



# GATE Syllabus

Part I – ENGINEERING SCIENCE (XE)

Section–XE-E Thermodynamics



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# SECTION – XE-E: THERMODYNAMICS

## Course Syllabus

### Unit 1: Basic Concepts

- Continuum and macroscopic approach
- Thermodynamic systems (closed and open)
- Thermodynamic properties and equilibrium
- State of a system, state postulate for simple compressible substances, state diagrams, paths and processes on state diagrams
- Concepts of heat and work, different modes of work
- Zeroth law of thermodynamics
- Concept of temperature

### Unit 2: First Law of Thermodynamics

- Concept of energy and various forms of energy
- Internal energy, enthalpy
- Specific heats
- First law applied to elementary processes, closed systems and control volumes, steady and unsteady flow analysis

### Unit 3: Second Law of Thermodynamics

- Limitations of the first law of thermodynamics:
  - Concepts of heat engines and heat pumps/refrigerators
  - Kelvin-Planck and Clausius statements and their equivalence
- Reversible and irreversible processes
- Carnot cycle and Carnot principles/theorems
- Thermodynamic temperature scale
- Clausius inequality and concept of entropy
- Microscopic interpretation of entropy:
  - The principle of increase of entropy
  - T-s diagrams
- Second law analysis of control volume
- Availability and irreversibility
- Third law of thermodynamics

#### **Unit 4: Properties of Pure Substances**

- Thermodynamic properties of pure substances in solid, liquid and vapor phases
- P-vT behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state
- Law of corresponding states, compressibility factor and generalized compressibility chart

#### **Unit 5: Thermodynamic Relations**

- T-ds relations
- Helmholtz and Gibbs functions
- Gibbs relations
- Maxwell relations
- Joule-Thomson coefficient
- Coefficient of volume expansion
- Adiabatic and isothermal compressibilities
- Clapeyron and Clapeyron-Clausius equations

#### **Unit 6: Thermodynamic Cycles**

- Carnot vapor cycle
- Ideal Rankine cycle
- Rankine reheat cycle
- Air-standard Otto cycle
- Air-standard Diesel cycle
- Air-standard Brayton cycle
- Vapor-compression refrigeration cycle

#### **Unit 7: Ideal Gas Mixtures**

- Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them
- Specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart