# CH Chemical Engineering

## Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra; Systems of linear equations; Eigenvalues and eigenvectors.

Calculus: Functions of single variable; Limit, continuity and differentiability; Taylor series; Mean value theorem; Evaluation of definite and improper integrals; Partial derivatives; Total derivative; Maxima and minima; Gradient, divergence, and curl; Vector identities; Directional derivatives; Line, surface, and volume integrals; Stokes, Gauss, and Green's theorems.

Differential Equations: First order equations (linear and nonlinear); Higher order linear differential equations with constant coefficients; Cauchy's and Euler's equations; Initial and boundary value problems; Laplace transforms; Solutions of one-dimensional heat equation, wave equation, and Laplace equation.

Complex Variables: Complex number; polar form of complex number.

Probability and Statistics: Definitions of probability and sampling theorems; Conditional probability; Mean, median, mode, and standard deviation; Random variables; Poisson, Normal, and Binomial distributions.

Fundamentals of AI/ML: Linear Regression; Principal Component Analysis (PCA).

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations; Integration by trapezoidal and Simpson's rule; Single and multi-step methods for numerical solution of ordinary differential equations; Finite-difference method for partial differential equations.

## Section 2: Process Calculations

Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems; Use of tie components; Recycle, bypass and purge calculations; Gibbs phase rule and degree of freedom analysis.

## Section 3: Thermodynamics

Laws of thermodynamics; Open and closed systems; Entropy and chemical potential; Thermodynamic properties of pure substances: equations of state and residual properties; Thermodynamic properties of mixtures: partial molar properties, fugacity, excess properties, and activity coefficients; Phase equilibria: predicting VLE of systems; Chemical reaction equilibrium.

## Section 4: Fluid Mechanics and Mechanical Operations

Newtonian and non-Newtonian fluids; Fluid statics; Surface Tension; Fluid kinematics; Equation of continuity, Equation of motion, Equation of mechanical energy; Macroscopic friction factors; Dimensional analysis and similitude; Inviscid flows: Euler equation; Flow through pipes: velocity profile, pressure drop, Bernoulli equation, flow meters; Pumps; Turbulent flow: fluctuating velocity, universal velocity profile, pressure drop; Elementary boundary layer theory; Flow past immersed bodies including packed and fluidized beds.

Particle size and shape; Particle size distribution; Size reduction and classification of solid particles; Free and hindered settling; Centrifuge and cyclones; Thickening and clarification; Filtration, agitation and mixing.

| Section 5: | Heat Transfer |
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| Equation of energy; Steady and unsteady heat conduction, convection, and radiation; Thermal boundary layer and heat transfer coefficients; Boiling, condensation, and evaporation; Types of heat exchangers and evaporators and their process calculations; Design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators. | |
| **Section 6:** | **Mass Transfer** |
| Fick's laws; Molecular diffusion in fluids; Mass transfer coefficients; Film, penetration and surface renewal theories; Momentum, heat and mass transfer analogies; Stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts.<br><br>Fundamentals concepts and design of mass transfer operations: distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations. | |
| **Section 7:** | **Chemical Reaction Engineering** |
| Theories of reaction rates; Kinetics of homogeneous reactions; Interpretation of kinetic data; Single and multiple reactions in ideal reactors; Kinetics of enzyme reactions (Michaelis-Menten and Monod models); Non-ideal reactors: residence time distribution, single parameter model; Non-isothermal reactors; Kinetics of heterogeneous catalytic reactions; Diffusion effects in catalysis; Catalyst deactivation. | |
| **Section 8:** | **Instrumentation and Process Control** |
| Measurement of process variables; Sensors and transducers; P&ID equipment symbols; Process modeling and linearization; State-space models; Transfer functions and dynamic responses of various systems; Systems with inverse response; Process reaction curve; Controller modes (P, PI, and PID); Control valves; Analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control. | |
| **Section 9:** | **Plant Design and Economics** |
| Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow; Optimization in process design and sizing of chemical engineering equipment such as heat exchangers and multistage contactors; Batch plant scheduling. | |
| **Section 10:** | **Chemical Technology** |
| Overview of raw materials, unit operations, and processes involved in inorganic chemical industries (synthesis gas, sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (ammonia, urea), natural products industries (pulp and paper, sugar and ethanol), petroleum refining and petrochemicals (ethyl benzene, styrene, ethylene oxide), polymerization industries (polyethylene and polyester). | |