SCHOOL OF AERONAUTICS (NEEMRANA)

I 04, RIICO Industrial Area, Neemrana, Dist. Alwar, Rajasthan.

IAE-I-QUESTION PAPER WITH ANSWERS

FACULTY NAME: D.SUKUMAR **CLASS: B.Tech AERONAUTICAL**
SUBJECT CODE: 6AN5 **SEMESTER: VI**
SUBJECT NAME: AIRCRAFT DESIGN

Max Marks: 30 DATE: 30/01/2019
Duration: 1Hr 45Min

Answer any four questions
(4X7.5=30 marks)

1. Explain the phase Preliminary design of Aircraft Design.

This stage of design process aims at producing a brochure containing preliminary drawings and stating the estimated operational capabilities of the airplane. This is used for seeking approval of the manufacturer or the customer. This stage includes the following steps.
(i) Preliminary weight estimate.
(ii) Selection of geometrical parameters of main components based on design criteria.
(iii) Selection of power plant.
(iv) Arrangement of equipment, and control systems.
(iv) Aerodynamic and stability calculations.
(vi) Preliminary structural design of main components.
(vii) Revised weight estimation and c.g. travel.
(viii) Preparation of 3-view drawing.
(ix) Performance estimation.
(x) Preparation of brochure. Section 10.3 deals with the items included in the brochure. It is also called aircraft type specification.

2. List down the Primary requirements for designing the Military Aircraft FIGHTERS-Tactical, FIGHTERS- Interceptor & Bomber.

Primary requirements for Military Aircraft – FIGHTERS-Tactical
- High speed (300-400 kmph- more than contemporary bomber speeds)
- High ceiling (2-4 km than bomber more than contemporary bomber ceilings)
- Maneuverability
- Sufficient endurance
- High rate of climb
- Ability to launch repeat- ed attacks
- All-weather flying
- Ability to use field aerodromes
- Ease of dismantling and assembling

Primary requirements for Military Aircraft – FIGHTERS- Interceptor
- High rate of climb

- High ceiling (3-4 km contemporary ceilings)
- High speed (500-600 kmph more than contemporary bomber speeds
- High Maneuverability
- All-weather flying
- Ability to fire powerful single volley at target
- Ease of dismantling and assembling

Primary requirements of bomber

- Long range,
- High load carrying capacity,
- High speed ,
- High endurance,
- High ceiling and
- Adequate fire protection.

3. Explain the classification of aircraft based on the Wing configuration & fuselage configuration.

Classification of airplanes based on wing configuration

Early airplanes had two or more wings e.g. the Wright airplane had two wings braced with wires. Presently only single wing is used. These airplanes are called monoplanes. When the wing is supported by struts the airplane is called semi cantilever monoplane. Depending on the location of the wing on the fuselage, the airplane is called high wing, mid-wing and low wing configuration. Further, if the wing has no sweep the configuration is called straight wing monoplane. The swept wing and delta wing configurations are shown in Figs.

(a) Shape and Position of the Wing

(1) Braced airplane – D.H. Tigermoth
(2) Braced sesquiplane – An- 2
(3)Semi-Cantilever monoplane, Pushpak, Piper Cub,
(4)Semi-cantilever parasol monoplanes…Baby Ace
(5) Cantilever low-wing monoplaneDC-3, HJT-16, IL-18, DH Comet
(6) Cantilever mid-wing monoplane …Hawker Hunter, Canberra
(7)Cantilever high-wing monoplane…An-22, Breguet 941, Fokker friendship
(8)Straight wing monoplane… F-104 A….
(9)Swept-wing monoplane… F-24, MIG-21, Lightning ……
(10)Delta-monoplane with small ARAvro-707, B-58 Hustler, Avro Vulcan.

Classification of airplanes based on fuselage

Generally airplanes have a single fuselage with wing and tail surfaces mounted on the fuselage. In some cases the fuselage is in the form of a pod. In such a case, the horizontal tail is placed between two booms emanating from the wings. These airplanes generally have two vertical tails located on the booms. The booms provide required tail arm for the tail surfaces. Some airplanes with twin fuselage had been designed in the past. However, these configurations are not currently favoured.

(b) Type of fuselage

(1) Conventional single-fuselageHT-2, Boeing 707,
(2) Twin-fuselage design
(3) Pod and Boom construction. Fairchild Packet, Vampire

4. Explain the aerodynamics consideration for designing the aircraft.

(I) Aerodynamic considerations – drag, lift and interference effects

The aerodynamic considerations in the design process involve the following.

(A) Drag
The drag of the entire configuration must be as small as possible. This requires (a) thin wings, (b) slender fuselage, (c) smooth surface conditions, and (d) proper values of aspect ratio (A) and sweep (Λ).
(B) Lift
The airplane must be able to develop sufficient lift under various flight conditions including maneuvers. The maximum lift coefficient also decides the landing speed. These considerations require proper choice of (a) aerofoil, (b) means to prevent flow separation and (c) high lift devices.
(C) Interference effects
In aerodynamics the flows past various components like the wing, the fuselage and the tail are usually studied individually. However, in an airplane these components are in proximity of each other and the flow past one component affects the flow past the others(components). The changes in aerodynamic forces and moments due to this proximity are called interference effects. The lay-out of the airplane should be such that increase in drag and decrease in lift due to interference effects are minimized. These can be achieved in subsonic airplanes by proper fillets at the joints between
(a) Wing and fuselage,
(b) Tail and fuselage and
(c) Wing and engine pods.

5. Explain about the Structural Design Criteria (SDC) different types of load acting on the aircraft.

Structural Design Criteria (SDC)
Aircraft loads are determined according to requirements and regulations collected in a systems specification document called Structural Design Criteria, the major reference for loads and structural analysis engineers during the design phase.
Many of the SDC requirements come from the customer; others are prepared in co-operation between customer and original equipment manufacturer (OEM), usually the principal design contractor. The SDC are also subject to revisions during the design process.
Some of the more important items regarding loads and structures are:
Design masses are defined for different flight conditions to cover the whole mass and centre of gravity (C.G.) range, i.e.:

- Basic flight design mass
- Landing design mass
- Maximum take off mass

Total mass and mass distribution not only affect loads on wing as is sometimes believed but loads on most parts of the aircraft's structure. Design mass is one of the most important criteria for structural design. For example the basic flight design mass is coupled to the max/min allowed vertical load factor Nz, for increased masses through the rule: Nz.Weight **-** const. to avoid overloads or assessing the effects of over-g.

6. With neat sketches, explain the V-n diagram.

A V-n diagram shows the flight load factors that are used for the structural design as a function of the air speed. These represent the maximum expected loads that the aircraft will experience. These load factors are called as limit load factors. These diagrams are used primarily in the determination of combinations of flight condition and load factors to which the airplane structure must be designed.

For purposes of structural sizing, analysis is performed at four extreme loading conditions on the V-n diagram. The Positive High Angle of Attack (PHAA) is the loading condition represented by the intersection between the positive operational load limit line and the positive maximum lift curve. The Positive Low Angle of Attack (PLAA) is at the intersection between the positive operational load limit line and the dive speed. The Negative High Angle of Attack (NHAA) and Negative Low Angle of Attack (NLAA) are defined similarly except are for the negative loads. Should the gust envelope extend beyond the manoeuvring envelope in any of these four locations, the load factor of the gust envelope is instead used for the extreme loading condition. The high angle of attack conditions are characterized by a high coefficient of lift and high drag. The low angle of attack conditions are characterized by a high lift force. Designing to accommodate these four extreme loading conditions will guarantee that the wing will not undergo structural damage so long as operational load limits are not exceeded.

The control of weight in aircraft design is of extreme importance. Increase in weight requires stronger structures to support them, which in turn lead to further increase in weight & so on. Excess of structural weight means lesser amounts of payload, affecting the economic viability of the aircraft. Therefore there is need to reduce aircraft's weight to the minimum compatible with safety. Thus to ensure general minimum standards of strength & safety, airworthiness regulations lay down several factors which the primary structures of the aircraft must satisfy. These are,

- **LIMIT LOAD**: the maximum load that the aircraft is expected toexperience in normal operation.
- **PROOF LOAD**: product of the limit load and proof factor
- **ULTIMATE LOAD** : product of limit load and ultimate factor

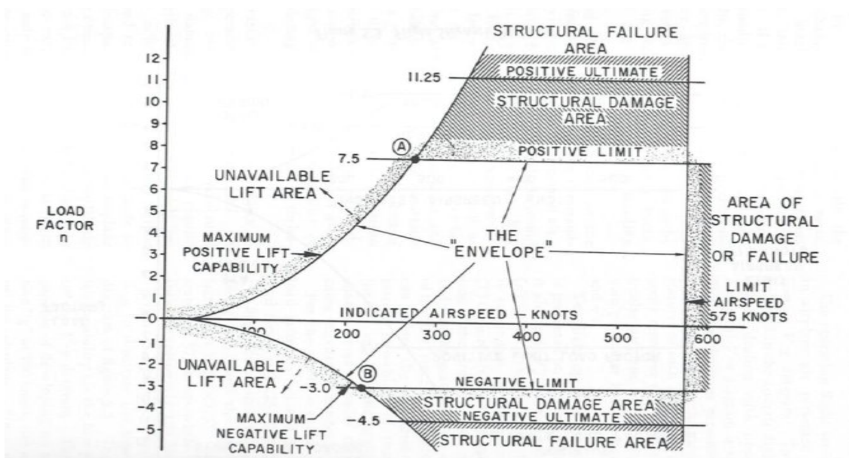


Figure 5.4. Significance of the V–n Diagram

7. Write the formula for n_{max}, V_{stall} , V_c, Stall Speed And Minimum Speeds

$$n_{max} = \left(\frac{L}{D}\right)_{max} \times \left(\frac{T}{W}\right)_{max}$$

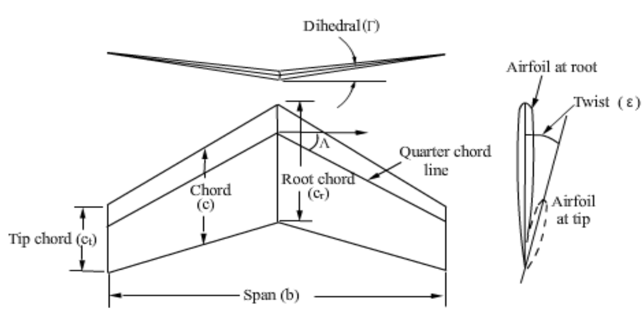
$$n_{max} = \frac{1}{2}\,\rho_\infty V_\infty^2 \frac{C_{L_{max}}}{\left(\frac{W}{S}\right)}$$

$$V_C = \sqrt{\frac{\left[\frac{T}{W} \times \frac{W}{S}\right] - \sqrt{\left[\frac{W}{S} \times \left(\frac{T}{W}\right)^2_{max} - (4\,k\,C_{D,0}\right]}}{\rho\, C_{D,0}}}$$

$$V_S = \sqrt{\frac{2W}{\rho C_{L_{max_{trim}}} S}}$$

$$V_S = \sqrt{\frac{2W}{\rho C_{L_{max_{controllable}}} S}}$$

8. Write down the parameters required to design the wing of an aircraft in Airplane Data Sheet.



i) Airfoil section:
ii) Span (m):
iii) Root chord (m):
iv) Tip chord (m):
v) Area (S) (m^2):
vi) Mean chord* (m):
vii) Mean aerodynamic chord* (m):
viii) Sweep (Λ):
ix) Dihedral. (Γ):
x) Twist (ε)*:
xi) Incidence (i)*:
xii) Flap area (m^2):
xiii) Aileron area (m^2):
xiv) Type of high-lift devices:
xv) Location of spars:
xvi) Taper ratio (λ)*:
xvii) Aspect ratio (A)*:
xviii) Flap area/wing area:or S_{flap}/S
xix) Aileron area/wing area or $S_{aileron}/S$:
xx) Flap chord/ wing chord or C_{flap}/C_{wing}:
xxi) Aileron chord/wing chord or $C_{aileron}/C_{wing}$:
xxii) Location of wing on fuselage (high wing/mid wing/low wing):
xxiii) Construction and other details:

THESE ARE THE POSSIBLE CORRECT ANSWER, IF STUDENTS ANSWERED WITH THE REFERENCE TO OTHER STANDARD TEXT BOOKS IT CAN BE ALSO CONSIDER