# FLIGHT VEHICLE DESIGN

**III Semester:** **CSE/IT**

| Course Code | Category | Hours / Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| AAE017 | Core | 3 | 1 | 4 | 3 | 30 | 70 | 100 |
| Contact Classes: 45 | Tutorial Classes: Nil | Practical Classes: Nil | | | | Total Classes: 60 | | |

## OBJECTIVES:

**Students will try to Learn:**

I. The fundamental concepts of various aerofoil characteristics and blend the best suitable requirements for various applications designing in various applications.
II. Initial sizing of fuselage and tail plane design; static stability; structural loading; cost analysis; takeoff and landing; and specification of (T/W) ratio and wing loading (W/S).
III. The characteristics of stability and performance of an aircraft and the role of primary and secondary controls in longitudinal and lateral stability.
IV. The Conceptual designs of aerospace vehicles, components, missions, or systems that incorporate realistic constraints/applicable engineering standards.

## COURSE OUTCOMES:

**After Successful completion of this course, students will be able to:**

CO 1 Understand the concept of phases of aircraft design and the importance of conceptual design process involved in the aerodynamic design of an airplane.
CO 2 Describe the concept of airfoil selection, design and airfoil design considerations for wing and tail geometry.
CO 3 Explain geometrical sizing of fuselage, wing, tail, control surfaces, and development of configuration lay out for conceptual sketch.
CO 4 Explain the effects of camber, angle of attack and thickness on the aerodynamic characteristics of an airfoil.
CO 5 Discuss the importance of the aircraft wing, for generating maximum lift by reducing the specific fuel consumption.
CO 6 Solve the performance parameters of an aircraft takeoff stage to landing based on the aerodynamic forces and moments acting on the body.
CO 7 Classify the types of landing gears and sub systems arrangements, guidelines and significance of design layout for the report of initial specifications.
CO 8 Calculate jet and propeller driven airplane performance for (takeoff/landing distance, range, endurance, climb, maneuver).
CO 9 Understand selection criteria and properties of materials to perform under adverse conditions for design the new components as per the requirements.
CO 10 Understand Elements of life cycle cost parametric analysis, optimization, refined sizing & trade studies and its estimating methods for airline economics.
CO 11 Discuss the importance of the aircraft wing, for generating maximum lift by reducing the specific fuel consumption.
CO 12 Explain different material properties and their usage in different segments of aircraft and spacecraft.

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| MODULE-I | OVERVIEW OF THE DESIGN PROCESS |
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| 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. | |
| **MODULE-II** | **INITIAL SIZING & CONFIGURATION LAYOUT** |
| Sizing with fixed engine and with rubber engine. geometry sizing of fuselage, wing, tail, control surfaces, development of configuration lay out from conceptual sketch. the inboard profile drawing, loftingdefinition, significance and methods, flat wrap lofting, special consideration in configuration lay out, Isobar tailoring, Sears-Haack volume distribution, structural load paths, radar, IR, visual detectability, aural signature, considerations of vulnerability, crashworthiness, producibility, maintainability, fuselage design, crew station, passengers and payload. | |
| **MODULE-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.<br>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, Centre of gravity excursion control. | |
| **MODULE-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 and 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.. | |
| **MODULE-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, 3rd edn., AIAA Education Series, AIAA, 1999, ISBN: 1-56347-281-0.<br>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. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
2. K. J. Bathe, E. L. Wilson, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley and Sons, Inc., 2003.
4. Larry J Segerlind, "Applied Finite Element Analysis", 2nd Edition, John Wiley and Sons, Inc. 1984.