Written Test Pattern and Syllabus

1. Applicants who have qualified and have a valid score card in national level exams like GATE/UGC-NET/CSIR-NET/NBHM, etc. are exempted from the written test. Such applicants are expected to produce the valid score card while reporting at the institute.
2. The Question Paper consists two-parts. Part A consists of 50 Multiple Choice Type Questions, each carrying 1 mark. Part B consists of 10 Multiple Choice Type Questions, each carrying 5 marks.
3. The written test has NEGATIVE MARKING. For every incorrect 1-mark question, 1/3 marks are deducted and for every incorrect 5-mark question, 5/3 marks are deducted.
4. The duration of the examination is 180 mins.

Department of Mechanical Engineering PhD Admissions

Syllabus for Written Test

Engineering Mathematics

- Linear Algebra: Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.
- Differential equations: First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems.
- 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.

Fluid Mechanics and Thermal Sciences

- Fluid Mechanics: Fluid properties; fluid statics, 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; basics of compressible fluid flow.
- Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept and 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
- Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behavior 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.
- 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; steam and gas turbines

Applied Mechanics and Design

- Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.
- 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; concept of shear centre; 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.
- 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.
- Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.
- 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 and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Materials, Manufacturing and Industrial Engineering

- Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.
- 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.

- 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, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.
- Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).
- Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.
- Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing.
- Inventory Control: Deterministic models; safety stock inventory control systems.
- Operations Research: Linear programming, simplex method, transportation, assignment, network flow models

Mechatronics and Automation

- Overview of Mechatronics and Automation Systems: Accuracy-precision-resolution, automated feeding, transfer, retrieval mechanisms and devices, work cells and flexible manufacturing systems, material handling and storage systems, overview of sensors, transducers and control systems.
- Robots Mechanics: Links and joints, kinematic pairs, chains and mechanisms, kinematic inversions, velocity and acceleration of planar mechanisms-graphical and analytical methods, loop closure equation, four-bar mechanisms, Grashof criterion, robot classification and anatomy, workspace, robot kinematics-forward/inverse, DH matrix transformation, Jacobian and differential motion, dynamics and position control, path planning, industrial and medical applications.
- Pneumatic & Hydraulic Systems: Production, distribution and conditioning of compressed air, flow-pressure-direction control valves, actuators, supporting and control elements, pumps, proportional valves and their applications, servo valves and actuators, design of pneumatic and hydraulic systems, performance analysis.

- Mobile robots: Kinematics, degree of Mobility, steerability and manoeuvrability, sensors for localization and motion control, Holonomic robots.