Maharashtra Public Service Commission

Civil Services Exam – Mains Optional

Mechanical Engineering

(Code No : 406)

Paper - I

Standard : Degree in Mechanical Engineering. **Total Marks** : 200
Nature of Paper : Conventional Type **Duration** : 3 Hours

Note :
1) Answers to this paper must be written in English only.
2) This paper will test the candidate's ability to comprehend, to analyse, to interpret, to criticise and to appraise the subject matter related to the topics/sub topics mentioned below.
3) For judging candidates' conceptual understanding, appropriate number of numerical problems will be asked pertaining to the topics/sub topics mentioned below.
4) It is expected from candidates to study the latest and recent developments and happenings pertaining to the topics/sub topics mentioned below.

Section - A (Marks : 50)
Materials and Their Behaviour

1) **Fundamentals :** Force, moment, couple, resultant of forces, Equilibrium of forces, friction and friction angle, columb friction, rolling friction and belt friction, frictional torque in pivot and Collar bearings, M.I., Work and energy.

2) **Strength of Materials :** Normal and Shear stresses, Stress-strain diagram, thermal stresses, shear force and bending moment diagrams, bending stresses in solid, hollow and built up sections, deflection of beams, shear stress distribution, strain energy, torsion of bars, shafts and helical springs, Deflection of beam under different conditions, impact load.

3) **Theory of Machines :** Kinematic link, pair, chain, Mechanism and structure, degrees of freedom, Cams, Gear trains, fluctuation of speed and energy in flywheel, Gyroscope, Balancing of rigid rotor, Single and multi-cylinder engines and V-engines, belts and chain drives, Hydrodynamic bearing.

4) **Engineering Materials :** Crystalline structure of metals and alloys, defects in crystalline materials, Iron-Carbon equilibrium diagram, plain carbon steel, alloy steel, cast iron and types, Brass and Bronze, Aluminum, lead, Tin, Zinc- their properties and applications, Plastic deformation, bearing materials, plastics, ceramics, composite materials, Heat treatment of steels.

Section - B (Marks : 50)
Machine Design

5) **Design of Elements :** Theories of failure, factor of safety, combined stresses. Pressure vessels, struts and columns. Design of Screw and bolt, power screw, Design of Shafts and springs, keys, couplings.

6) **Design of Gears :** (Spur, helical, bevel and worm), Design of clutches and brakes, fatigue

consideration in design.

7) **System Design :** Design of mechanical systems, specification of components, Design of system including material handling systems, power plants, refrigeration and air conditioning systems, pneumatic and hydraulic systems, etc.

8) **Dynamics of machines :** Inertia force analysis, law of gearing, interference and minimum number of teeth, Longitudinal - transverse and torsional vibration, free-forced vibration, critical and whirling speed of shaft, vibration isolation.

Section - C (Marks : 50)

Manufacturing Science and Processes

9) **Manufacturing Science :** Theory of metal cutting, Merchant's force analysis, Tool materials, Taylor's tool life equation, Machinability, economics, cutting fluids, Chip removal, Calculation of cutting force on single point cutting tools, twist drills, milling cutter, broaches, reamers, Jigs and fixtures. Recent machining methods - EDM, ECM, PAM, Ultrasonic and Laser, etc.

10) **Manufacturing Processes :** Casting, moulding- Types, equipments and defects, hot and cold working of metals - blanking, shearing, punching, piercing, coining, embossing, drawing, spinning and forging, Metal joining processes- welding, soldering, brazing, High energy rate forming, electroplating, surface finishing processes.

11) **Manufacturing Management :** Production planning and control, forecasting - Moving average, moving range, exponential smoothening, scheduling, assembly line balancing, Inventory Control - ABC analysis, EOQ models, Statistical quality control and TQM, TPM. Elements of cost, job costing, process costing, estimation of machining time.

12) **Operation Research :** Linear programming - Graphical and simplex methods, transportation and assignment models, game theory, queuing models, CPM and PERT, Replacement models, value analysis.

Section - D (Marks : 50)

CAD / CAM

13) **CAD :** Overview and benefits of CAD, primitives, 2D / 3D animation, Bazier curves and splines, Wire-frame modeling, surface and solid modeling, kinematic analysis of open and closed loop mechanisms, stiffness matrix, finite element analysis, optimum design, constrained optimization - Penalty function method, computer aided optimum design of gears, bearing sand shafts.

14) **Product Development :** Design materials, human factors in design, applied ergonomics, product development processes, customer needs, product specifications, concept generation and selection, product architecture, product design methods - function analysis, objective trees, QFD, morphological chart method, weighted objective method, value engineering method. Design for manufacturing, legal issues in product design, economics.

15) **Machine Tool Design :** Kinematics of machine Tools, structural and ray diagrams for speed, stepped and step less regulation of speed, static and dynamic rigidity of machine tools, Vibration of machine tools, chatter, Slide ways and guide ways.

16) **CAM :** Types of automation, Steps in NC manufacturing, manual and NC part programming, APT, Machining centres, FMS, Computer Aided Process Planning, CMM, CIMS & its components, Robotics.

Paper - II

Standard : Degree in Mechanical Engineering. **Total Marks** : 200

Nature of Paper : Conventional Type **Duration** : 3 Hours

Note :
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Section – A (Marks : 50)
Thermodynamics, Heat and Mass Transfer

1) Thermodynamics :

.01) Fundamentals- Work, Heat, Zeroth law, First law- application to thermodynamic system components, efficiency, Second law (theoretical treatment only)- quality of energy, increase of entropy, availability and irreversibility, applications, Third law.

.02) Ideal gas, real gases, compressibility factor, Joule - Thomson Coefficient. Gas power cycles- Air standard work output and efficiency, mean effective pressure, indicated power, brake power.

.03) Vapour Power Cycles- Carnot and Rankine, Reheating and regenerative feed heating, Binary vapour cycle, Thermal efficiency and work ratio.

2) Heat and mass transfer :

.01) Various modes of heat transfer, Fourier's, Newton's and Stefan Boltzman's law, combined modes, overall heat transfer coefficient. Conduction-Thermal conductivity, factors influencing, measurement, general differential equation, steady state, linear heat flow through a plain and composite wall, tube and sphere, conduction with heat sources, heat transfer from rods, fins of uniform cross section.

.02) Convection- Forced and Natural, Heat Exchangers-Types, performance, analysis restricted to parallel and counter flow exchangers. Thermal Radiation- Black and non black bodies, Kirchoff's law, grey body radiation exchange, Mass transfer- mass and mole concentration.

Section - B (Marks : 50)
Fluid Mechanics and Machinery, Pneumatics and Hydraulics,

Power Plant Engineering, Energy Engineering

3) Fluid Mechanics : Fluid and flow-definition and types, properties of ideal and real fluids, Continuum concept, Lagrangian and Eulerian approach. Fluid statics, Kinematics and Dynamics of fluid, flow in pipes, Laminar flow of viscous fluids, Turbulent flow, Dimensional analysis, Compressible fluid flow.

4) Fluid Machinery : Introduction-Classification, energy transfer between fluid and rotor, flow through machines, ideal and actual slip. Hydraulic turbines, pumps, compressors and blowers.

5) Pneumatics and Hydraulics : Production of compressed air, Pneumatic control-Components and Systems, electro Pneumatic logic circuits, Pneumatic counters, Typical applications, Circuits, Sensors.

6) Power Plant Engineering : Sources of energy, variable load problem, power plant

economics and selection. Steam power plant- boilers, general layout, different systems, turbine auxiliary systems, heat balance and efficiency. Gas turbine power plant - regeneration, reheating, cogeneration, auxiliary systems, operation, Nuclear Power Plants - basic components, power stations. Hydro electric power plant - site selection, arrangement, operation. Electrical systems and instrumentation.

7) **Energy Engineering :** Energy conservation methods, audit. Solar energy - collectors, area calculations, Solar Systems - power plants, driers, cookers, refrigeration systems. Wind energy - rotors, system design, site selection. Biogas plants - Types, plant performance, Cogeneration Plants, Geothermal Plants. Direct Energy Conversion - Fuel Cells, Thermoelectric, Thermionic and MHD systems, Govt. policies and programmes for energy and environment conservation.

Section - C (Marks : 50)

I.C. Engines, Automobile Engineering, Refrigeration and Air Conditioning

8) **I.C. Engines :**

.01) Fuel air cycles, real cycles, volumetric efficiency and thermal efficiency, S.I. Engines - carburetion, combustion, combustion chambers, C.I. Engines - fuel injection, combustion, combustion chambers. Detonation - Knock rating of fuels, parameters. Emission Control Systems. Supercharging - effect of altitude on power output, types of superchargers.

.02) Cooling, lubrication and ignition systems, testing of I.C. engines. Compressors - centrifugal and axial, performance. Gas turbines - Ideal cycles, intercooling, regeneration, reheating. Jet propulsion.

9) **Automobile Engineering :** Testing of automobiles, resistances to motion, power requirement for propulsion, Automobile engines, frames, transmission systems, drive line and rear axle, wheels and tyres, steering systems, suspension systems, brakes, starter motors, emission norms.

10) Refrigeration and Air Conditioning : Refrigeration and heating systems, vapour compression and vapor absorption refrigeration systems, refrigeration equipments, psychrometrics, solar radiation, estimating requirements, ducting systems, automotive air conditioning.

Section - D (Marks : 50)

Measurement and Metrology, Numerical Analysis and Computer Programming, Numerical Control of Machine Tools, Automatic Control.

11) **Mechanical Measurement :**

.01) Measuring instruments, generalised measuring systems, static and dynamic performance characteristics of devices, calibration, error - sources and analysis. Sensors and Tranducers, Measurement of - displacement, angular velocity, pressure, strain, force and torque, temperature, flow, vibration and noise. Data acquisition systems.

.02) **Metrology :** Standards of linear measurement, Limits and Fits, Limit gauges, Measurement of geometric forms, Interferometry, Comparators, Measurement of screw threads and gears, surface texture.

12) **Numerical Analysis and Computer Programming :**

Approximations and round of errors, truncation errors and Taylor series, determination of roots of polynomials and transcendental equations, Programming using C and C++ languages for - Solutions of linear simultaneous algebraic equations, curve fitting, Backward, forward and Central Difference relations, Numerical solution of ordinary

differential equations.

13) **Numerical Control of Machine Tools :** Components, open and closed loop control, actuation and feedback systems, Point to Point, linear and contouring systems, Tooling for NC systems, Computer numerical control, Direct and distributed numerical control, adaptive control.

14) **Automatic Control :** Components of automation - actuators, sensors, vision systems, controllers, Logic control and PLCs, Factory communication, Mathematical models, transfer function, Block diagrams, proportional controls, derivative and integral control, steady state and transient response analysis, different inputs, root locus, frequency response methods, speed control systems.

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