INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**AEROSPACE STRUCTURES**				
Course Code	AAEB07				
Programme	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Dr. Y B Sudhir Sastry, Professor				
Course Faculty	Mr. GSD Madhav Asst. Professor				

I. COURSE OVERVIEW:

The primary objective of this course is to understand the different Aircraft structural component loads, and to equip the senior year aerospace engineering students with the relevant infrastructure to carry out the design of aircraft sub-structures like wings, fuselages, landing gears etc.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS007	I	Applied physics	4
UG	AME002	II	Engineering Mechanics	4
UG	AAE002	III	Theory of Structures	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Analysis of Aircraft Structures	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✘	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, five minutes video, MOOCs etc.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Seminar
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignment

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	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	2	Assignments
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	2	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	2	Laboratory
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	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Understand the aircraft structural components and its behavior under different loading conditions
II	Obtain knowledge in plate buckling and structural instability of stiffened panels for airframe structural analysis.
IV	Explain the thin walled section and structural idealization of panels and differentiate from the type of loads carried.
IV	Solve for stresses and deflection in aircraft structures like fuselage, wing and landing gear.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the concept of Structural components, structural joints, Monocoque and semi monocoque structures and also energy methods and principles.	CLO 1	Discuss the Aircraft Structural components, various functions of the components and airframe loads acting on it.
		CLO 2	Discuss different types of structural joints and the effect of Aircraft inertia loads, Symmetricmaneuver loads, gust loads on the joints.
		CLO 3	Differentiate Monocoque and semi monocoque structures and analyze stresses in thin and thick shells.
		CLO 4	Explain energy principles and its application in the analysis of structural components of Aircraft.
CO 2	Describe the concept of thin plates subject to different types of loads and also Buckling phenomena of thin plates, local instability and instability of stiffened panels.	CLO 5	Explain the Theory of thin plates and Analyze thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading.
		CLO 6	Describe Buckling phenomena of thin plates and derive Elastic, inelastic, experimental determination of critical load for a flat plate.
		CLO 7	Calculate the local instability, instability of stiffened panels, failure stresses in plates and stiffened panels.
		CLO 8	Discuss critical buckling load for flat plate with various loading and end conditions
CO 3	Understand the concept of symmetric and un-symmetric bending of beams shear stresses and shear flow distribution of thin walled sections and Torsion phenomenon.	CLO 9	Solve for bending and shear stresses of symmetric and un-symmetric beams under loading conditions
		CLO 10	Solve for deflections of beams under loading with various approaches
		CLO 11	Calculate the shear stresses and shear flow distribution of thin walled sections subjected to shear loads.
		CLO 12	Explain Torsion phenomenon, Displacements and Warping associated with Bredt-Batho shear flow theory of beams.
CO 4	Explore the concept of Structural idealization and stress distribution of idealized thin walled sections.	CLO 13	Explain the theory of Structural idealization
		CLO 14	Principal assumptions in the analysis of thin walled beams under bending, shear, torsion.
		CLO 15	Relate for stress distribution of idealized thin walled sections subjected to bending.
		CLO 16	Relate for stress distribution of idealized thin walled sections subjected to, shear and torsion.
CO 5	Discuss the concept of idealized thin walled sections, fuselage, Wing spar and box beams.	CLO 17	Calculate and analysis of idealized thin walled sections subjected to bending
		CLO 18	Calculate and analysis of idealized thin walled sections subjected to shear and torsion.
		CLO 19	Explain fuselage of variable stringer areas subjected to transverse and shear loads.
		CLO 20	Explain Wing spar and box beams of variable stringer areas subjected to transverse and shear loads.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAEB07.01	CLO 1	Discuss the Aircraft Structural components, various functions of the components and airframe loads acting on it.	PO 1	3
AAEB07.02	CLO 2	Discuss different types of structural joints and the effect of Aircraft inertia loads, Symmetricmaneuver loads, gust loads on the joints.	PO 1	3
AAEB07.03	CLO 3	Differentiate Monocoque and semi monocoque structures and analyze stresses in thin and thick shells.	PO 1	3
AAEB07.04	CLO 4	Explain energy principles and its application in the analysis of structural components of Aircraft.	PO 2	2
AAEB07.05	CLO 5	Explain the Theory of thin plates and Analyze thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading.	PO 1	3
AAEB07.06	CLO 6	Describe Buckling phenomena of thin plates and derive Elastic, inelastic, experimental determination of critical load for a flat plate.	PO 1, PO 2	2
AAEB07.07	CLO 7	Calculate the local instability, instability of stiffened panels, failure stresses in plates and stiffened panels.	PO 2	1
AAEB07.08	CLO 8	Discuss critical buckling load for flat plate with various loading and end conditions	PO 2	1
AAEB07.09	CLO 9	Solve for bending and shear stresses of symmetric and un-symmetric beams under loading conditions	PO 2	2
AAEB07.10	CLO 10	Solve for deflections of beams under loading with various approaches	PO 2	2
AAEB07.11	CLO 11	Calculate the shear stresses and shear flow distribution of thin walled sections subjected to shear loads.	PO 1	3
AAEB07.12	CLO 12	Explain Torsion phenomenon, Displacements and Warping associated with Bredt-Batho shear flow theory of beams.	PO 1	3
AAEB07.13	CLO 13	Explain the theory of Structural idealization	PO 1	3
AAEB07.14	CLO 14	Principal assumptions in the analysis of thin walled beams under bending, shear, torsion.	PO 1, PO 2	3
AAEB07.15	CLO 15	Solve for stress distribution of idealized thin walled sections subjected to bending.	PO 3	2
AAEB07.16	CLO 16	Solve for stress distribution of idealized thin walled sections subjected to, shear and torsion.	PO 2	2
AAEB07.17	CLO 17	Calculate and analysis of idealized thin walled sections subjected to bending	PO 2	3
AAEB07.18	CLO 18	Calculate and analysis of idealized thin walled sections subjected to shear and torsion.	PO 2	2
AAEB07.19	CLO 19	Analyze fuselage of variable stringer areas subjected to transverse and shear loads.	PO 3	3
AAEB07.20	CLO 20	Analyze Wing spar and box beams of variable stringer areas subjected to transverse and shear loads.	PO 3	3

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes (COs)	Program Outcomes (POs)			Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	3	2		2	2	
CO 2	3	2		2	2	
CO 3	3	2				2
CO 4	3	2	2	2	2	
CO 5		2	2		2	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO 1	3												2			
CLO 2	3												2			
CLO 3	3															
CLO 4		2														
CLO 5	3													2	2	
CLO 6	3	3													2	
CLO 7		1												2		
CLO 8		1														
CLO 9		2														
CLO 10		2														
CLO 11	3													2		
CLO 12	3															
CLO 13	3															
CLO 14	3	3														
CLO 15			2													
CLO 16		2														
CLO 17		3														
CLO 18		2														

CLO 19			3										2		
CLO 20			3										2		

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO2, PO3	SEE Exams	PO 1, PO2, PO3	Assignments	PO 3	Seminars	PO 2
Laboratory Practices	PO 3	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIII. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

MODULE -I	INTRODUCTION TO AIRCRAFT STRUCTURAL COMPONENTS AND ENERGY METHODS
Aircraft Structural components and loads, functions of structural components, airframe loads; Types of structural joints, type of loads on structural joints; Aircraft inertia loads; Symmetric manoeuvre loads, gust loads. Monocoque and semi monocoque structures, stress in thin and thick shells; Introductions to energy principles, castiglianos theorems, max wells reciprocal theorem, unit load method, Rayleigh Ritz method, total potential energy method, flexibility method.	
MODULE -II	**THIN PLATE THEORY, STRUCTURAL INSTABILITY**
Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading: Thin plates having small initial curvature, energy methods of analysis. Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate, local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams- complete diagonal tension, incomplete diagonal tension, post buckling behavior.	
MODULE -III	**BENDING, SHEAR AND TORSION OF THIN WALLED BEAMS**
Unsymmetrical bending: Resolution of bending moments, direct stress distribution, position of neutral axis; Deflections due to bending: Approximations for thin walled sections, temperature effects; Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping. Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams; Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.	
MODULE -IV	**STRUCTURAL IDEALIZATION**
Structural idealization: Principal assumptions, idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading- application to determining deflection of open and closed section beams. Fuselage frames - bending, shear and torsion.	
MODULE -V	**ANALYSIS OF FUSELAGE, WING AND LANDING GEAR**
Wing spar and box beams, tapered wing spar, open and closed sections beams, beams having variable stringer areas; wings – three boom shell in bending, torsion and shear, tapered wings, deflections, cutouts in wings; Cutouts in fuselages; Fuselage frame and wing rib; principle of stiffener, web constructions. Landing gear and types; Analysis of landing gear.	

TEXT BOOKS:
1. T. H. G. Megson, "Aircraft Structures", Butterworth-Heinemann Ltd, 5th Edition, 2012. 2. E. H. Bruhn, "Analysis and Design of Flight vehicles Structures", Tri-state off set company, USA, 4th Edition, 1965.
REFERENCES:
1. B. K. Donaldson, "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 3rd Edition, 1993. 2. S. Timoshenko, "Strength of Materials", Volumes I and II, Princeton D. Von Nostrand Co., Reprint, 1977.

XV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-3	Aircraft Structural components and loads.	CLO 1	T1:12.1
4-6	Functions of structural components, airframe loads.	CLO 1	T1:12.2
7-8	Types of structural joints, typeof loads on structural joints; Aircraft inertia loads.	CLO 2	T1:12.3
9-11	Symmetric maneuver loads, gust loads. Monocoque and semi monocoque structures, stress in thin and thick shells.	CLO 2, CLO 3	T1:14.2 R2:IV.25
12-14	Introductions to energy principles, castiglianos theorems, max wells reciprocal theorem, unit load method.	CLO 4	T1:5.5 T1:5.10
15-17	Rayleigh Ritz method, total potential energy method, flexibility method.	CLO 4	T1:5.6 T2:15.2
18-20	Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading.	CLO 5	T2:C5.6 R1:22.5
21-23	Thin plates having small initial curvature, energy methods of analysis. Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate.	CLO 6	T1:9.1 R1:22.6
24-26	Local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams-complete diagonal tension, incomplete diagonal tension, post buckling behavior.	CLO 7, CLO 8	T2:A18.20 T2:C11.1
27-30	Unsymmetrical bending: Resolution of bending moments, direct stress distribution, position of neutral axis.	CLO 9	T1:16.1
31-33	Deflections due to bending: Approximations for thin walled sections, temperature effects.	CLO 10	T1:16.6
34-37	Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping.	CLO 11	T1:17.1
38-39	Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams.	CLO 12	T2:A6.4 R2:X.62
40	Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.	CLO 12	T1:18.1.2
41	Structural idealization, Principal assumptions.	CLO 13	T1:20.1

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
42-44	Idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading.	CLO 14, CLO 15	T1:20.2
45-47	Application to determining deflection of open and closed section beams.	CLO 16	T1:16.3
48-50	Fuselage frames - bending, shear and torsion.	CLO 17, CLO 18	T1:24.2
51-53	Wing spar and box beams.	CLO 20	T2:A22.5
54-56	Open and closed sections beams, beams having variable stringer areas.	CLO 19	T1:27.1
57-59	Wings – three boom shell in bending, torsion and shear, tapered wings, deflections, cutouts in wings.	CLO 20	T1:23.8 T2:A19.14
60	Cutouts in fuselages; Fuselage frame and wing rib; principle of stiffener, web constructions. Landing gear and types; Analysis of landing gear.	CLO 20	T1:22.4 T2:A5.18

XVI. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Broad knowledge of engineering materials and material properties	Seminars / Guest Lectures/ NPTEL	PO 1	PSO 1
2	Practical Exposure about the stress deflections and stability of elements	Seminars / Guest Lectures / NPTEL	PO 3	PSO 3

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