AE Aerospace Engineering

Important Note for Candidates: In each of the following subjects, the topics have been divided into two categories – Core Topics and Special Topics. The corresponding sections of the question paper will contain at least 90% of the questions on Core Topics and the remaining 10% at most on Special Topics.

Section 1: Engineering Mathematics

Core Topics:

Linear Algebra: Vector algebra, matrix algebra, systems of linear equations, rank of a matrix; Eigenvalues and eigenvectors.

Calculus: Functions of single variable, limits, continuity and differentiability, chain rule, maxima and minima, Integration; Functions of several variables, partial derivatives, gradient, divergence and curl, directional derivatives; Line, surface and volume integrals. Theorems of Stokes, Gauss and Green.

Differential Equations: First order linear ordinary differential equations; Higher order linear ODEs with constant coefficients; Classification of partial differential equations; solution to: wave equation, Laplace equation, heat equation using separation of variables methods.

Numerical Methods: Numerical solutions for linear and nonlinear algebraic equations by bisection, Newton-Raphson method; basic numerical differentiation; numerical integration by trapezoidal and Simpson's rules; linear regression and least squares method; linear interpolation.

Special Topics:

Fourier series; complex numbers, analytic functions and Cauchy-Riemann equations.

Basics of probability and statistics: Bayes theorem, mean, median, & mode; variance; binomial, normal and Poisson distribution.

Section 2: Flight Mechanics & Space Dynamics

Core Topics:

Atmosphere: Properties of standard atmosphere.

Classification of aircraft. Airplane (fixed wing aircraft) configuration and various parts; Pressure altitude; equivalent, calibrated, indicated air speeds;

Primary flight instruments: Altimeter, air speed indicator, vertical speed indicator, turn-bank indicator.

Aerodynamic forces and moments; angle of attack; sideslip;

High-lift devices; roll, pitch & yaw controls.

Airplane performance: C_L-alpha curve, drag polar; take-off and landing; steady climb and descent; absolute and service ceiling; range and endurance, load factor, turning flight, V-n diagram. Winds: head, tail and cross winds.

Static stability: stability and control derivatives; longitudinal stick fixed and free stability; horizontal tail position and size; directional stability, vertical tail position and size; lateral stability; wing dihedral, sweep & position; hinge moments, stick forces.

Linear momentum and angular momentum balance for rigid bodies.

Space Dynamics: central force motion, Keplerian orbits, Kepler's laws; escape velocity.

Special Topics:
Equations of motion; Euler angles; decoupling of longitudinal and lateral-directional dynamics; longitudinal modes; lateral-directional modes, Hohmann orbital transfers.

Section 3: Aerodynamics

Core Topics:
Basic fluid mechanics: fluid kinematics, streamline, streakline, pathline; conservation laws: mass, linear momentum and energy (integral and differential form); dimensional analysis and dynamic similarity; incompressibility conditions; Newtonian fluids.

Elementary ideas of viscous flows: Hagen-Poiseulle flow, Couette flow, basic concepts in boundary layers, boundary layer thickness.

Two-dimensional potential flow theory: sources, sinks, doublets, point vortex and their superposition, Bernoulli's equation.

Airfoils and wings: airfoil nomenclature; aerodynamic coefficients: lift, drag and moment; Kutta-Joukoswki theorem; thin airfoil theory, Kutta condition, starting vortex; finite wing theory: induced drag, Prandtl lifting line theory; critical and drag divergence Mach numbers.

Compressible flows: basic concepts of compressibility, one-dimensional compressible flows, isentropic flows, normal and oblique shocks, Prandtl-Meyer flow; flow through nozzles and diffusers.

Special Topics:
Fanno flow; Rayleigh flow; pressure measurements using U-tube manometers and Pitot probe.

Section 4: Structures

Core Topics:
Strength of materials: Stress and strain, stress-strain curves of steel and Aluminium; stresses and deflections in statically determinate and indeterminate linear elastic trusses, bars, beams, and shafts; two-dimensional transformations of stresses and strains, Mohr's circle, principal stresses and strains; combined loading, failure criteria: maximum stress, Tresca, von Mises; strain energy; Castigliano's principles; three-dimensional Hooke's law; plane stress and strain; Euler buckling of columns.

Flight vehicle structures: torsion, bending and shear of open and closed thin-walled sections: symmetric and unsymmetric cross-sections; loads on aircraft.

Structural Dynamics: free and forced vibrations of undamped and damped SDOF systems; free vibrations of undamped 2-DOF systems.

Special Topics:
Equilibrium and compatibility equations in two-dimensional elasticity.

Section 5: Propulsion

Core Topics:
Basics of thermodynamics.
Aerothermodynamics of aircraft engines: thrust, efficiency, range. Brayton cycle.
Engine performance: ramjet, turbojet, turbofan, turboprop and turboshaft engines; after-burners.
Aerothermodynamics of non-rotating propulsion components such as intakes, nozzles.

Gas turbine combustor: types and configurations; combustion, stoichiometric fuel-to-air ratio.

Turbomachinery: Axial compressors: angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reaction, multi-staging; Centrifugal compressor: stage dynamics, inducer, impeller and diffuser; Axial turbines: stage performance.

Rockets: thrust equation and specific impulse, rocket performance; multi-staging; chemical rockets; performance of solid and liquid propellant rockets.

Special Topics:
Turbine blade cooling, compressor-turbine matching.