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 : 16th May 2016

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 regard to bilging:

   a) Briefly describe the consequences of bilging.

   (10 marks)

   b) A box-shaped vessel has length of 75 m, breadth 12 m and is floating on an even keel draught in salt water of 2.5 m. In this condition the KG is 3.00 m. An empty forward end compartment of length 6 m extending the full breadth and depth of the vessel is bilged. Calculate the fwd and aft draughts in the flooded condition.

   (20 marks)

2) With reference to a modern ship board stability and stress finding instruments:

   a) state the hydrostatic and stability data already pre-programmed into the instrument;

   (08 marks)

   b) describe the information to be entered into the instrument by the ship's officer;

   (10 marks)

   c) describe the output information.

   (12 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 **Datasheet – 1** "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 regard to inclining experiment:

a) Derive the following formula:

$$GM = \frac{w \times d \times \text{Pendulum length}}{W \times \text{Deflection}}$$

Where:

w = weight of inclining object
d = distance shifted
W = displacement of the vessel

(05 marks)

b) A Ro-Ro vessel is to be inclined at a displacement of 11100 t, KM 11.70 m. During the experiment liquid in the tanks are as follows:

No. 3 DB (slack) contains 110 t SW ballast (RD 1.025) (FSM 800 tm, basis FW)
No. 4 DB (slack) contains 38 t of fuel oil (RD 0.88) (FSM 670 tm, basis FW)

The movement of 14 t through a transverse distance of 22.2 m causes a 15.2 cm deflection of a 12 m long pendulum.

Calculate the effective KG as inclined

(05 marks)

c) The following changes are required to bring the ship to the light condition:

Discharge : 14 x 2 t inclining weights, KG 16.0 m
41 t equipment, KG 9.0 m
110 t SW ballast, KG 1.1 m
38 t fuel oil, KG 0.9 m
Load : 19 t machinery, KG 5.5 m

Calculate the lightship displacement and lightship KG.

(20 marks)

5) Answer the following questions with regard to angle of loll:

a) A box shaped vessel, length 90.00 m, breadth 10.00 m, depth 9.00 m, is floating at a draught of 4.10 m in salt water. Initial KG 3.70 m:

Calculate the angle of loll if 580 tonne of cargo, KG 7.80 m is loaded on deck.

(15 marks)

b) List the methods available to make the GM positive.

(05 marks)

c) Describe the procedure of correcting the angle loll by means of ballasting double bottom tanks.

(05 marks)

d) Briefly explain the reason to start ballasting from the lower side (heeled side) of the vessel.

(05 marks)

6) A vessel has a displacement of 70,000 t, KG_{solid} of 9.41 m, FSM of 6300 tm. With the aid of **Data sheet – 2** and **Data sheet – 3** draw a GZ curve for the present condition and evaluate the seaworthiness of the vessel against the IMO intact stability criteria to identify whether she is seaworthy or not. Assume the angle of down flooding is greater than 40^0 .

(30 marks)

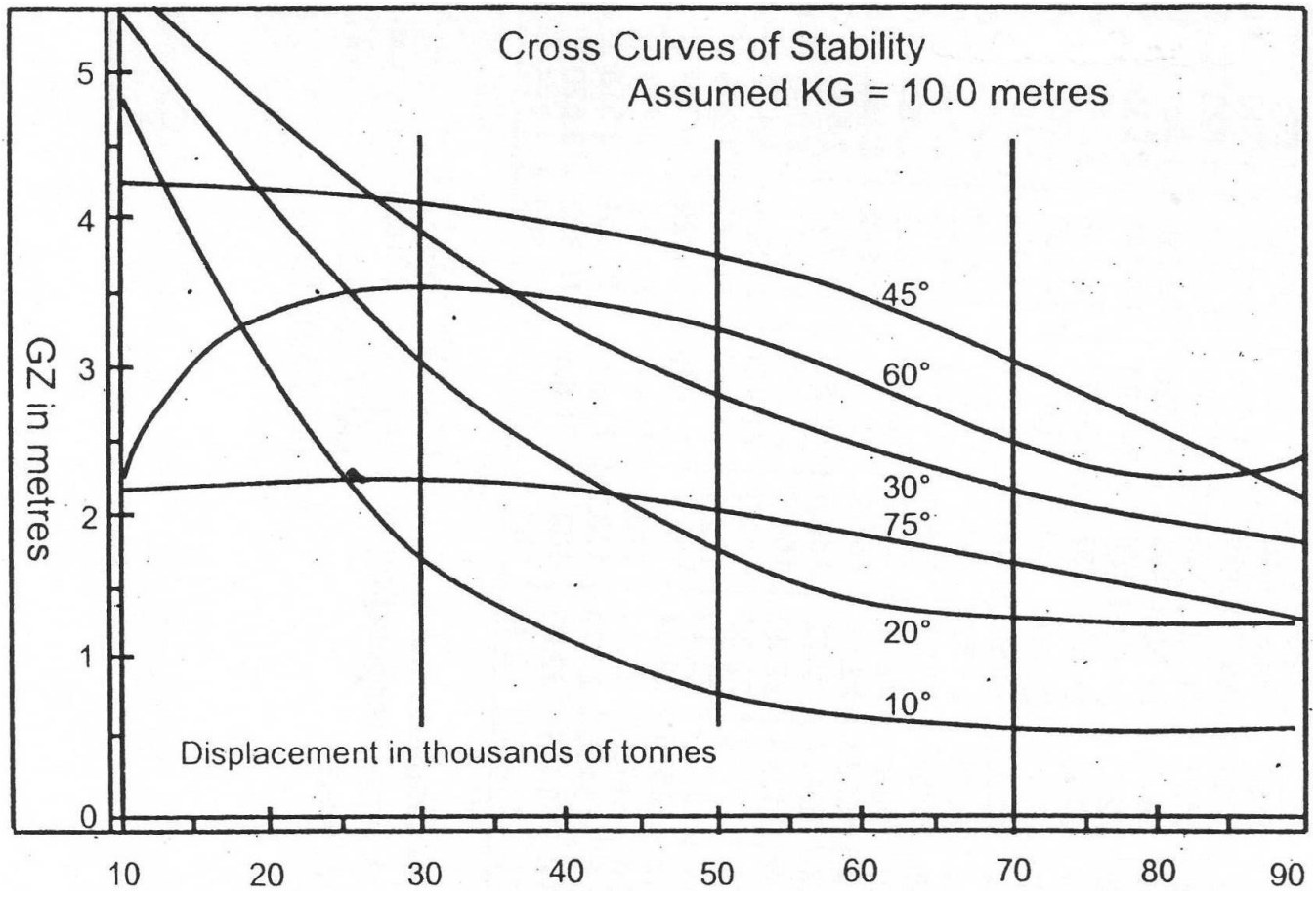
Datasheet – 1

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

Datasheet – 2


Cross Curves of Stability
Assumed KG = 10.0 metres
GZ in metres
Displacement in thousands of tonnes
45°
60°
30°
75°
20°
10°
0
1
2
3
4
5
10
20
30
40
50
60
70
80
90

Datasheet – 3

Hydrostatic particulars

d	W sw	TPC	MCTC	HB	HF	KB	KM_T	KM_L
11.00	70941	68.58	1083.0	5.37F	1.96F	5.64	13.24	366
11.20	72315	68.74	1091.3	5.30F	1.72F	5.75	13.22	362
11.40	73693	68.91	1099.5	5.23F	1.47F	5.85	13.20	358
11.60	75074	69.07	1107.8	5.16F	1.22F	5.95	13.18	354
11.80	76458	69.24	1115.9	5.09F	0.98F	6.06	13.17	351
12.00	77845	69.40	1124.0	5.02F	0.74F	6.16	13.16	347
12.20	79237	69.56	1131.3	4.94F	0.53F	6.26	13.16	343
12.40	80633	69.72	1138.4	4.87F	0.32F	6.37	13.16	340
12.60	82032	69.88	1145.5	4.79F	0.12F	6.47	13.16	336
12.80	83434	70.03	1152.4	4.71F	0.08A	6.58	13.17	333
13.00	84839	70.19	1159.1	4.62F	0.27A	6.68	13.18	329
13.20	86246	70.34	1165.8	4.54F	0.46A	6.79	13.19	326
13.40	87657	70.49	1172.3	4.46F	0.64A	6.89	13.21	323
13.60	89070	70.63	1178.8	4.38F	0.81A	7.00	13.22	320
13.80	90485	70.78	1185.1	4.29F	0.98A	7.10	13.25	316
14.00	91904	70.92	1191.3	4.21F	1.14A	7.21	13.27	313
14.20	93324	71.06	1197.4	4.13F	1.29A	7.31	13.30	310
14.40	94747	71.19	1203.3	4.04F	1.44A	7.42	13.33	308
14.60	96173	71.32	1209.2	3.96F	1.58A	7.52	13.36	305
14.80	97600	71.45	1215.0	3.88F	1.72A	7.63	13.39	302
15.00	99030	71.57	1220.7	3.79F	1.84A	7.73	13.43	299

d = draft in metres, K = keel, H = amidships, LOA 245 m,

LBP 236 m, GT 42000 Tons, NT 28000 Tons

Light W 14000 t, Load W 98000 t, Deadweight 84000 t.

Answers

Answer – 1(b)

Volume of buoyancy lost = volume of buoyancy gained

$6 \times 12 \times 2.5 = (75 - 6) \times 12 \times S$

S = 0.217 m

Mean bilged draught = 2.5 + 0.217 = 2.717 m

KB bilged = 2.717 / 2 = 1.359 m

Trimming moment = (75 x 12 x 2.5 x 1.025) x 3 = 6918.75 tm

$BM_L = BL^3 / 12V$

$= 12 \times (75 - 6)^3 / [12 \times (75 \times 12 \times 2.5)]$ = 146.004 m

$KM_L = KB\ bilged + BM_L$

= 147.363 m

$GM_L = KM_L - KG$ = 144.363

$MCTC = W \times GM_L / (100 \times LBP)$

$= (75 \times 12 \times 2.5 \times 1.025) \times 144.363 / (100 \times 75)$

= 44.392 tm

COT = trimming moment / MCTC = 6918.75 / 44.392 = 155.9 cm by head

Ta = COT x a / L = 155.9 x 34.5 / 75 = 71.7 cm

Tf = COT – Ta = 84.2 m

Final drafts:

	Fwd	Aft
Final mean	2.717	2.717
Tf / Ta	+ 0.842	- 0.717
Final	3.559	2.000

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

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

= 14 x 22.2 x 12 / (11100 x 0.152)

KG as inclined= 11.7 – 2.211 = 9.489 m

c) SW FSM = 800 x 1.025 / 1.000 = 820 tm
Fuel oil FSM = 670 x 0.88 / 1.000 = 590 tm

Remarks	Weight	KG	Moments
Ship	+ 11100	9.489	+ 105328
Inclining weights	- 28	16	- 448
Equipment	- 41	9	- 369
SW ballast	- 110	1.1	- 121
Ballast FSM			- 820
Fuel oil	- 38	0.9	- 34
Fuel oil FSM			- 590
Machinery	+ 19	5.5	+ 105
Final	10902		103051

Light ship displacement = 10902 t

Lightship KG = 103051 / 10902 = 9.452 m

Answer – 5(a)

Calculate the displacement of the box shaped vessel

Initial $\Delta = 90.00 \times 10.00 \times 4.10 \times 1.025 = 3782.25$ t

Calculate moments about the Keel to determine the Final KG

Weights (t)	KG (m)	Vertical Moments (tm)
3782.25	3.70	13994.325
580	7.80	4524
4362.25		18518.325

$\therefore$ Final KG = 4.245 m

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

Final Δ = 4362.25 = $90.00 \times 10.00 \times d \times 1.025$

$\therefore$ Final draught (d) = 4.729m

Calculate the final KM

KB = 4.729 / 2 = 2.365m

BM = $90.00 \times (10.00)^3 / (12 \times 90.00 \times 10.00 \times 4.729)$ = 1.762m

KM = 2.365 + 1.762 = 4.127m

Calculate the Final GM after loading the cargo

Final GM = 4.127 – 4.245 = (–) 0.118m

Calculate Angle of Loll

Tan (Angle of Loll) = $\sqrt{}$ (2 x 0.118) / 1.762

Angle of Loll = 20.1°

Answer – 6

FSC = FSM / W = 6300 / 70,000
= 0.09 m
KG_f 9.41 – 0.09 = 9.50 m

Calculation GZ values;

Heel	Assumed GZ	GG_1 x Sin heel	Actual GZ
0	0.0	0.5 x Sin 0	0.00
10	0.6	0.5 x Sin 10	0.687
20	1.38	0.5 x Sin 20	1.551
30	2.25	0.5 x Sin 30	2.5
45	3.13	0.5 x Sin 45	3.484
60	2.58	0.5 x Sin 60	3.013
75	1.68	0.5 x Sin 75	2.163