Assignment #4: Finite Wing Analysis — ME 515

due 3/18/2020 before midnight via Learning Suite — **50 possible points**

4.1 Rework any problems on the midterm that you missed. You'll earn points back towards your midterm score. Turn this in by 3/11 (separately from this homework).

4.2 Implement, verify, and validate a vortex lattice method.

(a) On Learning Suite there is a short excerpt from "Aerodynamics for Engineers" by Bertin and Cummings containing a simple example with just four panels. Verify your numbers for the downwash, circulation, and lift coefficient. Note that they use a small angle approximation and so if you want a more exact comparison to our implementation you will need to replace α with $\sin\alpha$ for the results in their textbook.

(b) Verify your induced drag calculation. The easiest way to do that is to give it an elliptic lift distribution (bypassing the VLM solver). The inviscid span efficiency of an elliptic lift distribution is $e_{inv} = 1$ and so we know what the indued drag should be just based on the chosen lift, dynamic pressure, and span (see Anderson). Show a convergence plot of e_{inv} as a function of the number of "panels".

(c) Validate your VLM against the data in NASA TM-1422. There are three wings in that report, but we will just look at the second one: NACA 65-210 sections with 2 degrees washout. Note that the washout was created by increasing the twist at the root (tip twist remains at zero). From the provided experimental data, compare the lift coefficient as a function of angle of attack, and the induced drag coefficient as a function of lift coefficient. Also compare the c_l distribution at $C_{L_{max}}$