October 3rd, 2003

Quiz

(closed-book)

Hydrostatic, Small and Large Angle Stability

Problem 1

Consider a box shaped barge that is 100 m long, 20 m in total breadth, 10 m tall and with a draft of 4 m. The center of gravity is at amidships and on centerline at a height of 6 m above the keel. The barge is floating in water with a mass density of 1025 kg/m^3.

A. Determine the heeling moment to heel the barge by 10 degrees.

B. At what angle of heel, ϕ_c does one of the lower long edges of the barge come into contact with the water surface.

C. Determine the exact righting moment of the fluid on the barge based on the actual position of the center of gravity and the center of buoyancy at 25˚ of heel (Hint: ϕ_c is less than 25˚, which means that the lower corner is out of the water and the immersed shape looks like a triangle…).

D. If 10^6 Kg are placed in the center of the deck of the upright barge, how much does the barge sink?

E. If the 10^6 Kg on the deck are moved 2 m athwartships, what is the barge heel angle?

Report your result in the following table

Results			
A.	Heeling Moment(10 deg) =		Nm
B.	Heel angle ϕ_C =		deg
C.	Exact Righting Moment(25 deg) =		Nm
D.	Sinkage =		m
E.	Heel angle =		deg

Table 1 Results.

Problem 2

In this problem you are asked to calculate hydrostatic parameters and small angle stability for a sailing yacht starting from the data in Table 2, which contains the sectional areas A_S, vertical position of each section Z_0 with respect to the DWL (a negative value means below), and half-beam Y_0 at DWL for 11 equally spaced stations (x is positive forward). Do all the integrations with a hand calculator using Simpson's rule.

A. For a canoe body draft $T_C = 0.47$ m, which is achieved considering the weight of the canoe body and the keel, find the waterline length L_{WL}, the waterline beam B_{WL}, the canoe body volume ∇_C, the canoe body displacement Δ_C (consider salt water with density $\rho = 1025$ Kg/m^3), the block coefficient C_B, and the prismatic coefficient C_P.

B. Determine the waterplane area A_{WP}, the transverse moment of inertia I_{XX} of the waterplane, the vertical center of buoyancy VCB_C, and the metacentric height GM_C for the canoe body. The vertical center of gravity of the canoe body VCG_C 0.1 m above DWL.

	Position X [m]	Sect. Area A_S [m^2]	Center Z_0 [m]	Y_0 @ DWL [m]
Station 0	6.40	0.000	0.000	0
Station 1	5.12	0.113	-0.092	0.347
Station 2	3.84	0.384	-0.139	0.773
Station 3	2.56	0.736	-0.171	1.187
Station 4	1.28	1.080	-0.191	1.53
Station 5	0	1.308	-0.197	1.763
Station 6	-1.28	1.338	-0.194	1.828
Station 7	-2.56	1.175	-0.178	1.774
Station 8	-3.84	0.830	-0.134	1.655
Station 9	-5.12	0.370	-0.074	1.379
Station 10	-6.4	0.000	0.000	0

Table 2 Canoe Body data.

C. Let's now add a keel to the design (for simplicity the rudder is neglected). The data for the lead-filled keel are given in Table 3.

Keel Data	
Mass	4015.0 kg
Δ	374.45 kg
Volume	0.365 m^3
LCB	0.462 m
VCB	-1.784 m
VCG	-1.784 m

Table 3 Keel Data.

Now for the appended boat, calculate the total displacement Δ_{Tot}, the vertical position of the center of gravity VCG_{Tot}, the vertical position of the center of buoyancy VCB_{Tot}, and the metacentric height GM_{Tot}.

D. Report your results in the following table

Results					
Δ_C	Kg	C_B		A_{WP}	m^2
Vol_C	m^3	C_P		Δ_{Tot}	Kg
T_C	m	I_{XX}	m^4	Vol_{Tot}	m^3
L_{WL}	m	VCG_C	m	VCB_{Tot}	m
B_{WL}	m	GM_C	m	GM_{Tot}	m
VCB_C	m				

Table 4 Results.