12. Structural calculations (according to ABS Rules)

Hull Shell, Deck, Cockpit, Bulkheads, Stiffeners

See spreadsheet next pages...

Rudder Stock

(according to Fig 14.15 of Larsson&Eliasson, idem 9.1 ABS rules)

	Value	Unit	Comments
h/l	2.619		between 0 and 6 => ok
t/l	0.162		greater than 0.06 => ok
Clr	1.5		
Alr	1.60		
N	1		from LDR
Fr	31931	N	Formula 21
lc	0.1172		larger than 0.125.l=0.105 => ok
Tr	374236	Ncm	Formula 20
hb	2.2	m	
h	2.2	m	
lu	0.8	m	
ll	0.4	m	
Mr	3122183	Ncm	Formula 19
sigma_c	20700	N/cm2	Stainless steel type 316
Diameter	11.5931	cm	Formula 22

Keel Bolts

	Value	Unit		
Material	AH36 type steel			
Yk (mm)	898	mm		
Wk (ballast weight, N)	57494	N		
sigma_y (N/mm2)	245	N/mm2		
tau_y (N/mm2)	410	mm		
D_k (mm)	18.0	mm		
Number of keelbolts	19			
Grounding Loads:				
F_delta	1.3E+05	N		
Coeff	2.02	N		
load aft=Coeff*F_delta	2.6E+05	N		
load upward=1.5*F_delta	1.9E+05	N		
Total keelbolts surface	4827.51	mm2		
Grounding Design Stress Requirements	Stress	Requirement		
Shear Stress	53.1871	<	307.5	ok...
Primary Stress	39.4446	<	183.8	ok...

ABS definitions			
Quantity	Value	unit	Reference
L	14.2	m	2.1
B	4.24	m	2.3
D	1.92	m	2.5
d	0.60	m	2.7
H (keel span below Tc)	2.2148	m	Figure 7.1

Laminate properties		
reinforcement density	2600	kg/m3
resin density	1200	kg/m3
reinf/total weight fraction	0.35	
Laminate density	1479	kg/m3
Flexural strength (F)	172	N/mm2
Flexural modulus (E_F)	7580	N/mm2
Tensile strength (T)	124	N/mm2
Tensile modulus (E_T)	6890	N/mm2
Compressive strength (C)	117	N/mm2
Compressive modulus (E_C)	6890	N/mm2

Core properties			
density	85	kg/m3	4.11
ultimate shear strength	1.2	N/mm2	4.11 min
shear modulus	40	N/mm2	read in Larsson fig 13.19 for given density
Compressive modulus (E_CC)	68.9	N/mm2	assumed 1% of E_Cskins

Skin buckling stress requirement				
sigma_c	160.073	N/mm2	> 1.0*C=117N/mm2	ok...
(equation 7.3.2e only depends on core and laminate properties, so this is true for all sandwich construction based on the materials chosen here)				

Plating basic definitions			
min d for Basic Head	0.62	m	Table 7.1
d for Basic Head	0.62	m	
Basic Head	5.48	m	
Below/Above limit from Tc	0.77	m	
Below/Above limit from DWL	0.19	m	
sigma_a	86	N/mm2	Table 7.2 Design stress

Shell Below 19cm above DWL																	
	Bow	5%Lwl aft	Bulkhead 1		Bulkhead 2	40%Lwl	Bulkhead 3	Bulkhead 4	Bulkhead 5	Bulkhead 6	Stern						
x (m aft from FP)	-0.55	0.67	1.8		3.95	5.39	5.4	7.76	9.65	12.38	14.41						
coeff (Table 7.1)	0.8	1.2	1.2		1.2	1.2	1.2	1.07	0.96	0.81	0.7						
Local design head h (m)	4.381	6.571	6.571		6.571	6.571	6.569	5.852	5.278	4.448	3.833						
C_F	0.036	0.183	0.317		0.591	0.699	0.699	0.750	0.743	0.607	0.368						
F (Table 7.4)	1.000	0.789	0.653		0.426	0.361	0.360	0.340	0.343	0.416	0.602						
s (mm)	302	497	676		1040	1183.4	1184	1251	1242	1061	744						
A (mm)	0	98	188		128	143.93	144	185	142	97	33						
c=1-A/s	1.00	0.80	0.72		0.88	0.88	0.88	0.85	0.89	0.91	0.96						
p (N/mm2)	0.044	0.052	0.043		0.028	0.024	0.024	0.020	0.018	0.018	0.023						
Panel	Bow-B1			B1-B2		B2-B3		B3-B4		B4-B5		B5-B6		B6-S			
panel length (mm) (8.1.3)	2350			2150		1450		2360		1890		2730		2026			
panel aspect ratio	7.781	4.730	3.476	3.180	2.067	1.394	1.225	1.225	1.993	1.886	1.511	1.522	2.198	2.573	1.910	2.723	
k (Table 7.3)	0.500	0.500	0.500	0.500	0.496	0.461	0.422	0.422	0.495	0.493	0.475	0.476	0.497	0.499	0.494	0.499	
k1 (Table 7.3)	0.028	0.028	0.028	0.028	0.027	0.023	0.020	0.020	0.027	0.027	0.025	0.025	0.027	0.028	0.027	0.028	
t(a) (mm)	4.8	6.9	7.7	7.7	11.6	11.2	11.2	11.2	12.1	11.4	11.2	11.4	11.6	10.2	10.1	8.2	
t(b) (mm)	4.5	6.4	7.3	7.3	12.4	11.7	12.8	12.8	14.1	13.8	13.5	13.4	13.9	11.5	11.4	8.6	
Single skin laminate construction																	
panel skin thickness (mm)		7.7			12.4		12.8		14.1		13.5		13.9		11.4		
Group of Panels		Bow-B2							B2-B6						B6-S		
required skin thickness (mm)		12.4							14.1						11.4		
skin weight (kg/m2)		18.3							20.8						16.9		
Sandwich construction																	
Fs	0.839	0.724	0.618	0.618	0.403	0.403	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.578
required SMo (cm3) (7.3.2a)		0.311							0.341						0.237		
required SMi (cm3) (7.3.2b)		0.329							0.361						0.251		
required I (cm4) (7.3.2c)		0.411							0.606						0.324		
required (do+dc)/2 (mm) (7.3.2.d)		23.0							25.9						15.7		
required minimum reinforcement weight (kg/m2)		1.63							1.63						1.63		

For each "group of panels", let us build a sandwich that satisfies these requirements...

Group of Panels	Bow-B2	B2-B6	B6-S	
Sandwich geometry				
Inner skin thickness (cm)	**0.2**	**0.2**	**0.2**	
Core thickness (cm)	**2.05**	**2.35**	**1.4**	
Outer skin thickness (cm)	**0.35**	**0.35**	**0.35**	
Total thickness (cm)	2.6	2.9	1.95	
width (cm)	1	1	1	
Ai (cm2)	0.2	0.2	0.2	
Ao (cm2)	0.35	0.35	0.35	
center inner (cm)	0.1	0.1	0.1	
center outer (cm)	2.425	2.725	1.775	
neutral axis (cm)	1.580	1.770	1.166	
Ii (cm4)	0.0007	0.0007	0.0007	
Io (cm4)	0.0036	0.0036	0.0036	
Sandwich structural and weight characteristics				**meets ABS requirement?**
SMo (cm3)	0.678	0.780	0.461	**yes**
SMi (cm3)	0.438	0.498	0.310	**yes**
I (cm4)	0.692	0.881	0.361	**yes**
(do+dc)/2 (mm)	23.25	26.25	16.75	**yes**
outer skin reinforcement weight (kg/m2)	1.8	1.8	1.8	**yes**
outer skin weight (kg/m2)	5.2	5.2	5.2	
total skin weight (kg/m2)	8.1	8.1	8.1	
sandwich weight (kg/m2)	9.9	10.1	9.3	

Shell Above 19cm above DWL																	
	Bow	5%Lwl aft	Bulkhead 1		Bulkhead 2		40%Lwl	Bulkhead 3		Bulkhead 4		Bulkhead 5		Bulkhead 6		Stern	
x (m aft from FP)	-0.55	0.67	1.8		3.95		5.39	5.4		7.76		9.65		12.38		14.41	
coeff (Table 7.1)	0.7	1.08	1.08		1.08		1.08	1.08		0.96		0.87		0.73		0.63	
Local design head h (m)	3.833	5.914	5.914		5.914		5.914	5.912		5.267		4.750		4.004		3.450	
C_F	0.211	0.250	0.287		0.441		0.516	0.516		0.586		0.593		0.511		0.353	
F (Table 7.4)	0.759	0.720	0.683		0.537		0.479	0.479		0.430		0.425		0.483		0.617	
s (mm)	534	587	635		841		940	940		1033		1043		933		723	
A (mm)	0	0	0		36		50	50		63		70		111		47	
c=1-A/s	1.00	1.00	1.00		0.96		0.95	0.95		0.94		0.93		0.88		0.93	
p (N/mm2)	0.029	0.043	0.040		0.032		0.028	0.028		0.023		0.020		0.019		0.021	
Panel	Bow-B1		B1-B2		B2-B3			B3-B4		B4-B5		B5-B6		B6-S			
panel length (mm) (8.1.3)	2350		2150		1450			2360		1890		2730		2026			
panel aspect ratio	4.401	4.006	3.701	3.386	2.556	1.724	1.543	1.543	2.511	2.285	1.830	1.812	2.617	2.926	2.171	2.802	
k (Table 7.3)	0.500	0.500	0.500	0.500	0.499	0.488	0.478	0.478	0.499	0.498	0.492	0.491	0.499	0.500	0.497	0.499	
k1 (Table 7.3)	0.028	0.028	0.028	0.028	0.028	0.026	0.025	0.025	0.028	0.028	0.027	0.027	0.028	0.028	0.027	0.028	
t(a) (mm)	6.9	9.2	9.7	9.7	10.9	10.8	11.2	11.2	11.4	11.1	11.0	10.4	10.5	8.7	8.7	7.5	
t(b) (mm)	7.0	8.7	9.3	9.3	10.9	10.6	11.3	11.3	11.7	12.3	12.1	11.7	11.9	9.5	9.5	8.0	
Single skin laminate construction																	
panel skin thickness (mm)		9.7			10.9			11.3			12.3		12.1		11.9		9.5
Group of Panels			Bow-B2								B2-B6						B6-S
required skin thickness (mm)			10.9								12.3						9.5
skin weight (kg/m2)			18.3								20.8						16.9
Sandwich construction																	
Fs	0.702	0.671	0.642	0.642	0.521	0.521	0.463	0.462	0.462	0.408	0.408	0.402	0.402	0.467	0.467	0.590	
required SMo (cm3) (7.3.2a)			0.276						0.301							0.174	
required SMi (cm3) (7.3.2b)			0.292						0.319							0.185	
required I (cm4) (7.3.2c)			0.278						0.400							0.184	
required (do+dc)/2 (mm) (7.3.2.d)			21.6						21.6							14.5	
required minimum reinforcement weight (kg/m2)			1.63						1.63							1.63	

For each "group of panels", let us build a sandwich that satisfies these requirements...

Group of Panels	Bow-B2	B2-B6	B6-S	
Sandwich geometry				
Inner skin thickness (cm)	**0.2**	**0.2**	**0.2**	
Core thickness (cm)	**1.9**	**1.9**	**1.4**	
Outer skin thickness (cm)	**0.35**	**0.35**	**0.35**	
Total thickness (cm)	2.45	2.45	1.95	
width (cm)	1	1	1	
Ai (cm2)	0.2	0.2	0.2	
Ao (cm2)	0.35	0.35	0.35	
center inner (cm)	0.1	0.1	0.1	
center outer (cm)	2.275	2.275	1.775	
neutral axis (cm)	1.484	1.484	1.166	
Ii (cm4)	0.0007	0.0007	0.0007	
Io (cm4)	0.0036	0.0036	0.0036	
Sandwich structural and weight characteristics				**meets ABS requirement?**
SMo (cm3)	0.628	0.628	0.461	**yes**
SMi (cm3)	0.409	0.409	0.310	**yes**
I (cm4)	0.606	0.606	0.361	**yes**
(do+dc)/2 (mm)	2.175	2.175	1.675	**yes**
outer skin reinforcement weight (kg/m2)	1.8	1.8	1.8	**yes**
outer skin weight (kg/m2)	5.2	5.2	5.2	
total skin weight (kg/m2)	8.1	8.1	8.1	
sandwich weight (kg/m2)	9.7	9.7	9.3	

Deck, Cockpit and Reinforced shell above the keel

Station	Deck Bulkhead	Cockpit Bulkhead	Bulkhead 5
x (m aft from FP)	5.4	7.76	9.65
Local design head h (m) Table 7.1c	2.399	2.399	2.399
F (Table 7.5)	0.837	0.755	0.748
s (mm)	662	868	885
A (mm)	2.4	45	0
c=1-A/s	0.996	0.948	1.000
p (N/mm2)	0.020	0.018	0.018
Panel	B3-B4		
panel length (mm) (8.1.3)	2360		2730
panel aspect ratio	3.565	2.719	3.085
k (Table 7.3)	0.500	0.499	0.500
k1 (Table 7.3)	0.028	0.028	0.028
t(a) (mm)	7.1	8.4	9.0
t(b) (mm)	7.7	9.2	9.9
Single skin laminate construction			
Panel required skin thickness (mm)	9.2		9.9
skin weight (kg/m2)	13.6		14.6
Sandwich construction			
Fs	0.837	0.755	0.748
required SMo (cm3) (7.3.2a)	0.165		0.189
required SMi (cm3) (7.3.2b)	0.174		0.200
required I (cm4) (7.3.2c)	0.170		0.210
required (do+dc)/2 (mm) (7.3.2.d)	13.1		13.2
required minimum reinforcement weight (kg/m2)	1.63		1.63

Reinforced shell Station	Fwd	ymax (m from CI) Middle	Aft	0.697
x (m aft from FP)	4.90	6.83	8.40	
1.8*coeff (Table 7.1	2.16	1.998	1.872	
h (m)	11.828	10.940	10.251	
C_F	0.6994	0.7498	0.746	
F (Table 7.4)	0.3604	0.3401	0.342	
s (mm)	1184	1251	1246	
A (mm)	144	185	163	
c=1-A/s	0.878	0.852	0.869	
p (N/mm2)	0.043	0.037	0.035	
panel length (mm) (8		2360		
panel aspect ratio	1.993	1.886	1.894	
k (Table 7.3)	0.495	0.493	0.493	
k1 (Table 7.3)	0.027	0.027	0.027	
t(a) (mm)	16.3	15.6	15.3	
t(b) (mm)	17.1	17.0	16.9	
Required skin thickness		17.1		mm
Chosen skin thickness		18.0		mm
skin weight (kg/m2)		26.6		
Reinforcement surface (m2)		4.89		to be substracted from the sanwich panel surface
Reinforcement weight (kg)		130.0		

	Deck	Cockpit	
Sandwich geometry			
Inner skin thickness (cm)	**0.2**	**0.2**	we can use same sandwich for the deck and the cockpit
Core thickness (cm)	**1.1**	**1.1**	
Outer skin thickness (cm)	**0.35**	**0.35**	
Total thickness (cm)	1.65	1.65	
width (cm)	1	1	
Ai (cm2)	0.2	0.2	
Ao (cm2)	0.35	0.35	
center inner (cm)	0.1	0.1	
center outer (cm)	1.475	1.475	
neutral axis (cm)	0.975	0.975	
Ii (cm4)	0.00067	0.00067	
Io (cm4)	0.00357	0.00357	

Sandwich structural and weight characteristics			meets ABS requirement?
SMo (cm3)	0.363	0.363	**yes**
SMi (cm3)	0.251	0.251	**yes**
I (cm4)	0.245	0.245	**yes**
(do+dc)/2 (mm)	13.75	13.75	**yes**
outer skin reinforcement weight (kg/m2)	1.8	1.8	**yes**
outer skin weight (kg/m2)	5.2	5.2	
total skin weight (kg/m2)	8.1	8.1	
sandwich weight (kg/m2)	9.1	9.1	

Bulkheads	
Sandwich geometry	
Inner skin thickness (cm)	**0.25**
Core thickness (cm)	**1**
Outer skin thickness (cm)	**0.25**
Total thickness (cm)	1.5
width (cm)	1
Ai (cm2)	0.25
Ao (cm2)	0.25
center inner (cm)	0.125
center outer (cm)	1.375
neutral axis (cm)	0.75
Ii (cm4)	0.0013
Io (cm4)	0.0013
Sandwich structural and weight characteristics	
SMo (cm3)	0.264
SMi (cm3)	0.264
I (cm4)	0.198
(do+dc)/2 (mm)	1.25
sigma_c (equ 7.3.2e)	117
outer skin reinforcement weight (kg/m2)	1.3
outer skin weight (kg/m2)	3.7
total skin weight (kg/m2)	6.2
sandwich weight (kg/m2)	8.2

Stiffeners

Station	sigma_a (Bow	62 5%Lwl aft	Bulkhead 1			Bulkhead 2		40%Lwl :	Bulkhead 3	Bulkhead 4		Bulkhead 5		Bulkhead 6		Stern
x (m aft from FP)	-0.55	0.67	1.8			3.95		5.39	5.4	7.76		9.65		12.38		14.41
coeff (Table 7.1)	0.8	1.2	1.2			1.2		1.2	1.20	1.07		0.96		0.81		0.7
s(m)	0.534	0.58661	0.676			1.04		1.1834	1.184	1.251		1.242		1.061		0.744
Panel		Bow-B1		B1-B2			B2-B3			B3-B4		B4-B5		B5-B6		B6-S
panel length (m) (8.1.3)		2.35		2.15			1.45			2.36		1.89		2.73		2.026
C_F	1.58	1.58	1.58	1.43	1.43	0.90	0.90	0.90	1.58	1.58	1.23	1.23	1.86	1.86	1.33	1.33
F	0.25	0.25	0.25	0.25	0.25	0.28	0.28	0.28	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Local design head h (m)	1.095	1.643	1.643	1.643	1.643	1.841	1.841	1.841	1.642	1.463	1.463	1.319	1.319	1.112	1.112	0.958
required SM (cm3)	42.6	70.1	80.8	67.6	104.1	53.1	60.4	60.4	142.7	134.3	86.1	77.1	160.9	115.9	63.8	38.6
required I (cm4)	280.9	462.8	533.4	408.5	628.4	216.1	245.9	245.9	945.9	890.3	457.3	409.5	1234.0	888.5	363.2	219.4
Group of Panels			Bow-B2							B2-B6						B6-S
required SM (cm3)			104.1							160.9						63.8
required I (cm4)			628.4							1234.0						363.2

For each "group of panels", let us build a stiffener section that satisfies these requirements...

Stiffener geometry				
gap (b) (cm)	10	10	10	
bmax (cm)	36.45	39.51	29.35	**ok**
Flange thickness (t1) (cm)	0.4	0.5	0.4	
t1 min (cm)	0.33	0.396	0.297	**ok**
Crown thickness (t2) (cm)	0.4	0.6	0.4	
Crown width (Wc) (cm)	7	8	7	
Wc max	7.19	10.78	7.19	**ok**
Web height (h) (cm)	10	12	9	
h max	12.0	15.0	12.0	**ok**
Flange length (F) (cm)	5	5	5	
required min F (cm)	5	5	5	**ok**
maximum F (cm)	5	5	5	**ok**
t (cm)	2.03	2.19	1.63	
effective width	25	25	25	
max effective width	46.5	49.5	39.4	**ok**

Total moment of inertia of the stiffener				
K	1.00	1.00	1.00	
Aplating	50.63	54.87	40.77	
Cplating	1.01	1.10	0.82	
Astiff (cm2)	14.80	21.80	14.00	
Aflange	4.00	5.00	4.00	
Cflange	2.23	2.44	1.83	
Aweb	8.00	12.00	7.20	
Cweb	7.43	8.69	6.53	
Acrown	2.80	4.80	2.80	
Ccrown	12.63	14.99	11.23	
C_NA	2.37	3.24	2.17	
Iflange	0.05	0.10	0.05	
Iweb	66.67	144.00	48.60	
Icrown	0.04	0.14	0.04	
Iplating	17.31	22.03	9.03	**meets ABS requirement?**
Itot	**676.4**	**1441.7**	**499.8**	**yes**
SM	**285.7**	**444.4**	**230.0**	**yes**
Stiffener Weight				
Stiffener section weight (kg/m)	2.2	3.2	2.1	
Longitudinal length (m)	4.50	8.43	2.03	
Stiffener portion weight (kg)	9.8	27.2	4.2	
Total Stiffener weight (kg)	**41.2**			
if uniform with max Itot	**48.2**			

13. Large Angle Stability Analysis (Hydromax)

Item Name	Quantity	Weight kg	Long.Arm m	Vert.Arm m	Trans.Arm m	FS Mom. kg.m
Lightship	1	12940	-0.307	-0.203	0.000	0.000
	Total Weight=	**12940**	**LCG=-0.307**	**VCG=-0.203**	**TCG=0.000**	**0**

Heel angle	0	10	20	30	40	50	60
GZ m	0	0.333	0.61	0.81	0.956	1.042	1.068
WL Length m	13.98	13.992	14.014	13.945	13.631	13.453	13.451
Immersed Depth m	2.8	2.75	2.577	2.281	1.874	1.384	0.86
WL Beam m	3.497	3.429	3.217	3.008	2.868	2.791	3.154
Wetted Area m^2	47.619	47.126	45.201	43.581	42.492	41.455	38.81
Waterpl. Area m^2	34.038	33.345	31.481	29.793	28.89	26.89	24.737
Prismatic Coeff.	0.444	0.445	0.449	0.452	0.458	0.47	0.501
Block Coeff.	0.092	0.095	0.108	0.131	0.172	0.242	0.4
LCB from Amidsh. (+ve fwd) m	-0.307	-0.307	-0.304	-0.301	-0.29	-0.276	-0.26
VCB from DWL m	-0.28	-0.287	-0.301	-0.308	-0.303	-0.298	-0.307
TCF to zero pt. m	0	0.236	0.484	0.712	0.888	0.872	0.8

Heel angle	70	80	90	100	110	120	
GZ m	1.059	0.986	0.849	0.682	0.493	0.293	
WL Length m	13.004	12.98	13.37	13.739	14.043	14.319	
Immersed Depth m	0.872	0.934	1.071	1.17	1.226	1.236	
WL Beam m	4.131	2.117	2.094	2.115	2.144	2.209	
Wetted Area m^2	35.535	34.191	34.583	34.779	34.968	35.276	
Waterpl. Area m^2	23.557	21.815	20.782	20.498	20.492	20.874	
Prismatic Coeff.	0.583	0.628	0.613	0.599	0.586	0.572	
Block Coeff.	0.403	0.489	0.419	0.37	0.341	0.322	
LCB from Amidsh. (+ve fwd) m	-0.24	-0.225	-0.217	-0.217	-0.225	-0.243	
VCB from DWL m	-0.327	-0.347	-0.362	-0.375	-0.382	-0.382	
TCF to zero pt. m	0.712	0.697	0.573	0.449	0.314	0.185	

Heel angle	130	140	150	160	170	180	
GZ m	0.09	-0.1	-0.255	-0.335	-0.303	0	
WL Length m	14.581	14.584	14.567	14.532	14.461	14.203	
Immersed Depth m	1.199	1.115	0.989	0.847	0.789	0.702	
WL Beam m	2.318	2.522	2.884	3.369	3.848	4.166	
Wetted Area m^2	35.724	36.408	37.497	38.926	40.122	44.23	
Waterpl. Area m^2	21.648	22.856	24.921	28.012	31.455	36.729	
Prismatic Coeff.	0.551	0.523	0.48	0.433	0.387	0.378	
Block Coeff.	0.31	0.306	0.302	0.303	0.286	0.303	
LCB from Amidsh. (+ve fwd) m	-0.267	-0.295	-0.324	-0.349	-0.368	-0.372	
VCB from DWL m	-0.374	-0.355	-0.324	-0.283	-0.246	-0.214	
TCF to zero pt. m	0.064	-0.032	-0.085	-0.098	-0.117	0	

14. Performance Prediction (Span)

TWS (kts)	TWA (deg)	Spin-naker	AWS (kts)	AWA (deg)	Hull Speed (kts)	VMG (kts)	Heel Angle (deg)	Fwd Force (kN)	Side Force (kN)	Reef	Flat	Form Drag (kN)	Induced Drag (kN)	Aero. Heel.	Hydro. Heel.	Hull. Right.	Crew
6	35	down	9.47	21.04	3.97	3.25	3.87	0.46	2.75	1	1	0.36	0.09	2.56	0.34	1.65	1.24
6	39	down	9.84	22.25	4.5	3.49	4.21	0.56	3	1	1	0.47	0.09	2.79	0.37	1.79	1.37
6	42	down	10.07	23.18	4.84	3.6	4.42	0.64	3.15	1	1	0.56	0.08	2.93	0.39	1.87	1.45
6	45	down	10.24	24.14	5.14	3.64	4.58	0.72	3.26	1	1	0.64	0.08	3.03	0.4	1.93	1.5
6	50	down	10.42	25.8	5.56	3.57	4.76	0.84	3.37	1	1	0.77	0.07	3.13	0.41	2	1.55
6	60	down	10.48	29.28	6.17	3.09	4.78	1.05	3.38	1	1	0.99	0.06	3.14	0.41	2	1.56
6	75	down	9.98	34.97	6.64	1.72	4.21	1.21	2.98	1	1	1.17	0.04	2.77	0.37	1.76	1.38
6	90	down	8.85	42.08	6.57	0	3.23	1.17	2.21	1	1	1.14	0.02	2.05	0.27	1.35	0.97
6	100	down	7.81	48.43	6.21	-1.08	2.47	1.02	1.59	1	1	1.01	0.01	1.47	0.19	1.04	0.63
6	110	down	6.62	57.44	5.6	-1.91	1.66	0.79	0.96	1	1	0.78	0.01	0.89	0.12	0.7	0.31
6	80	up	9.69	37.73	6.62	1.15	4.89	1.21	3.06	1	1	1.16	0.04	3.24	0.38	2.03	1.58
6	90	up	9.26	40.56	7.03	0	5.18	1.38	3.18	1	1	1.34	0.04	3.4	0.39	2.15	1.65
6	100	up	8.47	44.44	7.1	-1.23	4.62	1.4	2.85	1	1	1.37	0.03	3.08	0.35	1.92	1.51
6	110	up	7.4	50.01	6.82	-2.33	3.6	1.27	2.18	1	1	1.25	0.02	2.37	0.27	1.5	1.13
6	120	up	6.14	58.4	6.24	-3.12	2.53	1.03	1.42	1	1	1.02	0.01	1.54	0.17	1.06	0.65
6	130	up	4.91	70.73	5.51	-3.54	1.63	0.75	0.81	1	1	0.75	0	0.89	0.1	0.69	0.3
6	140	up	3.89	88.65	4.72	-3.62	0.91	0.53	0.39	1	1	0.53	0	0.43	0.05	0.39	0.1
6	150	up	3.27	112.32	4	-3.46	0.43	0.37	0.17	1	1	0.37	0	0.19	0.02	0.18	0.02
6	165	up	2.87	146.98	3.43	-3.32	0.16	0.27	0.06	1	1	0.27	0	0.06	0.01	0.07	0
6	175	up	2.8	169.14	3.28	-3.26	0.06	0.24	0.02	1	1	0.24	0	0.02	0	0.03	0
6	180	up	2.8	180	3.25	-3.25	-0.02	0.24	-0.01	1	1	0.24	0	-0.01	0	0.01	0
8	35	down	12.45	21.17	5.13	4.2	7.93	0.8	4.76	1	1	0.63	0.17	4.43	0.58	3.3	1.72
8	39	down	12.84	22.51	5.72	4.44	8.91	0.98	5.12	1	1	0.82	0.16	4.75	0.63	3.67	1.71
8	42	down	13.07	23.53	6.11	4.54	9.49	1.11	5.31	1	1	0.96	0.15	4.94	0.65	3.88	1.71
8	45	down	13.25	24.55	6.46	4.57	9.94	1.24	5.47	1	1	1.1	0.14	5.08	0.67	4.04	1.71
8	50	down	13.47	26.23	7	4.5	10.48	1.45	5.63	1	1	1.32	0.13	5.24	0.69	4.23	1.7
8	60	down	13.41	30.17	7.64	3.82	10.19	1.79	5.51	1	1	1.69	0.1	5.12	0.68	4.09	1.7
8	75	down	12.55	37.11	7.96	2.06	7.78	2.06	4.64	1	1	1.99	0.07	4.31	0.57	3.16	1.72
8	90	down	11.17	44.94	7.9	0	4.86	1.97	3.4	1	1	1.93	0.04	3.16	0.42	2	1.58
8	100	down	10	51.14	7.65	-1.33	3.59	1.72	2.49	1	1	1.7	0.02	2.31	0.31	1.49	1.13
8	110	down	8.58	60.06	6.99	-2.39	2.41	1.33	1.52	1	1	1.32	0.01	1.42	0.19	1	0.6
8	80	up	12.24	39.32	8.07	1.4	11.6	2.2	5.29	1	1	2.12	0.08	5.64	0.65	4.6	1.7
8	90	up	11.43	43.6	8.28	0	11.34	2.46	5.16	1	1	2.39	0.08	5.56	0.63	4.49	1.7
8	100	up	10.42	48.75	8.27	-1.44	8.74	2.43	4.34	1	1	2.38	0.05	4.7	0.53	3.53	1.71
8	110	up	9.24	54.67	8.1	-2.77	5.6	2.18	3.31	1	1	2.15	0.03	3.6	0.41	2.3	1.7
8	120	up	7.88	62.1	7.72	-3.86	3.74	1.78	2.26	1	1	1.76	0.02	2.46	0.28	1.55	1.19
8	130	up	6.43	73.56	7	-4.5	2.46	1.33	1.35	1	1	1.32	0.01	1.48	0.17	1.02	0.62
8	140	up	5.18	91.42	6.05	-4.63	1.4	0.95	0.66	1	1	0.94	0	0.73	0.08	0.59	0.22
8	150	up	4.4	113.47	5.23	-4.53	0.72	0.67	0.3	1	1	0.66	0	0.33	0.04	0.3	0.06
8	165	up	3.86	147.27	4.54	-4.39	0.27	0.48	0.1	1	1	0.48	0	0.11	0.01	0.12	0.01
8	175	up	3.76	169.23	4.34	-4.32	0.1	0.44	0.04	1	1	0.44	0	0.04	0	0.04	0
8	180	up	3.76	180	4.3	-4.3	-0.04	0.43	-0.01	1	1	0.43	0	-0.02	0	0.02	0
10	35	down	15.12	21.3	6.01	4.93	13.73	1.17	6.77	1	0.96	0.93	0.25	6.3	0.83	5.45	1.68
10	39	down	15.53	22.53	6.7	5.21	16.11	1.43	7.49	1	1	1.19	0.24	6.96	0.92	6.21	1.66
10	42	down	15.78	23.5	7.16	5.32	17.08	1.61	7.74	1	1	1.39	0.23	7.2	0.95	6.49	1.66
10	45	down	15.9	24.63	7.5	5.3	17.6	1.8	7.87	1	1	1.58	0.21	7.32	0.97	6.63	1.65

10	50	down	15.92	26.8	7.89	5.07	17.64	2.1	7.86	1	1	1.9	0.19	7.3	0.96	6.62	1.65
10	60	down	15.58	31.73	8.33	4.16	16.08	2.6	7.39	1	1	2.45	0.15	6.87	0.91	6.11	1.66
10	75	down	14.54	39.89	8.6	2.23	11.97	2.99	6.09	1	1	2.89	0.1	5.65	0.75	4.71	1.69
10	90	down	13.01	48.97	8.54	0	7.06	2.85	4.37	1	1	2.8	0.05	4.05	0.54	2.87	1.72
10	100	down	11.74	55.88	8.3	-1.44	4.45	2.46	3.13	1	1	2.43	0.03	2.9	0.38	1.83	1.46
10	110	down	10.32	64.22	7.87	-2.69	3.01	1.92	2	1	1	1.9	0.01	1.87	0.25	1.25	0.87
10	80	up	13.99	41.35	8.77	1.52	20.05	3.3	7.43	1	1	3.16	0.14	7.97	0.91	7.25	1.63
10	90	up	13.07	46.82	8.95	0	17.76	3.61	6.84	1	1	3.5	0.11	7.4	0.84	6.59	1.65
10	100	up	12.02	53.17	8.95	-1.55	13.31	3.59	5.66	1	1	3.51	0.08	6.15	0.7	5.16	1.69
10	110	up	10.76	60.32	8.77	-3	8.65	3.24	4.28	1	1	3.19	0.05	4.66	0.52	3.47	1.71
10	120	up	9.34	68.54	8.45	-4.23	4.98	2.68	2.99	1	1	2.65	0.02	3.28	0.37	2.04	1.6
10	130	up	7.86	78.74	8.01	-5.15	3.23	2.06	1.88	1	1	2.05	0.01	2.08	0.23	1.34	0.97
10	140	up	6.49	93.53	7.32	-5.61	1.94	1.49	1	1	1	1.48	0	1.1	0.12	0.81	0.41
10	150	up	5.57	115.2	6.36	-5.51	1.04	1.06	0.46	1	1	1.06	0	0.51	0.06	0.44	0.13
10	165	up	4.9	147.82	5.59	-5.4	0.42	0.78	0.17	1	1	0.78	0	0.18	0.02	0.18	0.02
10	175	up	4.76	169.37	5.36	-5.34	0.16	0.7	0.06	1	1	0.7	0	0.07	0.01	0.07	0
10	180	up	4.76	180	5.32	-5.32	-0.07	0.69	-0.02	1	1	0.69	0	-0.03	0	0.03	0
12	35	down	17.58	21.39	6.71	5.5	18.49	1.48	8.16	1	0.86	1.19	0.29	7.59	1	6.95	1.64
12	39	down	17.92	22.74	7.38	5.74	20.68	1.77	8.69	1	0.87	1.5	0.27	8.08	1.07	7.52	1.62
12	42	down	18	23.92	7.72	5.74	21.86	2	8.95	1	0.89	1.74	0.26	8.32	1.1	7.81	1.61
12	45	down	17.99	25.18	7.98	5.64	22.81	2.24	9.15	1	0.91	1.98	0.26	8.5	1.12	8.03	1.6
12	50	down	17.83	27.38	8.3	5.33	24.09	2.63	9.39	1	0.96	2.38	0.25	8.73	1.15	8.3	1.58
12	60	down	17.37	32.58	8.76	4.38	23.08	3.35	9.14	1	1	3.14	0.21	8.5	1.12	8.03	1.59
12	75	down	16.35	41.9	9.12	2.36	16.77	3.97	7.55	1	1	3.83	0.13	7.01	0.93	6.28	1.66
12	90	down	14.78	52.21	9.06	0	9.79	3.81	5.33	1	1	3.74	0.07	4.95	0.65	3.89	1.71
12	100	down	13.44	59.99	8.79	-1.53	5.52	3.26	3.75	1	1	3.22	0.04	3.48	0.46	2.25	1.7
12	110	down	11.94	68.91	8.36	-2.86	3.53	2.53	2.41	1	1	2.51	0.02	2.26	0.3	1.45	1.1
12	80	up	15.32	42.75	9.19	1.6	27.38	4.1	8.72	1	0.96	3.93	0.18	9.38	1.07	8.92	1.54
12	90	up	14.37	48.87	9.45	0	24.89	4.63	8.25	1	1	4.48	0.15	8.94	1.01	8.38	1.57
12	100	up	13.46	56.43	9.53	-1.65	18.41	4.78	6.93	1	1	4.68	0.1	7.54	0.85	6.74	1.64
12	110	up	12.25	64.66	9.36	-3.2	12.28	4.42	5.33	1	1	4.36	0.06	5.82	0.65	4.79	1.69
12	120	up	10.81	73.82	9.05	-4.53	7.22	3.76	3.79	1	1	3.73	0.03	4.17	0.47	2.91	1.72
12	130	up	9.28	84.67	8.63	-5.55	4.01	2.97	2.4	1	1	2.95	0.02	2.65	0.29	1.64	1.3
12	140	up	7.85	98.41	8.12	-6.22	2.43	2.18	1.32	1	1	2.18	0.01	1.45	0.16	1.01	0.61
12	150	up	6.76	116.6	7.45	-6.45	1.4	1.56	0.66	1	1	1.56	0	0.72	0.08	0.58	0.22
12	165	up	5.97	148.39	6.6	-6.37	0.59	1.16	0.24	1	1	1.16	0	0.26	0.03	0.25	0.04
12	175	up	5.82	169.56	6.33	-6.3	0.24	1.05	0.09	1	1	1.05	0	0.1	0.01	0.1	0.01
12	180	up	5.82	180	6.28	-6.28	-0.1	1.03	-0.04	1	1	1.03	0	-0.04	0	0.04	0
14	35	down	19.83	21.56	7.21	5.91	22.1	1.71	9.04	1	0.75	1.41	0.31	8.4	1.11	7.91	1.6
14	39	down	20	23.2	7.75	6.02	23.8	2.04	9.38	1	0.76	1.76	0.29	8.72	1.15	8.28	1.58
14	42	down	19.99	24.55	8.02	5.96	24.75	2.31	9.55	1	0.77	2.03	0.28	8.88	1.17	8.48	1.57
14	45	down	19.91	25.95	8.24	5.83	25.56	2.58	9.69	1	0.79	2.31	0.27	9.01	1.19	8.63	1.56
14	50	down	19.67	28.32	8.55	5.49	26.71	3.02	9.87	1	0.83	2.76	0.26	9.18	1.21	8.85	1.55
14	60	down	18.94	33.24	9.04	4.52	28.27	3.87	10.1	1	0.93	3.63	0.24	9.39	1.24	9.1	1.53
14	75	down	17.92	43.04	9.55	2.47	22.47	4.89	8.97	1	1	4.72	0.17	8.32	1.1	7.82	1.6
14	90	down	16.51	54.67	9.55	0	12.83	4.83	6.34	1	1	4.74	0.09	5.88	0.78	4.97	1.69
14	100	down	15.15	63.22	9.23	-1.6	7.31	4.14	4.42	1	1	4.09	0.04	4.12	0.54	2.95	1.72
14	110	down	13.6	72.77	8.77	-3	4.13	3.21	2.87	1	1	3.19	0.02	2.69	0.35	1.69	1.35
14	80	up	16.73	44.73	9.49	1.65	30.13	4.7	9.06	1	0.83	4.52	0.18	9.77	1.11	9.39	1.5
14	90	up	15.46	50.63	9.81	0	30.16	5.38	9	1	0.95	5.22	0.16	9.75	1.1	9.36	1.5
14	100	up	14.65	58.75	10.02	-1.74	24.09	5.87	8.03	1	1	5.74	0.13	8.75	0.99	8.16	1.58

14	110	up	13.64	67.88	9.93	-3.4	16.52	5.68	6.42	1	1	5.6	0.08	7.03	0.79	6.16	1.66
14	120	up	12.28	77.77	9.64	-4.82	10.13	5.01	4.66	1	1	4.96	0.05	5.13	0.57	4	1.7
14	130	up	10.76	89.26	9.2	-5.92	5	4.06	2.98	1	1	4.04	0.02	3.28	0.37	2.04	1.61
14	140	up	9.3	103.19	8.68	-6.65	2.94	3.05	1.68	1	1	3.04	0.01	1.84	0.21	1.21	0.84
14	150	up	8.14	119.91	8.16	-7.07	1.78	2.24	0.89	1	1	2.24	0	0.97	0.11	0.74	0.35
14	165	up	7.09	149.01	7.55	-7.29	0.79	1.63	0.33	1	1	1.63	0	0.36	0.04	0.33	0.07
14	175	up	6.88	169.7	7.29	-7.26	0.33	1.47	0.13	1	1	1.47	0	0.13	0.02	0.14	0.01
14	180	up	6.87	180	7.24	-7.24	-0.14	1.44	-0.05	1	1	1.44	0	-0.05	-0.01	0.06	0
16	35	down	21.86	21.87	7.49	6.14	24.64	1.88	9.57	1	0.65	1.56	0.32	8.9	1.18	8.5	1.57
16	39	down	21.93	23.71	7.96	6.18	26.05	2.25	9.81	1	0.66	1.96	0.3	9.12	1.2	8.76	1.56
16	42	down	21.87	25.17	8.21	6.1	26.89	2.54	9.94	1	0.67	2.26	0.29	9.24	1.22	8.91	1.54
16	45	down	21.74	26.65	8.42	5.96	27.66	2.83	10.05	1	0.69	2.56	0.28	9.35	1.23	9.05	1.53
16	50	down	21.43	29.15	8.72	5.61	28.78	3.31	10.21	1	0.73	3.05	0.27	9.49	1.25	9.23	1.52
16	60	down	20.58	34.35	9.23	4.62	30.23	4.25	10.39	1	0.82	4	0.25	9.65	1.28	9.43	1.5
16	75	down	19.12	43.34	9.88	2.56	29.07	5.6	10.16	1	1	5.39	0.21	9.43	1.25	9.16	1.51
16	90	down	18.13	56.49	10.01	0	16.27	5.88	7.36	1	1	5.77	0.11	6.83	0.9	6.07	1.66
16	100	down	16.85	65.72	9.68	-1.68	9.45	5.09	5.17	1	1	5.04	0.06	4.82	0.63	3.75	1.71
16	110	down	15.29	75.82	9.16	-3.13	4.93	3.98	3.39	1	1	3.95	0.03	3.19	0.42	2.01	1.59
16	80	up	18.18	46.78	9.72	1.69	31	5.21	9.46	0.96	0.79	5.03	0.18	9.83	1.16	9.51	1.48
16	90	up	16.78	53.08	10.08	0	31.44	6.01	9.29	0.98	0.89	5.84	0.17	9.88	1.14	9.54	1.48
16	100	up	15.51	60.48	10.39	-1.8	29.91	6.74	8.87	1	1	6.6	0.14	9.67	1.09	9.26	1.5
16	110	up	14.85	70.43	10.43	-3.57	21.19	6.89	7.42	1	1	6.8	0.1	8.14	0.91	7.43	1.61
16	120	up	13.71	80.81	10.22	-5.11	13.39	6.36	5.57	1	1	6.3	0.06	6.13	0.68	5.13	1.68
16	130	up	12.27	92.68	9.78	-6.29	6.76	5.31	3.62	1	1	5.28	0.03	3.99	0.44	2.72	1.72
16	140	up	10.81	106.82	9.22	-7.07	3.54	4.09	2.09	1	1	4.08	0.01	2.29	0.26	1.44	1.1
16	150	up	9.62	123.08	8.72	-7.55	2.2	3.1	1.17	1	1	3.1	0	1.27	0.14	0.9	0.51
16	165	up	8.46	150.44	8.22	-7.94	1.02	2.31	0.45	1	1	2.31	0	0.49	0.06	0.42	0.12
16	175	up	8.17	170.09	8.02	-7.99	0.44	2.06	0.17	1	1	2.06	0	0.18	0.02	0.18	0.02
16	180	up	8.15	180	7.98	-7.98	-0.19	2.02	-0.07	1	1	2.02	0	-0.07	-0.01	0.08	0
20	35	down	25.59	22.7	7.74	6.34	27.29	2.09	10.31	0.96	0.55	1.74	0.35	9.31	1.27	9.04	1.54
20	39	down	25.53	24.82	8.17	6.35	28.09	2.53	10.59	0.94	0.59	2.2	0.33	9.38	1.3	9.15	1.53
20	42	down	25.38	26.43	8.42	6.26	28.71	2.87	10.76	0.93	0.62	2.55	0.32	9.44	1.32	9.25	1.52
20	45	down	25.18	28.05	8.64	6.11	29.33	3.21	10.92	0.92	0.66	2.9	0.31	9.51	1.34	9.34	1.51
20	50	down	24.77	30.82	8.96	5.76	30.12	3.77	11.14	0.91	0.72	3.47	0.3	9.57	1.37	9.44	1.5
20	60	down	23.77	36.65	9.52	4.76	30.87	4.88	11.37	0.89	0.86	4.6	0.28	9.6	1.4	9.51	1.49
20	75	down	21.93	46.01	10.27	2.66	31.52	6.52	11.1	0.92	1	6.29	0.23	9.65	1.36	9.53	1.48
20	90	down	20.82	58.88	10.76	0	24.19	7.8	9.22	1	1	7.66	0.14	8.57	1.13	8.12	1.58
20	100	down	20.09	69.32	10.52	-1.83	14.48	7.14	6.76	1	1	7.06	0.08	6.32	0.83	5.48	1.68
20	110	down	18.67	80.13	9.96	-3.41	8.08	5.74	4.62	1	1	5.7	0.04	4.37	0.57	3.22	1.71
20	80	up	21.05	50.24	10.12	1.76	31.6	6.12	10.45	0.84	0.85	5.92	0.21	9.76	1.28	9.57	1.47
20	90	up	19.45	57.25	10.52	0	32.16	7.12	10.3	0.85	0.98	6.94	0.19	9.81	1.26	9.61	1.47
20	100	up	17.78	65.11	10.87	-1.89	32.87	8.04	9.69	0.93	1	7.89	0.15	9.94	1.19	9.68	1.45
20	110	up	16.56	74.57	11.16	-3.82	30.63	8.89	8.82	1	1	8.76	0.12	9.7	1.08	9.29	1.49
20	120	up	16.23	85.67	11.21	-5.6	20.6	9.12	7.22	1	1	9.04	0.08	7.96	0.89	7.23	1.62
20	130	up	15.22	97.63	10.9	-7.01	11.58	8.2	5.05	1	1	8.16	0.04	5.55	0.62	4.48	1.7
20	140	up	13.86	111.54	10.34	-7.92	5.26	6.66	3.11	1	1	6.64	0.02	3.4	0.38	2.12	1.66
20	150	up	12.65	127.29	9.79	-8.48	3.18	5.32	1.85	1	1	5.31	0.01	2.01	0.23	1.3	0.95
20	165	up	11.44	152.88	9.29	-8.97	1.55	4.21	0.76	1	1	4.21	0	0.81	0.09	0.64	0.27
20	175	up	11.13	170.91	9.1	-9.06	0.73	3.82	0.3	1	1	3.82	0	0.32	0.04	0.3	0.06
20	180	up	11.1	180	9.06	-9.06	-0.34	3.75	-0.13	1	1	3.75	0	-0.14	-0.02	0.14	0.01
20	180	up	11.1	180	9.06	-9.06	-0.34	3.75	-0.13	1	1	3.75	0	-0.14	-0.02	0.14	0.01

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STANDARD NAVTEC ROD SPECIFICATIONS

NITRONIC 50 COIL

Rod Size	Diameter (in)	Diameter (mm)	Minimum Breaking Strength (lbs.)	Minimum Breaking Strength (mm)	Weight (lbs. / ft.)	Weight (kg. / m.)	Equivalent Wire Size (mm)	Equivalent Wire Size (in)
-4	0.172	4.4	4,700	2,136	0.079	0.118	5	7/32
-6	0.198	5.0	6,300	2,864	0.105	0.157	6	1/4
-8	0.225	5.7	8,200	3,727	0.136	0.202	7	9/32
-10	0.250	6.4	10,300	4,682	0.168	0.250	8	5/16
-12	0.281	7.1	12,500	5,682	0.212	0.316	9	3/8
-17	0.330	8.4	17,500	7,955	0.293	0.435	11	7/16
-22	0.375	9.5	22,500	10,227	0.378	0.562	12	1/2
-30	0.437	11.1	30,000	13,636	0.513	0.764	14	9/16
-40	0.500	12.7	38,000	17,273	0.672	1.000	16	5/8
-48	0.562	14.3	48,000	21,818	0.848	1.263	19	3/4
-60	0.660	16.8	67,000	30,455	1.170	1.742	22	7/8
-76	0.705	17.9	76,000	34,545	1.335	1.987		

Student name	Comments	Grade
Alexis Hanneville		
Oral Presentation Given to the 13.734 class.		7/8
Preliminary Design Design phylosophy, choice of initial parameters, comparison with existing designs.		10/10
Hull Design Line drawings, sectional area curve, maximum area section, canoe body specifications.		12/12
Appendage Design Planform design, profile choice, location.		7/7
Sailplan and Rig Design Sailplan choice, sailplan dimensions, rig dimensions, rig structural design.		10/10
Structural Analysis Construction method choice, deck and hull structural design, including internals, keel attachment, and rudder stock.		10/10
Weight Table Weight and center of gravity estimates of different components, final LCG and VCG.		6/6
Interior and Deck Layout Interior arrangements, and deck layout.		5/5
Stability Analysis Large angle stability analysis performed with Hydromax, including angle of positive stability nad hull characteristics when heeled.		7/7
Performance Analysis Polar graph from Span, comparison with existing designs.		5/5
Overall Design Achievement of initial goals.		5/5
Final Report Presentation, organization, completeness.		14/15
Final Grade		98/100

Student Name: **Alexis Manneville**

Design Philosophy

Clear and concise.

Preliminary Design

The choice of initial parameters is good.

Canoe Body Lines

The canoe body lines look well balanced.
Hydrostatic data seem reasonable, and the area curve looks nice.

Appendage Design

The design of the appendage is well done; the profiles chosen for both the keel and the rudder are very good. Two notes: the first is that the curved leading edge of the keel is not very smooth, or at least that is how it appears from the pictures. The second is about the planform of the rudder: as designed it will give a lot of helm to the skipper, making it heavy to adjust. Also the curved leading edge brings the rudder stock, that is straight, very close to the leading edge itself, where the rudder is not very thick. A straight leading edge might be a better choice.

Sailplan and Rig Design

The sailplan is very well developed.
Structural analysis is complete and correct.

Deck and Interior Layout

Deck is nicely laid out. In the interior, it would be nice to have some sea berths for the long passages.

Structural Analysis

The structural analysis seems correct and complete.

Weight Table

The weight table is as complete as it can be at this stage of the design.

Large Angle Stability Analysis

A righting arm plot as well as the Hydromax table is included. The angle of positive stability is very reasonable.
At 20 deg of heel the boat does not pick up any length, but it drops more than 2 m^2 of wetted surface, without acquiring a significant trim (0.5 deg.)

Performance Analysis

Complete.

Overall Design

The overall design is well developed and consistent with the initial goals set.

Final Report

The final report is well organized and well written. It is complete and concise, without useless information.

Comprehensive grade given is too high in view of deficiencies

Student name	Comments	Grade
Meghan Hendry-Bourgeau		
Grader Name Alexis Hanneville		
Preliminary Design Design phylosophy, choice of initial parameters, comparison with existing designs.		10
Hull Design Line drawings, sectional area curve, maximum area section, canoe body specifications.		11 12
Appendage Design Planform design, profile choice, location.		5 7
Sailplan and Rig Design Sailplan choice, sailplan dimensions, rig dimensions, rig structural design.		7 10
Structural Analysis Construction method choice, deck and hull structural design, including internals, keel attachment, and rudder stock.		10 10
Weight Table Weight and center of gravity estimates of different components, final LCG and VCG.		5 6
Interior and Deck Layout Interior arrangements, and deck layout.		5 5
Stability Analysis Large angle stability analysis performed with Hydromax, including angle of positive stability nad hull characteristics when heeled.	see evaluation report (attached)	7 7
Performance Analysis Polar graph from Span, comparison with existing designs.		5 5
Overall Design Achievement of initial goals.		5 5
Final Report Presentation, organization, completeness.		14 15
Final Grade		84 92

(95)

Student Report Evaluation

Yacht:
"Lazy Girl"
by Meghan Brogan

Evaluated by:
Alexis Manneville

- Preliminary Design: 10/10

The design philosophy is clear and very reasonable. The design is clearly inspired by the existing Fantasi 44, which justifies the choice of the initial parameters.

- Hull: 11/12

The line drawings do not show the buttocks neither the grid (x,y,z values of the positions of sections, buttocks and waterlines), so that the profile view and the body plan are not very useful. I could not find Figure 3 (perspective view of the Canoe body). The sectional area curve looks good. The canoe body specifications are reasonable (Cp and Tc), but we can not tell how the LCB and LCF were chosen. However, their positions can be computed at 3.8% and 5.7% of Lwl aft of amidships, which are pretty good values.

- Appendages: 5/7

We do not know the thickness-to-chord ratio of the rudder at the root, so that we can not check whether the rudder stock fits in it or not. The 80mm stock wouldn't fit unless t/c is larger than 8/61.7=13% at the root. We can not tell whether the stock diameter of 80mm computed according to the ABS rules or guessed. The keel looks good. The choice of the profile is not optimum (NACA 64- or 65- series), but performance is clearly not a prime design objective here. However, we do not know how the longitudinal position of the keel was chosen (Balance? value of the lead?).

- Sailplan and Rig: 7/10

The choice of a reasonable total sail area based on a Dellenbaugh Angle of 12.5 for comfort and handling reasons is good. With an overlap of 117%, the jib might interfere with the rig. We do not know if the position of the chain plates at 0.85*b/2 was imposed by this constraint, but this low value should hopefully prevent any interference. The required minimum transverse moment of inertia Ixmin is the MAXIMUM (Ixmin=164cm4) of the moment of inertia computed for the 3 panels, not the MINIMUM (Ixmin=117cm4), since the chosen mast section has to satisfy the requirements for all the 3 panels. However, the chosen Selden mast section still satisfies Ixmin=164cm4 since it has an Ix of 193cm4. We do not know which wire diameters are chosen following the shrouds loading computation. The forestay and backstay loads are not computed. What is the fractional-rig ratio?

- Structural Analysis: 10/10

The construction of cold molded wood is a good idea and leads to a light hull shell, as expected by the designer. It is strange that the reinforced shell required thickness (9.27mm) is smaller than that of the bottom (19.65mm). The deck is very light (310kg), which is good for stability. The keel bolts and the internals seem reasonable.

- Weight Table: 5/6

It is difficult to tell where the reference point for the VCG is. It seems different than for the Hydrostatics computation. Maybe the reference height is the freeboard forward? (Anchor at z=0?) The weight of the hull shell is not updated according to the structural calculation (571kg only, whereas structural calculation give 823kg+340kg). The LCG was not computed.

- Interior and Deck Layout: 5/5

The cockpit and the pilot house looks very good: the high head clearance should be very comfortable, and the windows are good for the interior lighting. The deck hardware is well detailed, as well as the interior. Both plan view and profile view are helpful to better visualize the interior layout. Is it safe to have the play area so close to the galley? (Kids playing while cooking at sea?).

- Stability Analysis: 7/7

We do not know whether the large angle stability analysis was run with the initial estimate of the VCG position, or with the VCG position computed in the Weight Table. The maximum angle of positive stability is very large (almost 140 degrees) which is very good from a safety point of view.

- Performance Analysis: 5/5

Taking into account the design objectives, the performance of the design is reasonable beating upwind in moderate to strong winds. This is good from a safety point of view. The design is obviously penalized downwind by its low Sail Area to Displacement ratio and it low Length to Displacement ratio. It is interesting to see that the initial VPP was very close to the final estimate by SPAN.

- Overall Design: 5/5

The design objectives are clearly achieved, in good agreement with the initial design philosophy.

- Final Report: 14/15

The final report is well presented and easy to read. It would have been more logical to place the weight table after the structural computations, and to update it according to the computed structural weights. The weight breakdown of the standing rigging could easily have been computed once the loads were known (shrouds and spreaders should push the total VCG up). Overall, the most important parts of the design of the yacht are globally well covered.

Final Grade: 84/92