scheid : Numerical Analysis, 1968, Schaum Series, McGraw Hill.
M.K.Jain and S.R.K.Iyengar and R.K.Jain, Numerical Methods for Scientific and Engineering Computations, 1985 Wiley Eastern.
Conte S.D and Carl De Boor, Elementary Numerical Analysis, edn., 1972, McGraw Hill.

CHM 201 Chemistry II (4 0 0 4)

Strength of organic acids and bases: Monobasic and dibasic acids – Effect of structure – Hydrogen bond – Stearic effect. Primary, Secondary and Tertiary amines – Heterocyclic bases

Grignard Reagents: Preparation and synthetic applications

Active Methylene Group Compounds: Acetoacetic ester – Malonic ester and Diazomethane – Preparation and synthetic applications

Carbohydrates: Classification – Optical activity – Polarimeter – Determination of specific rotation

Monosaccharides: General properties – Mutual conversions (Aldose to ketose and vice versa, Aldo-pentose to Aldo-hexose and vice versa) – Structure of Glucose and Fructose

Disaccharides: Sucrose, Lactose and Maltose – Source – Properties and structure

Polysaccharides: Starch and Cellulose – Source, Properties and structure

Amino acids: Classification – Essential amino acids – Synthesis of amino acids – General physical and chemical properties of amino acids

Peptides and poly-peptides: Classification – Importance in the body system – Methods of synthesis

Proteins: Classification – General Properties – Color tests – Structure of proteins

Enzymes: Co-enzymes – Enzymatic reactions – Specificity of enzymatic reactions – Applications of enzymes

Aromatics: Structure of benzene and theories of aromaticity – Electrophilic substitution reactions of benzene – Effect of substituents in electrophilic substitution

Hetero cyclic compounds: Classification – Aromaticity and Basicity of heterocyclic compounds – Preparation and properties of Furan – Thiphene – Pyrrole – Pyridine – Indole – Quinone

Dyes: Theories of dyes – Valence bond and M.O approach to color

Bathochromic and Hypsochromic effects – Classification of dyes according to applications and structures – Azodyes – Methyl orange – Methyl red – Congo red – Triphenyl methane dyes – Melachite green, Rosaniline, Crystal violet – Indigotin – Anthraquinone dyes – Fluorescent brightening agents

Recommended Books:

I.L. Finar, Organic Chemistry, Vol I
M.K.Jain, Modern Organic Chemistry
Morrison and Boyd, Organic Chemistry

CHM 203 Chemistry II Lab (0 0 3 1)

1. Preparation of m-Dinitrobenzene from Nitrobenzene by nitration
2. Preparation of Acetanilide from aniline by acetylation

3. Preparation of p-Bromo acetanilide from acetanilide by bromination
4. Preparation of Benzoic acid from benzaldehyde by oxidation
5. Preparation of Salicylic acid from methyl salicylate by hydrolysis
6. Determination of percentage purity of Phenol/Aniline by Winkler's method
7. Determination of the amount of Acetone/EtOH by Iodoform method
8. Determination of percentage purity of Acetic acid by titration method
9. Determination of the amount of Acetamide by alkali hydrolysis method
10. Determination of (i) Acid value and (ii) Iodine value of the given sample of oil/fat
11. Determination of the saponification value of the given sample of oil/fat

CHE 201 Introduction to Chemical Engineering (3 1 0 4)

Chemical engineering as a Profession – Role of Chemical Engineer – Unit operations and unit processes – Review of units and dimensions – Physical and chemical properties of compounds and mixtures – Techniques of problem solving – Choice of basis – Chemical equations and stoichiometry – Properties of gases – Ideal and real gases – Phase equilibrium – Vapor pressure – Raoult's law – Calculation of bubble point and dew point – Humidity and Saturation – Humidity charts and their use – Concepts of steady and unsteady state processes and material balance equations – Material balances involving unit operations and unit processes – Material balance with recycle, bypass and purge – Energy and energy balances – Balances on non-reactive and reactive systems – Heat of reaction, heat of formation and heat of combustion – Standard state – Calculation of heat of reaction at temperature different from standard state – Adiabatic reaction temperature and theoretical flame temperature

Recommended Books:

1. A. Hougen, K.M. Watson and R.A. Ragatz, Chemical Process Principles, Part – I, John Wiley and Asia Publishing Co. 1970.
2. Bhat B.I. and S.M. Vora, Stoichiometry 2nd ed., Tata McGraw-Hill, NY 1976
3. David M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Eastern Economy ed., Prentice Hall of India (P) Ltd. 1989.
4. Richard Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, 2nd edition, John Wiley and Sons.
5. Anderson and Wenzel, Introduction to Chemical Engineering, McGraw Hill, New York, 1961
6. Chemical Engineering Education Development Centre, IIT Madras, Process Calculations for Chemical Engineers, 1975
7. Kirk and Bride, Chemical Engineering Fundamentals, McGraw-Hill, 1947
8. Williams and Johnson, Stoichiometry for Chemical Engineers, McGraw-Hill
9. Edward V. Thomson and William H. Coker, Introduction to Chemical Engineering, McGraw-Hill, 1977

CHE 203 Momentum Transfer (3 1 0 4)

Properties of fluids – Rheological classification - Fluid statics – Static pressure – Variation of pressure with elevation – Pressure measurement – Manometers – Introduction to fluid flow – Types of flow – Basic equations of fluid flow – Continuity equation – One dimensional Euler and Bernoulli equation and applications – Laminar flow – Steady incompressible viscous flow through circular pipes – Hagen-Poiseuille equation – Flow between parallel plates – Flow through annuli – Turbulence – Turbulent flow in smooth pipes – Velocity profiles – Darcy equation – Flow in noncircular conduits – Losses in pipe flow - Power law of fluids – Flow of liquids in thin layers – Fluid flow past immersed bodies – Boundary layer and friction drag – Drag coefficient – Motion of particles through fluids – Flow of fluids through bed of solids – Ergun equation – Principles of fluidization – Hydrodynamic characteristics – Pneumatic conveyance – Agitation and mixing of liquids – Dimensional analysis – Flow of compressible fluids – Basic equations of one dimensional flow – Reversible adiabatic flow – Effect of area variation – Flow in convergent and divergent nozzles – Flow measurement – Venturi, Orifice and Pitot-tube – Variable area meter – Flow measurement in open channels – Introduction to unsteady flow – Time required for emptying tank – Fluid transportation machinery – Pumps and classification of pumps – Pump characteristics

Recommended Books:

- McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY, 1993
 Coulson and Richardson, Chemical Engineering – Vol I, Pergamon and ELBS, 3rd Ed., 1977
 Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980
 Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY

CHE 205 Mechanical Operations**(3 1 0 4)**

Particle size analysis – Representation of size analysis – Shape factor – Subsieve methods of analysis – Surface area determination – Industrial screening – Screening equipment – Efficiency of screen and performance of screen – Storage and conveyance of solids – Types of conveyers – Selection of conveyer – Size reduction – Energy relationships – Size reduction equipment – Crushers, grinders, ultrafine grinders and cutting machines – Open circuit and closed circuit grinding – Classifiers – Types of classifiers – Gravity settling – Centrifugal separation – Principles – Design of centrifuge, hydrocyclone – Electrostatic precipitator – Filtration – Filtration equipment – Selection, design and operation of filters – Filter aids – Thickening – Batch and continuous thickener – Design of continuous thickener – Magnetic separation – Electric separation – Froth flotation – Separation based on motion of particles through fluids – Jigging – Dense media separation – Mixing of powders and plastic masses

Recommended Books:

McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY, 1993
Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980
Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY
Coulson and Richardson, Chemical Engineering –Vol II, Pargamon and ELBS, 3rd Ed., 1970

CHE 207 - Chemical Engineering Thermodynamics - I (3 1 0 4)

Scope and limitations of classical thermodynamics, Fundamental concepts and definitions, Temperature and zeroth law of thermodynamics, P-V-T- relationships and application, First law of thermodynamics – Application of first law to different processes in closed systems – Limitations of first law, Second law of thermodynamics – Carnot cycle and concept of entropy- Heat engines – Entropy calculations, Third law of thermodynamics, Relations among thermodynamic properties – Thermodynamic functions in terms of measurable properties – Thermodynamic diagrams – Some applications of first law – Flow processes, power and refrigeration cycles, liquefaction processes.

Recommended Books:

1. K.V. Narayanan -A Textbook of Chemical Engineering Thermodynamics, Prentice – Hall of India Pvt. Ltd., 2001, ISBN: 81-203-1732-7
2. J. M. Smith, H.C. Van Ness, Michael M. Abbott, Smith J. M. -Introduction to Chemical Engineering Thermodynamics, 7th Edn. - McGraw- Hill, 2004, ISBN: 0073104450
3. T. E. Daubert - Chemical Engineering Thermodynamics, McGraw-Hill, 1985, ISBN: 007015413

CHE 209 Chemical Engineering Drawing**(0 0 3 1)**

Assembly drawing of some of the following:

Valves: Globe valve, Ball valve, Non-rising stem gate valve, Three-way stop valve, Needle valve, Gate valve, Diaphragm valve

Pumps: Centrifugal, Rotary, Vane and Gear pumps

Steam traps: Bucket type, Inverted bucket type and Thermodynamic steam traps

Joints: Cotter and Pin joint, Cotter joint with sleeve, Socket and Spigot cotter joint, Strap joint with Gib and Cotter Pipe joints, Flanged pipe joint, Hydraulic pipe joint, Gland and Stuffing box, Expansion joint, Union joint

Recommended Books:

N.D.Bhat, Machine Drawing
Gopal Krishna, Machine Drawing

MAT 202 Engineering Mathematics IV [3 0 0 3]

Solution of system of linear equations, Gauss Jacobi, Gauss- Seidel and Relaxation methods. Solution of tridiagonal systems

Eigen values and Eigen vectors of matrices and elementary properties computation of largest Eigen value by the power method

Numerical solution of initial value problems in ordinary differential equations by Taylor series method, Euler's method and Runge-Kutta methods of second and fourth order, predictor corrector methods, Adams- Bashforth, Adams- Moulton and Milne methods

Introduction to probability, finite sample spaces, conditional probability and independence, Baye's theorem, one-dimensional random variable, mean, variance, Chebyshev 's inequality

Two and higher dimensional random variables, covariance, correlation coefficient, regression, least squares principles of curve fitting

Distributions: Binomial, Poisson, uniform, normal, gamma Chi-square and exponential, simple problems

Finite element method, Introduction, Simple applications

Recommended Books:

1. P.L. Meyer, Introduction to Probability and Statistical Applications, 2nd edn. American Publishing Co., 1979
2. Introductory Methods of Numerical Analysis, 2nd edn., Prentice Hall 1990 by S.S.Sastry.
3. Hogg and Craig: Introduction of Mathematical Statistics, 4th edn. 1975 McMillan
4. Gerald C.F and Patrick Wheatley: Applied Numerical Analysis, 3rd edn., 1984., Addison Wesley
5. M.K.Jain, S.R.K. Iyengar and R.K. Jain: Numerical Methods for Scientific and Engg. Computations. edn.. 1985- Wiley Eastern

CHM 202 Chemistry II (3 0 0 3)

Solutions: Introduction – Expressing concentrations of solutions – Solutions of liquids in liquids – Ideal and non-ideal solutions – Raoult's law – Thermodynamics of ideal solutions – Free energy change of mixing of an ideal solution – Volume change and enthalpy change of mixing for an ideal solution – Entropy change of mixing for an ideal solution – Vapor pressure composition and boiling point composition curves of completely miscible liquids – Fractional distillation of binary liquid solutions with related examples – Solutions of gases in liquids – Factors influencing solubility of a gas – Henry's and Raoult's law. Colligative properties: Introduction – Lowering of vapor pressure by a non volatile solute – Determination of molar masses from vapor pressure lowering – Experimental measurement of vapor pressure lowering – Ostwald and Walkers method – Osmosis – Osmotic pressure – Measurement of osmotic pressure – Rerkely and Hartley method – Laws of osmotic pressure – Vat Hoff's theory of dilute solutions – Isotonic solutions – Relationship between osmotic pressure and vapor pressure – Concept of reverse osmosis – Boiling point elevation – Thermodynamic treatment – Molal elevation constant – Determination of molar masses from boiling point elevation – Determination of boiling point elevation – Landsberger's method – Depression of freezing point – Thermodynamic treatment – Molal depression constant – Determination of molar masses from freezing point depression – Determination of freezing point depression – Rast method – Vant Hoff's factor – Degree of association – Problems

Phase equilibria: Gibb's phase rule – Definition – Explanation and examples of terms involved in phase equilibria – Thermodynamic derivation of phase rule – Single component system – Water system – Discussion of vapor pressure curve – Sublimation curve – Fusion curve from Clausius-Claperon equation – Salient features of the water system – The triple point – Sulfur system – Salient features of the system – Two-component system – Simple eutectic systems (lead-silver system) – Formation of compounds with congruent melting point (Zn-Mg system) – Formation of compounds with incongruent melting point (Na-K system). Colloids: Introduction – Types of colloidal dispersions – Preparation of sols-dispersion methods and condensation methods – Purification of sols-dialysis – Electro-dialysis and ultra-filtration – General properties of sols – Optical property of sols – Tyndal effect – Electro osmosis – Determination of size and mass of colloidal particles – Kinetic properties of sols-diffusion – Brownian movement and sedimentation – Stability of sols-coagulation and protection of sols – Importance and application of colloids. Emulsions – Types – Function of emulsifiers and application. Gels – Preparation – Properties and applications. Adsorption: Adsorption of gases by solids – Freundlich's adsorption isotherm – Physisorption and chemisorption – Langmuir's theory of adsorption – BET theory of multilayer adsorption – Types of adsorption isotherm – Factors influencing adsorption – Adsorption from solution – Gibb's adsorption isotherm for adsorption from solution. Electroanalytical methods of analysis: Conductometric titrations – Basic principles of conductometric titrations – Applications – Strong acids with bases – Weak acids with strong bases – Weak acids with weak bases – Strong acid with weak bases – Mixture of strong and weak acids with strong base – Precipitation titrations. Potentiometry: Electrode potential – Direct potentiometry – Indicator electrode – Classification – Reference electrodes – Glass electrode – Asymmetric potential – Acid error and alkaline error – Ions selective electrode – Potentiometric titrations – Principle – Location of end points – Neutralisation titration – Oxidation reduction titration – Precipitation titration – Complexation titrations – Potentiometric titration in non aqueous solvents. Polarography: Basic principles – Residual current - Migration current – Diffusion current - Polarographic maximum – Half-wave potential – Equipment for polarography – Dropping mercury electrode – Polarographic cell – Maximum suppressors – Evaluation of quantitative results – Wave-height concentration plot – Method of standard addition – Measurement of wave heights – Polarograms – Applications – Determination of cadmium – Amperometric titrations

Recommended Books:

B.R.Puri and L.R. Sharma, Principles of Physical Chemistry
Alkins, Physical Chemistry
Skoog, West and Holler, Fundamentals of Analytical Chemistry
Vogel's Textbook of Quantitative Chemical Analysis, 5th Ed.

CHE 202 Mass Transfer I**(3 1 0 4)**

Introduction to mass transfer operations – Classification with examples gas/gas, gas/liquid, gas/solid, liquid/liquid, liquid/solid solid/solid operations, Steady and unsteady state operations – Stage wise and continuous contact operations

Diffusion mass transfer – Molecular diffusion in fluids – General equations for flux - Steady state diffusion in gases and multicomponent mixtures – Molecular diffusion in liquids – Application of molecular diffusion – Concepts related to momentum and heat transfer – Diffusion in Solids - Theoretical aspects – Unsteady state diffusion in slab –

Diffusion through polymers, crystalline and porous solids – Eddy diffusion – Concept of mass transfer coefficient – Relations between different mass transfer coefficients – Mass transfer coefficients in Laminar and Turbulent flow Theories of mass transfer – Film, surface renewal, penetration combination etc., – Analogies – Interphase mass transfer – Concept of equilibrium – Two resistance concept – Local and overall mass transfer coefficients – Concept of equilibrium curve and Operating line – Material balance approach for cocurrent and countercurrent processes Absorption and desorption – Equipment for gas-liquid operations – Principles of operation and critical parameters – Two component and multicomponent systems – Ideal and non-ideal solutions – Choice of solvent – Calculations and design of absorption equipment and continuous contact for stage by both coefficient and transfer unit methods – Concept of reflux – Reboiled absorbers – Absorption with chemical reaction Adsorption and adsorption isotherms – Batch and continuous adsorption – Adsorption equipment – Design – Break through curves – Transient bed analysis – Process Design – Criteria for choosing adsorbents – Application in process industries

Recommended Books:

R.E.Treybal, Mass Transfer Operations, McGraw-Hill, 1968
McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY,1993
Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980
Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY
Coulson and Richrdson, Chemical Engineering –Vol II, Pargamon and ELBS, 3rd Ed., 1970
Blackables, D.N. and Nedderman, R.M., A Handbook of Unit Operations
Bennet and Myers, Momentum, Heat and Mass Transfer

CHE 204 Chemical Engineering Thermodynamics - II (3 1 0 4)

Thermodynamic properties of pure fluids – Fugacity – Fugacity coefficient – Activity Properties of solutions – Ideal and non-ideal gas mixtures and liquid solutions – Partial molar properties- Chemical potential – Fugacity in solutions – Henry’s law – Activity coefficients – Gibbs-Duhem equations and its applications and limitations – Property change of mixing – Excess properties – Phase equilibrium – Vapour-liquid equilibrium- Equilibrium diagrams and their construction – Liquid-liquid equilibrium – Chemical reaction equilibrium – Criterion for equilibrium – Equilibrium constants – Gas phase reaction – Factors affecting equilibrium conversion – Multiple reaction equilibrium – Liquid phase reaction – Heterogeneous reaction equilibrium.

Recommended Books:

1. K.V. Narayanan -A Textbook of Chemical Engineering Thermodynamics , Prentice – Hall of India Pvt. Ltd., 2001, ISBN: 81-203-1732-7
2. J. M. Smith, H.C. Van Ness, Michael M. Abbott, Smith J. M., Introduction to Chemical Engineering Thermodynamics, 7th Edn. - McGraw- Hill, 2004, ISBN: 0073104450
3. T. E. Daubert - Chemical Engineering Thermodynamics, McGraw-Hill, 1985, ISBN: 0070154139

CHE 206 Heat Transfer Operations (3 1 0 4)

Modes of heat transfer – Steady state conduction – Development of equations for conduction through plane and curved surfaces – Compound resistances – Critical thickness of insulation – Heat transfer with internal heat generation – Introduction to transient heat conduction Convection – Forced and Natural convection – Enthalpy balances in an exchanger – Cocurrent and countercurrent flow – Overall heat transfer Coefficient – Individual heat transfer coefficients – Dirt factors – LMTD – Determination of individual heat transfer coefficients – Dimensional analysis – Analogies between transfer of heat and momentum – Principles of design of heat exchangers – Double pipe and 1-2 exchanger – Effectiveness of heat exchanger – Extended surfaces – Types of fins – Heat transfer in rectangular fins – Fin effectiveness – Fin efficiency Heat transfer to fluids with phase change – Heat transfer to boiling liquids – Types of condensation – Nusselt equation – Introduction to radiation heat transfer – Kirchhoff’s law – View factors – Net radiation between two large parallel planes – Radiation with shields – Temperature measurement of gases and radiation errors

Recommended Books:

McAdams, Heat Transmission, 3rd Ed., McGraw-Hill, 1954
McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY,1993
Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980
Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY
Coulson and Richrdson, Chemical Engineering –Vol I, Pargamon and ELBS, 3rd Ed., 1970
Donald Q. Kern, Process Heat Transfer, McGraw-Hill, 1950
Krieth, Fundamentals of Heat Transfer, Harper and Law, 4th Ed., 1986

CHE 208 Object Oriented Computing (3 1 0 4)

Object oriented programming: Basic concept – Benefits of OOP and C++
 Classes and objects: Specifying class – Defining member function and data members – Inline function – Nesting and private member function – Static data and member function – Array of objects – Friendly function
 Constructors and Destructors: Introduction – Parameterized, multiple and copy constructor – Constructor with default argument – Dynamic constructor – Destructors.
 Operator overloading and its rules
 Inheritance – Introduction and types – Polymorphism
 Numerical Techniques – Approximation and errors.
 Interpolation: Lagrange's and Newton's formula
 Curve fitting: Linear and polynomial – Exponential – Logarithmic
 Solution of Algebraic and transcendental equation: Newton – Raphson – Secant – Regula falsi – Bisection methods.
 Solution of system of linear algebraic equation: Gauss elimination – Gauss-Jordan – Gauss-Siedal – Jacobi's iterative methods
 Numerical Integation: Trapezoidal – Simpson's rule
 Solution of ordinary differential equations: Euler's – Modified Euler's method – Runge -Kutta fourth order method.
 Higher order differential equations: Runge – Kutta fourth order method.
 Solving of chemical engineering problems using the above techniques.

Recommended Books:

1. Object Oriented Programming with C++ by E.Balagurusamy, Tata McGraw Hill Publisher, 1995
 2. Numerical Methods by E. Balagurusamy, Tata McGraw Hill Publisher, 1995
 3. Numerical Methods in Engineering and Science by B.S.Grewal, Khanna Publishers, 1997
 4. Numerical Techniques in C by Kameshwar E.V, BPB publication.
 5. Numerical Methods for Scientific and Engineering Computation by Jain M.K , Iyengar SRK, Jain R.K, Wiley Eastern, 1989.
- E. Balaguruswamy, Object Oriented Programming with C++, Tata McGraw-Hill Publishers, 1995
 C++ - Programming Language, Njarne Stronstrup, 3rd ed., Addison Wesley, 1997
 C++ - The Complete Reference, Herbert Schildt, 2nd Ed., Tata McGraw-Hill, 1998
 H.M.Deitel and P.J.Deitel, C++ - How to Program, 3rd Ed., Pearson Education, Asia

CHE 210 Momentum Transfer and Mechanical Operations Lab (0 0 3 1)

Experiments based on Momentum Transfer and Mechanical operations coursework

CHE 212 Object Oriented Computing Lab (0 0 3 1)

Ten to twelve experiments based on chemical engineering problems using C++ (MATLAB software wherever possible)

CHM 204 Chemistry III Lab (0 0 3 1)

1. Titration of a given mixture of weak and strong acid against a strong base – conductometric method
2. Precipitation titration between lithium sulphate and barium chloride by conductometric method
3. Redox titration of Mohr's salt against $K_2Cr_2O_7$ – Potentiometric method
4. Colorimetric determination of Copper/iron
5. Percentage composition of binary mixture using viscometer
6. Bimolecular reaction between $K_2S_2O_8$ and KI
7. Determination of velocity constant for the saponification of ethyl acetate
8. Determination of surface tension of liquid using stalagmometer
9. Kinetics of inversion of sucrose using polarimeter
10. Determination of percentage composition of binary mixture using Abbe's refractometer

CHE 301 Analytical Methods and Instrumentation [4 0 0 4]

1. Spectroscopic methods of Analysis:

Introduction to spectroscopy

Microwave spectroscopy: Rotation of molecules, rotational spectra-rigid diatomic

Molecules, nonrigid diatomic molecules, Techniques and Instrumentation, applications

Infrared spectroscopy: Vibrating diatomic molecule – simple harmonic oscillator, enharmonic oscillator. Diatomic

vibrating rotator. Vibrations of polyatomic molecules. Techniques and Instrumentation, double beam IR

Spectrophotometer, FTIR, and applications

Raman spectroscopy: Quantum theory, molecular polarizability, characteristics of Raman lines, Techniques and

Instrumentation, applications

Ultraviolet spectroscopy: Types of transitions in organic molecules, instrumentation and applications

Visible spectroscopy: Beer – Lambert's law and its deviations, instrumentation, double beam Spectrophotometer, applications

X-ray spectroscopy: Continuous and line spectra, production of x-rays, principle instrumentation and applications of x-ray absorption method, x-ray emission method, x-ray fluorescence method, x-ray diffraction method

NMR spectroscopy: Classical and Quantum theories. Chemical shift, Spin – spin splitting instrumentation, applications of proton NMR

2. Thermal methods of Analysis:

Thermogravimetry (TG): Introduction, information from TG curve, factors affecting TG curves, instrumentation, applications

Differential Thermal Analysis (DTA): introduction, factors affecting DTA curve, instrumentation, applications

Derivative Thermogravimetry (DTG)

Differential Scanning Calorimetry (DSC)

Solvent extraction: Principle, efficiency of extraction, extraction techniques, applications

3. Chromatography:

General description, classification, migration rates of solutes, Band broadening and column efficiency, column resolution, applications

Paper chromatography: principle, types, applications

Thin layer chromatography: scope, experimental techniques, advantages, applications

Liquid chromatography: HPLC, scope, column efficiency, instrumentation, applications, column chromatography, adsorption chromatography, Ion exchange chromatography, size exclusion chromatography (or Gel chromatography)

Gas chromatography: principle of gas-liquid chromatography, instrumentation, applications, gas-solid chromatography. Electro chromatography

Recommended Books:

1. Vogel's Text Book of Quantitative Analysis, 5th edition, ELBS Longman
2. Instrumental Methods of Chemical Analysis, G. Chatwal and S.Anand, Himalaya Publishing House
3. Fundamentals of Analytical Chemistry, Skoog, West and Holler
4. Principles of Instrumental Analysis, Skoog, Holler and Nieman
5. Fundamentals of Molecular Spectroscopy, C.N. Banewell and McCash, TMH edition 3rd edn, Tata Mc-Graw Hill Publishers
6. Instrumental Methods of Chemical Analysis, Ewing

CHE 301 Simultaneous Heat and Mass Transfer

(3 1 0 4)

Evaporation – Evaporation equipment – Energy balances – Boiling Point Rise (BPR) – Calculations for single effect and multi-effect systems – Performance of Evaporators – Design calculations

Theories of crystallization – Mier's theory – Nucleation and crystal growth – Delta L law – Material balances – Industrial crystallisers – Swenson-Walker crystallizer – Calculations

Humidification and dehumidification and water cooling operations – Psychrometric chart – Development and applications – Equipment – Design calculations – Cooling towers – design of cooling towers

Drying – Theory and mechanism of drying operation – Rate curves – Batch and continuous drying – Industrial dryers – Design criteria –Design of rotary dryers – Special methods of drying such as freeze drying and Infra-red drying

Recommended Books:

McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY,1993

Coulson and Richardson, Chemical Engineering –Vol I, Pargamon and ELBS, 3rd Ed., 1977

R.E.Treybal, Mass Transfer Operations, McGraw-Hill, 1968

Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980

Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY

CHE 303 Energy Engineering (3 1 0 4)

Energy scenario in India – Renewable sources of energy – Availability – Generation and utilization of solar, wind, geothermal and tidal energies

Solid fuels: Testing methods – Proximate and ultimate analysis – Calorific value – Weathering and grindability index of coal – Theories of origin and stages of formation – Coal washing techniques – Carbonisation – Coke ovens – Gasification – Briquetted and pulverized fuels

Liquid fuels: Testing methods – Aniline point – Viscosity index – ASTM distillation – Flash and fire point – Carbon residue – Moisture – Smoke point and char value – Calorific value – Origin, composition and classification of petroleum – Distillation of crude and purification of petroleum products

Gaseous fuels: Fuel gas and flue gas analysis – Calorific value – Production and utilization of Natural gas, producer gas, water gas and carbonated water gas

Combustion: Terminology – Calculation of air requirement – Grates, burners and stokers

Furnaces: Classification – Construction – Thermal efficiency – Fuel economy – Furnace aerodynamics – Types of furnaces used in process industries – Chimneys and draughts

Nuclear energy: Nuclear fuels – Nuclear reactors – Classification – Various types of nuclear reactors and principles of working

Energy audit: Energy conservation and auditing – Guidelines and procedures for energy audit – Domestic, industrial and transportation sectors

Recommended Books:

Sharma, S.P. and Chander Mohan, Fuels and Combustion, Tata McGraw-Hill, 1982

Saha, A.K., Combustion Engineering and Fuel technology, Oxford Press

Gilchrist, J.D., Fuels, Furnaces and Refractories, Pergamon Press, 1977

Manson L. Smith and Keri W. Stinson, Fuels and Combustion, McGraw-Hill, 1952

CHE 305 Chemical Reaction Engineering I

(3 1 0 4)

Kinetics of homogeneous chemical reactions – Classification of chemical reactions – Rate expressions – Analysis of simple rate equations – Interpretation of kinetic data for single and complex reaction under constant volume and variable volume conditions – Differential, integral, half life and total pressure method – Temperature dependence of rate – Arrhenius – Collision and activated complex theories.

Non elementary reaction kinetics – Fundamentals – Active intermediates – Pseudo, steady state hypothesis – Searching for a mechanism – Enzymatic reaction fundamentals – Michaelis and Menten Equation – Batch reactor calculations – Inhibition of enzyme reactions – Multiple enzyme and substrate systems.

Isothermal reactor design – Design structure for isothermal reactors such as batch, semi-batch, CSTRs and PFRs for single and complex reactions – Problems on optimization – Startup of CSTRs

Multiple reactor systems – Reactors in series or/and parallel combinations – CSTRs series – Performance analysis – Recycle reactors – Batch and continuous – Derivation of rate equations and applications.

Multiple reaction system – Series and parallel reactions in flow reactors – Product distribution – Yield and selectivity – Maximizing the desired product in parallel reactions – Different reactors and schemes for minimizing the unwanted product – Maximizing the desired product in series reactions – Algorithms for solution to complex reactions

Recommended Books:

Octave Levenspiel, Chemical Reaction Engineering, 3rd Ed., John Wiley and Sons, 2003

H. Scott Foyler, Elements of Chemical Reaction Engineering, 3rd Ed., Prentice Hall, India, 2002

J.M. Smith, Chemical Engineering Kinetics, 4th Ed., McGraw-Hill, International Student Edition, 1995

CHE 307 Mass Transfer II

(3 1 0 4)

Concept of vapor-liquid equilibrium – P-x-y, T-x-y, Relative volatility – Raoult's law – Deviations from ideality – Azeotropes and types – Enthalpy concentration diagrams – Relation between H-x-y and x-y diagrams – Multi component systems – Principles of distillation – Single stage operations – Flash vaporisation – Partial condensation – Simple distillation – Differential condensation – Multicomponent mixtures – steam distillation

Continuous rectification – Binary systems – Fractionation – Equipment – Ponchan-Savarit method – Feed tray location – Minimum reflux ratio – Optimum reflux ratio – Total reflux

McCabe – Thiele method – Calculation of ideal stages for situations such as total condenser, partial condenser – Concept of q-line – Location of feed tray – Minimum reflux ratio – Calculations for total reflux – Rectification of Azeotropic mixtures – High purity products – Kremser's equation – Packed bed distillation – Introduction to Transfer unit concept – Introduction to multicomponent distillation

Liquid extraction – Applications – Equilibria – Ternary systems – triangular and other coordinates – Choice of solvent – Single stage and multistage cross current and counter current extraction with reflux – Extraction equipment – Design criteria Leaching – Applications of leaching operation – Leaching equipment – Equilibria – Batch and multi stage cross current and counter current leaching operations

Recommended Books:

R.E. Treybal, Mass Transfer Operations, McGraw-Hill, 1968

McCabe and Smith, Unit Operations in Chemical Engineering, 5th Ed., McGraw-Hill, NY, 1993

Foust et al, Principles of Unit Operations, John Wiley and Sons, NY, 2nd Ed., 1980

Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY

Coulson and Richardson, Chemical Engineering – Vol II, Pergamon and ELBS, 3rd Ed., 1970

Norman, Absorption, Distillation and Cooling Towers

Robinson and Gilliland, Distillation

CHE 309 Process Plant Materials

(4 0 0 4)

Selection of process materials – Economic considerations – Fabrication, mechanical properties and strength of materials – Effect of temperature on mechanical properties – Testing and inspection of materials

Properties and uses of ferrous metals – Cast iron – plain carbon steels – Classification of steel – alloy carbon steels – alloy steels – Thermal and electrical insulating materials
Non-ferrous metals and alloys – Generalised properties and field of application of nonmetals – Wood, Stoneware – Glass – Fused silica – Carbon – Natural and synthetic rubber
Plastics as material of construction – PVC, Polyfibres, PTFE, Glass, FRP – Protective coating and cladding – Glass, rubber and metal lining of process vessels – Ceramic protective materials
Corrosion resistance: Uniform, galvanic, pitting, crevice, intergranular, erosion – Selective leaching and stress corrosion – High temperature oxidation – Hydrogen embrittlement – Corrosion charts – Design for corrosion resistance

Recommended Books:

Gackembach, R.E., Materials Selection for Process Plants, Rein Hold Publishing Company, New York
Fontana, M.G., Corrosion Engineering, McGraw-Hill, 1986
William F.Smith, Principles of Materials Science and Engineering, McGraw-Hill
Moffat et al., Structural Properties of Materials, Vol.4, Wiley, 1964
J.M.Coulson and J.F. Richardson- Chemical Engineering, Vol. 6, 2nd edn. Pargamon Press, 1993.

CHE 311 Heat Transfer Operations Lab (0 0 3 1)

Experiments based on Heat Transfer operations

CHM 303 Chemistry IV lab (0 0 3 1)

Experiments:

1. Gravimetric estimation of silica and Fe in Haemetite ore
2. Gravimetric estimation of Cu in brass
3. Gravimetric estimation of Ni in stainless steel
4. Gravimetric estimation of Zn in ZnO pigment
5. Gravimetric estimation of Pb in white lead pigment
6. Gravimetric estimation of total lead in red lead pigment
7. Gravimetric estimation of BaSO₄ in lithopone
8. Gravimetric estimation of Phosphorous in phosphate fertilizer
9. Gravimetric estimation of Silica and R₂O₃ in cement
10. Qualitative/quantitative analysis using UV- visible spectrophotometer
11. Qualitative/quantitative analysis using IR spectrophotometer
12. Separation and estimation of anions/cations by chromatographic method

Recommended Books:

Vogel Text book of Quantitative Chemical Analysis 5th Ed.

CHE 302 Process Equipment Design and Drawing (4 0 3 5)

Introduction to process and mechanical design – Design preliminaries.
Parts of chemical process equipments - Cylindrical shell, covers, flanges, supports – Welded and bolted-flange connections between parts – Process equipment internals – Material specifications - Equipment fabrication and testing.

Design of cylindrical and spherical vessels under internal pressure – Design of covers – Compensation for openings in process equipment – Design of non-standard flanges – Design of process vessels under external pressure – Design of tall vessels – Design of supports for process vessels.

Hydrodynamic and mass transfer aspects.

Detailed process, mechanical design and drawing of the following chemical process equipments are to be carried out:

Heat exchangers – Double Pipe, Shell and Tube Heat Exchangers

Evaporators- Standard Vertical Tube Evaporators

Reactors- Tank Reactor, Tubular Reactor

Tall towers – Distillation columns – Absorption towers – Packed, Sieve-Tray and Bubble-Cap columns.

Recommended Books:

1. Bhattacharyya B.C.– Introduction to Chemical Equipment Design- Mechanical Aspects, CBS Publishers & Distributors, New Delhi, 1998
2. Unfired Pressure Vessel code - BIS 2825.
3. Shell and Tube Heat Exchanger Code- BIS 4503
4. Donald Q. Kern – Process Heat Transfer, McGraw-Hill Co., 1950
5. Robert E.Treybal – Mass Transfer Operations, McGraw – Hill Co., 1981
6. J.M.Coulson, J.F. Richardson- Chemical Engineering- Vol. 6- Design, 2nd edn. Pargamon Press, 1993.

7. Robert H. Perry and Don Green – Perry’s Chemical Engineer’s Hand Book, 7th Ed., McGraw-Hill Co., 1997
8. Brownell L.E. and E.H. Young – Process Equipment Design, John Wiley & Sons,
9. Smith D.D. – Design of Equilibrium Stage Processes, McGraw – Hill, 1963
10. Thomas K. Sherwood, Robert L. Pigford, Charles R. Wilke- Mass Transfer, McGraw-Hill, 1975

CHE 304 Pollution Control and Safety

(4 0 0 4)

Man and environment – Nutrient and hydrologic cycles – Types of pollution – Legislation to environmental pollution – Aspects of pollution control
 Evaluation and characterization of wastewater – Treatment methods – Advanced wastewater treatment – Sludge treatment and disposal – Solid waste management
 Noise pollution and control
 Ambient and stack gas sampling – analysis of air pollutants – Principles of air pollution – Plume behavior – Meteorological factors affecting air pollution – Equipment for control and abatement of air pollution
 Pollution control of effluent in chemical industries such as Fertiliser, Petroleum refinery, Pulp and paper and Tannery industries

Scientific and engineering aspects of safety in industry – Considerations – Hazards of industrial chemicals – Fire and explosion – Prevention and control – Ventilation and lighting – Personal protective devices – Legal aspects and labor relations in safety – Cost considerations

Recommended Books:

1. S.P. Mahajan, Pollution Control in Process Industries, Tata McGraw Hill, 1990
2. C.S. Rao Environmental Pollution Control Engineering, Wiley Eastern, 1992.
3. V. Cavaseno – Industrial Air Pollution Engineering., McGraw Hills, 1980

CHE 306 Chemical Reaction Engineering II

(3 1 0 4)

Isothermal non-ideal flow reactors – RTD in chemical reactors – Different age distribution functions and relation amongst them – Conversion in non ideal flow reactors – Single and multi-parameter models for non ideal flow – Concepts of mixing –Micro and macro mixing – Intensity of segregation and coalescence parameter
 Non isothermal homogeneous reactions – Temperature effects – Principles of stability – Design procedures for adiabatic and non-isothermal conditions for batch and flow reactors – Optimum temperature progression – Multiple reactions and effect of temperature on product distribution
 Heterogeneous reactions – Rate equation for heterogeneous systems – Contacting patterns for two phase systems – Fluid particle non-catalytic reactions – Different models – Derivation of rate equations – Application to design – Fluid-fluid non- catalytic reactions – Overall expression – Kinetic regimes – Rate equations - Application to design of towers for slow reactions - Mixer settlers – Slurry reaction kinetics – Reactive distillation and extractive reactions.
 Design and analysis of biological reactors – Cell growth – Batch bioreactor - Chemostat system – Oxygen limited fermentation – Scaleup.

Heterogeneous catalysis – Types and classification of catalysts – Desirable characteristics and the method of determination –Selection and preparation of catalysts for industrial reactions – Kinetics of heterogeneous solid catalysed gas reactions - Mechanisms – Langmuir -Hinshelwood, Riedel, Redox, Houghen and Watson approach – Derivation of mathematical models based on different mechanism - Rate controlling step – Analysis of external transport processes – Intrapellet mass transfer -Heat transfer – Effectiveness factors – Introduction to slurry and trickle bed reactors – Reactor design – One dimensional and two-dimensional models.

Recommended Books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd edition, John Wiley and Sons, 2001.
2. Smith, J.M., Chemical Engineering Kinetics, 4th edition, McGraw-Hill International Student Edition,1995
3. Fogler,S., Elements of Chemical Reaction Engineering ,3rd edition, Prentice Hall of India, 2002.

CHE 308 Transport Phenomena

(3 1 0 4)

Analogy for momentum, heat and mass transport – Shell balance approach for analysis of individual and simultaneous momentum, heat and mass transport – Hydrodynamic and thermal boundary layers – Velocity , temperature and concentration distributions in turbulent flow – Interphase transport for isothermal and non isothermal systems.

Recommended Books:

Robert S. Brodkey and Harey C. Hershey, Transport Phenomena' A unified approach Mc. Graw Hill book Co., 1988.
 R.B. Bird, W.E. Stewart and E.W. Lightfoot. Transport Phenomena, John-Wiley, 1994
 McCabe and Smith, Unit Operations in Chemical Engineering, McGraw Hill, 5th Ed., 1993.
 J.C. Slathery, Advanced Transport Phenomena, Cambridge University Press, 1999
 C.J. Geankoplis, Transport Process and Unit Operations.

CHE 310 Process Dynamics and Control (3 1 0 4)

Introduction – Process models – Linearisation – Laplace transform – Process dynamics – Processes with complex dynamics – Time delay and Inverse response – Parts of feed back control system – Block diagram – Algebra – Transient response – Stability – Routh criterion – Root locus diagram – Frequency response analysis – Bode and Nyquist plots – Design of feed back controllers – Introduction to advanced process control

Recommended Books:

- 1) Stephano Poulos G., Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall of India, 1997.
- 2) Thomas E. Marlin, Process Control, McGraw Hill Int. Ed., 1995
- 3) Carlos A. Smith and Armando B. Corripio, Principles and Practice of Automatic Process Control, John Wiley
- 4) Jairath, A.K., Control Systems, CBS Publishers
- 5) Dale E. Seborg, T.F. Edgar, Duncan A. Mellicamp Process Dynamics and Control, John Wiley Sons, 1989
- 6) Donald R. Coughnowr, Process Systems Analysis and Control, McGraw-Hill, 1991

CHE 312 Elective I**(3 0 0 3)****ECE 308.4 Neural Networks and Fuzzy Logic**

Neural Networks: Fundamental concepts and models of Artificial Neural Systems –Biological neurons, Mc-culloch pitts model, Feed forward and Fib network, Supervised and unsupervised learning. N/N learning rules.

Classifiers: Classification model, features and decision regions, discriminant functions - Linear single layer classifiers, Multi layer classifiers – Linearly non separable pattern classification – error back propagation training – learning factors – applications of EBPTA Single layer feedback networks – Basic concepts of dynamical systems – Discrete time and gradient type Hopfield networks – Applications in optimization problems such as A/D networks, Travelling salesman tour length etc.

Associative Memories: Basic concepts of recurrent auto associative memories – storage and retrieval algorithms, Energy function reduction, Hamming distance calculation – Bidirectional associative memory, Matching and self organizing networks – Hamming net and maxnet, Feature mapping, Kohenen's self organizing feature maps, cluster discovery network (ART1). Applications of neural algorithms -Character classification and recognition, Inverted pendulum neurocontroller, Robot kinetics, Medical expert systems.

Fuzzy Logic: Introduction – Block diagram representation of different types of fuzzy systems – Concept of membership functions – Generation of membership functions with examples – Fuzzy mathematics – Brief comparison of classical sets and fuzzy sets – Basic operation on fuzzy sets – fuzzy complement – fuzzy union (s-norms) – Fuzzy intersection (t-norms) – Averaging operators – Fuzzy relations and extension principle – Fuzzy relations – Cartesian product - Composition of fuzzy projection and cylindrical extension – Extension principle Linguistic variables and fuzzy IF- THEN rules: Linguistic variables, linguistic hedges, fuzzy IF- THEN rules – fuzzy propositions, interpretations of fuzzy IF- THEN rules, different implications Fuzzy logic and Approximate reasoning- Compositional rule of inference, Properties of the implication rule-generalized modus ponens, generalized modus tollens and generalized hypothetical syllogism.

Fuzzy rule base and fuzzy inference engine: Fuzzy rule base, structure of fuzzy rule base and properties of set of rules. Fuzzy inference engine -composition based inference, individual rule based inference, details of some inference engines.

Fundamental concepts and models of artificial neural systems – Biological neurons – Mc-culloch pitts model – Feed forward Fuzzy Logic: Introduction-Block diagram representation of different types of fuzzy systems, concept of membership functions, generation of membership functions with examples Fuzzy mathematics- Brief comparison of classical sets and fuzzy sets, Basic operation on fuzzy sets, fuzzy complement, fuzzy union(s-norms), fuzzy intersection (t-norms), averaging operators Fuzzy relations and extension principle -Fuzzy relations, Cartesian product, composition of fuzzy relations projection and cylindrical extension, extension principle.

Fuzzifiers and defuzzifiers: Fuzzifiers -exponential, triangular and trapezoidal fuzzifiers. Defuzzifiers- Centre of gravity, center average, Maximum defuzzifiers Design of fuzzy systems -Design of Fuzzy rule based systems to develop nonlinear functions, inverted pendulum controller, modeling of serial transmission of a digital signal over a channel etc.

Recommended Books:

1. Neural Networks for Pattern Recognition , Bishop, Oxford University Press
- 2.Introduction to Artificial Systems by Jacek M. Zurada, Jaico publications
- 3.Neural Networks, A Comprehensive Foundation by Simon Haykin, 1999. 2nd edition, Pearson Education, Asia

4. Introduction to Fuzzy Systems and Control by Li Xin Wang.
5. Fuzzy Logic with Engineering Applications by Timothy J. Ross, Intl. Edition, 1997, McGraw Hill Publications.
6. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications by Rajasekaran and Pai, Prentice Hall of India, 2003

CHE 312.1 Introduction to Cryogenic Engineering

Introduction – Liquefaction of gases – Ideal gas – Liquefaction process – Liquefaction of air – Hydrogen and Helium – Separation of gases – Air, Helium from natural gas – Deuterium from natural hydrogen – Purification – Cooling by adiabatic demagnetization – Low temperature thermometry – Gas – Vapor pressure – resistance magnetic thermometry – Liquid in thermometer – Insulation – vacuum insulation – Gas filled powders and fibrous materials – Solid foams – storage and transporting liquefied gases – Dependence of rate of evaporation on size and shape of vessels – Commercial containers for liquid oxygen, Helium, Hydrogen etc. – Liquid level indicator – Transfer of liquid gases – Two phase flow – Transfer through uninsulated line – transfer lines insulated with porous material and vacuum – Valves used in pumping cryogenic liquid – Long distance transfer – Properties of cryogenic fluid – Specific heats – Low temperature properties for structural materials – Uses of cryogenics in gas separation – Space research – Biology – Food handling – Electronics – Super conductive devices – Nuclear physics – Metal fabrication etc.

Recommended Books:

Russel B. Scott, Cryogenic Engineering, D.Van Nostrand Co., Inc.,
 Marshal Sitting, Cryogenic Research and Applications, D.Van Nostrand Co., Inc.,
 R. Barron, Cryogenic Systems, McGraw-Hill, 2nd ed., 1985

CHE 312.2 Project Engineering

Preliminary data on projects – Process Engineering – Project evaluation and development – Block flow diagram – Process flow diagram – Process and instrumentation diagram – Pilot plants – Engineering design and drafting – Plant location and layout – Piping design – Plant utilities – Insulation – Instrumentation – Safety in plant design – Project engineering management – Project scheduling – PERT and CPM techniques – Gantt chart – Optimum project design with suitable examples such as heat exchangers, pumps, vessels and evaporators

Recommended Books:

1. Howard F. Rase and M.H. Barrow, Project Engineering of Process Plants, John Wiley
2. Warren D. Sieder, J.D. Seader and Daniel R. Lewin, Product and Process Design Principles, John Wiley, 2004
3. Gael D. Ulrich, A Guide to Chemical Engineering Process Design and Economics, John Wiley
4. Max S. Peters, Klaus D. Timmerhaus and Ronald E. West, Plant Design and Economics for Chemical Engineers, McGraw-Hill, 2003
5. E.E.Ludwig, Applied Project Engineering, Gulf Publishing Co., Houston, 1988
6. V.W.Uhl and A.W.Hawkins ; Technical Economics for Chemical Engineers; AIChe ; 1971
7. J.Modes and Philips ; Project Engineering with CPM & PERT, Renhold Publishing Co.

CHE 312.3 Introduction to Biochemical Engineering

Introduction – Principles of microbiology – Structure of cells – Microbes – Bacteria – Fungi – Actinomycetes – Algae – Chemicals of life – Lipids – Sugars and polysaccharides of cellular organization – cell nutrients – Macronutrients – Growth media

Kinetics of enzymes – Catalysed reactions – Enzyme substrate complex and enzyme action – Simple enzyme kinetics with one and two substrates – Determination of elementary step rate constants – Isolation and utilization of enzymes – Production of crude enzyme extracts – Enzyme purification – enzyme immobilization – Application of hydrolytic enzymes – Immobilised enzyme technology – Methods of immobilization – Enzyme production – Intracellular and extracellular enzymes

Metabolic pathways and energetic of the cell – Glucose metabolism – Glycolysis and TCA cycle – Respiration – Control sites of aerobic glucose metabolism – Metabolism of nitrogenous compounds – Nitrogen fixation – Metabolism of hydrocarbons – Overview of biosynthesis – Anaerobic metabolism – Photosynthesis – Autotropic metabolism – transport across cell membranes

Cell growth – Batch growth – Determining cell mass concentration – Growth patterns and kinetics in batch culture – Factors affecting growth kinetics

Quantification of growth kinetics – Unstructured non-segregated models to predict specific growth rate – Models with growth inhibitors – Logistic equation – Growth models for filamentous organisms – Models for transient behaviour – Models with time delay – Chemically structured models

Recommended Books:

1. J.S.Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, NY, 1986
2. M.L.Shuler and F.Kargi, Bioprocess Engineering Basic Concepts, Prentice Hall of India, New Delhi, 1998
3. H.W. Blanch and D.S.Clerk, Biochemical Engineering, Merce Dekker Inc., 1996

BIO 312 E FOOD PROCESSING TECHNOLOGY**[4 0 0 4]****INTRODUCTION TO FOOD PROCESSING**

Biotechnology in relation to the food industry; nutritive value of food; types of microorganisms associated with food - their sources, types and behavior

FOOD SPOILAGE & PRESERVATION

Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry, and Seafood. Spoilage of Miscellaneous Foods, Food – borne illnesses.

Food Preservation : Rheology of Food Production, Food Preservation Using Irradiation, Characteristics of Radiations of Interest in Food Preservation., Principles Underlying the Destruction of Microorganisms by Irradiation, Processing of Foods for Irradiation, Application of Radiation. Legal Status of Food Irradiation, Effect of Irradiation of Food constituents; Food Preservation with Low Temperatures, Food Preservation with High Temperatures, Preservation of Foods by Drying.

BIOTECHNOLOGY IN FOOD INDUSTRY

Characteristics of Food Industry. Food manufacturing & processing, common additives, bioorganic additives, spoilage, prevention of spoilage, storage and preservation through biotechnological means, food packaging. Factors influencing food product development, marketing, and promotional strategies.

Food Industry: Basal metabolic rate, influences on nutritional status, dietary strategies for individuals, diet for specific groups, Market Place, ecologically sustainable production, risks and benefits of biotechnology to food industry.

APPLIED UNIT OPERATIONS IN FOOD PROCESSING

Unit operations applied to the food processing industry – Fluid flow applications, Heat transfer applications, Centrifugation, Filtration, Extraction, Membrane separations, Evaporation, Distillation, Absorption, Size reduction, Mixing, Drying, and Crystallization

Textbook:

1. Food biotechnology, A Roger, B Gordon and T John

Reference Books:

1. Modern food Biology. J.M. Jay, Van Nostrand Reinhold Company, New York.
2. Biotechnology – Challenges for the flavor and food industry, W Lindsay, Elsevier applied science
3. Unit operations in food processing Earle, R. L. Pergamon Press

CHE 314 Mass Transfer Operations Lab**(0 0 3 1)**

Experiments based on Mass Transfer I and II course work

CHE 316 Seminar I**(0 0 3 1)**

This first course in seminar at level I is designed mainly for the student to develop oral communication skills. Each student shall give an oral presentation of the topic assigned to him. Simple topics of descriptive nature related to Process Instrumentation for which information is readily available will be allocated for each student. The student will make an oral presentation of the topic through overhead projector/slides for the presentation and submit the prepared manuscript after the presentation.

HS 401/402 Essentials of Management [3 0 0 3]

Definition of Management, its nature and scope, the functions of managers.

Planning: Types of plans, steps in planning, process of MBO, How to set objectives, strategies, policies and planning premises.

Strategic planning process: Decision making: steps in decision making, systems approach.

Organizing: Nature and purpose of organizing, span of management, factors determining the span, basic departmentation, Line and staff concepts, functional authority, art of delegation, decentralization of authority.

Human Resource Management: Systems approach to staffing, selection process, techniques and instruments, approaches to manager development and training

Human factors in managing: Theories of motivation, special motivation techniques. Leadership – leadership behaviour and styles, Managerial grid.

Communication: Process, barriers, effective communication techniques.

Basic control process, critical control points and standards.

Control Techniques: Budgets, non-budgetary control devices. Overall and preventive controls: Budget summaries: Profit and loss control, control through ROI, direct control, preventive control, developing excellent managers.

International management: Managerial practices in Japan and USA and application of theory Z. The nature and purpose of international business and multinational corporations, unifier global theory of management.

Recommended Books:

1. Peter Drucker: Management, Task and Responsibility
2. Peter Drucker: The Practice of Management
3. Koontz: Essentials of Management

CHE 401 Process Engineering Economics

(3 1 0 4)

Introduction to Process Engineering Economics – Economic decision making – Mathematics of cost comparisons
Time value of money – Types of interest – Rate return relationships – Series of cash flow – Annuities – Gradient and geometric series – Capitalised cost – Concept of continuous interest
Equivalence – Minimum Acceptable rate of return – Economics of selecting alternatives – Annual, present worth, future worth, rate of return and capitalized cost methods – Extra investment analysis – Mutually exclusive basis – Replacement economy – Project evaluation methods – Payout period, Return on investment – Net present value – Discounted cash flow rate of return
Depreciation and Amortisation – Methods of depreciation – Comparison – Accelerated cost recovery systems – Depreciation accounting procedures – Depletion – Cost and percentage methods – Taxes and implication of taxes
Break even and sensitivity analysis – Break even charts – Optimisation – Single and double variable optimization – Optimum production rates – Maximum profit and minimum cost – Selected unit operations such as Fluid flow (optimum diameter of pipe), heat transfer (optimum thickness of insulation, optimum temperature or flow rate of fluid in a double pipe exchanger/condenser, optimum number of effects in an evaporator, optimum rate of heat transfer and cycle time) and Filtration (optimum number of cycles and time of filtration)
Cost estimation – Types of estimates – Method of estimating equipment costs – Cash flow operations – Methods of estimation of Fixed capital and Total capital – product cost estimation
Elements of book keeping – Profit and loss accounts – Balance sheet – PERT and CPM techniques – General considerations for Plant location and layout

Recommended Books:

1. Peters, M.S. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, 4th edn., McGraw-Hill, New York, 1980.
2. Schweyer, H.E., Process Engineering Economics, McGraw-Hill, 1955.
3. Frederic C. Jelen and James H. Black, Cost and Optimisation Engineering, McGraw-Hill, 1983.
4. Taylor, G.A., Managerial and Engineering Economy, 3rd edn., D van Nostrand Co., 1980.
5. John A. White, Kenneth E. Case, David B. Pratt and John H. Agee, Principles of Engineering Economic Analysis, John Wiley and Sons Inc., 1998.

CHE 403 Process Modeling and Simulation

(3 1 0 4)

Introduction – Models and model building – Principles of model formulation – Degrees of freedom – Analysis – Precautions in model building – Benefits of modeling and simulation – Fundamental laws and constitutive relations – Stratum of physio-chemical description – Different phases of model building – Numerical solutions of mathematical equations – Algebraic equations in one variable and multi-variables – Linear and non linear equations – Use of computer software for analysis and solutions of mass and energy balance problems – Decomposition and tearing algorithms – Numerical methods for solving nonlinear ordinary differential equations – Methods for convergence promotion and solving chemical engineering problems – Solution methods for stiff differential equations.
Lumped parameter models (steady state and unsteady state) – Formulation and solution techniques to be discussed for vapour-liquid equilibrium models – Multi-component dew point and flash calculations – Boiling operations – Batch and continuous distillation – Tank models – Tanks with flow rate as function of level – Mixing tank – Stirred tank with heating jacket – CSTR with multiple series parallel reactions – Chlorination of benzene – Auto catalytic reactions – Order of magnitude analysis – Non-isothermal CSTR – Multiplicity and stability – Van Heedran criteria – PI control of CSTR at the unstable steady state.
Distributed parameter models – Formulation and solution of typical chemical engineering problems – Solution of SPLIT boundary value problems – Shooting technique – Counter current heat exchanger – Tubular reactor with axial dispersion – counter current gas absorber – Tubular permeation process – Pipe line flasher etc.
Unsteady state distributed parameter models (one dimension) – Formulation and solution of chemical engineering examples – Solution of partial differential equations by finite difference – Methods – Convection problems – Explicit and implicit centered difference methods – Diffusive problems – Crank -Nicholson finite difference scheme – Examples of unsteady state conduction and diffusion problems – Introduction to population balance models – Estimation of model parameters – Method of moments.

Recommended Books:

1. Hanna, O.T. and O.C Sandall, Computational Methods in Chem.Engg, Prentice Hall NJ, 1995.
2. Computational Methods in Process Simulations. W.F Ramirez, Butter worths Publishers-1989.
3. Modeling & Simulation in Chemical Engg. R.E.Franks, John Wiley & Sons 1972.
4. Process Dynamics, Modeling Analysis and Simulation, B.W. Bequette Prentice Hall, International INC 2002.
5. Computational Methods in Process Simulations, W.F. Ramirez, Butterworth Publishers, 1989
6. Modelling and Simulation in Chemical Engineering, Boger E. Franks, John Wiley and Sons 1972.
7. Mathematical Methods in Chemical Engineering, Seinfeld and Lapidus, Prentice-Hall, 1974.
8. Process Modelling, Simulation and Control for Chemical Engineers, W.L. Lyben, McGraw Hill, 1990
9. Process Dynamics, Modelling, Analysis and Simulation, B.W. Bewuette Prentice Hall Int. Series, 1998
10. Numerical Methods for Engineer's Strength, K. Gupta, Nevage International Publishers Ltd, Wiley Eastern Ltd., 1995

CHE 405 Chemical Process Industries**(4 0 0 4)**

Indian industry – A brief review

Detailed description of the processes along with neat flow diagrams, engineering problems that are encountered frequently

during the process and major uses and application are to be discussed for the following.

Industrial gases: Carbon dioxide – Hydrogen – Oxygen – Nitrogen – Synthesis gas

Chloroalkali industry: Common salt – Caustic soda – Chlorine – Hydrochloric acid – Bleaching powder – Soda ash

Sulfur and sulfuric acid: Extraction of sulfur – Production of sulfuric acid from sulfur and other sources – Recent advances

Fertiliser industry:

Ammonia – Nitric acid – Ammonium nitrate – Ammonium sulfate – Ammonium chloride – Urea

Phosphate industry: Elemental Phosphorous – Phosphoric acid – Superphosphates – NPK fertilizers

Oils, fats and waxes: Edible oils – Extraction of vegetable oil – Hydrogenation of oil – Soaps and detergents – Manufacturing processes – Glycerin recovery

Pulp and paper : Chemical and mechanical pulp – Pulping methods – Chemical recovery of black liquor – Paper and paper board

Sugar and starch: Sugar – Starch and modified starches – Glucose – Fermentation – Media for growth - Industrial alcohol – Absolute alcohol – Acetone and Butanol

Petroleum: Origin – Composition – Classification of petroleum – Refinery operations – Products and their uses

Polymerisation: Classification of polymers – Modes of polymerization – Polyvinyl chloride – Polyethylene – Viscose rayon , Nylon 6 and Nylon 66 – Natural and synthetic rubber

Recommended Books:

1. Faith, Keyes and Clark, Industrial Chemicals, 4th edn., F.A.Lowenheim and M.K.Moran, Wiley Interscience, 1975.
2. Charles E. Dryden, Outlines of Chemical Technology, Edited and revised by M. Gopala Rao and Marshall Sittig, Affiliated East Press Ltd., 2nd edn., 1975.
3. CHEM TECH – Vol 1 – 4, Chemical Engineering Education Development Centre, IIT, Madras, 1975 – 78.
4. Austin G.T., Shreve's Chemical Process Industries, 5th edn, McGraw-Hill, 1986.

CHE 407 Elective II**(3 0 0 3)****CHE 407.1 Polymer Engineering**

Introduction – Definitions and concepts used in polymer engineering- Polymerisation reactions – Polymer structures – Functionality and degradation – Characterisation of polymers – Natural and modified natural products – Synthetic polymers – Addition and condensation products and their preparation

Methods pf polymerization – Mass, solution,emulsion and suspension polymerization processes – Reactions and equipment used

Polymer processing – Moulding – Cold and hot compression – Transfer injection and jet types – Extruding –

Calendaring and skiving – Sheet forming – Atmospheric and fluid pressure forming – Lamination and impregnating

– Coating – Expanding – Casting and embedding – Spinning and finishing

Recommended Books:

Herman S. Kaufman and Joseph J. Falcetta (Editors), Introduction to Polymer Science and Technology, Wiley Inter Science Publications, 1977

David J. Williams, Polymer Science and Engineering, Prentice Hall Inc., 1971

Stanley Middleman, Fundamentals of Polymer Processing, McGraw-Hill,

Fred W. Billmeyer, Text Book of Polymer Science, Wiley Inter Science Publication

CHE 407.2 Advanced Biochemical Engineering

(3 0 0 3)

Genetic engineering – aims, techniques, achievements and prospects of genetic engineering – Process of gene expression, split genes and mRNA modification in eukaryotes, post translational modifications of proteins – Induction and mutation

Alteration of cellular DNA: Virus and phages – cell fusion – Commercial applications of microbial genetics and mutant populations – Recombinant DNA technology

Transport phenomena in bioprocess systems – Gas liquid mass transfer in cellular systems – Determination of oxygen transfer rates – Power requirements for sparged and agitated fermentors – Scale up and scale down of bioreactors

Recovery and purification of fermentation products: Filtration – Centrifugation – coagulation and flocculation – separation of soluble products – Liquid-liquid extraction – adsorption- dialysis – reverse osmosis – ultrafiltration and microfiltration, chromatography, electrophoresis, electro dialysis

Design and analysis of biological reactors – Ideal bioreactors – Sterilisation of reactors – Batch and continuous – Immobilised biocatalysts – Formations – Characterisation and applications – multiple bioreactors – Packed, fluidized and trickling bed reactors

Alternate bioreactor configurations – animal and plant cell reactor technology

Analysis for mixed culture fermentation systems – Neutralism, mutation, commensalisms and amensalism – Classification of interaction between two species – Competition and survival of the fittest – Volterra's analysis of competition – competition and selection in a chemostat – Predation and parasitism – Model development via stability analysis – Effects of number of species and their interactions – definitions – Population dynamics in model of mass action form

Biological reactors in the mixed culture and with natural systems – uses of well defined mixed populations

Medical applications of bioprocessing engineering – Tissue engineering – Commercial tissue culture process

1. Bailey, J.S. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill, New York, 1986
2. Shuler, M.L. and Kargi, F., Bioprocess Engineering Basic Concepts, Prentice Hall of India, New Delhi, 1988
3. Blanch, H.W. and Clerk, D.S., Biochemical engineering, Marcel Dekker Inc., New York, 1996

CHE 407.3 Petrochemicals

General introduction – History – Economics and future prospects of petrochemicals – Energy crisis and petrochemical industry – Sources and classification of petrochemicals

First generation petrochemicals – Alkanes – Alkenes and alkynes – BTX aromatics – Diene base petrochemicals

Second generation petrochemicals – Synthesis gas – Methanol – Formaldehyde – Chloromethanes – Ethanol – Acetaldehyde – Acetic acid – Acetic anhydride – Isopropyl alcohol – Ethylene oxide – Propylene oxide – Acetone – Vinyl chloride – Phenol – Aniline – Styrene

Third generation petrochemicals – Plastics – Rubber – fibres – olefinic polymers – Polyethylene – Polypropylene – Poly-isobutylene – Diene polymers – Polybutadiene – Neoprene – Polyisoprene – SBR – Synthetic fibres

Miscellaneous: Petroleum proteins – Synthetic detergents – Resins and rubber chemicals – Explosives (TNT, RDX, HMX)

Recommended Books:

Maiti, S., Introduction to Petrochemicals, Oxford and IBH Publishing Co. Ltd., 1992

Chem Tech IV, Chemical Engineering Education Development Centre, IIT Madras, 1978

Austin, G., Shreve's Chemical Process Industries, 5th edn., McGraw-Hill, NY, 1986

CHE 407.4 Unit Processes in Organic Synthesis

Nitration: Mechanism of nitration reaction – Mixed acids for nitration – Preparation of nitrobenzene – Equipment used in nitration processes

Amination: Reaction mechanism – Reduction of nitrocompounds – ammonolysis – Amination agents – Preparation of aniline – Ethylene diamine and p-phenylene diamine – Equipment used in amination processes

Diazotization: Reaction mechanism – Reactions of diazonium salts – Sulphonates – Carboxylates – Diazo oxides – preparation of simple amines and nitroamines – Equipment used

Halogenation: Reaction mechanism – Chlorination of paraffins – Ethanol and aliphatic acids – Dehydrohalogenation – Sandmeyer reaction – Bromination and iodination – Equipment used

Sulphonation: Reaction mechanism – Sulphonation agents – Treatment of aliphatic and aromatic compounds with sulfuric acid – Preparation of benzene sulphonic acid – Sulphonation of fatty acids – Equipment used

Oxidation: Mechanism of oxidation reaction – Oxidation agents – Vapor phase and liquid phase oxidation – Conversion of Iso to camphor – Aniline to quinine – Cyclohexane to adipic acid – acetaldehyde to acetic acid – Equipment used

Hydrogenation: reaction mechanism – Catalysts used – Hardening of fats – Hydrogenation of hydrocarbons – Equipment used

Alkylation: Reaction mechanism – Reagents – Preparation of anisole – carbitol and ethylene cellulose – Equipment used

Esterification: Reactions and mechanism – Esterification of inorganic and organic acids – Catalytic and vapor phase esterification - Alcoholysis – Esterification of amides – Preparation of ethyl, amyl and butyl acetates – Cellulose xanthates – Nitroglycerin and cellulose nitrate – Equipment used
Hydrolysis: Reaction Mechanism and reagents – Preparation of soaps – Fatty acids – Saccharification of wood – Amyl alcohols from chloropentane and phenol – Equipment used

Recommended Books:

Groggins, P.H., Unit Processes in Organic Synthesis, 5th edn., McGraw-Hill, NY, 1958
George T. Austin, Shreve's Chemical Process Industries, 5th edn., McGraw-Hill, NY, 1984

CHE 407.5 Advanced Process Dynamics and Control

Laplace domain analysis of advanced control systems – Cascade control – Feed forward control – Open loop unstable processes – Processes with inverse response – Adaptive control – Model based control – Introduction to multivariable control – Matrix properties – State variable – Solution of state equations – Controllability and observability – Analysis of multivariable systems stability – Resiliency – Interaction – RGA – Robustness – Design of controllers for multivariable processes – Selection of controlled variables – SVD-BLT tuning of multivariable controllers – Multivariable DMC – Multivariable IMC – Model predictive control – Introduction to sampled data control system – Sampling – Hold element – z transforms – Stability analysis and design of digital compensators

Recommended Books:

- 1.W.L. Luyben, Process Modelling, Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
- 2.Donald R. Coughnour, Process Systems Analysis and Control, McGraw-Hill, 1991
- 3.D.W. Seborg, T.F. Edgar and D.A. Millichamp, Process Dynamics and Control, John Wiley & Sons, 1989
- 4.George Stephanopoulos, Chemical Process Control, Prentice-Hall
- 5.Process Control, Thomas E. Marlix, McGraw Hill International Student Edition, 1995.

Elective III

BIO 403.1

BIONANOTECHNOLOGY

[4 0 0 4]

Introduction: From Biotechnology to Bionanotechnology, What is Bionanotechnology.

Biomaterials: Historical Overview and Current Directions; Proteins; Nucleic acids; Lipids, Polysaccharides; Host Response to Implantable Devices

Biomolecular Design: Recombinant Technology – Engineered DNA, Site-directed mutagenesis, Fusion Proteins; Regulation of Protein activity and action; Biomolecular motors – ATP, ATP synthase, Brownian ratchets; Traffic across Membranes – Potassium Channels, ABC Transporters, Bacteriorhodopsin; Biomolecular Sensing; Self-Replication; Machine-Phase Bionanotechnology – Muscle sarcomeres, Nerves.

Modern Bionanotechnology: Basic Capabilities; Nanomedicine – Computer-aided drug design, Immunotoxins, Liposomes, Artificial Blood, GeneTherapy, Personalized Medicine; Self-Assembly – DNA Scaffolds, Nanotubes, Fusion Proteins, Organic Molecules; DNA Computers; Molecular Design using Biological Selection; Artificial Life; Tissue Engineering and Artificial Cells; Hybrid Materials; Biosensors – Antibodies, Glucose levels, Engineered nanopores.

Case Studies and Ethical Issues: Nanotube synthase; Nanoscale assembler; Nanosurveillance
Ethical considerations – Respect for life and Potential Dangers.

Textbooks:

1. "Bionanotechnology" by Goodsell David S, John Wiley & Sons
"Nanoscale Technology in Biological Systems" by Greco Ralph S, CRC Press

CHE 409.1 Fertiliser Technology

Indian Fertiliser industry – An overview – Fertiliser production and consumption
Role of fertilizers in agriculture – Nutrients for plant growth – Micro and macro nutrients – General concepts - Fertiliser raw materials and reserves – Global and Indian reserves – Ammonia feed stocks – Phosphate rocks – sulfur – Potash etc.
Production, transmission and storage of ammonia through various processes and raw materials – Ammonium salts and Nitric acid – Production of urea through various processes - Important applications
Phosphate rock – Geology, mining and beneficiation – Phosphoric acid production – different methods – Fertilisers derived from phosphoric acid
Potash fertilizers – Potassium chlorides, Sulphates and Nitrates – Compound fertilizers – Production and their applications – Problems encountered in fertilizer plants

Recommended Books:

1. Development and Transfer of Technology Series, Fertiliser Manual – 13, United Nations Industrial Development Organisation, 1980
2. Sanchilli, V., Chemistry and Technology of Fertilisers, Reinhol Publishing Co, 1965
3. Shreve's Chemical Process Industries, McGraw-Hill, NY, 1984
4. Charles E. Dryden, Outlines of Chemical Technology, Edited and revised by M. Gopala Rao and Marshall Sittig, Affiliated East Press Ltd., 2nd edn., 1975.
5. Shukla and Pandey, A Text Book of Chemical technology, Vikas Publishing House, 1965

CHE 409.2 Environmental Impact and Assessment and Environmental Management Plan

Introduction and need for impact assessment – Legislation and Pollution Control acts and Notifications
Methodologies – Application of impact assessment methods in specific developmental projects – Impact assessment report – Contents for developmental projects – Ranking of impacts – Concept and contents of environmental management plan – Environmental audits – Waste audit – Life cycle assessment – Industrial symbiosis – Clean technology options

Recommended Books:

Peter Wathern, Environmental Impact Assessment – Theory and Practice, Unwin Hyman Ltd., 1988
Environmental Health and Safety Auditing Handbook, McGraw-Hill, NY, 1994

CHE 409.3 Petroleum Refinery Engineering

Genesis – Occurrence – Exploration – Drilling and production of crude oil – Pre-treatment of crude – Transportation – Composition, characterization and evaluation of crude oil and refinery products – World and Indian demand and supply of crude oil and petroleum products – Energy equivalence – OPEC – Euro and Bharat Specifications for refinery products – Refining of petroleum – Topping of crude oil and vacuum distillation – Catalytic reforming – Isomerisation- Catalytic cracking – Hydrocracking - Alkylolation – Visbreaking – Coking – Hydrotreating – Acid gas treatment – Solvent dewaxing

Recommended Books:

- 1) Robert A Meyers, Hand Book of Petroleum Refining Processes, McGraw Hill book Co.1986.
- 2) Bhasker Rao B.K., Modern Petroleum Refining Processes, Oxford & IBM publishing Co.1984.
- 3) Hobson, G. D. and Pohl, W., Modern Petroleum Technology, Applied Science Publishers, 4th edition,1975
- 4) Nelson, W.L., Petroleum Refining Engineering, McGraw Hill Book Co., 4th edition,1958.

BIO 403.2

METABOLIC ENGINEERING

[4 0 0 4]

Induction-Jacob Monod model, catabolite regulation, glucose effect, cAMP deficiency, feed back regulation, regulation in branched pathways, differential regulation by isoenzymes, concerted feed back regulation, cumulative feed back regulation, amino acid regulation of RNA synthesis, energy charge, regulation, amino acid regulation of RNA synthesis, energy charge, regulation, permeability control passive diffusion, active transport group transportation. Alteration of feed back regulation, limiting accumulation of end products, feedback, resistant mutants, alteration of permeability, metabolites.

BIOSYNTHESIS OF SECONDARY METABOLITES

Precursor effects, prophophase, idiophase relationship, enzyme induction, feedback regulation, catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites. Advantages of Bioconversions, specificity, yields, factors important to bioconversion, regulation of enzyme synthesis, mutation, permeability, co-metabolism, avoidance of product inhibition, mixed or sequential bioconversions, conversion of insoluble substances. Strain selection, improving fermentation, recognizing growth cycle peak, induction, feed back repression, catabolite repression, mutants resistant to repression, gene dosage.

Textbook:

Wang D.I.C., Cooney C.L., Demain A.L., Dunnill.P., Humphery A.E., Lilly M.D.,
"Fermentation and Enzyme Technology ", John Wiley and Sons.

References:

1. Stanbury P.F., and Whitaker A., "Principles of Fermentation Technology ", Pergamon Press.
2. Zubay G., "Biochemistry ", Macmillan Publishers.

CHE 411 Reaction Engineering and Process Dynamics Control Lab (0 0 3 1)

Experiments based on the course work of Reaction Engineering and Process Dynamics and Control

CHE 413 Process Modeling and Simulation Lab (0 0 3 1)

Experiments based on Process Modeling and Simulation

CHE 402 Industrial Training

(- - - 1)

As a part of curriculum, the student is required to undergo industrial training for a period of not less than four weeks in an industry during the vacation period, preferably at the end of V or VI semester. However, the report may be submitted during the VIII semester for evaluation.

CHE 404 Seminar II

(- - - 1)

This course is aimed at developing skills in searching technical literature, coordinating and making a good technical written report. The students will give a seminar on the topic assigned to them on soft skills or technical topics. Proper weightage will be given to both types of presentation in the evaluation.

CHE 499 Project Work

(- - - 20)

Project work is to be carried out by the student(s) individually or in a group for the entire eighth semester (16 weeks) in an Industry or the Institute itself. The topics will be assigned at the beginning of VIII semester and the student(s) will work under the supervision of a guide and after completion of the project, the reports will be submitted for the purpose of evaluation.