

UPSC CSE Mechanical Engineering Syllabus 2024

The UPSC Mechanical Engineering syllabus 2024 aims to test the conceptual knowledge and practical skills of aspirants in the field. The key topics covered include thermodynamics, mechanics, engineering materials, production engineering, industrial engineering, turbo machinery, machine design, robotics, mechatronics and CAD/CAM. Candidates need to have a strong grasp of engineering fundamentals and the ability to apply these concepts to solve real-world mechanical engineering problems.

UPSC CSE Mechanical Engineering Syllabus 2024 Paper 1

1. Mechanics:

1.1 Mechanics of Rigid Bodies:

- Equations of equilibrium in space and its application
- First and second moments of area
- Simple problems on friction
- Kinematics of particles for plane motion
- Elementary particle dynamics

1.2 Mechanics of Deformable Bodies:

- Generalized Hooke's law and its application
- Design problems on axial stress, shear stress, and bearing stress
- Material properties for dynamic loading
- Bending shear and stresses in beams
- Determination of principle stresses and strains - analytical and graphical
- Compound and combined stresses
- Bi-axial stresses - thin-walled pressure vessel
- Material behavior and design factors for dynamic load
- Design of circular shafts for bending and torsional load only
- Deflection of beam for statically determinate problems
- Theories of failure

2. Engineering Materials:

- Basic concepts on the structure of solids
- Common ferrous and non-ferrous materials and their applications
- Heat treatment of steels
- Non-metals - plastics, ceramics, composite materials, and nano-materials

3. Theory of Machines:

- Kinematic and dynamic analysis of plane mechanisms
- Cams, gears, and epicyclic gear trains
- Flywheels, governors
- Balancing of rigid rotors

- Balancing of single and multicylinder engines
- Linear vibration analysis of mechanical systems (single degree of freedom)
- Critical speeds and whirling of shafts

4. Manufacturing Science:

4.1 Manufacturing Process:

- Machine tool engineering - Merchant's force analysis
- Taylor's tool life equation
- Conventional machining
- NC and CNC machining process
- Jigs and fixtures
- Non-conventional machining - EDM, ECM, ultrasonic, water jet machining
- Application of lasers and plasmas
- Energy rate calculations
- Forming and welding processes - standard processes
- Metrology - concept of fits and tolerances; tools and gauges; comparators; inspection of length, position, profile, and surface finish

4.2 Manufacturing Management:

- System design: factory location - simple OR models; plant layout - methods based
- Applications of engineering economic analysis and break-even analysis for product selection, process selection, and capacity planning
- Predetermined time standards
- System planning; forecasting methods based on regression and decomposition
- Design and balancing of multi-model and stochastic assembly lines
- Inventory management - probabilistic inventory models for order time and order quantity determination; JIT systems; strategic sourcing; managing inter-plant logistics
- System operations and control: scheduling algorithms for job shops; applications of statistical methods for product and process quality control
- Applications of control charts for mean, range, percent defective, number of defectives, and defects per unit
- Quality cost systems
- Management of resources, organizations, and risks in projects
- System improvement: Implementation of systems such as total quality management, developing and managing flexible, lean, and agile organizations

UPSC CSE Mechanical Engineering Syllabus 2024 Paper 2

1. Thermodynamics, Gas Dynamics, Turbine:

1.1 Basic Concepts of First Law and Second Law of Thermodynamics:

- Concept of entropy and reversibility
- Availability and unavailability
- Irreversibility

1.2 Fluid Dynamics:

- Classification and properties of fluids
- Incompressible and compressible fluid flows
- Effects of Mach number and compressibility
- Continuity, momentum, and energy equations
- Normal and oblique shocks
- One-dimensional isentropic flow
- Flow of fluids in ducts with friction

1.3 Turbines and Compressors:

- Flow through fans, blowers, and compressors
- Axial and centrifugal flow configurations
- Design of fans and compressors
- Compressor and turbine cascades
- Open and closed cycle gas turbines
- Work done in gas turbines
- Reheat and regenerators

2. Heat Transfer:

2.1 Conduction Heat Transfer:

- General conduction equations
- Fourier law of conduction
- One-dimensional steady-state heat conduction applied to various geometries

2.2 Convection Heat Transfer:

- Newton's law of convection
- Free and forced convection
- Heat transfer during laminar and turbulent flow over flat plates and through horizontal tubes
- Concepts of Nusselt number, boundary layer thickness, and Prandtl number
- Heat transfer during free convection from plates

2.3 Radiation Heat Transfer:

- Basic radiation laws such as Stefan-Boltzmann law, Planck distribution, and Wein's displacement law

2.4 Heat Exchangers:

- Basic heat exchanger analysis
- Classification of heat exchangers

3. Engines:

3.1 Thermodynamic Cycles:

- Classification of engines
- Determination of brake power, indicated power, mechanical efficiency
- Heat balance sheet
- Interpretation of performance characteristics of petrol, gas, and diesel engines

3.2 Combustion in IC Engines:

- Normal and abnormal combustion
- Effect of working parameters on knocking
- Forms of combustion chambers
- Rating of fuels
- Emissions

3.3 Systems of IC Engines:

- Fuels, lubrication, cooling, and transmission systems
- Alternate fuels in IC engines

4. Steam Engineering:

4.1 Steam Generation:

- Modified Rankine cycle analysis
- Modern steam boilers
- Steam turbines: principle, types, compounding

4.2 Steam Nozzles:

- Flow of steam in convergent and divergent nozzles
- Supersaturated flow of steam
- Wilson line

4.3 Rankine Cycle:

- Internal and external irreversibility
- Reheat and regeneration

4.4 Steam Power Plants:

- Combined cycle power generation
- Heat recovery steam generators (HRSG)
- Co-generation plants

5. Refrigeration and Air Conditioning:

5.1 Vapour Compression Refrigeration Cycle:

- Cycle on p-H & T-s diagrams
- Eco-friendly refrigerants

5.2 Psychrometry:

- Properties and processes
- Humidification and dehumidification
- Air conditioning load calculation
- Simple duct design

