

Proposed Syllabus and Curriculum for M.Tech. Structures and Design (2026 Admission onwards)

Curriculum

Semester 1

Sl. No.	Course Name	Credits	Type
1	Mathematics \$	3	Core
2	Elements of Aerospace Engineering*	3	Core
3	Advanced Solid Mechanics	3	Core
4	Finite Element Methods	3	Core
5	Structural Dynamics	3	Core
6	Aerospace Structures Lab	1	Lab
Total		16	

Semester 2

Sl. No.	Course Name	Credits	Type
1	Mechanics of Composite Materials	3	Core
2	Stream Elective-1	3	Elective
3	Stream Elective-2	3	Elective
4	Stream Elective-3	3	Elective
5	Open Elective	3	Elective
6	Design practice	1	Other
Total		16	

Semester 3

Sl. No.	Course Name	Credits	Type
1	Project Work – Phase I	18	Project
Total		18	

Semester 4

Sl. No.	Course Name	Credits	Type
1	Project Work – Phase II	18	Project
Total		18	

Total Credits: 68

Note:

- \$ - Any PG level Mathematics course
- * - Students with an Aerospace Engineering background can opt for a stream elective instead of the Elements of Aerospace Engineering course
- Any one relevant NPTEL/Swayam course can be taken as a stream elective

Summary

Core courses:	6
Elective courses:	4
Lab:	1
Design practice:	1
Main project:	1

Syllabus

Semester 1

Mathematical Methods in Aerospace Engineering (3 – 0 – 0) 3 Credits

Vector spaces: definition, linear independence of vectors, basis, inner product and inner product space, orthogonality, subspaces.

Linear algebraic equations: existence and uniqueness of solution, elementary row/column operations, Gauss elimination and Gauss Jordan methods, Echelon form, pivoting, LU decomposition and Cholesky method, Gauss-Seidel and Jacobi iterative methods, condition number, minimum norm and least square error solutions

Eigenvalues and eigenvectors of matrices: properties like multiplicity, eigenspace, spectrum and linear independence of eigenvectors, similarity transformation and Jordan canonical form, eigenvalues/eigenvectors of symmetric matrices: orthogonal diagonalization, Singular value decomposition

Vector Calculus (Review of multi-variable calculus and calculus of variations, curves, surfaces, vector and scalar fields, Line integral and path independence, Surface and volume integrals; Gauss (divergence), Stokes and Green's theorems),

ODEs : IVP (1st and 2nd order), BVP (2nd order), existence and uniqueness. Laplace transform, Fourier series, orthogonal functions, Fourier transform. System of ODEs: existence and uniqueness of IVP, solution of the homogeneous system with constant coefficients, generalized eigenvector to find other fundamental solutions, method of variation of parameter. Series solutions and special functions, Sturm-Liouville Theory

References:

1. Kreyszig, Erwin. Advanced Engineering Mathematics. 8th rev. ed., John Wiley & Sons, 1999.
2. Dasgupta, B. Applied Mathematical Methods. Pearson Education, 2006.
3. Strang, Gilbert. Linear Algebra and Its Applications. 4th ed., Brooks/Cole, 2006.
4. Arfken, George B., Hans J. Weber, and Frank E. Harris. Mathematical Methods for Physicists: A Comprehensive Guide. 7th ed., Academic Press, 2012.

5. Greenberg, Michael D. Advanced Engineering Mathematics. 2nd ed., Prentice Hall, 1998.

Course Outcomes (COs):

CO1: Apply concepts of linear algebra—vector spaces, eigenvalue problems, matrix decompositions, and tensor algebra—to model and analyze systems arising in aerospace engineering.

CO2: Compute and evaluate vector and tensor differential operations (gradient, divergence, curl, line/surface/volume integrals) and use integral theorems in solving aerospace-related field problems.

CO3: Formulate and solve ordinary differential equations (ODEs), including higher-order and systems of ODEs, using analytical techniques such as integrating factors, undetermined coefficients, variation of parameters, and series solutions.

CO4: Analyze existence, uniqueness, and stability of solutions for initial value and boundary value problems relevant to aerospace dynamical systems.

CO5: Apply Sturm–Liouville theory, special functions, and transform techniques (Laplace and Fourier) to solve complex engineering problems in vibration, stability, heat transfer, and wave propagation.

CO6: Classify and solve partial differential equations (PDEs) of elliptic, parabolic, and hyperbolic type and apply separation of variables to aerospace applications such as 1D/2D wave and heat equations.

CO7: Implement numerical methods (finite difference and iterative methods) to approximate solutions of ODEs/PDEs and evaluate their accuracy and convergence for engineering simulations.

Elements of Aerospace Engineering (3 – 0 – 0) 3 Credits

History of aviation – types of flying machines – anatomy of an aircraft; fundamental aerodynamic variables – aerodynamic forces – lift generation – airfoils and wings – aerodynamic moments – concept of static stability – control surfaces; mechanism of thrust production – propellers – jet engines and their operation – elements of rocket propulsion; loads acting on an aircraft – load factor for simple maneuvers – Vn diagrams; aerospace

materials; introduction to aerospace and aircraft structures; basic orbital mechanics – satellite orbits; launch vehicles and reentry bodies.

References:

1. Anderson, John D. Introduction to Flight. 7th ed., McGraw-Hill, 2011.
2. Anderson, David F., and Scott Eberhardt. Understanding Flight. 2nd ed., McGraw-Hill, 2009.
3. Szebehely, Victor G., and Hans Mark. Adventures in Celestial Mechanics. 2nd ed., Wiley, 1998.
4. Turner, Martin J. L. Rocket and Spacecraft Propulsion: Principles, Practice and New Developments. 3rd ed., Springer, 2009.

Course Outcomes (COs):

CO1: Develop a basic understanding about the classification of aircraft and its anatomy.

CO2: Equip with fundamental aerodynamic concepts related to aircraft.

CO3: Develop a basic knowledge about aircraft performance, aerospace materials and structures.

CO4: Exposure to various air breathing engines and its working principle for thrust generation in aircraft.

CO5: Equip with the basics of rocket propulsion and orbital mechanics.

Advanced Solid Mechanics (3 – 0 – 0) 3 Credits

Introduction to Cartesian tensors, Strains: Concept of strain, derivation of small strain tensor and compatibility; Stress: Derivation of Cauchy relations and equilibrium and symmetry equations, principal stresses and directions, octahedral shear stresses; Constitutive equations: Generalized Hooke's Linear Elasticity, Material symmetry; Boundary Value Problems: concepts of uniqueness and superposition; Plane stress and plane strain problems, introduction to governing equations in polar and cylindrical coordinates, axisymmetric problems; Application to thick cylinders, rotating discs, torsion of non-circular cross-sections, stress concentration, thermo-elasticity; Solutions using

potential energy methods, Introduction to plasticity. Introduction to thin walled beams - shear centre.

Textbook:

- Sadd, Martin H. Elasticity: Theory, Applications, and Numerics. 3rd ed., Academic Press, 2014.

References:

1. Srinath, L. S. Advanced Mechanics of Solids. 3rd ed., Tata McGraw-Hill, 2010.
2. Mase, George T., Ronald E. Smelser, and George E. Mase. Continuum Mechanics for Engineers. 3rd ed., CRC Press, 2009.
3. Timoshenko, Stephen P., and James N. Goodier. Theory of Elasticity. 3rd ed., McGraw-Hill, 1970.

Course Outcomes (COs):

CO1. Apply Cartesian tensor notation to represent stress, strain, and constitutive relations, and analyze small strain and compatibility conditions in complex deformation states.

CO2. Determine stress components using Cauchy's relations, evaluate principal stresses, principal directions, and octahedral shear stresses, and interpret stress states using Mohr's circle and related tools.

CO3. Formulate and solve linear elastic problems using generalized Hooke's law, identify material symmetry conditions, and apply uniqueness and superposition principles to boundary value problems.

CO4. Model and analyze plane stress and plane strain conditions; derive and use governing equations in Cartesian, polar, and cylindrical coordinate systems, including axisymmetric geometries.

CO5. Evaluate stress and deformation in thick cylinders, rotating discs, and torsion of non-circular cross-sections, and assess stress concentration and thermo-elastic responses for engineering applications.

CO6. Apply energy methods (e.g., strain energy, Castigliano's theorem) to obtain approximate or exact solutions of elasticity problems and describe the fundamental concepts of plasticity relevant to material yielding.

Finite Element Methods (3 – 0 – 0) 3 Credits

Introduction and History of FEM- Spring systems, Truss and Boundary conditions-Finite Element Formulation starting from GDE-Finite Element Formulation starting from stationarity of a functional-One dimensional FE analysis-Two Dimensional FE analysis-Introduction to Dynamic Analysis- Research & industrial applications.

Textbook

- Seshu.P. Textbook of Finite Element Analysis, Prentice Hall of India, 2009.

References:

1. Ferreira, Antonio J. M., and Nicola Fantuzzi. MATLAB Codes for Finite Element Analysis. Vol. 157, Solid Mechanics and Its Applications, Springer, 2020.
2. Fish, Jacob, and Ted Belytschko. A First Course in Finite Elements. John Wiley & Sons, 2007.
3. Hutton, David V. Fundamentals of Finite Element Analysis. McGraw Hill Education (India) Pvt. Ltd., 2017.
4. Cook, Robert D., David S. Malkus, Michael E. Plesha, and Robert J. Witt. Concepts and Applications of Finite Element Analysis. 4th ed., John Wiley & Sons, 2003.
5. Chandrupatla, Tirupathi R., and Ashok D. Belegundu. Finite Elements in Engineering. 2nd ed., Prentice Hall of India, 2000.

Course Outcomes (COs):

CO1: Students should have an understanding of the theory and procedures of FE

CO2: Develop 1D & 2D elements for structural mechanics problems. Solve problems related to element formulation both from GDE and Potential and numerical integration

CO3: Should be able to develop a code for simple 1D & 2D FE problems so that proper element selection, convergence, input and output are understood by the students. Should be able to implement the various procedures of FE to create the code.

CO4: Use a commercial FE program to solve a 2D sufficiently complex problem wherein modeling, element selection, and post-processing issues are understood. Should be able

to differentiate and compare between some of the elements available for solution of a problem.

Structural Dynamics (3 – 0 – 0) 3 Credits

Elements of analytical dynamics – discrete systems with multiple degrees of freedom – elastic and inertia coupling – natural frequencies and mode – free vibration response – uncoupling of equations of motion – modal analysis – forced vibration response – vibration isolation – vibration of continuous systems – differential equations and boundary conditions – longitudinal, flexural and torsional vibrations of one-dimensional structures – vibration analysis of simplified aircraft and launch vehicle structures – structural damping – free and forced response of continuous systems – introduction to concepts of nonlinear and random vibrations – elements of vibration testing and experimentation.

References:

1. Meirovitch, Leonard. Elements of Vibration Analysis. 2nd ed., McGraw-Hill, 1986.
2. Paz, Mario. Structural Dynamics: Theory and Computation. 2nd ed., CBS Publishers & Distributors, 2004.
3. Weaver, William, Jr., Stephen P. Timoshenko, and Donovan H. Young. Vibration Problems in Engineering. 5th ed., John Wiley & Sons, 1990.
4. Meirovitch, Leonard. Computational Methods in Structural Dynamics. Sijthoff & Noordhoff, 1980.
5. Clough, Ray W., and Joseph Penzien. Dynamics of Structures. 2nd ed., McGraw-Hill, 1993.

Course Outcomes (COs):

- CO1: Apply the knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
- CO2: Create simple computational models for engineering structures using the knowledge of structural dynamics.
- CO3: Interpret the dynamic analysis results for design, analysis and research purposes.

Aerospace Structures Lab (0 – 0 – 3) 1 Credit

1. Strain measurements
2. Structural vibration
3. Wave propagation
4. Fabrication and testing of laminated composites
5. Static and stability behaviour of thin-walled structures
6. Non-destructive testing
7. Structural modelling and analysis in CAE environment
8. Unsymmetrical bending & Shear centre

Course Outcomes (COs):

CO1: To verify, understand and apply the structural engineering concepts they learned by conducting simple experiments using benchmark experimental setups.

CO2: To develop simple experimental set ups using available resources by their own and conduct experiments to understand the mechanics involved in the problems that they come across in different fields of aerospace structural mechanics.

CO3: To develop the capability of using basic concepts for design of Aerospace structural components.

Semester 2

Mechanics of Composite Materials (3 – 0 – 0) 3 Credits

Introduction, definition, classification, behaviors of unidirectional composites – lamina: prediction of stiffness & strength – factors influencing strength and stiffness – multiaxial failure criteria – Micromechanical strength models - hygrothermal behaviour; discontinuous fibre reinforced lamina; constitutive classical laminate theory – theories of failure – design consideration – mechanical properties of composite materials – analysis of composite laminated beams – bending of composite plates.

Text Book:

- Gibson, Ronald F. *Principles of Composite Material Mechanics*. 2nd ed., CRC Press, 2014.

References:

1. Jones, Robert M. *Mechanics of Composite Materials*. 2nd ed., CRC Press, 1998.
2. Kollár, László P., and George S. Springer. *Mechanics of Composite Structures*. Cambridge University Press, 2003.
3. Altenbach, Holm, Johannes Altenbach, and Wilfried Kissing. *Mechanics of Composite Structural Elements*. Springer, 2000.

Course Outcomes (COs):

CO1: Introduction to advanced composite materials and their applications.

CO2: Develop micro-mechanical and macro-mechanical relationships for lamina and laminated materials.

CO3: Failure analysis of the composites.

CO4: The material, structural, and strength optimization to design laminated composite materials.

Design Practice (1 credit)

The objective of the design project is to promote design thinking as an interdisciplinary approach for solving real-world problems. The project aims to provide accessible learning

resources and activities that introduce students and educators to human-centered design, creativity, and innovation. It encourages hands-on learning through ideation, prototyping, and testing of solutions. The initiative also seeks to integrate design methodologies into STEM education and foster collaborative problem-solving skills for addressing societal challenges.

List of Electives

- Linear Algebra and Perturbation Methods
- Probability and Statistics for Engineers
- Operations Research
- Artificial Intelligence and Robots
- Aeroelasticity
- Continuum Mechanics
- Introduction to Robotics
- Multi-Rigid Body Dynamics
- Energy Methods in Structural Mechanics
- Advanced Finite Element Method
- Molecular Dynamics and Materials Failure
- Fracture Mechanics and Fatigue
- Stochastic Mechanics and Structural Reliability
- Elastic Wave Propagation in Solids
- Aerospace Materials and Processes
- Smart Materials and Structures
- Structural Acoustics and Noise Control
- Mechanics of Aerospace Structures
- Design and Analysis of Aerospace Structures
- Robot Mechanisms and Technologies
- Analysis and Synthesis of Mechanisms
- Rotordynamics

- Experimental Modal Analysis
- Random Vibrations and Applications