Department of Mechanical Engineering, IIT Tirupati
Syllabus for MS/PhD Written Examinations and Interviews

The written test and interview will be on engineering mathematics and the candidate's chosen stream (Design and Solid Mechanics, Robotics, Manufacturing, or Fluid and Thermal Engineering)

Engineering Mathematics (Common for all candidates)

Linear Algebra: Algebra of matrices; Inverse and rank of a matrix; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalisation of matrices; Cayley-Hamilton Theorem.

Calculus: Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima. Evaluation of definite and indefinite integrals; Applications of integrals to evaluate areas and volumes, Double and triple integrals, and their applications.

Vector Calculus: Gradient, divergence and curl; applications of these concepts in engineering analyses.

Ordinary Differential Equations: First order equations (linear and nonlinear); Second order linear differential equations with variable coefficients.

Fluid & Thermal Engineering

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.

Fluid Mechanics: Introduction – definition of a fluid, continuum hypothesis, fluid properties, stress at a point, classification of flows, rheological classification; Fluid statics, manometry, buoyancy, forces on submerged

bodies, stability of floating bodies; Fluid kinematics, Lagrangian and Eulerian description, vorticity and rotationality; Reynolds transport theorem, Bernoulli equation, conservation of mass, continuity equation, stream function, potential function, conservation of momentum, momentum analysis of flow systems; Dimensional analysis; Internal flow, flow through pipes, head losses in pipes, laminar and turbulent flow in pipes, Moody's chart; External flow, lift and drag, flow over flat plates, cylinders and spheres; Viscous flow of incompressible fluids, boundary layers; Elementary turbulent 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.

Applied Thermal Engineering and CFD: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles. Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines. Classification of PDEs, finite difference approximations, order of accuracy, Taylor’s series, explicit and implicit time-stepping

Solid Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; trusses and frames; degrees of freedom and constraints; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; Instantaneous center, impulse and momentum (linear and angular) and energy formulations; collisions; rotating frames and transformations.

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; thermal stresses; strain gauges and rosettes, testing of materials with universal testing machine;

testing of hardness and impact strength. Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram.
Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic gear trains.
Vibrations: Free and forced vibration of single degree of freedom systems; effect of damping; vibration isolation; resonance.

Mechatronics and Robotics

Engineering Mechanics: Free-body diagrams and equilibrium; trusses and frames; degrees of freedom and constraints; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; Instantaneous center, impulse and momentum (linear and angular) and energy formulations; collisions; rotating frames and transformations.
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; thermal stresses; strain gauges and rosettes, testing of materials with universal testing machine; testing of hardness and impact strength. Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram.
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Manufacturing

Material Science and Engineering: Introduction to crystallography: Crystal Structure – Atomic bonding, Unit cells and crystal systems, Metallic crystal structures, imperfections in solids; Principles of alloy formation: Solid solution, Hume-Rothery rules, Binary phase diagrams, Development of microstructure under equilibrium cooling and effects of non-equilibrium cooling, Iron-Iron Carbide Phase diagram; Elastic and Plastic deformation: Slip systems, Critical resolved shear stress, Frank-Read source, Work hardening and dynamic recovery, Strengthening Mechanisms, Recovery, Recrystallization and Grain growth, Cold and hot working; Heat Treatment: Types of heat treatment, isothermal transformation diagram and continuous cooling transformation diagram.

Manufacturing Technology: Methods of manufacturing – metal casting, metal joining, and metal forming: basic principles, Classification, equipment, process variables, defects in manufactured components, and applications; Non-destructive examination of manufactured components.

Metal Cutting and Metrology: Machine Tools – Types, Parts, Working, Machining time estimation; Tool Geometry - ASA system, Significance of various angles, Orthogonal Rake System (ORS), Normal Rake System (NRS), Mechanics of chip formation, Merchant's analysis, Effect of tool geometry on cutting forces and surface finish, Tool materials, Thermal aspects in machining, Grinding and finishing processes, Cutting fluids; Advanced machining processes – mechanical, thermo-mechanical, thermo-electrical, chemical, thermo- chemical and hybrid processes; Basic terminology, Errors in Measurement, Uncertainty and Calibration, Limits, Fits, Tolerances and Gauging, Comparators, Surface Roughness Measurement, Geometric Form Measurement.