INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**FLIGHT VEHICLES DESIGN**				
Course Code	AAE017				
Programme	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mrs.M. MaryThraza, Assistant Professor				
Course Faculty	Mrs.M. MaryThraza, Assistant Professor Ms. K.SaiPriyanka, Assistant Professor				

I. COURSEOVERVIEW:

The aim of Flight Vehicle design (FVD) is to introduce students the overview of the design process. The course covers basic principles of conceptual design process of an aircraft and the related details of all design techniques. After completion of the course the student gains adequate knowledge to design all the different phase of an aircraft design.Weight estimation of aircraft for differentaircrafts.

II. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AAE004	IV	Low Speed Aerodynamics	4
UG	AAE011	V	Aircraft Performance	3
UG	AAE006	IV	Analysis Of Aircraft Structures	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Flight Vehicles Design	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATIONMETHODOLOGY:

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 aquestion.

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 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	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 CIEexams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be

answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentations on real world problems
PO 2	**Problem analysis**: 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.	3	Assessing real-world problems by case study
PO 3	**Design/development of solutions**: An ability to design and conduct experiments, analyze and interpret data related to various areas of Aeronautical Engineering.	2	Seminar/ Research papers
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid Conclusions.	1	Assignments

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

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	Lectures, Assignments, Seminars
PSO2	**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	Tutorials, Software Practice
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	-	-

PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aeronautical/aerospace allied systems to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Understand the basic skills involved in weight estimation for aircraft conceptual design process
II	Illustrate relevant theoretical knowledge, applicable for initial sizing and configuration layout of aircraft
III	Evaluate basic techniques in literature retrieval and query, also creative and have systematic scientific research methods and working abilities
IV	Observe different designing processes and how an aircraft production company works on it.
V	Explore the new concepts of aerodynamics propulsion and fuel system integration

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe different phases of aircraft design , weight estimation and few basics of aerodynamics	CLO 1	Understanding the different designing concepts like preliminary design conceptual design and detail deign
		CLO 2	Interpret the weight estimation of propulsion system structural weight empty weight
		CLO 3	Calculating the dimensioning of engine inlet location and capture area
CO 2	Differentiating size estimation fuel system and understanding the installation of engine systems	CLO 4	Estimation of wing geometry and wing vertical location, wing tip shapes, tail geometry and arrangements, thrust to weight ratio-statistical estimation
		CLO 5	Apply a theories and to predict the maximum lift coefficient, and complete drag build up, installed performance of an engine
		CLO 6	Development of configuration lay out from conceptual sketch.
		CLO 7	Calculating the velocity, angle of Attack, angle of attack rate, pitch rate, elevator angle.
CO 3	Estimation of lift curve slopes maximum lift coefficient and different material selection can be found	CLO 8	Constructing v-n diagram, air load distribution on lifting surfaces
		CLO 9	Developing the concept of Propulsion selection fuel selection
		CLO 10	Plotting the mission segment with different weight fractions
CO 4	Understanding the concepts of stability for different control surfaces and also understanding the methods of structural analysis	CLO 11	Understanding the concepts of different landing gear system
		CLO 12	Estimation of design-stability and control
		CLO 13	Analysis of performance under constrained conditions constraint
CO 5	Acquiring knowledge on cost estimation research, Development, Test, and Evaluation and product cost for designing an aircraft	CLO 14	Acquire Basic knowledge to solve real time problems in Aircraft propulsion and structure with different loading conditions
		CLO 15	Apply the fundamental concepts in competitive examinations

X. COURSE LEARNING OUTCOMES(CLOs):

CLOCode	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAE017.01	CLO 1	Understanding the different designing concepts like preliminary design conceptual design and detail design	PO 1	3
AAE017.02	CLO 2	Interpret the weight estimation of propulsion system structural weight empty weight	PO 2	3
AAE017.03	CLO 3	Calculating the dimensioning of engine inlet location and capture area	PO 2	2
AAE017.04	CLO 4	Estimation of wing geometry and wing vertical location, wing tip shapes, tail geometry and arrangements, thrust to weight ratio-statistical estimation	PO 2	3
AAE017.05	CLO 5	Apply a theories and to predict the maximum lift coefficient, and complete drag build up, installed performance of an engine	PO 3	2
AAE017.06	CLO 6	Development of configuration lay out from conceptual sketch.	PO 3	3
AAE017.07	CLO 7	Calculating the velocity, angle of Attack, angle of attack rate, pitch rate, elevator angle.	PO 2	2
AAE017.08	CLO 8	Constructing v-n diagram, air load distribution on lifting surfaces	PO 1	2
AAE017.09	CLO 9	Developing the concept of Propulsion selection fuel selection.	PO 3	1
AAE017.10	CLO 10	Plotting the mission segment with different weight fractions	PO 4	1
AAE017.11	CLO 11	Understanding the concepts of different landing gear system	PO 1	2
AAE017.12	CLO 12	Estimation of design-stability and control	PO 3	3
AAE017.13	CLO 13	Analysis of performance under constrained conditions constraint	PO 2	2
AAE017.14	CLO 14	Acquire Basic knowledge to solve real time problems in Aircraft propulsion and structure with different loading conditions	PO 1	3
AAE017.15	CLO 15	Apply the fundamental concepts in competitive examinations	PO 2	1

3 = High; 2 = Medium; 1 = Low

XI. 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	PO 4	PSO 1	PSO 2
CO 1	3	3			2	
CO 2		3	3			2
CO 3	2		1	1	2	2
CO 4	2	2	3			
CO 5	3	1			2	2

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFICOUTCOMES:

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															
CLO 2		3											3			
CLO 3	2													2		
CLO 4		3														
CLO 5			2										2			
CLO 6			3											2		
CLO 7		2														
CLO 8	2															
CLO 9			1											2		
CLO 10				1									2			
CLO 11	2												2			
CLO 12			3											2		
CLO 13		2											2			
CLO 14	3															
CLO 15		1												2		

3 = High; 2 = Medium; 1 = Low

XIII.ASSESSMENTMETHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2 PO 3, PO 4 PSO1, PSO2	SEE Exams	PO 1, PO 2 PO 3, PO 4 PSO1, PSO2	Assignments	PO 4	Seminars	PO 2
Laboratory Practices	PO 4	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV.ASSESSMENTMETHODOLOGIES-INDIRECT

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

XV. SYLLABUS

UNIT-I	OVERVIEW OF THE DESIGN PROCESS
Phases of aircraft design, aircraft conceptual design process, project brief / request for proposal, problem definition, information retrieval, integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation, airfoil selection, airfoil design, airfoil design considerations, wing geometry and wing vertical location, wing tip shapes, tail geometry and arrangements, thrust to weight ratio, thrust matching, wing loading performance, constraint analysis	
UNIT-II	**INITIAL SIZING & CONFIGURATION LAYOUT**
Sizing with fixed engine and with rubber engine. Geometry sizing of fuselage, wing, tail, control surfaces, and development of configuration lay out from conceptual sketch. the inboard profile drawing, lofting definition, significance and methods, flat wrap lofting, special consideration in configuration lay out, Isobar tailoring, Sears-Hack volume distribution, structural load paths, radar, IR, visual detectability, aural signature, considerations of vulnerability, crashworthiness, producibility, maintainability, fuselage design, crew station, passengers and payload	
UNIT-III	**PROPULSION, FUEL SYSTEM INTEGRATION, LANDING GEAR AND BASELINE DESIGN ANALYSIS - I**
Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements, guidelines and significance of design layout, report of initial specifications. Estimation of lift curve slope, maximum lift coefficient, complete drag build up, installed performance of an engine, installed thrust methodology, net propulsive force, part power operation, aircraft structures and loads categories, air load distribution on lifting surfaces, review of methods of structural analysis, material selection, weights and moments statistical group estimation method, center of gravity excursion control.	
UNIT-IV	**BASELINE DESIGN ANALYSIS - II**
Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives, static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale, relation to aircraft dynamic characteristics, performance analysis and constraint analysis– steady level flight, minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight, best angle and rate of climb, time to climb, fuel to climb, level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns, the aircraft operating envelope, take off analysis, balanced field length, landing analysis, fighter performance measures of merit, effects of wind on aircraft performance, initial technical report of baseline design analysis and evaluation, refined baseline design and report of specifications.	
UNIT-V	**COST ESTIMATION, PARAMETRIC ANALYSIS, OPTIMISATION, REFINED SIZING AND TRADE STUDIES**
Elements of life cycle cost, cost estimating method, RDT&E and production costs, operation and maintenance costs, cost measures of merit, aircraft and airline economics, DOC and IOC, airline revenue, breakeven analysis, investment cost analysis, parametric analysis and optimization, improved conceptual sizing methods, sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods, measures of merit, determination of final baseline design configuration, preparation of type specification report. Case studies on design of DC-3 and Boeing B-707&747; General dynamics F-16, SR-71 Blackbird, Northrop-Grumman B-2 Stealth Bomber.	

Text Books:

1. Raymer, D.P., Aircraft Design: A Conceptual Approach, 3rdedn., AIAA Education Series, AIAA, 1999, ISBN: 1-56347-281-0.
2. Howe, D., Aircraft Conceptual Design Synthesis, Professional Engineering Publishing, London, 2000, ISBN: 1-86058-301-6.
3. Fielding, J.P., Introduction to Aircraft Design, Cambridge University Press, 2005, ISBN: 0-521-657222-9.

Reference Books:

1. E. Torenbeek, Synthesis of Subsonic Airplane Design, Delft University Press, New York, 1986.
2. E. H Bruhn, Analysis and Design of Flight Vehicles Structures, Jacobs Publishing House, USA, New Edition, 1973.
3. E. E Scheler, L.G Dunn, Airplane Structural Analysis and Design, John Wiley & Sons, USA, 1963.
4. D. Howe, ―Aircraft conceptual Design Synthesis‖, John Wiley and Sons Publishers, USA, 2005.

XVI. COURSEPLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Describe the basic Phases of aircraft design, aircraft conceptual design process, project brief / request for proposal, problem definition, information retrieval	CLO 1	T2: 1.1-1.5, T1: 4.1
3-4	Recall the integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation	CLO 1	T2: 2.1-2.2, R1: 3.1
5-6	Identify the airfoil selection, airfoil design,	CLO 2	T2: 2.3-2.4
7-8	Recall airfoil design considerations	CLO 2	T2: 2.5-2.6, R1: 3.3
9-10	Recognize the wing geometry and wing vertical location	CLO 3	T2: 3.3
11	Explain about wing tip shapes, tail geometry and arrangements	CLO 4	T2: 3.4, R1:4.1
12	Explain about trim tabs and types of trim tabs, static margin for stick fixed and stick free conditions.	CLO 5	T2: 3.4
13-14	Explain the concept of thrust to weight ratio	CLO 5	T2: 3.3
15-16	Recognize thrust matching, wing.	CLO 6	T2: 4.2
17-18	Explain about the aircraft loading performance, constraint analysis.	CLO 6	T2: 5.1
19-20	Define about the aircraft Sizing with fixed engine and with rubber engine.	CLO 7	T2: 5.2
21-22	Estimate the aircraft geometry sizing of fuselage, wing, tail, control surfaces	CLO 7	T2: 5.3
23-24	Recognize description of surfaces	CLO 8	T2: 4.5
25	Recall development of configuration lay out from conceptual sketch.	CLO 8	T1: 4.1
26	Define. the inboard profile drawing, lofting definition, significance and methods, flat wrap lofting, special consideration in configuration lay out	CLO 9	T1: 4.2
27-28	Recognize Isobar tailoring, Sears-Haack volume distribution, structural load paths	CLO 9	T1: 4.3
29-30	Recall radar, IR, visual delectability, aural signature, considerations of vulnerability	CLO 10	T2: 5.2
31	Describe Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements, guidelines and significance of design layout	CLO 10	T2: 5.2
32	Explain report of initial specifications	CLO 11	T2: 5.2
33	Interpret description of installed performance of an engine, installed thrust methodology, net propulsive force, part power operation, aircraft structures and loads categories, air load distribution on lifting surfaces	CLO 11	T2: 5.3
34	Estimation of review of methods of structural analysis, material selection, weights and moments statistical group estimation method, center of gravity excursion control.	CLO 11	T2: 5.3

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
35-36	Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives, static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale	CLO 11	T1: 6.1-6.2
37-38	Identify liberalized of , relation to aircraft dynamic characteristics, performance analysis and constraint analysis– steady level flight	CLO 12	T1: 6.3, R2:6.1
39-40	Inferred derivatives of minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight, best angle and rate of climb.	CLO 12	T1: 6.4
41-42	Identify Principle modes of time to climb and 140 | P a g e fuel to climb, level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns.	CLO 13	T1: 6.5
43-44	Interpret undammed natural frequency and damping ratio, mode shapes, significance.	CLO 13	T1: 7.1
45-46	Recall the aircraft operating envelope, take off analysis, balanced field length, landing analysis, fighter performance measures of merit	CLO 14	T1: 7.2
47	State and apply effects of wind on aircraft performance, initial technical report of baseline design analysis and evaluation	CLO 14	T1: 7.3
48-49	Explain refined baseline design and report of specifications	CLO 14	T1: 7.4, R2: 4.1-4.4
50	Explain Elements of life cycle cost, cost estimating method, RDT&E and production costs, operation and maintenance costs, cost measures of merit, aircraft and airline economics.	CLO 15	T1: 7.5, R2: 7.3
51	DOC and IOC, airline revenue, breakeven analysis, investment cost analysis, parametric analysis and optimization, improved conceptual sizing methods	CLO 15	T1: 7.5, R2: 7.3
52	Apply the concept of aircraft spin- entry, balance of forces in steady spin.	CLO 15	T1: 7.6
53	Explain sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods	CLO 15	T1: 7.5, R2: 7.4
54	Explain the measures of merit, determination of final baseline design configuration, preparation of type specification report.	CLO 15	T1: 7.7
55	Case studies on design of DC-3 and Boeing B-707&747; General dynamics F-16, SR-71 Blackbird, Northrop-Grumman B-2 Stealth Bomber.	CLO 15	T1: 7.5, R2: 7.5

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSIONREQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Application of knowledge and skills in the estimation of aircraft stability and control system	Seminars / Expert Lectures / Flight testing	PO 2, PO 4	PSO 1
2	Experimental knowledge of aircraft Stability measurement and data handling.	Experimental work	PO 2, PO 4	PSO 2

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