7.1 $C_{M_{cg}} = C_{M_{ac}} + C_L (h - h_{ac})$

$$C_{M_{cac}} = C_{Mcg} - C_L (h - h_{ac}) = 0.005 - 0.05\,(0.03) = \boxed{-0.01}$$

7.2 $q_\infty = \frac{1}{2} \rho_\infty V_\infty^2 = \frac{1}{2} (1.225)(100)^2 = 6125 \text{ N/m}^2$

At zero lift, the moment coefficient about c.g. is

$$C_{M_{cg}} = \frac{M_{cg}}{q_\infty S\ c} = \frac{-12.4}{(6125)(1.5)(0.45)} = -0.003$$

However, at zero lift, this is also the value of the moment coefficient about the a.c.

$$C_{M_{ac}} = \boxed{-0.003}$$

At the other angle of attack,

$$C_L = \frac{L}{q_\infty S} = \frac{3675}{(6125)(1.5)} = 0.4$$

and $$C_{M_{cg}} = \frac{M_{cg}}{q_\infty S\ c} = \frac{20.67}{(6125)(1.5)(0.45)} = 0.005$$

Thus, from Eq. (7.9) in the text,

$$C_{M_{cg}} = C_{M_{ac}} + C_L (h - h_{ac})$$

Thus,

$$h - h_{ac} = \frac{C_{M_{cg}} - C_{M_{ac}}}{C_L} = \frac{0.005 - (-0.003)}{0.4}$$

$$h - h_{ac} = \boxed{0.02}$$

The aerodynamic center is two percent of the chord length <u>ahead</u> of the center of gravity.

7.3 From the results of problem 7.2,

$$q_\infty = 6125 \text{ N/m}^2$$

$$C_{M_{ac}} = -0.003$$

$$h - h_{ac} = 0.02$$

In the present problem, the c.g. has been shifted 0.2c rearward. Hence,

$$h - h_{ac} = 0.02 + 0.2 = 0.22$$

Also, $$C_L = \frac{L}{q_\infty S} = \frac{4000}{(6125)(1.5)} = 0.435$$

Thus, $$C_{M_{cg}} = C_{M_{ac}} + C_L (h - h_{ac})$$

$$C_{M_{cg}} = -0.003 + 0.435\ (0.22) = \boxed{0.0927}$$

7.6 $h_n = h_{ac_{wb}} + V_H \frac{a_t}{a}\left(1 - \frac{\partial \varepsilon}{\partial \varepsilon}\right)$

From Problem 7.2, $h_n - h_{ac_{wb}} = 0.02$

Hence,

$$h_{ac_{wb}} = h - 0.02 = 0.26 - 0.02 = 0.24$$

$$h_n = 0.24 + 0.593 \left(\frac{0.12}{0.09}\right) (1 - 0.42)$$

$$h_n = \boxed{0.70}$$

By definition,

$$\text{static margin} = h_n - h = 0.70 - 0.26 = \boxed{0.44}$$

7.7 $$\delta_{trim} = \frac{C_{M_o} + \left(\partial C_{M_{cg}} / \partial \alpha_a\right)\alpha_n}{V_H\left(\partial C_{L_t} / \partial \delta_e\right)}$$

$C_{M_o} = 0.139$ (from Problem 7.5)

$\partial C_{M_{cg}} / \partial \alpha_a = -0.039$ (from Problem 7.5)

$\alpha_n = 8^\circ$

$V_H = 0.593$ (from Problem 7.4)

$\partial C_{L_t} / \partial \delta_e = 0.04$ (given)

Thus, $$\delta_{trim} = \frac{0.139 + (-0.039)(8)}{(0.593)(0.04)} = \boxed{-7.29^\circ}$$
