MIT ART, DESIGN AND TECHNOLOGY UNIVERSITY, PUNE

SCHOOL OF ENGINEERING AND SCIENCES PUNE

STRUCTURE and SYLLABUS

FOR

M. Tech. Aerospace Engineering

(Specialisation in Structures)

(76 Credits)

UNDER FACULTY OF ENGINEERING & SCIENCES

w.e.f. 2025-2026

MIT ADT University
Aerospace Engineering Department
M. Tech Aerospace Engineering
Specialisation: Aero-Structures
2025-26 Pattern

Semester I

Course Code	Course Name	Hours/week				Maximum Marks			Assessment
		L	T	P	C	CA	FE	Total	
25MTAS101R	Advanced Aerospace Structural Mechanics	3		02	4	50	50	100	Open Book
25MTAS102R	Computational Structural Analysis	3	--	--	3	50	50	100	Closed Book Exam
25MTAS103R	Aerospace Materials and Manufacturing Processes	3	--	--	3	50	50	100	Closed Book Exam
25MTAS104R	Data-driven Aerospace Engineering	3	--	--	3	50	50	100	Closed Book Exam
25MTAS105R	Advanced Research Techniques & Ethics	3	--	--	3	50	50	100	Jury-based evaluation
25MTAS206R	Technical Seminar-I	--	--	4	2	50	50	100	Jury-based evaluation
25MTAS107R	Finite Element Analysis Lab	--	--	4	2	50	50	100	Laboratory/Practical Exams
25MTAS108R	Introduction to Aerospace Engineering	3	--	--	--	--	--	--	Audit
	Total	**18**	**00**	**10**	**20**	**350**	**350**	**700**	

Semester II

Course Code	Course Name	Hours/week				Maximum Marks			Assessment
		L	T	P	C	CA	FE	Total	
25MTAS201R	Aeroelasticity and Structural Dynamics	3	--	--	3	50	50	100	Open Book
25MTAS202R	Composite Structures and Smart Materials	3	--	02	4	50	50	100	Closed Book Exam
25MTAS203R	Optimisation & Computational Techniques in Aerospace Structures	3	--	02	4	50	50	100	Closed Book Exam
21MTAS104R	Engineering Economics & Financial Decision-Making	2	--		2	50	50	100	Closed Book Exam

25MTAS--	Elective-I	3	-		3	50	50	100	Open Book Exam
25MTAS205R	Advanced FEA and Coupled Phenomena – Lab	--	--	4	2	50	50	100	Laboratory/Practical Exams
25MTAS206R	Mini Project	--	--	4	2	50	50	100	Jury-based evaluation
	Total	**14**	**00**	**12**	**20**	**350**	**350**	**700**	

Specialisation (Aero Structure)								
Elective-I								
Course Code	**Course Name**	**Hours/week**				**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**FE**	**Total**
25MTAS211R	Nonlinear Finite Element Analysis for Aerospace Applications	3	-	--	3	50	50	100
25MTAS212R	Structural Health Monitoring and Damage Prognosis							
25MTAS213R	Advanced Optimization Techniques in Structural Design							

Semester III									
Course Code	**Course Name**	**Hours/week**				**Maximum Marks**			**Assessment**
		L	**T**	**P**	**C**	**CA**	**FE**	**Total**	
25MTAS--	Elective-II	3	--	--	3	50	50	100	Open Book Exam
25MTAS301R	Advanced Research Methodologies and Scientific Communication	3	--	--	3	100	--	100	Case Study
25MTAS302R	Technical Seminar-II	--	--	4	2	50	50	100	Jury-based evaluation
25MTAS303R	Dissertation Phase -I	--	--	16	08	50	50	100	Jury-based evaluation
	Total	**06**	**00**	**20**	**16**	**250**	**150**	**400**	

Specialisation (Aero Structure)								
Elective-II								
25MTAS221R	Vibration and Noise Control in Aerospace Structures	3	-	--	3	50	50	100
25MTAS222R	Crashworthiness and Impact Analysis							
25MTAS223R	Fluid–Structure Interaction in Aerospace Engineering							

Semester IV									
Course Code	**Course Name**	**Hours/week**				**Maximum Marks**			**Assessment**
		L	**T**	**P**	**C**	**CA**	**FE**	**Total**	
25MTAS401R	Dissertation Phase-II	--	--	32	16	100	200	300	Jury-based evaluation
	Total	**00**	**00**	**32**	**16**	**100**	**200**	**300**	

SEMESTER – I

Course Code	Course Title				Category
25MTAS101R	**Advanced Aerospace Structural Mechanics**				
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**T**	**D/P**			
3	**0**	**02**	**50**	**50**	**4**

Prerequisite:

1. Understanding of structural mechanics and material behavior (typically covered in undergraduate Mechanics of Materials courses).
2. Basic knowledge of composite materials and introductory finite element concepts.

Course Objectives:

The primary purpose of this course is to:

1. Understand the fundamental concepts of stress–strain behavior, elasticity, and plasticity in aerospace structures.
2. Explain the principles underlying beam, plate, and shell theories.
3. Analyze various failure mechanisms through established failure theories and criteria.
4. Examine the behavior of composite materials using laminate theory and assess typical failure modes.
5. Design aerospace structural components by integrating safety factors, load path analysis, and design redundancy.

Course Outcome:

By the end of this course, students will be able to:

1. Identify and explain the basic material behavior including stress–strain relationships, elasticity, and plasticity.
2. Demonstrate knowledge of beam, plate, and shell theories by applying appropriate models to practical problems.
3. Evaluate failure mechanisms by comparing yield criteria, fracture mechanics, and fatigue theories.
4. Analyze composite structures by applying laminate theory and predicting anisotropic behavior and failure modes.
5. Synthesize design principles by integrating safety factors, load path analysis, and redundancy into aerospace structural design.

COURSE CONTENTS

Unit 1: Stress–Strain Relationships and Material Behavior (9 Hours)

Definitions of stress and strain; Hooke's Law; Elastic behavior: Young's modulus, Poisson's ratio, and shear modulus; Plasticity concepts: yield point, strain hardening, and ductility.

Unit 2: Structural Theories – Beam, Plate, and Shell Theories (9 Hours)

Beam theories: Euler–Bernoulli beam theory and Timoshenko beam theory. Fundamentals of plate theories: Kirchhoff–Love plate theory and Mindlin plate theory. Introduction to shell theories for curved aerospace structures.

Unit 3: Failure Theories and Criteria **(9 Hours)**

Yield criteria: Von Mises and Tresca theories. Fundamentals of fracture mechanics: Griffith's theory and Irwin's modifications. Fatigue analysis: S–N curves, endurance limits, and damage accumulation models.

Unit 4: Composite Mechanics **(9 Hours)**

Laminate theory: formulation, assumptions, and stacking sequence effects. Anisotropic material behavior in composites. Failure modes in composites: fiber breakage, matrix cracking, and delamination.

Unit 5: Design Considerations in Aerospace Structures **(9 Hours)**

Safety factors: determination and application in aerospace design. Load path analysis: methods to trace and evaluate load distribution. Redundancy in design: principles of robust design to ensure structural reliability.

Textbooks

1. R. M. Jones, *Mechanics of Composite Materials*, 2nd ed., CRC Press, 1998.
2. R. C. Hibbeler, *Mechanics of Materials*, 10th ed., Pearson, 2016.

Reference Books

1. S. Timoshenko and J. N. Goodier, *Theory of Elasticity*, 3rd ed., McGraw-Hill, 1970.
2. D. Hull and T. W. Clyne, *An Introduction to Composite Materials*, 2nd ed., Cambridge University Press, 1996.
3. W. Bert, *Aircraft Structures: An Introduction*, 4th ed., American Institute of Aeronautics and Astronautics, 2003.
4. Select AIAA Journal/Conference Papers for recent developments in flow control, unsteady aerodynamics, and advanced CFD validations.

Course Code	Course Title				Category
25MTAS102R	**Computational Structural Analysis**				DCC
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	0	50	50	3

Prerequisite:
Basic knowledge of structural mechanics and material behavior.
Introductory understanding of numerical methods and finite element concepts.

Course Objectives:
The primary purpose of this course is to:
1. Understand the mathematical foundations of the finite element method (FEM) and associated variational principles.
2. Explain the derivation and formulation of element equations using the Galerkin method, and classify finite elements using standard theories.
3. Analyze discretization techniques, applying mesh generation theories and refinement strategies.
4. Evaluate numerical integration methods and iterative solvers based on convergence and stability theories, with emphasis on error estimation methods.
5. Apply computational tools (ANSYS, Abaqus) to simulate and validate static and dynamic structural problems following the principles of computational mechanics.

Course Outcomes:
By the end of this course, students will be able to:
1. **Identify** and **explain** the underlying mathematical principles of FEM, including variational and weak form formulations (Galerkin method).
2. **Compare** different finite element types and **justify** their use for specific structural problems using classical structural analysis theories.
3. **Develop** high-quality meshes by **applying** discretization theories (e.g., Delaunay triangulation) and **assessing** mesh quality.
4. **Critically evaluate** numerical integration and solver methods by **validating** simulation results with analytical benchmarks and error estimation theories.
5. **Implement** industry-standard software to **simulate**, **analyze**, and **interpret** complex structural problems in line with computational mechanics theories.

COURSE CONTENT

Unit 1: Introduction to Finite Element Method (9 Hours)

Mathematical Foundations: Derivation of governing differential equations from physical principles. Variational Principles: Application of the principle of minimum potential energy. Weak Formulation: Derivation using the Galerkin method. Discussion on the existence and uniqueness of solutions. Formulation of Element Equations: Concept of shape functions and interpolation functions. Assembly of element stiffness matrices and force vectors using the principle of virtual work. Classification of Finite Elements: Linear vs. higher-order elements in the context of polynomial approximation theories. Comparison of 1D, 2D, and 3D elements with references to classical beam, plate, and solid theories.

Unit 2: Discretization Techniques (9 Hours)

Mesh Generation: Overview of mesh types: structured, unstructured, and hybrid meshes. Mesh Generation Theories: Including Delaunay triangulation and advancing front methods. Techniques for generating meshes manually and using automated mesh generators. Mesh Quality and Refinement: Discussion on mesh density, aspect ratio, skewness, and quality metrics based on mathematical error estimates. Adaptive Meshing Theories: Strategies for local and global mesh refinement. Element Selection Criteria: Criteria for choosing element types based on geometry, load conditions, and expected behavior using classical error analysis. Trade-offs between computational cost and accuracy.

Unit 3: Numerical Integration & Solvers (9 Hours)

Numerical Integration Techniques: Gauss Quadrature: Rules for numerical integration within elements. Discussion on integration points and weights for different element types. Techniques to reduce integration errors and manage singularities using theoretical error analysis. Iterative Solvers: Overview of direct versus iterative solution methods. Solver Theories: Detailed treatment of iterative methods such as the Conjugate Gradient Method and GMRES, with discussion on convergence theory and error norms. Solver Implementation: Assembly of the global system and application of boundary conditions using the theory of weighted residuals. Preconditioning techniques and strategies to accelerate convergence.

Unit 4: Error Estimation and Validation (9 Hours)

Error Estimation Techniques: Discussion on global vs. local error norms (e.g., L^2 norm, energy norm). A Posteriori Error Estimation: Techniques and indicators for adaptive refinement based on error theory. Validation of FEM Solutions: Comparison of FEM results with analytical solutions using benchmark problems. Techniques for verifying convergence and ensuring numerical stability grounded in convergence theories. Post-Processing: Interpretation of stress, strain, and displacement fields. Visualization techniques for identifying error hotspots and guiding adaptive refinement.

Unit 5: Software Integration (9 Hours)

Introduction to FEM Software: Overview of industry-standard FEM software such as ANSYS and Abaqus. Discussion on the theoretical basis for numerical simulation in software environments using virtual work and energy methods. Model Setup and Preprocessing: Defining geometry, material properties, and boundary conditions within the software framework. Mesh generation and selection in a practical software context, linking back to the theory covered in Unit 2. Simulation and Post-Processing: Running static and dynamic analyses using standard solver routines. Validation Techniques: Interpretation of output data (stress, displacement, modal analysis) and comparing with theoretical predictions. Integration of numerical results with error estimation methods to ensure simulation accuracy.

Textbooks

1. J. N. Reddy, *An Introduction to the Finite Element Method*, 3rd ed., McGraw-Hill, 2006.

2. D. L. Logan, *A First Course in the Finite Element Method*, 5th ed., Cengage Learning, 2011.

Reference Books

1. O. C. Zienkiewicz and R. L. Taylor, *The Finite Element Method: Its Basis and Fundamentals*, 7th ed., Elsevier, 2013.
2. K. J. Bathe, *Finite Element Procedures*, Prentice Hall, 1996.
3. J. N. Reddy, *An Introduction to the Finite Element Method* (also serving as a reference for extended topics).

Course Code	Course Title				Category
25MTAS103R	Aerospace Materials and Manufacturing Processes				DCC
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	0	50	50	3

Prerequisite:

1. Understanding of material science and mechanical behavior from undergraduate courses.
2. Familiarity with fundamental manufacturing processes and engineering design principles.

Course Objectives:

The main purpose of this course is to:

1. Understand the fundamental principles governing the mechanical properties and microstructure–property relationships of aerospace materials.
2. Explain the behavior of advanced materials—including composites, ceramics, and smart materials—using established theories.
3. Analyze various manufacturing processes and joining techniques by applying theoretical models and process selection criteria.
4. Evaluate quality control methods and non-destructive testing techniques using appropriate failure and evaluation theories.
5. Apply sustainable design and cost-performance analysis for material selection and process optimization in aerospace components.

Course Outcomes:

After learning this course, students shall be able to:

1. Identify and explain the mechanical properties of metals, polymers, and composite materials based on microstructure theories (e.g., dislocation theory, Hall–Petch relationship).
2. Demonstrate knowledge of advanced material behavior by applying laminate theory for composites, ceramic fracture mechanics, and piezoelectricity in smart materials.
3. Analyze fabrication and joining processes by utilizing theories such as thermomechanical processing and adhesion theory.
4. Evaluate quality control and non-destructive testing methods by comparing outcomes using NDE principles and failure analysis theories.
5. Synthesize sustainable material selection and process optimization strategies by integrating life cycle assessment and cost–benefit analysis (Ashby selection criteria).

COURSE CONTENT

Unit 1: Materials Science Basics and Fundamental Theories (9 Hours)

Mechanical Properties: Overview of elastic, plastic, and fracture behaviors. Measurement and interpretation of yield strength, tensile strength, ductility, and hardness. Microstructure–Property Relationships: Fundamentals of crystallography, dislocation theory, and grain boundary effects (e.g., Hall–Petch relationship). Phase diagrams and heat treatment effects on material properties. Theoretical Foundations: Continuum mechanics as applied to material behavior.

Unit 2: Advanced Materials and Their Theories (9 Hours)

Composite Materials: Properties and behavior of fiber-reinforced polymers. Laminate Theory: Analysis of stacking sequences, anisotropy, and failure modes in composites. Ceramics:

Mechanical behavior of ceramics and brittle fracture theories. Smart Materials: Introduction to piezoelectric, shape memory, and other adaptive materials. Piezoelectricity Theory: Coupling between mechanical deformation and electric field generation.

Unit 3: Manufacturing Processes for Aerospace Components (9 Hours)

Fabrication Methods: Conventional machining and modern techniques such as additive manufacturing. Manufacturing Process Selection Theory: Criteria and decision-making models for process selection. Composite Lay-Up: Manual and automated processes for fabricating composite structures. Theoretical Foundations: Thermomechanical processing theories as they apply to machining and forming operations.

Unit 4: Joining Techniques, Heat Treatment, and Quality Control (9 Hours)

Joining Techniques: Welding fundamentals, adhesive bonding, and mechanical fastening methods. Weld Metallurgy and Adhesion Theory: Basic principles governing joint performance. Heat Treatment Processes: Processes such as annealing, quenching, and tempering; effects on microstructure and mechanical properties. Testing and Quality Control: Non-destructive testing (NDT) methods including ultrasonic testing, radiography, and eddy current inspection. Failure Analysis Theories: Techniques for identifying and analyzing defects and failures.

Unit 5: Sustainability, Cost Considerations, and Material Selection (9 Hours)

Sustainability in Manufacturing: Environmental impact assessment and sustainable manufacturing practices. Life Cycle Assessment (LCA): Evaluating the environmental footprint of materials and processes. Cost–Performance Analysis: Balancing performance, weight, and cost in material selection. Ashby Selection Theory: Use of material indices and charts for design optimization. Material Selection Criteria: Strategies for choosing materials based on performance, durability, and economic considerations.

Textbooks

1. W. D. Callister, *Materials Science and Engineering: An Introduction*, 9th ed., Wiley, 2014.
2. R. M. Jones, *Mechanics of Composite Materials*, 2nd ed., CRC Press, 1998.

Reference Books

1. D. Hull and T. W. Clyne, *An Introduction to Composite Materials*, 2nd ed., Cambridge University Press, 1996.
2. M. F. Ashby, *Materials Selection in Mechanical Design*, 4th ed., Butterworth-Heinemann, 2011.
3. R. C. Hibbeler, *Mechanics of Materials*, 10th ed., Pearson, 2016.

Course Code	Course Title				Category
25MTAS104R	Data-driven Aerospace Engineering				
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	-	-	50	50	3

Prerequisite: Basic Programming Skills; Fundamentals of Mathematics; Introductory Knowledge of Aerospace Engineering.

Course Objectives:

1. **Introduce AI/ML Fundamentals**: Provide a solid overview of Artificial Intelligence, Machine Learning, and Deep Learning, especially in the context of aerospace applications.
2. **Develop Practical Skills**: Enable students to use Python/Jupyter Notebook for data analysis and model building.
3. **Explore Core Algorithms**: Familiarize students with essential ML algorithms and how they can be adapted to aerospace problems.
4. **Integrate Theory and Practice**: Demonstrate real-world aerospace case studies where AI/ML solutions can offer tangible benefits.
5. **Promote Industry-Relevant Expertise**: Equip students with the knowledge and skills that align with current industry needs in the aerospace sector.

Course outcome (CO):

By the end of this course, students will be able to:

1. **CO1:** Explain the evolution, importance, and industry demand for AI/ML in aerospace engineering. (Understanding – Bloom's Level 2)
2. **CO2:** Identify and apply fundamental ML algorithms for basic classification, regression, and clustering tasks. (Applying – Bloom's Level 3)
3. **CO3:** Demonstrate proficiency in setting up programming environments (Jupyter Notebook) and coding essential AI/ML workflows. (Applying – Bloom's Level 3)
4. **CO4:** Implement and analyse AI/ML models to address typical aerospace engineering challenges (e.g., fault detection, performance prediction). (Analyzing – Bloom's Level 4)
5. **CO5:** Evaluate the performance and limitations of AI/ML solutions, proposing improvements for aerospace-specific applications. (Evaluating – Bloom's Level 5)

Course Content

Unit 1: Introduction to AI/ML in Aerospace (9 Hours)

Milestones in AI development, early machine learning successes; Current aerospace industry trends: predictive maintenance, design optimization, autonomous systems; Role of AI/ML in reducing costs, improving safety, and accelerating innovation; Distinctions between AI, ML, and DL; Overview of supervised vs. unsupervised learning, reinforcement learning (brief mention); Examples from leading aerospace companies (e.g., Boeing, Airbus, SpaceX)

Unit 2: Key Machine Learning Algorithms (9 Hours)

Linear Regression / Logistic Regression; Decision Trees / Random Forests; Support Vector Machines (SVM); K-Means Clustering; Basic Neural Networks (intro to feed-forward architecture); Bias-Variance trade-off, overfitting vs. underfitting; Performance metrics (accuracy, precision, recall, F1-score); Data preparation, feature engineering, scaling; Hyperparameter tuning (grid search, cross-validation)

Unit 3: Introduction to Programming with Jupyter Notebook (9 Hours)

Installing Anaconda, creating virtual environments, accessing Jupyter Notebook; Basic syntax, data types, control structures; Libraries: NumPy, Pandas, Matplotlib, scikit-learn (high-level introduction); Reading/writing data, cleaning and preprocessing; Plotting libraries (Matplotlib or Seaborn); Simple dataset exploration (e.g., reading CSV, basic statistics, plotting)

Unit 4: Coding ML Models in Jupyter Notebook (9 Hours)

Step-by-step guides to coding the chosen 5 algorithms from Unit 2 using scikit-learn or TensorFlow/Keras (basic introduction); Train/test splits, cross-validation, confusion matrix (for classification); Debugging, troubleshooting common errors, performance optimization; Real-time coding with example datasets (e.g., classification of aircraft types, regression on flight performance data)

Unit 5: Aerospace Case Studies & Applications (9 Hours)

Predictive Maintenance of aircraft components (fault detection); Flight Path Optimization (basic scenario modeling); Wind Tunnel Data Analysis (drag/lift prediction); Autonomous Aerial Vehicles (simplified control strategy); Satellite Image Analysis (basic object detection or cloud cover classification); Planning an end-to-end AI/ML project in aerospace: data sources, project scoping, resource requirements

Text Books

1. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, 2nd ed., O'Reilly Media, 2019.
2. Sebastian Raschka and Vahid Mirjalili, *Python Machine Learning*, 3rd ed., Packt Publishing, 2019.

Reference Books

1. François Chollet, *Deep Learning with Python*, 2nd ed., Manning Publications, 2021.
2. Steven L. Brunton and J. Nathan Kutz, *Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control*, Cambridge University Press, 2019.

Course Code	Course Title				Category
25MTAS105R	**Advanced Research Techniques & Ethics**				RM
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	0	50	50	3

Prerequisite:
Basic Understanding of Probability and Statistics; General Knowledge of Scientific Inquiry.

Course Objectives:
The primary purpose of this course is to:

1. **Introduce Research Methodology Basics**: Provide a foundational understanding of what constitutes a research topic, how to conduct a literature review, and the overall research process.
2. **Develop Data Collection and Sampling Skills**: Equip students with the knowledge to design surveys and experiments effectively, distinguishing between primary and secondary data sources.
3. **Apply Statistical and Analytical Methods**: Teach students to use statistical modeling, time-series analysis, and multivariate methods for data interpretation.
4. **Explore Evolutionary Algorithms and Optimization**: Familiarize students with genetic algorithms, neural network-based optimization, and other advanced tools for research.
5. **Enable Effective Research Reporting**: Guide students in structuring and writing clear, comprehensive research reports, covering layout and ethical considerations.

Course Outcomes:
After learning this course, students shall be able to:

1. **CO1**: **Identify** the key components of research methodology, framing appropriate research questions and objectives.
2. **CO2**: **Design** suitable data collection methods, including questionnaires, surveys, and sampling strategies, and **evaluate** their merits and limitations.
3. **CO3**: **Apply** statistical tools and time-series analysis to interpret data, drawing meaningful inferences for research studies.
4. **CO4**: **Implement** evolutionary algorithms and advanced optimization methods (genetic algorithms, simulated annealing, etc.) for complex research problems.
5. **CO5**: **Compose** well-structured research reports, demonstrating ethical standards and clear scientific communication.

COURSE CONTENT

Unit 1: Introduction to Research Methods (9 Hours)

What is research methodology?, What constitute a research topic? What is literature review?, Research process, Classification of research, Research ethics, Objectives of research, Motivation in research, Criteria of good research.

Unit-2: Data collection and sampling design (9 Hours)

Sources of Data: Primary Data, Secondary Data: Procedure Questionnaire – Survey and Experiments – Design of Survey and Experiments – Sampling Merits and Demerits – Control Observations – Procedures – Sampling Errors.

Unit-3: Statistical Modelling and Analysis, Time Series Analysis (9 Hours)

Probability Distributions, Fundamentals of Statistical Analysis and Interference, Multivariate methods, Concepts of Correlation and Regression, Time Series and Spectral Analysis.

Unit-4: Evolutionary algorithms **(9 Hours)**

Introduction to evolutionary algorithms – Fundamental of Genetic Algorithms, Simulated Annealing, Neural Network based optimisation, Optimization of fuzzy systems.

Unit-5: Research report **(9 Hours)**

Structure and Components of Research Report, Types of Report, Layout of Research Report, Mechanism of writing a research report.

Text Books:

1. **R. Kumar**, *Research Methodology: A Step-by-Step Guide for Beginners*, 4th ed., London, U.K.: SAGE Publications Ltd, 2014.
2. **C. R. Kothari**, *Research Methodology: Methods and Techniques*, 2nd ed., New Delhi, India: NEW AGE, 2014.
3. **P. Pruzan**, *Research Methodology: The Aims, Practices and Ethics of Science*, 1st ed., Cham, Switzerland: Springer, 2016.

Reference Books:

1. **P. Engelbrecht**, *Computational Intelligence: An Introduction*, 2nd ed., West Sussex, U.K., Wiley-Blackwell, 2007.
2. **J. Hayter**, *Probability and Statistics for Engineers and Scientists*, 4th ed., Boston, MA, USA: CENGAGE Learning Custom Publishing, 2011.
3. **C. Beins and M. A. McCarthy**, *Research Methods and Statistics*, Boston, MA, USA: Pearson, 2011.
4. **Neville**, *The Complete Guide to Referencing and Avoiding Plagiarism*, Maidenhead, U.K.: Open University Press, 2007.
5. **Kumar**, *Research Methods for Successful PhD*, River Publishers Series in Innovation and Change in Education — Cross Cultural Perspective, 2017.
6. **M. van Dongen**, *LaTeX and Friends*, Heidelberg, Germany: Springer, 2012.

<table>
<tr><th colspan="2">Course Code</th><th colspan="3">Course Title</th><th>Category</th></tr>
<tr><td colspan="2">25MTAS106R</td><td colspan="3">TECHNICAL SEMINAR -I</td><td>Program Core</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>50</td><td>50</td><td>2</td></tr>
<tr><td colspan="6">Prerequisite: A fundamental understanding of the core concepts in the relevant subject area, with the ability to read and interpret technical papers and research articles.</td></tr>
<tr><td colspan="6">Course Objectives
The primary purpose of this course is to:
1. Identify and Compare Technical & Practical Issues: Enable students to explore advanced or emerging topics in their area of specialisation.
2. Develop Scholarly Skills: Encourage creating an annotated bibliography from research papers, demonstrating thorough literature investigation.
3. Refine Technical Writing & Critical Thinking: Train students to prepare well-structured reports and technical documents.
4. Enhance Presentation Skills: Improve competence in describing, interpreting, and analysing technical findings, culminating in effective oral presentations.</td></tr>
<tr><td colspan="6">Course Outcomes
By the end of the course, students will be able to:
1. Establish Motivation for a chosen topic and develop a structured thought process for technical communication.
2. Organize a Detailed Literature Survey and synthesise findings in a coherent document referencing significant technical publications.
3. Analyze and Comprehend proof-of-concept data or theoretical underpinnings related to the selected topic.
4. Deliver Effective Presentations that showcase clarity of thought, improved soft skills, and command of the subject.
5. Utilize Modern Tools (e.g., LaTeX) for preparing high-quality technical reports, thereby embracing recent technology in document creation.</td></tr>
</table>

Course Content

During Technical Seminar - I, students shall:

1. Select a Research Topic: Identify an advanced or emerging area relevant to their specialization.
2. Conduct a Literature Review: Summarize and critique research papers, focusing on existing methodologies, findings, and gaps in knowledge.
3. Perform Data Collection & Analysis: Gather information from published works, compare methodologies, and draw inferences.
4. Prepare a Seminar Report: Document objectives, literature findings, methods (if any data were collected), and conclusions in a structured format.
5. Deliver a Presentation: Present the summarised work, highlighting the key concepts, contributions, and future scope.

Course Code	Course Title				Category
25MTAS107R	**Finite Element Analysis Lab**				
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**T**	**D/P**			
-	**-**	**4**	**50**	**50**	**2**

Prerequisite:
1. Basic knowledge of structural mechanics and material behavior.
2. Introductory understanding of finite element analysis concepts.
3. Familiarity with computer-aided engineering tools and the ANSYS interface.

Course Objectives:

The primary purpose of this course is to:
1. **Introduce** and **explain** the fundamental principles and mathematical foundations of the Finite Element Method (FEM) in structural analysis.
2. **Facilitate** hands-on experience in setting up and solving basic static structural problems using ANSYS Mechanical.
3. **Deepen** understanding of geometric modeling, advanced mesh generation, and comprehensive result interpretation.
4. **Strengthen** the ability to validate simulation outcomes through rigorous comparison with analytical solutions.
5. **Introduce** and **apply** optimization techniques to refine design performance and enhance structural integrity.

Course Outcomes

By the end of the course, students will be able to:
1. **CO1: Identify** and **explain** fundamental FEA concepts, methodologies, and key terminology through practical, introductory experiments.
2. **CO2: Apply** static structural analysis techniques using ANSYS Mechanical to simulate and analyze simple geometries.
3. **CO3: Demonstrate** proficiency in generating effective meshes and establishing appropriate boundary conditions to ensure accurate results.
4. **CO4: Evaluate** simulation outcomes by systematically comparing them with established analytical predictions and hand calculations.
5. **CO5: Optimize** design parameters to mitigate stress concentrations and enhance overall structural performance based on detailed case studies.

LIST OF EXPERIMENTS

Any ten experiments should be selected from the list provided.

1. **Plate With a Hole – Basic Static Structural Analysis**
   Description: Set up a simple model of a plate with a central hole, apply static loading, and analyze the stress concentration around the hole.
2. **Cantilever Beam – Deflection and Stress Distribution**
   Description: Model a cantilever beam under a point load. Validate deflection and stress results against analytical solutions.
3. **Bike Crank – Initial Structural Analysis**
   Description: Create a model of a bike crank and perform a static analysis. Observe stress distributions and identify critical regions.

4. **Bike Crank: Part 2 – Mesh Sensitivity Study**
   Description: Refine the bike crank model with different mesh densities. Evaluate how mesh quality influences stress and displacement results.
5. **A Stepped Shaft in Axial Tension – Axial Stress Evaluation**
   Description: Simulate a stepped shaft under axial tension. Determine the variation of axial stresses across the steps.
6. **A Non-Slender Cantilever Beam Under Tip Loading – Comparative Analysis**
   Description: Analyze a non-slender cantilever beam with a point tip load. Compare simulation outcomes with theoretical predictions.
7. **Plane Frame – Basic Structural Framework**
   Description: Develop and analyze a simple plane frame subjected to static loads. Assess load distribution and member forces.
8. **A Four-Point Bend Test on a T-Beam – Flexural Behavior**
   Description: Model a T-beam in a four-point bending scenario. Evaluate the bending moment distribution and deflection profile.
9. **Planar Approximation for a 2D Beam – Model Simplification Study**
   Description: Use a 2D approximation for a beam analysis. Compare the simplified model's results with a full 3D analysis to understand limitations.
10. **Three-Dimensional Analysis of Combined Loading in a Signpost**
    Description: Simulate a signpost subjected to multiple load types (axial, bending, and torsion). Interpret the combined stress responses.
11. **Hoop and Axial Stresses in Thick-Walled Pressure Vessels**
    Description: Set up a static analysis of a thick-walled cylinder. Evaluate both hoop and axial stress distributions under internal pressure.
12. **Plate With a Hole: Optimization Study**
    Description: Revisit the plate with a hole model and perform an optimization study. Modify design parameters to reduce stress concentrations, comparing different configurations.

Textbooks

1. K. J. Bathe, *Finite Element Procedures*, Prentice Hall, Upper Saddle River, NJ, USA, 1996.
2. J. N. Reddy, *An Introduction to the Finite Element Method,* 3rd ed., McGraw-Hill, 2006.

Reference Book

1. Z. Li and J. Zhang, *Advanced Finite Element Methods for Structural Analysis*, Springer, 2010.

Additional Video/Online Resource

1. Cornell University FLUENT Learning Modules
   (A collection of step-by-step tutorials and video guides illustrating how to set up and solve fluid flow problems in ANSYS Fluent.)

Course Code	Course Title				Category
25MTAS108	Introduction to Aerospace Engineering				
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	-	-	50	50	0

Prerequisite: Basic Physics and Mathematics.

Course Objectives:

The primary purpose of this course is to:

1. **Understand Historical Evolution**: Familiarize students with the early developments and key milestones in aerospace engineering, from early flight to modern spacecraft.
2. **Grasp Fundamental Aerodynamics**: Introduce the physics of fluid flow, airfoil theory, and fundamental forces acting on aircraft.
3. **Explore Propulsion Systems**: Examine various propulsion methods, including jet and rocket engines, and emerging green/electric aircraft propulsion.
4. **Examine Aerospace Structures & Materials**: Study the design, stress analysis, and material selection for aerospace applications, including advanced manufacturing techniques.
5. **Introduce Instruments & Navigation**: Provide insight into measurement techniques, navigation principles, and data acquisition in modern flight operations.

Course outcome (CO)

By the end of the course, students will be able to:

1. CO1: Describe the historical evolution of aerospace engineering and significant achievements in flight and space exploration.
2. CO2: Explain fundamental aerodynamic concepts, including lift, drag, and the effects of different flight regimes (subsonic, supersonic, and hypersonic).
3. CO3: Compare various propulsion systems (piston, turbojets, turbofans, ramjets, scramjets) and evaluate emerging technologies such as electric propulsion.
4. CO4: Analyze aerospace structures, recognizing key load-bearing configurations, material properties, and manufacturing processes.
5. CO5: Interpret instrument data and navigation principles in aviation and demonstrate understanding of basic UAV systems and their applications.

COURSE CONTENTS

Unit-1 HISTORICAL EVALUATION (9 Hours)

Introduction to Aerospace Engineering: Scope, Applications, and Historical Evolution, Overview of Aeronautics and Astronautics, Basic Aerodynamics: Properties of the Atmosphere, Standard Atmosphere, and Types of Flow, Fundamental Forces on an Aircraft: Lift, Drag, Thrust, and Weight, history of spaceflight, development of space vehicles, classification of duct jet propulsion, rocket propulsion, advance propulsion and applications.

Unit-2 BASIC AERODYNAMICS (9 Hours)

Anatomy of flight vehicles, components of airplanes and their function, Types of Aircraft: Subsonic, Supersonic, and Hypersonic Flight, bluff bodies v/s streamlined body, airfoil, NACA nomenclature . lift generation, significance of L/D ratio, aerodynamic forces, Basic Flight

Mechanics: Straight and Level Flight, Climbing, and Gliding, Stability and Control: Static and Dynamic Stability, Control Surfaces

Unit-3 PROPULSION (9 Hours)

Classification and essential features of propulsion, jet propulsion, Types of Aircraft Engines, Piston Engines, Turbojets, Turbofans, Ramjets, and Scramjets, Thrust Generation and Specific Fuel Consumption, general characteristics of rocket engines, theory of propulsion, elementary gas dynamics, Emerging Propulsion Technologies: Green Propulsion and Electric Aircraft

Unit-4 AEROSPACE STRUCTURES AND MATERIALS (9 Hours)

General types of construction and structural layout, Stress and Strain in Aerospace Structures, flight envelope and V-n diagrams, monocoque, semimonocoque, corrugated, sandwich structure, reinforced and honeycomb structures, geodesic construction, aerospace materials, metallic and non-metallic materials, use of aluminum alloy, titanium, stainless steel, composite and ceramic materials, Manufacturing Techniques: Additive Manufacturing and Composite Fabrication

Unit-5 INSTRUMENTS AND NAVIGATION (9 Hours)

Measurements in aerodynamics, flight structures, and flight control, principles of navigation, celestial, radio, and inertial navigation, Introduction to computer-based data acquisition. Introduction to basics of UAVs., their types, working and applications.

TEXT BOOKS

1. Anderson, J. D., "Introduction to Flight", McGraw-Hill, 2000.
2. John Fay, “ The Helicopter : History,Piloting and How it Flies ”, Sterling Book House, 2007.
3. Newman D, “Interactive Aerospace Engineering and Design”, McGraw-Hill, 1st Edition, 2002
4. Shevel, "Fundamentals of Flight", Prentice Hall, 1989.

REFERENCE BOOKS

1. Kermode, A. C., "Flight without Formulae", Pitman, 1970
2. Turner, M. J. L., “Rocket and Spacecraft Propulsion: Principles”, Practice and New Developments, Springer, 2009, 3rd Edition.

SEMESTER –II

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>25MTAS201R</td><td colspan="4">Aeroelasticity and Structural Dynamics</td><td>DCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>50</td><td>50</td><td>3</td></tr>
<tr><td colspan="6">Prerequisite:
1. Fundamental knowledge of structural dynamics (vibration theory, modal analysis).
2. Basic understanding of aerodynamics and fluid mechanics.</td></tr>
<tr><td colspan="6">Course Objectives:
The primary purpose of this course is to:
1. Understand the principles of structural dynamics and aeroelastic phenomena through classical theories.
2. Explain vibration theory, modal analysis, and damping mechanisms using established analytical methods.
3. Analyze flutter, divergence, and control reversal phenomena with the application of aeroelastic theories.
4. Evaluate the interaction between aerodynamic forces and structural response by using coupled analysis theories.
5. Design mitigation strategies for dynamic instabilities and resonance in aerospace structures.</td></tr>
<tr><td colspan="6">Course Outcomes:
After learning this course, students shall be able to:
1. Identify and explain free and forced vibration concepts (Euler–Bernoulli and Timoshenko beam theories).
2. Calculate natural frequencies and mode shapes using analytical and numerical techniques.
3. Assess various damping mechanisms and their effects on transient responses.
4. Apply classical aeroelastic theories (e.g., Theodorsen’s theory) to evaluate flutter and divergence.
5. Synthesize design modifications to avoid resonance and reduce dynamic loads.</td></tr>
</table>

COURSE CONTENT

Unit 1: Vibration Theory and Modal Analysis (9 Hours)

Fundamentals of single-degree-of-freedom (SDOF) systems; free and forced vibrations. Multi-degree-of-freedom (MDOF) systems and modal superposition. Mathematical derivation of natural frequencies and mode shapes using eigenvalue analysis. Application of energy methods (Rayleigh’s method) to approximate modal parameters. Underlying Theories: Euler–Bernoulli beam theory and Timoshenko beam theory. Modal analysis and eigenvalue problems.

Unit 2: Damping Mechanisms and Transient Response (9 Hours)

Classification of damping: viscous, hysteretic, and Rayleigh damping. Analysis of underdamped, critically damped, and overdamped systems. Transient response under various loading conditions (step, impulse, and harmonic loads). Time-history analysis and response spectrum methods for dynamic loading. Underlying Theories: Viscous damping theory and Rayleigh damping concepts. Transient dynamics and time-domain analysis methods.

Unit 3: Fundamentals of Aeroelasticity (9 Hours)

Introduction to aeroelasticity: definition, significance, and historical context. Detailed discussion on flutter: onset conditions, critical speed, and amplitude growth. Analysis of divergence and control reversal in flexible structures. Basic computational methods to model unsteady aerodynamic forces acting on elastic structures. Underlying Theories: Classical flutter theory and Theodorsen's unsteady aerodynamic theory. Linear aeroelastic analysis methods.

Unit 4: Coupled Aeroelastic Analysis (9 Hours)

Coupling between aerodynamic forces and structural responses: formulation of coupled equations. Analytical and numerical methods for coupled field analysis (e.g., partitioned vs. monolithic approaches). Experimental modal analysis techniques in aeroelastic testing. Data interpretation from wind tunnel experiments and flight test measurements. Underlying Theories: Coupled field theory and linear/nonlinear aeroelastic coupling. Unsteady aerodynamics as applied to flexible structures.

Unit 5: Design Strategies for Dynamic Environments (9 Hours)

Design considerations to avoid resonance: identification of critical speeds and modal interactions. Strategies for dynamic load mitigation (use of tuned mass dampers, active control systems). Integration of material selection and structural configuration to enhance dynamic performance. Guidelines for designing wings, control surfaces, and fuselage components under turbulent and high-speed conditions. Underlying Theories: Resonance theory and dynamic stability criteria. Mitigation strategies based on vibration control and energy dissipation methods.

Textbooks:

1. A. K. Chopra, *Dynamics of Structures: Theory and Applications to Earthquake Engineering*, 4th ed., Prentice Hall, 2012.
2. B. E. Bisplinghoff, H. Ashley, and R. L. Halfman, *Aeroelasticity*, 2nd ed., Dover Publications, 2003.

Reference Books:

1. R. H. Scanlan and D. G. Tomko, “Experimental and theoretical investigations of flutter in aircraft wings,” *AIAA Journal*, 1964.
2. J. C. Nelson, *Aircraft Structures for Engineering Students*, 4th ed., Elsevier, 2013.
3. L. Meirovitch, *Elements of Vibration*, McGraw-Hill, 2001.

Course Code	Course Title	Category
25MTAS202R	Composite Structures and Smart Materials	CFD

Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	02	50	50	4

Prerequisite:

1. Basic knowledge of material mechanics and composite behavior.
2. Familiarity with conventional material testing and analysis.

Course Objectives:

The primary purpose of this course is to:

1. Understand the mechanical behavior and failure modes of composite materials using established micromechanics theories.
2. Explain laminate theory and its application in predicting composite performance.
3. Analyze the design parameters for composite structures, including ply orientation and stacking sequence effects.
4. Evaluate the integration of smart materials in adaptive structures by using principles of piezoelectricity and thermomechanical coupling.
5. Design hybrid structures that optimize performance by combining traditional and composite materials.

Course Outcomes:

After learning this course, students will be able to:

1. Identify composite material properties and explain laminate theory using micromechanics models.
2. Apply Classical Laminate Theory (CLT) to predict stiffness and strength in composites.
3. Evaluate failure modes in composites by employing criteria such as Tsai–Wu and Hashin models.
4. Analyze the behavior of smart materials (e.g., piezoelectric, shape memory alloys) using coupling theories.
5. Synthesize design solutions for hybrid structures integrating traditional and composite materials.

COURSE CONTENT

Unit 1: Composite Material Fundamentals (9 Hours)

Overview of composite materials: fiber, matrix, and interface properties. Mechanical behavior of composites: stiffness, strength, and failure mechanisms. Micromechanics models: Rule of Mixtures, Voigt and Reuss averages, and their limitations. Experimental determination of material properties (tensile, compression, shear tests). Underlying Theories: Micromechanics theory and homogenization. Rule of Mixtures and composite stress–strain relationships.

Unit 2: Macro-mechanics for Lamina (9 Hours)

Hooke's law for isotropic, orthotropic, and anisotropic materials. Elastic and engineering constants for an orthotropic lamina, Modified stress strain relations for a lamina, structural axes system and material axes system for a lamina, reduced stiffness and transformed reduced stiffness matrix, variation of elastic constants and engineering constants with respect to fiber orientations.

Unit 3: Laminate Theory and Ply Analysis (9 Hours)

In-depth study of Classical Laminate Theory (CLT): formulation of stiffness matrices. Effects of ply orientation, stacking sequence, and anisotropy on structural behavior. Calculation of laminate properties (A, B, D matrices) and prediction of in-plane and bending responses. Comparative analysis of symmetric and unsymmetric laminates. Underlying Theories: Classical Laminate Theory (CLT) and anisotropic elasticity.

Unit 4: Failure Modes and Strength Prediction (9 Hours)

Detailed discussion of common failure modes: fiber breakage, matrix cracking, delamination, and interfacial debonding. Quantitative prediction of failure using failure criteria (Tsai–Wu, Hashin). Comparison of experimental failure data with theoretical predictions. Influence of manufacturing defects and environmental factors on composite performance. Underlying Theories: Tsai–Wu failure criterion, Hashin criteria, and fracture mechanics for composites.

Unit 5: Smart Materials Integration (9 Hours)

Introduction to smart materials: piezoelectric materials, shape memory alloys, and electroactive polymers. Fundamental principles of piezoelectricity: coupling between mechanical and electrical fields. Thermomechanical behavior of shape memory alloys and their actuation properties. Applications of smart materials in adaptive structures: vibration control, self-sensing, and morphing structures. Underlying Theories: Piezoelectric theory, thermomechanical coupling, and actuation principles.

Textbooks:

1. R. M. Jones, *Mechanics of Composite Materials*, 2nd ed., CRC Press, 1998.
2. D. Hull and T. W. Clyne, *An Introduction to Composite Materials*, 2nd ed., Cambridge University Press, 1996.

Reference Books:

1. P. Talreja and M. K. Banerjee, *Composite Materials: Design and Applications*, 2nd ed., Elsevier, 2016.
2. J. W. Gillespie, Jr. and N. S. Palladino, *Composite Materials: Science and Applications*, CRC Press, 2009.
3. L. Tong, *Hybrid Composite Structures*, Elsevier, 2012.

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>25MTAS203R</td><td colspan="4">Optimisation & Advanced Computational Techniques in Aerospace Structures</td><td>DCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>3</td><td>0</td><td>02</td><td>50</td><td>50</td><td>4</td></tr>
</table>

Prerequisite:

1. Proficiency in finite element methods and structural analysis.
2. Basic knowledge of numerical optimization and sensitivity analysis.

Course Objectives:

The main purpose of this course is to:

1. Understand the fundamentals of optimization algorithms and their relevance to structural design.
2. Explain topology optimization methods and the mathematical formulation of design sensitivity.
3. Analyze nonlinear finite element analysis techniques under large deformations and complex boundary conditions.
4. Evaluate the coupling of multiple physical fields (thermal, dynamic, fluid–structure interaction) in structural simulations.
5. Apply optimization and advanced computational techniques to enhance aerospace design performance.

Course Outcomes:

After learning this course, students shall be able to:

1. Understand the fundamentals of optimization algorithms and their relevance to structural design.
2. Explain topology optimization methods and the mathematical formulation of design sensitivity.
3. Analyze nonlinear finite element analysis techniques under large deformations and complex boundary conditions.
4. Evaluate the coupling of multiple physical fields (thermal, dynamic, fluid–structure interaction) in structural simulations.
5. Apply optimization and advanced computational techniques to enhance aerospace design performance.

COURSE CONTENT

Unit 1: Optimization Fundamentals (9 Hours)

Introduction to optimization in engineering design: objective functions, constraints, and design variables. Overview of gradient-based methods: formulation, sensitivity analysis, and convergence criteria. Fundamentals of evolutionary algorithms: genetic algorithms, particle swarm optimization, and their advantages in complex design spaces. Case examples demonstrating objective function formulation in aerospace design. Underlying Theories: Gradient-based optimization theory; evolutionary algorithm principles.

Unit 2: Topology Optimization (9 Hours)

Formulation of topology optimization problems: objective function, design domain, and constraints. Detailed study of the SIMP (Solid Isotropic Material with Penalization) method: interpolation schemes, penalization factors, and numerical implementation. Introduction to level set methods for topology optimization. Sensitivity analysis for material distribution and design update. Underlying Theories: SIMP method, level set methods, and sensitivity analysis theories.

Unit 3: Nonlinear Finite Element Analysis (9 Hours)

Fundamentals of nonlinear analysis: geometric and material nonlinearity, and incremental-iterative solution techniques. Nonlinear material models: plasticity, hyperelasticity, and viscoelasticity. Treatment of complex boundary conditions and large deformation problems. Discussion of convergence strategies and error control in nonlinear simulations. Underlying Theories: Nonlinear finite element analysis theory; incremental load methods; Newton–Raphson and arc-length methods.

Unit 4: Coupled Field Analysis (9 Hours)

Fundamentals of multiphysics coupling: thermal–structural, dynamic–structural, and fluid–structure interaction (FSI). Formulation of coupled equations and approaches to solve them (partitioned vs. monolithic methods). Examples of coupled simulations: thermal stress analysis, vibration under aerodynamic loading, and FSI in wing structures. Discussion on the integration of experimental validation with simulation results. Underlying Theories: Coupled field theory, multiphysics simulation frameworks, and partitioned solution methods.

Unit 5: Case Studies and Project Work (9 Hours)

Presentation of real-world case studies: optimization of wing spars, fuselage frames, and other critical components. Step-by-step project work: formulation of design objectives, simulation setup, sensitivity analysis, and iterative optimization. Discussion of challenges encountered in multi-physics simulations and the strategies to overcome them. Guidelines for interpreting simulation data and integrating design improvements. Underlying Theories: Design iteration theory, sensitivity analysis, and iterative optimization methods.

Textbooks:

1. O. Sigmund and K. Maute, *Topology Optimization: Theory, Methods, and Applications*, 2nd ed., Springer, 2014.
2. T. Belytschko, W. K. Liu, and B. Moran, *Nonlinear Finite Elements for Continua and Structures*, Wiley, 2000.

Reference Books:

1. M. P. Bendsoe and O. Sigmund, *Topology Optimization: Theory, Methods, and Applications*, 2nd ed., Springer, 2004.
2. R. W. Pryor, *Multi-Physics Modeling Using COMSOL 5 and MATLAB*, Wiley, 2013.
3. S. P. Venkatesh, *Structural Optimization*, Wiley, 2010.

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>21MTAD204R</td><td colspan="4">Engineering Economics & Financial Decision-Making</td><td></td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>50</td><td>50</td><td>2</td></tr>
<tr><td colspan="6">Prerequisite: Basic Mathematics and Statistics.</td></tr>
<tr><td colspan="6">Course Objective:
The primary purpose of this course is to:
1. Account for the Time Value of Money: Develop the ability to incorporate present worth, annual worth, future worth, and capitalised cost in economic analyses.
2. Make Informed Economic Decisions: Apply concepts of investment analysis, including various costing methods, to guide managerial and engineering decisions.
3. Calculate Rates of Return: Gain proficiency in determining different rates of return on investments and interpreting their significance.
4. Use Economic Analysis Business from a Financial Perspective: Reasoning in Business: Adopt systematic approaches to solving business problems, integrating economic theories and financial data.
5. Understand and evaluate the financial health and strategic decisions of organisations through key financial metrics.</td></tr>
<tr><td colspan="6">Course Outcome:
By the end of the course, students will be able to:
1. CO1: Apply finance and accounting terminologies accurately in economic evaluations.
2. CO2: Prepare and appraise financial statements, interpreting their performance implications.
3. CO3: Conduct financial analyses and propose appropriate financing options based on organisational needs.
4. CO4: Use different capital budgeting methods (e.g., NPV, IRR) to foster effective financial growth and resource allocation.
5. CO5: Estimate the required return on projects with varying risks, determine cash flows, compute discount rates, and recommend accept/reject investment decisions.</td></tr>
</table>

Course Content

Unit No. 1 Introduction to Economics (9 Hours)

Economics, managerial Economics and Engineering Economics, Managerial decisions and analysis (Case study), Objectives of the firm and its attainment strategies, Elements of cost in decision making – Marginal cost Marginal revenue, Opportunity cost trade off situation, replacement decisions, recurring cost, Break Even Analysis – (Problems), Trade cycle – phases and business strategies.

Unit No. 2 Analysis of Economic Theory (9 Hours)

Demand- demand schedule and demand curve. Demand Forecasting – methods and problems, Supply – supply schedule and supply curve, Elasticity of demand – calculation, types and strategies. Market Structure, Government budget – structure and components, Pricing – methods and strategies, Taxation – tax effect analysis, GST.

Unit No. 3 Introduction to Financial Management (9 Hours)

Concept of Finance, Corporate Finance, Finance Functions and other functions. Financial statements – Balance sheet and Profit & Loss. Financial Management – Meaning and Objectives, Scope and Functions of Financial Management, Financial Planning and Forecasting.

Unit No. 4 Working Capital Management (9 Hours)

Working Capital Management – Nature of Working Capital Management, need for working capital – operating cycle, estimation of working capital requirement –Management of Cash and Receivables, Cash Budget.

Unit No. 5 Ratio Analysis and Capital Budgeting (9 Hours)

Liquidity ratios, Profitability ratios, Turnover ratios, Solvency ratios, Technics of Capital Budgeting – Pay-Back Period, Average Rate of Return, Net Present Value, Profitability Index and Internal Rate of Return.

Textbook:

1. I. M. Pandey, *Financial Management*. New Delhi, India: Vikas Publishing House.

Reference Books:

1. N. M. Vechalekar, *Financial Management*. Pune, India: Nirali Publication.
2. P. Chandra, *Financial Management*, 9th ed. New Delhi, India: McGraw Hill Education.
3. R. M. Shrivastava, *Financial Management & Policy*. Mumbai, India: Himalaya Publishing House.
4. M. Y. Khan and P. K. Jain, *Financial Management*, 7th ed. New Delhi, India: McGraw Hill Education.

<table>
<tr><th colspan="2">Course Code</th><th colspan="3">Course Title</th><th>Category</th></tr>
<tr><td colspan="2">25MTAS205R</td><td colspan="3">Advanced FEA and Coupled Phenomena – Lab</td><td>CFDL</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>50</td><td>50</td><td>2</td></tr>
<tr><td colspan="6">Prerequisite:
1. Successful completion of Lab 1 with fundamental FEA skills.
2. Basic understanding of heat transfer and dynamics concepts.
3. Familiarity with static structural analysis in ANSYS.</td></tr>
<tr><td colspan="6">Course Objectives:
The primary purpose of this course is to:
1. Develop advanced simulation skills by incorporating thermal, dynamic, and coupled analyses using ANSYS Mechanical.
2. Enhance the capability to model and analyze complex aerospace structures under a variety of loading conditions.
3. Integrate experimental validation techniques with simulation processes to ensure the reliability of advanced FEA outcomes.
4. Expand understanding of modal analysis to accurately identify and interpret vibration characteristics in aerospace components.
5. Introduce and apply fluid–structure interaction (FSI) concepts for addressing multidisciplinary engineering challenges.</td></tr>
<tr><td colspan="6">Course Outcomes:
After learning this course, students shall be able to:
1. CO1: Develop robust ANSYS models that incorporate thermal, dynamic, and coupled load cases for advanced aerospace structural analysis.
2. CO2: Interpret complex simulation results by systematically comparing them with analytical solutions and experimental data to ensure accuracy.
3. CO3: Analyze the vibration modes and dynamic responses of aerospace components to identify critical performance characteristics.
4. CO4: Critique and synthesize advanced FEA techniques to effectively address real-world structural challenges in aerospace engineering.
5. CO5: Integrate fluid–structure interaction concepts into structural analysis to evaluate the impact of aerodynamic forces on design performance.</td></tr>
</table>

LIST OF EXPERIMENTS

Any eight experiments should be selected from the list provided.

1. **Heat Conduction in a Cylinder – Steady-State Thermal Analysis**
   Description: Model a cylindrical domain to analyze steady-state heat conduction. Validate simulation results with analytical solutions.
2. **2D Steady Conduction in a Rectangular Domain**
   Description: Develop a 2D thermal model of a rectangle. Investigate temperature gradients under uniform and non-uniform boundary conditions.
3. **Cantilever Beam Modal Analysis – Vibration Characteristics**

Description: Extend the cantilever beam model to perform modal analysis. Determine natural frequencies and mode shapes.

4. **Modal Analysis of a Wing – Dynamic Behavior**
   Description: Create a wing model and perform a modal analysis. Identify critical modes that may influence aeroelastic performance.
5. **Tensile Bar – Results Interpretation and Verification**
   Description: Analyze a tensile bar model, then compare ANSYS results with hand calculations to verify accuracy and consistency.
6. **Bending of a Curved Beam – Advanced Result Interpretation**
   Description: Set up a curved beam under bending loads. Focus on interpreting stress distributions and verifying results against theoretical predictions.
7. **Aircraft Wing Rib Assembly – Structural and Dynamic Analysis**
   Description: Model an aircraft wing rib assembly to study load distribution, stress concentration, and dynamic response under aerodynamic loads.
8. **Fuselage Panel Buckling and Impact Analysis – Stability Assessment**
   Description: Analyze a fuselage panel subjected to compressive loads and impact forces, evaluating buckling behavior and post-impact damage resistance.
9. **Composite Material Analysis for Aircraft Structures – Failure and Deformation Study**
   Description: Develop a model of a composite aircraft component (e.g., a section of a wing or fuselage) to assess its failure modes, damage tolerance, and deformation characteristics under operational loads.
10. **Advanced FEA for a Large Telescope Truss**
    Description: Analyze a complex truss structure used in telescope assemblies. Evaluate load paths and structural stability under various load cases.
11. **Wind Turbine Blade FSI – Coupled Structural and Fluid Analysis**
    Description: Investigate the structural response of a wind turbine blade considering fluid–structure interaction effects. Focus on deformation and stress under aerodynamic loads.
12. **Modal Analysis of a Satellite/Composite Monocoque Structure**
    Description: Perform a modal analysis on a satellite or composite monocoque structure. Identify vibration modes and assess potential resonance issues in a space environment.

Textbooks

3. K. J. Bathe, *Finite Element Procedures*, Prentice Hall, Upper Saddle River, NJ, USA, 1996.
4. J. N. Reddy, *An Introduction to the Finite Element Method*, 3rd ed., McGraw-Hill, 2006.

Reference Book

3. Z. Li and J. Zhang, *Advanced Finite Element Methods for Structural Analysis*, Springer, 2010.

Additional Video/Online Resource

2. Cornell University FLUENT Learning Modules
   (A collection of step-by-step tutorials and video guides illustrating how to set up and solve fluid flow problems in ANSYS Fluent.)

Course Code	Course Title					Category
25MTAS206R	**Mini Project**					**Program Core**
Contact Hours per Week			**CA**	**FE**	**Credits**	
L	**T**	**D/P**				
0	**0**	**4**	**50**	**50**	**2**	

Prerequisite: A fundamental understanding of the core concepts in the relevant subject area, with the ability to read and interpret technical papers and research articles.

Course Objectives

The primary purpose of this course is to:

1. **Identify and Compare Technical & Practical Issues**: Enable students to explore advanced or emerging topics in their area of specialisation.
2. **Develop Scholarly Skills**: Encourage creating an annotated bibliography from research papers, demonstrating thorough literature investigation.
3. **Refine Technical Writing & Critical Thinking**: Train students to prepare well-structured reports and technical documents.
4. **Enhance Presentation Skills**: Improve competence in describing, interpreting, and analysing technical findings, culminating in effective oral presentations.

Course Outcomes

By the end of the course, students will be able to:

1. Establish Motivation for a chosen topic and develop a structured thought process for technical communication.
2. Organize a Detailed Literature Survey and synthesise findings in a coherent document referencing significant technical publications.
3. Analyze and Comprehend proof-of-concept data or theoretical underpinnings related to the selected topic.
4. Deliver Effective Presentations that showcase clarity of thought, improved soft skills, and command of the subject.
5. Utilize Modern Tools (e.g., LaTeX) for preparing high-quality technical reports, thereby embracing recent technology in document creation.

Course Content

During Mini Project, students shall:

1. Select a Research Topic: Identify an advanced or emerging area relevant to their specialization.
2. Conduct a Literature Review: Summarize and critique research papers, focusing on existing methodologies, findings, and gaps in knowledge.
3. Perform Data Collection & Analysis: Gather information from published works, compare methodologies, and draw inferences.
4. Prepare a Seminar Report: Document objectives, literature findings, methods (if any data were collected), and conclusions in a structured format.
5. Deliver a Presentation: Present the summarised work, highlighting the key concepts, contributions, and future scope.

Important Note on Paper Presentation (25% Weightage)

25% of the overall evaluation (Continuous Assessment) will be assigned to presenting a paper based on the seminar topic at a national or international conference (publication in conference proceedings is encouraged; online publication is optional).

ELECTIVE–I

(Specialisation in Structures)

Course Code	Course Title				Category
25MTASE211R	Nonlinear Finite Element Analysis for Aerospace Applications				DCC
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	0	50	50	3

Prerequisite:
1. Basic knowledge of linear finite element methods and structural mechanics.
2. Familiarity with numerical solution strategies and material behavior fundamentals.

Course Objectives:
The main purpose of this course is to:
1. Understand nonlinear material behavior and geometric nonlinearities as encountered in aerospace structures.
2. Explain the formulation of constitutive models for plasticity, hyperelasticity, and viscoelasticity.
3. Analyze large deformation and stability problems using nonlinear finite element formulations.
4. Evaluate contact and impact phenomena using appropriate computational techniques.
5. Apply advanced solution techniques to achieve convergence in nonlinear simulations.

Course Outcomes:
After learning this course, students shall be able to:
1. Identify and explain constitutive models for nonlinear material behavior.
2. Model large deformations and apply stability analysis techniques using geometric nonlinear theories.
3. Evaluate the performance of aerospace components under contact and impact conditions.
4. Implement convergence strategies and iterative solution techniques for nonlinear systems.
5. Synthesize simulation results to verify design integrity under non-ideal loading conditions.

COURSE CONTENT

Unit 1: Nonlinear Material Behavior (9 Hours)

Fundamentals of material nonlinearity: plasticity, hyperelasticity, and viscoelasticity. Constitutive models: Von Mises plasticity, Neo-Hookean and Mooney–Rivlin models, and viscoelastic models (Maxwell, Kelvin–Voigt). Comparison with linear behavior and implications for aerospace materials. Underlying Theories: Plasticity theory and hyperelasticity theory.

Unit 2: Geometric Nonlinearities (9 Hours)

Large deformation theory and nonlinear strain measures. Stability analysis: buckling and post-buckling behavior in thin-walled structures. Formulation of nonlinear kinematics and update strategies. Underlying Theories: Finite strain theory; Eulerian and Lagrangian formulations.

Unit 3: Contact and Impact Analysis (9 Hours)

Fundamentals of contact mechanics and frictional interfaces. Modeling impact events and transient dynamic responses. Techniques for handling contact constraints and discontinuities. Underlying Theories: Contact mechanics and impact theory; penalty methods and Lagrange multipliers for enforcing contact.

Unit 4: Solution Techniques in Nonlinear Systems (9 Hours)

Iterative solvers for nonlinear equations: Newton–Raphson and modified arc-length methods. Convergence criteria, error estimation, and load increment strategies. Handling computational challenges such as ill-conditioning and divergence. Underlying Theories: Newton–Raphson method, arc-length continuation, and convergence theories.

Unit 5: Integration and Verification (9 Hours)

Integration of nonlinear models into aerospace simulation workflows. Benchmark problems: crash simulations, buckling analyses, and impact resistance studies. Verification and validation strategies: comparing simulation outcomes with experimental data. Underlying Theories: Sensitivity analysis and verification methods in nonlinear FEA.

Textbooks:

1. B. E. Bisplinghoff, H. Ashley, and R. L. Halfman, *Aeroelasticity*, 2nd ed., Dover Publications, 2003.
2. T. Belytschko, W. K. Liu, and B. Moran, *Nonlinear Finite Elements for Continua and Structures*, Wiley, 2000.

Reference Books:

1. S. S. Simo and T. J. R. Hughes, *Computational Inelasticity*, Springer, 1998.
2. J. N. Reddy, *An Introduction to Nonlinear Finite Element Analysis*, Oxford University Press, 2004.
3. J. C. Nelson, *Aircraft Structures for Engineering Students*, 4th ed., Elsevier, 2013.
4. L. Meirovitch, *Elements of Vibration*, McGraw-Hill, 2001.

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>25MTASE212R</td><td colspan="4">Structural Health Monitoring and Damage Prognosis</td><td>ToT</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>50</td><td>50</td><td>4</td></tr>
</table>

Prerequisite:
1. Basic knowledge of materials, structural dynamics, and signal processing fundamentals.
2. Familiarity with experimental testing and data analysis methods.

Course Objectives:
The main purpose of this course is to:
1. Understand the sensor technologies used for structural health monitoring (SHM).
2. Explain the principles of data acquisition and signal processing applied in SHM systems.
3. Analyze damage detection algorithms using statistical and machine learning methods.
4. Evaluate prognostic models to predict damage progression in aerospace structures.
5. Apply SHM techniques to real-world aerospace systems for preventative maintenance.

Course Outcomes:
After learning this course, students shall be able to:
1. Identify various sensor types (strain gauges, fiber optics, acoustic emission sensors) and explain their operating principles.
2. Develop data acquisition frameworks and apply filtering and signal processing techniques.
3. Implement damage detection algorithms and evaluate their effectiveness using statistical analysis.
4. Assess prognostic models to predict damage evolution in critical components.
5. Synthesize SHM data to formulate predictive maintenance schedules for aerospace applications.

COURSE CONTENT

Unit 1: Sensor Technologies for SHM (9 Hours)

Overview of sensor types: strain gauges, fiber optics, acoustic emission sensors, and wireless sensor networks. Principles of sensor operation and selection criteria. Calibration and integration issues in aerospace structures. Underlying Theories: Sensor theory and signal transduction principles.

Unit 2: Data Acquisition and Signal Processing (9 Hours)

Data acquisition systems: sampling, noise reduction, and signal conditioning. Digital signal processing techniques: filtering, Fast Fourier Transform (FFT), and wavelet analysis. Data fusion techniques and multi-sensor integration. Underlying Theories: Signal processing theory and data analysis methodologies.

Unit 3: Damage Detection Algorithms (9 Hours)

Statistical methods for anomaly detection and thresholding. Machine learning algorithms: supervised and unsupervised approaches for damage detection. Feature extraction and dimensionality reduction in sensor data. Underlying Theories: Statistical analysis, pattern recognition, and machine learning theory.

Unit 4: Prognostic Models and Damage Evolution (9 Hours)

Prognosis techniques: remaining useful life (RUL) estimation, trend analysis, and damage propagation models. Integration of physics-based and data-driven prognostic approaches. Uncertainty quantification in prognostic models. Underlying Theories: Prognostic modeling, reliability engineering, and statistical forecasting methods.

Unit 5: Case Studies and Implementation in Aerospace (9 Hours)

Review of case studies in SHM for aircraft and infrastructure. Design and implementation of an SHM system: from sensor selection to data interpretation. Discussion on integration challenges and real-time monitoring strategies in UAVs and commercial aircraft. Underlying Theories: Systems engineering and implementation frameworks for SHM.

Textbook:

1. C. R. Farrar and K. Worden, *Structural Health Monitoring: A Machine Learning Perspective*, Wiley, 2012.

Reference Books:

1. V. Giurgiutiu, *Structural Health Monitoring: Advanced Methods and Applications*, Academic Press, 2014.
2. D. Balageas, C. P. Fritzen, and A. Güemes, *Structural Health Monitoring*, Wiley, 2006.

Course Code	Course Title				Category
25MTASE213R	Advanced Optimisation Techniques in Structural Design				EAD
Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	1	0	50	50	4

Prerequisite:

1. Proficiency in linear and nonlinear finite element analysis.
2. Basic understanding of optimization and sensitivity analysis.

Course Objectives:

The primary purpose of this course is to:

1. Understand multi-objective optimization and robust design principles in aerospace applications.
2. Explain various optimization algorithms and their mathematical foundations.
3. Analyze design sensitivity and iterative design processes using computational tools.
4. Evaluate design trade-offs by applying multi-objective and robust optimization strategies.
5. Apply optimization routines to refine aerospace structures for enhanced performance.

Course Outcomes:

After learning this course, students shall be able to:

1. Identify and explain multi-objective optimization techniques and trade-off analysis.
2. Develop robust design strategies by applying sensitivity analysis and uncertainty quantification.
3. Implement gradient-based and evolutionary algorithms to optimize material distribution and geometry.
4. Evaluate iterative design improvements using simulation feedback.
5. Synthesize optimization outcomes into practical design modifications that enhance performance and reduce weight.

COURSE CONTENT

Unit 1: Multi-Objective Optimization Fundamentals (9 Hours)

Formulation of optimization problems: objective functions, constraints, and design variables. Introduction to multi-objective optimization and Pareto efficiency. Overview of gradient-based methods and evolutionary algorithms (e.g., genetic algorithms). Underlying Theories: Optimization theory; Pareto optimality; evolutionary algorithm fundamentals.

Unit 2: Robust Design Strategies (9 Hours)

Techniques to handle uncertainty: probabilistic design, reliability-based design optimization. Robust design principles: sensitivity analysis, design for variability, and statistical methods. Methods to ensure performance under variable conditions. Underlying Theories: Robust optimization theory; reliability engineering and sensitivity analysis.

Unit 3: Design Sensitivity and Iterative Design (9 Hours)

Fundamentals of design sensitivity analysis: analytical and numerical differentiation techniques. Iterative design improvement and convergence of design parameters. Case examples: updating design parameters based on simulation feedback. Underlying Theories: Sensitivity analysis and iterative optimization methods.

Unit 4: Software Tools for Optimization (9 Hours)

Overview of optimization software and integration with finite element solvers. Hands-on sessions using optimization tools (e.g., MATLAB, ANSYS, Abaqus optimization modules). Workflow for integrating optimization routines into design processes. Underlying Theories: Computational optimization frameworks and software integration.

Unit 5: Case Studies and Integration of Optimization Routines (9 Hours)

Detailed case studies on optimizing wing spars, fuselage frames, and other aerospace components. Step-by-step project work: formulation, simulation, sensitivity analysis, and iterative improvement. Discussion on challenges, trade-offs, and integration of optimization results into final design. Underlying Theories: Design iteration theory; sensitivity and convergence analysis in optimization.

Textbooks:

1. O. Sigmund and K. Maute, *Topology Optimization: Theory, Methods, and Applications*, 2nd ed., Springer, 2014.

2. T. Belytschko, W. K. Liu, and B. Moran, *Nonlinear Finite Elements for Continua and Structures*, Wiley, 2000.

Reference Books:

1. M. P. Bendsoe and O. Sigmund, *Topology Optimization: Theory, Methods, and Applications*, 2nd ed., Springer, 2004.

2. R. W. Pryor, *Multi-Physics Modeling Using COMSOL 5 and MATLAB*, Wiley, 2013.

3. S. P. Venkatesh, *Structural Optimization*, Wiley, 2010.

SEMESTER –III

Course Code	Course Title	Category
25MTAD301R	**Advanced Research Methodologies and Scientific Communication**	**DCC**

Contact Hours per Week			CA	FE	Credits
L	T	D/P			
3	0	0	50	50	3

Prerequisite:

1. Basic knowledge of research methods and academic writing.
2. Familiarity with common computer applications (e.g., Microsoft Office).
3. An introductory understanding of data management and analysis concepts.

Course Objectives:

The main purpose of this course is to:

1. Introduce the fundamentals of scholarly research by identifying problems, defining objectives, and conducting literature reviews using both traditional and AI-enhanced methods.
2. Develop practical skills in managing and analyzing research data using tools like Microsoft Excel and Power BI.
3. Integrate AI tools to accelerate literature reviews, data cleaning, and preliminary report drafting.
4. Guide students in drafting professional theses and manuscripts with Microsoft Word and reference management software.
5. Enhance scientific communication and presentation skills to effectively convey research findings in academic and professional forums.

Course Outcomes:

After learning this course, students shall be able to:

1. CO1: Identify and articulate clear research objectives and gaps by conducting comprehensive literature reviews and leveraging AI tools like Semantic Scholar and ResearchRabbit.
2. CO2: Analyze and visualize research data effectively using tools such as Excel and Power BI, enabling data-driven decision making.
3. CO3: Apply AI-driven methodologies to streamline literature searches, data cleaning, and report drafting, thereby enhancing overall research productivity.
4. CO4: Produce high-quality research documents and manuscripts by mastering advanced documentation skills and peer-review processes using Microsoft Word, Zotero, or Mendeley.
5. CO5: Communicate research findings persuasively through well-designed presentations, academic posters, and digital media, utilizing AI design tools like Beautiful.ai and Canva.

COURSE CONTENT

Unit 1: Research Foundations – Defining Objectives, Literature Review, and Gap Analysis (9 Hours)

- Literature Search & Review Lab:
    - Conduct hands-on sessions using academic databases (e.g., IEEE Xplore, Google Scholar) to gather and synthesize key research findings.
    - Introduce AI tools such as Semantic Scholar, Connected Papers, and ResearchRabbit to streamline literature discovery and identify influential papers.
- Gap Analysis Exercise:
    - Participate in group discussions to identify areas where current research is lacking and propose potential research directions.
- Drafting a Research Proposal Outline:
    - Begin outlining a research proposal that captures your research rationale, objectives, and a preliminary methodology.

Unit 2: Data Management and Analytical Tools for Research (9 Hours)

- Excel Data Workshop:
    - Practice data entry, formatting, and basic formula applications using real-world research datasets.
    - Exercises include data validation, conditional formatting, and use of lookup functions.
- Data Analysis & Visualization:
    - Create pivot tables and construct charts to reveal trends and insights within datasets.
- Power BI Dashboard Lab:
    - Connect to diverse data sources and build interactive dashboards that effectively communicate research findings.
- Case Study Exercise:
    - Analyze a sample dataset from a research study to extract key insights and trends, presenting findings through visualizations.

Unit 3: Leveraging AI Tools for Enhanced Research and Writing (9 Hours)

- AI Tool Demonstrations:
    - Interactive sessions showcasing popular AI tools such as ChatGPT, Grammarly, Jasper, and Elicit.
    - Introduce additional tools like SciNote (for research data management) and Ref-N-Write (for academic writing assistance).
- Enhanced Literature Review:
    - Use AI tools to streamline literature searches, extract key insights, and generate summaries.
- Data Cleaning & Preliminary Analysis:
    - Hands-on sessions where AI automates data cleaning processes and assists with initial data analysis.
- Interactive Report Writing:
    - Draft and edit research report sections with AI assistance, focusing on improving clarity, grammar, and coherence.
- Case Study Analysis:
    - Work in groups to apply AI-driven approaches to solve specific research challenges, followed by group discussion on outcomes and tool effectiveness.

Unit 4: Scientific Documentation, Thesis Drafting, and Journal Manuscript Preparation (9 Hours)

- Microsoft Word Immersion:
  - Live demonstrations and guided exercises on the interface, formatting tools, and style management.
- Thesis Drafting Lab:
  - Create key sections of a thesis document, including the title page, abstract, and structured chapter headings using predefined templates.
- Document Formatting & Style Workshops:
  - Apply styles, headings, and automated tables of contents to ensure consistency throughout the document.
- Reference Management:
  - Utilize tools like Zotero or Mendeley for efficient citation management and seamless integration into your document.
- Journal Manuscript Structuring:
  - Learn to organize a journal article into clear sections—abstract, introduction, methodology, results, discussion, and conclusion.
- Drafting and Peer Review:
  - Participate in simulated peer-review sessions using track changes and comments to refine and polish manuscript drafts.
- Revision & Finalization Sessions:
  - Iteratively refine the document based on peer feedback to achieve a submission-ready manuscript.

Unit 5: Scientific Communication and Presentation Skills (9 Hours)

- Presentation Design Workshop:
  - Learn best practices for designing visually engaging slides using tools like PowerPoint and Canva.
  - Explore AI-driven design assistants such as Beautiful.ai or DesignScape for creating professional slide decks.
- Poster Development Lab:
  - Create academic posters that clearly present research objectives, methodology, results, and conclusions.
  - Utilize AI tools like PosterMyWall for layout and design enhancement.
- Mock Presentation Sessions:
  - Deliver short presentations to peers, with structured feedback sessions on clarity, content, and delivery.
- Interactive Communication Exercises:
  - Engage in role-playing scenarios to practice answering questions and defending research findings in academic settings.
- Digital Communication Tools:
  - Explore online platforms for webinars, virtual conferences, and digital content sharing (e.g., Zoom, Microsoft Teams, and Prezi).

Textbook

1. W. C. Booth, G. G. Colomb, and J. M. Williams, *The Craft of Research*, 3rd ed., Chicago, IL, USA: University of Chicago Press, 2008.

Reference Book

1. J. Schimel, *Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded*, New York, NY, USA: Oxford University Press, 2012.

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>25MTAS302R</td><td colspan="4">TECHNICAL SEMINAR -II</td><td>Program Core</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>50</td><td>50</td><td>2</td></tr>
<tr><td colspan="6">Prerequisite: Fundamental Research Exposure; Analytical and Presentation Skills.</td></tr>
<tr><td colspan="6">Course Objectives
The primary purpose of this course is to:
1. Identify and Compare Technical & Practical Issues: Enable students to delve deeper into advanced or emerging topics within their specialisation, building upon prior seminar experience.
2. Develop Scholarly Skills: Enhance competency in creating annotated bibliographies and critically reviewing research papers with a strong methodological focus.
3. Refine Technical Writing & Critical Thinking: Strengthen the ability to organise and compose technical reports demonstrating clarity, precision, and logical reasoning.
4. Enhance Presentation Competence: Foster the skills to describe, interpret, and analyse technical issues, culminating in clear oral communication.</td></tr>
<tr><td colspan="6">Course Outcomes (CO)
By the end of the course, students will be able to:
1. Establish motivation for a specialised topic and develop a coherent structure for technical presentations.
2. Organize an in-depth literature survey and compose a detailed document referencing core technical publications.
3. Analyse and synthesise proof-of-concept data or theoretical constructs relevant to advanced research problems.
4. Deliver impactful presentations, refining both communication techniques and subject-matter expertise.
5. Adopt contemporary tools (e.g., LaTeX) for producing high-quality, publication-ready technical reports.</td></tr>
</table>

Course Content

During Technical Seminar - II, students will:

1. Explore Advanced Research Themes: Identify current or emerging issues beyond the scope of prior seminars, ensuring progression in technical understanding.
2. Conduct Comprehensive Literature Reviews: Examine multiple research publications, focusing on experimental design, methodology, and data interpretation for comparative analysis.
3. Perform Critical Analysis: Evaluate the strengths, weaknesses, and potential gaps in existing studies, proposing potential areas for further inquiry.
4. Compile a Detailed Seminar Report: Document the research scope, findings, and synthesized perspectives with clarity and professional rigor.

5. Present Findings: Showcase the study's conclusions in a formal seminar setting, defending the rationale and significance of the chosen topic.

Important Note on Paper Presentation (50% of CA):

50% of the continuous assessment will be based on presenting a paper at an international conference (with online publication). This step ensures students gain real-world academic exposure and experience disseminating their research to a broader audience.

Course Code	Course Title				Category
25MTAS303R	**Dissertation Phase -I**				Program Core
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**T**	**D/P**			
0	**0**	**16**	**50**	**50**	**08**

Prerequisite: Fundamental Knowledge of Domain; Research Methodology Skills.

Course Objectives

The primary purpose of this course is to:

1. **Apply Fundamental Concepts:** Investigate related literature from fundamental subjects to identify a clear research gap.
2. **Formulate the Research Problem:** Define objectives and scope for the project, ensuring clarity in the problem statement.
3. **Analyze Available Resources:** Evaluate tools, methodologies, and data sources needed for successful project execution.
4. **Enhance Presentation & Communication Skills:** Improve clarity in reporting progress, findings, and project outcomes in both written and oral formats.

Course Outcome:

By the end of the course, students will be able to:

1. CO1: Identify a pertinent research gap through a detailed literature review, referencing at least five scholarly articles or industry sources.
2. CO2: Formulate a clear problem statement and research objectives, providing a structured plan (e.g., Gantt chart) to address the identified gaps.
3. CO3: Select and justify appropriate methodologies, tools, and resources, demonstrating alignment with project objectives and constraints (e.g., budget, time, scope).
4. CO4: Develop a comprehensive project proposal or progress report, incorporating standardized formatting and documentation guidelines, with at least 80% adherence to the specified criteria.
5. CO5: Present the proposed project approach and findings (e.g., methodology, preliminary data, expected outcomes) to a review committee, achieving a minimum set score or rubric standard for clarity and depth of analysis.

Course Content

During Project Phase - I, students shall:

1. **Finalize a Theme:** Select a topic aligned with their area of specialization for the dissertation work.
2. **Conduct Extensive Literature Review:** Define the research gap, objectives, and scope.
3. **Plan Methodology:** Propose a structured approach that may include laboratory experiments, model development, case studies, or field data collection.
4. **Compile Progress Report:** Document the chosen research approach, initial findings, and methodology in a cohesive format adhering to institutional guidelines.
5. **Present Work to the Review Committee:** Offer an oral presentation detailing the research plan, literature survey outcomes, and proposed methods.

ELECTIVE–II

(Specialisation in Structures)

<table>
<tr><th>Course Code</th><th colspan="3">Course Title</th><th colspan="2"></th><th>Category</th></tr>
<tr><td>25MTASE321R</td><td colspan="5">Vibration and Noise Control in Aerospace Structures</td><td>DCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td colspan="2" rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D/P</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>50</td><td>50</td><td colspan="2">3</td></tr>
</table>

Prerequisite:

1. Fundamental knowledge of vibrations, modal testing, and basic signal processing.
2. Introductory understanding of structural dynamics and acoustics.

Course Objectives:

The primary purpose of this course is to:

1. Understand the fundamental concepts of vibration analysis and noise generation in aerospace structures.
2. Explain modal testing and damping mechanisms using established theories.
3. Analyze passive and active noise control techniques and vibration isolation strategies.
4. Evaluate design modifications for noise reduction and vibration control through case studies.
5. Design aerospace components with enhanced vibration and noise control features.

Course Outcomes:

After learning this course, students shall be able to:

1. Identify and explain the principles of vibration analysis, modal testing, and damping mechanisms.
2. Apply noise reduction techniques (both passive and active) to aerospace design challenges.
3. Assess the effectiveness of vibration isolation systems and active damping technologies in real-world scenarios.
4. Develop design modifications to reduce cabin noise and control engine mount vibrations.
5. Synthesize integrated solutions to enhance overall ride quality and structural durability.

COURSE CONTENT

Unit 1: Fundamentals of Vibrations (9 Hours)

Vibration analysis fundamentals: free and forced vibrations, natural frequencies, and mode shapes. Modal testing techniques and damping mechanisms. Underlying Theories: Vibration theory, modal analysis, and damping models.

Unit 2: Noise Reduction Techniques (9 Hours)

Passive noise control: acoustic insulation materials and structural design modifications. Active noise control systems and feedback control. Underlying Theories: Acoustic theory and noise control principles.

Unit 3: Control Strategies (9 Hours)

Vibration isolation systems: design and implementation. Active damping technologies and smart material-based control strategies. Underlying Theories: Control theory and vibration isolation principles.

Unit 4: Application Case Studies (9 Hours)

Case study: Cabin noise reduction techniques.Case study: Engine mount vibration control. Underlying Theories: Application of experimental modal analysis and control systems in aerospace.

Unit 5: Integration and Design Implementation (9 Hours)

Integration of vibration and noise control strategies in overall aerospace design. Project work: Designing quieter cabins and enhancing structural durability. Underlying Theories: Systems engineering and integrated design methodologies.

Textbook

1. S. S. Rao, *Mechanical Vibrations*, 6th ed., Prentice Hall, 2010.

Reference Books

1. C. F. Gauntt, *Noise and Vibration Control Engineering: Principles and Applications*, 2nd ed., Wiley, 1998.
2. J. S. Bendat and A. G. Piersol, *Random Data: Analysis and Measurement Procedures*, 4th ed., Wiley, 2010.

Course Code	Course Title					Category
25MTASE322R	**Crashworthiness and Impact Analysis**					**RWA**
Contact Hours per Week			**CA**	**FE**	**Credits**	
L	**T**	**D/P**				
3	**1**	**0**	**50**	**50**	**4**	

Prerequisite:
1. Basic knowledge of material behavior and structural dynamics.
2. Familiarity with finite element methods and dynamic simulation concepts.

Course Objectives:
The primary purpose of this course is to:
1. Understand the principles of impact mechanics and energy absorption in aerospace structures.
2. Explain the deformation modes and failure mechanisms under impact loading.
3. Analyze dynamic simulation techniques and explicit solvers for impact events.
4. Evaluate progressive collapse and failure propagation through simulation and testing.
5. Design crash-resistant components using validated simulation and test data.

Course Outcomes:
After learning this course, students shall be able to:
1. Identify and explain the energy absorption mechanisms and deformation modes in impact events.
2. Model impact force analysis using dynamic simulation methods.
3. Assess progressive collapse and controlled deformation strategies in thin-walled structures.
4. Implement explicit solver techniques and contact-impact models in simulation.
5. Develop design solutions for crashworthiness and occupant protection.

COURSE CONTENT

Unit 1: Impact Mechanics (9 Hours)

Fundamentals of impact: energy absorption, deformation modes, and impact force characterization. Underlying Theories: Impact mechanics, energy absorption theory.

Unit 2: Simulation Techniques (9 Hours)

Dynamic simulation methods for impact analysis, including explicit solvers and contact-impact models. Underlying Theories: Dynamic simulation, explicit time integration methods.

Unit 3: Progressive Collapse Analysis (9 Hours)

Analysis of failure propagation and design strategies for controlled deformation. Underlying Theories: Progressive collapse theory and failure propagation.

Unit 4: Testing and Validation (9 Hours)

Correlating simulation data with physical crash test results. Underlying Theories: Validation and verification techniques in dynamic testing.

Unit 5: Design Implementation and Case Studies (9 Hours)

Case studies on crash-resistant components and energy-absorbing structures. Design integration for enhanced safety in commercial and military aircraft. Underlying Theories: Systems engineering and design integration.

Textbook:

1. T. Belytschko, W. K. Liu, and B. Moran, Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.

Reference Books:

1. W. W. Wang, Impact Engineering: Fundamentals, Testing, and Simulation, Elsevier, 2008.
2. A. D. F. Ansell, Crashworthiness and Occupant Protection, CRC Press, 2013.

Course Code	Course Title				Category
25MTASE323R	**Fluid–Structure Interaction in Aerospace Engineering**				
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**T**	**D/P**			
3	**-**	**-**	**50**	**50**	**3**

Prerequisite: Basic computer literacy

Course Objectives:

The primary purpose of this course is to:

1. Understand the fundamentals of fluid dynamics, including aerodynamic principles, turbulence, and boundary layer behavior, and their impact on aerospace structures.
2. Explain the techniques for coupling structural finite element methods with computational fluid dynamics (CFD) to analyze fluid–structure interactions (FSI).
3. Analyze aeroelastic phenomena—such as wing flutter and dynamic aeroelastic effects—by integrating simulation data with experimental validation.
4. Evaluate the capabilities of modern simulation tools and software packages in addressing complex FSI problems within aerospace applications.
5. Design integrated aerospace components by applying multiphysics analysis to optimize aerodynamic performance and structural integrity.

Course outcome

After learning this course, students shall be able to:

1. Identify and explain key fluid dynamics concepts, including flow regimes, turbulence models, and boundary layer theory, and their relevance to aerospace engineering.
2. Apply coupled field theories to set up and solve integrated FSI problems using both partitioned and monolithic approaches.
3. Analyze aeroelastic phenomena through detailed simulation and comparison with experimental data, and assess the impact on design parameters.
4. Implement state-of-the-art CFD and FEA tools to prepare, run, and validate coupled simulations for aircraft components.
5. Synthesize design proposals that incorporate FSI analysis, optimizing trade-offs between aerodynamic efficiency, weight, and structural performance.

Course Content

Unit 1: Fundamentals of Fluid Dynamics (9 Hours)

Basic Aerodynamic Principles: Flow regimes, Reynolds number, and laminar versus turbulent flow. Boundary layer theory and separation phenomena. Turbulence and Flow Regimes: Introduction to turbulence models (k-ε, k-ω). Discussion of compressible versus incompressible flow. Flow Visualization Techniques: Experimental methods such as smoke or dye visualization and PIV (Particle Image Velocimetry). Example Applications: Analysis of flow over airfoil sections. Simulation examples of boundary layer development. Underlying Theories: Fluid dynamics fundamentals, turbulence modeling, and boundary layer theory.

Unit 2: Coupled Analysis Techniques (9 Hours)

Coupling Methods: Partitioned and monolithic approaches for FSI. Advantages and challenges of each method. Numerical Integration: Integration of structural finite element methods with computational fluid dynamics (CFD). Data transfer between fluid and structural meshes. Stability and Convergence: Techniques to ensure stable coupling between disciplines. Time-stepping strategies and synchronization of solvers. Example Applications: Demonstration of a simple FSI problem using coupled solvers. Comparison of results between partitioned and monolithic approaches. Underlying Theories: Coupled field theory, multiphysics simulation frameworks.

Unit 3: Case Studies in Aeroelastic Phenomena (9 Hours)

Wing Flutter and Aeroelasticity: Analysis of flutter mechanisms and their dependence on aerodynamic forces. Case studies of wing and control surface oscillations. Aeroelastic Effects on Structural Integrity: Discussion of dynamic aeroelastic interactions. Impact of FSI on design parameters and performance. Data Comparison: Comparing simulation data with experimental flight test or wind tunnel data. Example Applications: Detailed review of a case study on wing flutter. Group exercises to interpret simulation versus experimental results. Underlying Theories: Aeroelasticity, unsteady aerodynamics, and experimental modal analysis.

Unit 4: Software and Tools (9 Hours)

Introduction to Simulation Tools: Overview of software packages for CFD and FEA (ANSYS, Fluent, COMSOL, etc.). Setting up a coupled simulation workflow. Model Preparation: Preprocessing: Mesh generation for both fluid and structural domains. Setting boundary conditions and initial conditions for FSI problems. Post-Processing: Analyzing simulation results: stress, strain, flow velocity, pressure distribution. Validation techniques against experimental data. Example Applications: Hands-on lab exercises using a commercial FSI software package. Demonstration of model validation techniques. Underlying Theories: Computational fluid dynamics, finite element analysis, and simulation validation methods.

Unit 5: Integration for Safer Aircraft Designs (9 Hours)

Design Integration: Strategies for incorporating FSI analysis into aircraft design. Evaluating the performance of wings, control surfaces, and fuselage under coupled loading. Optimization for Aerodynamic Efficiency: Use of FSI data to optimize aerodynamic performance and structural integrity. Trade-offs between weight, strength, and aerodynamic performance. Case Study Integration: Group project or design challenge where students propose design modifications based on FSI simulation data. Example Applications: Detailed project work on optimizing a wing or control surface using FSI techniques. Final presentations integrating simulation results and design proposals. Underlying Theories: Systems integration, design optimization, and multiphysics analysis.

Textbook:

- M. P. Paidoussis, *Fluid-Structure Interactions: Slender Structures and Axial Flow*, 2nd ed., Elsevier, 2014.

Reference Books:

1. H.-J. Bungartz and M. Schäfer, *Fluid-Structure Interaction: Modelling, Simulation, Optimization*, Springer, 2006.

C. Pozrikidis, *Introduction to Theoretical and Computational Fluid Dynamics*, 2nd ed., Oxford University Press, 2011.

SEMESTER –IV

Course Code	Course Title					Category
25MTAS401	Dissertation Phase-II					Program Core
Contact Hours per Week			CA	FE		Credits
L	T	D/P				
0	0	32	100	200		16

Prerequisite: Successful Completion of Dissertation Phase-I

Course Objectives

The primary purpose of this course is to:

1. Refine & Execute Methodology: Implement the full plan, making adjustments based on Phase-I feedback or newly encountered challenges.
2. Validate & Correlate Findings: Compare experimental outcomes with computational results, or vice versa, ensuring accuracy and consistency.
3. Present Final Deliverables: Compile comprehensive results, analyses, and conclusions, culminating in a final dissertation and viva-voce.

Course Outcomes (CO)

By the end of Project Phase – II, students will be able to:

1. CO1: Implement the research methodology thoroughly, incorporating necessary refinements from Phase-I feedback.
2. CO2: Analyze and Validate final data/results, using experimental or computational means (or both), demonstrating correlation and coherence.
3. CO3: Synthesize insights and draw evidence-based conclusions, highlighting advancements or innovative findings from the research.
4. CO4: Document and Present the comprehensive dissertation, adhering to technical writing standards and institutional guidelines.
5. CO5: Publish/Disseminate findings via a journal submission or international conference presentation, aligning with professional research standards.

Course Content:

1. Methodology Refinement: Address gaps or methodological issues identified during Phase-I, updating experimental setups or computational tools.
2. Comprehensive Data Collection: Execute final experiments or simulations, ensuring sufficient replication or validation.
3. Correlation & Validation:
   a. Experimental Approach: Validate findings via simulations, mathematical models, or correlation with existing literature data.
   b. Computational Approach: Confirm accuracy using experimental benchmarks or known theoretical results.
4. Analysis & Discussion:
   a. Process raw data and derive key metrics.
   b. Compare outcomes with objectives, highlighting successes or discrepancies.
5. Final Report Writing:
   a. Present exhaustive details on methodology, results, validation, and conclusion.

    b. Follow formatting guidelines (figures, tables, equations, references).

6. Viva-Voce & Dissemination:
    a. Defend the dissertation in front of an external committee.

These two phases collectively ensure that students’ progress from problem identification and planning to full-fledged research execution and scholarly dissemination.

--End of Document--