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 : 04th September 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) A box shaped vessel floating on even keel in dock water of R.D. 1.014 has the following particulars:

Length	124 m	Breadth	20 m
Draught	7.8 m	MCTC (salt water)	300.1

There is an empty watertight forward end bottom compartment, length 10 m, height 6.5 m, extending the full width of the vessel.

Calculate the draughts forward and aft, if this compartment is bilged.

(30 marks)

2) A vessel is upright, starboard side alongside; at an even keel draught of 5.00 m in salt water.

KG = 8.5 m

A 38 t generator is to be loaded from a railway truck ashore. The distance of the railway truck from the vessel's centerline is 19.3 m. The generator is to be loaded using the vessel's crane, the head of which is 25.1m above the keel.

Using the Hydrostatic particulars provided, calculate each of the following:

a) The maximum angle of heel during the loading operation;

(15 marks)

b) The maximum angle of heel if the vessel was listed 4^0 to port prior to loading;

(10 marks)

c) The weight of ballast water to transfer from No. 2 DB starboard to No. 2 DB port in order to achieve the list of 4^0 to port prior to loading (assume both tanks partly full and the transverse distance between the centroids of the tanks is 15 m)

(05 marks)

3) A vessel is floating upright in dock water of RD 1.012 and is about to dry dock. Her particulars are:

Draft fwd	5.34 m	Draft aft	6.66 m
KG	8.30	LBP	137.5 m

Using the hydrostatic particulars, calculate the vessel's effective GM at the critical instant.

(30 marks)

4) (a) State the minimum intact stability criteria required by the *IMO International Grain Code.*

(15 marks)

(b) Describe, with the aid of a sketch, of a curve of statical stability, the effect of increasing the GM on a vessel with a list due to a transverse shift of cargo.

(15 marks)

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

Present displacement 4700 t. KM 10.63 m

Total weights on board during the experiment:
Ballast 368 t, Kg 3.48 m. Tank full.
Bunkers 182 t, Kg 3.91 m. Free surface moment 974 tm.
Fresh Water 86 t, Kg 4.54 m. Slack tank. Free surface moment 799 tm
Two weights each 25 t, Kg 8.88 m.

At the time of the experiment the boilers are empty. They would usually contain a total of 26 t of water, Kg 4.22 m, with a free surface moment of 129 tm.

A deck crane, weight 21t and still ashore will be fitted on the vessel at a Kg of 9.86 m at a later date.

The plumbline has an effective vertical length of 7.90 m. The inclining weights are shifted transversely 7.50 m on each occasion and the mean horizontal deflection of the plumbline is 0.69 m. Calculate the vessel's Lightship KG.

(30 marks)

6) A vessel is floating in SW with draught Fwd 3.80 m, aft 6.40 m. A total of 2400 t of cargo is to be loaded.
   - Space is available in NO. 2 (LCG 100 m foap) and in No. 4 (LCG 54 m foap)
   - Length B.P. 136 m
   - LCF 67 m foap
   - TPC 21.8
   - MCTC 150

   a) Calculate the weight of cargo to load in each space in order to finish with a trim of 1.0 m by the stern.

   (20 marks)

   b) Determine the final draughts fwd and aft.

   (10 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

Answers

Answer 1

VGB = VLB

S = 6.5 x 10 x 20 / (124 x 20) = 0.524 m

Bilged hydraft = 7.8 + 0.524 = 8.324 m

Take moments of volumes around fwd perpendicular to calculate bilged $LCB_{\text{aft of forward perpendicular}}$

	Volume	LCB (aft of forward perpendicular)	Moments
Total volume after bilging	124 x 20 x 8.324	124 / 2	1279898.2
Bilged volume	- 6.5 x 10 x 20	10 / 2	- 6500
Final	19343.5		1273398.2

Bilged $LCB_{\text{aft of forward perpendicular}}$ = 1273398.2 / 19343.5 = 65.83 m

Trimming lever = 65.83 – 124 / 2 = 3.83 m

Displacement = 124 x 20 x 7.8 x 1.014 = 19614.8 t

$MCTC_{DW}$ = 300.1 x 1.014 / 1.025 = 296.88

COT = trimming lever x displacement / MCTC = 3.83 x 19614.8 / 296.88 = 253 cm

= 2.53 m

Since the final water plane area is intact, the COF is at the midship

Ta = T_f = COT / 2 2.53 / 2 = 1.265 m

	FWD	**AFT**
Bilged hydraft	8.324	8.324
T_f / Ta	+ 1.265	- 1.265
Final	9.589	7.059

Answer 2(a)

Initial displacement from tables = 10076 t

Displacement at the time of loading = 10076 + 38 = 10114 t

KM from tables = 8.97 m

$GG_1\uparrow$ = w x d / W = 38 x (25.1 – 8.5) / 10114 = 0.062 m

Therefore, GM at the time of taking the generator = 8.97 – 8.5 – 0.062 m = 0.408 m

Tan list = listing moment / (W x GM)

= 38 x 19.3 / (10114 x 0.408)

= 0.1777

Max list to stbd = 10^0

Answer 2(b)

From tables, for the initial condition;

Displacement = 10076 t

KM = 8.98 m

Therefore, initial GM = 8.98 – 8.5 = 0.48 m

Tan list = initial listing moment / (W x GM)

Therefore,

Initial listing moment = 10076 x 0.48 x tan 4^0 = 338.2 tm

When the load is taken with the initial list;

Final listing moment = 19.3 x 38 – 338.2 tm (to stbd)

= 395.2 tm (to stbd)

Tan list = final listing moment / (W x GM)

= 395.2 / (10114 x 0.408) = 0.0958

List = 5.5^0 (stbd)

Answer 2(c)

Initial listing moment = weight to transfer x distance between the centroids

338.2 = 15 x weight to transfer

Therefore, ballast to transfer = 22.5 t

Answer 3

AMD = (5.34 + 6.66) / 2 = 6 m

LCF for AMD = 68.39 m

TMD = 6.66 – (1.32 x 68.39) / 137.5 = 6.003 m

From tables for TMD

	Salt water	Fresh water
Displacement	12303.8	12147.8
MCTC	169.84	167.69
LCF_{foap}	68.39	68.39

P = COT x MCTC / LCF_{foap}

= 132 x 167.69 / 68.39 = 323.7 t

At the time of critical instant, displacement = 12147.8 – 323.7 = 11824.1 t

Above displacement is for DW. Therefore, SW displacement = 11824.1 x 1.025 / 1.012

= 11975.9 t

At the time of critical instant, KM (for above displacement from tables) = 8.57 m

Loss of GM at critical instant	GM at critical instant
P x KG / (W – P) = 323.7 x 8.30 / (12147.8 – 323.7) = 0.227	KM – KG = 8.57 – 8.30 – 0.229 = 0.041
P x KM / W = 323.7 x 8.57 / 12147.8 = 0.228	KM – KG = 8.57 – 8.30 – 0.228 = 0.042

One of the above methods in the table is sufficient

Answer 5

GM = d x w x pendulum length / (W x deflection)

= 7.5 x 25 x 7.9 / (4700 x 0.69) = 0.457

Effective GM = 0.457 m

FSC at during the inclining test = (974 + 799) / 4700 = 0.377 m

Solid GM during inclining test = 0.457 + 0.377 = 0.834 m

Solid KG during inclining test = 10.63 – 0.834 = 9.80 m

Remarks	Weight		KG	Moment about keel	
	Load	Disch.		Load	Disch.
Ship	4700		9.8	46060	
Ballast		368	3.48		1280.6
Bunkers		182	3.91		711.6
Fresh water		86	4.54		390.4
Inclining weights		50	8.88		444
Boiler water	26		4.22	109.7	
Crane	21		9.86	207.1	
Total	4747	686		46376.8	2826.6
	- 686			- 2826.6	
Resultant	4061			43550.2	

KG without boiler FSC = 43550.2 / 4061

= 10.72 m

Boiler FSC at light ship condition = 129 / 4061 = 0.032 m

Light ship KG = 10.72 + 0.032 = 10.752 m

Answer 6(a)

Bodily sinkage = 2400 / 21.8 = 110.09 cm

Weight of cargo to load in hold no 2 is Y tones.

Initial trim = 6.4 – 3.8 = 2.6 m by stern

Required trim = 1.0 by stern

Therefore, COT = 2.6 -1.0 = 1.6 m by head

Take moment about LCF

Weight	LCG from COF	Head moments	Stern moments
Y	33	33Y	
2400 - Y	13		13 x (2400 – Y)

Since COT is 1.6 m by head, 33Y should be higher than 13 x (2400 – Y).

Trimming moment = 33Y – 13 x (2400 – Y)

COT = trimming moment / MCTC

1.6 x 100 = [33Y – 13 x (2400 – Y)] / 150

24000 = 33Y – 31200 + 13Y

46Y = 55200

Y = 1200 t

Number 4 hold = 2400 – 1200 = 1200 t

Answer 6 (b)

T_a = COT x LCF / LBP

= 1.6 x 67 / 136 = 0.788 m

T_f = 1.6 – 0.788 = 0.812 m

	FWD	**AFT**
Initial drafts	3.8	6.4
Bodily sinkage	+ 1.101	+ 1.101
	4.901	7.501
T_f / T_a	+ 0.812	- 0.788
Final drafts	5.713	6.713