



# GATE Syllabus

## Chemical Engineering



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# CHEMICAL ENGINEERING

**Subject Code: CH**

## **Course Structure**

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

## **Course Syllabus**

### **Section A: Engineering Mathematics**

#### **Unit 1: Linear Algebra**

- Matrix algebra
- Systems of linear equations

- Eigen values
- Eigenvectors

## **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)