



# GATE Syllabus

Mechanical Engineering



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# MECHANICAL ENGINEERING

**Subject Code: ME**

## **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 Analysis
Unit 5	Probability and Statistics
Unit 6	Numerical Methods
<b>Section B</b>	<b>Applied Mechanics and Design</b>
Unit 1	Engineering Mechanics
Unit 2	Mechanics of Materials
Unit 3	Theory of Machines
Unit 4	Vibrations
Unit 5	Machine Design
<b>Section C</b>	<b>Fluid Mechanics and Thermal Sciences</b>
Unit 1	Fluid Mechanics
Unit 2	Heat-Transfer
Unit 3	Thermodynamics
Unit 4	Applications
<b>Section D</b>	<b>Materials, Manufacturing and Industrial Engineering</b>
Unit 1	Engineering Materials

Unit 2	Casting, Forming and Joining Processes
Unit 3	Machining and Machine Tool Operations
Unit 4	Metrology and Inspection
Unit 5	Computer Integrated Manufacturing
Unit 6	Production Planning and Control
Unit 7	Inventory Control
Unit 8	Operations Research

## Course Syllabus

### Section A: Engineering Mathematics

#### Unit 1: Linear Algebra

- Matrix algebra
- Systems of linear equations
- Eigenvalues and eigenvectors

#### Unit 2: Calculus

- Functions of single variable:
  - Limit
  - Continuity and differentiability
  - Mean value theorems
  - Indeterminate forms
- Evaluation of definite and improper integrals
- Double and triple integrals
- Partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series
- Gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems

#### Unit 3: Differential equations

- First order equations (linear and nonlinear)
- Higher order linear differential equations with constant coefficients

- Euler-Cauchy equation
- Initial and boundary value problems
- Laplace transforms
- Solutions of heat, wave and Laplace's equations

#### **Unit 4: Complex variables**

- Analytic functions
- Cauchy-Riemann equations
- Cauchy's integral theorem and integral formula
- Taylor and Laurent series

#### **Unit 5: Probability and Statistics**

- Definitions of probability, sampling theorems, conditional probability
- Mean, median, mode and standard deviation
- Random variables, binomial, Poisson and normal distributions

#### **Unit 6: Numerical Methods**

- Numerical solutions of linear and non-linear algebraic equations
- Integration by trapezoidal and Simpson's rules
- Single and multi-step methods for differential equations

### **Section B: Applied Mechanics and Design**

#### **Unit 1: Engineering Mechanics**

- Free-body diagrams and equilibrium
- Trusses and frames
- Virtual work
- Kinematics and dynamics of particles and of rigid bodies in plane motion
- Impulse and momentum (linear and angular) and energy formulations
- Collisions

#### **Unit 2: Mechanics of Materials**

- Stress and strain, elastic constants
- Poisson's ratio
- Mohr's circle for plane stress and plane strain

- Thin cylinders
- Shear force and bending moment diagrams
- Bending and shear stresses
- Deflection of beams
- Torsion of circular shafts
- Euler's theory of columns
- Energy methods
- Thermal stresses
- Strain gauges and rosettes
- Testing of materials with universal testing machine
- Testing of hardness and impact strength

### **Unit 3: Theory of Machines**

- Displacement, velocity and acceleration analysis of plane mechanisms
- Dynamic analysis of linkages
- Cams
- Gears and gear trains
- Flywheels and governors
- Balancing of reciprocating and rotating masses
- Gyroscope

### **Unit 4: Vibrations**

- Free and forced vibration of single degree of freedom systems, effect of damping
- Vibration isolation
- Resonance
- Critical speeds of shafts

### **Unit 5: Machine Design**

- Design for static and dynamic loading
- Failure theories
- Fatigue strength and the s-n diagram
- Principles of the design of machine elements such as:
  - Bolted
  - Riveted
  - Welded joints
- Shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs

## Section C: Fluid Mechanics and Thermal Sciences

### Unit 1: Fluid Mechanics

- Fluid properties:
  - Fluid statics
  - Manometry
  - Buoyancy
  - Forces on submerged bodies
  - Stability of floating bodies
- Control-volume analysis of mass, momentum and energy
- Fluid acceleration
- Differential equations of continuity and momentum
- Bernoulli's equation
- Dimensional analysis
- Viscous flow of incompressible fluids:
  - Boundary layer
  - Elementary turbulent flow
  - Flow through pipes
  - Head losses in pipes
  - Bends and fittings

### Unit 2: Heat-Transfer

- Modes of heat transfer:
  - One dimensional heat conduction
  - Resistance concept
  - Electrical analogy
- Heat transfer through fins:
  - Unsteady heat conduction
  - Lumped parameter system
- Heisler's charts:
  - Thermal boundary layer
  - Dimensionless parameters in free and forced convective heat transfer
  - Heat transfer correlations for flow over flat plates and through pipes
- Effect of turbulence:
  - Heat exchanger performance
- LMTD and NTU methods:
  - Radiative heat transfer
  - Stefan Boltzmann law
  - Wien's displacement law
  - Black and grey surfaces
  - View factors

- Radiation network analysis

### **Unit 3: Thermodynamics**

- Thermodynamic systems and processes
- Properties of pure substances, behaviour of ideal and real gases
- Zeroth and first laws of thermodynamics:
  - Calculation of work and heat in various processes
- Second law of thermodynamics
- Thermodynamic property charts and tables, availability and irreversibility
- Thermodynamic relations

### **Unit 4: Applications**

- Power Engineering:
  - Air and gas compressors
  - Vapour and gas power cycles
  - Concepts of regeneration and reheat
- I.C. Engines:
  - Air-standard Otto
  - Diesel and dual cycles
- Refrigeration and air-conditioning:
  - Vapour and gas refrigeration and heat pump cycles
  - Properties of moist air
  - Psychrometric chart
  - Basic psychrometric processes
- Turbomachinery:
  - Impulse and reaction principles
  - velocity diagrams
  - Pelton-wheel
  - Francis and Kaplan turbines

## **Section D: Materials, Manufacturing and Industrial Engineering**

### **Unit 1: Engineering Materials**

- Structure and properties of engineering materials
- Phase diagrams
- Heat treatment
- Stress-strain diagrams for engineering materials



## **Unit 2: Casting, Forming and Joining Processes**

- Different types of castings:
  - Design of patterns
  - Moulds and cores
  - Solidification and cooling
  - Riser and gating design
- Plastic deformation and yield criteria:
  - Fundamentals of hot and cold working processes
  - Load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes
  - Principles of powder metallurgy
- Principles of welding, brazing, soldering and adhesive bonding

## **Unit 3: Machining and Machine Tool Operations**

- Mechanics of machining
- Basic machine tools
- Single and multi-point cutting tools, tool geometry and materials, tool life and wear
- Economics of machining
- Principles of non-traditional machining processes
- Principles of work holding, design of jigs and fixtures

## **Unit 4: Metrology and Inspection**

- Limits, fits and tolerances
- Linear and angular measurements
- Comparators
- Gauge design
- Interferometry
- Form and finish measurement
- Alignment and testing methods
- Tolerance analysis in manufacturing and assembly

## **Unit 5: Computer Integrated Manufacturing**

- Basic concepts of CAD/CAM and their integration tools



## **Unit 6: Production Planning and Control**

- Forecasting models
- Aggregate production planning
- Scheduling
- Materials requirement planning

## **Unit 7: Inventory Control**

- Deterministic models
- Safety stock inventory control systems

## **Unit 8: Operations Research**

- Linear programming
- Simplex method
- Transportation
- Assignment
- Network flow models
- Simple queuing models
- PERT and CPM