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 : 05th February 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) A vessel operating in severe winter conditions may suffer from non-symmetrical ice accretion on decks and superstructure.

   Describe the effects on the overall stability of the vessel making particular reference to the curve of statical stability.

   (30 marks)

2) Answer the following questions with reference to bilging:

   a) Briefly describe the effects on a vessel's GM due to bilging

      (06 marks)

   b) A boxed shaped vessel floating on an even keel in salt water has the following particulars:

Length	120.0 m	Breadth	18.0 m
Draught	5.0 m	KG	4.8 m

   There is an empty deep tank amidships adjacent to the keel of length 20.00 m with a water tight flat 5.80 m above the keel, which extends the full width of the vessel.

   Calculate the final draughts and the change in metacentric height if this compartment is bilged.

   (24 marks)

3) A vessel displacement 10500 t KG 6.5 m loads the following grain cargo, stowage factor 1.53 m^3t^{-1}.

Hold	Weights (t)	Kg (m)	Transverse volumetric heeling moments (m^4)
1	3500	7.2	1200
2	4800	7.4	1650
3	4100	7.5	2000
4	3200	7.5	1110

The values of Kg are the volumetric centroids of the spaces.

The table below illustrates extracts from the Maximum Allowable Grain Heeling Moment Table in metre tone:

KG ⟶	**6.8**	**6.9**	**7.0**	**7.1**	**7.2**
Displacement					
25 500	5660	5450	5245	5040	4840
26 000	5600	5400	5200	5000	4800
26 500	5550	5360	5165	4970	4775

a) Demonstrate whether or not the vessel complies with the current Grain Rules.

(25 marks)

b) Calculate the approximate angle of heel due to the assumed grain shift

(05 marks)

4) Ship 'A' has a displacement of 13,000 t and a KG of 8.20 m in salt water.

With the aid of Data sheet – 1 (KN Curves) and Data sheet – 2 (Hydrostatic particulars) determine whether the vessel complies with the stability requirements of the current Load Line Rules.

(30 marks)

5) Answer the following questions with regard to ship's longitudinal stability:

a) "When calculating LCG (Longitudinal Centre of Gravity), more accurate results can be obtained if the moments are taken around aft or fwd perpendicular, instead of the COF". Briefly describe this statement.

(05 marks)

b) 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:

i. The quantities to be loaded in each of the holds

(15 marks)

ii. The final draughts in salt water

(10 marks)

6) A vessel floating upright has to load two weights using the ship's own derrick. The maximum allowable list at any time is 5^0.

Using the following particulars, calculate the minimum initial metacentric height required.

Initial displacement	15,200 t
KM	8.65 m (assume constant throughout)
Derrick head	27.0 m above the keel

Two weights, each 50 tonnes on the quay, 18 m from the centre line of the vessel to be loaded. Stowage positions on deck Kg 13.5 m, 8.0 m each side of the centerline. The inboard weight is to be loaded first.

(30 marks)

Data sheet – 1 (KN Curves)

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

Data sheet – 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 2 (a)

By means of the following formulas:

BM = I/V

KB = half the draft

KM = KB + BM

GM = KM – KG

Need describe that at times the GM may increase and at time the GM may reduce

Answer 2 (b)

First need to clarify whether the final water level is above the water tight flat or below the water tight flat

Volume of lost buoyancy = 5 x 20 x 18 = 1800 m^3

If, S = 5.8 – 5.0 = 0.8 m

Gain volume = 0.8 x (120 x 18 – 20 x 18) = 1440 m^3

In the above case, the lost volume > gain volume

Therefore, the final water plane is above the water tight flat.

Volume yet to regain = 1800 – 1440 = 360 m^3

Water plane area during above sinkage = 120 x 18 = 2160 m^2

Therefore, further sinkage = 360 / 2160 = 0.167 m

S = 0.8 + 0.167 = 0.967 m

Therefore, final draft = 5.967 m

Take moments of volume about the keel to calculate final KB,

120 x 18 x 5 x Final KB = 120 x 18 x 5 x 2.5 – 1800 x 2.5 + 1800 x 5.48

Final KB = 2.997 m = 3.0 m

BM is constant before and after bilging. Therefore, the KM has increased by "final KB – initial KB", i.e 3 – 2.5 = 0.5 m

Therefore, the GM is increased by 0.5 m

Answer 3(a)

Weight	**Kg**	**Moment about keel**	**VHM**
3500	7.2	25200	1200
4800	7.4	35520	1650
4100	7.5	30750	2000
3200	7.5	24000	1110
10500	6.5	68250	
26100		**183720**	**5960**

Final KG = 183720 / 26100 = 7.039 m

Grain heeling moment= 5960 / 1.53 = 3895 tm

From table, the maximum grain heeling moment for current displacement and KG = 5115 tm

Allowable maximum heeling moment > actual heeling moment

Therefore, she is complying

Answer 3(b)

List = 3895 x 12 / 5115 = 9.14^0

Answer 5(b)i

Cargo to load = 24800 – 21200 = 3600 t

Initial trim = 0.52 m stern

Final trim = 1.0 m stern

COT = 1.0 – 0.52 = 0.48 m (stern)

Assuming cargo to be loaded in hold number 7 is Y (t), the trimming moment around the COF
= 53 x Y – 81 x (3600 – Y)

= 134 x Y – 291600

COT = trimming moment/MCTC

0.48 x 100 = (134Y – 291600) / 210

134Y = 301680

Y = 2251.3 t

Cargo to load in hold no. 7 = 2251.3 t

Cargo to load in hold no. 1 = 3600 – 2251.3 = 1348.7 t

Answer 5(b)ii

Maximum even keel draught = 10.86 m

COT from this draught = 1.0 m by stern

Ta = 1 x 85 / 180 = 0.472 m

Tf = 1.0 – 0.472 = 0.528 m

Therefore draught fwd = 10.86 – 0.528 = 10.332 m

Aft draught = 10.86 + 0.472 = 11.332 m

Answer 6

Assume the initial KG is "Y"

Take moments about the keel for at the time of maximum list (when the last weight is hanging over the side)

Weight	Kg	Moment
15,200	Y	15200Y
50	13.5	675
50	27	1350
15300		15200Y + 2025

KG at the time of the maximum list = (15200Y + 2025) / 15300

At the same time, use the following formula at the time of maximum list occurs:

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

Tan 5 = (18 x 50 + 8 x 50) / (GM x 15300)

Therefore, GM at the time of maximum list = 0.971 m

Therefore, KG at the time of maximum list = 8.65 – 0.971 = 7.679 m

Therefore,

7.679 = (15200Y + 2025) / 15300

Y = 7.596 m

Therefore,

The minimum GM required = 8.65 – 7.596 = 1.054 m