Luke Verlangieri	AA 311	HW 6

6.2 given: $W = 5000\,lb$, Sealevel flight $V_\infty = 200\,mi/h$

$(L/D)_{v=V_\infty} = (L/D)_{max}$

$S = 200\,ft^2$, Oswald efficiency $(e) = 0.93$

$AR = 8.5$

Find

The total Drag on the aircraft

Properties

$C_D = C_{D,0} + C_{D_i}$ $C_{D_i} = \frac{C_L^2}{\pi e AR}$

@ max $\frac{L}{D} \rightarrow C_{D,0} = C_{D_i}$ $\frac{L}{D} = \frac{C_L}{C_D}$

$L = C_L \cdot q_\infty \cdot S$

$D = C_D \cdot q_\infty \cdot S$ $q = \frac{1}{2}\rho_\infty V_\infty^2$

Assumptions: Level flight

Analysis

@ sealevel $\rho_\infty = 0.002377 \frac{slug}{ft^3}$ → Appendix

$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}\left(0.002377 \frac{slug}{ft^3}\right)\left(200\,mi/h \cdot \frac{1\,h}{3600\,s} \cdot \frac{5280\,ft}{mi}\right)^2$

$q_\infty = 102.26\,psf$

For level flight, $L = W \rightarrow C_L = \frac{(5000\,lbs)}{(102.26\,psf)(200\,ft^2)} = 0.244$

Because max $\frac{L}{D} \rightarrow C_D = 2C_{D_i} = \frac{2C_L^2}{\pi e AR} = \frac{2(0.244)^2}{\pi(0.93)(8.5)} = 0.00481$

$\frac{L}{D} = \frac{C_L}{C_D} \rightarrow D = \frac{L\,C_D}{C_L} = \frac{(5000\,lbs)(0.00481)}{0.244} = \boxed{98.44\,lbs}$

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6.9 given: $\left(\frac{C_L}{C_D}\right)_{max} = 7.7$ $h = 5000$ ft

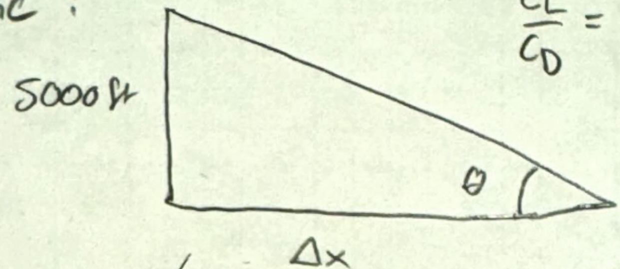
Find: glide distance Assumptions: gliding flight

properties:

$\tan\theta = \frac{1}{L/D}$ Where θ is the angle made with the horizontal

$\frac{C_L}{C_D} = \frac{L}{D}$ $\Delta y = h$

Schematic:



Analysis

$$\theta = \tan^{-1}\left(\frac{1}{L/D}\right) = \tan^{-1}\left(\frac{1}{7.7}\right) = 7.40 \text{ deg}$$

$$\tan\theta = \frac{\Delta y}{\Delta x} \rightarrow \Delta x = \frac{\Delta y}{\tan\theta} = \frac{(5000 \text{ ft})}{\tan(7.40 \text{ deg})} = \boxed{38500 \text{ ft}}$$

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6.11) given: $C_{D,0} = 0.025$ $AR = 6.72$ $e = 0.9$

Find: $(L/D)_{max}$

Assumptions: standard Atmosphere

properties

$L/D = C_L/C_D$ $C_D = C_{D,0} + C_{Di}$

$C_{Di} = \frac{C_L^2}{\pi e AR}$ $@\left(\frac{L}{D}\right)_{max} = C_{DO} = C_{Di}$

Analysis:

$C_{D,0} = C_{Di} = \frac{C_L^2}{\pi e AR} \Rightarrow C_L = \sqrt{C_{D,0}\pi e AR}$

$\rightarrow C_L = \sqrt{0.025 \cdot \pi \cdot 0.9 \cdot 6.72} = 0.6892$

$C_D = 2C_{D,0}$ @ max $L/D = 0.05$

$$\boxed{\left(\frac{L}{D}\right)_{max} = \left(\frac{C_L}{C_D}\right)_{max} = \left(\frac{0.6892}{0.05}\right) = 13.784}$$

6.16 given: Sea level, paved Runway $C_{L,max} = 0.8$

$S = 47\,m^2$, $AR = 6.5$, $e = 0.87$, $W = 103047$

$C_{D0} = 0.032$ 2 40298 N thrust jet engines

wings 5 ft off runway

Find: lift off distance.

$$S_{LO} = \frac{1.44W^2}{g\rho_\infty S C_{L,max}\{T - [D + \mu r(W-L)]_{avg}\}}$$

properties:

$h = 1.52\,m$

at lift off $L = W$

$C_D = C_{D_0} + C_{D_i}$ $\quad C_{D_i} = \frac{C_L^2}{\pi e AR} \cdot \phi$ ground effect

$L = C_L \cdot q_\infty \cdot S$ $\quad D = C_D \cdot q_\infty \cdot S$ $\quad q_\infty = \frac{1}{2}\rho_\infty V_\infty^2$

$\phi = \frac{(16h/b)^2}{1+(16h/b)^2}$ $\quad AR = \frac{b^2}{S}$

Assumptions

Sealevel, paved Runway

$\mu = 0.02$, $V_{LO} = 1.2V_{stall}$

$V_{avg} = 0.7 V_{LO}$

Analysis:

$b = \sqrt{S \cdot AR} = \sqrt{47 \cdot 6.5} = 17.48\,m$

$\phi = \frac{(16h/b)}{1+(16h/b)} = \frac{(16 \cdot \frac{1.52m}{13.78m})}{1+(16 \cdot \frac{1.52m}{13.78m})} = 0.661$

$C_D = C_{D_0} + \frac{C_{L,max}^2}{\pi e AR} \cdot \phi = 0.032 + \frac{0.8^2 \cdot 0.661}{\pi(0.87)(6.5)} = 0.0557$

from the textbook we assume the average velocity to be $0.7 \cdot V_{LO}$. therefore the average drag / Lift is $C_D \frac{1}{2}\rho_\infty V_{avg}^2 S$ & $C_L \frac{1}{2}\rho_\infty V_{avg}^2 S$

$\rho_\infty = 1.225\,\frac{kg}{m^3}$ $\quad L_{LO} = W = C_{Lmax}\frac{1}{2}\rho_\infty V_{stall}^2$

$V_{stall} = \sqrt{\frac{2W}{C_{Lmax} \cdot S \cdot \rho_\infty}} = \sqrt{\frac{2 \cdot 103047\,N}{(0.8 \cdot 47m^2 \cdot 1.225\,\frac{kg}{m^3})}} = 66.89\,\frac{m}{s}$

$V_{LO} = 1.2\,V_{stall} = \frac{V_{avg}}{0.7} \rightarrow V_{avg} = 0.7 \cdot 1.2 \cdot V_{stall} = 56.18\,\frac{m}{s}$

$D_{avg} = (0.0557)\frac{1}{2}(1.225\,\frac{kg}{m^3})(56.18\,\frac{m}{s})^2 \cdot (47m^2) = 5071.3\,N$

$L_{avg} = (0.8)\frac{1}{2}(1.225\,\frac{kg}{m^3})(56.18)^2 \cdot (47m^2) = 72710\,N$

$$S_{LO} = \frac{1.44W^2}{g\rho_\infty S C_{Lmax}(T - (D_{avg} + \mu r(W - L_{avg})))} = \boxed{451.7\,m}$$