1. An airplane has an AR = 12, \((L/D)_{\text{max}} = 20\) and \(C_{D_0} = 0.02\). Estimate the value of the Oswald Efficiency Factor for the airplane (hint, recall the relationship between \(C_{D_0}\) and \(C_{D_1}\) at \((L/D)_{\text{max}}\)).

\[
C_{D_0} = C_{D_1} = \frac{C_l^2}{\pi e^* \text{AR}} \quad \frac{C_l}{C_D} = 20 = \frac{C_l}{2C_{D_0}} \quad C_l = 40C_{D_0}
\]

\[
e^* = \frac{C_l^2}{C_{D_0} \pi e^* \text{AR}} = \left(\frac{40}{C_{D_0}}\right)^2 \frac{C_{D_0}^2}{C_{D_0} \pi e^* \text{AR}} = \frac{41}{\pi e^* \text{AR}}
\]

2. An aircraft has the following characteristics as given design parameters: \(W, S, \text{AR}, e^*, C_{D_0}\) The plane is flying straight and level \((T = D, L = W)\) at sea level conditions (STP).

a. For an assumed velocity, \(V_{\infty}\), determine the Thrust Required, \(T_R\).

\[
T_R = D = qS C_D = qS \left( C_{D_0} + \frac{C_l^2}{\pi e^* \text{AR}} \right)
\]

\[
C_l = \frac{W}{qS}
\]

\[
T_R = \frac{pV_{\infty}^2}{2} S C_{D_0} + \frac{2}{\rho V_{\infty}^2 S} \left( \frac{W^2}{\pi e^* \text{AR}} \right)
\]

b. Where is the AOA at a maximum

\(V_{\infty, \text{min}}\) or \(V_{\infty, \text{max}}\)

Where does \(C_{l,\text{max}}\) occur

\(V_{\infty, \text{min}}\) or \(V_{\infty, \text{max}}\)

Where does maximum parasite drag occur

\(V_{\infty, \text{min}}\) or \(V_{\infty, \text{max}}\)

Where does maximum induced drag occur

\(V_{\infty, \text{min}}\) or \(V_{\infty, \text{max}}\)

c. If a jet engine is attached to the airframe with a given \(T_{A_{\text{max}}},\) estimate \(V_{\infty, \text{max}}\).

(if you wish, you may use a simplification from part (b) in this estimate)

\[
T_R = T_{A_{\text{max}}} = \frac{pV_{\infty}^2}{2} S C_{D_0} + \frac{2}{\rho V_{\infty}^2 S} \left( \frac{W^2}{\pi e^* \text{AR}} \right)
\]

\[
\Rightarrow \quad V_{\infty, \text{max}} = \sqrt{2} \frac{T_{A_{\text{max}}}}{\rho S C_{D_0}}
\]

d. In terms of the given conditions, determine the airplane airspeed, \(V_{\infty}\), when operating at \((L/D)_{\text{max}}\).

(hint, you may need \(C_l\) at \((L/D)_{\text{max}}\)).

\[
C_l \left( \frac{C_l}{C_{D_0}} \right) \quad C_{D_0} = C_{D_2} = \frac{C_l}{\pi e^* \text{AR}} \quad C_l = \sqrt{C_{D_0} \pi e^* \text{AR}}
\]

\[
L = W = qS C_l \quad V_{\infty} = \sqrt{\frac{W}{\rho S}} C_l
\]

3. Consider climbing flight with constant \(V_x\), constant flight path angle \(\theta > 0\), and \(\alpha_T = 0\) (thrust alignment). Draw a free body diagram of the airplane properly showing the four principle forces, and derive the two equations of equilibrium, using a coordinate system parallel and perpendicular to the flight path.

\[
L = W \cos \theta \\
T - D - W \sin \theta = 0
\]