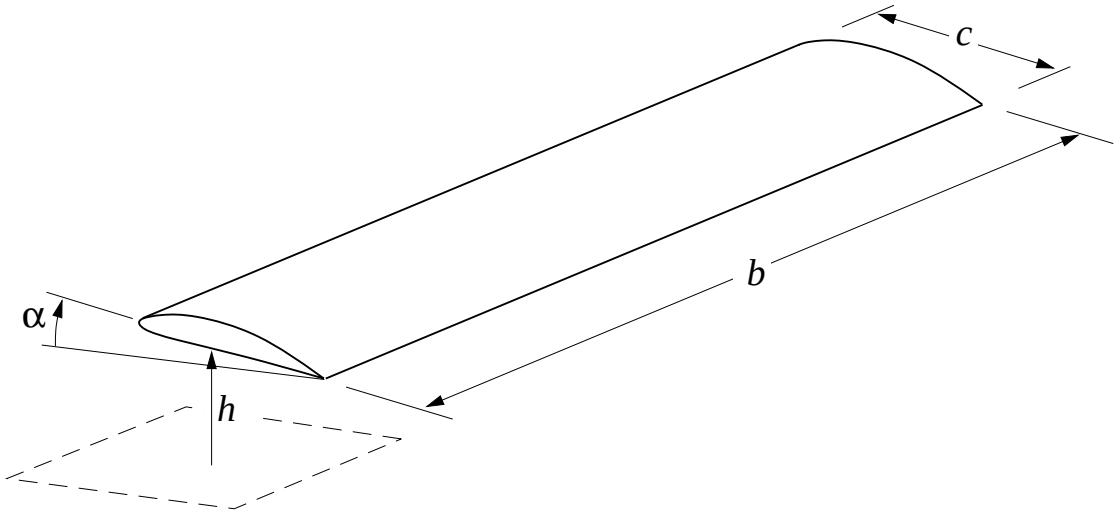
1. (35 %) A wing of span b and chord c is flying in air at an angle of attack α, at some height h from the ground.



a) List all the physical parameters which will influence the aerodynamic lift/drag ratio $\Lambda \equiv L/D$ of the wing.

$$\Lambda \;=\; f(\ldots ? \ldots)$$

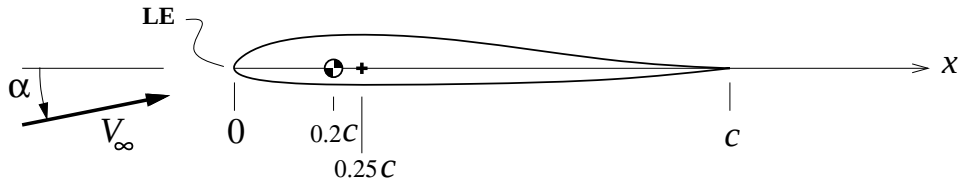
b) Determine a set of nondimensional parameters (or Pi products) which fully describe this situation.

c) You now want to fly the wing high enough so that the ground has no significant effect on Λ. Which nondimensional parameter or parameters tell you whether you are "high enough"?

2. (30 %) A "plank" flying wing aircraft consists of a simple rectangular wing with no tail, like the one in Problem 1. At some angle of attack α, the lift and moment for this particular wing are known to be

$$\begin{aligned} L &= q_\infty S\, 5\alpha \\ M_{\rm LE} &= q_\infty Sc\, (0.025 - 1.25\alpha) \end{aligned}$$

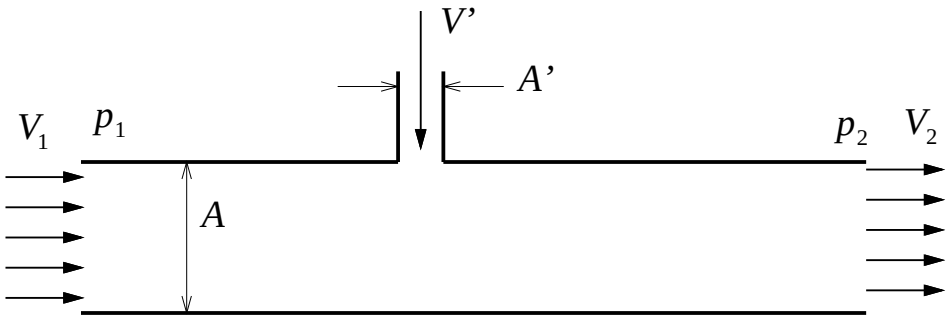
where α is in radians, $q_\infty = \frac{1}{2}\rho_\infty V_\infty^2$ is the known dynamic pressure, and $S = bc$ is the wing area.



a) Determine the moment $M_{c/4}$ about the quarter-chord location $x = 0.25c$ for any given α.

b) The flying wing has its center of gravity at $x = 0.2c$. At what α will it be able to maintain level-flight equilibrium?

3. (35 %) A channel with area A has a uniform inflow velocity V_1 at pressure p_1. A side pipe of area $A' = A/4$ delivers more fluid with velocity $V' = 2V_1$. The density ρ is constant everywhere.



a) Determine the exit velocity V_2.

b) Determine the exit pressure p_2.