

## **CHENNAI PORT AUTHORITY**

### **Competitive Examination for the Post of Executive Engineer (Mechanical)**

#### **Examination Syllabus**

#### **SECTION 1: TECHNICAL SPECIALIZATION**

##### **A. Engineering Mechanics**

###### **Free-Body Diagrams and Equilibrium**

- Construction and application of free-body diagrams
- Equilibrium of rigid bodies in two-dimensional and three-dimensional systems
- Analysis of support reactions and constraints

###### **Friction and Applications**

- Fundamental laws of friction and coefficient determination
- Rolling friction and practical applications
- Belt-pulley systems and power transmission mechanisms
- Design and analysis of brakes and clutches
- Mechanics of screw jacks, wedges, and vehicle systems

###### **Structural Analysis: Trusses and Frames**

- Method of joints and method of sections

- Analysis of statically determinate trusses
- Frame analysis and determination of internal forces

###### **Kinematics and Dynamics of Rigid Bodies**

- Virtual work principle and applications
- Kinematics of rigid bodies in plane motion
- Dynamics based on Newton's laws of motion
- Linear and angular impulse and momentum
- Work-energy theorem and energy formulations
- Lagrange's equations of motion

##### **B. Mechanics of Materials**

###### **Stress and Strain Analysis**

- Normal, shear, and principal stress analysis
- Elastic constants and Poisson's ratio
- Mohr's circle for plane stress and plane strain analysis
- Stress analysis in thin cylinders: hoop and longitudinal stresses

###### **Bending and Shear in Structural Members**

- Construction of shear force and bending moment diagrams
- Distribution of bending and shear stresses
- Shear center and unsymmetric bending concepts
- Beam deflection using double integration, moment-area, and conjugate beam methods

### **Torsion and Column Stability**

- Torsion in solid and hollow circular shafts
- Power transmission and torsional rigidity
- Euler's theory of columns and buckling analysis
- Energy methods in structural analysis

### **Material Testing and Properties**

- Thermal stress and strain analysis
- Strain measurement using gauges and rosettes
- Universal testing machine and material characterization
- Hardness testing methods: Brinell, Rockwell, and Vickers
- Impact strength testing: Charpy and Izod tests

### **C. Theory of Machines**

#### **Mechanism Kinematics**

- Displacement, velocity, and acceleration analysis of planar mechanisms
- Graphical and analytical solution methods
- Dynamic analysis of linkages and slider-crank mechanisms

#### **Machine Elements and Components**

- Cam design: types, profile design, and motion analysis
- Gear systems: types, velocity ratios, and gear tooth geometry
- Epicyclic gear trains and their applications

#### **Balancing and Machine Dynamics**

- Flywheel design and energy storage principles
- Governor types, characteristics, and stability analysis
- Balancing of reciprocating and rotating masses (static and dynamic)
- Gyroscopic principles and applications

### **D. Machine Design**

#### **Design Fundamentals**

- Design criteria for static and dynamic loading conditions
- Failure theories: maximum principal stress, maximum shear

stress, and distortion energy theory

- Fatigue analysis and S-N diagrams
- Factor of safety and reliability considerations

### **Design of Machine Components**

- Bolted joints: design for tension, shear, and combined loading
- Riveted joints: design methodology and efficiency calculations
- Welded joints: types, design procedures, and strength analysis
- Shaft design for torsion, bending, and combined loading
- Keys, couplings, and shaft accessories
- Gear design for strength and wear resistance
- Rolling contact bearings: selection criteria and life calculation
- Sliding contact bearings: design and lubrication requirements
- Brake and clutch design: types and applications
- Spring design: helical, leaf, and torsion springs

## **E. Fluid Mechanics**

### **Fluid Properties and Statics**

- Fundamental fluid properties: density, viscosity, surface tension, and compressibility
- Fluid statics and pressure measurement techniques
- Force analysis on submerged plane and curved surfaces
- Stability of floating bodies and metacentric height

### **Fluid Dynamics**

- Control volume analysis: mass, momentum, and energy conservation
- Fluid acceleration: convective and local components
- Differential equations of continuity and momentum
- Bernoulli's equation and practical applications

### **Flow Analysis and Dimensional Analysis**

- Buckingham Pi theorem and dimensional analysis
- Viscous flow of incompressible fluids
- Boundary layer theory: laminar and turbulent regimes
- Pipe flow analysis: major and minor losses
- Head losses in pipes, bends, and fittings

- Fundamentals of compressible fluid flow

## **F. Heat Transfer**

### **Fundamental Modes of Heat Transfer**

- Conduction, convection, and radiation mechanisms
- One-dimensional steady-state heat conduction analysis
- Thermal resistance concept and electrical analogy
- Heat transfer through composite walls and layered systems
- Heat transfer enhancement using fins and extended surfaces

### **Transient Heat Transfer**

- Unsteady heat conduction analysis
- Lumped parameter system approach
- Heisler charts for transient conduction problems
- Biot and Fourier number significance

### **Convective Heat Transfer**

- Thermal boundary layer development
- Dimensionless parameters: Nusselt, Prandtl, Reynolds, and Grashof numbers

- Free and forced convection heat transfer

- Correlations for flow over flat plates

- Heat transfer in internal pipe flow

- Turbulence effects on heat transfer

### **Heat Exchangers and Thermal Radiation**

- Heat exchanger classification and performance evaluation
- Log Mean Temperature Difference (LMTD) method
- Number of Transfer Units (NTU) effectiveness method
- Fundamentals of radiative heat transfer
- Stefan-Boltzmann law and Wien's displacement law
- Black body and grey body radiation
- View factor determination and radiation network analysis

## **G. Thermodynamics**

### **Fundamental Concepts**

- Thermodynamic systems, processes, and properties
- Properties of pure substances
- Ideal and real gas behavior
- Equations of state

## **Laws of Thermodynamics**

- Zeroth law and temperature measurement
- First law: work and heat calculations for various processes
- Second law and entropy analysis
- Thermodynamic property charts and tables
- Availability, irreversibility, and exergy analysis
- Thermodynamic relations: Maxwell relations and TdS equations

## **H. Power Engineering Applications**

### **Compressors**

- Classification and types of air and gas compressors
- Reciprocating compressor performance analysis
- Rotary compressors and multi-stage compression

### **Power Generation Cycles**

- Vapor power cycles: Rankine cycle and modifications
- Gas power cycles: Brayton cycle analysis
- Regeneration and reheat concepts
- Combined cycle power plant systems

### **Internal Combustion Engines**

- Air-standard cycles: Otto, Diesel, and Dual cycles
- Engine performance parameters and characteristics
- Combustion processes and emission analysis

### **Refrigeration and Air Conditioning**

- Vapor compression refrigeration cycle
- Gas refrigeration cycles
- Heat pump systems and coefficient of performance
- Properties of moist air and psychrometry
- Psychrometric chart applications
- Air conditioning processes: heating, cooling, humidification, and dehumidification

### **Turbomachinery**

- Impulse and reaction turbine principles
- Velocity diagrams and energy transfer mechanisms
- Pelton wheel turbine: design and performance characteristics
- Francis turbine: design features and applications
- Kaplan turbine: operational characteristics

- Steam turbines: impulse and reaction types
- Gas turbine components and performance analysis

## **I. Engineering Materials**

### **Material Structure and Properties**

- Crystalline and amorphous material structures
- Phase diagrams: binary systems and iron-carbon equilibrium diagram
- Heat treatment processes: annealing, normalizing, hardening, and tempering
- Stress-strain behavior of engineering materials
- Mechanical properties: strength, ductility, toughness, and hardness

### **J. Manufacturing Processes: Casting, Forming, and Joining**

#### **Casting Processes**

- Types of casting processes: sand, die, investment, and centrifugal casting
- Pattern, mold, and core design considerations
- Solidification and cooling phenomena
- Riser and gating system design
- Casting defects: identification and remedial measures

#### **Metal Forming Processes**

- Plastic deformation mechanisms and yield criteria
- Hot working and cold working processes
- Load estimation for bulk forming operations: forging, rolling, extrusion, and drawing
- Sheet metal forming: shearing, deep drawing, and bending processes
- Spring-back analysis and formability considerations
- Powder metallurgy principles and applications

#### **Joining Processes**

- Welding principles: arc, gas, and resistance welding
- Welding metallurgy and heat-affected zone characteristics
- Brazing and soldering techniques
- Adhesive bonding applications

### **K. Machining and Machine Tool Operations**

#### **Fundamentals of Machining**

- Merchant's circle diagram and cutting force analysis
- Chip formation mechanisms
- Cutting tool materials and their properties

## **Machine Tool Operations**

- Conventional machine tools: lathe, milling machine, drilling machine, shaper, and grinder
- Single-point and multi-point cutting tool characteristics
- Tool geometry: rake angle, clearance angle, and cutting edge angles
- Tool materials: high-speed steel, carbides, ceramics, cubic boron nitride, and diamond
- Tool wear mechanisms and Taylor's tool life equation
- Machining economics and optimization

## **Advanced Manufacturing Processes**

- Non-traditional machining: electrical discharge machining (EDM), electrochemical machining (ECM), ultrasonic machining (USM), laser beam machining (LBM), and water jet machining (WJM)
- Work-holding devices: jigs and fixtures
- Abrasive machining processes
- Numerical control and computer numerical control (NC/CNC) fundamentals
- CNC programming: G-codes and M-codes

## **L. Metrology and Quality Inspection**

### **Dimensional Metrology**

- Limits, fits, and tolerances: ISO system of limits and fits
- Linear measurement instruments: vernier caliper, micrometer, and slip gauges
- Angular measurement: bevel protractor and sine bar
- Comparators: mechanical, electrical, optical, and pneumatic types
- Interferometry and laser-based measurement systems

### **Quality Control and Form Measurement**

- Surface finish measurement and roughness parameters
- Form measurement: straightness, flatness, roundness, and cylindricity
- Alignment testing methods
- Tolerance analysis in manufacturing and assembly operations
- Coordinate Measuring Machine (CMM) concepts and applications

## **M. Computer Integrated Manufacturing**

### **CAD/CAM Systems**

- Computer-Aided Design (CAD) fundamentals

- Computer-Aided Manufacturing (CAM) principles
- CAD/CAM integration and data exchange standards
- Additive manufacturing: principles, technologies, and applications

## **N. Production Planning and Control**

### **Planning and Scheduling Systems**

- Forecasting models: qualitative and quantitative approaches
- Aggregate production planning methodologies
- Master production scheduling
- Material Requirements Planning (MRP)
- Manufacturing Resource Planning (MRP II)
- Lean manufacturing principles and practices

### **Inventory Management**

- Deterministic inventory models: Economic Order Quantity (EOQ) and Economic Batch Quantity (EBQ)
- Safety stock determination and reorder point calculation
- ABC analysis and inventory classification systems

- Inventory control systems: continuous review and periodic review

## **O. Operations Research**

### **Linear Programming**

- Formulation of linear programming problems
- Simplex method and solution algorithms
- Duality theory and sensitivity analysis

### **Network and Optimization Models**

- Transportation and assignment problems
- Network flow models: shortest path and maximum flow algorithms
- Queuing models: M/M/1 and M/M/c systems

### **Project Management Techniques**

- Programme Evaluation and Review Technique (PERT)
- Critical Path Method (CPM)
- Project crashing and resource leveling strategies

## **P. Government Rules and Regulations**

### **Procurement Guidelines**

- Manual for Procurement of Goods (Second Edition, 2024)

- Manual for Procurement of Works (2019)
- Manual for Procurement of Consultancy Services (Second Edition, 2025)
- Manual for Procurement of Non-Consultancy Services

### **Financial Regulations**

- General Financial Rules (GFR) 2017
- Financial management and accountability frameworks
- Delegation of financial powers

### **Port-Specific Legislation**

- Major Ports Authorities Act 2021
- Indian Ports Act 1908
- Dock Workers (Safety, Health and Welfare) Act 1986
- Dock Workers (Safety, Health and Welfare) Regulations 1990

## **SECTION 2: REASONING ABILITY**

### **Logical Reasoning**

- Statement and conclusion analysis
- Statement and assumption evaluation
- Statement and argument assessment
- Statement and course of action determination

- Cause and effect relationship analysis
- Analytical decision-making

### **Seating Arrangement Problems**

- Circular arrangement configurations
- Linear arrangement: single and double rows
- Square and rectangular seating patterns
- Floor-based puzzles
- Box-based arrangement puzzles

### **Puzzle Solving**

- Scheduling and timeline puzzles
- Blood relations-based puzzles
- Ranking and ordering problems
- Age calculation puzzles
- Day and month-based scheduling puzzles

### **Blood Relations**

- Family tree construction and relationship chains
- Coded relationship decoding

### **Syllogisms**

- Categorical syllogism analysis
- Advanced and reverse syllogisms
- Venn diagram applications

### **Coding-Decoding**

- Alphanumeric coding patterns
- Letter-based coding systems
- Number-based coding schemes
- Symbol-based coding methods

### **Direction Sense**

- Cardinal directions: North, South, East, and West
- Complex directional problems involving multiple turns and distance calculations

## **SECTION 3: QUANTITATIVE APTITUDE**

### **Data Interpretation**

- Tabular data analysis and interpretation
- Line graph interpretation
- Bar graph analysis
- Pie chart calculations
- Caselet-based data interpretation
- Mixed graph analysis
- Radar graphs (spider web diagrams)

### **Number Series**

- Missing number identification in series
- Wrong number detection in series

### **Simplification and Approximation**

- Simplification of mathematical expressions

- Approximation techniques for rapid calculation

### **Quadratic Equations**

- Solution of quadratic equations and root determination
- Comparative analysis of roots from different equations

### **Data Sufficiency**

- Evaluation of statement sufficiency for problem-solving

### **Arithmetic**

- **Percentages:** calculations, profit and loss, discounts
- **Ratio and Proportion:** direct and inverse proportion problems
- **Average:** calculation for various scenarios
- **Simple Interest and Compound Interest:** interest computations
- **Profit and Loss:** gain, loss, and discount calculations
- **Time and Work:** work completion, efficiency, and combined work problems
- **Time, Speed, and Distance:** including problems on boats, trains, and relative motion
- **Mixtures and Alligations:** mixture problems and cost-based calculations

- **Mensuration:** area, volume, and perimeter calculations for geometric shapes
- **Partnership:** profit sharing based on investment ratios
- **Probability:** basic probability and event outcome calculations
- **Permutation and Combination:** arrangement and selection problems

### **Mathematical Inequalities**

- Comparison of quantities using inequality principles

### **Miscellaneous Word Problems**

- Real-life application problems testing conceptual understanding

## **SECTION 4: GENERAL AWARENESS**

### **Current Affairs**

- Recent national and international events of significance
- Awards and honors: Padma Awards, Nobel Prizes, etc.
- Sports: major tournaments, championship winners, and records
- Government schemes, policies, and initiatives
- Important summits, conferences, and international meetings
- Economic and banking developments

- Important days and their themes

### **Indian History**

- **Ancient History:** Indus Valley Civilization, Vedic period, Mauryan and Gupta empires
- **Medieval History:** Delhi Sultanate, Mughal Empire, Bhakti and Sufi movements
- **Modern History:** British colonial rule, Revolt of 1857, Indian National Movement, and Independence struggle

### **Geography**

- **Physical Geography:** landforms, atmospheric phenomena, climate, and natural vegetation
- **Indian Geography:** river systems, mountain ranges, plateaus, deserts, soil types, and forest cover
- **World Geography:** continents, countries, capitals, and prominent physical features

### **Indian Polity and Constitution**

- Constitutional framework: Preamble, Fundamental Rights and Duties, Directive Principles of State Policy
- Government structure: roles and functions of Executive, Legislature, and Judiciary at Union and State levels

- Key constitutional amendments and important articles
- Political systems: Panchayati Raj institutions, Election Commission, and local governance structures

### **Economics and Finance**

- Basic economic concepts: microeconomics, macroeconomics, demand and supply, national income
- Indian economy: economic reforms, planning mechanisms, and economic terminology
- Banking and finance: Reserve Bank of India, money market operations, inflation, and economic policies
- Budget and fiscal policies: highlights from Union Budget and Economic Surveys

### **Science and Technology**

- **Biology:** human body systems, health and diseases, biological terminology
- **Chemistry:** elements and compounds, acids and bases, metals and non-metals
- **Physics:** laws of motion, work and energy, heat, light, sound, electricity, and magnetism
- **Computer Awareness:** basic terminology, networking concepts, internet, hardware, and software

- **Inventions and Discoveries:** significant scientific and technological developments

### **Environment and Ecology**

- Ecological concepts: biodiversity, conservation strategies, ecosystems, and food chains
- Environmental issues: pollution types, climate change, global warming, renewable and non-renewable resources
- International organizations and conventions: UNEP, Kyoto Protocol, Paris Agreement

### **General Knowledge**

- Important dams, rivers, and national parks in India
- International organizations: United Nations, WHO, WTO, IMF, World Bank
- Space research: recent developments by ISRO, NASA, and major space missions
- Ports, shipping, and maritime sector with emphasis on Indian ports
- Major engineering achievements and infrastructure projects

## **SECTION 5: ENGLISH LANGUAGE**

### **Reading Comprehension**

- Passage comprehension with questions on main ideas, themes, and supporting details
- Inference-based questions
- Vocabulary in context: synonyms and antonyms
- Tone and style identification

### **Grammar and Vocabulary**

- **Error Spotting:** identification of grammatical errors in sentences
- **Sentence Correction:** correction of grammatically incorrect constructions
- **Fill in the Blanks:** single and double blank completion exercises
- **Cloze Test:** passage-based word selection
- **Phrase Replacement:** correction of phrases for grammatical accuracy

### **Sentence Rearrangement (Para Jumbles)**

- Logical sequencing of jumbled sentences
- Identification of opening and closing sentences

### **Synonyms and Antonyms**

- Word meaning relationships
- Word replacement in context

### **Idioms and Phrases**

- Understanding and application of common idiomatic expressions
- Contextual usage of idioms in sentences

### **Word Association and Usage**

- Word pairing and relationship identification
- Homonyms and homophones: differentiation and usage
- Spelling accuracy assessment

### **Sentence and Paragraph Completion**

- Logical sentence completion
- Coherent paragraph construction
- Gap-filling for grammatical and logical correctness

### **Verbal Ability**

- Verbal reasoning and critical thinking exercises
- Sentence meaning comprehension
- Logical progression in language
-