5) i) De 2.3.21a ignorando efeitos propulsivos

$$C_{m_\alpha} = a(h - h_{n_{wb}}) - a_t \bar{V}_H \left(1 - \frac{d\varepsilon}{d\alpha}\right) \quad \mathrm{I}$$

De 2.2.10

$$\bar{V}_H = \frac{l_t S_t}{\bar{c} S} \quad \mathrm{II}$$

De 2.3.18

$$a = a_{wb}\left[1 + \frac{a_t}{a_{wb}}\frac{S_t}{S}\left(1 - \frac{d\varepsilon}{d\alpha}\right)\right] \quad \mathrm{III}$$

Usando $C_{m\alpha} < 0$, substituindo II e III em I

$$C_{m\alpha} = a\left(h - h_{n_{wb}}\right) - a_t \bar{V}_H \left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right) < 0$$

$$h < h_{n_{wb}} + \frac{a_t \frac{\bar{l}_t S_t}{\bar{c} S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)}{a_{wb}\left[1 + \frac{a_t}{a_{wb}} \frac{S_t}{S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right]} \qquad \text{IV}$$

$$h < 0{,}5607$$

ii) De 2.3.22a ignorando efeitos propulsivos

$$C_{m_0} = C_{m_{ac_{wb}}} + a_t \bar{V}_H (\varepsilon_0 + i_t) \left[1 - \frac{a_t}{a} \frac{S_t}{S} \left(1 - \frac{\partial \varepsilon}{\partial \alpha} \right) \right] \qquad \text{V}$$

Usando $C_{m_0} > 0$, substituindo II e III em V

$$C_{m_0} = C_{m_{ac_{wb}}} + a_t \bar{V}_H (\varepsilon_0 + i_t) \left[1 - \frac{a_t}{a} \frac{S_t}{S} \left(1 - \frac{\partial \varepsilon}{\partial \alpha} \right) \right] > 0$$

$$i_t > - \frac{C_{m_{acwb}}}{a_t \dfrac{\bar{l}_t S_t}{\bar{c} S} \left[1 - \dfrac{a_t \dfrac{S_t}{S} \left(1 - \dfrac{\partial \varepsilon}{\partial \alpha} \right)}{a_{wb} \left[1 + \dfrac{a_t}{a_{wb}} \dfrac{S_t}{S} \left(1 - \dfrac{\partial \varepsilon}{\partial \alpha} \right) \right]} \right]} - \varepsilon_0 \qquad (VI)$$

$$i_t > -0{,}193^\circ$$

iii) Para voo trimado $\delta_e = 0$, de 2.3.20a

$$C_m = C_{m_0} + C_{m_\alpha}\alpha = 0 \qquad \text{(VII)}$$

Em voo não acelerado e com $C_L = a\alpha$

$$L = W = a\alpha \frac{1}{2}\rho V^2 S$$

$$\alpha = \frac{2W}{\rho V^2 S a}$$

sendo

$W = mg = 22680 \cdot 9{,}81 = 222\,491\ N$

$S = (25)^2\ 0{,}139 = 86{,}875\ m^2$

Encontra-se α de III, logo $\alpha = 3{,}141°$

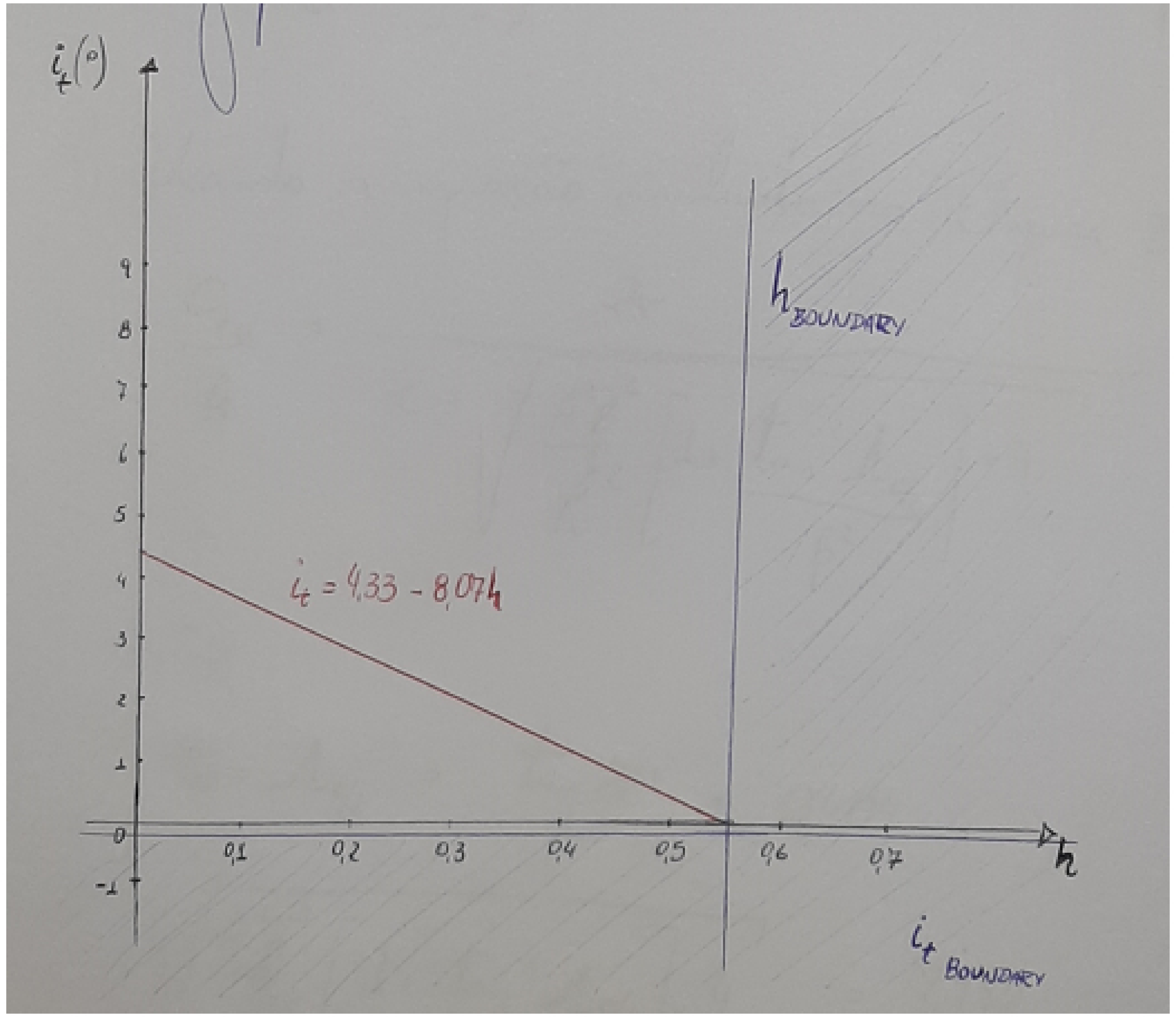
Combinando I, V, VIII em XII temos $i_t = f(h)$

$C_{m_0} + C_{m_\alpha}\ \alpha = 0$

$$C_{m_{ac_{wb}}} + a_t \bar{V}_H (\varepsilon_0 + i_t)\left[1 + \frac{a_t}{a}\frac{S_t}{S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right] + \left[a(h - h_{n_{wb}}) - a_t \bar{V}_H\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right]\frac{2W}{\rho V^2 S a} = 0 \qquad \text{IX}$$

$$i_t = \frac{- C_{m_{ac_{wb}}} - \left[a(h - h_{n_{wb}}) - a_t \bar{V}_H\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right]\frac{2W}{\rho V^2 S a}}{a_t \bar{V}_H\left[1 + \frac{a_t S_t}{a S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right]} - \varepsilon_0 \qquad \text{X}$$

$$i_t = (4{,}33 - 8{,}07h)\ deg$$



6) i) De C.2, temos

$$A = \frac{b^2}{S} = 7{,}16 \qquad \text{I}$$

$$\lambda = \frac{c_t}{c_r} = 0{,}236 \qquad \text{II}$$

Da tabela C.1

$$\bar{c} = \frac{2c_r}{3}\,\frac{1+\lambda+\lambda^2}{1+\lambda} = 7{,}92\,m\ (25{,}99\,ft) \qquad \text{III}$$

ic) Da eq. incluída na fig. B.1.2

$$\frac{C_{L\alpha}}{A} = \frac{2\pi}{2 + \sqrt{\frac{A^2\beta^2}{k^2}\left[1 + \frac{\tan^2 \Lambda_{c/2}}{\beta^2}\right] + 4}} \qquad \text{IV}$$

tem: $\tan \Lambda_{c/2} = \tan 22° = 0{,}404$

$$\sqrt{\frac{A^2\beta^2}{K^2}\left[1 + \frac{\tan^2 \Lambda_{c/2}}{\beta^2}\right] + 4} = 7{,}977 \qquad \text{V}$$

Em IV

$$a_w = C_{L\alpha} = \frac{2\pi A}{2 + \sqrt{\frac{A^2\beta^2}{K^2}\left[1 + \frac{\tan^2 \Lambda_{c/2}}{\beta^2}\right] + 4}} \qquad \text{VI}$$

$$a_w = C_{L\alpha} = 4{,}51 \ \text{rad}^{-1}$$

iii) Temos

$$\frac{\partial \varepsilon}{\partial \alpha} = \frac{2 a_w}{\pi A} = 0{,}4$$ (VII)

$$a_t = 0{,}068 \text{ deg}^{-1} = 3{,}90 \text{ rad}^{-1}$$ (VIII)

De 2.3.18

$$a = a_{wb}\left[1 + \frac{a_t}{a_{wb}} \frac{S_t}{S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)\right]$$ (IX)

$$a = 5{,}05 \text{ rad}^{-1}$$

iv) $l_t = \bar{l}_t$, então $V_H = \bar{V}_H$

De 2.2.11

$$V_H = \bar{V}_H - \frac{\bar{S}_t}{\bar{S}} (h - h_{nwb}) \quad (\mathrm{X})$$

Como $V_H = \bar{V}_H$

$$h = h_{nwb} \quad (\mathrm{XI})$$

De 2.3.23 com $h_{nwb} = h$ $\quad (\mathrm{XII})$

$$h - h_n = -\frac{a_t}{a} \bar{V}_H \left(1 - \frac{d\varepsilon}{d\alpha}\right)$$

De 2.2.10

$$\bar{V}_H = \frac{\bar{l}_t S_t}{\bar{c} S}$$

$(XIII)$

De 2.3.25c

$$C_{m_\alpha} = a(h - h_n)$$

(XIV)

Substi. (XII) e $(XIII)$ em (XIV)

$$C_{m_\alpha} = -a_t \bar{V}_H \left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right)$$

$$C_{m\alpha} = -a_t \frac{\bar{l}_t S_t}{\bar{c} S}\left(1 - \frac{\partial \varepsilon}{\partial \alpha}\right) = -1{,}90 \text{ rad}^{-1}$$

XV

v) Do gráfico C_m versus C_L observa-se que $C_{m_{\delta e}}$ é independente de C_L e C_m e A δe apenas muda as linhas por uma constante

$$C_{m_{\delta e}} = \frac{dC_m}{d\delta_e} = \frac{\Delta C_m}{\Delta \delta e} = \frac{C_{m_f} - C_{m_i}}{\delta e_f - \delta e_i} = \frac{-0{,}56}{20}$$

$$C_{m_{\delta e}} = -0{,}028 \ deg^{-1}$$

XVI

De $\delta_{e_{trim}}$ $C_{L_{trim}}$

- Para $h = 0{,}35$

$$\frac{d\,\delta_{e_{trim}}}{dC_{L_{trim}}} = \frac{\Delta\,\delta_{e_{trim}}}{\Delta C_{L_{trim}}} = \frac{\delta_{e_{trim_f}} - \delta_{e_{trim_i}}}{C_{L_{trim_f}} - C_{L_{trim_i}}} = \frac{-22{,}8}{2}$$

$$\frac{d}{dC_{L_{trim}}}\,\delta_{e_{trim}} = -11{,}4^{\circ}$$

XVII

- Para $h = 0{,}25$

$$\frac{d\,\delta_{e_{trim}}}{dC_{L_{trim}}} = \frac{-27{,}8}{1{,}85} = -15{,}03^\circ \qquad \text{(XVIII)}$$

De 2.4.13c

$$\frac{d\,\delta_{e_{trim}}}{dC_{L_{trim}}} = -\frac{C_{L\alpha}}{C_{L\delta t}}(h - h_n) \qquad \text{(XIX)}$$

$$= \frac{-a}{a_{\delta t}}(h - h_n)$$

sendo $\det = C_{L\alpha} C_{m_{\delta e}} - C_{L_{\delta e}} C_{m\alpha}$ (XX)

De (XIX)

$$h - h_n = -\frac{\det}{a} \frac{d\,\delta e_{trim}}{dC_{L_{trim}}}$$

Para as duas posições do CG temos:

$$\begin{cases} 0{,}35 - h_n = 11{,}4 \dfrac{det}{a} \\ 0{,}25 - h_n = 15{,}03 \dfrac{det}{a} \end{cases}$$

XXII

a)

b)

Assim encontraremos

$h_n = 0{,}665$

XXIII

$D = 2 \cdot 3 \cdot 25c$

$$C_{m_\alpha} = a\,(h - h_n)$$

para $h = 0{,}30$

$$C_{m_\alpha} = -1{,}84 \ \text{rad}^{-1}$$