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 : 15th December 2022

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) Answer the following questions with regards to bilging:
   a) With the aid of a diagram explain how a vessel will be trimmed when a forward end compartment is bilged.

   (05 marks)

   b) A box-shaped vessel 120 m long and 12 m wide floats at an even keel draught of 6 m in salt water. The foremost compartment, 10 m long and 12 m wide, which has cargo with a permeability of 50%, gets bilged. Calculate the new draughts forward and aft.

   (25 marks)

2) (a) State the minimum intact stability criteria required by the IS Code for a general cargo vessel.

   (15 marks)

   (b) The International Grain Code requires a vessel load with bulk grain to be upright before sailing, but, the IS Code does not require other vessels to be upright before departure. Explain the reasons with the aid of GZ curves.

   (15 marks)

3) The ship is floating at draughts 4.60 m fwd, 5.00 m aft in salt water. A total of 772 t of cargo is to be loaded in a position to keep draught aft constant. LBP is 146 m. Calculate each of the following by using the "Hydrostatic Particulars A":

   a) The distance from AP to load the cargo;

   (20 marks)

   b) The final draught fwd.

   (10 marks)

4) Answer the following questions with regards to the carriage of grain:

a) Define the word grain.

(05 marks)

b) List the dangers involved in carrying grain.

(05 marks)

c) A vessel has loaded grain, stowage factor 1.55 m3 t^{-1} to a displacement of 13500 t. In the loaded condition the effective KG is 7.12 m.

All grain spaces are full, except No. 3 tween deck, which is partly full.

The tabulated transverse volumetric heeling moments are as follows:

No. 1 hold	810 m^4
No. 2 hold	1042 m^4
No. 3 hold	1075 m^4
No. 4 hold	1185 m^4
No. 1 TD	723 m^4
No. 2 TD	675 m^4
No. 3 TD	403 m^4

The value of KG used in the calculation of the vessel's effective KG were as follows:

- for lower holds, the centroid of the space
- for tween decks, the actual KG of the cargo

i) Using Datasheet 1, determine the vessel's ability to comply with the statutory grain regulations.

(15 marks)

ii) Calculate the vessel's approximate angle of heel in the event of a shift of grain assumed in the grain regulations.

(05 marks)

5) A vessel is floating upright and is to load two weights using the ships own derrick. The maximum allowable list is 4^0. The initial condition of the vessel is as follows:
Displacement : 14,901 t
KM : 8.33 m (assume constant throughout)
Derrick head is 26.0 m above the keel

Two weights, each 42 tonnes, are on the quay 17.5 m from the vessel's centerline.

Stowage position on deck, Kg 12.0 m and 7.2 m either side of the vessel's centerline. The inboard weight is to be loaded first.

Calculate the minimum initial GM that the vessel must have not to exceed the said list.

(30 marks)

6) Answer the following questions with regards to dry docking of a vessel:

a) Explain the following terms:
   i) Critical period
   ii) Critical instant

(05 marks each)

b) A vessel proceeding to dry dock has the following particulars:
KG: 7.6 m
LBP : 180 m
Draughts
FWD : 6.0 m AFT : 6.8 m

With the aid of the "Hydrostatic Particulars A" calculate the GM at the time of the critical instant.

(20 marks)

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

TABLE OF MAXIMUM PERMISSIBLE GRAIN HEELING MOMENTS (tm)										
	FLUID KG (metres)									
Displacement tonne	6.50	6.60	6.70	6.80	6.90	7.00	7.10	7.20	7.30	7.40
14 500	6141	5820	5499	5179	4858	4537	4217	3896	3575	3255
14 000	5957	5647	5338	5028	4719	4409	4099	3790	3480	3171
13 500	5924	5625	5327	5028	4730	4431	4132	3834	3535	3237
13 000	5934	5647	5359	5072	4784	4497	4209	3922	3634	3347
12 500	5891	5614	5338	5062	4785	4509	4232	3956	3679	3403
12 000	5857	5591	5326	5061	4795	4630	4265	3999	3734	3468
11 500	5893	5639	5385	5130	4876	4622	4368	4113	3859	3605
11 000	5944	5701	5457	5214	4971	4728	4484	4241	3998	3755
10 500	5948	5716	5484	5251	5019	4787	4555	4323	4090	3858
10 000	5940	5719	5498	5276	5055	4834	4613	4392	4171	3950
9500	5961	5751	5541	5331	5121	4911	4701	4491	4281	4071
9000	6027	5828	5629	5430	5231	5032	4833	4634	4435	4236
8500	6127	5939	5751	5563	5375	5187	4999	4811	4623	4435
8000	6210	6033	5856	5679	5502	5325	5148	4971	4795	4618
7500	6252	6087	5921	5755	5589	5423	5257	5091	4926	4760
7000	6343	6189	6034	5879	5724	5569	5415	5260	5105	4950
6500	6550	6406	6262	6118	5975	5831	5687	5543	5400	5256
6000	6832	6699	6566	6434	6301	6168	6035	5903	5770	5637
5500	7120	6998	6877	6755	6633	6512	6390	6268	6147	6025
5000	7320	7209	7099	6988	6877	6767	6656	6546	6435	6325

Answers

Answer 1

S = (10 x 6 x 12) / (120 x 12 – 10 x 12 x 0.5) = 0.522 m
Bilged hydraft = 6.522 m

Calculation of 'd',

Remarks	Areas	LCF_{foap}	Moments
Total water plain area	120 x 12	120 / 2	86400
Bilged area	- 10 x 12 x 0.5	115	- 6900
Final water plain area	1380		79500

LCF_{foap} = 79500 / 1380 = 57.609 m
Therefore, 'd' = 120 – 57.609 = 62.391 m
Trimming lever = 60 – 57.609 = 2.391 m

I_{xx} = $(BL^3 – bl^3 \times \mu) / 3$ = $(12 \times 120^3 – 12 \times 10^3 \times 0.5) /3$ = 6910000
I_{II} = $I_{xx} – Ad^2$ = $6910000 – (120 \times 12 – 10 \times 12 \times 0.5) \times 62.391^2$ = 1538161.1

BM_L = I_{II} / V = 1538161.1 / (12 x 120 x 6) = 178.028 m

MCTC = W x BM_L / (100 x LBP) = 1.025 x 6 x 120 x 12 x 178.028 / (100 x 120)
= 131.385

COT = trimming lever x displacement / MCTC = 2.391 x 1.025 x 6 x 120 x 12 / 131.385
= 161.2 cm = 1.612 m

Ta = COT x LCF_{foap} / LBP = 1.612 x 57.609 / 120 = 0.774 m
T_f = 1.612 – 0.774 = 0.838 m

Bilged draft fwd = 6.522 + 0.838 = 7.36 m
Bilged draft aft = 6.522 – 0.774 = 5.748 m

Answer – 3(a)

AMD = (5.0 + 4.6) / 2 = 4.8 m

LCF for AMD = 69.29 m

Correction for hydraft = 0.4 x 69.29 / 146 = 0.19 = 0.2 m

Hydraft = 5 – 0.2 = 4.8 m

From the tables for above hydraft:

Displacement = 9638 t

TPC = 21.85

LCF = 69.26 m foap

To keep the draft aft constant:

Ta = bodily sinkage

COT x a / LBP = w / TPC

COT = w x LBP / (a x TPC)

= 772 x 146 / (21.85 x 69.29) = 74.4 cm = 0.744 m

At the same time if the distance from the COF to the position where the cargo to be loaded is "d":

COT = w x d / MCTC

d = COT x MCTC / w = 74.4 x 156.9 / 772 = 15.12 m

Therefore, cargo to be loaded = 15.12 + 69.26 = 84.38 m (foap)

Answer – 3(b)

Ta = 0.744 x 69.26 / 146

= 0.353 m

Tf = 0.744 – 0.353 = 0.391 m

Bodily Sinkage = 772 / 21.85 = 35.33 cm = 0.353 m

The final draughts:

	Fwd	**Aft**
Initial draughts	4.6	5.00
B/S	+ 0.353	+ 0.353
Tf / Ta	+ 0.391	- 0.353
Final draughts	5.344	5.00

Answer 4(c)(i)

Compartment	VHM	Factor	Assumed Volumetric heeling moments (m^4)
No. 1 hold	810 m^4	1.0	810
No.2 hold	1042 m^4	1.0	1042
No. 3 hold	1075 m^4	1.0	1075
No. 4 hold	1185 m^4	1.0	1185
No. 1 TD	723 m^4	1.06	766.4
No. 2 TD	675 m^4	1.06	715.5
No. 3 TD	403 m^4	1.12	451.4
Total			6045.3

Maximum permissible grain heeling moment for present displacement and KG = 4072.4 tm
Assumed grain heeling moments = 6045.3 / 1.55 = 3900.2 tm

Maximum permissible grain heeling moment for present displacement and KG > Assumed grain heeling moments

Therefore, complying with the grain regulations

Answer 4(c)(ii)

Maximum angle of list due to grain shift = 3900.2 x 12 / 4072.4 = 11.5^0

Answer 5

Initial KG = y tonnes

The maximum list occurs when the final weight is taken by the derrick from the pier.
Moments of about keel at that time;

Remarks	Weight	KG	Moments about the keel
Ship	14900	y	14900 x y
Weight loaded	+ 42	12	+ 504
Wight hanging on the derrick	+ 42	26	+ 1092
Total	14984		14900y + 1596

KG when the final weight is hanging on the derrick = (14900y + 1596) / 14984
GM at that time = 8.33 - (14900y + 1596) / 14984 = (123220.7 – 14900y) / 14984

Final listing moment when the last weight is hanging = 7.2 x 42 + 17.5 x 42 = 1037.4 tm

For that moment apply;
Tan (list) = listing moment / GM x Displacement
Tan (4) = 1037.4 / 14984 x [(123220.7 – 14900y) / 14984]
8616.4 – 1041.9y = 1037.4
y = 7.27 m

Therefore, initial KG required = 7.27 m
Initial GM required = 8.33 – 7.27 = 1.06 m

Answer 6(b)

AMD = (6 + 6.8) / 2 = 6.4 m

LCF for AMD from tables = 68 m

Correction for TMD = 0.8 x 68 / 180 = 0.302 m

Therefore, initial TMD = 6.8 – 0.302 = 6.5 m

For initial TMD, from table:

Displacement : 13429 t

MCTC : 176.8
LCF_{foap} : 67.9 m
KM : 8.39 m

P = COT x MCTC / LCF_{foap} = 0.8 x 100 x 176.8 / 67.9 = 208.3 t

Loss of GM = P x KG / (W-P) or P x KM / W
= 208.3 x 7.6 / (13429 – 208.3) 208.3 x 8.41 / 13429
= 0.12 m or 0.13 m