Research Topics

Mechanical and Aerospace Engineering Department, Mahindra University

Fluid & Thermal Engineering: Solar Thermal Power, Refrigeration and Air-Conditioning, Cell modelling, Experimental study on Battery thermal management, Direct/indirect cooling of Lithium-ion battery pack, ageing, thermal runaway of Lithium-ion cell, Data Center Cooling, Heat transfer, Microfluidics, Biofluid Dynamics, Biomechanics Modelling and Simulation.

Solid mechanics: Computational Mechanics, Theoretical solid mechanics, Computer Aided Design, mechanics of 3D printed cellular materials, functionalized 3D print resins (modelling + development)

Materials and Manufacturing Process: Cyber-Physical Systems, Advanced manufacturing systems, Sheet metal forming of Titanium Alloy Ti6AI4V, Finite Element Analysis and Experimental work on Incremental Sheet Forming using hybrid techniques (heat assisted, electric assisted), Solid State recycling of machining scrap, Rolling of Aerospace materials, Manufacturing process simulation for aerospace materials, Additive manufacturing, Numerical Modelling and Simulation of additive manufacturing, Friction based Additive Manufacturing, advance finishing process, Smart Manufacturing, Industrial Engineering, Automation in Manufacturing, Laser Additive Manufacturing, Post-processing of Additively Manufactured parts, AI and ML in Advanced Manufacturing, Advanced Micro-machining Processes. Nanomaterials Processing and Characterization - Tribology of hard coatings on cemented tungsten carbide - Composite oxide nano additives in lubricants

Robotics: Robotics, Cable-Driven Robotics, Exoskeletons, Exosuits, Unmanned Aerial Vehicles, legged robots, autonomous robot navigation, Robot control, Multibody dynamics, DRONES, Aerial robotics, Mechatronic system development, Robot-Assisted Surgery, Augmented and Virtual Reality based Medical Robots etc.

Aerospace Engineering: Gas turbine Combustion, Computational Turbomachinery, Scramjet Propulsion with hydrogen and hydrogen fuel, Regenerative Cooling in high speed flow, Turbulence modelling, Combustion modelling, Large Eddy Simulation, Direct Numerical Simulation, Turbulence-chemistry interaction, Laminar to Turbulent Transition, CFD code development in high speed reacting and non-reacting flows, Numerical Modelling of Solid Propellant Combustion, Combustion Instability; Experimental investigation of the burning rate characteristics of solid propellants containing additives and burn-rate modifiers; Experimental Aerodynamics, Fluid-Structure Interaction in Turbomachinery, Experiments in High-Speed Flows; Lighter-Than-Air (LTA) Systems, Buoyant Aerial Platforms, Planetary Exploration using Buoyant Systems, Buoyant Aerial Platforms for Renewable Energy Generation, Design of Unmanned Aerial Vehicles (UAVs), Urban Air Mobility, Guidance Navigation and Control of UAVs, Flapping Wing Aerodynamics, Micro-Aerial Vehicles (MAVs); Vibration of continuous systems, fluid-structure interaction, wind turbine structures, wind turbine blade design, offshore wind turbine dynamics, Computational Wave Mechanics in elastic solids, Nonlocal Elasticity Theories, Causality and Kramer-Kronig Relations.

Syllabus for Written examination

Engineering Mathematics: Vector calculus – Gradient, divergence, curl operators and properties, Line, surface and volume integrals, Divergence theorem, Stokes' theorem. Linear algebra – Solution of system of algebraic equations, Eigenvalues and Eigenvectors of a matrix. Ordinary differential equations – Solution of first and second order linear ODEs. Partial differential equations – Solution of Laplace, Wave and Diffusion equations. Complex analysis – Analytic functions, Contour integration, Taylor and Laurent series expansions. Numerical methods – Numerical solution of systems of algebraic equations, ODEs and PDEs

Engineering Mechanics: Equivalent force systems, Internal forces – Free body diagrams. Truss and frames. Dynamics of a particle and a system of particles. Dynamics of a rigid body. Vibration of a spring-mass-damper system.

Strength of Materials: Euler-Bernoulli Beam theory - shear force and bending moment, flexural and shear stresses in beams, deflection of beams. Torsion - Torsion of circular shafts. Buckling - Euler's theory of column buckling. Basics of elasticity - Stress and strain components and transformations, Elastic constants, plane stress and plane strain, Mohr's circle for 2D and 3D conditions

Thermodynamics: Thermodynamic systems. Zeroth, First and second Law of thermodynamics. Properties of Pure substances. Thermodynamics cycles

Fluid Mechanics: Fluid Properties. Lagrangian and Eulerian Descriptions; Material Derivative; Reynolds Transport theorem. Momentum and Energy Integral Equations and their applications. Navier-Stokes Equation; Velocity Potential and Stream Function. Non-dimensional Numbers in Fluid Mechanics. Boundary Layer Theory: Pipe flow and flow over flat plate

Heat Transfer: Basic Modes of Heat transfer. Electrical Resistance Analogy; Fins; Lumped Capacitance. Thermal and Momentum Boundary layers over a flat plate. Shape factor; Black and Grey body radiation. Non-dimensional Numbers in Heat Transfer

Materials and Manufacturing: Crystal structure of Solids. Phase Diagram of Simple Binary Alloys Mechanical Behavior of Materials. Metal Forming: Wire Drawing, Rolling, Extrusion Machining: Turning, Milling and Drilling. Welding: Arc Welding and Oxy-acetylene Welding. Metrology and Inspection – Limits, Fits, Tolerances, surface finish, form measurement. Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

Robotics: Under Graduate Mathematics (Calculus). Under Graduate Mechanics. Vectors and Transformations. Under Graduate Control Theory

Aerospace: Basic fluid mechanics: Viscosity, Potential flow, Navier stokes conservation laws for mass and momentum in differential form, Exact solutions of N-S equations Airfoils and wings: Aerodynamic coefficients: lift, drag and moment; Aerodynamic center, Finite wings - induced drag, wing sweep, drag polar, drag divergence Mach number. Compressible flows: One dimensional compressible flows, isentropic flows, Flows through nozzles and diffusers, Normal and oblique shocks, expansion fans. Structures: Static deformation for beams (flexural, axial, torsional). Shear stress and Shear centre. Buckling. Pressure vessels. Dynamics: Vibration of multi-DOF system, Energy-based methods, Vibration of continuous systems, random vibrations, fatigue. Composite structures: Micromechanics; Composite rods and beams (A, B, D matrices)

Paper Pattern

Type	Marks	No of questions	Remarks
Section A	15	15	**Compulsory for all candidates** – Fundamentals of UG Mechanical Engineering
Section B	45	5	Have to choose **any one** of the following sub-sections based on research area of candidate: (1) Thermals and Fluids, (2) Materials and Manufacturing (3) Mechanics and Design, (4) Robotics, (5) Aerospace Engineering

Note:
Exam Duration is for 2 hours.
Non-programmable scientific calculator is allowed.