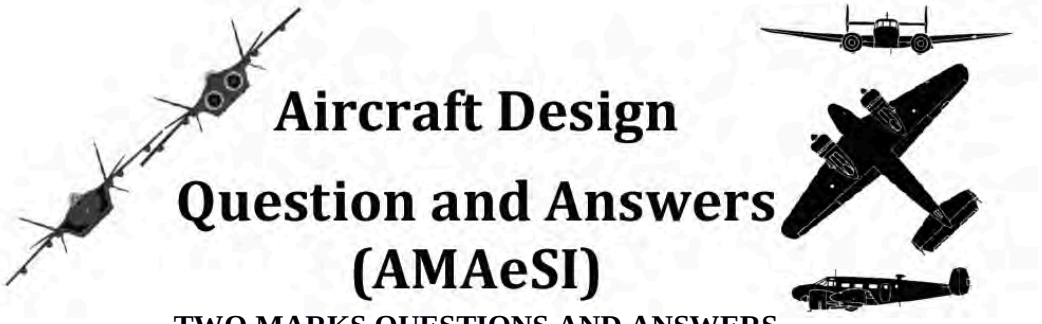


Aircraft Design
Question and Answers
(AMAeSI)

TWO MARKS QUESTIONS AND ANSWERS

1) Define Range of an aircraft.

   Range of an aircraft is defined as the total distance travelled by an aircraft on one load of fuel. It is denoted by R. **Range R=**$\frac{V\infty}{ct}\frac{L}{D}\ln\frac{Wo}{W1}$

2) Define endurance of an aircraft.

   Endurance of an aircraft is defined as the amount of time that an aircraft can stay in the air on one load of fuel. It is denoted by E. **Endurance E=**$\frac{1}{ct}\frac{L}{D}\ln\frac{Wo}{W1}$

3) Write the formula for thrust required and available.

   Thrust Required T_R= D = ½$\rho\infty\ V\infty^2\ SC_D$ and **Thrust Available** $T_A = \frac{pr\ P}{V\infty}$

4) Write down the conditions for unaccelerated, steady level flight?

   Thrust is equal to Drag,**T=D** and Lift is equal to weight**L=W**. Climb angle and roll angle is equal to zero

5) Define bye-pass ratio.

   Bye-pass ratio is defined as the ratio of mass flow passing through the fan, via bye pass duct to the mass flow passing through the core itself.

6) Write shortly about unpowered flight.

   When power required is larger than the power available the aircraft will descent rather than climb. At this condition there is no power at all and the aircraft is said to be in gliding or unpowered flight.

7) Write shortly about climbing flight.

   At steady condition of flight for increase in power of engine there will be corresponding increase of lift. The elevators are operated in such a condition that the increase in power can be used for climbing flight with nose up position.

8) Write the different types of power plants.

   1. Reciprocating Engine
   2. Turbojet
   3. Turbofan

4. Turboprop

9) Define thrust and propulsive efficiency.

Thrust is defined as the forward motion of an aircraft and is denoted by T, propulsive efficiency is defined as the ratio of useful power available to the total power generated.

10) What are the important components in turboprop engine?

The important component are diffuser,propeller,reduction gear, high pressure compressor,low pressure compressor, combustionchamber, high speed turbine, low speed turbine and nozzle.

11) Write the formula for power required and available.

Power required $P_R = T_R V\infty$

Power available $P_A = T_A V\infty$

12) Define absolute ceiling

Absolute ceiling of the aircraft is defined as the maximum height to which the aircraft can reach at this altitude Power required P_R = Power available P_A

13) Define Service ceiling

Service ceiling of the aircraft is defined as the altitude at which the rate of climb is 100 units per unit time.

14) Define rate of climb.

Rate of climb is defined as the rate at which the aircraft improves its altitude.

15) Which is the main parameter affecting rate of climb?

The main parameter affecting rate of climb is Excess power.

Rate of climb = Excess power / Weight

16) What are the assumptions made in Froude-Rankine Momentum Theory?

a) Fluid is incompressible and flow is irrotational and continuous across the disc.

b) Actual propeller is replaced by an **actuator disc**having an infinite number of blades and able to produce a uniform change in velocity of the fluid passing through the disc.

c) The disc is assumed to exert a uniform intensity of pressure to the fluid passing through it.

17) What are the factors affecting the actual efficiency of the propeller?

a) Thrust is not uniform over the disc due to losses at root and tip of blades.

b) There is loss of energy due to the rotation of the slip stream of real fluid.

c) Losses due to skin friction drag as the fluid is a real one.

18) Define Pitch of a propeller.

Pitch of a propeller is the forward distance moved by a point on the blade for a complete rotation of the propeller.

19) Define pitch angle

Pitch angle is defined angle between the plane of symmetry and the plane containing the chord of the airfoil.it is the angle at which each blade is set.

20) What is meant by advance ratio in a propeller blade?

Advance ratio is the dimensionless quantity given by J = V / ND

Where,

V= relative velocity of forward motion

N= speed of propeller in rps

D= Diameter of propeller.

21) Write down the formulas to calculate landing distance?

Landing distance = $S_a+S_j+S_g$

Where,

$S_a= \underline{50-h_f}$

$Tan\theta_a$

$S_j= R \sin\theta_s$

$S_g= JN\times(2/\rho\alpha\times W/S \times 1/C_{lmax})^{\wedge 0.5}+ \underline{J^2\times W/S}$

$g\times \rho\alpha C_{lmax}\mu_r$

22) Define geometrical pitch.

Geometrical pitch is defined as theoretical forward distance which should be advanced by a point on the blade if the blade can move into air as into a solid without any slip.

23) Define Blade angle.

The angle at which the chord of the blade element set to the plane of rotation is called blade angle.

24) Define Solidity.

The solidity of a propeller is defined as the ratio of the area of all the bade elements to the area of the complete annulus of the actuator disc of same outer diameter as the propeller.it is seen that minimum solidity of propeller yields maximum efficiency.

25) What are the disadvantages of aft-fuselage engine location?

- Center of gravity will move more rear
- Empennage should be structurally strong.
- At high angle of attack, nacelles will cover the airflow to the stabilizer
- High noise, high vibration
- Reduce rolling moment of inertia.

26) Write down the formulas to calculate the takeoff distance.

Take off distance = S_g+S_a

Where,

$S_g= \underline{1.21\ (W/S)}$

$g\rho_\alpha(c_l)_{max}(T/W)$

$S_a= R\sin\theta_{OB}$

.

27) Define Thrust grading.

The ratio of change of thrust to torque with radius is called thrust grading

28) What are the main aspects of requirements to be considered in airplane design?

1) Range

2) Takeoff distance

3) Stalling velocity

4) Endurance

5) Maximum velocity

29) Write down the phases of airplane design?

1) Conceptual design

2) Preliminary design

3) Detailed design

30) What is an actuator disc?

Actuator disc is an imaginary replacement to a propeller. It is assumed that an actuator disc has

- Infinite number of blades on it
- Produce uniform change in velocity of fluid passing through the disc.

31) What is meant by propeller disc?

This is the circular area traced out by rotating propeller blades.

32) Define effective pitch

It is the average of all pitch values at all points on the blades.

33) Define efficiency of propeller?

Efficiency of propeller is defined as the ratio of the power output to power input.

34) Why jet propulsion is insufficient at low speeds?

Jet engine throws back small mass of air at a very high velocity. Hence energy wasted is more at slow speeds.

35) Why propeller propulsion is insufficient at high speeds?

Propeller throws back a large mass of air at a comparably lower velocity. Hence at low speeds energy wasted is lesser.

36) Explain breaking propeller

In these propellers, the angle β is reduced to a negative value so that the power supplied to the to the propeller will result in a negative thrust or an anti-directional torque.

37) What factors make the efficiency of a propeller?

It is dependent on

Forward velocity

Thrust of propeller

Rotational Speed

Torque exerted by engine.

38) Define Pitch angle.

The angle at which the chord of the blade element set to the plane of rotation is called blade angle.

39) Define Torque grading.

Torque grading is defined as rate of change of torque with radius

40) How solidity can be increased?

Either increase the chord of the airfoil blade or increase number of blades.

41) Define crew weight.

The crew comprises the people necessary to operate the airplane in flight. E.g. Pilot

42) Define payload in aircraft.

The payload is what the airplane is intended to transport e.g. Passenger, baggage, freight etc. If the airplane is intended for military purpose then the payload includes bombs, rockets and other disposable ordnance.

43) Define fuel weight in aircraft?

This is the weight of the fuel in the fuel tanks. Since fuel is consumed during the course of the fuel $W_{fuel}$is a variable decreasing with time during the flight.

44) Explain empty weight of an aircraft?

This is the weight of everything else the structure, engine, electronic components,. Landing gear, fixed equipment and anything else that is not crew, payload and fuel.

45) Define overall weight of an aircraft?

The overall weight of an aircraft is defined as the sum of crew weight, payload, fuel weight and empty weight.

46) Define weight fraction

Weight fraction is defined as the airplane weight at end of the segment divided by the weight of the airplane at the beginning of the segment.

47) Define cruise weight fraction.

Cruise weight fraction is defined as the airplane weight at end of the cruise divided by the weight of the airplane at the beginning of the cruise.

48) Define aspect ratio

Aspect ratio is defines as ratio of square of wing span to the wing area.

49) Define taper ratio

Taper ratio is defined as ratio between tipchord to root chord

50) Define washout

When the tip chord incidence angle is smaller than that of root chord the configuration is called washout.

51) Define wash in

When the tip chord incidence angle is higher than that of root chord the configuration is called wash in.

52) Define mean aerodynamic chord

The mean aerodynamic chord is defined as the chord length that when multiplied by the wing area, the dynamic pressure and the moment coefficient about the aerodynamic Centre yields the value of the aerodynamic moment about the airplane's aerodynamic Centre.

53) What are the various types of drag?

Parasite drag, skin friction drag, wave drag, form drag, pressure drag, interference drag etc.

54) What are the critical parameters to be considered while designing an aircraft?

The critical parameters are lift to drag ratio, maximum lift coefficient, thrust to weight ratio and wing loading.

55) Define static stability

If an aircraft in steady level flight is disturbed and return to its original position it is known as statically stable.

56) Define dynamic stability

The characteristic of an aircraft when disturbed from its original state of steady motion in an upright position, to damp out the oscillations set by restoring moment and gradually returns to its original state.

57) Define Range of an aircraft.

Range of an aircraft is defined as the total distance travelled by an aircraft on one load of fuel. It is denoted by R. **Range R=** $\frac{V\infty}{ct}\frac{L}{D}\ln\frac{Wo}{W1}$

58) Define endurance of an aircraft.

Endurance of an aircraft is defined as the amount of time that an aircraft can stay in the air on one load of fuel. It is denoted by E. **Endurance E=** $\frac{1}{ct}\frac{L}{D}\ln\frac{Wo}{W1}$

59) Which are segments in takeoff performance?

The segments in takeoff performance are ground roll and airborne.

60) Which are segments in landing performance?

The segments in landing performance are ground roll, approach distance and flare distance.

61) What are the advantages of Tractor configuration?

1. The heavy engine is at the front, which helps to move the centre of gravity forward and therefore allows a smaller tail for stability considerations.
2. The propeller is working in an undisturbed free stream
3. There is a more effective flow of cooling air for the engine.

62) What are the disadvantages of Tractor configuration?

1. The propeller slipstream disturbs the quality of the airflow over the fuselage and wing root.
2. The increased velocity and flow turbulence over the fuselage due to the propeller slipstream increase the local skin friction on the fuselage.

63) What are the advantages of Pusher configuration?

1. Higher quality airflow prevails over the wing and fuselage.
2. The inflow to the rear propeller includes a favorable pressure gradient at the rear of the fuselage, allowing the fuselage to close at a steeper angle without flow separation. This in turn allows a shorter fuselage, hence smaller wetted surface area.
3. Engine noise in the cabin area is reduced
4. The pilot's front field of view is improved.

64) What are the disadvantages of Pusher configuration?

1. The heavy engine is at the back, which shifts the center of gravity rearward, hence reducing longitudinal stability.
2. Propeller is more likely to be damaged by flying debris at landing.
3. Engine cooling problems are more severe.

65) Define landing distance with formula.

Landing distance is defined as the sum of approach distance, flare distance

and ground roll

Landing distance = $S_a+S_j+S_g$

66) Define optimization.

The optimization will be carried out by a systematic variation of different parameters such as L/D, T/W and W/S producing large number of different airplanes and plotting the performance of all these airplanes on graphs which provide a sizing matrix or carpet plot from which the optimum design can be found.

67) Define constraint diagram

A constraint diagram consists of plots of the sea-level thrust-to-takeoff weight ratio T_0/W_0 versus the wing loading at takeoff W_0/S that are determined.

68) Define Neutral point.

It is defined as aerodynamic center of the wing when statically longitudinal stable center of gravity will lie ahead of neutral point.

69) What are the advantages of Mid- Wing configuration?

- The aircraft structure is heavier.
- The mid wing is more attractive compared with two other configurations

70)What are the disadvantages of Mid- Wing configuration?

- Worst structure
- The mid wing is more expensive compared with high and low wing configurations
- The strut is usually not used to reinforce the wing structure

71) what are the two types of high lift devices?

- Leading edge high lift device
- Trailing edge high lift device.
-

72)What are the advantages of Low- Wing configuration?

- The aircraft take off performance is better; compared with a high wing configuration; due to the ground effect.
- The pilot has a better higher-than-horizon view, since he/she is above the wing.
- The retraction system inside the wing is an option along with inside the fuselage

- Aircraft frontal area is less..

73)What are the advantages of High- Wing configuration?

- The aerodynamic shape of the fuselage lower section can be smoother
- There is more space inside the fuselage for cargo, luggage, passenger.
- Facilitates the installation of engine on the wing
- Facilitates the installation of strut

.

74) What are the disadvantages of High- Wing configuration?

- The aircraft frontal area is more this will increase drag.
- The ground effect is lower compared to low wing
- The wing has less induced drag.
- A high wing is structurally about 20% heavier than low wing

75) Write down the selection criteria for airfoil?

- Maximum lift coefficient $C_{L\ max}$
- Lowest minimum drag coefficient C_{Dmin}
- Highest lift to drag ratio $(C_l/ C_d)_{max}$
- Highest lift curve slope.

76) State down the group of NACA series airfoils?

There are three groups of NACA series airfoils. They are

1. Four digit NACA airfoils
2. Five digit NACA airfoils
3. Six digit NACA airfoils

77) Give examples for NACA 4,5,6 digit airfoils?

Four digit NACA airfoils are named as NACA 2415, for five digit NACA 23018 and for six digit NACA 63318.

78) Write down the advantages of swept wing?

- Improving the wing aerodynamic feature
- Adjusting the aircraft center of gravity
- Improving longitudinal and directional stability
- Increasing pilot view.

79) Define twist angle.

When the tip chord incidence angle is smaller than that of root chord the configuration is called twist angle α_t.

80) Define aerodynamic twist.

If the tip airfoil section and root airfoil section is not the same the twist is said to be aerodynamic twist.

81) What are the various air loads on an aircraft?

- Maneuver
- Gust
- Control Deflection
- Component Interaction
- Buffet

82) What are the various inertial loads experienced by an aircraft?

- Acceleration
- Rotation
- Dynamic
- Vibration
- Flutter

83)What are the various loads experienced due to landing gear by an aircraft?

- Vertical load factor
- Spin up
- Spring back
- Crabbed
- One wheel arrested
- Braking

84) What are the various loads experienced by an aircraft during take off and taxiing?

- Catapult
- Aborted
- Bumps
- Turning

85) What is a V-n diagram?

The V-n diagram is a graph which indicates the load factor(n) as a function of velocity. It helps to estimate the stalling velocity and to fix the maximum loading limits for the aircraft both for the positive and negative loading cases.

86) What are the various power-plant loads on an aircraft?

- Thrust
- Torque
- Gyroscopic
- Vibration

- Duct pressure

87) What are the three basic structural loads experienced by an aircraft?

- Tension
- Compression
- Shear

88) What are the important properties required for the material selection of an aircraft?

- Yield strength
- Ultimate strength
- Stiffness
- Density
- Fracture toughness

89) What are the various materials used in the aircraft?

- Wood
- Aluminium
- Steel
- Titanium

90) What are the various methods of structural analysis?

- Truss analysis
- Shear Force and Bending Moment Diagram
- Braced wing analysis
- Finite element structural analysis

91) What are the various types of testing of an aircraft?

- Wind tunnel testing
- Flight testing
- Computational fluid dynamics analysis

92) What are the various types of fuselage?

- Truss type
- Monocoque
- Semi monocoque

93) What are the classifications of composite materials?

- Fibrous composite material
- Laminated composite materials

- Particulate composite materials
- Combinations of some or all of the first three types

94) What are the properties that can be improved by forming a composite material?

- Strength
- Stiffness
- Corrosion resistance

95) How much "factor of safety" should be applied to aircraft design?

It is the multiplier used on limit load to determine the design load. The factor of safety has usually been 1.5. This was defined based upon the ratio between the ultimate tensile load and yield load of 24ST aluminium alloy and has proven to be suitable for other aircraft materials in most cases.

96) What are the members used in structural joints?

Solid rivets
Blind fasteners
Swaged collar/Upset-pin fasteners
Threaded fasteners

97) What are the various structural members in a fuselage?

Bulkhead
Skin
Stringers
Longerons

98) What are the basic types of wing structure?

Single spar mass boom structure
Box beam structure
Multi-spar structure

99) What are the various types of landing gear?

Tail wheel landing gear
Bicycle landing gear
Nose wheel gear

100) Define take off distance with formula

Take off distance is defined as sum of ground roll and airborne distance.

Take off distance = S_g+S_a

SIX MARKS QUESTIONS

1. Derive the equation for thrust and power required.

- Thrust is the forward motion of an aircraft.
- It is derived from the Newton's III law of motion.
- The general thrust equation is given by **$T=m(V_j-V_\infty)$**
- Power is the product of force and velocity.
- The general equation for power required is given by **$P_R=T_RV_\infty$**.

2. Differentiate between reciprocating and turboprop engines.

Reciprocating Engines	**Turboprop Engines**
Driven by a rotating crankshaft	Driven by a gas turbine engine
Power constant with velocity	Power available is constant with Mach number
SFC is constant with both velocity & altitude	SFC is constant with both velocity & altitude

3. Write down the conditions for minimum drag and minimum power required.

Conditions for minimum drag:

- $C_L = \sqrt{(\frac{C_{D0,L}}{k})}$
- $C_D = 2C_{D0,L}$

Conditions for minimum PR:

- ✓ When the airplane is flying such that **$C_L^{3/2}/C_D$** is a maximum value.
- ✓ Zero-lift drag equals one-third of the drag due to lift.
- ✓ **$V_{(C_L^{3/2}/C_D)}=(2/\rho\infty\sqrt{\frac{k}{3CD,0}}W/S)^{1/2}$**

4. Derive the thrust and efficiency for general propulsive devices.

- Thrust is the forward motion of an aircraft.

- It is derived from the Newton's III law of motion.
- The general thrust equation is given by **$T=m(V_j-V_\infty)$**
- ✓ Efficiency is defined as the ratio of useful power available to the total power generated.
- ✓ It is expressed as **$\eta_p=2/1+Vj/V\infty$**

5. Write shortly about climbing flight?

- Powered flight is known as the climbing flight.
- The rate of climb is given by **$R/C=V\infty\sin\theta$.**
- It is the condition at which the aircraft can increase its altitude.

6. What shortly about propeller characteristics?

- Pitch
- Blade angle
- Advance ratio
- Blade aerofoil

7.Write short notes on reciprocating-propeller driven engine and its variation of thrust and TSFC with velocity and altitude.

- Driven by a rotating crankshaft
- Power constant with velocity
- SFC is constant with both velocity & altitude

8. Derive the range equation for jet-propelled airplane.

- ✓ Range is defined as the total distance traversed by an airplane on one load of fuel.
- ✓ It is denoted by R and is given by Breguet Range equation.
- ✓ **$R=2/c_t\sqrt{2/\rho\infty}C_L^{3/2}/C_D(W_0^{1/2}-W_1^{1/2})$**

9. Write short notes on weight estimation of an aircraft.

- ✓ Estimate the overall weight using $W_0 = W_{crew} + W_{payload} + W_{fuel} + W_{empty}$
- ✓ Estimate W_e/W_0 from historical data and W_f/W_0 from mission profile.
- ✓ Estimate $W_0=\frac{W_{crew}+W_{payload}}{1-\frac{W_e}{W_0}-W_f/W_0}$

10. Write short notes on preliminary design of an aircraft.

- Geometric & aerodynamic parameters
- Weight estimation
- Estimation of critical performance parameters
- Maximum level speed
- Rate of climb at sea level
- Stalling speed
- Landing and takeoff distance

These are the factors to be estimated during preliminary phase of airplane design.

11.Write down the relative merits of power plant location.

- ✓ The arrangement of engines influences the aircraft in many important ways.
- ✓ Safety, structural weight, flutter, drag, control, maximum lift, propulsive efficiency, maintainability, and aircraft growth potential are all affected.
- ✓ Wing mounted engines
- ✓ Aft fuselage engine location

12. Write short notes on propeller characteristics.

- Propeller is the rotating part of an airplane which produces forward thrust
- Pitch of a propeller is the forward distance moved by a point on the blade for a complete rotation of the propeller.
- Geometrical pitch is the theoretical forward distance which should be advanced by a point on the blade if the blade can move into air as into a solid without any slip

13. Write short notes on gliding flight.

- The gliding flight is also known as unpowered flight.
- This will happens when there is an engine failure or running out of fuel.
- The glide angle θ can be found using the equation **Tan θ=1/ (L/D)max**

14. Explain briefly about load carrying methods.

- Tension
- Compression
- Shear
- Bending
- Torsion

15. Explain briefly about takeoff and landing distance calculation?

Take off distance is sum of ground roll and airborne distance.

Take off distance = S_g+S_a

Where,

S_g= 1.21 (W/S)

$g\rho_\alpha(c_l)_{max}(T/W)$

$S_a= R\sin\theta_{OB}$

Landing distance is defined as the sum of approach distance, flare distance

And ground roll

Landing distance = $S_a+S_j+S_g$

Where,

S_a= $50-h_f$

$\text{Tan}\theta_a$

$S_j= R\ \sin\theta_s$

$S_g= JN\times(2/\rho\alpha\times W/S \times 1/C_{lmax})^{\wedge 0.5}+ J^2\times W/S$

$g\times \rho\alpha C_{lmax}\mu_r$

16. Write short notes on static & dynamic stability estimates.

- The static and dynamic stability of an aircraft depends on the wing and empennage section.
- The wing aileron determines the lateral stability of an aircraft.
- The horizontal & vertical tail determines the longitudinal & directional stability of an aircraft respectively.
- The horizontal & vertical tail volume ratios $V_{HT} and V_{VT}$ has to be determined using $\boldsymbol{V_{HT} = l_{HT}S_{HT}/\bar{c}S}$ and $\boldsymbol{V_{VT} = l_{VT}S_{VT}/\bar{c}S}$

17. Write short notes on drag estimation of an aircraft.

- Drag estimation is one of the main calculations in the preliminary phase of an aircraft design.
- Drag in an airplane is the sum of the profile drag and induced drag.
- Drag D= $C_p + C_i$

18. What are the problems caused by overloading an aircraft?

Some of the problems caused by overloading an aircraft are:

• The aircraft will need a higher takeoff speed, which results in a longer takeoff run.

• Both the rate and angle of climb will be reduced.

• The service ceiling will be lowered.
• The cruising speed will be reduced.
• The cruising range will be shortened.
• Maneuverability will be decreased.
• A longer landing roll will be required because the landing speed will be higher.
• Excessive loads will be imposed on the structure,especially the landing gear.

19. Explain briefly about Stability and Balance Control.

- Balance control refers to the location of the CG of anaircraft.
- This is of primary importance to aircraft stability,which determines safety in flight.
- The CG is the point at which the total weight of theaircraft is assumed to be concentrated, and the CG mustbe located within specific limits for safe flight.
- Both lateral and longitudinal balance are important, but theprime concern is longitudinal balance; that is, the locationof the CG along the longitudinal or lengthwise axis.

20. Write briefly about Weight and Balance Theory

Two elements are vital in the weight and balance considerations of an aircraft:

- The total weight of the aircraft must be no greater thanthe maximum gross weight allowed by the FAA for theparticular make and model of the aircraft.
- The center of gravity, or the point at which all of theweight of the aircraft is considered to be concentrated,must be maintained within the allowable range for theoperational weight of the aircraft.

21. How will you determine the C.G location of an aircraft?

- ✓ Determination of CG location is an important part in the airplane design.
- ✓ It has to be done in two phases.
- ✓ Determination of CG without wing, considering the weight of engine, passengers and baggage only.
- ✓ Determination of CG including the weight of wing.

22. Write briefly about unsymmetrical loading.

Unsymmetrical loads on the horizontal tailmay occur from
• Buffet
• Misalignment
• Roll and yaw

- ✓ Buffet and misalignment cannot be determined analytically and are taken into account arbitrarily.
- ✓ Roll induces a damping load on the tail which can be determined from the same method used on a wing.
- ✓ Yawing will induce a rolling moment on the horizontal tail which is difficult to estimate because of fuselage interference.
- ✓ The rolling moment caused by yaw is particularly sensitive to dihedral on the horizontal tail.

23. What are the various loads affecting an aircraft fuselage design?

- ✓ Loads affecting fuselage design can result from flight maneuvers, landings or ground handling conditions.

- ✓ Fuselage loads are primarily a problem of determining the distribution of weight, tail loads, and nose landing gear loads.
- ✓ Weight distribution is important because a large part of fuselage loads stems from the inertia of mass items acted upon by accelerations, both translational and rotational.

24. What are the various landing gear loads acting in an aircraft?
    - ✓ Loads imposed on the various airframe components during landing and ground handling operation are of necessity dependent on characteristics of the airplane's landing gear.
    - ✓ A conventional landing gear performs two basic functions.
    - ✓ It dissipates the energy associated with vertical descent as the airplane contacts the ground; and, it provides a means of maneuveringthe airplane on the ground (taxiing).
    - ✓ Analysis of airplane behavior during the landing impact and during the taxiing operation is imperative in order that:

• The landing gear and its attachment be designed to a proper strength level
• Other components are investigated for every possible design condition.

25. What are the various miscellaneous loads acting on an aircraft?

    The following is a partial list of types of miscellaneous loads:

    - Ground handling loads
    - Control surface loads
    - Door loads (passenger, cargo, landing gear, and access)
    - Pressure loads (cabin, fuel tank, and local surface)
    - Nose radome loads
    - Fluid system requirements
    - Seat and floor loads
    - Auxiliary power unit loads (APU)
    - Environmental control system loads (ECS)
    - Jacking and mooring loads
    - Fixed leading edge loads

TEN MARKS QUESTIONS

1. Derive Breguet-Range Equation.

- ✓ Range is defined as the total distance traversed by an airplane on one load of fuel.
- ✓ It is denoted by R and is derived from the weight, specific fuel consumption and L/D ratio of an aircraft.
- ✓ The general range equation is given by an expression $\mathbf{R=V\infty/c_tL/Dln}\boldsymbol{W_0/W_1}$

2. Write short notes on Turbojet engine and explain its variation of thrust and TSFC with velocity and altitude.

- ➢ The turbojet engine comprises a diffuser, a compressor, burner, turbine and a nozzle.
- ➢ The thrust equation is slightly different from the general thrust equation.
- ➢ Thrust is reasonably constant with V∞.
- ➢ The thrust specific fuel consumption is constant with altitude and Mach number.

3. Write short notes on gliding and climbing flight.

Gliding Flight:

- The gliding flight is also known as unpowered flight.
- This will happens when there is an engine failure or running out of fuel.
- The glide angle θ can be found using the equation $\mathbf{Tan\,\theta=1/(L/D)max}$

Climbing Flight:

- Powered flight is known as the climbing flight.
- The rate of climb is given by $\mathbf{R/C=V\infty sin\theta.}$
- It is the condition at which the aircraft can increase its altitude.

4.Write short notes on Turbofan engine and its variation of thrust and TSFC with velocity and altitude.

- ✓ The turbofan combines the high thrust of a turbojet and high efficiency of a propeller.
- ✓ The turbojet engine forms the core of the turbofan.

- ✓ In addition to the components of turbojet it contains a bye-pass duct and a large fan external to the core.
- ✓ Thrust varies with velocity.
- ✓ Thrust specific fuel consumption for the low bye-pass ratio gradually increases as Mach number increases for subsonic and transonic speeds, and begins to rapidly increase at Mach 2 and beyond.

5. Write short notes on Turboprop engine and its variation of thrust and TSFC with velocity and altitude.

- The turboprop is essentially a propeller driven by a gas-turbine engine.
- It comprises a low pressure compressor, a high pressure compressor, a high pressure turbine, a low pressure turbine and a propeller connected to a propeller reduction gear.
- Power available is constant with Mach number.
- SFC is constant with both velocity and altitude.

6 Write short notes on endurance of an aircraft and derive an expression for both turbojet and propeller driven aircraft.

- Endurance of an aircraft is defined as the amount of time that an aircraft can stay in the air on one load of fuel.
- It is denoted by E and is derived from the weight, specific fuel consumption and L/D ratio of an aircraft.
- **Endurance** $\mathbf{E=\frac{1}{ct}\frac{L}{D}\ln\frac{Wo}{W1}}$

7. Derive Froude – Rankine Momentum Theory.

a) Fluid is incompressible and flow is irrotational and continuous across the disc.

b) Actual propeller is replaced by an actuator dischaving an infinite number of blades and able to produce a uniform change in velocity of the fluid passing through the disc.

c) The disc is assumed to exert a uniform intensity of pressure to the fluid passing through it.

8. Derive Simple Blade Element Theory.

- Geometrical pitch is defined as theoretical forward distance which should be advanced by a point on the blade if the blade can move into air as into a solid without any slip.
- The angle at which the chord of the blade element set to the plane of rotation is called blade angle.

- The solidity of a propeller is defined as the ratio of the area of all the bade elements to the area of the complete annulus of the actuator disc of same outer diameter as the propeller.it is seen that minimum solidity of propeller yields maximum efficiency.

9. Write short notes on conceptual design of an aircraft.

   - Geometric & aerodynamic parameters
   - Weight estimation
   - Estimation of critical performance parameters
   - Maximum level speed
   - Rate of climb at sea level
   - Stalling speed
   - Landing and takeoff distance

10. Write down the relative merits of power plant location.

    - ✓ The arrangement of engines influences the aircraft in many important ways.
    - ✓ Safety, structural weight, flutter, drag, control, maximum lift, propulsive efficiency, maintainability, and aircraft growth potential are all affected.
    - ✓ Wing mounted engines
    - ✓ Aft fuselage engine location

11. What are the main aspects of requirements to be considered in airplane design?

    1) Range

    2) Takeoff distance

    3) Stalling velocity

    4) Endurance

    5) Maximum velocity

    6) Rate of climb

    7) Maximum turn rate and minimum turn radius

    8) Maximum load factor

    9) Service ceiling

    10) Cost

    11) Reliability & maintainability

    12) Maximum size

12. What are the important properties required for the material selection of an aircraft?

- Yield strength
- Ultimate strength
- Stiffness
- Density
- Fracture toughness
- Fatigue crack resistance
- Creep
- Corrosion resistance
- Temperature limits
- Productibility
- Reparability
- Cost
- Availability

13. What are the various materials used in the aircraft?

- Wood
- Aluminium
- Steel
- Titanium
- Magnesium
- High-Temperature nickel alloys
- Composites

14. Explain the parameters considered for wing design?

1. Wing reference (or plan form) area

2. Number of the wings

3. Vertical position relative to the fuselage (high, mid, or low wing)

4. Horizontal position relative to the fuselage

5. Cross section (or airfoil)

6. Aspect ratio (AR)

7. Taper ratio

8. Tip chord (Ct)

9. Root chord (Cr)

10. Mean Aerodynamic Chord (MAC or C)

11. Span (b)

12. Twist angle (or washout)

13. Sweep angle

14. Dihedral angle

15. Incidence (iw)

16. High lifting devices such as flap

17. Aileron

15) What are the requirements for wing selection?

- Performance,
- stability,
- producibility,
- operational requirements,
- cost,
- flight safety

16) Explain the performance and characteristics graphs of an airfoil?

The performance and characteristics of an airfoil by looking at the following graphs:

1. The variations lift coefficient versus angle of attack

2. The variations pitching moment coefficient versus angle of attack

3. The variations of pitching moment coefficient versus lift coefficient

4. The variations of drag coefficient versus lift coefficient

5. The variations of lift-to-drag ratio versus angle of attack

17) Explain the selection criteria for airfoil?

1. The airfoil with the highest maximum lift coefficient

2. The airfoil with the proper ideal or design lift coefficient

3. The airfoil with the lowest minimum drag coefficient

4. The airfoil with the highest lift-to-drag ratio.

5. The airfoil with the highest lift curve slope.

6. The airfoil with the lowest pitching moment coefficient (C*m*).

7. The proper stall quality in the stall region (the variation must be gentile, not sharp).

8. The airfoil must be structurally reinforceable. The airfoil should not that much thin that spars cannot be placed inside.

9. The airfoil must be such that the cross section is manufacturable.

10. The cost requirements must be considered.

11. Other design requirements must be considered. For instance, if the fuel tank has been designated to be placed inside the wing inboard section, the airfoil must allow the sufficient space for this purpose.

12. If more than one airfoil is considered for a wing, the integration of two airfoils in one wing must be observed.

18) Explain briefly the practical steps for wing airfoil section selection?

- ✓ Determine the average aircraft weight (W_{avg}) in cruising flight:
- ✓ Calculate the aircraft ideal cruise lift coefficient. In a cruising flight, the aircraft weight is equal to the lift force.
- ✓ Calculate the wing cruise lift coefficient.
- ✓ Calculate the wing airfoil ideal lift coefficient.
- ✓ Calculate the aircraft maximum lift coefficient
- ✓ Calculate the wing maximum lift coefficient
- ✓ Select/Design the high lift device (type, geometry, and maximum deflection.
- ✓ Determine the high lift device (HLD) contribution to the wing maximum lift coefficient.
- ✓ Calculate the wing airfoil "*net*" maximum lift coefficient.

19) Explain the significance of lift and load distribution?

1. If the wing tends to stall (CLmax), the wing root is stalled before the wing tip (CLroot = CLmax while CLtip<CLmax).

2. The bending moment at the wing root is a function of load distribution.

3. The center of gravity of each wing section (left or right) for an elliptical load distribution is closer to the fuselage center line.

4. The downwash is constant over the span for an elliptical lift distribution (Ref. 3). This will influence the horizontal tail effective angle of attack.

5. For an elliptical lift distribution, the induced angle of attack is also constant along the span.

6. The variation of lift over the span for an elliptical lift distribution is steady (gradually increasing from tip (zero) to the root (maximum).

20) Explain the significance of control surface?

The sweep angle will influence the performance of high lift device (such as flap) as well as control surfaces (such as ailerons). In practice, since both high lift device and control surface have to have sweep angles (with slightly different values); their lifting forces will be spoiled. Consequently, the high lift device's contribution to generate lift at low speed will be reduced. With the same logic, it can be shown that the aileron will also produce less lateral control. To compensate for these shortcomings, both control surface and high lift device must have slightly larger areas.

21) Explain briefly about high lift device?

1. Lift coefficient (C*l*) is increased,

2. Maximum lift coefficient (C*lmax*) is increased,

3. Zero-lift angle of attack in changed,

4. Stall angle is changed,

5. Pitching moment coefficient is changed, and

6. Drag coefficient is increased.

7. Lift curve slope is increased.

22. Write briefly about material selection criteria in an airplane design.
Materials selection is quite frequently a compromise involving various considerations and the more important considerations have historically been thoseassociated with mechanical properties.
A list ofselection criteria for materials are as follows:

- Static strength efficiency
- Fatigue
- Fracture toughness and crack growth
- Corrosion and embrittlement
- Environmental stability
- Availability and Producibility
- Material costs
- Fabrication characteristics

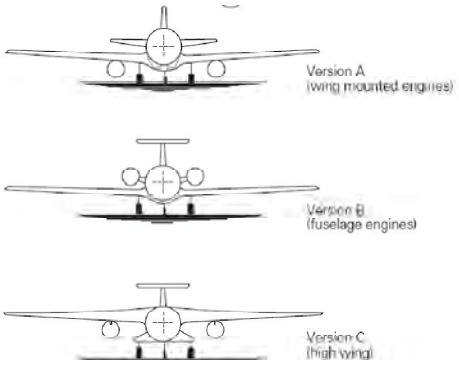
All of the criteria listed above are important to the selection of structural materials. In addition to these, the following are a few considerations that are more frequently related to specialized requirements:

a. Erosion and abrasion
b. Wear characteristics

c. Compatibility with other materials
d. Thermal and electrical characteristics
e. Hard coating to improve wear resistance
f. Metallic plating to provide galvanic compatibility

23. Explain briefly about conceptual layouts?

- This requires the wing to be moved back to balance the aircraft.
- The movement of the wing lift vector rearwards shortens thetail arm and consequently demands larger control surfaces.
- This increases profile drag and possibly trim drag in cruise



24. What are the inial estimates for aircraft design?

- Mass and balance analysis
- Tail structure
- Fuselage structure
- Nacelle structure
- Surface controls
- Aircraft structure
- Propulsion system

25.Write briefly about aerodynamic estimations?

Conventional methods for the estimation of aircraft drag can be used at this stage in the design process. As it is assumed that, with careful detail design, the aircraft can fly at speeds below the critical Mach number, substantial additions due to wave drag can be ignored. Therefore, only zero-lift and induced drag estimations are required. Parasitic drag is estimated for each of the main component parts of the aircraft and then summed to provide the 'whole aircraft' drag coefficient. The component drag areas are normalised to the aircraft reference area (normally the wing gross area). Component parasitic drag coefficient,

CDo = $CfFQ$[Swet/Sref]

Where,

Cf = component skin friction coefficient. This is a function of local Reynolds number and Mach number

F = component form (shape) factor which is a function of the geometry

Q = a multiplying factor to account for local interference effects caused by the component

Swet = component wetted area

Sref = aircraft drag coefficient