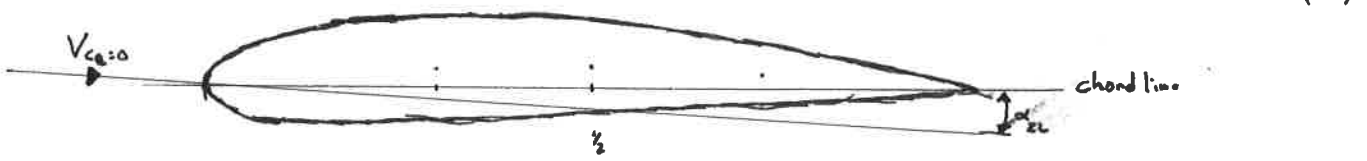
Ex: Joukowski

Given an airfoil profile, estimate C_{ℓ_α}, X_{ac}, and $C_{m_{1/4c}}$ and α_{zL}

Also, estimate $C_{\ell_{(\alpha=0)}}$



Measure

Chord ≈ 102 mm

Max thickness ≈ 14mm at 30mm chord

At half chord, the maximum camber is about 3mm (and importantly, max camber is at ½c)

Non-dimen'.

$$\text{Chord} = \frac{\text{Chord}}{102} = 1$$

$$t/c = \frac{14}{102} = 13.7\%$$

$$f/c = \frac{3}{102} = 3\%$$

Joukowski parameters

$$\epsilon \approx 77\% \, t/c = 0.77 \cdot 0137 = 0.105$$

$$C_{\ell_\alpha} \approx \frac{2\pi(1+\epsilon)}{1+\epsilon^2} \approx \frac{2\pi(1.105)}{1.01} = 2\pi \cdot 1.094 = 0.12 \text{ per degree}$$

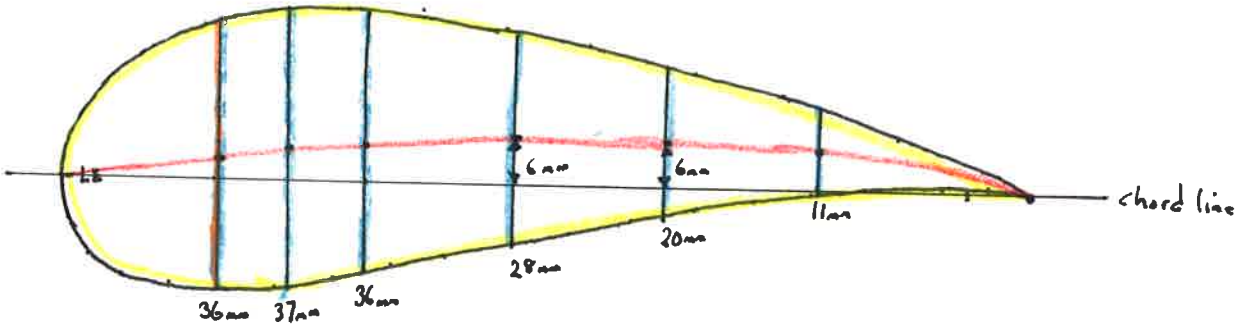
$$X_{ac} \approx \frac{1}{4} + \frac{\epsilon^2}{2} = \frac{1}{4} + 0.011 \approx 0.26 \approx 26\% \, c$$

$$C_{m_{1/4c}} \approx -\pi f/c = -\pi \cdot 0.03 = -0.094$$

$$\alpha_{zL} \approx \frac{-2f}{c} = -2 \cdot 0.03 = -0.06 \text{ rad} = -3.4 \text{ deg} \Rightarrow C_{\ell_{(\alpha=0)}} = 0.12 \cdot 3.4 = 0.41$$

This is the Goe 629.

Ex: Joukowski FX-69-PR-281



Measure: Chord = 129 mm Max thickness 37mm at 30 mm aft of LE $\left(\frac{t}{c} = \frac{37}{129} = 28.5\% \text{ or } 23\% \bar{c}\right)$

Find camber line by dividing upper and lower

Max camber ≈ 6mm at 50% $\bar{c}$ $\Rightarrow$ $\frac{f}{c} = \frac{6mm}{129mm} = 4.6\%$

Using Joukowski estimates:

- $C_{\ell}\underset{\text{thickness}}{\approx} 2\pi\left(\frac{1+\epsilon}{1+\epsilon^2}\right)\alpha$ where $\epsilon \approx 0.77 \cdot \frac{t}{c} = 0.77 \cdot 0.285 = 0.219$

  $= 2\pi\left(\frac{1+0.219}{1+0.219^2}\right)\alpha$

Notice that this ONLY considered the thickness. We consider the camber separately.

$C_{\ell} \approx 2\pi(1.16)(\alpha + 5.3^\circ)$ ($5.3^\circ = 0.092$ rad)

$C_{\ell} \approx 0.127(\alpha + 5.3^\circ)$

Degrees

- $C_{\ell_\alpha} = \frac{dC_\ell}{d\alpha} = \boxed{2\pi \cdot 1.16 \approx C_{\ell_\alpha}}$

- α_{zL}

From circular arc geometry, $C_{\ell} \approx 2\pi\left(\underbrace{\alpha + \frac{2f}{c}}_{\text{Needs to be } 0}\right)$ $\Rightarrow$ $\alpha_{zL} = -\frac{2f}{c}$

$\alpha_{zL} = -2 \cdot 0.046 = -0.092$ rad $\Rightarrow$ $\boxed{\alpha_{zL} \approx 5.3^\circ}$

- C_{ℓ_0}

$C_{\ell_0} \approx 2\pi\left(\cancel{\alpha}^{\,0} + \frac{2f}{c}\right) \approx 2\pi\frac{2f}{c} =$

$C_{\ell_0} = C_{\ell_\alpha}\frac{2f}{c} = 2\pi \cdot 1.16 \cdot 0.092^{rad} = \boxed{0.7 = C_{\ell_0}}$

- $C_{m_{c/4}} \approx -\pi\frac{f}{c} = -\pi\, 0.046$ $\Rightarrow$ $\boxed{C_{m_{c/4}} \approx -0.144}$

Later, we will compare this estimate to actual data. Again, this is only an estimate.