Luke Velangiori | AA 311 | Due 10/22

5.2) Given: infinite wing with a NACA 1412

$c_{(1)}$ = Chord Len = 3 ft $\alpha = 5°$

V_∞ = 100 ft/s   Sea level

Find: L, D, M

Assumptions: Infinite Length

Properties:

$P_\infty = 2.1162 \, lb/ft^2$ $\rho_\infty = 2.3769 \, \frac{slugs}{ft^3}$

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

$c_{m,c/4} = -0.025$

$c_l = \frac{L}{q_\infty c_{(1)}}$ $c_d = \frac{D}{q_\infty c_{(1)}}$ $c_m = \frac{M}{q_\infty c^2_{(1)}}$ $c_d = 0.0072$

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

Analysis

$q_\infty = \frac{1}{2}(2.3769 \frac{slugs}{ft^3})(100 \, ft/s)^2 = 11.8845 \frac{lb}{ft^2}$

$c_{(1)} = 3 ft$

$$\boxed{\begin{aligned} L &= c_l \cdot q_\infty \cdot c_{(1)} = (0.7 \cdot 3ft \cdot 11.8845 \tfrac{lb}{ft^2}) = 24.96 \text{ lbs/ft} \\ D &= c_d \cdot q_\infty \cdot c_{(1)} = (0.0072 \cdot 3ft \cdot 11.8845 \tfrac{lb}{ft^2}) = 0.26 \text{ lbs/ft} \\ M_{c/4} &= c_m \cdot q_\infty \cdot c_{(1)}^2 = (-0.025 \cdot (3ft)^2 \cdot 11.8845 \tfrac{lb}{ft^2}) = -2.67 \text{ lbs} \end{aligned}}$$

Luke Verlangieri | AA 311 | Due 10/22

5.14

Given: NACA 4415 Airfoil

$C_\ell = 0.85$

Mach 0.7

Assumption: Prandtl-Glauert rule applies

Mach =< 0.7

Find:

α

Properties: $C_\ell = \dfrac{C_{\ell,0}}{\sqrt{1-M_\infty^2}}$

Analysis

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

$C_{\ell_0} = C_\ell \cdot \sqrt{1-M_\infty^2} = 0.607$

Appendix D: NACA 4415 Airfoil

$\boxed{\rightarrow \text{ For } C_{\ell_\infty} = 0.607 \text{ angle of attack} = 2^\circ}$

1

Luke Velangieri | AA 311 | Due 10/22

5.19 Given : Wing Area : $210\ ft^2 = S$

$W = 16000$ lbs

$M_\infty = 2.2$

Altitude = 36000 ft

Find : D_{wave}

Assumptions

Flat plate, standard atmos, Level flight

Properties

$$C_w = \frac{4\alpha^2}{(M_\infty^2 - 1)^{1/2}} \qquad C_\ell = \frac{4\alpha}{\sqrt{M_\infty^2 - 1}}$$

ρ_∞ @ 36000 ft → $7.1028 \cdot 10^{-4}$ slugs/ft³

$$q = \frac{1}{2}\rho_\infty V_\infty^2 \qquad M = \frac{V_\infty}{a} \qquad a = \sqrt{\gamma R T}$$

$$D = C_d \cdot q_\infty \cdot S \qquad L = C_\ell \cdot q_\infty \cdot S$$

Analysis

T @ $= 390.53\ R^\circ$ $\qquad R = 1716 \frac{ft \cdot lb}{slug \cdot R^\circ}$

$\gamma = 1.4$

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

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

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

$$L = W = C_\ell \cdot q_\infty \cdot S \Rightarrow C_\ell = \frac{W}{q_\infty \cdot S} = 0.0472$$

$$C_\ell = \frac{4\alpha}{\sqrt{M_\infty^2 - 1}} \rightarrow \frac{C_\ell \cdot \sqrt{M_\infty^2 - 1}}{4} = \alpha = 1.326^\circ = 0.2315 \frac{rad}{s}$$

$$c_{D,w} = \frac{4\alpha^2}{\sqrt{M_\infty^2 - 1}} = 0.001093$$

$$\boxed{D_w = c_{D,w} \cdot q \cdot S = 370.3\ lbf}$$