

Home Work #2

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Question 1

Data:

$$\begin{aligned}\bar{x}_{ac} - \bar{x}_{cg} &= 0.05, \quad C_{m_{acwb}} = -0.016, \quad C_{L_{wb}} = 0.45 \\ C_m &= C_{m_{acwb}} + C_{L_{wb}}(\bar{x}_{ac} - \bar{x}_{cg})\end{aligned}\tag{1}$$

From equation 1 we have:

$$C_m = -0.016 + 0.45(0.05) = 0.0065 \rightarrow C_m = 0.0065$$

Question 2

(a)

We assume that $C_{L_{wb}}$ have linear behavior between -1.5° and 8° .

At (-1.5) degree $C_{L_{wb}}$ is 0 and at 5 degree $C_{L_{wb}}$ is 0.52.

$$\begin{aligned}\frac{\Delta C_{L_{wb}}}{\Delta \alpha} &= C_{L_{\alpha_{wb}}} \rightarrow C_{L_{\alpha_{wb}}} = \frac{0.52 - 0.0}{5 - (-1.5)} = 0.08 \\ C_{L_{wb}} &= C_{L_{0_{wb}}} + C_{L_{\alpha_{wb}}} \alpha = 0.12 + 0.08\alpha\end{aligned}\tag{2}$$

From equation 2 at 1 degree angle of attack $C_{L_{wb}} = 0.2$ and at 7.88 degree angle of attack $C_{L_{wb}} = 0.75$.

$$C_m = C_{m_0} + C_{m_\alpha} \alpha\tag{3}$$

$$C_{m_{wb}} = (C_{m_{acwb}} + C_{L_{0_{wb}}}(\bar{x}_{cg} - \bar{x}_{acwb})) + C_{L_{\alpha_{wb}}}(\bar{x}_{cg} - \bar{x}_{acwb})\tag{4}$$

From equation 4:

1. at 1 degree angle of attack:

$$-0.01 = C_{m_{acwb}} + 0.2(0.35 - \bar{x}_{acwb})$$

2. at 7.88 degree angle of attack:

$$0.05 = C_{m_{acwb}} + 0.75(0.35 - \bar{x}_{acwb})$$

There is 2 equation and 2 unknowns.

$$x_{acwb} = 0.24c, \quad C_{m_{acwb}} = -0.032$$

(b)

$$C_m = C_{m_0} + C_{m_\alpha} \alpha + C_{m_{i_H}} i_H \quad (5)$$

Now define every parameter in equation 5.

$$\begin{aligned} C_{m_0} &= C_{m_{ac_{wb}}} + C_{L_{0_{wb}}} (\bar{x}_{cg} - \bar{x}_{ac_{wb}}) \\ C_{m_\alpha} &= C_{L_{\alpha_{wb}}} (\bar{x}_{cg} - \bar{x}_{ac_{wb}}) - C_{L_{\alpha_H}} \eta_H \frac{S_H}{S} (1 - \frac{\partial \varepsilon}{\partial \alpha}) (\bar{x}_{ac_H} - \bar{x}_{cg}) \\ C_{m_{i_H}} &= C_{L_{\alpha_H}} \eta_H \frac{S_H}{S} (\bar{x}_{ac_H} - \bar{x}_{cg}) \end{aligned}$$

Data:

$$\alpha = 7.88^\circ, \quad C_{m_{ac_{wb}}} = -0.032, \quad C_{L_{\alpha_{wb}}} = 0.08$$