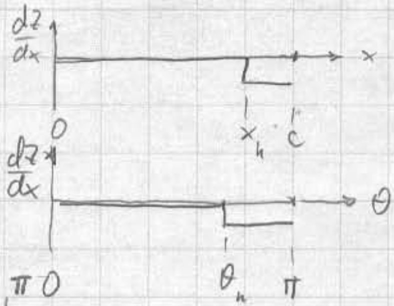
UE Fluids F04 Solution Spring '09



a) $\frac{dz}{dx} = \begin{cases} -\delta & x > x_h \;,\; \theta > \theta_h \\ 0 & x < x_h \;,\; \theta < \theta_h \end{cases}$ $\quad \theta_h = \arccos\left[1 - 2\frac{x_h}{c}\right] = 2.214 \text{ rad}$

b) $A_0 = \alpha - \frac{1}{\pi}\int_0^{\pi} \frac{dz}{dx}\, d\theta = \alpha + \delta\, \frac{\pi - \theta_h}{\pi} = \boxed{\alpha + 0.295\,\delta}$

$A_n = \frac{2}{\pi}\int_0^{\pi} \frac{dz}{dx}\cos n\theta\, d\theta = -\delta\,\frac{2}{\pi}\int_{\theta_h}^{\pi} \cos n\theta\, d\theta = -\delta\,\frac{2}{\pi}\left[\frac{1}{n}\sin n\theta\right]_{\theta_h}^{\pi}$

$A_1 = 0.509\,\delta$

$A_2 = -0.306\,\delta$

$\boxed{c_\ell = \pi(2A_0 + A_1) = 2\pi(\alpha + 0.295\delta) + \pi(0.509\,\delta) = 2\pi(\alpha + 0.55\,\delta)}$

$\boxed{c_{m_{c/4}} = \frac{\pi}{4}(A_2 - A_1) = \frac{\pi}{4}(-0.509\,\delta - 0.306\,\delta) = -0.640\,\delta}$

c) $\frac{dc_\ell}{d\alpha} = 2\pi = 6.283$

$\frac{dc_{m_{c/4}}}{d\alpha} = 0$

$\frac{dc_\ell}{d\delta} = 2\pi \cdot 0.55 = 3.456$

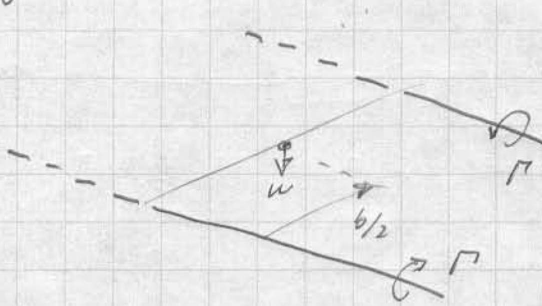
$\frac{dc_{m_{c/4}}}{d\delta} = -0.640$

UE Fluids F05 Solution Spring '09

a) Wing's TAT box sees two semi-infinite straight vortices

Each vortex contributes $w = \frac{1}{2}\left(-\frac{\Gamma}{2\pi b/2}\right)$

Total contribution: $\boxed{w = 2 \cdot \frac{1}{2} \cdot \left(-\frac{\Gamma}{2\pi b/2}\right) = -\frac{\Gamma}{\pi b}}$



b) $\alpha_{eff} = \alpha + \frac{w}{V_\infty} = \alpha - \frac{\Gamma}{\pi b V_\infty}$

c) In the Lab, α_{3D} was the angle of the 3D wing to the tunnel (freestream)

$$\alpha_{3D} = \alpha$$

α_{2D} was the angle seen by the local wing airfoil, so

$$\alpha_{2D} = \alpha_{eff}$$