$$\begin{array}{llllllll} 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array}$$

a) $L = f(b, c, h, \alpha, \rho_\infty, V_\infty, a_\infty, \mu_\infty)$

1 $D = f($ " $)$

$\Lambda \equiv L/D = f($ " $)$

b) # Parameters : $N = 9$

\# Units : $K = 3$ mass, length, time

6 Π groups expected

$\Pi_1 = \Lambda$

$\Pi_2 = \alpha$

$\Pi_3 = b/c$ aspect ratio

$\Pi_4 = h/c$ height/chord ratio

$\Pi_5 = V_\infty / a_\infty \equiv M_\infty$

$\Pi_6 = \rho_\infty V_\infty c / \mu_\infty \equiv Re_\infty$

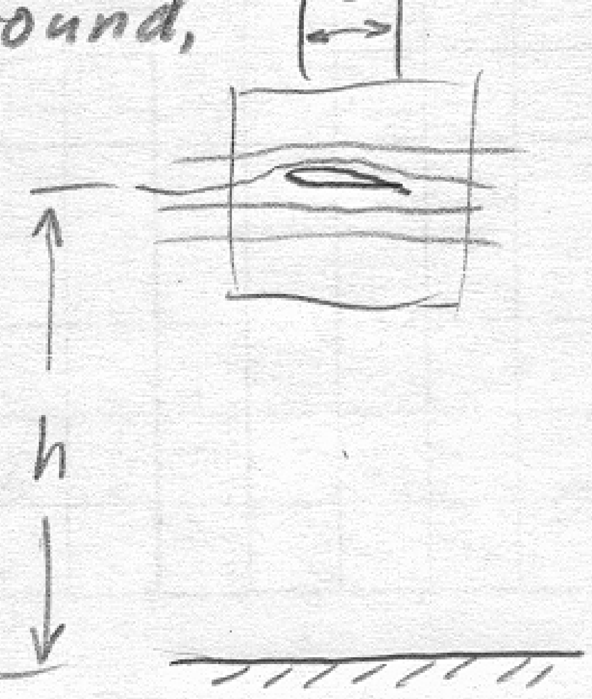
$$\rightarrow \boxed{\Lambda = \bar{f}\left(\alpha, \frac{b}{c}, \frac{h}{c}, M_\infty, Re_\infty\right)}$$

Many alternative Π sets are possible, e.g.

c/b instead of b/c
h/b instead of h/c etc.

c) Wing is "high enough" when $\boxed{\frac{h}{c} \gg 1}$, or $\boxed{\frac{h}{b} = \frac{h}{c} \cdot \frac{c}{b} \gg 1}$

Airflow then should not be significantly affected by ground.



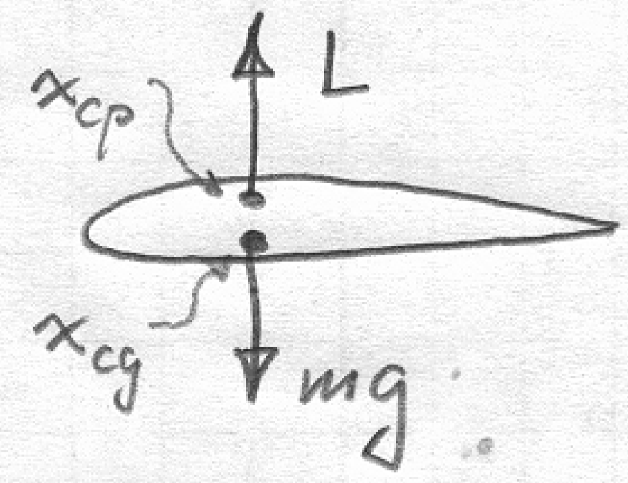
a) $\left(M'_{ref} = M'_{LE} + L' x_{ref} \right) b$, note: $M'b = M$, $L'b = L$

$$M_{ref} = M_{LE} + L\, x_{ref}$$

for this case we set $x_{ref} = 0.25c$

$$M_{c/4} = q_\infty S c (0.025 - 1.25\alpha) + q_\infty S \overbrace{5\alpha \cdot 0.25c}^{1.25\alpha}$$

$$\boxed{M_{c/4} = q_\infty S c \cdot 0.025} \quad (\text{independent of } \alpha)$$



b) In equilibrium flight, must have $x_{cg} = x_{cp}$ to get zero net moment.

Or, we can simply start by requiring $M_{0.2c} = 0$

$$M_{0.2c} = M_{LE} + L \cdot 0.2c = 0$$

$$q_\infty S c \cdot (0.025 - 1.25\alpha) + q_\infty S\, 5\alpha \cdot 0.2c = 0$$

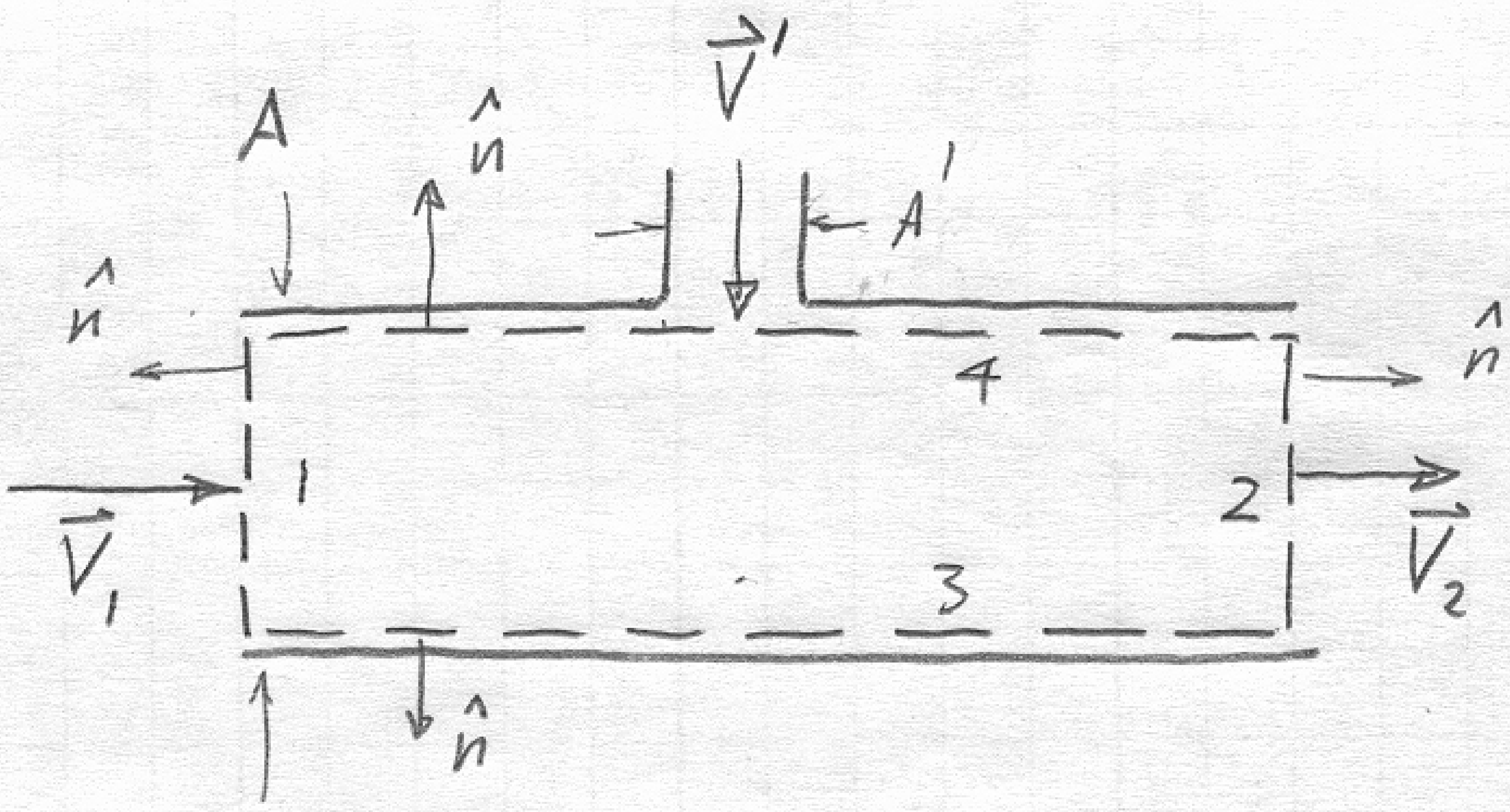
$$q_\infty S c \left(0.025 - 1.25\alpha + 1.0\alpha \right) = 0$$

$$0.025 - 0.25\alpha = 0$$

$$\boxed{\alpha = 0.1 \text{ radians}}$$

$$\oint\!\!\oint \rho (\vec{V}\cdot\hat{n})\, dA = 0 \qquad \text{(mass)}$$

$$\oint\!\!\oint \rho(\vec{V}\cdot\hat{n})\vec{V}\,dA + \oint\!\!\oint p\hat{n}\,dA = 0 \qquad \text{(mom.)}$$



a) Using mass equation:

$$I_1 = -\rho V_1 A$$
$$I_2 = \rho V_2 A$$
$$I_3 = 0$$
$$+\quad I_4 = -\rho V' A' = -\rho(2V_1)\cdot(\tfrac{1}{4}A) = -\tfrac{1}{2}\rho V_1 A$$

$$I = \rho V_2 A - \rho V_1 A - \tfrac{1}{2}\rho V_1 A = 0$$

$$\boxed{V_2 = \tfrac{3}{2} V_1}$$

b) Using x-component of momentum eq'n, $\oint\!\!\oint \rho(\vec{V}\cdot\hat{n})u\,dA + \oint\!\!\oint p\, n_x\, dA = 0$

$$I_1 = -\rho V_1^2 A - p_1 A$$
$$I_2 = \rho V_2^2 A + p_2 A$$
$$I_3 = 0 \qquad \text{since } n_x = 0 \text{ on } 3$$
$$+\quad I_4 = 0 \qquad \text{since } u = 0,\ n_x = 0 \text{ on } 4$$

$$I = \rho(V_2^2 - V_1^2)A + (p_2 - p_1)A = 0$$

$$p_2 - p_1 = \rho(V_1^2 - V_2^2) = \rho V_1^2\left(1 - \left(\tfrac{3}{2}\right)^2\right)$$

$$\boxed{p_2 = p_1 - \tfrac{5}{4}\rho V_1^2}$$