First Year First Semester

Hum/T/A HUMANITIES-A

English - 2 Pds/week - 50 Marks
Sociology - 2 Pds/week - 50 Marks

HUMANITIES

1.Basic writing skills
2.Report, Covering Letter & Curriculum-Vitae writing
3.Reading and Comprehension
4.Selected Short Stories

Text Book: ENGLISH FOR ALL

SOCIOLOGY

1.Sociology: Nature and scope of Sociology - Sociology and other Social Sciences - Sociological Perspectives and explanation of Social issues
2. Society and Technology: Impact of Technology on the Society - A case study
3. Social Stratification: Systems of Social Stratification - determinants of Social Stratification - Functionalist, Conflict and Elitist perspectives on Social Stratification
4.Work: Meaning and experience of work: Postindustrial society- Post-Fordism and the Flexible Firm
5.Development - Conceptions of and approaches to development - The Roles of State and the Market in the Development
6. Globalization: The concept of globalization - globalization and the nation state - Development and globalization in post colonial times.
7. Industrial Policy and Technological change in India - The nature and Role of the State in India
8. Technology Transfer: The Concept and Types of Technology Transfer-Dynamics of Technology Transfer
9. Technology Assessment: The Concept - Steps involved in Technology Assessment
10. Environment: Sociological Perspectives on Environment - Environmental Tradition and values in ancient India
11.The Development of Management: Scientific Management - Organic Organization - Net Work organization - Post modern Organization - Debureaucratization - Transformation of Management
12. Technological Problems and the Modern Society: Selected Case Studies - Electric Power Crisis, Industrial and/or Environmental Disaster, or Nuclear Accident.

ChE/Chem/T/112 INORGANIC CHEMISTRY

Atomic structure, Bonding and structure.
Theory of acids & bases, Stability of nucleus and modes of decay, Nuclear forces, mass defect and nuclear binding energy.

Nuclear reaction - fission and fusion.
Boron-hydrides, Barazole, Boron nitrides.
Silicon silicates, silicones, silica gel, carbon carbides, graphite compounds, teflon, freon.
General characteristics of transitional metals.
Environmental chemistry.
Chemical Kinetics - Preliminary approach.

ChE/T/113 OUTLINES OF CHEMICAL ENGINEERING

Purview of Chemical Engineering.
Unit Operations in Chemical Engineering - an overview.
Units and Dimensions - Systems of units, Conversion of units, Dimensional homogeneity and consistency, dimensional analysis, dimensionless groups and their use in chemical engineering.
Process Variables - mass, volume, pressure, temperature, chemical composition, flow rates.
Single Phase Systems: Solids, liquids, ideal gas and real gases; Equations of State; Compressibility factor charts; estimation of densities and heat capacities of solids, liquids and gases, and their mixtures, Mixing Rules e.g. Kay's Rule.
Multi-phase Systems: Outlines of unit operations involved in separating multiphase systems - distillation, crystallization, absorption, adsorption, extraction, leaching, evaporation, drying etc.; Single-component phase equilibrium - phase diagrams, estimation of vapor pressure using Clausius-Clapeyron Equation, Cox Charts and Antoine Equation, Gibbs' Phase Rule; Gas-Liquid Systems - saturation, saturated/ superheated vapor, humidity, psychrometric charts, boiling point, dew point, bubble point, degree of superheat, Raoult's Law and Henry's Law for multicomponent gas-liquid systems; Solutions of solids in liquids - solubility and saturation, phase diagrams; Immiscible and partially miscible liquids - miscibility and distribution coefficients, phase diagrams for ternary systems.
Process Data Representation and Analysis - interpolation and extrapolation, curve-fitting and least squares method, fitting a line to scattered data.

ChE/Math/T/114 MATHEMATICS – IB

Differential calculus: Review of limit, continuity and differentiability of functions of a single variable, Differential, Successive differentiation, Leibnitz Rule. Rolles Theorem. Lagrange’s and Cauchy’s Mean value Theorems. Taylor’s and Maclaunn’s expansions. Indeterminate Forms. L’Hospital’s Rule. Maxima and minima of functions of a single variable Curvature, concavity. Convexity, Points of inflexion.
Limit, Continuity and partial derivatives of functions of two or more variables. Partial derivatives, differentials and total derivatives of composite functions. Euler’s theorem on homogeneous functions. Taylor’s theorem for a function of two variables. Maxima and minima of a function of several variables Lagrange’s method of undetermined multipliers.
Int. Calculus: Riemann integral, Upper and lower sums, Fundamental theorem of integral calculus. Properties of definite integrals. Improper integrals. Beta and Gamma functions.

Quadrature, Rectification, Numerical integration by Trapezoidal Rule and Simpson's Rule.

AM/ME/T/1A ENGINEERING MECHANICS

Statics:
Introduction, Idealizations of Mechanics, Fundamentals of Vector Algebra, Application of Vectors in Mechanics, Equiv System, Equilibrium, FBD Concept, Fundamentals of Friction, Properties of surface, Centroid, Moment of Inertia
Dynamics:
Intro to vector calculus, Definition of vectors in Dynamics, Rectilinear Motion, Curvilinear motion of particle and description of different coordinate systems, Kinetics, Newton's Law and D' Alembert's principle and application to rectilinear and curvilinear motion, constrained motion, Energy and Momentum methods.

Ph/T/1B PHYSICS – IB

1. Use of vectors in particle mechanics, Unit vectors in spherical and cylindrical polar coordinates, Conservative vector fields and their potential functions - gravitational and electrostatic examples, Gradient of a scalar field, Equipotentials, States of equilibrium, Work and Energy, Conservation of energy, Motion in a central field and conservation of angular momentum.
2. Angular momentum of a system of particles, Torque, Moment of inertia , Parallel and Perpendicular axes theorem, Calculation of moment of inertia for (i) thin rod, (ii) disc, (iii) cylinder and (iv) sphere. Rotational dynamics of rigid body (simple cases).
3. Motion of fluids, Bernoulli's equation and its applications, motion of viscous fluids - Poiseuille's equation.
4. Simple harmonic motion, Composition of simple harmonic motion, Forced vibration and resonance, Wave equation in one dimension and travelling wave solution, Standing waves, Wave velocity and group velocity.
5. Assumption for the kinetic theory of gases, Expression for pressure, Significance of temperature, Deduction of gas laws, Qualitative idea of (i) Maxwell's velocity distribution. (ii) degrees of freedom and equipartition of energy, Specific heat of gases at constant volume and constant pressure.
6. Macroscopic and microscopic description, Thermal equilibrium, Zeroth law of thermodynamics, Concept of international practical temperature scale, Heat and Work, First law of thermodynamics and some applications, Reversible and irreversible processes, Carnot cycle, Second law of thermodynamics, Concept of entropy, Thermodynamic relations.
7. Statistical description of a system of particles, Phase space, Microstates and macrostates, Boltzmann's formula for the entropy, Canonical partition function, Free energy and other thermodynamic quantities in terms of the partition function, Classical ideal gas, Equipartition theorem and its applications.

Ph/S/1 PHYSICS LABORATORY-I

(Selected Experiments from the following)

1. Determination of Galvanometer resistance by half - deflection method.
2. Determination of Galvanometer resistance by Thomson's method.
3. To find high resistance by Galvanometer deflection method.
4. To measure mechanical equivalent of heat, J by electrical method (Joule's) using copper calorimeter (radiation correction to be done).
5. To compare to low resistance by drop of potential method.
6. To determine resistance per unit length of wire by using Carey Foster bridge.
7. To estimate strength of a current by using copper voltmeter.
8. a) To compare the EMF's of two cells by using a potentiometer
b) To measure current by using a potentiometer
9. To measure the horizontal components of earth's magnetic field intensity using deflection and vibrating magnetometers.
10. Determination of co efficient of linear expansion by optical lever method.
11. Determination thermal conductivity of metal by Searle's method.
12. To determine co-efficient of viscosity by Capillary flow method.
13. Determination of Young's modulus by Flexure method.
14. To draw mutual and anode characteristics of triode and hence too fine Rp, μ, and gm
15. To draw the transistor characteristics (NPN/PNP) in the given configuration and hence to find hi, hf
16. Determination of refractive index of the material of the glass prism by prism spectrometer (for at least two ?s)
17. Study of collisions in one dimension using a linear air track
18. Use of an air track for obtaining potential energy curves for magnetic interactions.
19. Study of oscillations under potential wells of various shapes using an air track.
20. Experiments on diffraction in single slit, double slit and plane grating using He- Ne laser
a) To find the wavelength of a monochromatic light by single slit.
b) To find slit separation of a double slit.
c) To find number of rulings per cm of a plane grating
21. To find the wavelength of a monochromatic light by Newton rings.
22. Fabry-Perot interferometry: To find out separation of wavelength of sodium D1 & D2 lines.

ChE/Chem/S/112 INORGANIC CHEMISTRY LABORATORY

Experiments to supplement the course on “Inorganic Chemistry”.

BED/ME/S/1 BASIC ENGINEERING DRAWING

Drawing primitives: instruments, letters, lines, title block, geometric curves & shapes, scale and dimension.
Projection: orthographic and isometric, sectional views.

WS/ME/S/7 WORKSHOP PRACTICE-VII (Fitter Shop and Welding)

Introduction to fitter’s tools, gauges, measuring instruments etc.; marking of jobs; fitter’s job involving chipping, filing, sawing, drilling; use of taps and dies; pipe fittings and plumbing.
Introduction to and practice of different welding processes- gas, SMAW, TIG, MIG, SAW, resistance welding etc.; introduction to gas cutting and its application; soldering, brazing etc.; making welded joints using different welding processes.

First Year Second Semester

AM/ME/T/3 STRENGTH OF MATERIALS

Uniaxial stress field, Thin pressure vessels, Torsion (inclusive of Helical spring), shear force and Bending moment, Bending and shear stress in beams, Deflection beams, Energy methods in Strength of Materials, Problem of Plane stress and strain, Theories of failure, Buckling of columns.

ETech/EE/T/B ELECTRICAL TECHNOLOGY-B

DC Circuits: Kirchhoff's Laws. Maxwell's Loop Current Methods of Analysis. Star-Delta Conversion. Superposition Theorem. Thevenin's Theorem. Maximum Power Transfer.
Magnetic Circuit: MMF, Flux ,Reluctance. B-H Loop. Hysteresis and Eddy current loss. Magnetic circuit analysis with air gap.
AC 1 -phase: Periodic Waves and Sinusoids. Average and RMS Values, Form Factor, Peak. Factor. Phasor concept of Sinusoids. Impedance and Admittance. Power, Power Factor, V A, V AR. Series R-L-C Circuit ,Parallel R-L-C circuit. Resonance.
Balanced 3-phase: 3-phase AC balanced circuits. Phase-sequence. Star and Delta connections. Power, V A, V AR, Power Factor _or balanced 3-phase circuits.
Power Measurement: Wattmeter circuit connection. Power Measurment by two wattmeter methods in 3phase system.
DC Machines: Construction and general priciple of operation. Generator EMF Equation. Field connection ,shunt series and compound. Generator characteristics.
Motor-equation and general operation. starting and speed control, torque -speed curve.
1-PhaseTransformer: Construction. EMF equation. Phasor diagram. Equivalent circuits. Losses and Efficiency. Open circuit and Short circuit test.
3-Phase Induction Machine: Types of induction machines. Rotating magnetic field, slip ,torque equation, torquespeed curve.DOL starting and reduced voltage starting.
3-Phase Synchronous Machines: Alternator, constructional features, EMF equation, synchronous reactance, power -angle characteristics.
Concept of synchronous motor.
Meters: DC and AC Ammeters and Voltmeters. Megger.Multiplier.

Books :
1. Electrical Science by Prof. S. Chowdhury, Prof. R. Chakraborty & Prof. P. K. Chatterjee.
2. Electrical Machines by Prof. P.K. Mukherjee & Prof. S. Chakravorti.

ChE/Math/T/123 MATHEMATICS – IIB

Determinants: Definition and properties. Minors and co-factors. Product of two determinants. Symmetric and skew-symmetric determinants. Cramer's Rules.
Matrices: Definition, Equality, Addition, Multiplication by a scalar. Product of two matrices. Transpose, Adjoint and Inverse of a square matrix. Symmetric and skew-symmetric matries; Orthogonal matrix. Solution of a system of linear equations by matrix method. Flow operations. Rank of a matrix. Cayley-Hamilton Theorem (statement only). Eigenvalues and eigenvectors.
Solid Geometry and Vector Algebra: Cartesian coordinates in three diamensions. Position Vectors. Addition of vectors. Multiplication of a vector by a scalar. Division of a line-segment in a given ratio Rectangular resolution of a vector. Scalar and vector products. Direction cosines, equations of Planes and straight lines. Distance between two skew lines. Products of three vectors. Volume of a tetrahedron. Equations of spheres, cylinders and cone.
Complex Numbers: De Moivre's theorem. Exponential values of sine and cosine. Exponential, Logarithmic and hyperbolic functions. Inverse circular and hyperbolic function. Direction cosines, equations of planes and straight lines.

ChE/T/124 INTRODUCTION TO COMPUTER PROGRAMMING

Formulation of algorithms and flow-charts for computer-based solutions of engineering problems.
Introduction to the digital computer.
Introduction to programming - variables, assignment, expressions, input/output, conditionals and branching, iteration, functions, recursion, arrays, pointers, structures, data-procedure encapsulation, dynamic allocation, linked structures, data structures.
Basis languages - FORTRAN, C/C++.
Computer programs for solution of chemical engineering problems.

ChE/Chem/T/125 ORGANIC CHEMISTRY

UNIT I: GENERAL
Electronegativity, Inductive effect, Resonance, Hyper conjugation, Steric effect, strength of organic acids and bases.
Conformational analysis of ethane and n-butane with energy diagram, elementary idea of Fischer projection, Newman projection and sawhorse representation of organic compounds with simple examples.
Cis, Trans, E, Z, optical rotations, specific and molecular rotations.
UNIT II: ALIPHATIC COMPOUNDS
Homolytic and Heterolytic cleavage of bonds, classification of reagents, (Electrophiles and Nucleophiles) and reaction intermediates.
Outline of preparations and reactions of different classes of organic compounds (alkanes, alkenes, alkynes, alkyl halides, alcohols, ethers, aldehydes and ketones, carboxylic acids and their derivatives,amines) with elementary idea on reaction mechanisms(Nucleophilic substitution reactions, E1,E2, Electrophilic addition

to olefins, Nucleophilic addition to carbonyl groups)
UNIT III: AROMATIC COMPOUNDS
Elementary idea on aromaticity, mechanism of electrophilic aromatic substitution reactions.
Outline of preparations and reactions of aromatic hydrocarbons, aryl halides,nitro compounds, amines, phenols, aldehydes and ketones, carboxylic acids and their derivatives.
UNIT IV: INDUSTRIAL PREPARATION OF ORGANIC COMPOUNDS
Synthesis of commercially important compounds (e.g. industrial reactions of ethylene and acetylene phenol from isopropylbenzene, phthalic anhydride from xylene and naphthalene, DDT from chlorobenzene, aspirin and methyl salicylate from phenol)
Elementary idea on Addition, condensation and coordination polymerization.

Ph/T/2A PHYSICS-IIA

1. Electric potential and intensity, Flux of electric field, Gauss's law and its application to problems with spherical and cylindrical symmetry, Capacitance- parallel plate and spherical condensers, Energy of a capacitor, Energy density of an electric field, Potential and field due to a dipole, Dielectric polarisation, Electric displacement vector, dielectric susceptibility.
2. Biot-Savart law and Ampere's law in magnetostatics, Calculation of magnetic field in simple situations like (i) straight wire (ii) circular wire (at a point on the symmetry axis) and (iii) Solenoid.
3. Time-varying fields, Faraday's law of electromagnetic induction, Self and mutual inductance, Resonance and oscillation in electrical circuits.
4. Nature of light waves, Interference of light waves, Young's experiment, Spatial and temporal coherence, Fresnel bi-prism, Interference in thin film, Newton's rings, Measurement of film thickness and wavelength, Diffraction of light waves, Huygen's construction, Fresnel and Fraunhoffer diffraction, Fraunhoffer diffraction due to single slit and plane diffraction grating, Approximate rectilinear propagation of light, Zone plate, Polarisation of light waves, Polarisation by reflection, Brewster's law, Double refraction- ordinary extraordinary rays, Polaroid, Optical activity.
5. Energy levels of the hydrogen atom and the Bohr atom model, X-ray spectra, X-ray diffraction, Bragg's law, Compton effect. De-Broglie waves, Particle diffraction, Uncertainty principle and its application.

Ph/S/2 PHYSICS LABORATORY-II

(Selected Experiments from the following)

1. Determination of Galvanometer resistance by half - deflection method.
2. Determination of Galvanometer resistance by Thomson's method.
3. To find high resistance by Galvanometer deflection method.
4. To measure mechanical equivalent of heat, J by electrical method (Joule's) using copper calorimeter (radiation correction to be done).
5. To compare to low resistance by drop of potential method.

6. To determine resistance per unit length of wire by using Carey Foster bridge.
7. To estimate strength of a current by using copper voltmeter.
8. a) To compare the EMF's of two cells by using a potentiometer
b) To measure current by using a potentiometer
9. To measure the horizontal components of earth's magnetic field intensity using deflection and vibrating magnetometers.
10. Determination of co efficient of linear expansion by optical lever method.
11. Determination thermal conductivity of metal by Searle's method.
12. To determine co-efficient of viscosity by Capillary flow method.
13. Determination of Young's modulus by Flexure method.
14. To draw mutual and anode characteristics of triode and hence too fine Rp, μ, and gm
15. To draw the transistor characteristics (NPN/PNP) in the given configuration and hence to find hi, hf
16. Determination of refractive index of the material of the glass prism by prism spectrometer (for at least two ?s)
17. Study of collisions in one dimension using a linear air track
18. Use of an air track for obtaining potential energy curves for magnetic interactions.
19. Study of oscillations under potential wells of various shapes using an air track.
20. Experiments on diffraction in single slit, double slit and plane grating using He- Ne laser
a) To find the wavelength of a monochromatic light by single slit.
b) To find slit separation of a double slit.
c) To find number of rulings per cm of a plane grating
21. To find the wavelength of a monochromatic light by Newton rings.
22. Fabry-Perot interferometry: To find out separation of wavelength of sodium D1 & D2 lines.

ChE/Chem/S/122 ORGANIC CHEMISTRY LABORATORY

Experiments to supplement the course on “Organic Chemistry”.

AED/ME/S/1 ADVANCED ENGINEERING DRAWING

True length, development of surface of simple objects. Threaded joint & riveted joints, cotter/knuckle joint. Pulley, shaft coupling.

WS/ME/S/8B WORKSHOP PRACTICE-VIII (Forging and Moulding)

Forging: Introduction to forging tools, furnaces and forging machines; to practice basic forging operations- drawing out, upsetting, necking etc.; introduction to forge welding. Introduction to moulding practice- preparation of moulding sand and use of moulder’s tools; making of moulds by using selected pattern’s; introduction to melting and pouring practice; experiments sand testing like permeability, moisture content, shutter index, mould strength, grain fineness number etc.; demonstration of injection moulding machine.

Second Year First Semester

ChE/Chem/T/212 PHYSICAL CHEMISTRY

PART I: QUANTUM MECHANICS, SPECTROSCOPY AND PHOTOCHEMISTRY
Quantum Mechanics : Introduction- Quantum postulates and operators - Schrodinger's wave equation - Particle in a box - Hydrogen atom
Spectroscopy : Electronic, vibrational, rotational and Raman Spectroscopy
Photochemistry : Laws of Photochemistry(Lambert-Beer, Grotthus-Draper and Stark-Einstein) - Quantum yield - Absorption and emission - Fluorescence and phosphorescence - LASER and its application.
PART II: PHYSICAL CHEMISTRY OF CONDENSED MATTER
Structure : Crystal structure - Liquid crystal - Water structure
Properties : Expansibility and compressibility - Permittivity - Polarisability - Refractive index - Optical activity - Viscosity
Surface phenomena : Surface tension - Curved interface - Adsorption - Colloidal state - Micelles
Electrical phenomena : Electrokinetic properties - Electrochemical cell - pH and its measurement - Electrometric titrations.

ChE/ME/T/213 ENGINEERING THERMODYNAMICS

Basic concepts: Systems-isolated, closed and open; thermodynamic state; state variables-intensive and extensive; process-cyclic process, reversible process; Zeroth law of thermodynamics-concept of temperature, properties of pure substances, energy interaction between system and surroundings-work and heat; adiabatic and isothermal processes.
Concept of internal energy; conservation of energy; first law of entropy; entropy change of the universe- possible and impossible processes; reversible and irreversible processes; internal and external reversibility; thermodynamic temperature.
Open systems- first and second law applications; second law efficiency and availability, irreversibility, lost work and energy.
Thermodynamic properties- enthalpy, Gibb's free energy and Helmholtz free energy; application of first and second law to closed systems; heat engines - Carnot cycle; Introduction to refrigeration and gas liquefaction processes, introduction to power cycles.

ChE/T/214 MECHANICS OF FLUID

Introduction: Fluid, Concept of continuum, Method of analysis: System and Control volume, Methods of description - Lagrangian and Eulerian
Fundamental Concepts: Velocity field, Streamlines, Streaklines, Pathlines, Timelines, Stress field, Viscosity, Newtonian fluid and Non-newtonian fluids, Description and Classification of fluid flow
Fluid Statics: Pressure variation in a static fluid
Control volume analysis (integral approach) - Reynolds transport theorem, conservation of mass and momentum theorem, angular momentum theorem, The first and second law

of Thermodynamics
Differential analysis of fluid motion:
Conservation of mass; Stream function for two-dimensional incompressible flow
Kinematics of flow field : Acceleration of a particle in a Velocity Field, Fluid Rotation, Vorticity, Fluid Deformation.
Momentum equation: Forces acting on a Fluid particle, Differential momentum Equation
Incompressible Inviscid flow : Momentum Equation for frictionless flow, Euler's equation, Bernoulli equation, Static, Stagnation and Dynamic pressures.
Incompressible Viscous flow - laminar and turbulent flow, boundary layer, corrections to Bernoulli's equation, Friction factor, flow through circular and noncircular conduits, Hagen Poiseuille equation, Fanning equation, major and minor frictional losses, skin friction and form friction, pressure drop in flow through multiple paths, pipeline design.
Drag and lift, drag coefficient, Stokes law
Flow measuring devices
Flow in agitated vessels
Flow through packed bed and fluidized bed
Fundamentals of compressible flow, momentum and energy balance equation, flow through convergent-divergent nozzles.

ChE/T/215 NUMERICAL METHODS

Linear Algebraic Equations:
Solution of simultaneous linear algebraic equations, Gaussian elimination, Thomas algorithm, LU Decomposition; Eigenvectors and eigenvalues; Determination of inverse of a matrix: Gauss-Jordan method; Iterative solution of a set of simultaneous linear algebraic equations: Jacobi method, Gauss-Seidel method, Relaxation method.
Error, Propagation of errors, ill-conditioned systems, condition number.
Nonlinear algebraic equations:
Single nonlinear equation: Bisection method, Successive substitution , Secant (Regula falsii) method, Newton-Raphson method, Order of convergence of different methods.
Determination of roots of a polynomial. Solution of simultaneous nonlinear algebraic equations: Successive substitution, Newton-Raphson method.
Regression: Method of Least Squares, Linear and Nonlinear Least Squares, Marquardt algorithm.
Interpolation/Extrapolation:
Newton's Divided Difference Formulae, Lagrange Interpolation; Equispaced base-point methods - Newton's Forward Difference and Backward Difference Formula. Cubic Spline Interpolation.
Numerical Differentiation - based on interpolation formulae.
Numerical Integration (Quadrature) - Newton-Cotes formulae, Trapeziodal Rule, Simpson's Rule, Composite formulae, Romberg formula, Gaussian quadrature, Chebyshev formulae.
Ordinary Differential Equations - Initial Value Problem (IVP):
Explicit methods: Adam-Bashforth techniques; Implicit methods: Adams-Moulton techniques;
Predictor-Corrector Formulae; Runge-Kutta and Runge-Kutta-Gill methods.

Ordinary Differential Equations - Boundary Value Problem (BVP):
Finite Difference Methods; Finite Element Methods.
Partial Differential Equations:
Elliptic, Hyperbolic and Parabolic PDEs; Nonlinear PDEs, Laplace's equation, Bi-harmonic equation, Characteristic value problems and solution.

ChE/Math/T/216 MATHEMATICS – IIIB

Infinite series: Concept of a sequence and its limit sum of an infinite series as the limit (if exists) of its partial sum upto terms. The geometric series.
The comparison test, D'Alembert's ratio test and Cauchy's root test for the convergence of an infinite series.
Fourier's series. Periodic functions. Trigometric series of sines and cosines. Euler formulac. Dirichlet's conditions. Even and odd functions. Half-range sine and cosine series.
Ordinary Differential Equation. First order linear and non-linear equations. Linear second order equations. Ordinary point and regular singular point of linear second order equations. Series solutions. Bessel , Legendre, Hermite and Laguerre equations. Generating functions and recurrence relation of Bessel functions and Legendre polynomials. Orthogonality of Legendre polynomials. Partial Differential Equations of Mathematical Physics: Solutions of one-dimensional wave equation, one dimensional heat flow equation and two-dimensional Laplace equation by the method of separation of variables. Applications to physical problems.

ChE/Chem/S/211 PHYSICAL CHEMISTRY LABORATORY-I

1. Determination of viscosity coefficient
2. Determination of surface tension
3. Determination of distribution coefficient
4. Determination of equilibrium constant (homogeneous)
5. Determination of phase diagram (ternary system)
6. Determination of adsorption isotherm

MDD/ME/T/1
MDD/ME/S/1 MACHINE DESIGN AND DRAWING

Basic idea of design, factor of safety, modes of failure, theories of failure, design under static and fatigue loading.
Design of Cotter/knuckle Joint, threaded and riveted joint, eccentric loading. Shaft coupling (rigid / flexible). Belt-pulley drive. Pressure vessel.

MDR/ME/S/1 MACHINE DRAWING

Stuffing Box, Pipe Joints, Valves, Tool head of shaping machine, Plummer Block, Engine Parts.

Second Year Second Semester

ChE/T/221 CHEMICAL PROCESS CALCULATIONS

Material balances:
Fundamentals; Batch and flow processes, Steady-flow and unsteady processes, material balance calculations for single-unit and multiple-unit processes, material balance for reactive and non-reactive systems, processes with recycle and/or bypass with or without purge, material balance for combustion reactions, unsteady-state and transient processes.
Energy balances:
Introduction to energy balances, energy balances on closed and open systems - the steady-flow energy equation, mechanical energy balances, tables of thermodynamic data. Energy balances on nonreactive processes - state properties and hypothetical process paths employed for their estimation, energy balances for phase change operations, heat of mixing and heat of solution - energy balance for mixing and dissolution processes. Energy balances on reactive processes - heats of reaction, measurement and calculation of heats of reaction - Hess's Law, formation reactions and Heats of Formation, Heats of Combustion, Energy balances for combustion reactions - adiabatic reaction temperature, theoretical flame temperature.
Combined material and energy balances including some typical industrial problems. Unsteady state material and energy balances.

ChE/T/222 STATISTICAL METHODS

Introduction: Inductive and descriptive statistics; Variables - discrete and continuous; Population and sample; Data.
Frequency Distributions; Histograms and Frequency polygons; Relative-Frequency and Cumulative-Frequency Distributions; Ogives; Frequency Curves.
Measures of Central Tendency: Mean (A.M.), Median and Mode; Geometric mean (G.M.) and Harmonic Mean (H.M.); Relation between A.M., G.M. and H.M.; Quartiles, deciles and percentiles; Root-Mean-Square (RMS) Mean.
Measures of Dispersion: Range, Mean Deviation, Standard Deviation; Variance; Coefficient of Variation;
Standardized Variables and Standard Scores.
Moments, Skewness and Kurtosis.
Probability Theory: Classical definition; Probability as relative frequency; Set-theoretic concept of probability; Conditional Probability - Dependent, Independent and Mutually exclusive events; Mathematical Expectation - Bayes' Theorem; Probability Distributions - discrete and continuous; Probability mass function and Probability density function; Binomial, Poisson, Exponential and Gaussian (Normal) Distributions; Multinomial Distribution; Fitting theoretical distributions to Sample Frequency Distributions.
Sampling: Population and sample; Random Sampling - with and without replacement; Sampling Distributions - Means, Proportions, Differences and Sums; Standard Errors.
Statistical Estimation: Estimates of parameters; Point estimators and Interval estimators; Unbiased and efficient estimates; Confidence-Interval estimates of population

parameters; Probable Error.
Test of Hypotheses - Statistical Decision Theory; Type I and Type II Errors; Level of Significance; Tests involving Binomial and Normal Distributions; Two-tailed and One-tailed tests; One-sample and two-sample tests; Special tests; Operating-characteristic curves; Power of a test; Control charts;
Sampling Distributions - Student's-'t', Chi-square and 'F' distributions; Confidence Intervals; Degrees of Freedom; Chi-square test for Goodness of Fit; Contingency Tables and Coefficient of Contingency; Correlation of Attributes.
Statistical Correlation: Measures of correlation; correlation coefficient; spurious correlation; Linear correlation coefficient - Product-Moment Formula; Correlation of Time Series; Correlation of Attributes; Sampling Theory of Correlation.
Regression Analysis, Curve Fitting and Least Squares:
Regression Analysis; Linear Regression; Curve-fitting; Method of Least Squares; Sum of Squares of Residuals (SSR) as a criterion of goodness of fit of a curve to sample data; Linearly transformable nonlinear relationships; Multivariable linear regression; Introduction to Nonlinear Least Squares.
Analysis of Variance (ANOVA): One-Way and Two-Way ANOVA; ANOVA Tables; Experimental Design;
Nonparametric tests - Sign test; 'U' test; 'H' test; Runs test; Rank correlation.
Analysis of Time Series: Moving Averages; Estimation of Trend and Seasonal Variations; Seasonal Index; Deseasonalization of data; Comparability of Data; Forecasting.
Statistical Quality Control: Control Charts - X-bar, R, P- and NP- Charts.

ChE/T/223 CHEMICAL ENGINEERING THERMODYNAMICS

Thermodynamic property relations:
Maxwell Relations, The Jacobian Method, Relation between heat capacities, Joule-Thompson coefficient, Clapeyron equation.
Postulational thermodynamics - Thermodynamic Potential, Criteria for equilibrium, Euler relation.
Thermodynamic analyses of industrial processes.
Introduction to the Third Law of thermodynamics.
Thermodynamic properties of pure substances:
Equations of State - Ideal gas law, Cubic equations of state, Van der Waals equation, Redlich-Kwong, Soave-Redlich-Kwong, Peng-Robinson and Benedict-Web-Rubin equations; Properties of equations of state; Corresponding States correlations - Acentric factor; Generalized compressibility factor Z and state correlations based on it; approaches of Lee and Kesler, and of Pitzer et al. Estimation of densities of pure liquids.
Thermodynamic properties of real gases - Residual properties and Property estimation from experimental data, Fugacity and fugacity coefficient. Estimation of fugacities of solids, liquids and gases.
Thermodynamic properties of mixtures:
Partial molar properties and relation with total mixture property; Gibbs'-Duhem equation; Chemical Potential, Mixing Rules, Departure functions for real gas mixtures, fugacity and fugacity coefficients of real gas mixtures.

Solution Thermodynamics:
Ideal and non-ideal solutions; Dilute Solutions; Thermodynamic Properties of Solutions; Lewis-Randall rule, Raoult's Law and Henry's Law; Colligative properties; Excess properties; Activity and activity coefficient; Estimation of activity coefficients using Redlich-Kister, Margules, Van Laar, Wilson, NRTL, UNIQUAC and UNIFAC models.
Phase Equilibria:
Phase transitions and phase equilibria; Gibbs' phase rule; Binary Vapor-Liquid equilibria (VLE); VLE at low and high pressures; Modified Raoult's Law; VLE for miscible, partially miscible and immiscible systems; VLE using equations of state, Liquid-Liquid Equilibria (LLE), Adsorption equilibria - common adsorption isotherms.
Chemical Reaction Equilibria:
Extent of reaction; Equilibrium constant; Effect of operating conditions on equilibrium conversion; determination of equilibrium compositions for homogeneous gas-phase reactions - single and multiple reactions; liquid-phase reaction equilibria.
Electrochemical Equilibria and applications.

ChE/T/224 INTRODUCTION TO TRANSPORT PROCESSES

Importance of heat, mass and momentum transfer in chemical engineering operations and processes.
Overview of transport mechanisms - molecular, convective and turbulent.
Molecular transport - driving force, gradient, flux, rate and generalized diffusivity.
Diffusivities of heat, mass and momentum - Fourier's Law, Fick's Law and Newton's Law. Analogy between molecular diffusion of heat, mass and momentum and its limitation.
Estimation of transport properties.
Determination of diffusive fluxes in various conditions.
Convective transport of heat and mass - molecular diffusion and advection. Free and forced convection. Convective heat and mass transfer coefficients; resistances to heat and mass transfer; transport across multiple resistances - in series and/or in parallel. Concept of controlling resistance. Illustrative applications in heat transfer and interphase mass transfer. Heat transfer by combined conduction and convection - overall heat transfer coefficients.
Conservation Equations - Differential heat, mass (species) and momentum balance, dimensionless form.
Equations of Change - Equation of Continuity and Equations of Motion (the Navier-Stokes equations), Euler equation, Energy equation, species balance equation.
Dimensionless groups from the Navier-Stokes' and other equations.
Turbulent transport - eddy diffusivities.
Boundary layer theory - Convective boundary layers, boundary layer similarity.
Models for mass transfer - film theory, penetration theory and surface renewal theory.
Analogies between heat, mass and momentum transfer.

ChE/T/225 CHEMICAL TECHNOLOGY-I

Water for the chemical process industry and its treatment, Boiler feed-water, Cooling tower water, Process Plant water, Treatment of water: lime-soda process, Flocculation, aeration, deaeration, ion-exchange etc.
Acid industries : Sulfuric, hydrochloric and nitric.
Alkali industries: Caustic soda, Sodium carbonate, Chlorine, Bleaching powder.
Cement.
Fertilizers.

ChE/Math/T/226 MATHEMATICS – IVB

Functions of a complex variable: Limit, continuity and differentiability of the function of a complex variable. Cauchy – Riemann differential equations. Harmonic functions. Line integral. Complex integral. Cauchy's fundamental theorem. Cauchy's integral formula. Taylor's and Laurent's theorems. Singularity, Pole, Cauchy's residue theorem. Contour integration.
Integral transforms: Fourier Transform, Laplace Transform, Z-Transform, Applications.
Vector Calculus: Vector function of a scalar variable. Derivative of a vector function. Applications to geometry and mechanics. Gradient. Divergence. Curl, Diadics. Vector integration. Line surface and volume integrals. Green's theorem in the plane. Theorems of Gauss and Stokes' (statement only) Applications.
Tensor Algebra:
Definition, Covariant and contravariant tensors, properties. Christoffel symbols. Cartesian tensors.

ChE/S/221 APPLIED NUMERICAL ANALYSIS LABORATORY

Application of Numerical techniques for : Solution of Linear and nonlinear algebraic equations, Function approximation, Solution of ODEs and PDEs arising in Chemical Engineering problems.

ChE/Chem/S/222 PHYSICAL CHEMISTRY LABORATORY-II

1. Conductometric titration
2. Potentiometric/pH-metric titration
3. Verification of Beer's law
4. Determination of specific rotation
5. Determination of CMC
6. Analytical application of refractive index measurement
7. Determination of decomposition voltage

ChE/EE/S/223 ELECTRICAL ENGINEERING LABORATORY

Experiments to supplement the course on "Electrical Technology-B".

Third Year First Semester

ChE/T/311 SEPARATION PROCESSES-I

Interphase mass transfer: Material balance of one-component transfer in cocurrent and countercurrent process, Stage, Cross flow and Countercurrent cascades; Efficiencies - definition and estimation; Entrainment. Packed columns and staged columns.
Gas absorption: Equilibrium data - representation and estimation; Cocurrent and countercurrent flow - dilute and concentrated solution; Countercurrent multistage operations - absorption factor, tray efficiencies; Continuous countercurrent contact.
Distillation: Equilibrium data - representation and estimation; Steam distillation, Differential distillation, Flash vaporization; Multistage tray towers (Ponchon-Savarit and McCabe- Thiele methods); Use of open steam, Multiple feeds, Side stream, Tray efficiencies; Design of continuous contactors; Azeotropic, extractive and molecular distillation.
Liquid Extraction: Equilibrium data - representation and estimation, method of calculation - one- component transferring and all three- component transferring (representation on equilateral diagram and solvent free basis) in single-stage, multistage - crosscurrent and countercurrent operation; Design of continuous contact equipment.
Adsorption: Equilibrium data - representation and estimation (Langmuir, Freundlich, B.E.T. etc. models); one-component and two-component adsorbed in Single-stage, Multistage crosscurrent and countercurrent operation; Design of continuous-contact adsorbers.
Leaching: Method of calculation for Single-stage, multistage crosscurrent and countercurrent operation.

ChE/T/312 CHEMICAL REACTION ENGINEERING

Material balance for a reactive process - rate of a chemical reaction; expression of reaction rate for unsteady and steady-flow stirred-tank reactors and tubular reactors. Performance equation (design equation) and rate equation.
Kinetics of chemical reactions - elementary and non-elementary reactions, nth-order kinetics, rate equations with multiple rate constants, shifting-order kinetics, interpretation of batch reactor data for simple and complex reactions, dependence of reaction rate on environmental conditions - Arrhenius' equation.
Concept of fractional conversion in batch and flow reactors. Constant-volume and variable-volume reactors.
Homogeneous gas-phase and liquid-phase reactions: Performance equations for batch, semibatch, continuous-flow stirred-tank and plug-flow reactors. Design for single and multiple (i.e. series-parallel) reactions. Reactors in series. Isothermal, adiabatic and temperature-programmed reactors, concept of mixed reactors, thermal stability of reactors.
Heterogeneous reactions: Introduction to non-catalytic and catalytic heterogeneous reactions, kinetically -controlled and diffusion-controlled regimes, determination of rate controlling steps. Catalysis - principles, types of catalysts and catalytic reactors. Packed-

Bed and Fluidized-Bed Reactors.
Heat effects of reactions - cooling arrangements for isothermal reactors.

ChE/ET/T/313 ELEMENTARY ELECTRONICS

Energy band structure of metals, semi-conductors and insulators; Electron conduction in intrinsic and extrinsic semiconductors; P-Type and N-Type semiconductors; P-N junction; Metal-conductor junction
Junction diode, zenner and avalanche breakdown, rectifiers, filters and voltage regulators, BJT and its characteristics in CB and CE configurations; Bias stability, Low frequency, small signal analysis of BJT using simplified hybrid models; basic concepts of feedback amplifiers.
FET and MOSFET - Characteristics and applications
Digital System; Elements of Digital Circuits - AND, OR, NOT, NOR, NAND gates. Flip-flops (R-S, J-K, Master-Slave), ExOR, Half Adder & Full Adder.

ChE/T/314 MECHANICAL OPERATIONS

Crushing and grinding - principles, different types of equipment, open circuit and closed circuit grinding, power requirement.
Granulation and other size enlargement operations.
Particle separation - Sampling and screening, particle size measurement, cyclone separator, hydrocyclone, bag filter, magnetic and electrostatic separator.
Hydraulic separation, heavy media separator, jigging, froth flotation, elutriation, tabling.
Free and hindered setting, thickening, counter-current decantation, flocculation and flocculating agents.
Filtration - Theory of filtration, filter equipment, filter medium, filter aid, filter auxiliaries; Centrifuges and centrifugal filtration.
Mixing of solids, liquids and slurries.
Material handling - handling and conveying of fluids, slurries and solids; pumps - types, applicability and characteristics.

ChE/T/315 CHEMICAL TECHNOLOGY-II

High polymers (including plastics, rubbers, fibres) - their chemistry and technology, cellulose and cellulose products.
Petroleum refining operations and Petrochemicals.
Oils and fats - chemistry, refining, bleaching, deodorization, applications e.g. soaps and detergents.
Paints and varnishes.
Pulp and paper.
Sugar.
Leather.
Industrial fermentation and ethyl alcohol.

ChE/T/316 PROCESS HEAT TRANSFER

Conduction: Mechanism of heat transfer, Fourier's law, steady state heat transfer through composite slabs, composite cylinders and unsteady state heat transfer.- use of Gurney-Lurie chart.
Convection: Heat flow mechanism by convection, Individual & overall heat transfer coefficient, log-mean temperature difference, forced convection inside tubes and ducts - Dittus-Boelter equation, Reynold's analogy, Natural convection, condensation of single and mixed vapors, heat transfer to boiling liquids. Types of heat exchange equipment and design of heat exchangers; Shell-and-tube heat exchangers, Double-pipe heat exchanger, Condenser and Reboiler.
Radiation: Concept of black body and laws of black body radiation, Kirchhoff's law, emissivity, radiant heat transfer between surfaces separated by non-absorbing media, radiation error in Pyrometry.
Evaporation : The mechanism of vaporization, single & multiple effect evaporators, types of evaporators with accessories, design calculations for evaporators and optimum number of effects, Thermo-compression evaporator.

ChE/S/311 MOMENTUM TRANSFER AND MECHANICAL OPERATION LABORATORY

Study of pipe fittings, valves and other equipment, pressure drop for flow through pipe line - valves and fittings, Pump characteristics, Flow measurement by orifice meter, venturimeter, rotameter, pitot tube, weirs. Pressure drop for flow through packed bed and fluidised bed, studies on crushing and grinding, screening efficiency. Studies on filtration and other mechanical operation.

ChE/S/312 COMPUTER APPLICATIONS IN CHEMICAL ENGG. LABORATORY

Solving assorted chemical engineering problems using software packages e.g. MATLAB, Mathematica etc.

WS/ME/S/12A WORKSHOP PRACTICE-XII (Machine Shop)

Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; machine shop work involving different operations by using the above mentioned machines through making of jobs.
Experiments on: Study of the speed structure of a lathe, study of apron mechanism and calibration of feeds in a lathe.
Study and grinding of various cutting tools.

Third Year Second Semester

ChE/EE/T/321 PRINCIPLES OF MEASUREMENT AND INSTRUMENTATION

Introduction: Need for measurement of Process variables, Classification of measurement errors (Deterministic and Probabilistic)
Steady state and Dynamic characteristics of instruments, Instrument calibration technique, Selection of instruments.
Process transducers and application:
Temperature Measurement - Thermocouple, RTD, Optical & Radiation pyrometer.
Pressure measurement- manometers, instruments based on mechanical elastic element, strain gauge, electrical transducers, High vacuum and differential pressure measurement.
Flow measurement- Constant and variable area flow meters, Anemometers, Open channel flow - Weirs, Special flow measurement devices, Granular solid flow measurement.
Level measurement - Direct and Inferential type instruments, Granular solid level measurement.
Chemical composition measurement based on - Optical properties, Thermal conductivity, para-magnetic properties, conductivity of solution, Combustion products, adsorption properties, Chomatography, Molecular and Atomic Properties.
Density, Viscosity and Humidity measurement.
Instrumentation Devices and Systems:
Controller - Pneumatic, electronic, analog and digital controller, self-tuning and multifunction controllers.
Actuators: Pneumatic, Hydraulic, Valve positioner.
Indicating, Recording and Data acquition devices.
Final controlling elements - Control valve and their types and characteristics, Valve sizing.
Industrial Instrumentation Systems:
Components, structure, specification, planning, monitoring and design, case study.

ChE/T/322 PROCESS DYNAMICS AND CONTROL

Introduction to dynamics of variables, Dynamic Characteristics as an extension of Steady State behavior, examples, Dynamic Elements of a Process, Introduction to Feedback Control Theory, Instrument Symbols.
Dynamic model, Input/Output (I/O), State variable, Transfer function description of dynamic models of processes - 1st order, 2nd order systems - Interaction, Linearization, Dead-time, Multiple I/O systems, Degree of freedom.
Dynamic Response of Open-loop processes.
Ideal Controller dynamics, The PID Control Algorithm, Lead-Lag
Feedback Control System Synthesis, Block diagram, Loop transfer function, closed loop dynamics,
Analysis of Temperature-Loop, Pressure-loop, Flow-loop, Level-loop, and Composition-loop.
Stability of dynamic systems - Concept of pole location and movement of poles on complex s-plane; Routh-Hurwitz criteria; Root Locus method
Selection and Tuning of Controllers - Methods based on FOPDT model and PRC;

Integral Error Criteria; Model-independent methods based on field trials - Continuous Cycling and Frequency Response. Bode Stability Criterion. Nyquist Stability Criterion; Applications.
Advanced Control Strategies - Preliminary treatment - Ratio Control, Feed forward control, Cascade control, Selective Override control, Adaptive control.
Computer Based Control - Preliminary treatment - I/O peripheral devices- Analog programming, Introduction to PLC.
Examples of Control Systems employed for Process Plant Equipment.

ChE/T/323 ENERGY RESOURCES AND THEIR UTILIZATION

Introduction -Survey of different sources of energy and their utilization.
Fossil Fuels - coal, crude petroleum and natural gas.
Processed Fuels - Charcoal, coke, water gas, producer gas, refinery gas, LPG and synthetic petrol.
Nuclear Fuels - Sources of nuclear fuels and introduction to nuclear reactions.
Solar Energy-. Effective utilization of solar energy for room heating, water heating and other industrial processes.
Energy from Biodegradable Materials - Survey of bio-degradable materials, Methods of processing the materials with special reference to gobar gas plant.
Energy utilization - Thermodynamic and economic aspects of utilization:. Design of burners stokers, and furnaces for. combustion of various conventional fuels.
Waste Heat Recovery - Analysis of waste heat systems and efficient methods of heat recovery.

ChE/T/324 SEPARATION PROCESSES-II

Humidification Operations: Equilibrium data of pure substance - representation and estimation; Adiabatic saturation curves, Wet-bulb temperature; Design of towers for water cooling of air, dehumidification of air-water vapor system.
Drying: Equilibrium data representation; Batch drying; Drying theories; Cross circulation drying; Through circulation drying; Continuous drying - design of driers operating at high and low temperatures.
Crystallization: Equilibrium data representation; Supersaturation; Origin of crystals in crystallizers, crystal growth; Estimation of CSD in idealized crystallizers; Continuous crytallizers; Temperature-programmed crystallizers - cooling curves.
Membranes: Theory, fields of application and design of modules for gas separation, pervaporation, dialysis, electrodialysis, reverse osmosis, ultrafiltration, liquid membranes.

ChE/T/325 OPTIMIZATION METHODS

Introduction to optimization.
Single-variable optimization - local and global extrema; stationary points - conditions for a stationary point to be a mimimum, maximum or inflection point.
Unconstrained Multi-variable optimization - necessary and sufficient conditions for a

stationary point to be an extremum or saddle point based on definiteness of the Hessian matrix; convex and concave functions;
Multi-variable optimization with Equality Constraints - Method of Constrained Derivatives (Jacobian method) and Method of Lagrangean multipliers.
Multi-variable optimization with Inequality Constraints - the Kuhn-Tucker conditions.
One-dimensional minimization methods: (A) Elimination methods - Unrestricted search, exhaustive search, dichotomous search, Fibonacci search, Golden Section method; (B) Interpolation methods - Quadratic interpolation method, Cubic interpolation method, Direct root method.
Unconstrained optimization methods: (A) Direct Search Methods - Random Search methods, Univariate Method, Pattern Search methods, Rosenbrock's Method of Rotating Coordinates, Simplex Algorithm; (B)Descent Methods - Gradient of a function, Steepest Descent method, Conjugate Gradient method (Fletcher-Reeves algorithm), Quasi-Newton methods, Variable Metric method (Davidon-Fletcher-Powell algorithm).
Constrained Optimization Methods - (A) Direct methods - The Complex method, Cutting Plane method, Method of Feasible Directions; (B) Indirect Methods - Transformation techniques, Interior and Exterior Penalty Function methods or Sequential Unconstrained Minimization Techniques (SUMT), Convex Programming, Convergence of constrained optimization problems. Other constrained optimization techniques - separable programming, quadratic programming, geometric programming and stochastic programming.
Optimization of dynamic processes - ODE constraints, the Optimal Control problem, Trajectory optimization;
Nontraditional Optimization Algorithms - Genetic Algorithms, Simulated Annealing, Differential Evolution.

ChE/Met/T/326 MATERIAL SCIENCE & ENGINEERING

Properties of solids that chemical engineers need to understand and exploit in regard to chemical processing and industrial equipment; Chemical and physical bonds; Crystal structure and defects; Metals and alloys; mechanical properties; phase transformations; diffusion nucleation; microstructure. Structure and properties of polymers, Semiconductors, Electrochemical reactions and corrosion.

ChE/S/321 REACTION ENGINEERING AND THERMODYNAMICS LABORATORY

Kinetic study in a batch reactor.
Kinetic study in adiabatic batch reactor.
Study of the performance of a mixed flow reactor i.e. isothermal condition.
Study of the performance of a Tubular Reactor - isothermal condition.
Kinetic study of a mixed reactor.
Polymerization reaction study in a batch kettle.
Study on a immobilized enzyme Reactor.
Kinetic study of a gas-liquid reaction in a packed bed.
Kinetics of a combustion reaction.

Study of binary VLE.
Estimation of distribution coefficient.
Study of binary SLE.

ChE/S/322 CHEMICAL EQUIPMENT DESIGN & DRAWING –I

Flow-sheeting - Plan and Space layout of Chemical Processes. Design of orifice meter, Venturimeter, Rotameter etc. Pipeline Design.
Pressure Vessel Design.

Fourth Year First Semester

ChE/T/411 BIOPROCESS ENGINEERING

Overview of biological basics.
Bio-reaction engineering:
Stoichiometry, energetics and kinetics of microbial cell growth and product synthesis. Culture media formulation and optimization. Sterilization. Bioreactors - operation, selection, design, scale-up, stability and control. Kinetics of biofilms (surface-attached cultures) - bioreactors for culturing surface-attached microorganisms, e.g. rotating-disk bioreactors. Other non-conventional bioreactors.
Population dynamics of mixed cultures. Recombinant DNA technology - culture kinetics and stability, selection and design of host-vector systems.
Enzyme technology - Enzyme kinetics, enzyme immobilization and industrial production of enzymes.
Bio-separation engineering:
Introduction and scope. Solids removal operations - settling, centrifugation and filtration. Product isolation - adsorption and extraction. Purification techniques - precipitation, ultrafiltration, chromatography and electrophoresis. Product polishing operations - crystallization and drying.
Integrated bio-reaction and bio-separation processes - membrane bioreactors, extractive fermentation.
Bioprocess considerations for plant cell and animal cell cultures.
Environmental biotechnology - wastewater engineering, bioremediation.
Bioprocess instrumentation. Regulatory issues.

ChE/T/412 MATHEMATICAL MODELLING IN CHEMICAL ENGINEERING

Analytical Methods for solution of linear and nonlinear ODEs and PDEs.
Application of Operational Mathematics in solving ODEs and PDEs.
Calculus of Variations.
Formulation and solution of mathematical models of chemical engineering processes (steady and transient) involving momentum, heat and mass transfer (with or without chemical reaction), using analytical and numerical techniques.
Uniqueness condition for linear and nonlinear systems, multiple steady states.
Stability analysis - bifurcation theory and applications.

ChE/T/413 ENVIRONMENTAL SCIENCE AND ENGINEERING

Air Pollution:
Types of Pollutants, Sources of Pollutants, Classification of Pollutants: Particulates, Hydrocarbons, Carbon Monoxide, Oxides of Sulfur, Oxides pf nitrogen, Photochemical Oxidants, Indoor Air pollution.
Control Devices for Particulate Contaminants: Gravitational Settling Chambers, centrifugal Collectors, Wet Collectors, Fabric Filters, Electrostatic Precipitators, Control Devices for gaseous Contaminants
Adsorption, Absorption, Condensation, Combustion, Automotive Emission Control.
Water Pollution:
Introduction, Water quality standards and parameters, Aquatic pollutants, Freshwater pollution, Marine pollution; Wastewater Treatment
Pre-treatment of water: Sedimentation, coagulation and flocculation, Filtration, Disinfection, Fluoridation
Primary Treatment: Screening, Comminuting, Grit Removal, Primary sedimentation
Secondary Treatment:
Growth and Food utilization, Activated Sludge, Ponds and Lagoons, Attached Culture systems, Secondary Clarification.
Introduction to anaerobic digestion, Microbiology of anaerobic digestion, Reaction configurations, Methane Production, Application of anaerobic digestion
Tertiary Treatment:
Membrane Separation Processes, Ion Exchange, Chemical Methods
Hazardous Waste Treatment:
Introduction, Definition of hazardous waste, Hazardous waste generation, Medical hazardous waste, Hazardous waste treatment facility, Treatment of systems for hazardous waste, Disposal of hazardous waste.

ChE/T/414 CHEMICAL PROJECT ENGINEERING & ECONOMICS

Introduction to Chemical Plant Design; Functions of Project Engineer. Process selection and evaluation;
Essential Flow Diagrams for understanding chemical processes - Block Flow Diagrams (BFD), Process Flow Diagrams (PFD), Piping and Instrumentation Diagram (PID).
Plant Layout - Location of Chemical plant, raw materials and utilities.
Project Costs - Capital Costs and Manufacturing Costs - their estimation.
Engineering Economic Analyses - Return on Investments and the Time Value of Money, Simple and Compound Interest, Discrete and Continuous compounding, Inflation, Inflation-adjusted interest rates.
Cash Flow Diagrams - Discrete and Cumulative. Annuities - their present and future worth, discount factors. Depreciation of Capital Investment - Type of depreciation. Taxation, Cash Flow and Profit.
Profitability Analysis of Projects and Equipments - Discounted and non-discounted profitability criteria, Incremental Economic analysis, Evaluation of Process Equipment alternatives, Incremental Analysis for Retrofitting Facilities - Discounted and non-discounted methods.

Methods of cost calculations of chemical process equipment.
Optimum design of pipe line, lagging thickness, heat exchanger, distillation column, reactor, storage vessels, evaporators etc.
Scale-up - Introduction; Principles and theory; Concept of similarity - different types of similarity. Scale equations for common chemical engineering systems - applications and limitations.
Application of Scale-up techniques to the selection and specification of chemical process equipment - solid-liquid separations, reactors, heat exchangers etc. Limitations of scale-up.

ChE/T/415 ELECTIVE-I

ChE/T/415A SEPARATION OF MULTI-COMPONENT SYSTEMS

Prediction of equilibrium data and equilibrium flash separators for multi-component mixtures. Theory and design of multi-component separation - Methods for distillation, absorption and extraction, Tray-hydraulics and tray efficiency.

ChE/T/415B MODERN SEPARATION PROCESSES

Fixed bed processes: Ion-exchange, Molecular sieve
Membrane separation processes: Reverse Osmosis, Dialysis, Ultrafiltration, Microfiltration, Nanofiltration, Pervaporation.
Diffusional Processes: Gaseous diffusion, Thermal diffusion.
Processes based on electric field: Electrophoresis, Electrodialysis.

ChE/T/415C CATALYSIS & CATALYTIC REACTOR DESIGN

Homogeneous and heterogeneous catalysis.
Nature and mechanism of catalytic reactions.
Physical properties of catalyst, Determination of surface area of catalyst, void volume, solid density and pore-volume distribution.
Classification of catalysts, catalyst preparation.
Promoters and inhibitors, catalyst life and deactivation.
Transport processes with fluid-solid catalytic reactions. Design of fixed bed catalytic reactors for isothermal and adiabatic operations. Design of fluidised bed reactors, Slurry reactors, Paddle reactors and recycle reactors.

ChE/T/415D INTERFACIAL SCIENCE AND TECHNOLOGY

Surfaces and Colloids: The twilight zone, colloidal stability and its applications
General concepts: Surface free energy, the work of cohesion and adhesion, The molecular nature of the interfacial region
Stability and Forces: Chemical and physical interactions, The importance of long range physical forces, classification of physical forces, van der Waals forces, interaction between Surfaces and particles, Lifshitz theory
Hydrodynamic flow effects in interfacial effects, Electrostatic forces and the electric double layer, Colloidal stability, Coagulation kinetics
Characterization of liquid and solid surfaces in terms of Interfacial Tension; Capillarity: Theory of capillarity, equilibrium and dynamics of free fluid surfaces, Contact angle, Young Laplace equation, Measurement of surface tension from Capillary rise, Capillary flow, Wetting and Spreading, Spreading coefficient, Rayleigh Instability.
Effect of surface curvature on vapor pressure, Kelvin equation, Oswald ripening, capillary condensation practical systems: Wetting in woven fibers and papers, waterproofing or repellency control, capillary action in detergency
Adsorption: Gibbs surface excess, Gibbs adsorption equation, Adsorption at Solid - vapor interface, energetic considerations, chemi-sorption and heterogeneous catalysis, Solid - vapor adsorption isotherms, Adsorption at solid -liquid interfaces, Quantification of Surfactant adsorption
Surfactant, Emulsions, Foams, Aerosols.

ChE/T/426
ChE/S/411
ChE/S/421 EXPERIMENTAL PROJECT / DESIGN

Specific projects/designs will be assigned by the teachers concerned.

ChE/S/412 SEMINAR

Seminar on some current topics in chemical engineering.

ChE/S/413 CHEMICAL EQUIPMENT DESIGN AND DRAWING –II

Process and Mechanical design with drawing of the following: Shell and tube heat exchanger, Evaporator. Reactors, Dryer.

ChE/S/414 ENERGY ENGINEERING LABORATORY

Proximate analysis of coal
Properties of liquid fuels: Flash point & Fire point, Carbon residue, Viscosity & Viscosity Index, Distillation characteristics.
Hard groove grindability index of coal.
Calorific values of solid, liquid & gaseous fuels. Ors at analysis of gaseous mixture.
Washability of coal
Caking Index of coal, Swelling Index of coal.
Studies of operating character of solar collectors.

Studies on flame stability and burner characteristics.
Studies on properties of bio-mass.

Fourth Year Second Semester

ChE/T/421 CHEMICAL PROCESS SYNTHESIS

Introduction to system syntheses, Synthesis of reaction paths.
Flow-sheet synthesis, Synthesis of pipe-line network.
Heat exchanger network design.
. Analysis of reactor systems.
Synthesis of separation sequences.
Conservation of energy - optimum energy recovery network.
Synthesis of control systems.

ChE/T/422 ELECTIVE -II

1. HIGH POLYMER TECHNOLOGY
2. FLUIDIZATION ENGINEERING
3. COMPUTATIONAL FLUID DYNAMICS
4. STATISTICAL THERMODYNAMICS

ChE/T/422A HIGH POLYMER TECHNOLOGY

Fundamentals of polymerization, classification of polymers based on reaction, based on properties, Types of polymers, Methods of polymerization.
Molecular weight of Polymers, their determination and distribution. Effect of molecular weight distribution on polymer properties.
Fundamentals of Rheology and Visco-elasticity of Polymer systems. Non-Newtonian fluids, types of viscometers, Hookean body, Visco-elastic body, Dynamic behaviour of Polymer system, different mechanical models.
Rubbery state, Glass transition temperature, Natural and Synthetic Rubber, mastication, compounding, curing of rubber, processing machineries like calendaring, extrusion, molding etc.
Fibre state, Crystallinity, Synthetic and Natural fibres, Processing of fibres.
Processing of plastics - extrusion, molding, calendaring, mixing, vacuum forming etc.

ChE/T/422B FLUIDIZATION ENGINEERING

Basic concept of fluidization, Comparison of fluidized bed and fixed bed. Advantages and disadvantages of fluidized bed. Industrial application of fluidization technique. Particulate and aggregative fluidization. Pressure drop flow diagram. Channeling and slugging in fluidized bed. Distributor for fluidized bed. Estimation of minimum fluidization velocity and range of velocities for fluidization. Stratification of particles in

fluidized bed. Fluidization efficiency. Voidage variation in fluidized bed. Transport disengaging height. Heat and mass transfer in fluidized bed.

ChE/T/422C COMPUTATIONAL FLUID DYNAMICS

Review of equations governing fluid flow and heat transfer, applied numerical methods; Consistency, stability and fundamentals of fluid flow modeling; Finite difference applications in heat conduction and convection; Solution of viscous incompressible flows by the stream function- vorticity formulation; Solution of Navier-Stokes equations for incompressible flows using MAC; Introduction to spectral methods, Automatic grid generation for complex geometry problems.

ChE/T/422D STATISTICAL THERMODYNAMICS

Principles of statistical thermodynamics:
Foundations of statistical mechanics - Classical Mechanics (Lagrangian and Hamiltonian formulations, Poisson Brackets and Canonical Transformations).
Phase space, Liouville's Theorem and Equipartition Theorem; Ensemble Theory - Microcanonical, Canonical and Grand Canonical Ensembles; Density Matrix, Partition Function, Energy Levels, Thermodynamic Probability, Statistical interpretation of entropy, Quantum States, Degeneracy and Pauli Exclusion Principle.
Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann Statistics. Bosons and Fermions.
Applications of statistical thermodynamics:
Applying the results of statistical thermodynamics to obtain expressions for macroscopic intensive thermodynamic properties (e.g. pressure, temperature, entropy, free energy, specific heats etc.) for some simple systems, viz. ideal monatomic gas, ideal diatomic gas, photon gas, crystals (Einstein model and Debye model), ideal gas mixtures - non-reacting and reacting.

ChE/T/423 ELECTIVE-III / OPEN ELECTIVE

ChE/T/423A OPERATIONS RESEARCH

Overview of operations research.
(A) Deterministic Methods:
Introduction to Linear Programming - The Simplex Algorithm, Dual Simplex Method, Primal -Dual computations, sensitivity analysis.
Transportation Model and its variants - Transportation algorithm, the Assignment model - the Hungarian method, the Transshipment model.
Network Models and Algorithms - Scope and definitions, Minimal spanning tree

algorithms, Shortest route problem, Maximal flow model.
Advanced Linear Programming - Efficient Computational algorithms, Duality, parametric linear programming, Karmarkar Interior Point algorithm.
Goal Programming - Problem Formulation, Algorithms- Weighting Method and Preemptive Method.
Integer Linear Programming - illustrative applications (Sequencing - processing 'n' jobs through 'm' machines; the Travelling Salesman problem), Algorithms - Branch & Bound (B&B), Cutting-Plane, Zero-One Implicit Enumeration Algorithms.
Deterministic Dynamic Programming - Forward and backward recursion, applications - cargo-loading model, work force size model, equipment replacement model, investment model, inventory models.
Deterministic Inventory Models - Static and Dynamic 'Economic Order Quantity' (EOQ) models.
(B) Stochastic Methods:
Forecasting - Moving averages, exponential smoothing, regression.
Decision Analysis - Decision-making under certainty, under risk and under uncertainty.
Game Theory - Introduction, Optimal solution of two-person zero-sum games, solution of mixed strategy games.
Probabilistic Dynamic Programming - A game of chance, the Investment Problem.
Probabilistic Inventory Models - Continuous Review, Single-Period and Multi-Period models.
Queueing Theory - role of exponential distribution, pure birth and death models, generalized Poisson queueing model, specialized Poisson queues.
Simulation Modelling - Monte Carlo Simulation, Discrete Event Simulation.
Markovian Decision Processes.

ChE/T/423B ADVANCED PROCESS CONTROL

Modelling of engineering systems - state variables and transfer function representations; analytical and numerical solutions of state variable equations; Observability, controllability and stability; Optimal control of linear systems with quadratic performance index; Classical design and stabilization by pole assignment. Systems with delay. Systems with noise. Nonlinear systems - Phase plane analysis, Describing function techniques.
Digital Simulation of Dynamic Systems - Integration algorithms, Lumped parameter, Lumped parameter with stages, Distributed parameter systems.
Controllers, Function generation through Interpolation, Delay, Final Control Elements, Simulation of Control systems. Introduction to Simulator Packages - PCSA, DYFLO, MATLAB
Advanced Control Strategies - Ratio, Feed forward, Cascade, Selective Override, Programmed, Internal Model Reference, Adaptive, Smith's Predictor Algorithm.
Introduction to Control system design for staged systems. Distributed parameter systems. Nonlinear systems.
Discrete systems -'z'-transforms; Pulse transfer function, modified short form, Controller Synthesis, Stability analysis.
Computer Based Control Systems - Micro-Processor based systems, PC based systems,

Direct Digital Control (DDC), Distributed Control System (DCS), Programmable Logic Controller (PLC) - Relay Logic, Ladder Diagram, Synthesis of simple systems
Case Studies on the Control system of Heat Exchanger, Distillation Column, Chemical and Bio-chemical Reactors.

ChE/T/423C RISK ASSESSMENT & SAFETY IN PROCESS INDUSTRIES

Concepts and definition, Safety culture, storage of dangerous materials, plant and plant layout, Safety systems, technology and process selection, Control of Toxic chemicals, Run away reactions, High pressures, Relief systems.
Risk and hazard management, safety versus production, Risk assessment and analysis, Hazard models and risk data. Identification, minimization and analysis of hazards.
Tackling disaster, Plans for emergency, Risk management routines, Emergency short down systems, role of computers in safety.
Prevention of hazard, Human elements, Technology and process selection, design of safety.

ChE/T/423D ENERGY CONSERVATION & MANAGEMENT

Energy crisis and India. Energy conservation measures in process industries and its strategy.
Energy Audit in Process industries. Waste heat management and utilization.
Optimum design of heat exchange equipment. Selection of Energy efficient process and equipment.
Energy conservation--a case study in the petrochemical industries.
Integrated energy management--a case study in heavy and fine chemical industries, and in combustion and incineration processes.
Energy systems modeling and analysis.

MNG/ME/T/1 INDUSTRIAL MANAGEMENT

Growth of Industries, Management thoughts and scientific management, Taylorism; Factory system of production, Introduction to management problems, Types of manufacture, Planning analysis and control aspects in industries.
Types of business ownership, means of finance and business combinations, organization structures, committee organization, authority and responsibility, duty and span of control. Plant location, factory buildings and physical facilities, plant layout, tools and techniques of plant layout, materials - handling arrangements. Product development, standardization, simplification and diversification.
Functions of production, planning and control, production forecasting, production scheduling and network techniques, Gantt chart, CPM, PERT etc.
Work study, job evaluation and merit rating; purchase system and inventory control. Inspection and quality control of systems, statistical quality control, maintenance and replacement policies for machine and equipments; decision making theories, breakeven analysis cost benefit analysis, evaluation of financial and managerial efficiencies.
Introduction to operational research techniques. Application of fuzzy logic in modern

management concepts. Human relations in industry and labour compensation. Personnel management, provision of industrial legislations in India. Wage and salary administrations. Welfare and safety provisions, trade union acts. Study of environmental impacts and environmental laws.

Text Book:
Production and operations management: S.N.Chari

Reference books:
1. " Industrial Management" by: Basu & Majmundar (Birla Pub., Newdelhi)
2. " Quantitative techniques in management" by: N.D.Vohra (Tata Mcgraw Hill)
3. "Production systems analysis and control" by : Riggs
4. "Works organization and management by: Basu, Sahoo & Dutta.
5. Fuzzy logic with Engineering applications: Timothy J. Ross (Mcgraw Hill)

ChE/T/425 GENERAL VIVA-VOCE

Based on all the theoretical and sessional subjects of the B.Ch.E course.

ChE/S/422 PROCESS INSTRUMENTATION AND CONTROL ENGINEERING LABORATORY

Testing of the characteristics of Pneumatic Control Valve Measurement of liquid level by pressure bulb type level indicator and recorder
Testing of a Pressure Gauge
Studies on a Bubbler type Liquid level Measuring Device
Studies on the Dynamics and Two position Control of a level Control Set up.
Studies on the dynamic and Control of Pressure of an Air Reservoir.
Determination of Dynamic Model from the Response Characteristics of a Thermocouple.
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Dynamics and Temperature Control of a Hot Air Blower (Process Trainer)

ChE/S/423 HEAT & MASS TRANSFER LABORATORY

Determination of heat transfer coefficient. Unsteady state heating in a jacketed vessel. Studies on heat loss from a pipe. Studies on heat exchanger performance, evaporator performance. refrigerator performance.
Determination of mass transfer coefficient. Experiment on batch distillation.
Studies on distillation column performance, humidification column performance, dehumidifier performance, drier performance, Determination of drying rate.

ChE/S/424 CHEMICAL EQUIPMENT DESIGN & DRAWING –III

Absorption/Stripping Column.
Rectification column - multi-feed / multi-stream.

Humidifier, Dehumidifier and Cooling towers.
Leaching/liquid-liquid extraction.