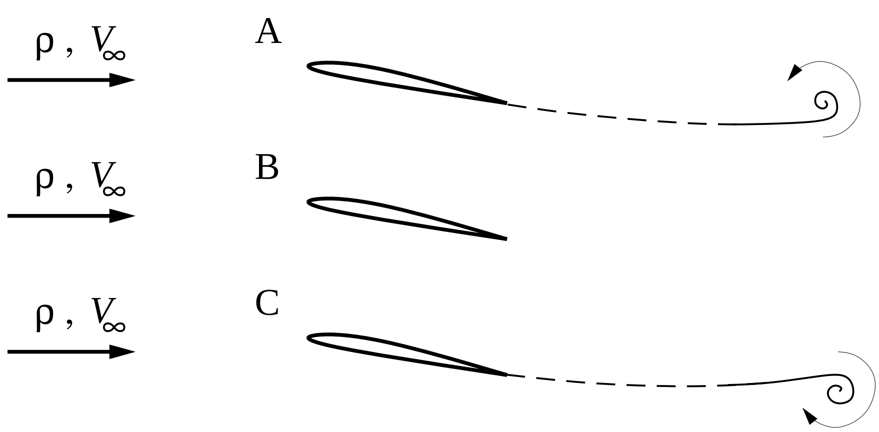
1. (25 %) Three identical airfoils are flying at the same α (three separate flow situations). Airfoil A has recently increased its α, so there's a starting vortex behind it. Airfoil C has recently decreased its α, so there's an opposite "stopping" vortex behind it. Airfoil B has had no change in α. For each part a) and b), circle the statement which is true. Hint: Consider the total velocity seen by each airfoil.

a)
- i) $L'_A < L'_B < L'_C$
- ii) $L'_A = L'_B = L'_C$
- iii) $L'_A > L'_B > L'_C$
- iv) $L'_A < L'_B > L'_C$

b)
- i) $D'_A < D'_B < D'_C$
- ii) $D'_A = D'_B = D'_C$
- iii) $D'_A > D'_B > D'_C$
- iv) $D'_A < D'_B > D'_C$



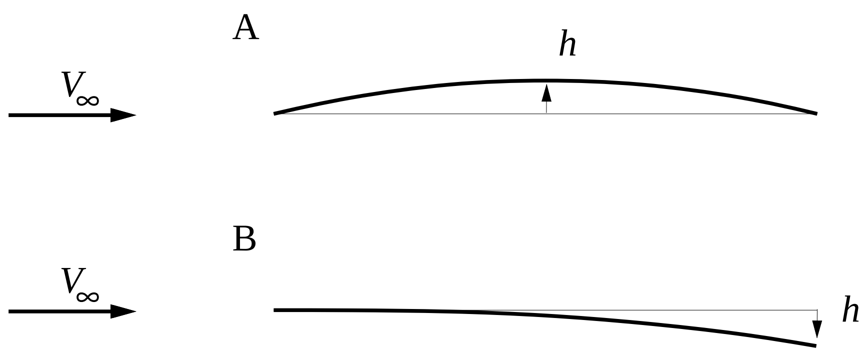
2. (35 %) A deforming airfoil is proposed for aerodynamic control in lieu of an aileron. The airfoil is to be deformed by an actuator with maximum stroke h. Two installations A and B are considered as shown in the figure. The resulting camberlines are:

$$\begin{aligned} Z_A(x) &= 4h\,\frac{x}{c}\left(1-\frac{x}{c}\right) \\ Z_B(x) &= -h\left(\frac{x}{c}\right)^2 \end{aligned}$$

Determine and compare the following quantities for each installation.

a) The control derivative $dc_\ell/d(h/c)$.
The larger this number, the more effective the actuator (good).
Hint: First determine the c_ℓ resulting from the imposed h/c deflection.

b) The moment derivative $dc_{m,c/4}/d(h/c)$.
The larger this number, the larger the structural torque on the wing (bad).



3. (40 %) We wish to design the geometry of a rectangular wing which is to have a nearly-constant circulation distribution and the following parameters:

$$\begin{aligned} b &= 2\,\mathrm{m} \\ V_\infty &= 5\,\mathrm{m/s} \\ \Gamma(y) &\simeq \Gamma_0 \;=\; 0.5\,\mathrm{m^2/s} \end{aligned}$$

It is recognized that this $\Gamma(y)$ must drop abruptly to zero at each tip. For simplicity we will also make the following choices:

$$\begin{aligned} \alpha_{L=0} &= 0 \qquad \text{(zero-camber airfoil)} \\ \alpha &= 0 \qquad \text{(common ref. axis placed along } V_\infty) \end{aligned}$$

a) First, determine the downwash distribution $w(y)$, and sketch the associated $\alpha_i(y) = -w/V_\infty$. Give numerical values of α_i at the three points $y = 0\,\mathrm{m}, 0.75\,\mathrm{m}, 0.95\,\mathrm{m}$.

b) We now choose a constant chord distribution $c(y) = 0.2\,\mathrm{m}$. What are the required $c_\ell(y)$ and $\alpha_{\mathrm{geom}}(y)$ distributions?

c) What difficulties to you see with trying to build such a wing?