

FLIGHT VEHICLE DESIGN LABORATORY

LAB MANUAL

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Department of Aeronautical Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad



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AERONAUTICAL ENGINEERING

| Program Outcomes | |
|------------------|--|
| PO1 | Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering 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 |
| 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. |
| PO4 | 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. |
| PO5 | Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| PO7 | Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| PO11 | Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |
| PO12 | Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |

Program Specific Outcomes

| | |
|-------------|---|
| PSO1 | Professional skills: Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products |
| 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 |
| PSO3 | 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 |
| PSO4 | 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. |

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ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

| Exp. No. | Experiment | Program Outcomes Attained | Program Specific Outcomes Attained |
|-----------------|--|----------------------------------|---|
| 1 | Objectives and requirements of the vehicle | PO1 | PSO 1 |
| 2 | Conceptual sketch and weight estimation | PO2 | PSO 1 |
| 3 | Airfoil design and constraint analysis | PO1 | PSO 1 |
| 4 | Constraint analysis | PO2 | PSO 1 |
| 5 | Initial sizing-I | PO1 | PSO 2 |
| 6 | Initial sizing-II | PO3 | PSO 2 |
| 7 | Performance estimations | PO1 | PSO 1 |
| 8 | Load estimations- I | PO1 | PSO 2 |
| 9 | Load estimations- II | PO2 | PSO 2 |
| 10 | Cost estimation | PO3 | PSO 1 |
| 11 | Design case study- I | PO1 | PSO 1 |
| 12 | Design case study- II | PO3 | PSO 2 |

FLIGHT VEHICLE DESIGN LABORATORY

OBJECTIVE:

The objective of this lab is to equip students with knowledge of how to draw conceptual sketch of aircrafts based on client requirements such as type, role, payload, mission, aerodynamic & performance requirements and calculations to estimate total takeoff gross weight, thrust-weight ratio, wing loading parameters using data sheets along with idea develop initial layouts for major components such as fuselage, empennage, landing gears and wings.

OUTCOMES:

Upon the completion of flight vehicle design laboratory course, the student will be able to attain the following:

1. Knowledge about different techniques to calculate the size and shape of different key components of an aircraft.
2. Understand different phases of design and responsibilities of a designer in each phase.
3. Analyze different aircrafts that are currently in use and to create new designs with these references as bench mark.
4. Use MATLAB / MS excel to produce different graphs from the calculations done.

EXPERIMENT-1

OBJECTIVES AND REQUIREMENTS OF THE VEHICLE

AIM:

To collect data required for freezing of a design which includes type of mission, payload and aerodynamic & performance requirements.

SOFTWARES USED:

MATlab / MS Excel

THEORY:

Conceptual design begins with a specific set of design requirements established from customer or a company-generated guess what future customers may need.

Design requirements include:

- a) Aircraft range
- b) Payload
- c) Take-off distance
- d) Landing distance
- e) Maneuverability and speed requirements

Design begins with innovative idea rather than as a response to a given requirement. Before design a decision is made to what technologies to incorporate, it must use only currently available technologies as well as existing engines and avionics. If designed to build in more distant future, then an estimate technological state of the art must be made to determine which emerging technologies will be ready for use at that time

PROCEDURE:

1. Write the request for proposal for the given aircraft. It should be in the form of parameters and requirements for the aircraft.
2. Draw the conceptual sketch of the aircraft as explained in theory.

3. Draw the mission profile for the aircraft.

RESULT:

1.1 PRE LAB VIVA QUESTIONS:

1. Explain typical mission profiles.
2. What is meant by design lift coefficient?
3. What are the three different phases of aircraft design requirements?

1.2 POST LAB VIVA QUESTIONS:

1. Name the affects of airfoil during all phases of flight.
2. How it is empty weight fraction calculated?
3. Explain the take-off weight buildup and the empty weight estimation for a new aircraft design.
4. Explain stall speed of an aircraft determined by wing loading maximum lift coefficient.

EXPERIMENT-2

CONCEPTUAL SKETCH AND WEIGHT ESTIMATION

AIM:

Perform rubber engine sizing of a given fighter aircraft requirements.

SOFTWARES USED:

MATlab / MS Excel

THEORY:

Given warm-up/take-off, climb and landing weight fractions from historical trends: The warm-up, take-off and landing weight fractions can be estimated historically from table below

| Empty weight fraction vs W_0, A, T/W_0, W_0/S, and M_{max} | | | | | | | |
|--|-------|------|-------|------|------|-------|------|
| $W_e/W_0 = (a + bW_0^{C1} A^{C2} (T/W_0)^{C3} (W_0/S)^{C4} M_{max}^{C5}) K_{vs}$ | | | | | | | |
| | a | b | $C1$ | $C2$ | $C3$ | $C4$ | $C5$ |
| Jet trainer | 0 | 4.28 | -0.10 | 0.10 | 0.20 | -0.24 | 0.11 |
| Jet fighter | -0.02 | 2.16 | -0.10 | 0.20 | 0.04 | -0.10 | 0.08 |
| Military cargo/bomber | 0.07 | 1.71 | -0.10 | 0.10 | 0.06 | -0.10 | 0.05 |
| Jet transport | 0.32 | 0.66 | -0.13 | 0.30 | 0.06 | -0.05 | 0.05 |

K_{vs} = variable sweep constant = 1.04 if variable sweep
= 1.00 if fixed sweep

Procedure:

1. Draw the mission profile as per the given aircraft requirements, and decide the weight fractions in the mission.
2. Calculate the value of take off weight from table 1 as per your aircraft requirements
3. Calculate the climb weight fraction by considering the following equation
4. Calculate the value for cruise weight segment
5. Calculate the loiter weight fraction by using
6. Calculate the combat weight fraction
7. Calculate the Descent weight segment
8. Calculate the Landing weight segment
9. Calculate Fuel weight fraction

10. Calculate the gross takeoff weight and empty weight fraction
11. W_e/W_0 is function of W_0 , W_f / W_0 is also a function of is calculated from equation through process of iteration. W_0 has to be assumed, then RHS value of equation is calculated which should match the value of assumed, if it doesn't, increment the assume by some value and iterate it. This process is continued till the absolute difference of RHS value and assumed value is the least and that iteration step will be your nearest solution.

This is done using following iteration table:

| Iteration. No | Guess weight | Empty weight fraction | Fuel weight fraction | Calculated weight | Difference = guess calculations |
|---------------|--------------|-----------------------|----------------------|-------------------|---------------------------------|
| | | | | | |
| | | | | | |

RESULT:

2.1 PRE LAB VIVA QUESTIONS:

1. What is power loading?
2. What is design wheel sketch?
3. What detail design process?

2.2 POST LAB VIVA QUESTIONS:

1. What is the Fuel-fraction?
2. What is horse power-to-weight ratio?
3. What is wing loading?
4. What tail volume coefficient?
5. What are the factors involved in deciding the location of the wing?
6. What is ground roll and ground rolling resistance with different surfaces?

EXPERIMENT-3

AIRFOIL DESIGN AND CONSTRAINT ANALYSIS

AIM: To generate airfoil coordinates of a given airfoil series and generate airfoil geometry.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

Airfoil Nomenclature

C: chord length – length from the LE to the TE of a wing cross section that is parallel to the vertical axis of symmetry .

Mean camber line – line halfway between the upper and lower surfaces –

Leading edge (LE) is the front most point on the mean camber line.

Trailing edge (TE) is the most rearward point on mean camber line .

Camber – maximum distance between the mean camber line and the chord line, measured perpendicular to the chord line

Thickness – distance between upper surface and lower surface measured perpendicular to the mean camber line

Airfoil Nomenclature

2 NACA – National Advisory Committee for Aeronautics - precursor to NASA - National Aeronautics and Space Administration - systematically investigated (and cataloged) effects of various airfoil profile parameters on aerodynamic behavior - developed several series of airfoils and classification systems β many of these airfoils are still commonly used .

4-digit series first number is camber in percentage of chord second number is location of maximum camber in tenths of chord measured from LE last two digits give maximum thickness in percentage of chord

PROCEDURE:

1. Calculate the m, p, t from the given airfoil series
2. Consider a for loop to solve the above equations for the airfoil chord length
3. Calculate $Y_t, Y_c, d_Y, c_{d_x}, \theta$
4. Calculate x_u, x_l, y_u, y_l
5. Then generate a plot for above to obtain airfoil configuration.

RESULTS:

3.1 PRE LAB VIVA QUESTIONS:

1. Define Tandem wing.
2. What are tail arrangement configurations?
3. What the configuration layout?
4. What is rubber engine sizing?

3.2 POST LAB VIVA QUESTIONS:

1. What is control surfaces sizing?
2. What types of materials types of control surfaces?
3. Explain types of stall and what are the stall characteristics.
4. What are the major differences in the designs of the fuselage of a fighter and bomber plane.?
5. Write the expressions of vertical tail volume coefficient, horizontal tail volume coefficient

EXPERIMENT-4

CONSTRAINT ANALYSIS

AIM:

To estimate take-off gross weight for the given aircraft requirements and its mission profile using weight estimation algorithm.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

Weight components of airplane explained as follows:

1) Crew weight (W_c):

The crew comprises the people necessary to operate the airplane in flight e.g., Pilot, Co-pilot, Airhostess etc.

2) Payload weight (W_p):

The payload is what the airplane is mentioned to transport passengers, baggage, freight etc. (Military use the payload includes bombs, rockets and other disposable ordnance).

3) Fuel weight (W_f):

This is the weight of the fuel in the fuel tanks. Since fuel is consumed during the course of flight. W_f is a variable, decreasing with time during the flight.

4) Empty weight (W_e):

This is weight of everything else-the structure engines (with all accessory equipment), electronic equipment landing gear, fixed equipment and anything else that is not crew, payload or fuel.

5) Gross weight (W_0):

The sum of these weights is the total weight of the airplane W_0 . Gross weight or total weight W_0 varies through the flight because fuel is being consumed. The design take off gross weight W_0 is the weight of the airplane at the instant it begins its mission. It includes the weight of the fuel.

$$W_0 = W_c + W_p + W_f + W_e$$

Mission profiles:

Typical mission profiles for various types of aircraft are shown in Fig1. The simple cruise mission is used for many transport and general aviation designs, including home built. Following are the briefly explained the terms that are used in mission profiles:

Warm Up and Take-Off:

Warm Up is the engine start up for the airplane kept idling for some time to warm up. Take Off is the point where aircraft is made lift off from ground. It is the motion after warm up i.e., moving of airplane after starting and till it lifts off from the ground.

Climb:

It is between take-off (TO) and cruise (stead level flight with constant speed) Increase in height until airplane achieves steady level flight.

Cruise:

It is the steady level flight to cover the mission distance. The mission distance is called Range.

Loiter:

Represent the airplane spending in air for some fixed number of minutes near airport before getting the clearance from airport signal or simple spending some time to collect data of some mission (Terrain data).

Dash:

It is the mission that must be flown at just a few hundred numbers of feet of the ground for low level strike.

Landing:

It is the aircraft landing on the runway till stopping of engine.

Procedure

Estimation of gross weight, calculated using following steps:

1. Calculate the mission weight fraction of individual segment:
2. Mission weight fractions of following individual segments:
3. Take-off (W_1/W_0): This is taken from W_1/W_0
4. Climb : This is taken from Table2. $1/2 W/W$
5. Landing : This is taken from Table2. $4/5 W/W$
6. In cruise, Weight fraction for cruise segment is found using Breguet range formula.
7. In loiter weight fraction for loiter segment is found using Endurance formula
8. Empty Weight fraction: The empty weight fraction can be estimated from Table1 based on the aircraft type and wing sweep.

RESULT:

4.1 PRE LAB VIVA QUESTIONS

1. What is Airfoil Linear Interpolation?
2. What types of jet engine?
3. What are the common problems in lofting
4. What is fuel tank volume plotting?

4.2 POST LAB VIVA QUESTIONS

1. What is different types of subsystems?
2. What are the common options for landing-gear arrangement?
3. Write about jet engine integration.
4. Which is the hardest material? And why?
5. Explain how CL max varies with the different types of flaps?

EXPERIMENT-5

INITIAL SIZING-I

AIM:

To estimate the total drags on an aircraft and calculate the total weight, thrust and drsg from the given equations.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

1. Drag (sometimes called air resistance, a type of friction, or fluid resistance, another type of friction or fluid friction) is a force acting opposite to the relative motion of any object moving with respect to a surrounding fluid.
2. This can exist between two fluid layers (or surfaces) or a fluid and a solid surface. Unlike other resistive forces, such as dry friction, which are nearly independent of velocity, drag forces depend on velocity.
3. Drag force is proportional to the velocity for a laminar flow and the squared velocity for a turbulent flow.
4. Even though the ultimate cause of a drag is viscous friction, the turbulent drag is independent of viscosity.
5. Types of drag are generally divided into the following categories:
 - i) parasitic drag, consisting of
 - ii) form drag,
 - iii) skin friction drag,
 - iv) lift-induced drag, and
 - v) wave drag (aerodynamics) or wave resistance (ship hydrodynamics).

PROCEDURE:

1. Calculate the weight, thrust, lift and drag from the given equations.
2. Calculate the exit pressure and mach number for the given nozzle configurations

RESULT:

5.1 PRE LAB VIVA QUESTIONS:

1. What is production cost?
2. What are trade studies??
3. Give of life cycle cost?
4. What are DOC and IOC??

5.2 POST LAB VIVA QUESTIONS:

1. What is break even analysis?
2. What is final base line?
3. Write and explain the equation for Refined sizing?
4. What is design optimization method?
5. What is pusher and tractor?

EXPERIMENT-6

INITIAL SIZING-II

AIM:

To design crew compartment with the given requirement.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

In conventional aircraft the fuselage serves to accommodate the payload. The wings are used to store fuel and are therefore not available to accommodate the payload. The payload of civil aircraft can consist of passengers, baggage and cargo. A fuselage fineness ratio l_d / F of approximately 6 provides the smallest tube drag. Fig. 6.1 also gives the number of seats per row for other fineness ratios. A circular or near-circular cross-section is suitable for a pressure cabin for reasons of strength. If no baggage is to be transported under the cabin floor, the fuselage can be flattened out at the bottom (Fokker 50, for example). The fuselage cross-section can also be composed of two overlapping circular cross-sections. The certification regulations define minimum requirements for the width and number of aisles. However, the figures in the certification regulations should be seen as minimum safety standards, which are, for example, intended to allow successful emergency evacuation. Today's comfort standards require larger aisle widths and fewer seats at the aisles than prescribed.

Equations used:

1. $nSA = 0.45 nPAX$.
2. JAR 25.817 says:
3. $nSA \leq 6$: one aisle
4. $6 < n \leq 12$ SA : two aisles
5. $V(V * V) V \text{ CARGO_COMPARTMENT BAGGAGE CARGO OVERHEAD_STOWAGE}$

RESULT:

6.1 PRE LAB VIVA QUESTIONS:

1. Which steel have you tested?
2. In Explain stall speed?
3. Why implications of a using loading?
4. What is empty weight estimation?

6.2 POST LAB VIVA QUESTIONS:

1. What is thrust lapse at cruise?
2. What affects of airfoil during all phases of flight?
3. Explain the comparison of selected engines thrust available during cruise to estimated aircraft.
4. Write types of control surfaces explain in detail with neat sketches?

EXPERIMENT-7

PERFORMANCE ESTIMATIONS

AIM:

Design wing according to the given data and plot the graph for α Vs CL and CL Vs CD

SOFTWARES USED:

- MAT lab / MS Excel

THEORY:

Oswald's span efficiency method:

According to classical wing theory, the induced drag coefficient of 3D-Wing with an elliptical lift distribution equals the square of lift coefficient divided by πA (A = Aspect Ratio or Effective Aspect Ratio)

$$K = 1 / \pi A e$$

A = Aspect Ratio

e = Oswald's span efficiency (The value of e varies from 0.7 to 0.85)

PROCEDURE:

1. Calculate K, CD, C r, b, Λ t/c, M efft, β from the equations mentioned.
2. Calculate C L $\alpha=0$, dCL/d α , C L from the given equations.
3. Consider switch case to find area for your prompted wing shape.
4. Consider a for loop to find drag for the given wing chord length by considering it as a flat.
5. Calculate C f, S wet, F, C D,o
6. Consider for loop for various α values
7. Plot α Vs C L and C L Vs CD.

TABULAR COLUMN:

When one end is hinged and other end is fixed before loading.

| α | C_l | C_d | L | D |
|----------|-------|-------|-----|-----|
| | | | | |
| | | | | |
| | | | | |

RESULT:**7.1 PRE LAB VIVA QUESTIONS:**

1. What do how specific fuel consumption?
2. What is control surfaces sizing?
3. What are methods to assess the fuel tank volume?
4. List out types of springs?

7.2 POST LAB VIVA QUESTIONS:

1. What propeller specific fuel consumption?
2. What is the difference between a closed coil helical spring and open coil helical spring?
3. Explain weapons carriage for military aircraft and gun installation?
4. What type of factors involving design layout of aircraft?

EXPERIMENT-8

LOAD ESTIMATIONS-I

AIM:

To determine the wing loading on an aircraft empennage for different mission segments.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

The horizontal tail plane should be installed in a position so that it does not lie in the slip- stream. If this rule is not observed, it may have the following effects:

1. structure fatigue due to tail buffeting;
2. increased noise in the cabin due to tail buffeting;
3. considerable trim changes with differing choice of engine performance.

In some small single-engine aircraft the empennage is deliberately placed in the slipstream. Then one benefits from an increased efficiency of the tail assembly during take-off and landing, but may have to accept the disadvantages described above.

The detailed placement of the horizontal tail plane can be determined from Fig. 9.5: low- lying horizontal tail planes are most suitable for getting an aircraft out of a stall. With sub- sonic aircraft the empennage can also be installed at the same height as the wing. A T-tail may only be used if the wing is uncritical and is not susceptible to excessive pitch-up (compare Section 9.2: "T-tail").

The lever arm of the empennage should be as large as possible, thereby making it possible to keep the tail areas small, which reduces weight and drag.

The aspect ratio of the horizontal tail plane should be about half the aspect ratio of the wing. T-tails have a smaller aspect ratio of the vertical tail plane than conventional tails (Table 9.1). This allows weight disadvantages to be kept to a minimum.

Tails with a taper ratio of 1 are built in some cases as rectangular tail especially for general aviation aircraft. Rectangular tails reduce production costs.

The sweep of the horizontal tail plane should be approximately 5° larger than the sweep of the wing. Thus a higher critical Mach number of the horizontal tail plane can be achieved and a loss of efficiency due to shock waves is avoided. In addition, the lift gradient of the horizontal tail plane can be less than the lift gradient of the wing due to the increased sweep, so that the horizontal tail plane only reaches the stall state at larger angles of attack than the wing.

The sweep angle of the vertical tail plane is 35° to 55° for aircraft with "high airspeeds" (flight with compressibility effects). The sweep angle of the vertical tail plane for aircraft with "low airspeeds" (flight without compressibility effects) should be less than 20° . A large sweep angle increases the lever arm and the angle where the vertical tail plane goes into stall, but reduces the maximum lift coefficient.

The horizontal tail plane should have a relative thickness that is approximately 10 % less than the relative thickness in the outer wing. Thus, a higher critical Mach number of the horizontal tail plane can be achieved and a loss of efficiency due to shock waves is prevented. Symmetrical airfoils are chosen exclusively for vertical tail planes. Symmetrical or virtually symmetrical airfoils with 9% to 12% relative thickness are chosen for horizontal tail planes. For example, NACA 0009 or NACA 0012 (Abbott 1959) can be chosen. Asymmetrical horizontal tail plane airfoils are installed "upside-down" because the horizontal tail plane has to create negative lift.

PROCEDURE:

1. Calculate b , C_r , C_t , S_{ht} , mac for horizontal tail with the given equations.
2. Plot the coordinates to obtain horizontal tail configuration.
3. Calculate b , C_r , C_t , S_{vt} , mac for vertical tail with the given equations.
4. Plot the coordinates to obtain vertical tail configuration.
5. Develop 3D model in catia.

RESULTS:

8.1 PRE LAB VIVA QUESTIONS

1. What load categories?
2. What is net propulsive force corrections?
3. Draw and explain shock absorber types.
4. What is minimum thrust required?

8.2 POST LAB VIVA QUESTIONS:

1. What are effects of wind on aircraft performance?
2. What do you know about static pitch stability?
3. Explain briefly about about nozzle integration.
4. Explain about calculations of static loads on tires.

EXPERIMENT-9

LOAD ESTIMATIONS-II

AIM:

To determine the wing loading of an aircraft for different mission segments.

SOFTWARES USED:

MAT lab / MS Excel

PROCEDURE:

1. Calculate q , V for various segments by using above equations.
2. Calculate W/S stall condition by using the equation $= 1/2 * \rho * (V_{stall})^2 * C_{Lmax}$.
3. Calculate W/S takeoff condition by using the equation $= (TOP) * (\sigma) * (C_{LTO}) * (T/W)$
4. Calculate W/S climb condition by using the equation =
$$\frac{(T/W) + ((T/W)^2 - ((4 * n^2 * C_{D,o}) / (\pi * A * e)))^{1/2}}{((2 * n^2) / (q * \pi * A * e))}$$
5. Calculate W/S cruise condition by using the equation $= q * ((\pi * A * e * C_{D,o}) / 3)^{1/2}$
6. Calculate W/S loiter condition by using the equation $= q * (\pi * A * e * C_{D,o})^{1/2}$
7. Calculate W/S landing condition by using the equation $= ((S_{landing}) - (S_a)) * (\sigma) * (C_{Lmax}) / 80$

RESULT:

9.1 PRE LAB VIVA QUESTIONS

1. What static pitch stability
2. What is trim?
3. What velocity stability
4. What is directional stability?

9.2 POST LAB VIVA QUESTIONS

1. What do you mean by tire sizing?
2. What is the equation for range?
3. Derive an equation for critical load.
4. Explain briefly about characteristic estimation of dynamic aircraft.
5. What is the different between beam and column?

EXPERIMENT-10

COST ESTIMATION

AIM:

To estimate the RDT&E cost for 2016 and 2017 as per the given data.

SOFTWARES USED:

MAT lab / MS Excel

THEORY:

RDT&E and production costs are frequently combined to develop CERs. It is difficult to separate clearly the RDT&E from production cost, especially in the areas of engineering and prototype fabrication for example production of long-lead-time items.

The CER is one of the fundamental techniques used to estimate aircraft cost. A CER is formally defined as a “technique used to estimate a particular cost or price by using an established relationship with an independent variable”

The CER is a mathematical relationship that predicts the dependent variable as a function of the independent variables. This relationship is typically developed using a historical dataset of variables and applying a statistical technique, usually regression, to find the parameter estimates of the independent variables.

RDT&E (Research, Development, Test and Evaluation): technology research, design engineering, prototype fabrication, flight and ground testing and evaluations for operational suitability. RDT&E costs are fixed costs (non-recurring costs).

Elements of life cycle cost

- Flyaway (production) costs: labor and material costs to manufacture the airplane including the airframe, engines and avionics.
- Includes production tooling (jigs, fasteners, molds, etc.), manufacturer’s overhead and administrative expenses.
- Production costs are recurring.

Elements of life cycle cost :

- Program cost: the total cost to develop and deploy a new airplane into the inventory (mostly military).
- Some aircraft require special ground facilities for operational deployment.

Elements of life cycle cost :

- Operations and maintenance: covers fuel, oil, aircrew costs, maintenance, insurance and depreciation.
 - Disposal: getting rid of the airplane after its useful life has ended. RDT&E and Production Costs (DAPCA IV model) Development and Procurement Costs of Aircraft Model is a cost estimation relationship model and it estimates the hours required for RDT&E and production by the engineering, tooling, manufacturing and quality control groups.
 - These are multiplied by hourly rates to yield costs.
- RDT&E and Production Costs (DAPCA IV model)
- Engineering hours: include airframe design and analysis, test engineering, configuration control and systems engineering.
 - Tooling hours: includes preparation for production.

PROCEDURE:

1. Calculate the above costs from the given equations
2. Calculate RDT&E costs
3. Plot the pie chart for 2016 and 2017.

RESULT

10.1 PRE LAB VIVA QUESTIONS:

1. What is the base line design?
2. What is maneuverability?
3. What do you mean by steady climbing?
4. What are aerodynamic damping forces?

10.2 POST LAB VIVA QUESTIONS:

1. How is effective length play a critical role?
2. what are the assumptions of loiter endurance?
3. What is Refined sizing?
4. Explain briefly about the cooper-harper scale.

EXPERIMENT-11

DESIGN CASE STUDY-I

AIM:

To study the given aircraft model and write a report on it.

MODEL:

Model I:

The Douglas DC-3 is a fixed-wing propeller-driven airliner that revolutionized air transport in the 1930s and 1940s. Its lasting effect on the airline industry and World War II makes it one of the most significant transport aircraft ever produced. It has a cruise speed of 207 mph (333 km/h), capacity of 21 to 32 passengers or 6,000 lbs (2,700 kg) of cargo, and a range of 1,500 mi (2,400 km).



Model II:

The Boeing 747 is an American wide-body commercial jet airliner and cargo aircraft. The first wide-body airplane produced, it was the first plane dubbed a "Jumbo Jet". Its distinctive hump upper deck along the forward part of the aircraft has made it one of the most recognizable aircraft. Manufactured by Boeing's Commercial Airplane unit in the United States, the 747 was originally planned to have 150 percent greater capacity than the Boeing 707,[8] a common large commercial aircraft of the 1960s. First flown commercially in 1970, the 747 held the passenger capacity record for 37 years

11.1 PRE LAB VIVA QUESTIONS

1. What is the range of DC 3?
2. How many Douglas DC 3 have been built?
3. Does MC Donnel Douglas still exist?
4. Is Boeing still making 747?

11.2 POST LAB VIVA QUESTIONS

1. How many 747 crashed?
2. Which airline has the most 747?
3. Explain about the first wide-body airplane.
4. Explain about Boeing 707 aircraft.

EXPERIMENT-12

DESIGN CASE STUDY-II

AIM:

To study the given aircraft model and write a report on it.

MODEL:

Model I:

The General Dynamics F-16 Fighting Falcon is a single-engine supersonic multirole fighter aircraft originally developed by General Dynamics (now Lockheed Martin) for the United States Air Force (USAF). Designed as an air superiority day fighter, it evolved into a successful all-weather multirole aircraft. Over 4,600 aircraft have been built since production was approved in 1976.



Model II:

The Lockheed SR-71 "Blackbird" is a long-range, Mach 3+ strategic reconnaissance aircraft that was operated by the United States Air Force. It was developed as a black project from the Lockheed A-12 reconnaissance aircraft in the 1960s by Lockheed and its Skunk Works division. American aerospace engineer Clarence "Kelly" Johnson was responsible for many of the design's innovative concepts. During aerial reconnaissance missions, the SR-71 operated at high speeds and altitudes to allow it to outrace threats.



12.1 PRE LAB VIVA QUESTIONS:

1. What is the range of Dynamics F-16 ?
2. What is the range of Lockheed SR-71?
3. What is the range of Lockheed A-12.
4. What does F in F stands for?

12.2 POST LAB VIVA QUESTIONS:

1. Why is F16 famous?
2. Why was the Lockheed SR 71 blackbird retired?
3. Explain how high can the Lockheed blackbird can fly.
4. Explain the difference between OXCART vs BLACKBIRD