2.23 Hydrofoils & Propellers
Homework Assignment #5

Assigned: Friday April 6, 2007

Due: Friday Apr. 13, 2007

1) A two-dimensional hydrofoil section is to be designed to achieve proper lift and cavitation performance using Brockett diagrams. The foil section is to be designed with a NACA 6t thickness form ans a NACA a=0.8 meanline. It is to be designed to operate at the following conditions.

   Design Speed: 21 m/s
   Design sectional lift: 11,000 N/m
   Density; 1000 kg/ m3 Vapor pressure: 2500 kPa
   Surface pressure: 101 kpa
   Depth to foil: 2 meters
   Vertical velocity inflow variation: +/- 0.5 m/s

   Find the chordlength, camber ratio, foil angle of attack and thickness ratio such the foil satifies the required performance without cavitation.

2) A section of a propeller is to be designed to achieve the desired performance while remaining cavitation free. The following data has been extracted from the lifting line design of the propeller:

   - r/R of section 0.7
   - Propeller diameter: 4 m
   - Ship speed 10 m/s
   - Prop RPM : 120
   - Inflow angle β: 29.6 deg
   - Induced velocity angle βi: 32.1 deg
   - Section circulation (Γ) : 2.5 m2/s
   - Depth of shaft centerline: 4 m
   - Variation in axial inflow at section : +/- 0.5 m/s
   - Sectional friction drag coef: 0.008
   - Fluid density 1000 kg/m3
   - Fluid vapor pressure 2500 Pa
   - Surface pressure 101 kPa

   Find the following:

   a) Sectional Cavitation number, and inflow angle variation
   b) Design Chordlength for cavitation free operation
   c) Thrust/span and torque/span (including friction drag)
   d) Design camber, thickness and pitch/D

3) Do the following problem by hand. We can simulate a flat plate at angle of attack (crudely!) using two point vortices and two control points as shown below.

a. Find the strength of each vortex in terms of Uo and alpha such that the vertical velocity at each control point is zero (no flow through the plate)
b. Noting that for this configuration the velocity at each point vortex is Uo find the lift coefficient of the plate?
c. How does this compare to the classical result of lift on a flat plate, $Cl=2\Pi\alpha$? How could the accuracy be improved?
d. Implement this solution in matlab and vary the control point position LC be careful not to let LC=0 or LV. Find the value of LP that gives a result closest to the flat plate result. Plot Cl vs. LP for your solution.