

Mathematical Analysis

Preliminaries. Real functions of a real variable: definitions; function classes; properties. Limits and continuity: definitions; theorems. Differential calculus: definition of derivative and geometric interpretation; differentiability and continuity; derivation rules; Bolzano's, Weierstrass's, Rolle's, Lagrange's and Cauchy's theorems; Cauchy's and L'Hôpital's rules; derivative applications; increments and differentials. Integral calculus: antiderivatives; techniques of integration; definite integral; applications: areas and volumes; improper integrals.

Linear Algebra

Matrices and systems of linear equations. Vector spaces: subspaces, linear spanning; linear independence; basis and dimension; applications. Determinants and their application to the solution of linear systems and computation of the inverse of a square matrix. Analytic geometry: dot, vectorial and mixed product of vectors; applications; representation of straight lines and planes in the Euclidean space; application to distances. Eigenvalues and eigenvectors of square matrices: application to matrix diagonalization.

General Chemistry

Tools of Chemistry. Atoms, molecules and ions. Chemical reactions and stoichiometry. General principles of chemical reactivity. The structure of atoms and molecules. Electron configuration and periodic relationships among the elements. Chemical bonding. Molecular geometry. Physical states of matter. Gases. Intermolecular forces, liquids and solids. Solutions and physical properties of solutions. Chemical equilibrium. Acid-base equilibria. Solubility equilibria.

Physics I

Mathematical tools in Physics: vectors operations, geometric and analytic differentiation and integration of real variable functions. One and two Dimension Motion: instantaneous position, velocity and acceleration; motions with constant velocity, constant acceleration and varying acceleration. Particle dynamics: force and Newton's Laws; linear momentum and impulse; conservation and variation of linear momentum; angular momentum and force momentum; conservation and variation of angular momentum; work-energy theorem and kinetic energy; law of conservation and variation of energy.

Introduction to Chemical and Biochemical Engineering

Integrated vision and strategy in chemical and biological process Engineering. Introduction to industrial health and safety. Regulatory constraints. Unit systems and dimensional analysis. Introduction to Engineering calculations. Chemical/biochemical processes and process variables. Flowcharts. Examples of chemical and biological process industries.

Applied Computing

All problems are solved according the following task sequence: 1. Thinking and understanding the problem; 2. Strategy and algorithm definition, 3. Development (using C Language and MS Excel); 4. Application go live; 5. Maintenance and continuous improvement;

1. **C Programming Language:** Basic IT concepts; Introduction to Algorithms; C Programming Introduction; Input and Output Instructions; Execution Flow Control; Graphics Output; Mathematics and Arrays; User Defined Functions;
2. **MS Excel Application:** Exploit Excel Environment

Mathematical Analysis II

Numerical and function series: definitions; tests for convergence; power series; Taylor and Maclaurin series; applications of power series. Real functions of several real variables: definitions; limits and continuity; partial derivatives; differentiability; increments and differentials; directional derivatives; extreme values and saddle points; optimization problems with constraints. Multiple integrals: definition and properties of double and triple integrals; geometric interpretation of double integral; double integrals in polar coordinates ; triple integrals in cylindrical and spherical coordinates; applications of double and triple integrals.

Organic Chemistry I

Structure and bonding in organic molecules. Functional groups. Reactions in organic chemistry. Introduction to reaction mechanisms. Reactants, intermediates and products. Electrophiles and nucleophiles. Chemical structure, nomenclature, physical properties and reactivity of the main categories of organic compounds: alkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, ethers, phenols, amines, aldehydes, ketones, carboxylic acids and their derivatives.

Inorganic Chemistry

Theories of chemical bonding. Valence Bond Theory and Molecular Orbital Theory. Electrochemistry. Review of redox reactions. Metallurgy and the chemistry of metals. Bonding in metals and semiconductors. Nonmetallic elements and their compounds. Transition metal chemistry and coordination compounds. Crystal field theory. Nuclear chemistry. Nuclear stability and radioactivity. Nuclear transformations and energy.

Physics II

Vibration and Wave mechanics: harmonic, amortised and forced vibrations; wave function and wave equation; sinusoidal progressive waves and stationary waves; interference, reflection, and diffraction; electromagnetic and sound waves; Doppler effect. Electrostatics: electric charge, electrization, electric/gravitational interactions, Coulomb's law, electrical field and electrical potential, flux law, condensators and associations. Continuous current: isolators and conductors, Ohm's law, Kirchhoff's laws and Joule effect, isolators associations and measure equipments. Magnetic field and electromagnetic induction.

Fluid Mechanics

Introduction to the physical principles of the fluid mechanics applied to chemical engineering. Study of hydrostatic problems, such as manometers and impulsion forces, hydrodynamic problems, such as energy curves, pumps and turbines and problems associated to continuous energy loss in pressurized flows (pipes).

Probability and Statistics

Probability. Discrete and Continuous Random Variables. Probability Distributions: Discrete Uniform, Binomial, Poisson, Continuous Uniform, Normal and Exponential; Normal approximation to the Binomial and Poisson distributions. Sampling Distributions. Estimation using a single sample of the mean, variance and proportion. Hypothesis testing using a single sample about the mean, variance and proportion, Hypothesis Tests using the p-value. Simple Linear Regression and Correlation.

Organic Chemistry II

Stereochemistry. Stereoisomery – enantiomers and diastereomers. Meso compounds. Absolute configurations –R/S and Z/E systems. Polyfunctional compounds: dienes, polyenes, diols, polyols, dicarboxylated compounds, aldols, ketols, ketonic esters and acids, amino acids. Names, structure and properties. Heterocycles –heteroatoms in cyclic organic compounds. Introduction to polymer chemistry. Study of the main groups of organic pollutants.

Chemistry of Solutions

Conductimetry. Reduction-oxidation reactions. Precipitation reactions. Complexes and complexometry reactions.

Chemical Thermodynamics I

Ideal and real gases. The zeroth law of thermodynamics. Internal energy and the first law of thermodynamics. Thermochemistry. Entropy and the second law of thermodynamics. Third law of thermodynamics. The Helmholtz and Gibbs functions. Combining the first and second laws. Chemical potential. Chemical equilibrium. Physical transformations in pure substances. Phase rule. Ideal solutions. Raoult's law and Henry's law. Colligative properties. Mixtures of volatile liquids.

Material and Energy Balances

Fundamentals of material balances. Definition, calculation and process variables prevision. Material balances on processes with and without chemical reaction. Energy balances fundamentals. Energy balances on processes with and without chemical reaction. Material and energy balances integration.

Physical Chemistry

Quantum Mechanics principles. Translational, vibrational and rotational motion. Atomic structure and atomic spectra. Rotational and vibrational spectroscopy. Introduction to chemical kinetics. The rates of chemical reactions. The Arrhenius equation. The kinetic theory of gases. Molecular dynamics. Electronic transfer in homogeneous and in heterogeneous systems. Voltammetry. Electrolysis. Galvanic cells. Corrosion.

Applied Numerical Methods

Error and stability: number representations, definition and sources of error, propagation and stability. Iterative methods for linear systems of equations: Jacobi and Gauss-Seidel methods. Nonlinear equations and systems of equations: bisection, fixed-point, Newton and secant methods. Polynomial interpolation: Lagrange, finite difference and divided difference algorithms. Numerical integration: trapezoid and Simpson methods. Numerical methods for ordinary differential equations: Taylor, Euler and Runge-Kutta algorithms.

Chemical Analyse

Optical absorption methods, radiant energy emission and dispersion. Visible and U.V spectrophotometry. Turbidimetry and nephelometry. Emission flame photometry. Atomic absorption spectrometry. Solvent extraction.

Microbiology

Introduction and overview of the science of microbiology. A survey and classification of life at the cellular level. Microbial diversity and classification.

Prokaryotic and eukaryotic cell organization. Bacterial morphology and growth patterns. In vitro development and pure cultures isolation. Fungi and virus – morphology, classification and life cycles. Sterility and disinfection. Microbial control.

Laboratorial techniques in microbiology.

Transport Phenomena

Mechanisms of energy transport. Fourier's law of heat conduction, thermal conductivity. Temperature distributions in solids and laminar flow. Thermal insulation, fins. Unsteady-state heat conduction. Forced and natural convection. Interphase transport, heat transfer coefficients. Radiation heat transfer. Heat exchangers. Mechanisms of mass transport. Fick's law, diffusivity. Concentration distributions in solids and laminar flow. Unsteady-state molecular diffusion. Convective mass transfer. Interphase mass transport, mass transfer coefficients. Momentum, heat and mass transfer analogies.

Chemical Thermodynamics II

Real solutions. Excess functions. Liquid-liquid equilibria and immiscibility in liquid phase. Theories of solutions. Phase diagrams. Liquid-vapour equilibria. Ternary systems. Statistical thermodynamics. The Maxwell-Boltzmann distribution. Statistical thermodynamics of the perfect monoatomic gas. Diatomic and polyatomic gases. The third law of thermodynamics. Solids. The Einstein model. Heat capacity of solids. Law of Dulong and Petit.

Biochemistry

Bio molecules – structure, properties and metabolism.

Carbohydrates – mono, di, oligo and polysaccharides. Glycosidic linkage.

Amino acids and peptides – structure, peptide bonds. Proteins and biological activity.

Lipid Classes. Functions in biological membranes.

Nucleic acids. DNA and chromosome structure. Genetic code. Informational nature of genetic processes.

Chemical Reactors I

Kinetic data analysis. Introduction to chemical reactor design. Ideal homogeneous chemical reactors. Continuous stirred tank reactors. Continuous stirred tank reactors in series. Batch and semi-batch reactors. Tubular reactors Tubular reactors with recycling. Sequences of reactors of different types.

Separation Processes I

Principles of distillation and gas absorption/stripping processes. Equipment construction and applications. Design calculations for the determination of stream flow rates, compositions and the number of distillation stages in batch distillations, flash distillations, ordinary fractionating column distillations and fractionating column distillations with multiple feeds or side streams. Design calculations for the determination of stream flow rates and compositions, the number of equilibrium stages, diameter and length of gas absorption/stripping columns operating in counter-current.

Economy and Business Administration

Basic principles of economy. Microeconomics and macroeconomics fundamentals. The organization concept and management objectives. Management of the main corporate functions. Corporate planning - strategic management and strategic planning models. Economic evaluation of engineering projects - project concept and goals, determination and estimates of project economic data, project evaluation and selection criteria. R&D management, entrepreneurship and business creation.

Instrumentation and Control

Classification and characterization of industrial measurement instruments (temperature, pressure level and flow). Analysis of process diagrams and layout of industrial facilities. Acquire the ability to decide what equipment to choose from a range of available equipments. Final control and signal transmitters.

Industry and Environmental Impact

- 1-Pollution: standards and regulations. Monitoring. Kyoto Protocol.
- 2-Water pollution. Measurement. Types of treatment. In-plant abatement.
- 3-Solids handling. Land disposal.
- 4-Air pollution. Sources and sampling. Metereologic factors. Unit operations for air pollution abatement

Chemical Reactors II

Yield and selectivity optimization in complex reactions. Catalytic heterogeneous reactions kinetics - characterization and deactivation of catalysts. Heterogeneous reactors. Brief reference to the models of fixed-bed catalytic reactors. Residence time distribution. Real reactors modelling.

Industrial Utilities

- BOILERS-watertube and firetube boilers, combustion and types of combustion systems, types of fuels, boiler efficiency, heat losses, conservation of energy . Rotary dryer dimensioning for solid granular fuels. Boiler water treatment.
- ELECTRICITY-Ohm's law and electrical resistance, Resistance combinations, Kirchoff's rules, Magnetic field produced by a coil and a solenoid, Magnetic induction (Faraday's law and Lenz), Motors and generators Autoinduction, Alternating current in resistances, condensers and coils, Impedance. RCL circuits with a generator Power Factor Correction
- COGENERATION–Basic Concepts; Topping cycle, Bottoming cycle, combined cycle
- COMPRESSED AIR SYSTEMS – Compressor types, equipment (dryer, filters, coolers, drains, separators, storage)

Genetic Engineering

DNA replication, restriction and repair. Homologous and heterogeneous recombination of genes. Transcription in Eukaryotes and prokaryotes. Protein synthesis. Regulation of genetic expression. Genetic manipulation techniques – DNA recombination in vitro; Methodology to introduce recombinant DNA in clone cells; Genomic banks; Homologous and heterogenic expression of genes; Specific amplification of DNA; Interruption and removal of genes; Technology of genetically manipulated organisms

Enzyme Engineering

Structure and function of enzymes. Classification and nomenclature. Large-scale production. Kinetics of enzyme catalysed reactions. Enzyme activity, inhibition, stability and deactivation. Protein Engineering. Immobilised enzyme technology. Immobilised enzyme kinetics. Film and intraparticle mass transfer resistances. Design and analysis of ideal, and non-ideal, enzyme immobilised reactors. Bio-catalysis in non-conventional media. Applied enzyme catalysis. Medical and industrial utilization of free and immobilised enzymes.

Raw Materials

Introduction to materials science. Structure of materials.
Physical and mechanical properties of fibrous materials.
Linking water-fiber. Effect of refining operation on fibers.
Influence of refining in the physical and mechanical properties of paper.
Properties of the non-fibrous materials.
Mineral fillers. Binders. Retention agents. Optic whiteners.

Cellulose Technology

Introduction to the cellulose technologies behind fiber modification, pulping, and bleaching; Raw materials, wood handling; Fiber line operations : principles of wood chip delignification (cooking), pulp washing , pulp cleaning and screening, oxygen delignification, bleaching of pulp and bleaching process units; Chemical recovery and evaporation of black liquor; Drying of pulp; Environmental aspects concerning pulp production .

Quality Management

Development and implementation of Guarantee and Quality Control Systems.
The study of influence of human factors in the motivation for Quality.

Development and analysis of procedures for test, sampling and inspection.
Analysis of Quality costs.
Management of certification processes.
Implementation and analysis of statistical control systems.

Health and Safety

An introduction to industrial hygiene and safety; Occupational health (hazardous workplace exposures, types of occupational disease, and techniques for the recognition and prevention of occupational disease); Risk managing; Fire, explosion and process safety work environment (noise monitoring, individual protection, ergonomics)

Project

Acquisition of skills on selection techniques and on the installation of equipments and facilities.
Study of economical analysis and project evaluation techniques.
Writing a final report in which students describe the project design and the experiments and calculations carried out.

Separation Processes II

Fluid and particle mechanics. Flow and separation of solids through fluid mechanics concepts. Washing. Centrifugal separators. Sedimentation. Flow through beds of solids (fixed). Flow through beds of solids (fluidized). Filtration.
Laboratory work
Filtration with different beds.
Operation performance.

Chemical Processes

Prediction and correlation of thermo-physical and thermo-chemical properties. Material and energy balances on special cases: multiphasic processes; processes with mixture, dissolution or dilution effects; combined mass-energy balances. Solving of mass and energy balances with the aid of computer methods. Solving mass and energy balances in the context of the chemical engineering plant design.

Separation Processes on Biotechnology

Biological products recovery and purification principles. Recovery of cellular materials. Cellular rupture operations. Recovery of soluble products. Purification procedures. Industrial applications examples.

Biological Reactors

Stoichiometry and kinetics of substrate utilization, product formation and biomass production in cell cultures. Elemental balances. Balance to biomass, substrates and products. Design and analysis of biological reactors: fed-batch reactor, continuous-flow stirred-tank with recycle and wall growth, plug-flow reactor with recycle, bubble-column, fluidized-bed, trickle-bed, CSTRs in series, association CSTR-PFR. Oxygen transfer, consumption rates and oxygen-limited fermentations. Heat balance, sterilisation. Scale-up criteria. Industrial bioreactor construction.

Paper Technology

Introduction to papermaking processes and mill operations; Raw materials; stock preparation and wet end operations; Refining; Stock approach flow system; Web forming; wet pressing; Drying (fundamentals of paper drying); Paper finishing operations; Papermaking chemistry; Process control; Energy and environmental aspects concerning papermaking.

Paper Converting

- 1-Surface treatments of paper: sizing, coating and calendering.
- 2-Multiply paperboard. Formers. Plybonding.
- 3-Corrugated board. Manufacture. Board properties. Boxes Project.
- 4- Printing process. Ink-paper relationship.