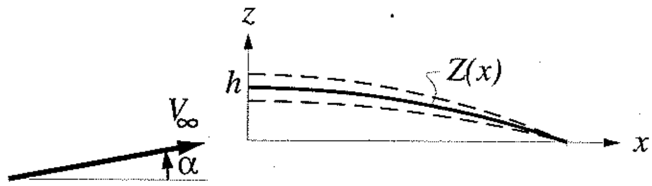
1. (35 %) A thin airfoil has an adjustable camberline defined by

$$Z(x) \;=\; h\left[1-\left(\frac{x}{c}\right)^2\right]$$



where h is the camberline height at the leading edge.

a) Determine the coefficients A_0, A_1, A_2, ...for this camberline, either by manipulation and inspection of dZ/dx, or by direct Fourier Analysis of dZ/dx. Assume there's also some arbitrary α as shown.

b) Determine the airfoil's c_ℓ and $c_{m_{c/4}}$, as functions of h/c and α.

c) Determine the zero-lift angle $\alpha_{L=0}$, as a function of h/c.

2. (40 %) A wing operating at velocity V_∞ and air density ρ has the following circulation distribution:

$$\Gamma(y) \;=\; \Gamma_0 \left[1 - (2y/b)^2\right]$$

a) Determine the lift L.

b) Determine the downwash velocity $w(y)$. Evaluate $w(0)$ at the center of the wing, and also $w(b/4)$ halfway out. Roughly sketch $\Gamma(y)$ and $w(y)$.

c) Write down an expression for the induced drag D_i for this particular wing, but don't bother integrating it (too messy).

d) Determine how both L and D_i will change for each of the following two cases:
i) Γ_0 is doubled with the same b, and
ii) b is doubled with the same Γ_0.

3. (25 %) An elliptically-loaded wing with aspect ratio $\mathcal{R} = 10$ has an airfoil with the following 2D profile drag polar:

$$c_d(c_\ell) = 0.025 + 0.015c_\ell^4$$

We will assume that $c_\ell = C_L$.

a) Write an expression for the overall drag coefficient C_D of the wing.

b) Determine the maximum lift/drag ratio C_L/C_D (or equivalently, the minimum C_D/C_L) that this wing can produce.

c) The airplane using this wing has a wing loading of $W/S = 10\,\text{Pa}$. Determine the flight speed V it needs to fly so that it operates at its maximum lift/drag ratio. Assume $\rho = 1.2\,\text{kg/m}^3$.