COURSE CONTENT

COMPUTATIONAL AEROSPACE ENGINEERING LABORATORY								
I Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
BAED12	Core	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	4	2	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Aircraft Structures								

I. COURSE OVERVIEW:

This course aims to enhance the skills through a detailed introduction to the state-of-the-art computational methods and their applications for digital age aerospace engineering applications. It provides a unique opportunity for cross-disciplinary education and knowledge transfer in the computational engineering of fluid and solid mechanics for aerospace industrial applications. Focusing on fully integrated digital design for aerospace applications, you will be able to understand and implement numerical methods on various computing platforms for aerospace applications

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basic ANSYS software and use them to solve structural aero dynamic and flight control system problems.

II. Basics of plotting in ANSYS both in two dimensional and three dimensional.

III. Coding for solving structural response problems, aerodynamic simulation problems and flight control system analysis and design.

III. COURSE OUTCOMES:

After successful completion of the course, students will be able to:

CO 1 Develop the appropriate method for predicting ultimate load on wing using MATLAB.

C0 2 Make use of MATLAB and Simulink tools for solving aerospace engineering problem in designing.

CO 3 Examine the vibrational characteristics of various supported beams for obtaining structural stability.

CO 4 Make use of the structural fatigue concept for obtaining desired flexural characteristics.

CO 5 Analyze the effect of bending for failure rate of an aircraft structure.

CO 6 Determine the effect of Tortion during fracture of an aircraft component for assessing the structural stability.

IV. COURSE CONTENT:

1. Introduction

MATLAB introduction, Plotting and graphics: Plot, log and semi-log plots, polar plots; Subplots, axis, mesh, contour diagrams, flow diagrams, movies, MATLAB toolboxes: continuous transfer functions, root locus, Nichols chart, Nyquist chart, linear quadratic regulator, state space design, digital design, aerospace toolbox; M cells, structures and M-files, MEX files.

Standard Simulink libraries, Simulink aerospace block set, Building Simulink linear models: transfer function modelling in Simulink, zero pole model, state-space model; Simulink LTI viewer and usage of it, equivalent Simulink LTI models, single input single output design tool, building Multi-input, multi output models, building Simulink S-functions; State flow introduction: Opening, executing, and saving state flow models, constructing a simple state flow model, using a state flow truth table.

2. Generation of structures and unstructured Grid

Laboratory experiments involving the generation of structured and unstructured grids are essential in the field of computational fluid dynamics (CFD) and finite element analysis (FEA). Grid generation plays a crucial role in modeling and simulating various physical phenomena in engineering and science.

2.1 Grid Quality Assessment: Evaluation of the quality of the structured grid, including measures of grid orthogonality, skewness, and smoothness. High-quality grids improve the accuracy and convergence of numerical simulations.

2.2 Grid Density Control: Study of techniques to control grid density in specific regions of the domain. Grid refinement and coarsening methods can be assessed to optimize computational resources.

2.3 Grid Convergence Study: Determination of how the solution changes as the grid is refined, enabling the calculation of numerical error and assessment of grid convergence.

2.4 Boundary Layer Resolution: Assessment of grid structures near boundaries to ensure that boundary layers, where gradients are high, are properly resolved.

2.5 Structured Grid Topology: Analysis of the structured grid topology, including the layout of cells, nodes, and grid lines in 2D and 3D domains.

2.6 Grid Spacing Variation: Investigation of grid spacing variation in different regions to adapt to the physics of the problem, such as increasing grid resolution near a shock wave or stagnation point.

3 Plate bending

The specific outcomes of plate bending lab experiments will depend on the nature of the experiments, the type of plates being studied, and the equipment and measurement techniques used. These outcomes are valuable for understanding the behavior of plates and can have practical applications in engineering and design

3.1 Software development for Plate bending using finite element method.

3.2 Deformation Patterns: Students observe the deformation patterns of the plates under different loads. These patterns may include modes such as pure bending, twisting, and combined bending and twisting.

3.3 Stress Distribution: Students can measure and analyze the stress distribution across the plate's surface. Typically, the stress is highest at the points of maximum deformation, which is often at the plate's center.

3.4 Strain Measurement: Strain gauges or other strain measurement devices are used to determine the strain in various parts of the plate. This helps in understanding how the material responds to bending.

4. Beams analysis

The specific outcomes of beam analysis lab experiments will depend on the nature of the experiments, the type of beams being studied, and the equipment and measurement techniques used. These outcomes provide essential data for structural design and analysis and can help engineers and researchers make informed decisions about the behavior and performance of beams in real-world applications.

4.1 Software development for Beams analysis using finite element method.

4.2 Deflection Profile: Measurement of the beam's deflection under applied loads. The deflection profile can be plotted to understand how the beam's shape changes as loads are applied.

4.3 Load-Deflection Relationship: Determination of the relationship between the applied load and the resulting deflection. This relationship is typically nonlinear, and experiments help to understand how the beam behaves under different loads.

4.4 Strain and Stress Distribution: Measurement of strain and stress distributions within the beam. Strain gauges are often used to measure strains at various points on the beam's surface. Stress distributions can be inferred from strain measurements.

5. Trusses analysis

Experimental analysis of trusses in a laboratory setting is essential for understanding the behavior of truss structures, which are commonly used in engineering and architecture. Trusses are load-bearing structures composed of connected bars (members) and joints (nodes). Conducting lab experiments on trusses can provide valuable insights into their structural properties and performance

5.1 Software development for Trusses analysis using finite element method

5.2 Force Distribution: Measurement of the internal forces (axial forces) in the truss members. Understanding how loads are distributed among the members helps in assessing their load-carrying capacity.

5.3 Load-Carrying Capacity: Determination of the maximum load the truss can support before failure. This is crucial for evaluating the structural integrity and safety of truss designs.

5.4 Stress Analysis: Measurement of stress distribution in the truss members, which can help identify high-stress areas and potential failure points.

5.5 Deformation Analysis: Assessment of truss deflection under applied loads. Measuring the truss's deformation can provide insights into its rigidity and structural behavior.

6. Thin shells analysis

Experimental analysis of thin shells in a laboratory setting is crucial for understanding the behavior of shell structures, which are widely used in engineering and architecture for applications like pressure vessels, aircraft fuselages, and architectural domes. Conducting lab experiments on thin shells can provide valuable insights into their structural properties and performance.

6.1 Software development for thin shells analysis using finite element method

6.2 Deformation Profile: Measurement of the deformation and shape changes in the thin shell under applied loads. This includes the observation of membrane (in-plane) and bending (out-of-plane) deformations.

6.3 Buckling Behavior: Investigation of buckling behavior for thin shells under different loading conditions. Determination of the critical buckling loads and buckling modes is crucial for assessing stability.

6.4 Stress and Strain Distribution: Measurement of the stress and strain distributions within the shell's material. This information helps identify regions of high stress and assess material behavior.

6.5 Load-Carrying Capacity: Determination of the maximum load that the thin shell can support before failure. This is essential for evaluating structural integrity and safety.

7. Free vibration of a Cantilever Beam

A lab experiment on the free vibration of a cantilever beam involves studying the natural frequencies and mode shapes of the beam when it is subjected to initial displacement and released without any external forcing. The outcomes of such experiments provide insights into the dynamic behavior of cantilever beams.

7.1 Natural Frequencies: Measurement of the natural frequencies of the cantilever beam. These frequencies correspond to the beam's resonant frequencies at which it vibrates without external excitation.

7.2 Mode Shapes: Determination of the mode shapes of vibration associated with each natural frequency. These mode shapes describe how the beam deforms during free vibration. For a cantilever beam, the first mode shape is typically a simple vertical bending, and higher modes may involve additional bending patterns.

7.3 Damping Effects: Observation of the damping effects in the beam's vibrations. Damping may be natural (structural damping) or intentionally introduced to mimic real-world conditions.

7.4 Time Periods: Calculation of the time periods associated with each natural frequency. Time periods are the time it takes for the beam to complete one full cycle of vibration at a specific frequency.

8. Forced vibration of a Cantilever Beam

A lab experiment on the forced vibration of a cantilever beam involves studying the behavior of the beam when subjected to external periodic forces or excitations. The outcomes of such experiments provide insights into how the beam responds to dynamic loads.

8.1 Frequency Response: Measurement of the frequency response of the cantilever beam, which shows how the beam's displacement or response amplitude varies with the frequency of the applied force.

8.2 Resonance Frequencies: Identification of the resonance frequencies at which the beam exhibits maximum displacement or response amplitudes. Resonance occurs when the excitation frequency matches a natural frequency of the beam.

8.3 Amplitude-Frequency Relationship: Determination of the relationship between the applied force's frequency and the beam's response amplitude at various excitation levels.

8.4 Phase Lag Analysis: Measurement and analysis of the phase lag between the applied force and the beam's response. This phase lag is important for understanding the dynamic behavior of the system.

9. Free vibration of a simply supported Beam

A laboratory experiment on the free vibration of a simply supported beam involves studying the natural frequencies and mode shapes of the beam when it is initially displaced from its equilibrium position and released without any external forces acting on it. The outcomes of such experiments provide insights into the dynamic behavior of simply supported beams.

9.1 Natural Frequencies: Measurement of the natural frequencies of the simply supported beam. These frequencies correspond to the beam's resonant frequencies at which it vibrates without external excitation.

9.2 Mode Shapes: Determination of the mode shapes of vibration associated with each natural frequency.

These mode shapes describe how the beam deforms during free vibration. For a simply supported beam, the first mode shape is typically a vertical bending mode, and higher modes may involve additional bending patterns.

9.3 Damping Effects: Observation of the damping effects in the beam's vibrations. Damping may be natural (structural damping) or intentionally introduced to mimic real-world conditions.

9.4 Time Periods: Calculation of the time periods associated with each natural frequency. Time periods are the time it takes for the beam to complete one full cycle of vibration at a specific frequency.

9.5 Amplitude Decay: Analysis of how the amplitude of vibration decays over time. This provides insights into the energy dissipation and the effectiveness of any damping mechanisms.

10. Forced vibration of a simply supported Beam

A laboratory experiment on the forced vibration of a simply supported beam involves studying how the beam responds to external periodic forces or excitations. The outcomes of such experiments provide insights into how the beam reacts to dynamic loads and how its response changes with different forcing frequencies and amplitudes.

10.1 Frequency Response: Measurement of the frequency response of the simply supported beam, illustrating how the beam's displacement or response amplitude varies with the frequency of the applied force.

10.2 Resonance Frequencies: Identification of resonance frequencies at which the beam exhibits maximum displacement or response amplitudes. Resonance occurs when the excitation frequency matches one of the natural frequencies of the beam.

10.3 Amplitude-Frequency Relationship: Determination of the relationship between the applied force's frequency and the beam's response amplitude at various excitation levels.

10.4 Phase Lag Analysis: Measurement and analysis of the phase lag between the applied force and the beam's response, providing insights into the dynamic behavior of the system.

10.5 Dynamic Stiffness Analysis: Calculation of the dynamic stiffness of the simply supported beam, describing its ability to resist deformation when subjected to dynamic loads. Dynamic stiffness is frequency-dependent.

11. Determination of Elastic constants for a Composite flexural specimen

A laboratory experiment aimed at determining the elastic constants of a composite flexural specimen involves assessing the mechanical properties of a composite material, particularly its stiffness and elasticity. The outcomes of such experiments provide valuable data for characterizing the material's behavior and for design and engineering purposes.

11.1 Flexural Modulus (Young's Modulus in Flexure): Determination of the flexural modulus, also known as the flexural Young's modulus or simply the modulus of elasticity in flexure. This is a measure of the material's stiffness when subjected to bending loads. The flexural modulus quantifies the relationship between stress and strain during bending.

11.2 Flexural Strength: Measurement of the flexural strength, which is the maximum stress the composite material can withstand before failure in a flexural test. This value provides insight into the material's load-carrying capacity in bending.

11.3 Load-Deflection Curve: Generation of a load-deflection curve, showing the relationship between the applied load and the deflection of the composite flexural specimen. The shape of this curve reveals important information about the material's behavior, such as its stiffness and ductility.

11.4 Strain Measurement: Use of strain gauges or other strain measurement devices to determine the strains experienced by the specimen during bending. This data is essential for calculating the elastic constants.

12. Combined bending and Torsion of a Hollow Circular Tube

A laboratory experiment on the combined bending and torsion of a hollow circular tube involves studying how a cylindrical structure responds to simultaneous bending and torsion loads. The outcomes of such experiments provide insights into the behavior of tubular structures subjected to complex loading conditions

12.1 Load-Deformation Response: Measurement of the load-deformation relationship for the hollow circular tube subjected to combined bending and torsion. This involves tracking the applied loads and the corresponding deformations or displacements.

12.2 Combined Stress Analysis: Assessment of the combined stresses in the tube, including bending stress, torsional shear stress, and their interaction. This analysis helps determine the critical regions where stress concentrations occur.

12.3 Interaction of Bending and Torsion: Observation of how the simultaneous application of bending and torsion loads affects the tube's deformation patterns and the distribution of stresses.

V. TEXT BOOKS:

1. Richard Colgren, "Basic MATLAB, Simulink, and State Flow", AIAA Education Series, 1st Edition, 2007.
2. Steven T. Karris, "Introduction to Simulink with Engineering Application", Orchard Publication, 3rd Edition, 2006.

VI. REFERENCE BOOKS:

1. Ashish Tewari, "Atmospheric and Space Flight Dynamics", Birkhauser Publication, 1st Edition, 2007.
2. A. Tewari, "Modern Control Design with MAT LAB and Simulink", Wiley, 1st Edition, 2002.

VII. ELECTRONICS RESOURCES:

1. http://www.springer.com/us/book/9780817644376
2. https://www.scribd.com/doc/53680598/Modern-Control-Design-With-MATLAB-and-SIMULINK

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual