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XFOIL and Low Speed Airfoil Design/Analysis
Notes from presentation by Mark Drela

<u>Equations</u>

Aspect ratio:	$AR = \frac{b^2}{S}$ S = Area b = Span L = Lift $c = \frac{S}{b}$ = chord	(1)
Induced angle	$\alpha_i = \frac{C_L}{\pi AR}$	(2)
3D angle	$\alpha_{3D} = \alpha_{2D} + \alpha_i$	(3)
Lift coefficient	$C_L = \frac{L}{\frac{1}{2}\rho V^2 S}$	(4)
Lift	$L = \frac{1}{2}\rho V^2 S C_L$	(5)
3D Lift ≈ 2D Lift	$C_L \approx C_l$	(6)
Drag	$D = \frac{1}{2}\rho V^2 S C_D$	(7)
Coefficient of Drag	$C_D = C_d + C_{D_i}$	(8)
Induced Drag	$C_{D_i} = \frac{C_L^2}{\pi AR}$	(9)
Center of Lift	$\left(x/c\right)_{cp} = \frac{1}{4} - \frac{C_m}{C_l}$	(10)
Reynolds Number	$\mathrm{Re} = \frac{Vc}{\nu}$ $\nu = 1.45 \cdot 10^{-5}\ m^2/s$	(11)

For a 20” chord, $\mathrm{Re} \approx 10^7$

Procedure

Step 1: 2D simulation in XFOIL

Obtain C_l, C_d, C_m & α_{2D} for your airfoil

Get AR (equation 1)

Get $\left(x/c\right)_{cp}$ (equation 10)

Step 2: Calculating Lift

Get C_L (equation 6)

Get L (equation 5)

Step 3: Calculating Drag

Get C_{D_i} (equation 9)

Get C_D (equation 8)

Get D (equation 7)

Step 4: Calculating the Angle of Attack

Get α_i (equation 2)

Get α_{3D} (equation 3)

Structural Considerations

Center of Lift along chord: $\left(x/c\right)_{cp}$ is normally between 0.3 & 0.4

Place the spar at this location to avoid twisting of the airfoil. This is usually the thickest point.

Apply fiberglass at 45° to the leading edge of the airfoil, (not 0° & 90°) for torsional stiffness. If you are not using a spar then you need to apply fiberglass at 0° & 90°, allowing the fibers to act as a spar and bear the load.

To transfer load out of the wing, you must add *hard points* to the foam wing.

It is recommended to fiberglass and vacuum bag the wing for trailing edge strength, especially if you are using a thin trailing edge.