



MERCHANT SHIPPING SECRETARIAT
GOVERNMENT OF SRI LANKA
CERTIFICATE OF COMPETENCY EXAMINATION

GRADE : CHIEF MATE ON SHIPS OF 500 GT OR MORE (UNLIMITED)
SUBJECT : SHIP'S STABILITY
DATE : 02nd October 2020

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) A vessel is to transit a canal with a minimum clearance of 0.4 m under a bridge, the underside of which is 21.26 m above the waterline.

Present draughts in salt water: FWD 5.38 m AFT 6.56 m

The foremast is 110 m foap and extends 26 m above the keel.

The aft mast is 36 m foap and extends 27.2 m above the keel.

Vessel's particulars are as follows:

LBP 137.5 m

LCF_{foap} 68.56 m

TPC 22.06 m

Calculate the following assuming the masts are perpendicular to the waterline throughout:

- a) The final draughts forward and aft in order to pass under the bridge with minimum clearance.

(20 marks)

- b) The maximum weight of cargo that can be discharged in order to pass under the bridge with minimum clearance.

(10 marks)

- 2) A box shaped vessel 100 m long & 10 m wide and afloat in salt water at an even keel draft of 3.0 m. She has a double bottom which is 1 m high. A midship cargo compartment is rectangular in shape, 8.0 m long, 10 m wide and has cargo with a permeability of 70%. If the KG is 3.0 m, calculate the GM if this compartment is bilged.

(30 marks)

- 3) Answer the following questions with regards to ship's stability data books and manual stability calculations:
- What are the precautions that needs to be taken when using hydrostatic particulars in a stability book?
(10 marks)
 - Briefly describe the purpose of 'loading conditions' given in a stability book.
(05 marks)
 - Describe the available methods of 'simplified stability information' in evaluating the seaworthiness of a vessel against the IMO stability criteria.
(15 marks)

4) A vessel, initially upright, is to carry out an inclining test.

At present;

Displacement 5300 t

KM 10.96 m

Total weights onboard during the test:

Ballast 390 t (Kg 3.45 m and tank full)

Bunkers 175 t (Kg 4.01 m and FSM 996 tm)

Water 102 t (Kg 4.45 m and FSM 890 tm)

Boiler water 20 t (Kg 4.19 m and FSM 101 tm)

Inclining weights 48 t (Kg 8.42 m)

A weather deck hatch cover, weight 20 t, ashore for repair will be fitted on the vessel at a Kg of 9.46 m prior sailing.

The plumb lines have an effective vertical length of 8.00 m. the inkling weights are shifted transversely 7.6 m on each occasion and the **mean horizontal deflection** of the plumb line is 0.68 m.

Calculate the vessels light ship displacement and the lightship KG

(30 marks)

- 5) A vessel has a summer displacement of 24 800 t which corresponds to an even keel draught of 10.86 m in salt water.

In a partly loaded condition the vessel has the following particulars:

Length B.P.	180.0 m	LCF	85.0 m (foap)
Displacement	21 200 t	MCTC	210
Drafts (in SW) fwd	8.96 m	aft	9.48 m

The vessel is to complete loading at the summer displacement, with a trim of 1.00 m by the stern.

The remaining cargo is to be loaded into two holds:

No. 1 Hold (Lcg 166.0 m, foap)

No. 7 Hold (Lcg 32.0 m, foap)

Calculate:

- a) The quantities to be loaded in each of the holds (20 marks)
- b) The final draughts in salt water (10 marks)
- 6) a) With the aid of a diagram, derive the below formula;

$$GZ = KN - KG \times \sin \theta$$

- b) A vessel with a KG 8.20 m, is floating at an even keel draught of 6.80 m in salt water. With the aid of Datasheet – 1 (Tabulated KN values) and Datasheet – 2 (Hydrostatic particulars), compare the ship's stability values with those required by the current IMO stability criteria.

(30 marks)

HYDROSTATIC PARTICULARS

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

TABULATED KN VALUES

		ANGLE OF HEEL — DEGREES						
		12	20	30	40	50	60	75
DISPLACEMENT — TONNE	15000	1.72	2.98	4.48	5.72	6.48	6.91	7.05
	14500	1.73	2.98	4.51	5.79	6.58	6.95	7.08
	14000	1.74	2.98	4.55	5.85	6.68	7.00	7.10
	13500	1.75	2.99	4.58	5.90	6.73	7.08	7.13
	13000	1.77	3.00	4.62	5.93	6.78	7.14	7.16
	12500	1.78	3.03	4.63	5.98	6.83	7.18	7.18
	12000	1.78	3.05	4.65	6.04	6.88	7.20	7.20
	11500	1.80	3.12	4.70	6.10	6.93	7.25	7.22
	11000	1.82	3.15	4.75	6.15	6.98	7.30	7.24
	10500	1.83	3.19	4.79	6.18	7.02	7.35	7.27
	10000	1.86	3.23	4.83	6.22	7.07	7.40	7.30
	9500	1.93	3.28	4.91	6.25	7.11	7.45	7.35
	9000	2.00	3.36	5.00	6.28	7.18	7.50	7.40
	8500	2.05	3.43	5.04	6.32	7.20	7.55	7.41
	8000	2.10	3.52	5.10	6.36	7.22	7.60	7.42
	7500	2.17	3.62	5.18	6.38	7.24	7.65	7.46
	7000	2.22	3.70	5.25	6.40	7.26	7.70	7.50
	6500	2.32	3.85	5.35	6.43	7.27	7.70	7.51
6000	2.42	4.00	5.45	6.48	7.28	7.70	7.52	
5500	2.57	4.15	5.55	6.53	7.29	7.68	7.51	
5000	2.72	4.32	5.65	6.58	7.30	7.66	7.50	

Answers

Answer 1(a)

$$\text{Req. draught under fwd mast} = 26 - (21.26 - 0.4) = 5.14 \text{ m}$$

$$\text{Req. draught under aft mast} = 27.2 - (21.26 - 0.4) = 6.34 \text{ m}$$

$$\text{Req. trim between masts} = 6.34 - 5.14 = 1.2 \text{ m by stern}$$

$$\text{Dist. Between masts} = 110 - 36 = 74 \text{ m}$$

$$\text{Final draft aft} = 6.34 + (1.2 \times 36) / 74 = \underline{\underline{6.924 \text{ m}}}$$

$$\text{Final draft fwd} = 5.14 - [1.2 \times (137.5 - 110)] / 74 = \underline{\underline{4.694 \text{ m}}}$$

Answer 1(b)

$$\text{Final AMD} = (6.924 + 4.694) / 2 = 5.809 \text{ m}$$

$$\text{Final trim} = 6.924 - 4.694 = 2.23 \text{ m}$$

$$\text{Final TMD} = 6.924 - (2.23 \times 68.56) / 137.5 = 5.812 \text{ m}$$

$$\text{Initial trim} = 6.56 - 5.38 = 1.18 \text{ m by stern}$$

$$\text{Initial TMD} = 6.56 - (1.18 \times 68.56) / 137.5 = 5.972 \text{ m}$$

$$\text{Req. reduction in TMD} = 5.972 - 5.812 = 16 \text{ cm}$$

$$\text{Max. cargo to discharge} = 16 \times 22.06 = \underline{\underline{352.96 \text{ t}}}$$

Answer 2

$$\text{Increased draught} = 2 \times 10 \times 8 \times 0.7 / (100 \times 10 - 8 \times 10 \times 0.7) = 0.119 \text{ m}$$

$$\text{Bilged hydrafft} = 3.119 \text{ m}$$

Take moments of volumes about keel to calculate bilged KB

Remarks	Volume	KB	Moments
Bilged v/l	$3.119 \times 100 \times 10$	$3.119 / 2$	4864.1
Bilged comp	$- 2.119 \times 10 \times 8 \times 0.7$	$2.119 / 2 + 1$	- 244.4
Final v/l	3000		4619.7

$$\text{Bilged KB} = 4619.7 / 3000 = 1.54 \text{ m}$$

$$\begin{aligned} \text{Bilged BM} &= (LB^3 - lb^3) / 12V = (100 \times 10^3 - 8 \times 10^3 \times 0.7) / (12 \times 10 \times 100 \times 3) \\ &= 2.62 \text{ m} \end{aligned}$$

$$\text{Therefore, bilged KM} = 1.54 + 2.62 \text{ m} = 4.16 \text{ m}$$

$$\text{GM} = \text{KM} - \text{KG} = 4.16 - 3.0 = 1.16 \text{ m}$$

Answer 4

$$\begin{aligned} \text{Effective GM} &= \text{inclining weight} \times \text{transferred dist} \times \text{plumb length} / (\text{W} \times \text{deflection}) \\ &= 48 \times 7.6 \times 8 / (5300 \times 0.68) = 0.81 \text{ m} \end{aligned}$$

$$\text{Therefore, effective KG} = 10.96 - 0.81 = 10.15 \text{ m}$$

Take moments about Keel

Remarks	Weight	KG	Moments
Present v/l	+ 5300	10.15	+ 53795
Ballast	- 390	3.45	- 1346
Bunkers	- 175	4.01	- 702
Bunker FSM			- 996
Water	- 102	4.45	- 454
Water FSM			- 890
Inclining weights	- 48	8.42	- 404
Hatch cover	+ 20	9.46	+ 189
Total	4605		49192

$$\text{Light ship KG} = 49192 / 4605 = 10.68 \text{ m}$$

$$\text{Light ship displacement} = 4605 \text{ t}$$

Answer 5(a)

$$\text{Cargo to load} = 24800 - 21200 = 3600 \text{ t}$$

$$\text{Initial trim} = 0.52 \text{ m stern}$$

$$\text{Final trim} = 1.0 \text{ m stern}$$

$$\text{COT} = 1.0 - 0.52 = 0.48 \text{ m (stern)}$$

Assuming cargo to be loaded in hold number 7 is Y (t), the trimming moment around the COF

$$= 53 \times Y - 81 \times (3600 - Y)$$

$$= 134 \times Y - 291600$$

$$\text{COT} = \text{trimming moment/MCTC}$$

$$0.48 \times 100 = (134Y - 291600) / 210$$

$$134Y = 301680$$

$$Y = 2251.3 \text{ t}$$

$$\text{Cargo to load in hold no. 7} = 2251.3 \text{ t}$$

$$\text{Cargo to load in hold no. 1} = 3600 - 2251.3 = 1348.7 \text{ t}$$

Answer 5(b)

$$\text{Maximum even keel draught} = 10.86 \text{ m}$$

$$\text{COT from this draught} = 1.0 \text{ m by stern}$$

$$T_a = 1 \times 85 / 180 = 0.472 \text{ m}$$

$$T_f = 1.0 - 0.472 = 0.528 \text{ m}$$

$$\text{Therefore draught fwd} = 10.86 - 0.528 = 10.332 \text{ m}$$

$$\text{Aft draught} = 10.86 + 0.472 = 11.332 \text{ m}$$

Answer 6(b)

Displacement for 6.8 m = 14115 t

KN values for 14115 t

Angle of heel	KN	KG x Sin θ	GZ
12	1.74	1.705	0.035
20	2.98	2.805	0.175
30	4.54	4.1	0.44
40	5.84	5.271	0.569
50	6.66	6.282	0.378
60	6.99	7.101	0.111
75	7.10	7.921	-0.821