4.19

An aircraft is described in prob 4.19.

The 4 state longitudinal equations of motion are:

$$\frac{d}{dt}\begin{pmatrix}\Delta u\\ \Delta w\\ \Delta q\\ \Delta\theta\end{pmatrix}=\begin{bmatrix}X_u & X_w & 0 & -g\\ Z_u & Z_w & u_0 & 0\\ M_u+M_{\dot{w}}Z_u & M_w+M_{\dot{w}}Z_w & M_q+M_{\dot{w}}u_0 & 0\\ 0 & 0 & 1 & 0\end{bmatrix}\begin{pmatrix}\Delta u\\ \Delta w\\ \Delta q\\ \Delta\theta\end{pmatrix}$$

Do NOT reverse engineer C_{D_0} :

$$C_D = C_{D_0} + \frac{1}{\pi ARe}C_L^2 = C_{D_0} + \frac{S}{\pi b^2 e}C_L^2$$

$$0.102 = C_{D_0} + \frac{5500}{\pi \cdot 195.68^2 \cdot 0.85}1.11^2$$

$$C_{D_0} = 0.0357$$

The "nought" refers to the reference flight condition. CL0 refers to the reference condition NOT the zero lift condition. Similarly, CD0 is the reference drag condition NOT the zero lift drag condition. CD0 = 0.102.

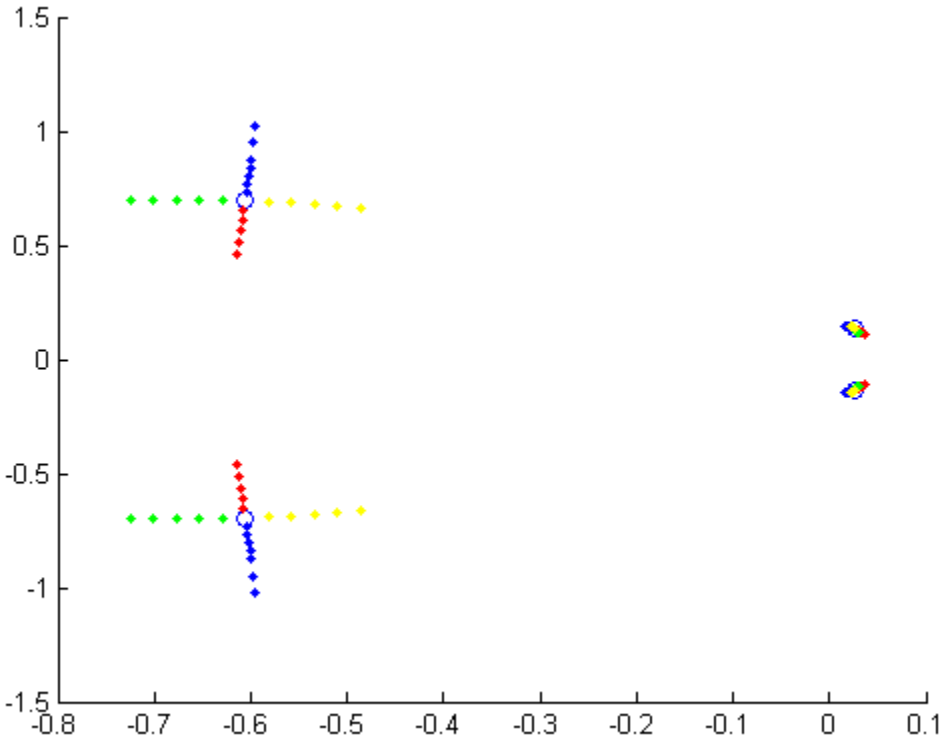
The book has seriously wrong units and typos in chapter 4. The -3.2 1/rad value term should be $C_{m_{\dot{\alpha}}}$ with units of s/rad. Verify this with the 747 data in the Appendix (this is the aircraft in 4.19). Worse, the example on page 157 also has wrong units.

Long' derivatives:

$$X_u = \frac{-(C_{Du}+2C_{D0})qS}{mu_0} \qquad X_w = \frac{-(C_{D\alpha}+2C_{L0})qS}{mu_0}$$

$$Z_u = \frac{-(C_{Lu}+2C_{L0})qS}{mu_0} \qquad Z_w = \frac{-(C_{L\alpha}+2C_{D0})qS}{mu_0}$$

$$M_u = C_{m\alpha}\frac{qS\bar{c}}{I_y u_0} \qquad M_{\dot{w}} = C_{m\dot{\alpha}}\frac{\bar{c}}{2u_0}\frac{qS\bar{c}}{u_0 I_y}$$



Green: Increase Cmq -> increase short period damping

Yellow: Decrease Cmq

Blue: Increase Cma -> Increase short period frequency, slightly increase phugoid damping

Red: Decrease Cma