Homework 6

Mapping

Your answers to these questions, and what you learn from them, will be greatly enhanced through collaboration and discussion amongst your discussion group and in the recitation. This is actively encouraged. However, once you have decided how to answer these, the final solutions must be prepared individually.

1. Wind tunnel experiments of wings must subtract the influence of walls to accurately estimate the forces that wings would experience in free flight. Such corrections, known as blockage corrections, are accomplished using method of images or, in some cases, conformal mapping. A Rankine half-body a reasonable proxy for airfoil flow since it includes the boundary layer thickness (due to viscous effects) and the downstream wakes (that tend to exist for long distances). Consider a semi-infinite Rankine body in free flight
   a. Write down the complex potential and velocity for the flow for a source of strength q and velocity V_∞ at zero angle of attack. Determine the C_p distribution on the half-body.
   b. Determine the complex potential and velocity for the flow of Rankine half-body in a channel where the channel walls are at y = -π and π. Determine the stagnation point of the rankine half-body.
   c. Consider a freestream of 10 m/s and a source q such that the stagnation point in the free flight is at -0.3 m. How strong should the source be such that the stagnation point is exactly at the same distance in the channel flow.

2. Consider a Joukowski mapping with a mapping constant C=1. The thickness, t, of a Joukowski airfoil generated using this mapping can be determined, to a fair approximation, by placing the mapping circle a distance 0.7698(t/c) to the left of the imaginary axis. Write a Matlab program to generate and plot Joukowski airfoil sections and the pressure distributions they produce as a function of the thickness and zero lift angle of attack. Plot Joukowski airfoil shapes (in their true aspect ratio) and the pressure distributions they produce at 3 degrees angle of attack (with -Cp plotted vs. x/c, with x measured from the leading edge) for the following combination of thickness to chord ratio and zero lift angle of attack: (a) 10% and -3 degrees, (b) 18% and -5 degrees. Include with your plots the values of the lift coefficients obtained from the analytic formula. Submit a copy of your code and the plots with your solution.