

AA200b - Applied Aerodynamics II

Winter Quarter 2004-05

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PROBLEM SET 4

Due Date: March 4th, 2005

Problem 1. A wing is to be designed so as to produce 6000 lbs of lift at 100 ft/sec at an altitude at which $\rho = 0.0025$ slug/ft³. Consider three planforms: elliptical, rectangular, and tapered with a tip-to-root chord ratio of 0.5. For each case find (according to lifting line theory)

1. The load distribution that minimizes the induced drag for a given span.
2. The associated required distribution of absolute angle of attack $\alpha - \alpha_{L0}$ (take $m_0 = 2\pi$), in terms of the span b , root chord c_s , and Γ_{max} .

If the maximum section lift coefficient is 0.5, what minimum areas are required for the three wings? Note that $S = \pi/4bc_{max}$ for an ellipse. *Hints:*

1. Knowing L , ρ , and V_∞ , determine SC_L , and hence $\Gamma_{max}b$.
2. Find the value of y at which $c_l = c_{l_{max}}$. Then knowing $c_{l_{max}}$, determine $(\Gamma/c)_{max}$.
3. Thus you can calculate $S = \text{constant} \times b c_{max}$.

Problem 2. An elliptically-loaded wing (A) with 5% more span than another elliptic wing (B) with the same total lift has 5% higher bending moment at the wing root. If the lift distribution is changed so that the lift at the tips is reduced, we can build the higher span wing with the same root bending moment as the one with lower span. Find the span efficiency (e) of wing A when it is designed with the same lift and root bending moment as wing B and the induced drag is minimized. How does the induced drag (in lbs) compare? Use lifting line theory and include only the first two symmetric terms in the Fourier series.

Problem 3. The distribution of C_l on a wing at two different angles of attack is shown below. The airfoil section $C_{l_{max}}$ is 1.4.

1. Estimate the wing maximum lift coefficient.
2. Does the wing have washout?
3. Do you think the wing is swept forward or backward?
4. Can you use the program provided in the web page to obtain a plausible planform that creates the indicated lift and C_l distributions?

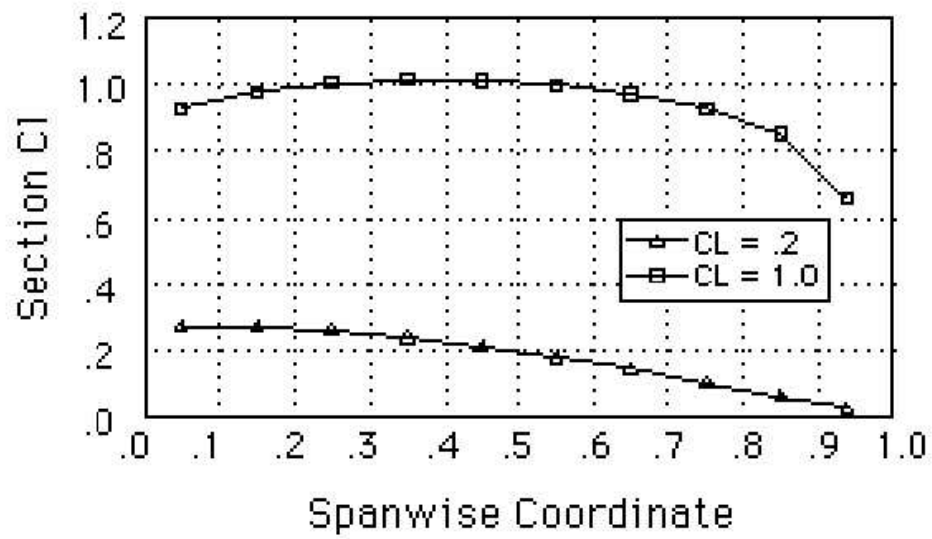


Figure 1: Wing C_l Distribution