Subject Code: CH

Course Structure

<table>
<thead>
<tr>
<th>Sections/Units</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>Engineering Mathematics</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Linear Algebra</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Calculus</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Differential equations</td>
</tr>
<tr>
<td>Unit 4</td>
<td>Complex variables</td>
</tr>
<tr>
<td>Unit 5</td>
<td>Probability and Statistics</td>
</tr>
<tr>
<td>Unit 6</td>
<td>Numerical Methods</td>
</tr>
<tr>
<td>Section B</td>
<td>Process Calculations and Thermodynamics</td>
</tr>
<tr>
<td>Section C</td>
<td>Fluid Mechanics and Mechanical Operations</td>
</tr>
<tr>
<td>Section D</td>
<td>Heat Transfer</td>
</tr>
<tr>
<td>Section E</td>
<td>Mass Transfer</td>
</tr>
<tr>
<td>Section F</td>
<td>Chemical Reaction Engineering</td>
</tr>
<tr>
<td>Section G</td>
<td>Instrumentation and Process Control</td>
</tr>
<tr>
<td>Section H</td>
<td>Plant Design and Economics</td>
</tr>
<tr>
<td>Section I</td>
<td>Chemical Technology</td>
</tr>
</tbody>
</table>

Course Syllabus

Section A: Engineering Mathematics

Unit 1: Linear Algebra

- Matrix algebra
- Systems of linear equations
Eigen values
Eigen vectors

Unit 2: Calculus

- Functions of single variable
- Limit
- Continuity and differentiability
- Taylor series, Mean value theorems
- 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

Unit 3: 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 and wave equations and Laplace equation

Unit 4: Complex variables

- Complex number
- Polar form of complex number
- Triangle inequality

Unit 5: Probability and Statistics

- Definitions of probability and sampling theorems
- Conditional probability
Mean, median, mode and standard deviation
Random variables, Poisson, Normal and Binomial distributions
Linear regression analysis

Unit 6: 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 differential equations

Section B: Process Calculations and Thermodynamics
Steady and unsteady state mass and energy balances including multiphase:
  - Multicomponent
  - Reacting and non-reacting systems
Use of tie components
  - Recycle
  - Bypass
  - Purge calculations
Gibb’s phase rule and degree of freedom analysis

First and Second laws of thermodynamics
Applications of first law to close and open systems
Second law and Entropy
Thermodynamic properties of pure substances
Equation of State and residual properties
  - Properties of mixtures Partial molar properties
  - Fugacity
  - Excess properties
  - Activity coefficients
Phase equilibria:
  - Predicting VLE of systems
  - Chemical reaction equilibrium

Section C: Fluid Mechanics and Mechanical Operations
Fluid statics
Newtonian and non-Newtonian fluids
Shell-balances including differential form of Bernoulli equation and energy balance
Macroscopic friction factors
Dimensional analysis and similitude
Flow through pipeline systems
Flow meters
Pumps and compressors
Elementary boundary layer theory
Flow past immersed bodies including packed and fluidized beds
Turbulent flow
Fluctuating velocity
Universal velocity profile
Pressure drop
Particle size and shape
Particle size distribution
Size reduction and classification of solid particles
Free and hindered settling
Centrifuge and cyclones
Thickening and classification, filtration, agitation and mixing
Conveying of solids

Section D: Heat Transfer
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
Single and multiple effect evaporators

Section E: Mass Transfer
Fick’s laws
Molecular diffusion in fluids
Mass transfer coefficients
Film
Penetration
Surface renewal theories
Momentum, heat and mass transfer analogies
Stage-wise and continuous contacting and stage efficiencies
HTU & NTU concepts:
• Design and operation of equipment for distillation
• Absorption
• Leaching
• Liquid-liquid extraction
• Drying
• Humidification
• Dehumidification
• Adsorption

Section F: Chemical Reaction Engineering

➢ Theories of reaction rates
➢ Kinetics of homogeneous reactions
➢ Interpretation of kinetic data
➢ Single and multiple reactions in ideal reactors
➢ Non-ideal reactors
➢ Residence time distribution
➢ Single parameter model
➢ Non-isothermal reactors
➢ Kinetics of heterogeneous catalytic reactions
➢ Diffusion effects in catalysis

Section G: Instrumentation and Process Control

➢ Measurement of process variables
➢ Sensors
➢ Transducers and their dynamics
➢ Process modeling and linearization
➢ 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 H: 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 compressors
- Heat exchangers
- Multistage contactors

Section I: Chemical Technology

- Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry)
- Fertilizers (Ammonia, Urea, SSP and TSP)
- Natural products industries (Pulp and Paper, Sugar, Oil, and Fats)
- Petroleum refining and petrochemicals
- Polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers)