Unified Engineering Spring 2008
Fluids Problem 8

You are to design a suitable wing for a sport RC electric aircraft to the following low-speed requirements:

density:	$\rho = 1.2\,\mathrm{kg/m^3}$
low speed:	$V = 6\,\mathrm{m/s} = 13.4\,\mathrm{mph}$
high speed:	$V = 12\,\mathrm{m/s} = 26.8\,\mathrm{mph}$
weight:	$W = 3.0\,\mathrm{N} = 11\,\mathrm{oz}$
span:	$b = 1.8\,\mathrm{m} = 71\,\mathrm{in}$

Assume an elliptic load distribution $\Gamma(y) = \Gamma_0\sqrt{1-(2y/b)^2}$. Assume $dc_\ell/d\alpha = 2\pi$ for the wing airfoils.

Assume a spanwise-constant $c_\ell = 0.8$ for the low-speed case in level flight. Also assume the wing reference line (e.g. fuselage axis) is aligned with the flight direction in the low-speed case, so that $\alpha = 0°$.

1a) Determine the chord distribution $c(y)$ and sketch the planform.
1b) Determine $\alpha_{\mathrm{aero}}(y)$.
1c) What will $\alpha_{\mathrm{geom}}(y)$ look like if the same cambered airfoil is used all across the span?
1d) Determine the wing's C_{D_i}. If the airfoil's profile drag is $c_d \simeq 0.015$, estimate the overall L/D ratio of the wing.

The wing designed above must also operate at the high speed condition in level flight.

2a) Still assuming an elliptic load distribution, determine the necessary Γ_0 for this case.
2b) Determine α_i, and the overall α for this speed.
2c) If the airfoil's profile drag is still $c_d \simeq 0.015$, determine C_{D_i} and the overall L/D