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AA 311

Due 10/22

S.2

Given: Infinite wing with a NACA 1412

$$c_{m0} = \text{Chord Len} = 3 \text{ ft} \quad \alpha = 5^\circ$$

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

Find

L, D, M

Assumptions: Infinite Length

Properties:

$$\rho_\infty = 2.1162 \text{ lb/ft}^3 \quad \mu_\infty = 2.3769 \frac{\text{slug}}{\text{ft}^3}$$

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

$$C_L = \frac{L}{q_\infty c_{m0}} \quad C_D = \frac{D}{q_\infty c_{m0}} \quad C_m = \frac{M}{q_\infty c_{m0}^2} \quad C_m, c/4 = -0.025$$

$$C_D = 0.0072$$

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

Analysis

$$q_\infty = \frac{1}{2} (2.1162 \frac{\text{lb}}{\text{ft}^3}) (100 \text{ ft/s})^2 = 111.8845 \frac{\text{lb}}{\text{ft}^2}$$

$$c_{m0} = 3 \text{ ft}$$

$$L = C_L \cdot q_\infty \cdot c_{m0} = (0.7 \cdot 3 \text{ ft} \cdot 111.8845 \frac{\text{lb}}{\text{ft}^2}) = 24.96 \text{ lbf}$$

$$D = C_D \cdot q_\infty \cdot c_{m0} = (0.0072 \cdot 3 \text{ ft} \cdot 111.8845 \frac{\text{lb}}{\text{ft}^2}) = 0.26 \text{ lbf}$$

$$M_{c/4} = C_m \cdot q_\infty \cdot c_{m0}^2 = (-0.025 \cdot (3 \text{ ft})^2 \cdot 111.8845 \frac{\text{lb}}{\text{ft}^2}) = -2.67 \text{ lbf}$$

Like Verlangieri

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S. 14

Given: NACA 4415 Airfoil

$$C_L = 0.85$$

$$\text{Mach } 0.7$$

Assumption: Prandtl-Glauert rule applies

$$\text{Mach} < 0.7$$

Find

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

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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

→ For $C_{L,0} = 0.607$ angle of attack = 2°

5.19

Given : Wing Area : $210 \text{ ft}^2 = S$
 $W = 18000 \text{ lbs}$
 $M_{\infty} = 2.2$
 Altitude : 36000 ft

Find

Dwave

Assumptions

Flat plate, standard atmos, Level flight

Properties:

$$C_W = \frac{4\alpha^2}{(M_{\infty}^2 - 1)^{3/2}}$$

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

$$\rho_{\infty} @ 36000 \text{ ft} \rightarrow 7.1028 \cdot 10^{-4} \text{ slug/ft}^3$$

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

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

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

$$D = C_D \cdot q_{\infty} \cdot S$$

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

Analysis

$$T @ 390.53 \text{ R}^{\circ}$$

$$R = 1716 \frac{\text{ft} \cdot \text{lb}}{\text{slug} \cdot \text{R}^{\circ}}$$

$$\gamma = 1.4$$

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

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

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

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

$$C_L = \frac{4\alpha}{\sqrt{M_{\infty}^2 - 1}} \rightarrow \frac{C_L \cdot \sqrt{M_{\infty}^2 - 1}}{4} = \alpha = 2.954^{\circ}$$

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

$$D_W = C_{D,W} \cdot q \cdot S = 1875 \text{ lbf}$$