

5.2

Given: infinite wing with a NACA 1412

$$C_{r10} = \text{Chord Len} = 3\text{ft} \quad \alpha = 5^\circ$$

$$V_\infty = 100 \text{ ft/s} \quad \text{Sea level}$$

Find

L, D, M

Assumptions: Infinite Length

Properties:

$$\rho_\infty = 2.1162 \frac{\text{lb}}{\text{ft}^3} \quad S_\infty = 2.3769 \frac{\text{slugs}^2}{\text{ft}^3}$$

From appendix D: for NACA 1412 $C_L = 0.7$

$$C_L = \frac{L}{q_\infty C_{r10}} \quad C_D = \frac{D}{q_\infty C_{r10}} \quad C_m = \frac{M}{q_\infty C_{r10}^2} \quad C_{L4} = -0.025$$

$$C_D = 0.0072$$

$$q_\infty = \frac{1}{2} \rho_\infty V_\infty^2$$

Analysis:

$$q_\infty = \frac{1}{2} (2.1162) \frac{\text{slugs}^2}{\text{ft}^3} (100 \text{ ft/s})^2 = 11.8845 \frac{\text{lb}}{\text{ft}^2}$$

$$C_{r10} = 3\text{ft}$$

$$L = C_L \cdot q_\infty \cdot C_{r10} = (0.7 \cdot 3\text{ft} \cdot 11.8845 \frac{\text{lb}}{\text{ft}^2}) = 24.46 \text{ lbs/ft}$$

$$D = C_D \cdot q_\infty \cdot C_{r10} = (0.0072 \cdot 3\text{ft} \cdot 11.8845 \frac{\text{lb}}{\text{ft}^2}) = 0.26 \text{ lbs/ft}$$

$$M_{L4} = C_m \cdot q_\infty \cdot C_{r10}^2 = (-0.025 \cdot (3\text{ft})^2 \cdot 11.8845 \frac{\text{lb}}{\text{ft}^2}) = -2.67 \text{ lbs}$$

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Due 10/22

Given: NACA 4415 Airfoil

$$C_L = 0.85$$

$$\text{Mach } 0.7$$

Assumption: Prandtl-Glauert rule applies

$$\text{Mach} = 0.7$$

Find

Properties: $C_L = \frac{C_{L,0}}{\sqrt{1 - M_\infty^2}}$ α

Analysis

Because the given lift coef is "experimental"
 Solving for $C_{L,0}$ will give a value to consider
 in the table.

$$C_{L,0} = C_L \cdot \sqrt{1 - M_\infty^2} = 0.607$$

Appendix D: NACA 4415 Airfoil

\rightarrow For $C_L = 0.607$ angle of attack = 2°

5.19

Given : Wing Area : $210 \text{ ft}^2 = S$

$$W = 18000 \text{ lbs}$$

$$M_\infty = 2.2$$

$$\text{Altitude} = 36000 \text{ ft}$$

F_{infty}P_{wave}Assumptions

Flat plate, standard atmos, Level flight

Properties

$$C_W = \frac{4\alpha^2}{(M_\infty^2 - 1)^2}$$

$$C_L = \frac{4\alpha}{\sqrt{M_\infty^2 - 1}}$$

$$\begin{aligned} P_0 @ 36000 \text{ ft} \\ \rightarrow 7.1028 \cdot 10^{-4} \text{ slug} / \text{ft}^3 \end{aligned}$$

$$q = \frac{1}{2} P_0 V_\infty^2$$

$$M = \frac{V_\infty}{a}$$

$$a = -\sqrt{\gamma R T}$$

$$D = C_W \cdot q \cdot S$$

$$L = C_L \cdot q \cdot S$$

Analysis

$$T @ 390.53 \text{ R}^0 \quad R = 1716 \frac{\text{ft} \cdot \text{lbf}}{\text{slug} \cdot \text{R}^0}$$

$$\gamma = 1.4$$

$$\rightarrow a = \sqrt{\gamma R T} \Rightarrow a = 968.612 \frac{\text{ft}}{\text{s}^2}$$

$$V_\infty = M \cdot a = 2130.95 \frac{\text{ft}}{\text{s}}$$

$$q = \frac{1}{2} (7.1028 \cdot 10^{-4} \frac{\text{slug}}{\text{ft}^3}) (2130.95 \frac{\text{ft}}{\text{s}})^2 = 1612.67$$

$$L = W = C_L \cdot q \cdot S \rightarrow C_L = \frac{W}{q \cdot S} = 0.1063$$

$$C_L = \frac{4\alpha}{\sqrt{M_\infty^2 - 1}} \rightarrow \frac{C_L \cdot \sqrt{M_\infty^2 - 1}}{4} = \alpha = 2.984^\circ$$

$$C_{D,W} = \frac{4\alpha^2}{\sqrt{M_\infty^2 - 1}} = 0.0055'$$

$$D_W = 2 \cdot C_{D,W} \cdot q \cdot S = 3749.5 \text{ lbf}$$

↑

2 sides of plate