D – 11, Q-1 - A.

Define the following:

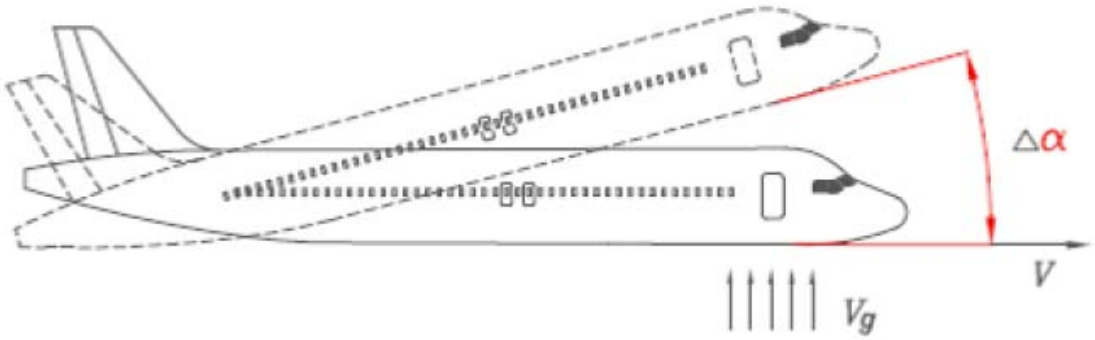
a) **Aspect Ratio**
b) **Gust load factor**
c) **Static Margin**
d) **Power loading**
e) **Pitching Moment coefficient**

A.

a) **Aspect Ratio:** aspect ratio *AR* is defined as the square of the wingspan *b* divided by the area *S* of the wing planform

$$AR = \frac{b^2}{S}$$

b) **Gust Load Factor:** Gust load factor is a percentage increase of the load caused by a gust.



When an upward gust with a velocity of V_g, hits under the nose of an aircraft with the velocity of V, the instantaneous change (increase) in the angle of attack, is determined through:

$$\Delta\alpha = \tan^{-1}\left(\frac{V_g}{V}\right) \approx \left(\frac{V_g}{V}\right)$$

Any sudden change (increase) in the angle of attack will produce a sudden change (increase) in the aircraft lift coefficient:

$$\Delta C_L = C_{L_\alpha} \Delta\alpha$$

This in turn will generate a sudden change (increase) in lift as:

$$\Delta L = qS\Delta C_L$$

Recall the definition of load factor. This change in lift will create a change in load factor:

$$\Delta n = \frac{\Delta L}{W}$$

c) Static Margin : Static margin is a concept used to characterize the static stability and controllability of aircraft and missiles.

In aircraft analysis, static margin is defined as the distance between the center of gravity and the neutral point of the aircraft.

In missile analysis, static margin is defined as the distance between the center of gravity and the center of pressure.

NOTE: The response of an aircraft or missile to an angular disturbance such as a pitch disturbance is determined by its static margin.
With the center of gravity forward of the neutral point, an aircraft has positive longitudinal static stability. (For an aircraft this may be described as negative static margin.) With the center of gravity aft of the neutral point, an aircraft is statically unstable, and requires some form of augmentation to be flown with an acceptable workload. (For an aircraft this may be described as positive static margin.)

d) Power loading: power loading is the ratio of the weight of an airplane to its engine power.
power loading is a calculation commonly applied to aircraft enable the comparison of one aircraft performance to another.

e) Pitching moment coefficient: The **pitching moment coefficient** is important in the study of the longitudinal static stability of aircraft and missiles.

The pitching moment coefficient C_m is defined as follows[3]

$$C_m = \frac{M}{qSc}$$

where M is the pitching moment, q is the dynamic pressure, S is the planform area, and c is the length of the chord of the airfoil. C_m is a dimensionless coefficient so consistent units must be used for M, q, S and c.

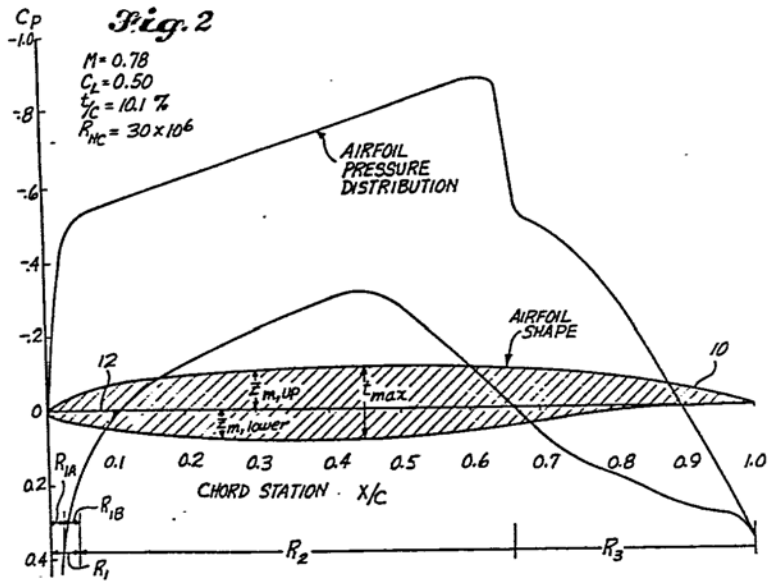
D – 11, Q-1 - B.

Neatly sketch the following:

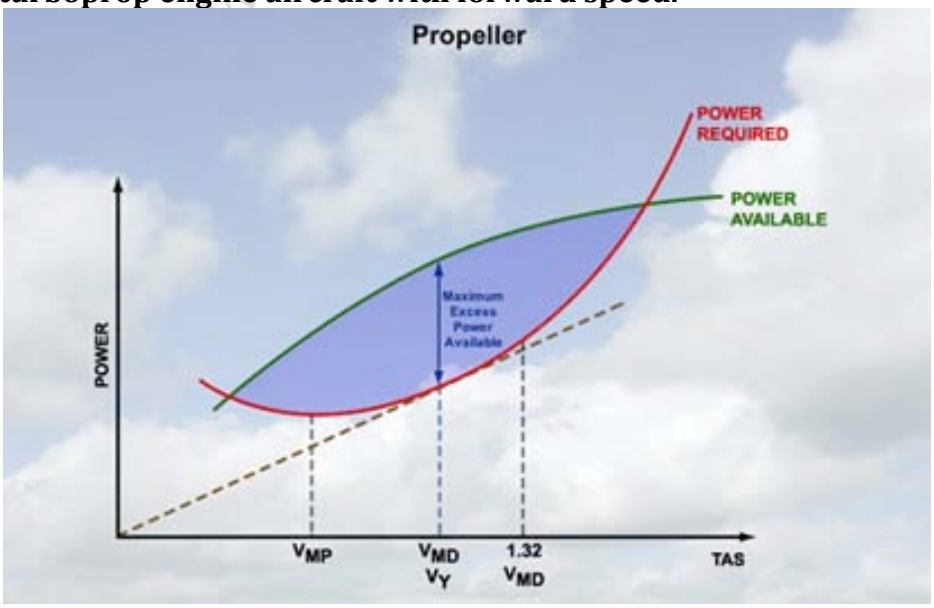
a) **Pressure distribution over a supercritical airfoil.**
b) **Typical variation of Power required and Power available for a turboprop engine aircraft with forward speed.**
c) **V-N diagram for maneuver loads acting on the commuter aircraft.**
d) **Variation of lift coefficient with angle of attack for a tapered wing, at various aspect ratios**
e) **Shear force and bending moment diagrams on a cantilever beam with UDL.**

A.

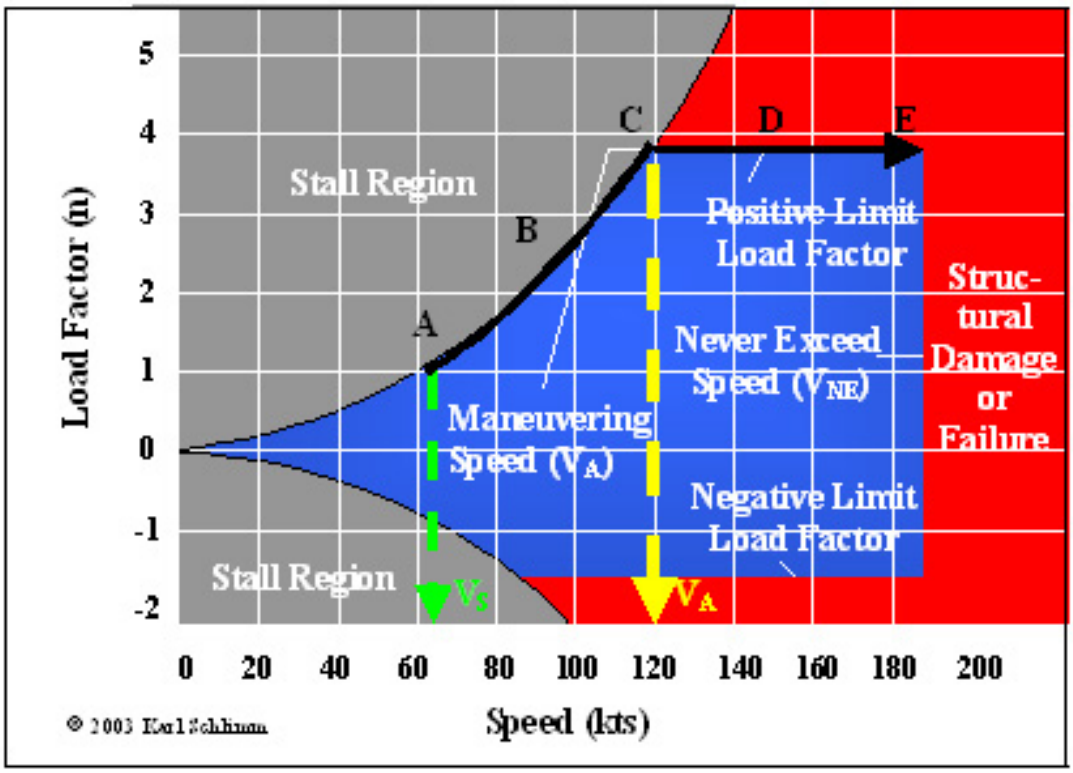
i) **Pressure distribution over a supercritical airfoil.**

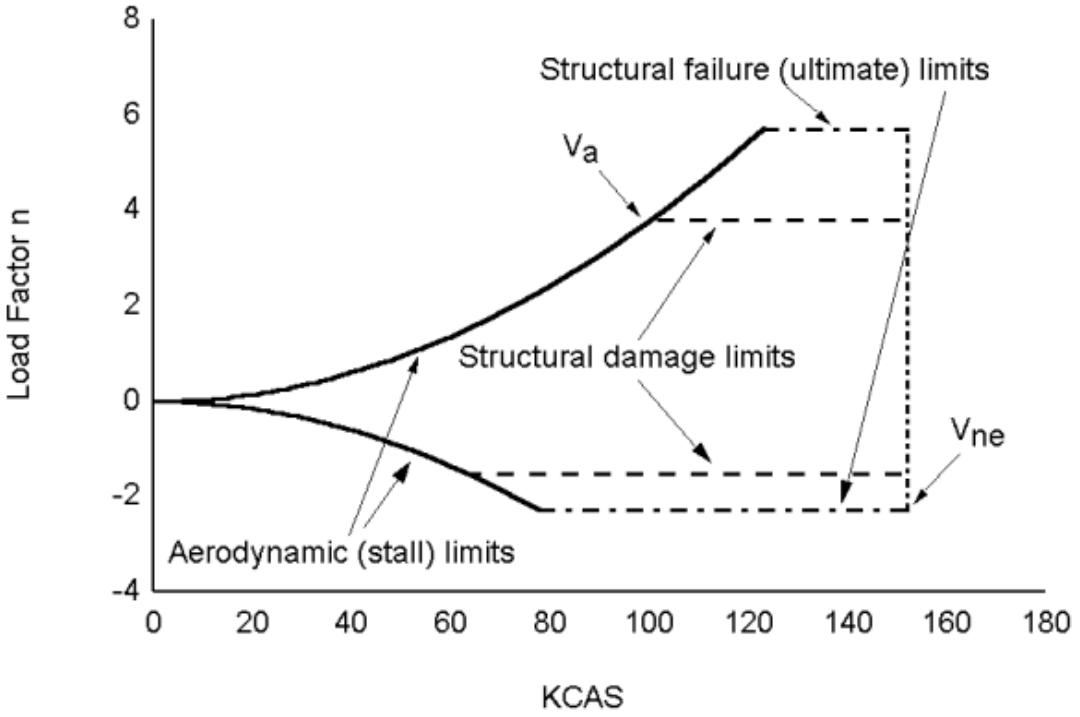


ii) **Typical variation of Power required and Power available for a turboprop engine aircraft with forward speed.**

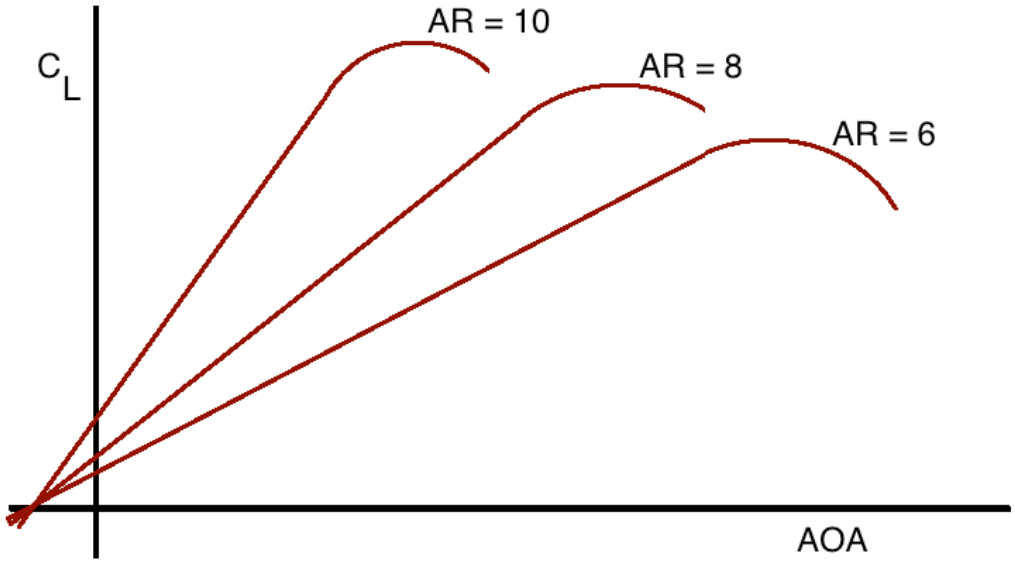


iii) V-N diagram for maneuver loads acting on the commuter aircraft.

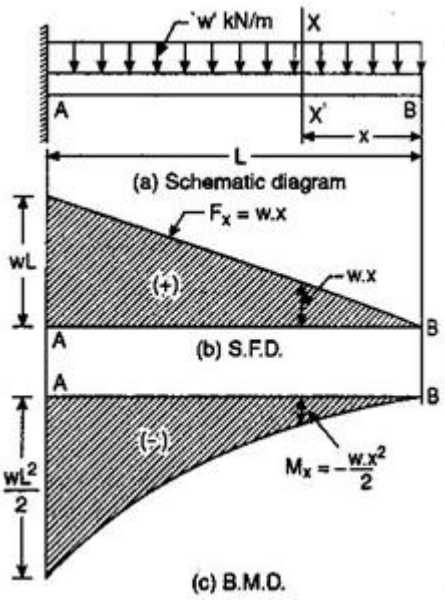




iv) Variation of lift coefficient with angle of attack for a tapered wing, at various aspect ratios



v) Shear force and bending moment diagrams on a cantilever beam with UDL.



D – 11, Q-2 Answer the following questions:

a) What kind of wing layout (low, mid, or high) is most suitable for an aerobatic aircraft and why?

b) A single-engined two-seater general aviation aircraft is to be designed with a top speed of 350 kmph. What kind of engine will you recommend for such an aircraft and why?

c) Explain the relative merits and demerits of providing Taper on an aircraft wing.

d) Why are many pusher aircraft seen with a boom type fuselage layout?

A.

a) Mid-Mount:

➔ Most fighter airplanes and some GA aircraft have mid wing.

➔ A considerable aerodynamic (drag) advantage is associated with the mid wing configuration. Such a wing arrangement tends to minimize interference drag. Because of this, in fighter and trainer airplanes the mid wing configuration is often selected. In aerobatics no passengers need to be carried so a carry through structure passing through the middle of the fuselage can be used.

➔ Mid-mounted wings have the advantage of being structurally efficient when aerospace engineers desire to incorporate a swept or tapered wing design on the aircraft. This increase in structural integrity is essential for aircraft that perform extreme maneuvers or aerobatics.

b)

c) Merits of providing taper:

i. The wing taper will change the wing **lift distribution**. This is assumed as an advantage of the taper, since it is a technical tool to improve the lift distribution. One of the wing design objective is to generate the lift such that the spanwise lift distribution be elliptical.

ii. The taper will reduce the wing **weight**, since the center of gravity of each wing section (left and right) will move toward fuselage center line. This results in a lower bending moment at the wing root. Consequently, this will improve the aircraft **lateral control**.

Demerits of providing taper:

i. The wing taper will increase the **cost** of the wing manufacture, since the wing ribs will have different shapes. Unlike a rectangular planform that all ribs are similar; each rib will have different size. If the cost is of major issue (such as for homebuilt aircraft), do not taper the wing. Thus the primary disadvantage of a tapered wing is that it is more difficult to build.

ii. The typical tapered wing planform has to employ more washout than the elliptical planform wing to see similar stall performance, which puts the tapered wing at a disadvantage.