Problem Set 4

Detailed Hull Design

This problem set is to design the hull of a small cruising sailboat for inland waters. The parameters for the design are:

Dimension	Value		
Length Overall	10.50	± 0.1	m
Waterline Length	9.00		m
Forward Overhang	0.50	± 0.1	m
Aft Overhang	1.00	± 0.1	m
Maximum Beam	3.25		m
Waterline beam	2.70	± 0.1	m
Canoe Body Draft	0.54	± 0.05	m
Overall weight (mass)	5300	± 20	Kg
Freeboard Forward	1.33	± 0.1	m
Freeboard Aft	1.06	± 0.1	m
Canoe body Prismatic Coefficient	0.57	± 0.01	
Canoe body LCB	3.50	± 0.2	% of LWL aft of amidships
LCF	5.00	± 1.0	% of LWL aft of amidships

Table 1 Principal dimensions.

To determine the volume for the canoe body, use the facts that the boat is floating in sea water with a density of 1025 kg/m^3, the volume of the fin keel is 0.173 m^3 and the volume of the rudder is 0.040 m^3.

Presume the distribution of weights of the entire boat with hull, deck, keel, rudder, rig, sails, auxiliary engine with shaft and propeller, interior, deck fittings, crew, and everything else is such that the center of gravity is 0.05 m above the waterline.

1. Before you start the work with MaxSurf, calculate the crossectional immersed area of the largest section which will be very close to the LCB. Then make as sketch on graph paper of a preliminary area curve that has the correct total area (canoe body volume), Cp and LCB. The bow end of the curve should be hollow and the stern end should be either very slightly hollow or linear.

2. Make sketches (again it is easiest to get the values if you use graph paper) of the approximate profile with the correct maximum draft and with a shearline that has the correct values of freeboard forward and freeboard aft. You can assume that the

freeboard aft occurs on a vertical station at the stern of the boat, even if you would build such a boat with a reverse angle (top forward) transom.

3. Next, make a sketch on graph paper of the station of maximum area up to the shearline, having the correct area and maximum waterline beam. The maximum overall beam is usually slightly aft of the section of maximum area, therefore the section you sketch should have a beam at the shearline that is slightly less than the overall maximum beam of the boat.

4. Now use MaxSurf to design the hull with the sketches on graph paper as a guide. Put one of the columns of control points at the position of the station of maximum area. All the values of the dimensions given in Table 1 have to be within the prescribed intervals.

5. When the hull design is complete, starting with a sailplan having a total sail area of 51 m^2, and adjusting it up or down as necessary, design a sloop rig (main and jib) that gives a Dellenbaugh angle of 20 degrees based on total sail area. Use the method on page 52 of the text, with the center of effort of each sail at 40% of its height, but use the actual sail area instead of the triangular area. Even though it is an approximation, assume that the main and jib have equal lift coefficients so you can calculate the height of the heeling arm for the Dellenbaugh angle formula. In calculating the heeling arm, assume that the lateral center of resistance of the hull with appendages is 0.76 meters below the waterline. Make a dimensioned sketch of the sailplan.

For this exercise, we will not do the detailed appendage or desk designs, leaving those to the final design project.

6. Turn in Your sailplan sketch and Maxsurf output showing the lines of the hull and the upright hydrostatic calculations. Run the large angle stability analysis in Hydromax from 0 to 180˚ of heel in steps of 10˚; make sure to adjust the longitudinal position of the center of gravity so that the boat as zero trim when upright. Print out and turn in the stability vs. heel angle curve and the associated table; include also the loadcase table that you used.