INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal- 500 043, Hyderabad.

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**AEROSPACE VEHICLE STRUCTURES-1**			
Course Code	A42103			
Regulation	**R13 - JNTUH**			
Course Structure	Lectures	Tutorials	Practicals	Credits
	3	1	-	4
Course Coordinator	Mr. G S D Madhav, Assistant Professor			
Team of Instructors	Mr. G S D Madhav, Assistant Professor			

I. COURSE OVERVIEW:

The subject provides students with necessary skills and knowledge in basic aerospace structures to confidently analyze and design different aircraft structures with particular reference to aerospace industry. Each unit contrasts theoretical application to determine stability of aerospace structures. The role of approximate methods of analysis and their interaction with design process is highlighted.

II. PREREQUISITE(S):

Level	Credits	Periods/ Week	Prerequisites
UG	4	4	Basic concepts of Engineering mechanics, Some mathematical concepts and Advanced solid mechanics

III. MARKS DISTRIBUTION:

Sessional Marks	University End Exam marks	Total marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. **Assignment** Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course.	75	100

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1.	I Mid Examination	80 minutes	20
2.	I Assignment	-	5
3.	II Mid Examination	80 minutes	20
4.	II Assignment	-	5
5.	External Examination	3 hours	75

V. COURSE OBJECTIVES:

I. **Discuss** the basic tasks of theory of elasticity and methods of solving the problems and to apply the methods in technical calculations on the basis of illustrative examples.
II. **Understand** to determine the components of the stress and strain tensors and how to apply the conditions of compatibility and equations of equilibrium.
III. **Analyze** statically indeterminate structure by using different approximate methods.
IV. **Demonstrate** curvature beams and how to determine deflection using various approximation methods.
V. **Understand** concept of stability of structural systems and different modes of instability of structures.
VI. **Demonstrate** the basic concepts energy methods and to apply them on different structures.
VII. **Understand** the concept of shear flow for various aerospace structures.

VI. COURSE OUTCOMES:

At the end of the course the students are able to:

1. **Apply** the stress strain relations in conjunction with elasticity and material properties to determine the strain given stress or vice versa.
2. **Differentiate** between redundant structures and determinate structures.
3. **Analyze** the redundant structures of complex structural components subjected to different loading and boundary conditions.
4. **Evaluate** beams with elastic supports.
5. **Analyze** the stability of structural elements and determine buckling loads.
6. **Apply** the structural analysis theories and to predict the performance of bars under axial loading including buckling.
7. **Analyze** the behavior of thin-walled beams subjected to combined loads, including bending, torsion, and shear.
8. **Discuss** about exact solution methods for various members.
9. **Calculate** analysis for different structural members by different energy methods.
10. **Explain** shear analysis for aerospace closed section box structures.

Program Outcomes		Level	Proficiency assessed by
PO 1	Knowledge in fundamentals of mathematics, science and engineering.	H	Discussions
PO 2	An ability to identify, formulate and solve problems in key areas of Aerodynamics, Structures, Propulsion, Flight Dynamics and Control, Design, Testing, Space and Missile Technologies and Aviation of Aeronautical Engineering discipline	H	Discussions Assignments
PO 3	An ability to design and conduct experiments, analyze and interpret data related to various areas of Aeronautical Engineering.	S	Discussions
PO 4	An ability in conducting investigations to solve problems using research based knowledge and methods to provide logical conclusions.	H	Mini Projects
PO 5	Skills to use modern engineering and IT tools, software and equipment to analyze the problems in Aeronautical Engineering.	S	Mini Projects

PO 6	Understanding of impact of engineering solutions on the society to assess health, safety, legal, and social issues in Aeronautical Engineering.	N	
PO 7	The impact of professional engineering solutions in environmental context and to be able to respond effectively to the needs of sustainable development.	N	
PO 8	The knowledge of Professional and ethical responsibilities.	N	
PO 9	An ability to work effectively as an individual and as a team member/leader in multidisciplinary areas.	S	
PO 10	An ability to critique writing samples (abstract, executive summary, project report), and oral presentations.	S	
PO 11	Knowledge of management principles and apply these to manage projects in multidisciplinary environments.	N	
PO 12	The need of self education and ability to engage in life - long learning.	H	Assignments

N-None **S-Supportive** **H-Highly Related**

Program Outcomes		**Level**	**Proficiency assessed by**
PSO 1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Discussions
PSO 2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	H	Discussions Assignments
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	H	Project
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	H	

N-None **S-Supportive** **H-Highly Related**

VII. SYLLABUS:

UNIT – I
INTRODUCTION TO THEORY OF ELASTICITY
Equilibrium and Compatibility conditions for elastic solids- 2D elasticity equations for plane stress, plane strain and generalized plane strain cases Airy's stress function. Simple problems in plane stress / plane strain. Stress and strains on arbitrary planes and transformations. Concept of principal planes, stress and strains, construction of Mohr's circle.

UNIT– II
REDUNDANT STRUCTURES
Indeterminate structures and order of redundancy. Introduction to redundant analysis. Statically determinate models- Area movement method, Claypron's method- use of free body diagrams to explain compatibility and redundant analysis principles. Singularity method for uniform beams with various boundary and support conditions (props, hinges and fixities) subjected to distributed / discrete loads (including moments).

UNIT– III
BEAMS WITH ELASTIC SUPPORTS AND INITIAL CURVATURE:
Direct solution of beams on elastic foundation, Deflection of beams with discrete elastic supports using singularity methods and modeling concepts. Equation of equilibrium for curved beam stress and deflections of a typical curved beam (Bulk Head segments on fuselages).

UNIT– IV
STABILITY
Stability of Structural systems, Modes of instability of columns. Euler's formula for critical loads of column. Slenderness ratio, Effect of boundary conditions on mode shapes and critical loads. Column with initial curvature, effect of eccentricity. Long, medium and short column ranges. Rankine and Jhonson's formulae. Eigen values and Eigen modes. Effect of intermediate supports. Concept of beam column.

UNIT– V
ENERGY PRINCIPLES AND METHODS
Introduction to energy principles and methods. Principles of Virtual Displacement and Principle of Virtual Force Castigliano's theorems, Maxwell's reciprocal theorem and Unit load method. The displacement method (Rayleigh Ritz method). Admissible functions energy and work expressions for redundant analysis of 1-D structures (rods, shafts and beams). Various 1D Structures subjected to Complex loading. Stresses of errors and convergence. Direct application of energy principles to beams and trusses. Bredt-Batho formula. Single and multi-cell closed box structures. Semi monocoque and moncoque structures. Approximate method for box beams. Shear flow in single and multicell monocoque and semi monocoque box beams subject to torsion.

Text books:

1. Megson THG, "Aircraft Structures for Engineering students", Edward Arnold Publication
2. B.C.Punmia, "Theory of Structures", Laxmi Publication.
3. R K **B**ansal, "strength of material", ,Laxmi Publication.

References:

1. Shames I. H. and Dym C. L, Energy and finite element methods structural analysis McGraw Hill
2. Timoshenko S. P. and J.N. Goodier, "Theory of Elasticity McGraw Hill Book Co.
3. David J. Peery" Aircraft Structures" McGRAW-HILL Book Company.
4. S.Ramamrutham, R.Narayanan, "Theory of Structures" – Dhanpat Rai Publishing Co, 2003
5. Argyris J. H. and Kelsey S. Energy theorems and structural analysis, Butterworths Scientific Publications.1960
6. Donaldson, B. K. Analysis of Aircraft Structues-An introduction "McGraw Hill.
7. David H. Allen, and Walter E. Haiseler Introduction to Aeronautical Stuructre Analysis, John Wiley & Son, 1985.

VIII. COURSE PLAN:

At the end of the course, the students are able to achieve the following course learning outcomes.

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
1-3	**Define** stress and strain. Equations associated with them	**UNIT 1** **INTRODUCTION TO THEORY OF ELASTICITY** Equilibrium and Compatibility conditions for elastic solids, 2D elasticity equations for plane stress,	T1
4-6	**Examine** stress functions associated with stress and strain	2D elasticity equations plane strain and generalized plane strain cases Airy's stress function	T1
7-8	**Analyze** plane stress and plane strain	Simple problems in plane stress and plane strain.	T1
9-11	**Relate** stress and strain to other planes	Stress and strains on arbitrary planes and transformations	T3
12-14	**Describe** method of analysis	Concept of principal planes, principal stress and Strains	T3
15-17	**Evaluate** problems on methods	Construction of Mohr's circle	T3
18-20	**Describe** statically indeterminate structures and equations	**UNIT 2** **REDUNDANT STRUCTURES** Indeterminate structures and order of redundancy, Introduction to redundant analysis, Statically determinate models, Use of free body diagrams to explain compatibility and redundant analysis principles.	T2
21-23	**Evaluate** methods of analysis of statically indeterminate beams	Statically determinate models- Area movement method use of free body diagrams to explain compatibility and redundant analysis principles.	T2
24-26	**Evaluate** methods of analysis of statically indeterminate beams	Statically determinate models- Clayprons method use of free body diagrams to explain compatibility and redundant analysis principles.	T2
27-29	**Explain** methods of analysis of statically indeterminate beams	Singularity method for uniform beams with various boundary and support conditions (props, hinges and fixities) subjected to distributed / discrete loads (including moments).	-
30-32	**Explain** different types of beams and solutions for beam having initial curvature	**UNIT 3** **BEAMS WITH ELASTIC SUPPORTS AND INITIAL CURVATURE:** Direct solution of beams on elastic foundation,	-
33-35	**Discuss** deflection methods for beams with initial curvature.	Deflection of beams with discrete elastic supports using singularity methods and modeling concepts.	-
36-38	**Define** stress for beam with initial curvature	Equation of equilibrium for curved beam stress and deflections of a typical curved beam (Bulk Head segments on fuselages).	T3
39-41	**Describe** stability of structures and column.	**UNIT 4** **STABILITY** Stability of Structural systems, Modes of instability of columns. Euler's formula for critical loads of column.	T3
42-44	**Explain** method to solve critical loads for columns	Slenderness ratio, Effect of boundary conditions on mode shapes and critical loads.	T3
45-47	**Discuss** classification of columns	Column with initial curvature, effect of eccentricity. Long, medium and short column ranges.	T3
48-50	**Describe** methods to solve short columns	Rankine and Jhonson's formulae. Eigen values and Eigen modes. Effect of intermediate supports. Concept of beam column.	T3
51-53	**Discuss** energy principles for different conditions	**UNIT 5** **ENERGY PRINCIPLES AND METHODS** Introduction to energy principles and methods. Principles of Virtual Displacement and Principle of Virtual Force Castigliano's theorems.	T2

54-56	**Explain** method of solution by applying theorems	Maxwell's reciprocal theorem and Unit load method. The displacement method (Rayleigh Ritz method).	T2
57-59	**Discuss** various expressions for 1D structures	Admissible functions energy and work expressions for redundant analysis of 1-D structures (rods, shafts and beams). Various 1D Structures subjected to Complex loading. Stresses of errors and convergence.	T2
60-62	**Explain** solution of beams and trusses by energy principle method	Direct application of energy principles to beams and trusses.	T2
63-65	**Discuss** shear stresses in thin walled structures	Bredt-Batho formula. Single and multi-cell closed box structures. Semi monocoque and moncoque structures.	T1
66-68	**Explain** method of solution for different thin walled structures.	Approximate method for box beams. Shear flow in single and multicell monocoque and semimonocoque box beams subject to torsion.	T1

IX. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
I	S	H	S		S					S		H	H	S	S	
II	H	H	S	S	S							H	H	S	S	
III	H	H	H		S					S		H	S	H		
IV	H	S	S	H	S					S		H	H	S		
V	H	H	H	H	S					S		H	H		S	
VI	H	H	S	S	S							H	H	S		
VII	H	H	H	H	S					S		H	H	S		

S = Supportive **H = Highly Related**

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcomes													**Program Specific**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
1	**H**	**H**	**H**	**S**	**H**				**S**			**H**	**H**	**S**		
2	**H**				**H**								**H**	**S**		
3	**H**	**H**	**H**	**H**	**H**							**H**		**H**	**S**	
4	**H**	**H**	**H**	**H**								**H**		**H**	**S**	
5	**H**	**S**	**H**	**H**	**H**							**H**		**H**	**S**	
6	**H**	**S**	**H**	**H**								**S**	**H**	**S**		
7	**H**	**H**		**H**	**S**							**H**		**H**	**S**	
8	**H**			**S**								**H**	**H**	**S**		
9	**H**													**H**	**S**	
10	**H**												**H**	**S**		

S = Supportive **H = Highly Related**

Prepared by: Mr. G S D Madhav, Assistant Professor,

HOD, AERONAUTICAL ENGINEERING