Homework #3

Due 12^{th} Oct, 5pm

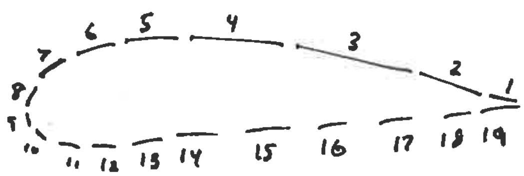
1) Develop a discrete vortex solver to evaluate the NACA 4412 at $\alpha = 0^\circ, 5^\circ, 10^\circ$. Compare C_L, C_M, and the C_p distribution with XFOIL (inviscid).

2) 20 pt bonus for plotting a reasonable/helpful number of streamlines.

3) 20 pt bonus for plotting C_p as a field variable (i.e. $C_p(x,z)$)

Hints:

1) Decompose airfoil curve into elements running from TE to LE along the top and back to the TE along the bottom. Other orders are ok, but will require preprocessing the standard order (TE → LE → TE).



2) Use a cosine spacing of elements such that the LE and TE have higher resolution. Ensure your element sizes are converged (i.e. your results should not depend on the # elements beyond N elements)

3) Apply the vortex at the ¼ chord  and the collocation pt at ¾ c

4) Vortex strength vs velocity is: (Eq 2.30 FVA) Freestream is $V = V_\infty(\cos\alpha\,\hat{x} + \sin\alpha\,\hat{z})$

$$V_\Gamma(r) = \sum \frac{\Gamma}{2\pi} \frac{(z-z')\hat{x} - (x-x')\hat{z}}{(x-x')^2 + (z-z')^2}$$

5) The collocation boundary condition is $V \cdot n = 0$. $V = \sum V_i$ of each Γ on each collocation pt.

6) Arrange into a matrix of Aerodynamic Influence Coefficients

$$[AIC] \Rightarrow \quad [AIC]\begin{pmatrix}\Gamma_1 \\ \Gamma_2 \\ \vdots \\ \Gamma_n\end{pmatrix} = \begin{pmatrix}\text{Freestream} \\ \text{Components}\end{pmatrix}$$

How is the strength j related to velocity at i.

Invert AIC with Matlab or "Eigen" or ??? to solve for Γ_i

7) Compute Average C_p on an element from V at collocation point.

8) C_L and C_m are integrated terms from element size, C_p, and normals.