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 : 17th November 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) A vessel will be trimmed by forward if a forward compartment is bilged. Briefly explain this statement.

(05 marks)

b) A box-shaped vessel has length of 100 m, breadth 10 m and is floating on an even keel draught of 3.0 m in salt water. There is a double bottom tank, depth 1.0 m, with a hold above. Both compartments are 8.0 m in length, in the mid-ship of the vessel and extend the full breadth of the vessel. Homogenous cargo with a permeability of 70% loaded in the said hold. Calculate the change of GM of the vessel if this hold is bilged.

(25 marks)

2) Answer the following questions with regard to dry docking:

a) Describe the meaning of:

i. Critical period and
ii. Critical instant

(05 marks)

b) Explain clearly why the values of trim and the metacentric height in the freely afloat condition are important when considering the suitability of a vessel for dry docking.

(15 marks)

c) Describe how to determine the metacentric height:

i. During the critical period;
ii. After the vessel has taken the blocks overall

(05 marks each)

3) A ship in light condition has the following particulars:

Draughts : Fwd – 1.06 m Aft – 3.11 m
Displacement : 3831 t
LCF : 71.12 m foap
LCG : 61.67 m foap
MCTC : 130.1
KG : 8.21 m
Length BP : 137.5 m

The ship loads cargo and consumables as follows:

Compartment No.	**Weight (t)**	**LCG (m) foap**	**Kg**	**FSM (tm)**
1	2082	114.5	3.10	-
2	5606	89.9	3.44	-
3	Zero	-	-	-
4	4169	51.7	3.44	-
5	1954	17.2	5.80	-
Consumables	1364	42.0	2.96	2450

For the loaded condition the hydrostatic data are as follows:

Displacement : 19006 t
Hydraught (TMD) : 8.87 m
KM : 8.46 m
LCB : 69.19 m foap
LCF : 65.70 m foap
MCTC : 211.04

Calculate:

a) The sailing draughts

(20 marks)

b) The sailing GM

(10 marks)

4) Answer the following questions with regard to shear forces (SF) and bending moments (BM):

   a) Differentiate between the "harbor condition limits" and "sea condition limits" of SF and BM as given in a ship's stability computer:

   (05 marks)

   b) A box shaped barge 40 m long and 5 m width has light salt water draught of 0.8 m fwd and aft. It has four identical holds, each 10 m long. Cargo is loaded level as follows:

No. 1 hold : 198 t	No. 2 hold : 100 t
No. 3 hold : 100 t	No. 4 hold : 198 t

   Draw the SF and BM curves to scale.

   (25 marks)

5) Ship '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 load line rules

   (30 marks)

6) A vessel, initially upright, with a timber deck cargo, has the following particulars:

Displacement	- 10,000 t	KG	- 9.336 m
KB	- 4.26 m	BM	- 5.13 m

   60 t of FO (RD 0.90), is transferred from the settling tank (previously full & now empty), to a rectangular DB (double bottom) tank, (previously empty and now slack). There is a transverse distance between centroids of 4.0 m and a vertical distance between centroids of 6.00 m. Remember the settling tank is above the DB tank.

   The DB tank dimensions are length 12.00 m & breadth 10.00 m.

   Calculate the final list assuming the KM & KB remains constant throughout.

   (30 marks)

Datasheet – 1

(Tabulated KN values)

DISPLACEMENT — TONNE	ANGLE OF HEEL — DEGREES						
	12	20	30	40	50	60	75
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

Datasheet – 2 (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

Answers

Answer – 1 (b)

Initially,

KB = 3 / 2 = 1.5 m

BM = LB^3 / (12V) = 100 x 10^3 / (12 x 100 x 10 x 3)

= 2.778 m

Initial KM = 1.5 + 2.778 = 4.278 m

After bilging;

Increased draught = lost buoyancy / intact water plane area

= 2 x 8 x 10 x 0.7 / ((100 x 10) – (10 x 8 x 0.7))

= 0.118 m

Bilged draught = 3 + 0.118 m =3.118 m

BM = LB^3 / (12V)

= (100 – 8 x 0.7) x 10^3 / (12 x 100 x 10 x 3)

Bilged BM = 2.622 m

	Volume	KB	Volume x KB
Bilged v/l	3.118 x 100 x 10	3.118 / 2	4860.96
Bilged compartment	- 2 x 10 x 8 x 0.7	2	- 56
Final vessel	3 x 100 x 10	1.602	4804.96

Bilged KB = 1.602 m

Bilged KM = 1.602 + 2.622

Bilged KM = 4.224 m

Therefore, change of KM = 4.278 – 4.224 = 0.054 m (decreased)

Answer – 3 (a)

Weight (t)	LCG (m)	Moments about the aft perpendicular (tm)
3831	61.67	236257.77
2082	114.5	238389
5606	89.9	503979.4
4169	51.7	215537.3
1954	17.2	33608.8
1364	42.0	57288
19006		**1285060.27**

Final LCG = 1285060.27 / 19006 = 67.61 m foap

Trim = W x (LCB – LCG) / MCTC

= 19006 x (69.19 – 67.61) / 211.04 (by stern)

= 142.29 cm = 1.42 m

T_a = trim x LCF / LBP

= 1.42 x 65.70 / 137.5 = 0.68 m

T_f = 1.42 – 0.68 = 0.74 m

Sailing draughts

Aft = 8.87 + 0.68 = 9.55 m

Fwd = 8.87 – 0.74 = 8.13 m

Answer – 3 (b)

Weight (t)	Kg (m)	Moments about the keel (tm)
3831	8.21	31452.51
2082	3.10	6454.2
5606	3.44	19284.64
4169	3.44	14341.36
1954	5.80	11333.2
1364	2.96	4037.44
19006		**86903.35**

Sailing KG_s = 86903.35 / 19006 = 4.57 m

FSC = FSM / W = 2450 / 19006 = 0.13 m

KG_f = 4.57 + 0.13 = 4.7 m

Sailing GM_f = 8.46 – 4.7 = 3.76 m

Answer – 4 (b)

Light W = 40 x 5 x 0.8 x 1.025 = 164 t

Cargo loaded = 596 t

Loaded W = 760 t

Buoyancy = 760 t

	Weight per m run	1 & 4 holds	2 & 3 holds
Cargo loaded		19.8	10.0
Barge alone	164 / 40	4.1	4.1
Total weight		- 23.9	- 14.1
Buoyancy	760 / 40	+ 19.0	+ 19.0
Load		- 04.9	+ 04.9

SF and BM values

Point	A	B	C	D	E	F	G	H	I
SF	0	-24.5	-49	-24.5	0	+24.5	+49	+24.5	0
BM	0	-61.25	-245	-428.75	-490	-428.75	-245	-61.25	0

Answer – 5

Displacement for 6.8 m = 14115 t

KN values for 14115 t

Angle of heel	KN	KG x Sinθ	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

Answer – 6

KM = KB + BM = 4.26 + 5.13 = 9.39 m

Initial GM = $KM - KG_{initial}$

= 9.39 – 9.336 = 0.054 m

Downward shift of GG_1 due to oil transfer

= w x d / W = 60 x 6 / 10000 = 0.036 m

New GM_{solid} = 0.054 + 0.036 = 0.09 m

FSC = I x d_i / W = LB^3 x d_i / (12 x W) = 12 x 10^3 x 0.9 / (12 x 10000)

= 0.09 m

Therefore, new GM_{fluid} = New GM_{solid} – FSC = 0.09 – 0.09 = 0.0 m

Since the initial GM after the oil transfer is zero, the normal formula for the list calculation can not be used. In this case;

Cos θ = GZ / GG_1

But, GG_1 = wd / W

Therefore,

$\cos \theta = GZ \times W / wd$

$GZ = wd \times \cos \theta / W$

At the same time,

$GZ = (GM + ½ \times BM \times \tan^2 \theta) \times \sin \theta$

Since, initial GM is zero,

$GZ = ½ \times BM \times \tan^2 \theta \times \sin \theta$

Therefore,

$wd \times \cos \theta / W = ½ \times BM \times \tan^2 \theta \times \sin \theta$

$\tan^3 \theta = (2 \times wd) / (BM \times W)$

$\tan \theta = \sqrt[3]{[(2 \times wd) / (BM \times W)]}$

The list can be calculated by this formula.

Therefore, $\tan \theta = \sqrt[3]{[(2 \times 60 \times 4) / (5.13 \times 10000)]}$

$= 0.009356725$

List $= 11.9^0$