1. (25 %) Three identical airfoils are flying at the same $\alpha$ (three separate flow situations). Airfoil A has recently increased its $\alpha$, so there’s a starting vortex behind it. Airfoil C has recently decreased its $\alpha$, so there’s an opposite “stopping” vortex behind it. Airfoil B has had no change in $\alpha$. 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:

\[
Z_A(x) = 4h \frac{x}{c} \left( 1 - \frac{x}{c} \right) \\
Z_B(x) = -h \left( \frac{x}{c} \right)^2
\]

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 $c_\ell$ resulting from the imposed $h/c$ deflection.

b) The moment derivative $dc_{m,c}/4d(h/c)$.
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:

\[ b = 2 \text{ m} \]
\[ V_\infty = 5 \text{ m/s} \]
\[ \Gamma(y) \approx \Gamma_0 = 0.5 \text{ m}^2/\text{s} \]

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

\[ \alpha_{L=0} = 0 \quad \text{(zero-camber airfoil)} \]
\[ \alpha = 0 \quad \text{(common ref. axis placed along } V_\infty) \]

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

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

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