5TH SEMESTER

AIRCRAFT STRUCTURAL ANALYSIS

Subject Code – BANES1-501 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

- To enable the student to describe and calculate inelastic buckling characteristics of columns and plates.
- The student should be able to evaluate stresses in various aircraft components like wing, fuselage and wing ribs.
- The student should be able to apply concept of structural idealization for stress analysis of open and closed section beams.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Carry out stress analysis of aircraft wing, fuselage and wing ribs .
- Apply concept of structural idealization for stress analysis of open and closed section beams.
- Structural analysis of aircraft wing, fuselage and wing ribs.
- Compute loads acting on an aircraft
- Compute aircraft fatigue life

UNIT –I (13 Hrs.)

Inelastic buckling: Flexural - torsional buckling of thin walled columns, buckling of thin plates, inelastic buckling of plates ,experimental determination of critical load, local instability, instability of stiffened panels, full tension and semi tension field beams

UNIT –II (15 Hrs.)

Airframe loads: Aircraft inertia loads, symmetric maneuver loads, steady pull out, correctly banked turn, numerical problems, fatigue, safe life and fail-safe structures, designing against fatigue, fatigue strength of components, prediction of aircraft fatigue life.

Bending and shear of open and closed tubes: Symmetrical bending, direct stress due to bending, deflection due to bending, approximation for thin walled section, shear centre, shear of open section beams, shear of closed section beams.

UNIT –III (16 Hrs.)

Structural Idealization: Analysis of combined open and closed sections in shear and torsion, effect of idealization on bending, shear and torsion analysis of open and closed section beams, deflection of open and closed section beams.

Stress analysis of wing and fuselage: Tapered wing spar, open and closed sections, beams with variable stringer areas, bending, shear and torsion analysis of fuselage.

UNIT –IV (16 Hrs.)

Stress analysis of aircraft components: Analysis of wing in bending, shear and torsion, stress analysis of tapered wings, cut – outs in wings, stiffened webs, fuselage frame, wing ribs.

INSTRUCTIONAL STRATEGY

Aircraft Structures II being an advanced course, teachers are expected to lay emphasis on the stress analysis of aircraft components by explaining the detailed procedure of solution. The teachers are expected to give the students home assignments, project problems and quizzes to test the students skills.

RECOMMENDED BOOKS

1 "Aircraft Structures for Engineering Students": T.H.G.Megson ,4th Edition., Elsevier Ltd., 2012
2 "Structural stability of Columns and Plates",N G R Iyengar, John Wiley and sons, 1988
3 "Aircraft structures", D.J.Peery and J.J.Azhar, 2nd Edition., McGraw Hill
4 "MITOPENCOURSEWARE" Masschusetts institute of technology ocw.mit.edu/courses/aeronautics-and-astronautics, 1996

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

HIGH SPEED AERODYNAMICS

Subject Code –BANES1-502 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVE

- Differentiate between compressible and incompressible aerodynamics.
- Understand various phenomenon in compressible subsonic, supersonic and hypersonic flow
- Know various experimental techniques for measurement of aerodynamic forces & moments.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Design supersonic nozzle and diffuser by applying theory
- Analyze characteristics of compressible flow over different bodies
- Evaluate flow characteristics across shock wave of various strengths
- Compare various experimental methods for measurement of aerodynamic characteristics.

DETAILED CONTENTS

UNIT – I (15 Hrs.)

Incompressible flow: Classical thin airfoil theory, Prandtl's classical lifting line theory, fundamental equations

Compressible flow: Introduction: thermodynamics, compressibility, governing equations of inviscid compressible flow, subsonic compressible flow: velocity potential equation, compressibility correction, critical Mach number and drag divergence Mach number, supercritical airfoil

UNIT – II (18 Hrs.)

Normal and Oblique Shock Waves: Point source in a compressible flow, Mach waves and shock waves. Normal Shock waves: equation of motion for a normal shock, normal shock relations for a perfect gas.

Introduction to oblique shock relations, M-θ-β relations, shock polar, supersonic flow over wedge and cone, weak oblique shock. Supersonic expansion by turning, Prandtl-Meyer flow, Numerical problems

UNIT – III (15 Hrs.)

Compressible flow through nozzle and diffuser: Quasi 1-D flow and its governing equations, nozzle flow, diffuser, linearized supersonic pressure coefficient formula.
Hypersonic flow: qualitative aspects of hypersonic flow, Newtonian theory and application to flat plat a different angles of attack, Mach number independence, computational techniques for hypersonic flow

UNIT – IV (12 Hrs.)

Numerical techniques for supersonic flow: Introduction to computational fluid dynamics, Method of characteristics, Finite difference method, time-dependent techniques and its application

Measurement Techniques in Aerodynamics: Subsonic, Transonic, supersonic wind tunnels, shock tube, wind tunnel balances, wind tunnel corrections, measurement of forces and moments, measurement of profile drag by pitot traverse of wake, shadowgraph system, Schlieren system, interferometer, Hot wire Anemometer

INSTRUCTIONAL STRATEGY

Video and other visual aids may be resorted to, in order to generate interest of the students.

RECOMMENDED BOOKS

1. "A First course in Turbulence" by Tennekes and Lumley. MIT Press
2. "Fluid Mechanics", Frank M.White 2nd Edition,McGraw Hill
3. "Fluid Mechanics" by Kundu & Cohen
4. "Aerodynamics", L.J.Clancy, 5th Ed. Himalayan Books
5. "Aerodynamics for Engineering Students", E.L.Houghton and P.W.Carpenter, 4th Edition., CBS Publishers , India

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

AIRCRAFT MATERIALS AND PROCESSES

Subject Code – BANES1-503 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

- This course builds up a strong knowledge base of aerospace students in respect of various important materials used in the manufacture of aircraft including certain salient manufacturing processes that are specific to the aircraft manufacturing.

- The course also covers the design principles of jigs and fixtures, Electron Beam welding, etc, which are used for manufacturing various components and assemblies of aircraft so as to ensure symmetry of the geometric shapes and to obtain accuracy / repeatability in dimensions.

LEARNING OUTCOME

After undergoing the subject, the student will be able to:

- Describe and identify materials for development of aircraft and its components.
- Apply engineering processes associated with aircraft manufacture.
- Analyze Properties of Aircraft Light Alloys, Aircraft Steels & Composites.
- Review standardization of Aircraft materials, Crystalline / material micro-structures.
- Evaluate modern aircraft component fabrication Techniques.
- Apply qualitative and quantitative methods in the selection of materials as a fundamental step in the design phase of aircraft structures and components.
- Explain recent scientific and technological developments in the field of aircraft materials, and assess their potential to enhance the performance of aircraft in near future (e.g. smart-materials, functionally graded materials, new alloys and fabrication processes)

DETAILED CONTENTS

UNIT – I (14 Hrs)

Introduction: Properties of Flight Vehicle Materials, Importance of strength/weight ratio of materials for Aerospace vehicles structures, Importance of temperature variations, factors affecting choice of material for different parts of Airplane. Weldability, standard welding practices e.g. gas welding, resistance welding.

Light Metal Alloys: Aluminum alloys, heat treatment, High strength and high corrosion resistant alloys. Magnesium alloys and their properties, Application of Aluminum & Magnesium alloys to Aerospace vehicles. Titanium and its alloys. Welding of light alloys, Riveting.

UNIT – II (14 Hrs)

Aircraft Steels: Classical of alloys steels, Effect of alloying elements, Carbon Steel V/s Alloys. Effects of alloying elements & micro structures. Heat treatment, Application to Aerospace Vehicle of these alloys. Fatigue & Creep in aeronautical components

High Strength and Heat Resistant Alloys: Classification of heat resistant materials, Iron, Nickel and Cobalt base alloys, Refractory materials, Ceramics, , properties of Inconel Monel & K-Monel, Nimonic and Super Alloys; Application to Aerospace Vehicles.

UNIT – III (17 Hrs)

Composite and advanced Materials: Introduction, Fibers, glass fibers, carbon fibers, Aramid fibers, Baron Fibers, Engineering ceramics. Matrix Materials – Their functions, various types, curing of resins. Modern Fighter aircraft, Transport aircraft & Helicopters materials for various components & Parts. Stealth material and the applications.

UNIT – IV (15 Hrs)

Metal Joining Processes: General methods of construction of aircraft and aero engine parts. Profiling, Hydro forming, forming bending rolls, Spar milling, Spark erosion and Powdered metal parts, integral machining, Contour etching, High energy rate forming, Manufacturing of honeycomb structures, Electron Beam Welding, Hydro-forming.

RECOMMENDED BOOKS

1. Aircraft Material and Processes: G F Titterton, Himalayan Books, New Delhi. 5th Edition
2. Advanced Composite materials: Lalit Gupta, Himalayan Books, New Delhi, 2005
3. Workshop technology: WAJ Chapman, Replika Press Pvt. Ltd.

EFFECTIVE TECHNICAL COMMUNICATION

Subject Code BHSMC0-005 | **L T P Cr** | **Duration:45 Hours**
3 0 0 3

ORGANIZATIONAL BEHAVIOUR

Subject Code – BHSMC0-016 | **L T P Cr** | **Duration:45 Hours**
3 0 0 3

NUMERICAL METHODS

Subject Code – BANED1-511 | **L T P Cr** | **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVE

- Differentiate between different numerical methods applicable to different type of equations
- Apply numerical techniques in solving mathematical equations

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Evaluate total error in calculations rising due to different factors
- Develop understanding of different numerical methods if solving equations.
- Apply interpolation techniques for finding results for missing data points
- Differentiate and integral using different numerical techniques
- Solve linear system of equations using numerical methods
- Apply numerical methods for solving differential equations

DETAILED CONTENTS

UNIT – I (15 Hrs.)

Error calculation: Errors in numerical calculations, Absolute, relative and percentage errors, Round off and truncation errors, Error propagation, Loss of significant digits, Errors in series approximation, Speed of convergence.

Solution of equations: Bisection method, fixed point iteration and its convergence, Acceleration of convergence using Aitken's method; Regula-Falsi, Newton-Raphson, Generalized Newton's, Chebyshev's and Halley's methods.

UNIT – II (14 Hrs.)

Interpolation: Lagrange Interpolation, Newton's divided difference interpolation, Finite differences, Newton's, Bessel's, Stirling's and Guass' difference formulae.

UNIT – III (15 Hrs.)

Numerical differentiation & integration: Differentiation using differences, Integration using Newton-cote's formulas with errors, Gaussian Quadrature

UNIT – IV (16 Hrs.)

Solution of linear system of equations: Direct methods - Gauss elimination, partial pivoting, complete pivoting, Gauss-Jordan and factorization methods, Iterative methods-Gauss Siedal and Jacobi's methods.

Numerical methods for differential equations: Solution of first order differential equations using Taylor's series, Euler's, Picard's and Runge-Kutta method upto 4th order, Predictor-Corrector methods (Adam's and Milne's method),

INSTRUCTIONAL STRATEGY

Assignments should be designed to give students exposure to computationally solving different numerical methods.

RECOMMENDED BOOKS

1. "Advanced Engineering Mathematics", E. Kreyszig, John Wiley
2. "Numerical Methods for Mathematics, Science and Engineering", Mathews, Prentice Hall
3. "An Introduction to Numerical Analysis", Atkinson, John Wiley

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

FINITE ELEMENT METHODS

Subject Code – BANED1-512 | **L T P Cr** | **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

- The course will introduce the numerical analysis techniques to solve the various problems related to structural loading like bending, deflection and buckling etc.
- It will teach the students how to model the loading problems in structures like trusses and beam which can't be easily solved by analytical approaches.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Apply finite element method to analyze airplane structures under various load conditions.
- Analyze formation of stress and strain matrix in 2D and 3D cases.
- Analyze various shape functions in higher order elements in 2D and 3D cases.
- Develop various codes of FEM to analyze structural loads on different aircraft components.

DETAILED CONTENT

UNIT- I (16 Hrs.)

Introduction to Finite Element Method and One-Dimensional Elements: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design., Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods.

Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1-D Bar Element, Admissible displacement function, Strain matrix, Stress recovery, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multipoint constraint, 2-D Bar Element, Shape functions for Higher Order Elements.

UNIT- II (14 Hrs.)

Dimensional Elements: Analysis of Plane Elasticity Problems: Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8), Analysis of Bodies of Revolution under axi-symmetric loading: Axisymmetric Triangular and Quadrilateral Ring Elements. Shape functions for Higher Order Elements.

UNIT III (15 Hrs.)

Dimensional Elements: Applications to Solid Mechanics Problems: Basic Equations and Potential Ene Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Sh functions for Higher Order Elements.

Unit IV (15 Hrs.)

Application to Finite Element Method: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilatateral element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

INSTRUCTIONAL STRATEGY

Session Plan / course-material uploading, Class-room teaching associated with assignments**,** presentations**,** quiz, viva-voce and evaluation.

RECOMMENDED BOOKS:

1. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2007.
2. Lakshminarayana H. V., Finite Elements Analysis – Procedures in Engineering, Universities Press, 2004
3. Rao S. S., Finite Elements Method in Engineering, 4th Edition, Elsevier, 2006.
4. P.Seshu, Textbook of Finite Element Analysis -PHI, 2004.
5. J.N.Reddy, Finite Element Method, McGraw -Hill International Edition.
6. Bathe K. J. Finite Elements Procedures, PHI.
7. Finite Element Analysis C.S. Krishnamoorthy, TMH

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

CONSTITUTION OF INDIA

Subject Code: BMNCC0-001 **L T P Cr** **Duration:30 Hours**
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ESSENCE OF INDIAN KNOWLEDGE TRADITION

Subject Code: BMNCC0-006 **L T P Cr** **Duration:30 Hours**
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AIRCRAFT STRUCTURAL ANALYSIS LAB

Subject Code – BANES1-504 **L T P Cr** **Duration:30 Hours**
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COURSE OBJECTIVES

- The course will enable the students perform experiments on various analysis of structures, so that they understand the theoretical concepts, better and execute the analysis efficiently.

DETAILED CONTENTS

1	Stress analysis of landing gear using software
2	Stress analysis of statically determinate truss using software
3	Stress analysis of rectangular wing using software
4	Stress analysis of fuselage using software
5	Stress analysis of rudder using software
6	Stress analysis of wing ribs using software
7	Stress analysis of tapered wing using software
8	Stress analysis of swept back wing using software
9	Stress analysis of wing spars using software
10	Stress analysis of statically indeterminate truss using software

RECOMMENDED BOOKS

1	"Aircraft Structures for Engineering Students": T.H.G.Megson ,4th Ed. Elsevier Ltd., 2012
2	"Structural stability of Columns and Plates", N G R Iyengar, John Wiley and sons, 1988
3	"Aircraft structures", D.J.Peery and J.J.Azhar, 2nd Ed., McGraw Hill, 1996
4	ocw.mit.edu/courses/aeronautics-and-astronautics

MEANS OF ASSESSMENT

Actual laboratory and practical work, model/prototype making, assembly and disassembly exercises and viva-voce.