



DIRECTORATE OF MERCHANT SHIPPING
GOVERNMENT OF SRI LANKA
CERTIFICATE OF COMPETENCY EXAMINATION

GRADE : CHIEF MATE ON SHIPS OF 500 GT OR MORE (UNLIMITED)
SUBJECT : SHIP'S STABILITY
DATE : 27th February 2017

Time allowed THREE hours	Total marks : 180
ANSWER ALL QUESTIONS	Pass marks : 60%

Formulae and all intermediate steps taken in reaching your answer should be clearly shown. You may draw sketches wherever required. Electronic devices capable of storing and retrieving are **not** allowed.

- 1) Worksheet -1 (Trim and Stability pro-forma) provides data relevant to a particular condition of the loading of a vessel in salt water.

By the completion of the Worksheet – 1 with the aid of the 'Hydrostatic Particulars Table A' and showing all additional calculations in your answer book, determine each of the following:

- a) Final fwd and aft draughts (12 marks)
- b) Final transverse GM_f (18 marks)

- 2) Answer the following questions with regard to bilging:

- a) Manual stability calculation of a bilged vessel is very complicated to be carried out onboard a vessel. Briefly describe the actions taken by the IMO and also the shipping industry to overcome the situation. (05 marks)
- b) A box shaped vessel 75 m long, 10 m wide and 6 m deep is floating in salt water on an even keel at a draught of 4.5 m. Find the new draughts if a forward end compartment of 5 m long extending the full breadth is bilged. (25 marks)

- 3) A vessel loads a packaged timber cargo on deck such that there is an increase in the vessel's KG and an effective increase in freeboard.

- a) Sketch the vessel's GZ curve, showing the effect of loading this cargo. (14 marks)

b) Sketch how the GZ curve for a vessel with a zero GM is affected by EACH of the following:

i) a rise in the vessel's KG;

(08 marks)

ii) a reduction in the vessel's KG.

(08 marks)

4) A vessel with a high deck cargo of containers will experience adverse effects due to strong beam winds on lateral windage areas.

Explain, with the aid of a sketch of the statical stability curve, how the effects of steady and gusting winds are determined, stating the minimum stability requirements with respect to wind heeling under the current regulations.

(30 marks)

5) A box shaped vessel, length 96.00m, breadth 11.00m, is floating at a draught of 4.20m in salt water. Initial KG 4.18m.

a) Calculate the angle of loll if 620 tonne of cargo, Kg 7.78m, is loaded on deck.

(20 marks)

b) Briefly describe the methods available to eliminate the angle of loll

(10 marks)

6) A vessel is floating in salt water with the following particulars;

Fwd draft 4.2 m

Aft draft 5.4 m

LBP 142 m

LCG 68.906 m.

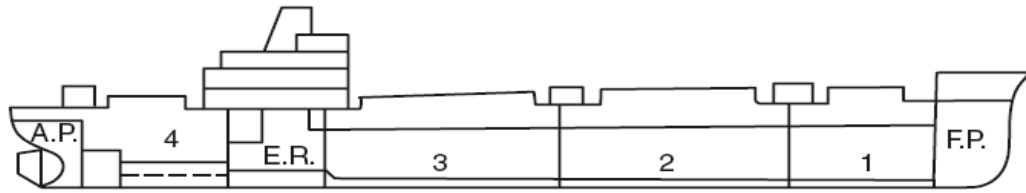
She is expected to carryout following operations at the port;

Remarks	Weight (t)	Lcg (m)	Load/discharge
No. 1 hold	650	132	Load
No. 2 hold	750	105	Load
No. 3 hold	1500	56	Load
No. 4 hold	1600	48	Load
No. 4 centre DB Tk	50	138	De-ballast
No. 2 centre DB Tk	25	58	De-ballast

With the aid of the hydrostatic particulars (Hydrostatic particulars 'A') provided, calculate the anticipated drafts fwd and aft, at the completion of above operations.

(30 marks)

Worksheet -1 (Trim and Stability pro-forma)



CONDITION: FULLY LOADED – GENERAL CARGO

Compartment	Capacity m ³	Stowage Factor m ³ /t	Weight t	KG m	Vertical Moment tm	Free Surface Moment tm	LCG foap m	Longitudinal Moment tm
All Holds	13 507	2.01		6.76			74.90	
1 TD	936	2.38		10.89			114.60	
2 TD	1297	2.65		10.71			92.80	
3 TD	1579	2.13		10.51			63.80	
Consumables			1812	–	4784	2324	–	58 736
Deadweight								
Lightship			4029	8.13			61.50	
DISPLACEMENT								
HYDROSTATICS			True Mean Draught			LCB foap	LCF foap	
LENGTH B.P. 133.0m.			MCTC					
TRIM							KM _T	
							KG	
DRAUGHTS: F.					A.		GM	

HYDROSTATIC PARTICULARS 'A'

Draught m	Displacement t		TPC t		MCTC tm		KMt M	KB m	LCB foap m	LCF foap m
	SW RD 1.025	FW RD 1.000	SW RD 1.025	FW RD 1.000	SW RD 1.025	FW RD 1.000				
7.00	14576	14220	23.13	22.57	184.6	180.1	8.34	3.64	70.03	67.35
6.90	14345	13996	23.06	22.50	183.0	178.5	8.35	3.58	70.08	67.46
6.80	14115	13771	22.99	22.43	181.4	177.0	8.36	3.53	70.12	67.57
6.70	13886	13548	22.92	22.36	179.9	175.5	8.37	3.48	70.16	67.68
6.60	13657	13324	22.85	22.29	178.3	174.0	8.38	3.43	70.20	67.79
6.50	13429	13102	22.78	22.23	176.8	172.5	8.39	3.38	70.24	67.90
6.40	13201	12879	22.72	22.17	175.3	171.0	8.41	3.33	70.28	68.00
6.30	12975	12658	22.66	22.11	173.9	169.6	8.43	3.28	70.32	68.10
6.20	12748	12437	22.60	22.05	172.5	168.3	8.46	3.22	70.35	68.20
6.10	12523	12217	22.54	21.99	171.1	167.0	8.49	3.17	70.38	68.30
6.00	12297	11997	22.48	21.93	169.8	165.7	8.52	3.11	70.42	68.39
5.90	12073	11778	22.43	21.87	168.5	164.4	8.55	3.06	70.46	68.43
5.80	11848	11559	22.37	21.82	167.3	163.2	8.59	3.01	70.50	68.57
5.70	11625	11342	22.32	21.77	166.1	162.1	8.63	2.95	70.53	68.65
5.60	11402	11124	22.26	21.72	165.0	161.0	8.67	2.90	70.57	68.73
5.50	11180	10908	22.21	21.66	163.9	160.0	8.71	2.85	70.60	68.80
5.40	10958	10691	22.15	21.61	162.9	158.9	8.76	2.80	70.64	68.88
5.30	10737	10476	22.10	21.56	161.8	157.9	8.81	2.74	70.68	68.95
5.20	10516	10260	22.05	21.51	160.8	156.9	8.86	2.69	70.72	69.02
5.10	10296	10045	22.00	21.46	159.8	155.9	8.92	2.63	70.75	69.09
5.00	10076	9830	21.95	21.41	158.8	154.9	8.98	2.58	70.79	69.16
4.90	9857	9616	21.90	21.36	157.9	154.0	9.06	2.53	70.82	69.23
4.80	9638	9403	21.85	21.32	156.9	153.1	9.13	2.48	70.86	69.29
4.70	9420	9190	21.80	21.27	156.0	152.2	9.22	2.43	70.90	69.35
4.60	9202	8978	21.75	21.22	155.1	151.3	9.30	2.38	70.93	69.42
4.50	8985	8766	21.70	21.17	154.2	150.5	9.40	2.32	70.96	69.48
4.40	8768	8554	21.65	21.12	153.3	149.6	9.49	2.27	71.00	69.55
4.30	8552	8344	21.60	21.07	152.4	148.7	9.60	2.22	71.04	69.62
4.20	8336	8133	21.55	21.02	151.5	147.8	9.71	2.17	71.08	69.68
4.10	8121	7923	21.50	20.97	150.6	146.9	9.83	2.12	71.12	69.74
4.00	7906	7713	21.45	20.93	149.7	146.0	9.96	2.07	71.15	69.81
3.90	7692	7505	21.40	20.88	148.7	145.1	10.11	2.01	71.18	69.88
3.80	7478	7296	21.35	20.83	147.8	144.2	10.25	1.96	71.22	69.94
3.70	7265	7088	21.30	20.78	146.8	143.3	10.41	1.91	71.25	70.00
3.60	7052	6880	21.24	20.72	145.9	142.3	10.57	1.86	71.29	70.07
3.50	6840	6673	21.19	20.67	144.9	141.3	10.76	1.81	71.33	70.14

THESE HYDROSTATIC PARTICULARS HAVE BEEN DEVELOPED WITH THE VESSEL FLOATING ON EVEN KEEL

Answers

Answer 1



CONDITION: FULLY LOADED – GENERAL CARGO

Compartment	Capacity m ³	Stowage Factor m ³ /t	Weight t	KG m	Vertical Moment tm	Free Surface Moment tm	LCG foap m	Longitudinal Moment tm
All Holds	13 507	2.01	6720	6.76	45 427		74.90	5 03 328
1 TD	936	2.38	393	10.89	4280		114.60	45 038
2 TD	1297	2.65	489	10.71	5237		92.80	45 379
3 TD	1579	2.13	741	10.51	7788		63.80	47 276
Consumables			1812	–	4784	2324	–	58 736
Deadweight			10 155					
Lightship			4029	8.13	32 756		61.50	2 47 784
DISPLACEMENT			14 184	7.07	100 272	2324	66.80	9 47 541
HYDROSTATICS			True Mean Draught 6.83 m			LCB foap 70.11 m		LCF foap 67.54 m
LENGTH B.P. 133.0 m			MCTC = 181.9 tm					
TRIM = 2.58 m by the stern								KM_T = 8.36 m
								KG_{FL} = 7.23 m
DRAUGHTS: F. = 5.56 m				A. = 8.14 m				GM_T = 1.13 m (fluid)

Answer 2(b)

$$\begin{aligned} S &= \text{volume of lost buoyancy} / \text{Intact water plan area} \\ &= 4.5 \times 10 \times 5 / (75 \times 10 - 10 \times 10) \\ &= 0.346 \text{ m} \end{aligned}$$

$$\text{Therefore new draught} = 4.5 + 0.346 = 4.846 \text{ m}$$

$$\begin{aligned} \text{Displacement} &= 75 \times 10 \times 4.5 \times 1.025 \text{ t} \\ &= 3459.4 \text{ t} \end{aligned}$$

$$\begin{aligned} BM_L &= I_L / V \\ &= BL^3 / 12V \\ &= 10 \times 70^3 / (12 \times 75 \times 10 \times 4.5) \\ &= 84.7 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{MCTC} &= W \times BM_L / 100L \\ &= 3459.4 \times 84.7 / (100 \times 75) \\ &= 39.07 \end{aligned}$$

$$\begin{aligned} \text{COT} &= \text{trimming moment} / \text{MCTC} \\ &= 230.6 \times 37.5 / 39.07 \\ &= 221.3 \text{ cm} = 2.21 \text{ m (by head)} \end{aligned}$$

$$\begin{aligned} T_a &= 2.21 \times 35 / 75 \\ &= 1.03 \text{ m} \end{aligned}$$

$$T_f = 2.21 - 1.03 = 1.18 \text{ m}$$

	Fwd draught	Aft draught
Initial	4.846	4.846
Change of draughts	+ 1.18	- 1.03
Final draughts	6.026	3.816

Answer 5(a)

Calculate the displacement of the box shaped vessel

$$\text{Initial } \Delta = 96.00 \times 11.00 \times 4.2 \times 1.025 = 4546.1 \text{ t}$$

Calculate moments about the Keel to determine the Final KG

Weights (t)	KG (m)	Vertical Moments (tm)
4546.1	4.18	19002.7
620	7.78	4823.6
5166.1		23826.3

∴ Final KG = 4.61 m

Calculate the final draught of the box shaped vessel after loading the cargo

$$\text{Final } \Delta = 5166.1 = 96.0 \times 11.0 \times d \times 1.025$$

∴ Final draught (d) = 4.77 m

Calculate the final KM

$$\text{KB} = 4.77 / 2 = 2.386 \text{ m}$$

$$\text{BM} = 96.0 \times (11.0)^3 / (12 \times 96.0 \times 11.0 \times 4.77) = 2.11 \text{ m}$$

$$\text{KM} = 2.386 + 2.11 = 4.496 \text{ m}$$

Calculate the Final GM after loading the cargo

$$\text{Final GM} = 4.496 - 4.61 = (-) 0.114 \text{ m}$$

Calculate Angle of Loll

$$\text{Tan (Angle of Loll)} = \sqrt{(2 \times 0.114) / 2.11}$$

$$\text{Angle of Loll} = 18.2^\circ$$

Answer 6

$$\text{AMD} = (4.2 + 5.4) / 2 = 4.8 \text{ m}$$

$$\text{From tables, LCF for AMD} = 69.29 \text{ m}$$

$$\text{Correction to calculate TMD} = 1.2 \times 69.29 / 142 \text{ m} = 0.586 \text{ m}$$

$$\text{TMD} = 5.4 - 0.586 = 4.814 \text{ m}$$

$$= 4.81 \text{ m}$$

$$\text{Initial displ.} = 9659.9 \text{ t}$$

Take moments about aft perpendicular to calculate the final LCG

Remarks	Weight (t)	Lcg (m)	Moments (tm)	
			Load (t)	Discharge (t)
Ship	+ 9659.9	68.91	665663.7	
No. 1 hold	+ 650	132	85800	
No. 2 hold	+ 750	105	78750	
No. 3 hold	+ 1500	56	84000	
No. 4 hold	+ 1600	48	76800	
No. 4 centre DB Tk	- 50	138		6900
No. 2 centre DB Tk	- 25	58		1450
Total	14084.9		991013.7	8350
			- 8350	
Resultant			982663.7	

$$\text{Final LCG} = 982663.7 / 14084.9 = 69.77 \text{ m}$$

For the displacement of 14084.9 t, from tables;

$$\text{Hydraft} = 6.79 \text{ m}$$

$$\text{MCTC} = 181.20$$

$$\text{LCB} = 70.125 \text{ m}$$

$$\text{LCF} = 67.584 \text{ m}$$

Final LCB is larger than the final LCG, therefore, she is trimmed by stern

$$\text{COT} = W \times (\text{LCB} - \text{LCG}) / \text{MCTC}$$

$$\text{COT} = 14084.9 \times (70.125 - 69.77) / 181.2$$

$$= 27.6 \text{ cm} = 0.28 \text{ m}$$

$$T_a = 0.28 \times 67.58 / 142 = 0.133 \text{ m}$$

$$T_f = 0.28 - 0.133 = 0.147 \text{ m}$$

	FWD draft (m)	AFT draft (m)
Final hydraft	6.79	6.79
T_f / T_a	- 0.147	+ 0.133
Final drafts	6.643	6.923